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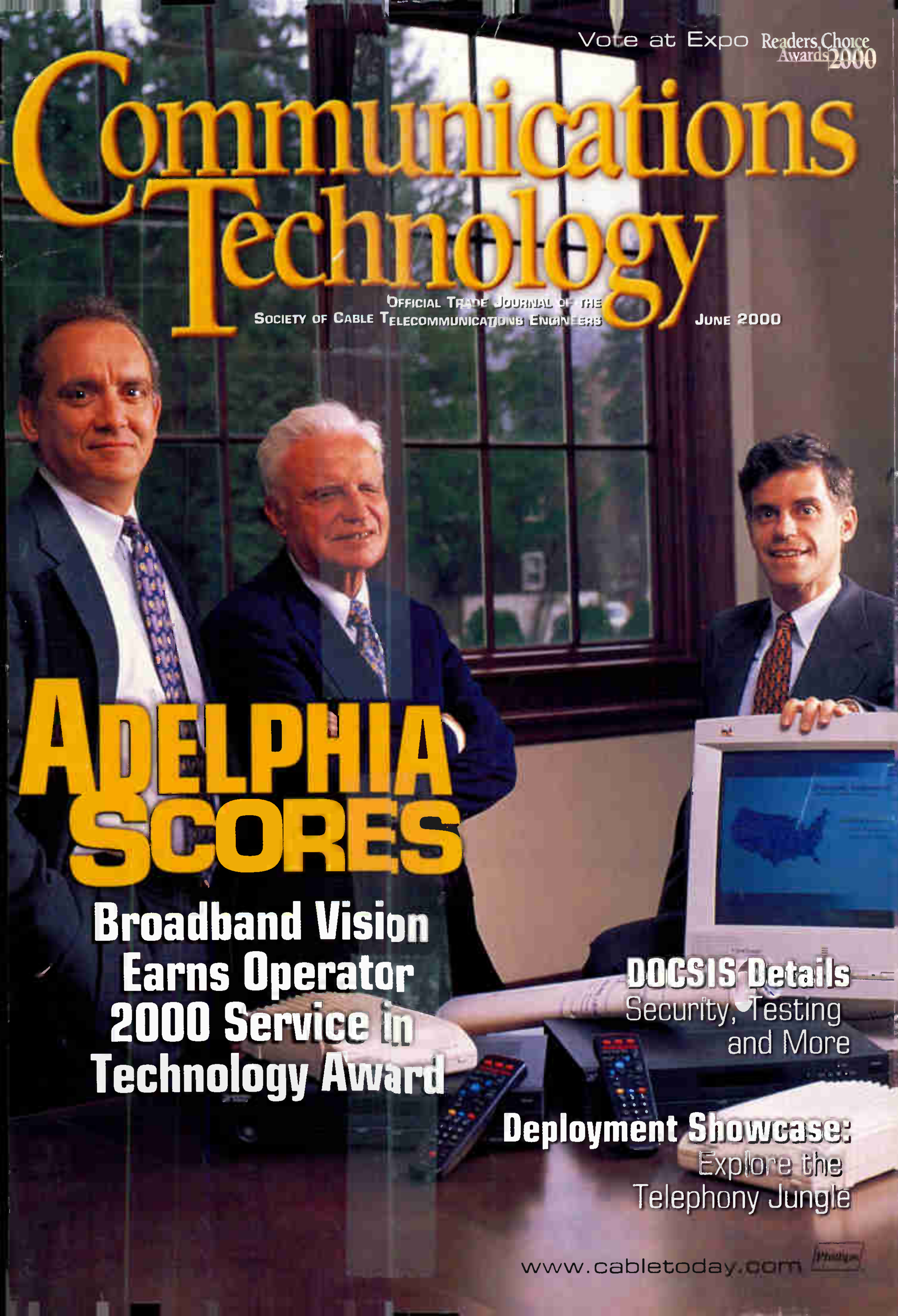
Communications Technology

Official Trade Journal of the Society of Cable Telecommunications Engineers

June 2000



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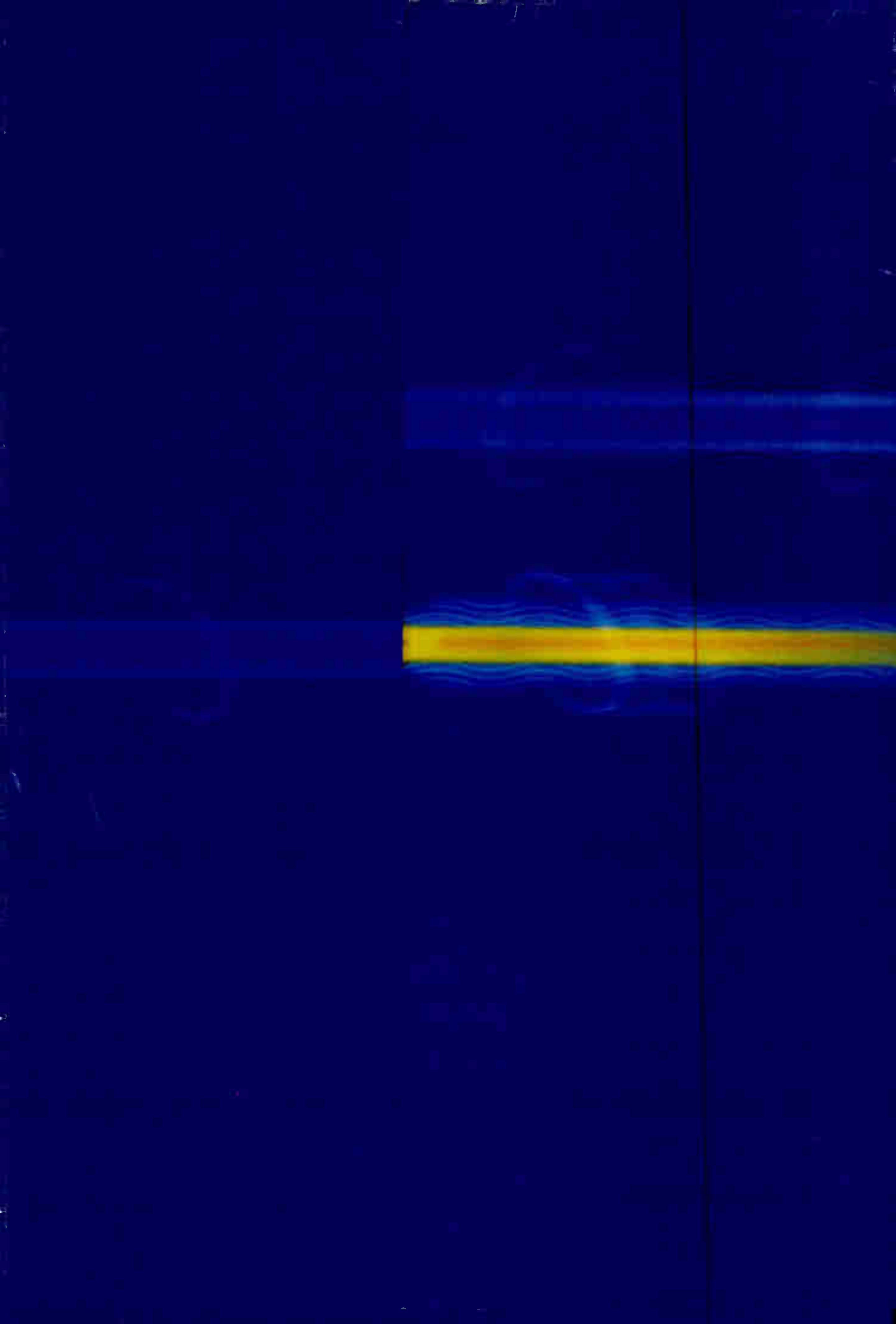

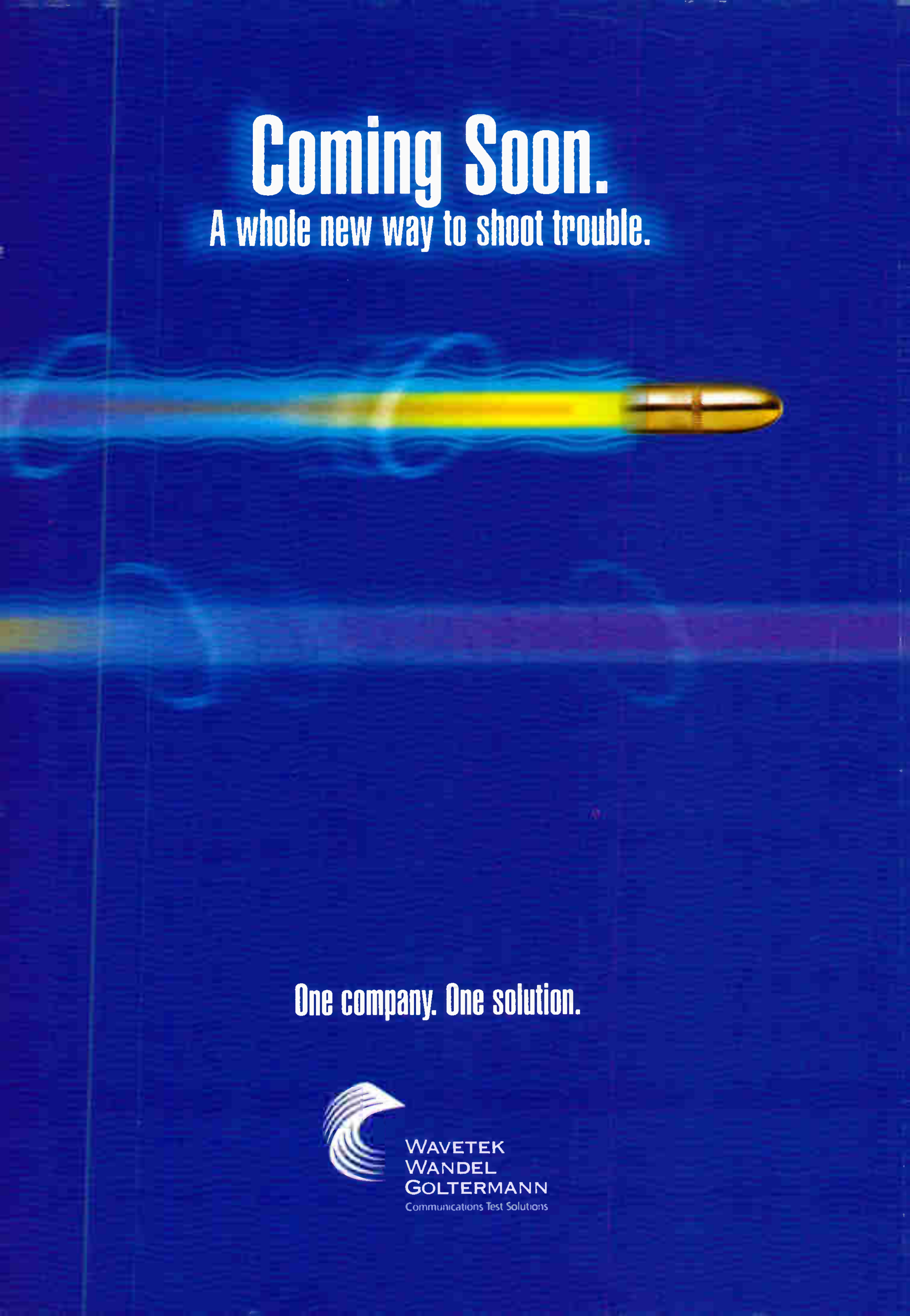
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CONTENTS

June 2000 volume 17 number 6

>>>>>>>Service in Technology: Adelphia Wins > 84

Service in Technology > 84

DOCSIS Update > 104

PacketCable Security > 112

Test and Measurement > 126

Data Self-Diagnosis > 134

Modem Cloning > 142

Compression 3: DCT > 156

Reverse Maintenance > 162

Make Way for PODs > 176

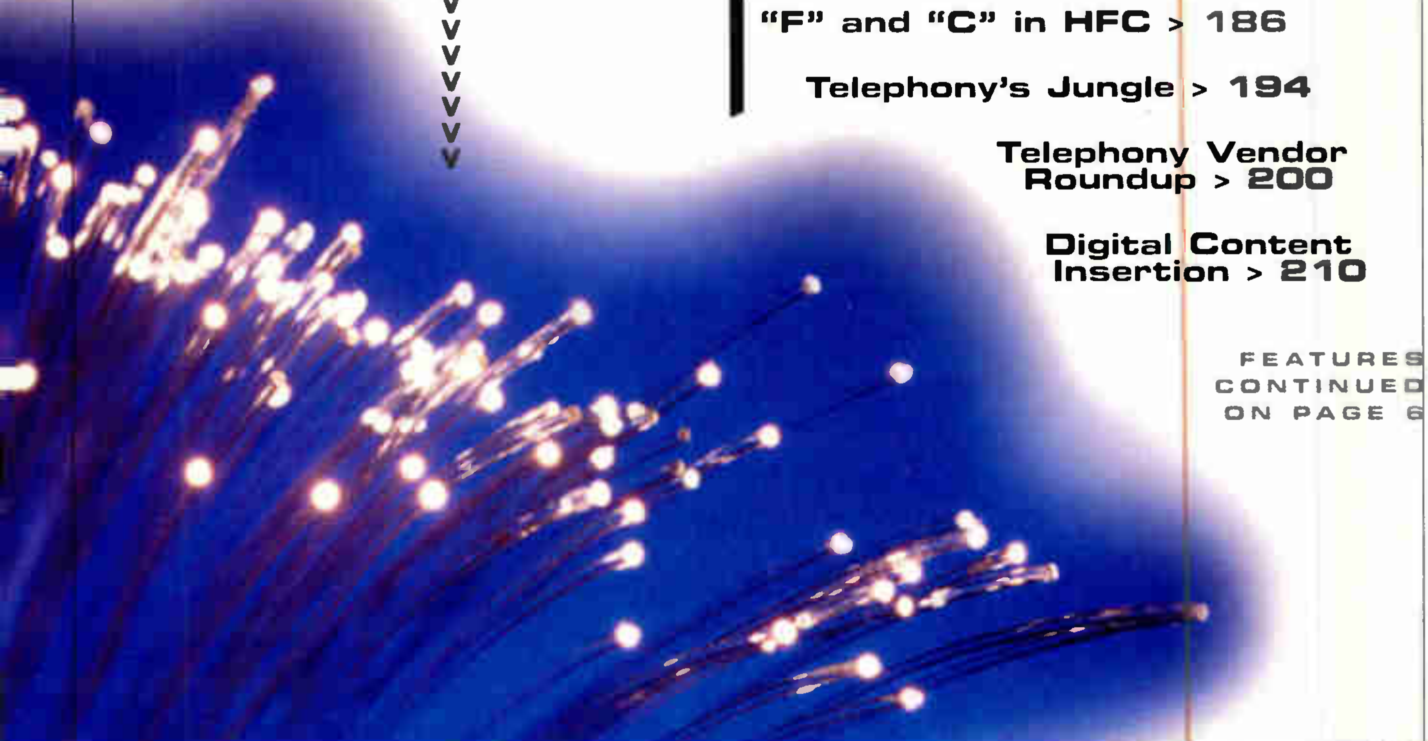
"F" and "C" in HFC > 186

Telephony's Jungle > 194

Telephony Vendor Roundup > 200

Digital Content Insertion > 210

How Much "F" and "C" in HFC? > 186



FEATURES CONTINUED ON PAGE 6

Cover

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Original photo courtesy of Adelphia

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CONTENTS

June 2000 volume 17 number 6

Aerial Safety > 232

FEATURES CONTINUED

VOD Tug o' War > 216

The Wireless Air Raid > 226

Aerial Safety Practices > 232

Enclosure News > 242

Embrace Backing Up > 252

COLUMNS

Interview with a Leader > 32
CT Editor-in-Chief Rex Porter talks with Rogers Cablesystems' Nick Hamilton-Piercy.

Broadband > 55
CT Senior Technical Editor Ron Hranac expounds upon "the powers that be."

Telephony > 62
CT Telephony Editor Jay Junkus looks into defining the latest buzzword: "carrier grade."

Analysis > 68
CT Editor Jennifer Whalen reviews new research on high definition TV (HDTV) and new revenues you can expect in the not-so-far-off future.

Data > 72
C-Cor.net's Terry Wright examines what you'll need to keep chaos from taking over your network in an open access environment.

Standards > 80
Society of Cable Telecommunications Engineers Director of Standards Ted Woo runs down the details of four standards sent to the ITU-T.

NEWS & OPINION

Editor's Letter > 8

Letters to the Editor > 12

Pulse > 16

Marketplace > 260

REFERENCE

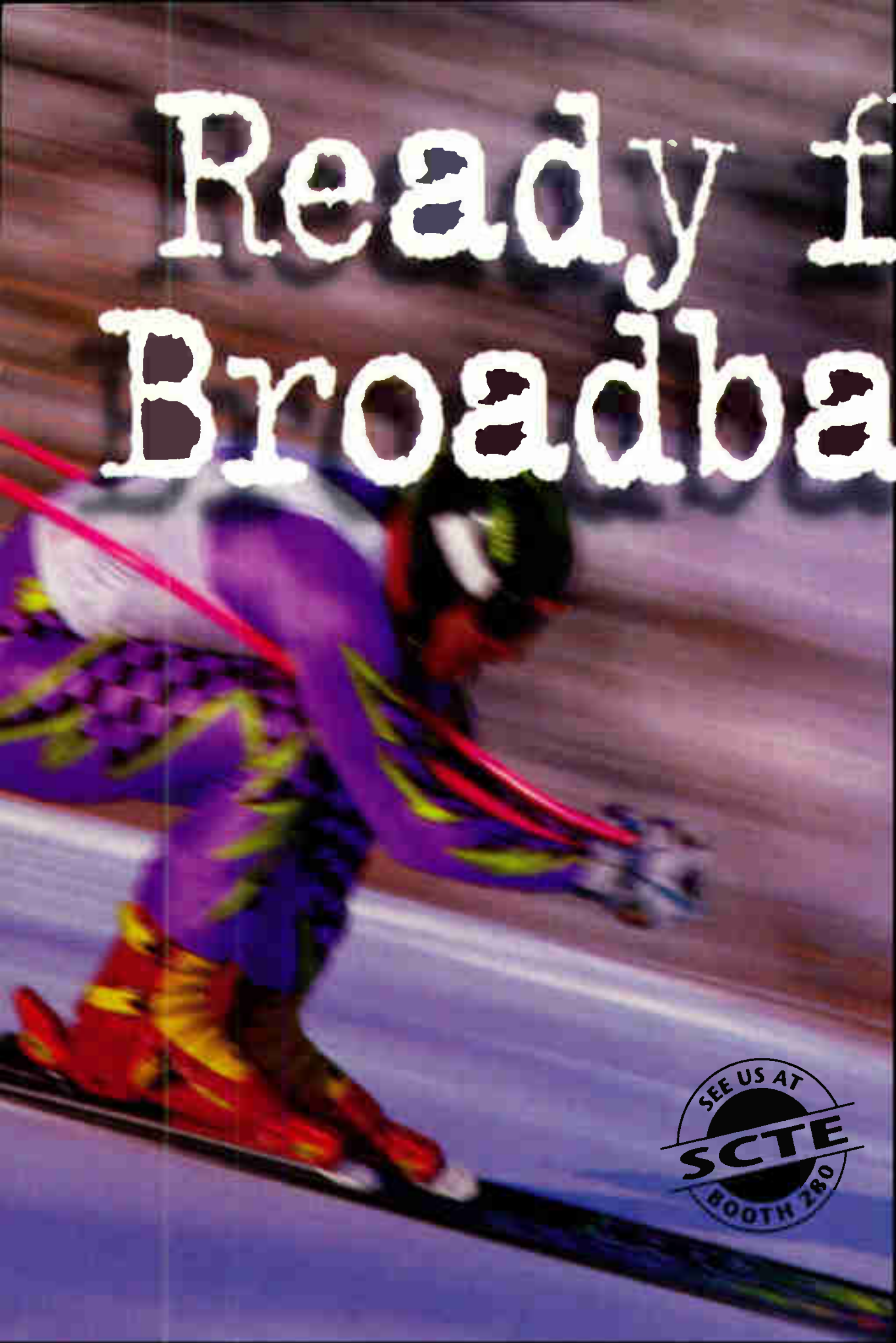
Training > 258

Advertiser Access > 266

Web Connect > 268

Business/Classifieds > 272

Ready for Broadband?



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The Book On OpenCable

Michael Adams is the principal network architect for Time Warner Cable, responsible for networking in its Pegasus Digital Program. He also chairs one of the Society of Cable Telecommunications Engineers Working Groups of the SCTE Digital Video Standards Committee. He recently asked me to review his new book, *OpenCable Architecture*.

After receiving it, I read it from cover to cover, though I must admit that I only scanned some sections that would be important to a working engineer—I hung up my spurs some years ago.

This book begins by introducing the need for OpenCable in language everyone in the broadband industry can understand, from installer to engineer to marketing director.

After the foreword by Jim Chiddix, Time Warner's chief technical officer, "Why Digital Television" describes the history and advantages of digital vs. analog. Other chapters detail both analog and digital set-tops. Then Mike covers digital technology in today's modern systems, explaining local area network (LAN) extensions, synchronous optical network (SONET), asynchronous transfer mode (ATM) and Internet protocol (IP) networks.

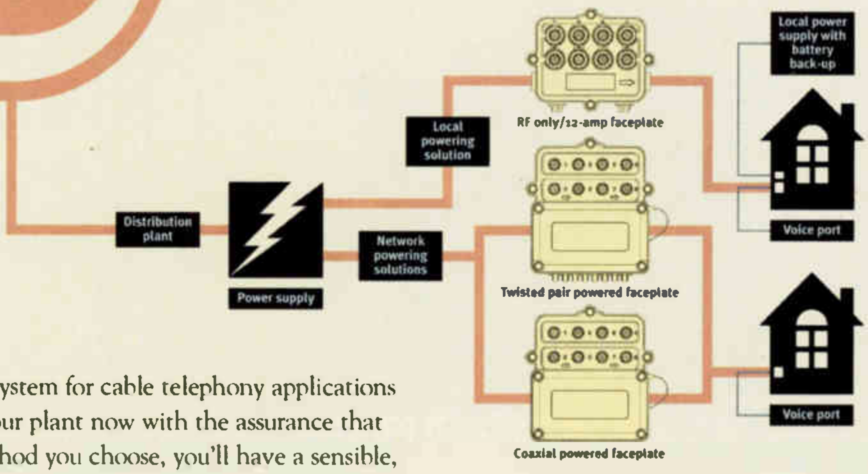
There are chapters on interactive services, interactive cable system case studies, and on-demand services with case studies. "Why OpenCable" covers its architectural model and functional requirements, ending with OpenCable's headend, network, consumer and security interfaces.

Industry reaction to an earlier book, *Modern Cable Television Technology: Video, Voice, and Data Communications*, by Walt Ciciora, Jim Farmer and Dave Large, has made that book required reading for everyone technical in the industry. I expect Mike's book will be purchased with the same enthusiasm. If you enjoy *Modern Cable Television Technology*, you will want to pick up a copy of *OpenCable Architecture* to complete the set. They go hand-in-hand. The book is published by the Cisco Press, www.ciscopress.com.

Let's hope Mike will be on hand at the 2000 SCTE Cable-Tec Expo to personally sign copies.

Rex Porter
Editor-in-Chief

3 faces
1 body
0 worries



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> Praise for *Communications Technology's* Redesign

Hi, Tim:
Congratulations on getting your picture in *Communications Technology*. OK, congratulations on the publisher's job, too. The new look for *CT* is great—I really like it. Definitely a jump in the right direction.
Regards,

Jim Lepsch
Monroe Electronics

Tim:
Your final comment in your letter (Publisher's Letter, April 2000, page 10) is something we at Broadband Access Systems strongly agree with: "... just like a broadband system, both the content and the delivery vehicle must be operating at peak performance."

Navigation is always important, whether you're viewing a Web site or a publication, and you have achieved that seamlessly.
Thanks,

Susan Costa
Marketing Communications Manager
Broadband Access Systems

Tim:
I like the new look within *Communications Technology*. I think your bolder type, bigger headings, shorter stories and broader coverage all work very well. Great work.
Sincerely,

Bailey Shewchuk
Vice President of Business Development
INT2

Publisher's response: Thanks, all—glad you like it. —TH

Cable's Top 10 Technologies

Ron:
I enjoyed your article ("Cable's Top 10 Technologies," March 2000, page 24), but I would not have put harmonically related carriers (HRC) on the list. HRC (and incrementally related carriers, or IRC) were interesting technologies, but I don't recall them being widely used, at least in my time.

Technology or technique—heterodyne channel processing certainly had a big impact on headends. It took us out of the strip amplifier era and gave us flexibility in making channel assignments.

Frank Baxter
Retired

Editor's response: Other technologies that were suggested by readers include hardline coaxial cable. If you ever worked with ladder line, G-line, or even some of the early strip-braid and other coaxial cable configurations, you no doubt have a deep appreciation for modern cables.

Another suggestion offered was contemporary amplifier housing designs. Some of you may remember the old pole-mounted tin boxes with tube—and later solid state—rack mount-type amplifiers and RG-11 jumper cables from the amplifier to bulkhead connectors located on the box exterior. Certainly

not elegant, not really weatherproof, and they made great homes for critters.

I once worked in a system that had an eight-amp cascade of the old Jerrold TML solid-state trunk amplifiers. The TMLs were Jerrold's replacement for the older tube versions, and they were a direct bolt-in. If you've never seen these old amplifier housings, imagine a big metal box perched on crossarms up on the pole.

Still other ideas for the top 10 list include converters (set-top boxes in today's vernacular), cable-ready TV sets ("cable-compatible" is really more accurate), and fiber-optic cable.

With regard to my comments about HRC channelization, I'd like to clarify that in addition to third order distortions falling zero beat with the visual carriers, so do the second order distortions. —RH

Industry doin's

Art,

I read the "Time Warner Soars with Pegasus" article (April 2000, page 78) with much interest. Do you know of any good resources of information for the current status of the industry and the major multiple system operators' (MSOs') roll-out of these services?

Mike Lynch
Sales Engineer
Artel Video Systems

Editor's response: Be sure to check out our Deployment Watch update in CT's Pulse section. Each month, we highlight new service launches and product deployments by MSOs and their competitors. It will give you a quick snapshot of what's happening around the country. —JW

> Write to Us

What do you think of this month's issue? If you agree, disagree, or have comments on what you've read, please let us know. Simply e-mail *Communications Technology's* editors at tvrex@earthlink.net or jwhalen@phillips.com. *CT* may edit letters for clarity and space.

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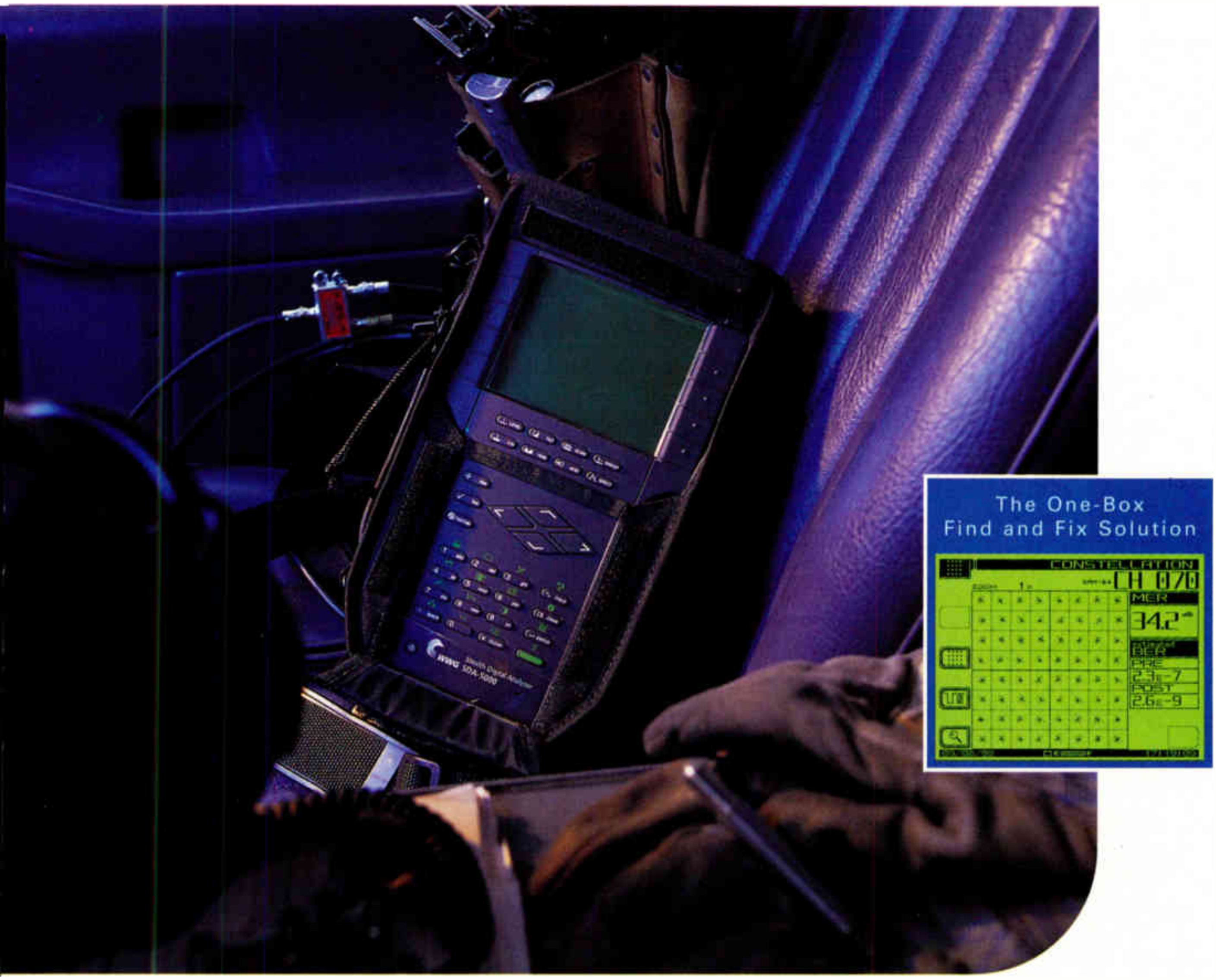

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VOD Dark Horse Quick Out of Box

By Jonathan Tombes,
Deployment Editor

A company whose computers detect wind shear for airline pilots appears to have taken an early lead in the video-on-demand (VOD) race. Concurrent Computer is expanding its VOD rollout with Time Warner, initiating deployments with Cox Communications and trialing with Comcast. By late summer, it could have several hundred thousand activated set-top boxes.

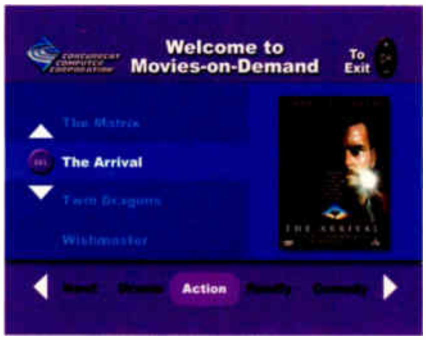
Concurrent Vice President of Engineering Bob Chism said that his company's MediaHawk VOD system currently has about 42,000 activated subscribers in Time Warner's Oceanic Cable operation in Hawaii. He added that Time Warner is also testing the system in its Tampa Bay division and plans an initial deployment there of about 100,000 activated set-tops. A recently announced deal has Concurrent supplying Time Warner with VOD equipment through 2001.

"We looked at our core competencies and said, 'Wow, this would make a great video server.'"

—Bob Chism, Concurrent Computer

Cox has also selected Concurrent, building upon an ongoing VOD trial. "In a month or so, we'll roll it out to several thousand paying customers, and then a few months later, we'll roll it out as rapidly as we can across all of San Diego," said Alex Best, Cox senior vice president for engineering.

The Concurrent system uses the MediaHawk video server to house the titles, a back-office software suite that tracks assets and customers, system management maintenance software for such tasks as propagating content out through the hub, and a network manager for provisioning total system bandwidth.



Concurrent's VOD order screen

In distributed architectures, Concurrent places multiple video servers in the hubs, which also carry network gear enabling two-way digital traffic. "The idea obviously is to put the high-usage titles out in the hub," said Chism.

Concurrent is taking VOD in stride. "Our legacy core business (is) in real-time systems, very mission-critical applications, that require a lot of custom work," said Chism. In addition to detecting wind shear, Concurrent systems are used for Doppler radar weather predictions, engine testing and military applications. "I don't mean to downplay VOD, but believe it or not, once you're playing out a movie, it's a very repetitive process," added Chism.

While Concurrent's XSTREME video division generates only 2 percent of the company's revenues, it leverages the company's strengths and is poised for growth. "It's not as if we started day one saying that we're going to design a video server from scratch," said Chism. "We looked at our core competencies and said, 'Wow, this would make a great video server.'"

Some operators agree. "We did a very thorough evaluation of all the vendors out there," said Best, "and we felt that at this time Concurrent had the best product for what we were trying to do."

This dark horse may be hard to beat. Chism said Cox ran "the most extensive, formal request for proposal (RFP) process that I have seen." He added that Tampa and Oceanic were also competitions, and that Concurrent has won two of Comcast's three ongoing trials.

Best said, that Cox will not be sole-sourced. Charter Communications' decision to launch Diva in Los Angeles, which represents the largest VOD deployment to date, is a reminder that the race has only begun.

NEWSBITES

> **Middleware Standards**

The Society of Cable Telecommunications Engineers has launched a new standards-developing group, the Cable Applications Platform subcommittee. CAP held its first meeting April 24 at CableLabs in Louisville, Colo. Chairman Jean-Pol Zundel, chief software architect for Comcast Cable, said company members so far include Canal+, Liberate, Microsoft, OpenTV, and PowerTV.

> **Modem Count**

Kinetic Strategies reported that as of March 31, the total number of cable modem subscribers in the United States and Canada was 2.7 million, a 33-percent increase since the end of 1999. Time Warner led the industry with 400,000 installed customers, followed by AT&T with 294,000, MediaOne with 278,000, Cox with 259,770, Shaw with 235,000, and Rogers with 215,200. >

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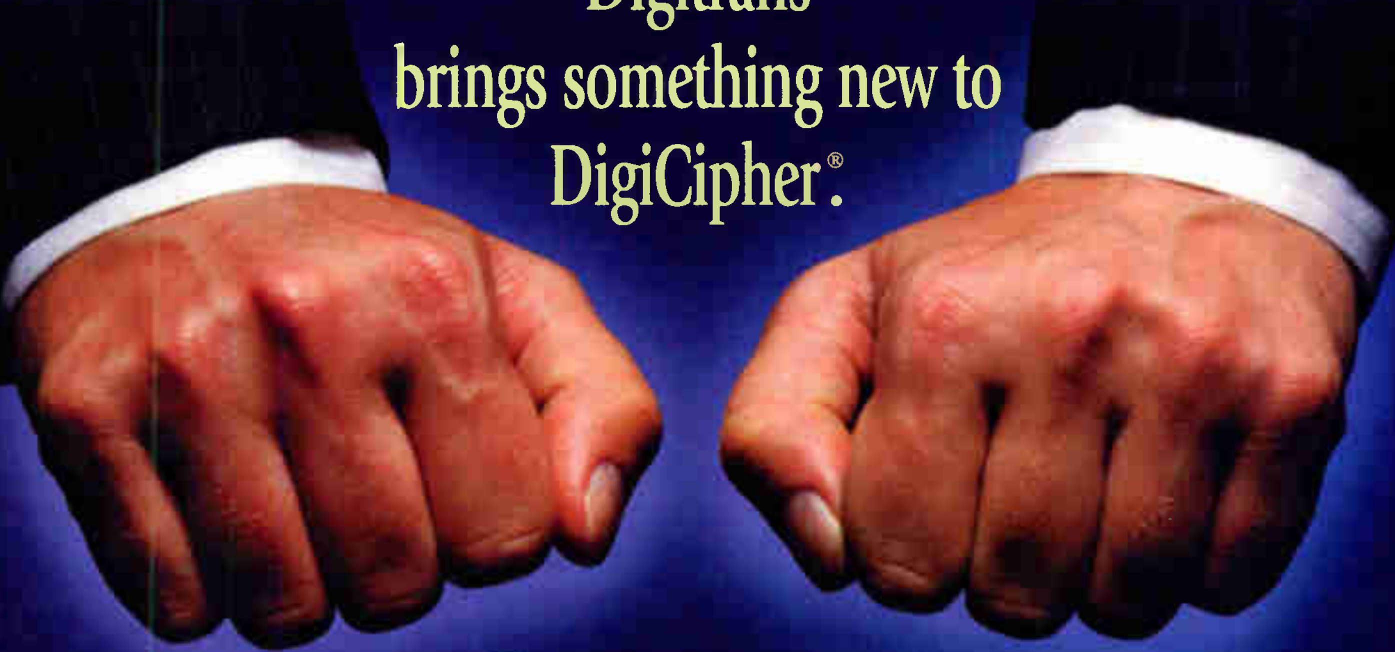

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Cable/Telco Battle Takes to the Skies

By Natalia A. Feduschak, Senior Editor

The battle between cable operators and phone companies over interactive TV and video content just got hotter.

AlphaStar International and mPhase Technologies have joined forces to create a global broadband TV distribution network, called mPhase Television, which is expected to become a viable alternative to cable and provide customers with more programming at a lower cost.

"This is competition because broadband and high speed will compete with (cable companies) on an equal ground," said Mahmoud Wahba, president of the Greenwich, Conn.-based AlphaStar, one of four original direct-to-home satellite broadcasting companies.

Customers will be able to download movies, video games and receive digital TV (DTV) programs on a monthly subscription basis, or receive video-on-demand (VOD) and pay-per-view (PPV) options directly from their local phone company via the mPhase Traverser Digital Video and Data Delivery System (DVDDS).

The Traverser, which was created by mPhase Technologies in cooperation with the Georgia Tech Research Institute in Atlanta, allows phone companies to deliver simultaneously high-speed Internet access, 400 channels of DTV programming and traditional voice services over existing twisted-pair copper telephone wires.

"This allows us to be in control of the content itself and have the lowest possible downlink cost," said David Klimek, mPhase's chief technology officer and director.

Three years in the making, the Traverser is similar to a cable box that telcos install at the customer site, along with common equipment at the serving central office, to provide voice, video and data services.

The Traverser uses rate adaptive digital subscriber line (RADSL) technology. The box provides broadcast quality video in Moving Picture Experts Group (MPEG)-2 format and a dedicated Internet path to each subscriber. AlphaStar pulls local and international TV content and sends it to telcos via a small dish satellite. Mphase DSL then is distributed to households via standard copper wire.

The venture's first client is Hart Telephone, a local exchange carrier (LEC) in Hartwell, Ga. Deployment is expected late in the third quarter. Other installations are planned.

With 185 million copper wire telephone lines in the United States and more than 827 million worldwide, the joint venture hopes to target new service providers, including LECs, long distance carriers, and Internet service providers (ISPs). The joint venture has met with several national hotel and motel chains and is hot to bring its services to college campuses.

"Everyone wants to see the price of equipment come down," said Klimek. Because adding cable can be costly, hospitality organizations have shown great interest in being able to use their existing phone lines to deliver VOD and other services typically offered by cable, he said.

The mPhase Television project aims at putting phone companies on the same footing as cable companies. "The impact on customers is that they have an option of going to phone rather than video," said Michelle Abraham, senior analyst at Cahners In-Stat group.

Abraham added that smaller phone companies are most likely to use satellite services because cable is either not accessible in parts of the country, or municipalities have opted not to be serviced by large cable operators. "In rural areas, their only alternative is to get satellite," she said.

NEWSBITES

> ### Industry Course

The National Cable Television Institute has launched a college-level course, "Principles of Management for the Broadband Industry," geared for the broadband sector. The curriculum combines textbook principles with workbook exercises. For more information, contact the NCTI at www.ncti.com.

> ### Antec's DWDM Selected

The Time Warner Charlotte Division has selected Antec's dense wavelength division multiplexing (DWDM) system. Time Warner/Charlotte will use the Laser Link 1,550 nm DWDM Transplex Transport System to connect its headend in Monroe, N.C., to its headend in Charlotte.

> ### Back-Office Allies

Ceon Corp. plans to develop a direct interface between its Net-Express service fulfillment software and Infranet, customer management and billing software from Portal. The combined application should help providers manage a range of telephony, cable TV and Internet services. The operations support system (OSS) allows customers to buy services directly over the Internet.

> ### Certified Modem and POD Tester

CableLabs has certified modems from High Speed Surfing and Toshiba. HSS was the 18th manufacturer to have a high-speed, always-connected Data Over Cable Service Interface Specification (DOCSIS) 1.0 cable modem certified for retail. CableLabs also announced that it is working with Margi Systems to develop a test tool for OpenCable point of deployment (POD) modules.

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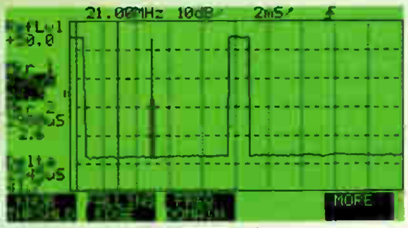

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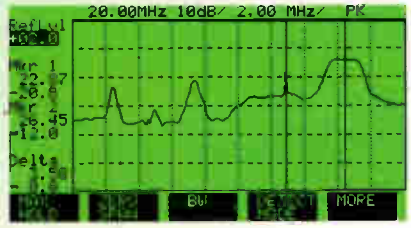

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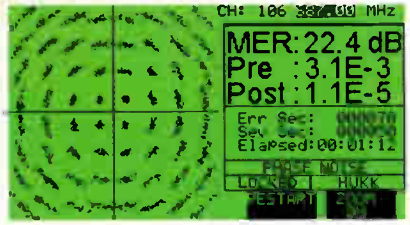

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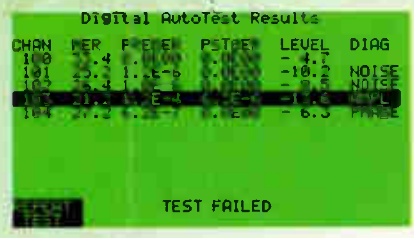

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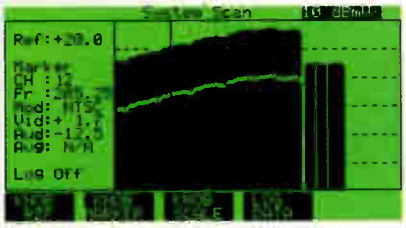

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Charter Upgrades With Harmonic

By Jonathan Tombes, Deployment Editor

Charter Communications has chosen Harmonic to help it upgrade 135,000 miles of cable plant. That's a big project, so big the announcement didn't even mention dollar amounts or product units.

"We've historically been doing business with them, but it's been awarded on a project-by-project basis," said Patrick Harshman, vice president of marketing for Harmonic. He said that with the aggressive rollout of interactive services, Charter was "really taking a larger system view."

Charter Vice President for Engineering Larry Schutz said that in meetings last year, the company told contractors that it "wanted to break out of the historical contractor/multiple system operator (MSO) relationship and work as partners."

Several things impressed Charter about Harmonic's capabilities. Schutz pointed to the flexibility of Harmonic's dual receiver nodes and the work the company has done in the area of digital upstream transmission. Harmonic's PWRBlazer II optical nodes can be configured with digital dense wavelength division multiplexing (DWDM) transmitters.

Harshman noted that driving bandwidth deep into neighborhoods with DWDM technology entails "very tight control over optical transmission wavelength." He described Harmonic's work in the requisite temperature control of optical equipment as a "technical breakthrough."

"To be able to really get the segmentation and to fully utilize this technology, you want to put it in the node," said Harshman. "But from the digital technology point of view and the DWDM point of view, you really need to overcome the environmental issues to make sure that everything works properly and is stable."

Harmonic offers digital DWDM return from within an environmentally hardened node.

Shutz anticipates completing 45,000 miles of upgrades this year, roughly divided between Charter's eastern and western regions. At the same time, Charter plans to build more than 500 new master headend, primary hub and secondary hub structures.

The Bick Group of St. Louis is acting as prime contractor for 200 planned master headend and primary hub buildings over the next four years. The total number of master headends under this plan will drop from about 1,250 to less than 500. Alcoa Fujikura of Spartanburg, S.C., is building the smaller, prefabricated, secondary hub structures.

"Most of those secondary hubs will be located at or near where existing small headends are," said Schutz. "And they will replace those smaller headends and will become tied into a master headend facility that will be 40, 50, or 60 miles away."

In other headend-related news, stockholders of Harmonic and C-Cube Microsystems approved Harmonic's acquisition of the DiviCom unit of C-Cube. DiviCom provides digital TV (DTV) technology, including headend equipment.

PEOPLE

Hranac Appointment
Ron Hranac has been appointed to the American Radio Relay League's Radio Frequency Interference (RFI) Task Force.

Bennet Promoted At Tiernan
Tiernan Communications has promoted Christopher Bennett to chief technical officer. He will focus on identifying key technology areas for the company's current activities and future growth.

WorldGate Gets New Veep
WorldGate Communications has appointed Richard Westerfer as vice president of engineering for the company's converter system division. Westerfer comes to WorldGate from GI/Motorola, where he received four patents for his work.

Vela Lands Robertson
Bill Robertson has been promoted to vice president of technology, marketing and planning for Vela LP. He will oversee engineering and marketing.

New RF Chief
Richard Hinkle has been appointed to director of RF engineering at Broadcast Electronics, a provider of digital audio delivery and management systems. Hinkle will be responsible for all RF design sustaining engineering activities.

Robertson to Oversee Management
Convergys Corp. has appointed Stephen L. Robertson executive vice president of operations for the corporation's Information Management Group. Robertson will be responsible for the cable, wireless, wireline and utility billing businesses of Convergys' Information Management Group plus its data center operations.

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US West, CLECs Deal May Speed DSL Rollout

By Paul Coe Clark, III. Editor, Communications Technology

Incumbent local carrier US West and 13 data CLECs inked a deal on line-sharing rates, a move that will hasten the spread of digital subscriber line (DSL) access in US West's region.

The CLECs agreed to pay US West $5.40 a month for the data frequencies of shared lines until state commissions set line-sharing rates. Alternately, the CLECs can pay nothing until at least Jan. 1, when they will start paying $8.25 a line per month, unless the commissions have set rates. The signing CLECs include Arrival Communications, Contact Communications, Covad Communications, Jato Communications, New Edge Networks and Northpoint Communications.

US West will continue to negotiate permanent rates with individual CLECs. A negotiated rate would probably supersede state rate proceedings, US West spokesman David Fish said.

The zero-charge interim arrangement is similar to the separate deal US West cut in April with Rhythms NetConnections, which agreed to an increase to $8.25 as of June 2001. As part of that agreement, Rhythms agreed to drop its opposition to US West's merger with Qwest.

Thus, the new deal left the CLECs free to oppose the merger, although it will largely remove any incentive for them to do so. "There's nothing discussing the merger in this agreement at all," said US West spokesman Steve Hammack.

US West, eager to close its merger, is the first ILEC to reach a region-wide line-sharing agreement. The FCC in November voted to require incumbents to share their local loops by June 6, but little line-shared DSL is available yet in the states.

Clay Deanhardt, senior counsel for Covad, said the US West deal would speed the rollout of DSL to customers. "This agreement proves that the FCC's line-sharing mandate is clearly executable by the incumbent local exchange carriers," he said. "Not only will this agreement provide consumers with greater choice in DSL service providers, but we also expect line sharing to result in more competitive DSL pricing and faster installations."

ILECs already are splitting lines to provide their own DSL and voice services on a single local loop. At year's end, US West had 110,000 such DSL customers. It is now installing about 10,000 new DSL connections a month, Hammock said. A continuation of that rate would put US West at 120,000 lines for the year. Other ILECs have grander target. Bell Atlantic, for example, has set a target of 500,000 DSL lines by year's end.

> Trouble in DSL Paradise

By Mark Mueller
Editor, *Broadband Networking News*

While you can't ignore competition from digital subscriber lines (DSL), it's not all cozy partnerships.

Incumbent and competitive local exchange carriers are at odds over access to remote terminals (RT).

The FCC met last month to determine whether vendors are developing, and carriers are deploying, new RT technologies in a pro-competitive and cost-effective manner. What they heard was not positive.

Access to ILEC copper loops by way of RTs is quickly becoming a necessary part of CLEC expansion strategies, especially for DSL. CLECs want RTs to house as many of their systems as possible. ILECs, stressing economic realities, municipal regulations and deployment time considerations, appear to be in no rush to acquiesce to CLEC demands.

"The remote terminal is becoming the new central office, we really need to be there," said Stephen Bowen, legal council for **Rhythms NetConnections**. "The problem we see is that (RT) cabinets are designed for a specific vendor," he said.

CLECs want unqualified open access, and they want bigger RTs. "We think it's possible, under any configuration, to [make] them in sizes big enough for space for other competitors," Bowen said.

ILECs disagree. "There is no economic reason to [add] space to existing cabinets," said Wayne Masters, Senior VP of broadband services for **SBC**. Doing so would defeat the purpose of moving fiber deeper into the networks and would take too long, he said.

SBC serves more than 40 percent of its households by way of 40,000 RTs. Another 13,000 units are being added, and 10,000 are being upgraded, Masters said. Refitting those for multiple CLECs would be an impossibility, he said.

"Maybe one or two CLECs could be added, but how do you get 34 in each one?" asked Masters.

Meeting CLEC demands, and adding an additional rack to an RT unit (which usually hold two to three racks) would cost $10,000 per rack, said Charles Kiederer, director of technology planning for **Bell Atlantic**. CLECs would be unlikely to foot the bill, he said.

Com21 Attacks Telephony With GADline Purchase

By Natalia A. Feduschak, Senior Editor

In a deal expected to bolster its plans to implement voice over cable, modem manufacturer Com21 plans to acquire GADline Ltd. for 2.8 million shares of Com21 stock. The acquisition, worth more than $70 million, will expand Com21's technology portfolio and telephony product line, while providing GADline with additional resources for research and development.

GADline, an Israeli firm, focuses on telephony and high-speed data over hybrid fiber/coax (HFC) infrastructure. Its products include the CyberMode Data Over Cable Service Interface Specification (DOCSIS) cable modem; the ANEXT System, a public switched telephone network (PSTN) and integrated services digital network gateway (ISDN); as well as the VIVID 1 System, a voice over Internet protocol (VoIP) gateway with multivendor network management system (NMS) for headend and cable modem management.

"We were looking for additional products and technology, and additional people in this marketplace," said Buck Gee, Com21's vice president of marketing. GADline's "existing and future products were a good match for what Com21 wanted to do and the direction it wanted to take in voice over cable."

As a result of the purchase, Com21 will now be able to offer enhanced telephony solutions to cable operators worldwide, using circuit-switched plain old telephone service (POTS) and ISDN over HFC networks.

The two companies are discussing how to integrate their product lines, said Gee. The acquired technologies, however, will hasten time-to-market for Com21 VoIP products, while complementing the company's current integrated voice/data technology and its ComUNITY VoX (Voice over eXchange), a newly introduced extension of its ComUNITY Access cable modem system. GADline, meanwhile, is expected to continue to manufacture is own products.

GADline brings to Com21 a well-regarded product in the circuit-switched voice-over-cable market. It has announced new VoIP technology, expected to be available in the fourth quarter.

The GADline acquisition indicates that "circuit-switched telephony continues to play an important role in the marketplace, despite all the buzz around IP," said Michael Harris, president of Kinetic Strategies, a Phoenix-based research firm. "GADline's first primary offering was a circuit-switch telephony system, although they're able to offer DOCSIS services in addition to it."

GADline's technology will also help Com21's ISDN services over cable. "As they look to go IP, (the acquisition) will certainly help their strategy, as well as gain additional telephony expertise," said Harris.

"We think we have a very strong full system solution, which is all managed by the same network management system that we've developed ourselves," noted Larry Ruben, GADline's chief executive officer. "We believe that's going to be a major contribution to helping Com21 be a leader in the voice field as well as the data field."

Currently, Com21 is the second largest seller of cable modems worldwide and third in the United States. Since, March 31, Com21 has shipped 524,000 modems worldwide. The deal is expected to close by the end of July.

Deployment Watch Monthly Update

Provider/Operator	Service/Feature	Communities	Vendor/Partner
ANTEC Corp.	Laser Link 1550 nm DWDM Transplex Transport System (Digital Signal QAM transmission)	Monroe, NC	Time Warner/Charlotte Division
Bell Atlantic Video	DIRECTV (210 channels)	New York Area (Long Island, Brooklyn, Queens)	Hughes Electronics Corp.
Charter Communications	Video-on-demand (VOD)	Los Angeles (Pasadena, Alhambra, Monterey Park, Glendale, Burbank, Long Beach)	Diva (VOD)
DIRECTV	Digital TV Service	Salt Lake City, Indianapolis, Charlotte, Milwaukee	Primestar
High Speed Access Corp.	High speed data services	Birmingham, Hickory, N.C., Vincennes, Ind., Stevens Point, Wisc.	Charter Communications
ISP Channel	High speed data services	Point Magu, Calif.; Doral, Fla.; Thief River Falls, Minn.; Northfield, Vt.; Brownwood, Texas	Communications Services, Strategic Technologies, Sjoberg's Cable, Trans-Video, Brownwood Television Cable Service Inc.
Mpower Communications	Live voice and data	Las Vegas	Lucent Technologies
Road Runner	Live voice over the Internet	Nationwide	Lipstream
SoftNet Systems, Inc.	High speed broadband Internet access	Alberta, Canada	Northern Cablevision Ltd.
Vyyo	DOCSIS Cable Modems	Great Falls, Montana	SoFast Internet Services
Williams Communications	Network capacity and services	Charlotte, Chicago, Dallas, Indianapolis, Los Angeles, New York, Orlando, San Jose, Tampa, Washington, D.C.	Time Warner Telecom Inc.

Motorola Nabs Major Cable Purchase

By Natalia A. Feduschak, Senior Editor

In what is one of the largest modem purchases in North America to date, Time Warner Cable has committed to deploying up to 500,000 Motorola Data Over Cable Service Interface Specification (DOCSIS) SURFboard 3100 and DM100 cable modems in various systems within the next two years.

"We chose Motorola because it is a very high quality company," said Mike Luftman, a spokesman for Time Warner, of the purchase.

"Both are solid products," added John Burke, vice president of marketing for Motorola's Internet protocol (IP) Network Systems business unit. "Clearly this is a sign of Time Warner's commitment to high-speed Internet access space. They are one of the leading companies in cable television."

Like other multiple system operators (MSOs), Time Warner has been eagerly awaiting the unveiling of DOCSIS 1.1 modems that would allow the company to expand its services to include voice over cable.

The SB3100, which Motorola acquired through its purchase of General Instrument, is hardware-ready to support the new DOCSIS 1.1 specification. It calls for advanced quality of service (QoS) and IP filtering functions. The modem also enables the prioritization of voice calls to support real-time voice over Internet Protocol (VoIP). Motorola has installed a high-speed processor, which is five times faster than its SB2100, in the SB3100 to handle current and future advanced DOCSIS functions, reported the company.

The SB3100 has been shipping since the third quarter of last year, said Burke.

The DM100 receives 64/256-QAM (quadrature amplitude modulation) signals, which supports downstream throughputs of up to 40 Mbps, from the cable modem termination system (CMTS) and transmits quadrature phase shift keying (QPSK)/16-QAM signals upstream and supports throughputs up to 10 Mbps.

Both modems sell in the $175-$185 range.

Mike Harris, president of Phoenix-based research firm Kinetic Strategies, said one of the interesting aspects of the purchase is that Motorola chose to sell its modems directly to Time Warner rather than shipping them off to retail stores. It made that decision despite the introduction of the products standard, which would phase in the sale of modems to retail outlets.

Time Warner is "remaining with the status quo," said Harris.

There is some concern among vendors that the purchase of cable modems might slow if consumers are required to purchase their modems from stores rather than through their cable vendors because they will not know how to install them or get the service they are used to, said Harris.

"This is a quality control issue," he added.

Time Warner will continue to purchase cable modems from other companies, but Motorola remains its preferred vendor, Luftman said.

The use of North American cable modem users is predicted to grow from 1.8 million in 1999 to 15.9 million in 2003, according to Kinetic Strategies.

Charter Places Big Order with S-A

By Jonathan Tombes, Deployment Editor

Scientific-Atlanta has agreed to provide Charter Communications with 1.3 million Explorer 3000 digital set-tops. Charter also ordered 200,000 Data Over Cable Service Interface Specification (DOCSIS) cable modems, a new S-A product.

"Basically, they came to us and said they wanted to deploy deeper and faster," said Robert Van Orden, vice president of product strategy and management for S-A's Subscriber Networks. He said that consumer preference and competitive pressures facing multiple system operators (MSOs) are behind the broader trend for accelerated digital deployments.

"Consumers love the product," said Van Orden. "For $8 to $10 more per month, they get the digital quality pictures, more channels, more choice, a very easy-to-use, but slick—sexy, if you will—interactive program guide, digital music."

In Charter's case, a deal with Diva adds video-on-demand (VOD) to that product mix in some areas.

Can supply meet demand? Van Orden said that quarterly S-A production of digital set-tops increased from 250,000 to 500,000 to more than one million units, in three successive quarters. "And that's still probably not enough," he added.

Charter's purchase of S-A's new DOCSIS cable modems marks S-A's re-entry into the modem market, which also is facing soaring demand and capacity constraints.

In addition, Charter agreed to purchase 15 Continuum headends for select systems by year's end. S-A's SciCare Broadband Services will support Charter's implementation of these networks and product.

The agreement covers a two-year period and is subject to certain conditions.

Road Runner Carries Software-On-Demand

By Jonathan Tombes, Deployment Editor

The commercial launching of an Into Networks offering over Road Runner's high-speed data service is another indication that a niche broadband industry has arrived.

PlayNow.com is the software-on-demand service of Into Networks (formerly Arepa). "The company was founded in '96 on the vision that CD-ROMs were just not the best delivery platform for all those kind of rich media, and that broadband could really open up a lot of new doors for it," said Bill Holding, Into Networks' vice president of marketing.

The visionaries took action and created a proprietary encoding format and delivery platform. Their encoding process compresses and encrypts CD-ROM files into units called briqs, which are then replicated to random access file transfer (RAFT) servers at network broadband network headends.

"Then they get delivered over the last mile, fat-piped to the end-user's desk, where (the users) can then execute on demand on their desktop with our thin client, the IntoPlayer," explained Holding.

Into Networks' prior relationship with multiple systems operator (MSO) MediaOne led to a trial in its New England network last February.

"What we were testing was success of downloading the player and also getting a title to play, and we reached a threshold we were pretty comfortable with," said Phil Weinstock, MediaOne's director of products and programming in New England.

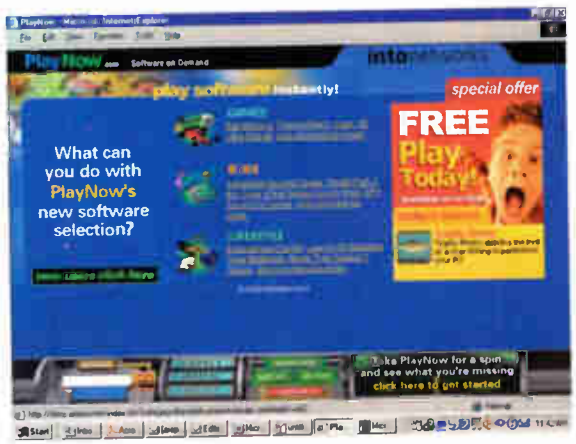
Road Runner, which has a strategic equity and revenue sharing relationship with Into Networks, handled the next stage. "Our partnership with Into Networks gets them fully deployed across our entire affiliate base by the end of the year," said Meredith Flynn-Ripley, Road Runner's vice president of corporate development.

"The large appeal of Into is that it's truly a broadband application," said into™ NETWORKS

Flynn-Ripley. She added it was a good fit for Road Runner because it creates an optimal customer experience and showcases the power of broadband. Subscribers gain access to licensed entertainment, educational and business application titles.

While software-on-demand may be new, the business model looks familiar. Holding explained that PlayNow.com is like "HBO for the computer." Anyone can sample the

What the Sub Sees: A software-on-demand order screen from PlayNow.com



content, and subscribers purchase titles on a tiered basis. "Our pricing model is very similar to cable TV," said Holding. This business also requires conditional access (CA), as do advanced cable services.

Could this broadband software network end up on the TV screen?

"As the products come more integrated, and I expect that to happen in the next year or two, there'll be opportunities to trial some of these things on different platforms," predicted MediaOne's Weinstock.

High Speed Access Rings Lucent

By Jonathan Tombes, Deployment Editor

Lucent's agreement to supply High Speed Access Corp. with network equipment, software and other services valued at up to $100 million should lead to third quarter offerings of Internet protocol (IP) telephony service in selected cable TV networks.

Using Lucent's CableConnect solution, HSA plans to deploy the PathStar access server, which acts as a central office Class 5 switch and router for the IP world. In addition to the PathStar platform, the deal gives HSA access to Bell Labs capabilities.

"If they keep pushing (DOCSIS) 1.1 certification testing back, it has an impact on launch dates because you can't get the ... equipment."
—J.R. Anderson, HSA

"We've been using their equipment and plotting with the Bell Labs people since last November/December," said J.R. Anderson, HSA vice president for voice service. "I can't express the value of the Bell Labs resources; that really helps you sleep at night."

Lucent's own calculations included surveying 160 cable executives about their concerns for new services, including telephony. "The highest two priorities were billing and provisioning," said Dee Dee Nye, vice president of Lucent's cable solutions group.

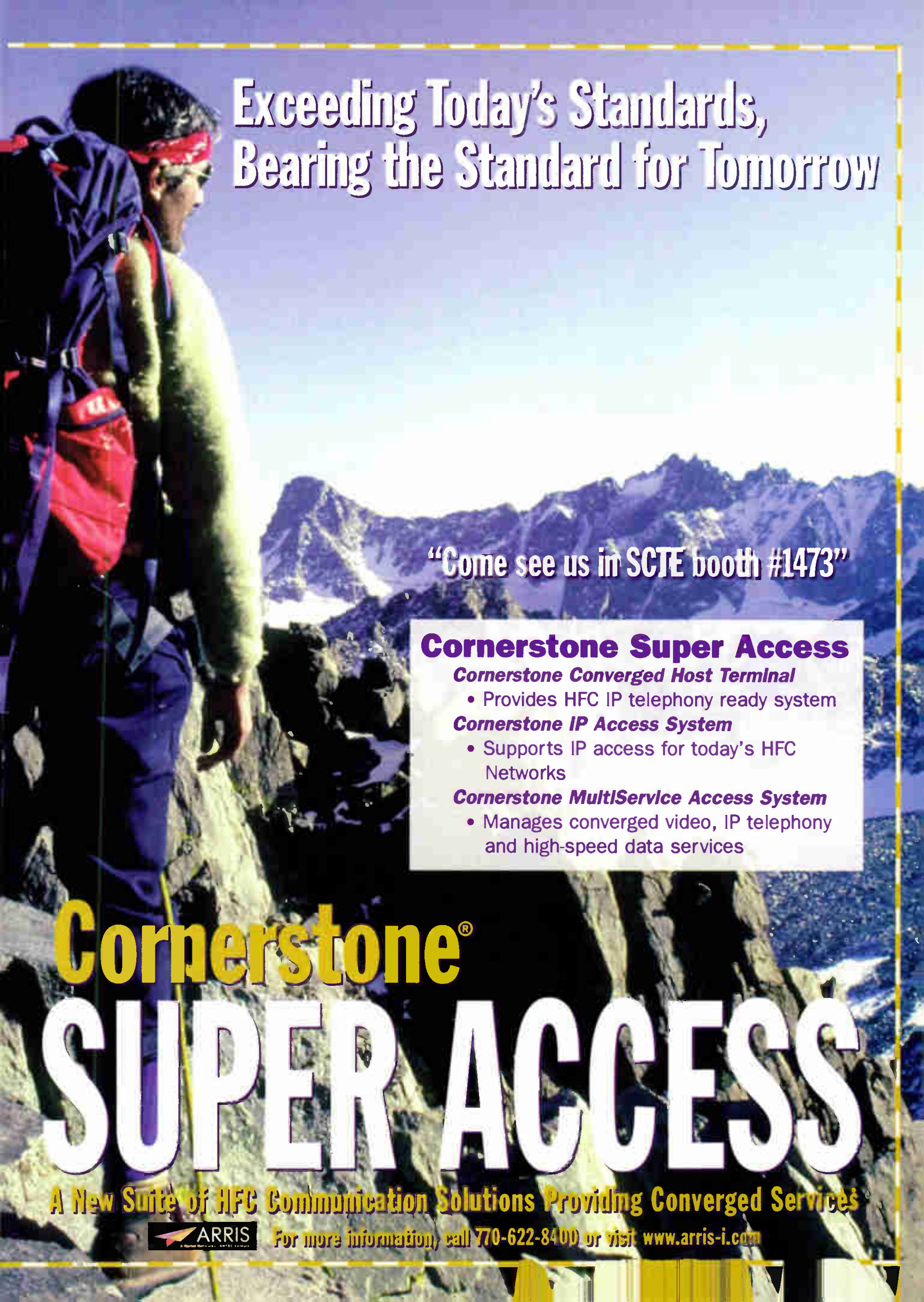
Anderson agreed that back office is a key issue. "If you can't get the customers successfully entered into your control mechanism and your care platform, the best technology in the world is going to be underutilized and financially unsound," he said.

The timing of this partnership appears propitious, if a tad early. "The good news is that DOCSIS (Data Over Cable Service Interface Specification) came and 1.1 is on the verge," said Anderson. The bad news is, well, DOCSIS 1.1 remains on the verge. "If they keep pushing 1.1 certification testing back, it has an impact on launch dates because you can't get the install equipment," said Anderson. Anderson also mentioned network preparation among HSA's multiple system operator (MSO) partners and local regulatory environments as issues that still need to be resolved in IP telephony deployment.

The deal with market behemoth Lucent, however, clearly accelerates the process on the technical front. It also gives Lucent valuable entrée to the cable market.

Nye said some colleagues initially asked why Lucent was "messing around with a small player." Paul Allen, HSA's largest shareholder, may have gotten similar questions when he invested in late 1999. HSA currently provides broadband Internet access via cable modem in 137 communities nationwide.

The agreement also calls for Lucent to make an equity investment in HSA and arrange third-party equipment financing. It builds on an ongoing telephony trial in Georgia. CT



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Nick Hamilton-Piercy: The "Engineer's Engineer"

By Rex Porter

Truly an engineer's engineer, Nick Hamilton-Piercy has been honored with almost every cable engineering award possible, including the prestigious Vanguard Award for Science and Technology. I was pleased to sit down with Nick at a recent show and learn about his fascinating life. Let's get to know him a little better.

Communications Technology: Nick, you grew up in an interesting era. Tell us about your childhood in England.
Nick Hamilton-Piercy: I was born, 1938, in Crowborough, Sussex, in South England. I lived through the war years in South England, and that was pretty exciting. We saw the Spitfires shooting down flying bombs and the dogfights and things like that. Because we were in a flight path between France and London, we saw German bombers daily and heard them nightly as they flew over on raids of London—scary, but pretty exciting years.

After the war, lots of interesting stuff was left over from the troops. This got me into the whole area of tinkering and some trouble. There were ammunition dumps, military radio equipment and so forth. I'm not sure whether it was the discarded electronic gear or the hoards of live ammunition, mortars and shells that intrigued me the most.

Nothing can give you such an adrenaline rush as swinging a bunch of mortar shells from a long rope against a cliff face and ducking behind rocks as stones and shrapnel showered everywhere. The local "bobby" (policeman) only had a bicycle, and it was easy to dodge the not-so-long arm of the law, even though my mum was regularly visited.

"My parents were asked that I be removed after blowing up the school toilets. This was quite accidental, I assure you."

While I was this young kid, about six or seven, I started dabbling with the electronic stuff and even got some of it sort of working—that is, a crackle from the earphones and maybe a whistle. I started with the discarded military equipment. My mom also helped. When she would go to yard sales, jumble sales as they are called in England, she used to bring back old radios, which I started tinkering with. So by the time I was 10, I was pretty familiar in getting that "valve," not tube as it is called here, equipment working.

I took great pride in getting those old radios—that is, the old battery radios from prewar years—tuning in stations and squeaking out their tinny voices and music. This got me more and more involved on the electronic side, and because I was an avid tinkerer, I also got into the mechanical side by "improving the performance" of my brother's toys and the neighbor's power lawn mower and old tractor and things like that. So I both became an engine hobbyist as well as an electronic hobbyist.

CT: And that led you into electronics?
NHP: By the time I was 12, I was into building one-valve radio receivers and crystal sets from kits and my own design, and also buying old military surplus equipment. I was trying to make homemade transmitters. I didn't have a license, and I'm sure I annoyed many an amateur radio enthusiast by what must have been very impure carrier transmission, my having not yet learned about stable oscillators and sideband filtering and so on. But I passionately enjoyed it, sometimes working right through the night.

My hobbies continued to be tinkering with electronics and, although it frequently got me in trouble, explosives. In practicing this creative sideline at boarding

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school, it seemed others did not appreciate this developing skill—to the extent that my parents were asked that I be removed after blowing up the school toilets. This was quite accidental, I assure you.

CT: So how did you get into electronics professionally?
NHP: In 1954, Dad's business took a down turn. I had to leave the private college and attend a polytech college and, as was popular at that time, take on a five-year apprenticeship. The company that accepted my application was Elliott Automation at Rochester, Kent, in southeast England, a company building instrumentation, military electronics, aviation and navigation equipment, and stuff like that.

The arrangement worked well in that Elliott put me through college and allowed me to get my engineering degree while doing a mixture of part-time day courses and night courses along with various work assignments in different company divisions. This arrangement spread the schooling over five years, so it was a long haul. But it certainly was a very good program, in that it mixed the practical side of work with the theoretical side of schooling.

At Elliott I learned both the machinist trade and electronics. For the first two years, I was trained to operate lathes, mills, gear-cutting machines, various numerical control machines and sheet metal work. The second two years took us into electronics, starting with designing and winding transformers for both power and signal conversion. Following this, I got much more involved in electronic equipment design, fabrication and test.

The first assignment was helping design and build two huge computers, each the size of two or three houses, consuming tens of kilowatts of power. I was in heaven now, doing what I had dreamed of since my pre-teens. It was a very exciting, very interesting job involving literally thousands of vacuum tubes and huge electronic chassis as semiconductors, although speculated about, were still not reality.

During the final year of the apprenticeship and for a full year thereafter, I was into research and development as a full member of the design team assigned to supporting a senior project engineer. We were engaged in extremely classified equipment designs associated with nuclear weapons.

This was great for a kid less than 20. It also allowed me to bypass army conscription, as the work was deemed vital for defense. Because costs were deemed inconsequential for these critical designs, we had access to some of the first advanced lab-fabricated semiconductors, which cost hundreds of pounds apiece and were routinely destroyed as we learned how to use them. You had to work at it to blow a vacuum tube, but simply had to look at one of these early transistors for it to become a dead lump of crystal.

Nick and his grandson Connor in the winter of '99 at Loon's Landing.

CT: Did you work for other British firms?
NHP: Early 1960, I got itchy feet for heftier remuneration than was forthcoming from Elliott and moved to Spembly Ltd., an engineering consulting company that designed and built prototypes for a variety of manufacturers and other organizations. The engineering challenges were numerous.

One was to devise a device that would measure the temperature of test tubes in a centrifuge, rotating at 30,000 rpm, in a vacuum. Accuracy was important, and the test tube temperature had to be monitored within +/- 1°. I simply could not see how to do this, but an idea came as I was exploring, of all places, some underground passages in ancient ruins (another hobby I'd picked up). I was thinking about infrared monitors for some reason or another, and it immediately occurred to me these would work in a vacuum. Why hadn't I thought of this before? Eureka. Applying infrared sensors, very high gain amplifiers, and for stability arranging them in a pulsed integrator design, I managed to accomplish that task and met the customer's deadline.

Another design challenge was a portable radar simulator for counter-

Convergence is governed by two immutable laws.

#1

If things can come together, they will.

#2

If things can go wrong, they will.

Agilent has the tools to help you deliver the quality that convergence demands.

System Maintenance

FCC Proof of Performance

Cable TV Analyzer

- The industry standard Proof Tool with versions compatible with worldwide formats and standards
- Economical, portable, easy-to-use

Available option 107 makes the 8591C a complete FCC one-box solution for making automatic non-interfering cable TV RF and video measurements.

8591C

Return Path Monitoring and Trend Analysis

accessCable

- Comprehensive measurement tool details system problems and service degradation
- Characterizes return path to prepare for new services
- Presents a visual representation of the frequency allocation of the entire spectrum

Sophisticated and affordable, this tool can help reduce system maintenance costs and ensure high quality service.

H7297ZA

Sweep/Ingress Analyzer & Signal Level Meter

2010B/3010B, 3010R and 3010H

- Field-rugged, easy-to-use and accurate in all environments
- Four modes of operation including time-saving channel scan
- Full system sweep capability for the forward and return path

Allows immediate trouble shooting to restore return path communication between a field portable unit and an installed headend unit

85960B, 85961B, 85962A and 85963A

Field Spectrum Analysis

ESA Series Portable Spectrum Analyzer

- Fast and accurate with 5mSec sweep times for ingress troubleshooting
- Portable, battery powered and rugged
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E4411B and option HDx

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Digital Video

QAM Analyzer

- A comprehensive solution for RF installation and maintenance testing of 64QAM and 256QAM signals
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- New metrics of MER/EVM and in-channel group delay are necessary to characterize signals and troubleshoot digital modulation problems

A QAM testing solution from the headend to the subscriber drop with easy-to-access measurements and clear graphical displays.

8594Q

Digital Video

MPEGscope

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- Combines both real-time and post-analysis tools for quick and easy testing
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E6277C

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Telephony-VoIP

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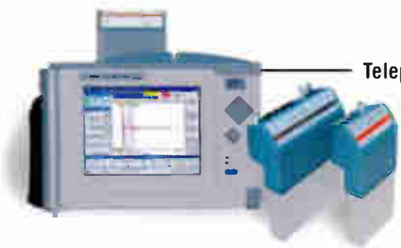

Telephony Toolkit

Service Advisor

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Easy to operate Windows CE operating system and touch screen, the Service Advisor has a growing suite of test capabilities covering DSL, TIMS, TDR, ATM, SONET/SDH and DS1/0.

N1610A

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37907A

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J3953B

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Mini OTDR

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E6000B

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This analyzer reduces complexity, scans over the defined region at a touch of a button and reports data in real-time.

86121A

Optical Spectrum Analysis

OSA

- Ideal for WDM applications
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86140A, 86142A, 86143A, 86145A, and 86141B

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HP971A, HP972A, HP973A, HP974A

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85921B

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E4444A

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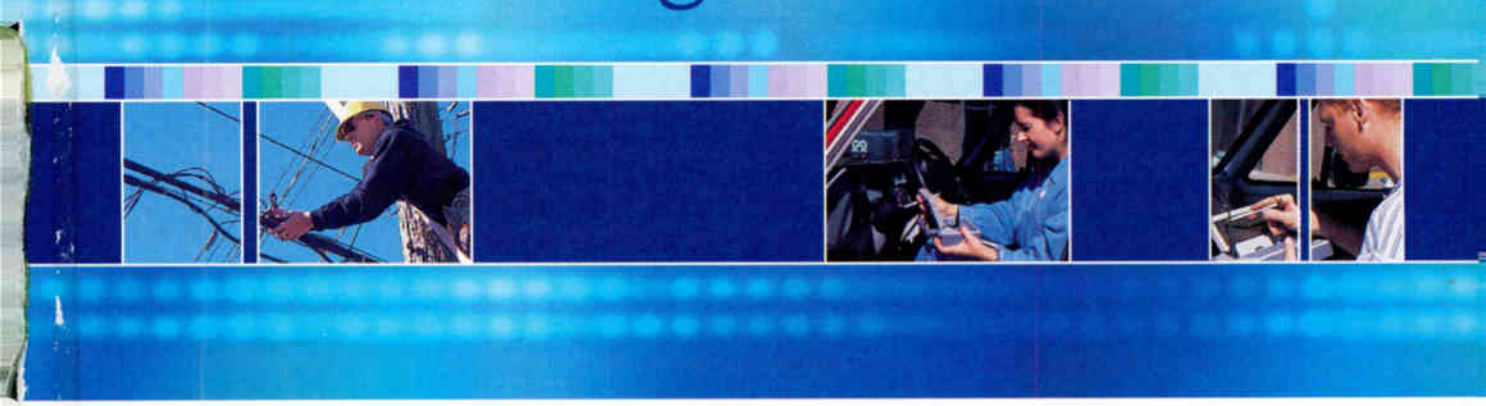

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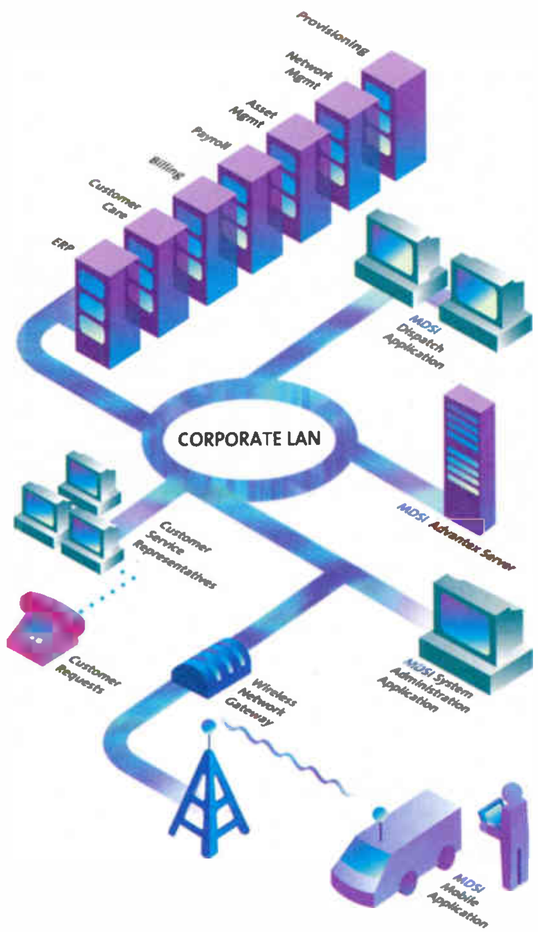

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Mobile Data Solutions

The radome on the CN Tower in Toronto where Nick and his colleague Sammy Ting had a close call in the mid-1970s.

measures. The customer's request was for a device that could be placed in the battlefield and was to electromagnetically look like a radar installation, with simulated side and main lobes with pulsated microwave carrier. The intent was to make these field-placed units look like multiple sites of radar with rotating antennas to keep the enemy from locating the real radar facility.

I devised a design consisting of a hybrid of semiconductors (still in their infancy), high-powered pulse tubes, magnetrons and a new device called a PIN diode to amplitude modulate the magnetrons' RF output simulating the signal characteristic of antenna side lobes and main lobe of a rotating antenna.

CT: And then you came to North America?

NHP: In January 1962, I decided that England was getting a bit too crowded for my misadventures and me. I needed to establish a foothold in North America, and Canada seemed the easiest way during the early 1960s. I landed in Montreal, Quebec, which was a boom city at that time and center of the Canadian electronics industry. I joined the Canadian Marconi Company.

Assignments started with updating and repairing multichannel microwave equipment and facilities used in the Mid-Canada and the Pine Tree Line defense systems. I was also involved in repairs for certain RF gear for Marconi's TV broadcasting entity, CFCF-TV, a division that was later sold. This latter engagement is where I first encountered real tower climbing by working 600 feet up a TV tower, in the middle of the night, at the Lord only knows how many degrees below zero wind chill, trying to locate cause for a high standing wave ratio (SWR) in the transmitter antenna. Trying to operate a General Radio Admittance Bridge while balancing on a square-foot platform with a frosting-up meter face and a flashlight isn't really becoming of accuracy. Anyway, the diagnostics proved successful; a carbonized pigeon—or maybe it was a seagull—was bridging an insulator.

At Marconi, I made a lot of radio and microwave equipment, RF components, and equipment conversions from tube equipment to semiconductors and so on. A notable design I was responsible for at Marconi was the development of HF/VHF/UHF transmitters and receivers for tactical radio systems specified by the U.S. Army Signal Corps. Some of these radios are still in use today.

Prior to leaving Marconi, I had progressed to management of the RF and analog engineering labs and the manufacturing side of the transmitter and receiver equipment. While pursuing this side of the business, I became involved in the development of integrated microwave circuits and other microwave equipment, which gave me my first contact with the cable TV industry. Hughes, and some others, were looking for design and fabrication houses with expertise in 12 GHz microwave developments and in particular microwave integrated circuits (ICs) operating at these frequencies.

So, about 1970, I was introduced to some of the cable TV players. Coming from the strict disciplines of designing military systems, I found the cable guys less than technically sophisticated and could not, at that time, see how they would ever be able to move from a "TV repair shop" mentality to telecommunications systems operators.

CT: But how did you get involved in cable TV?

NHP: In the early 1970s, my brother-in-law left Marconi to become the vice president of science and engineering for the Canadian Cab Television Association. He encour aged me to take a look at cable T\ as a career move. He had been approached by the management of tl then largest Canadian multiple sys tems operator (MSO), Canadian C blesystems Ltd., which was lookin for a director of engineering. CCL had about 338,000 subscribers at that point.

Their board of directors strongly fe that they should develop a more p fessional engineering approach. Tl were convinced this was essential planning the new cable TV netwo developing new services and taking company from the service-reactive trepreneurial culture to a more dis plined professional culture.

They were looking for an indi ual to head the engineering por of this change, and they asked brother-in-law if he knew of an qualified for the job. When the contacted me, I recall showing

little interest due to my previous contact with the cable guys. However, I was pressured to at least meet with their founder, Ed Jarmain, an original cable pioneer in Canada and a great gentleman. He's still active today, although I believe he is in or close to his 90s.

Having met Jarmain, I realized he was a true visionary and one hell of a fellow. He saw fiber optics well before any of us even thought they would be used for cable TV. He saw 40-plus channel distribution and two-way long before any of us thought it could be possible. He foresaw using computers in cable network design and over-the-air signal reception. He was doing so prior to 1974, so he was a very, very advanced-thinking gentleman. I was sold.

CT: So your first job in cable was as engineer in a system?

NHP: No, my first assignment at CCL was to build a professional engineering group charged with technical strategic planning, selecting and standardizing components to be used in the networks, testing/evaluating components, developing measurement standards and performing R&D for new services and broadband technologies.

My group became known as Cablesystems Engineering Ltd. The engineering team gained excellent respect from the vendor community as we contributed a lot of ideas, know-how, solid analysis—as well as purchasing their equipment, of course. Although officially retired at this time, Jarmain was always available as mentor and friend.

The only cabled fiber commercially available then was multimode fiber, relatively high loss. To reach any useful distance, repeaters were needed, and due to the limited linearity of early lasers, only digital transmission made sense. We teamed up with the Harris Corp. from Florida to develop a 7.8-km supertrunk linking our London, Ontario, cable systems' headend to the cable systems hub. The link was designed for carrying 15 high quality video signals and 12 FM stereo radio channels using multiple fibers, each operating at over 300 Mbps.

The link was formally energized April 2, 1979, after about two years of engineering work. We had excellent picture quality but, during wind, we had intermittent transmissions, the cause of which took the longest time to diagnose. It was multimoding of the lasers when they saw mismatches from moving connectors. Optical isolators were not available at that time. Fusion-splicing everything fixed the problem. We learned a lot about fiber from that activity, including that it was not yet ready for prime-time cable TV deployment.

CT: I understand you had a "close call" about this time.

NHP: During the mid-1970s, the Toronto, Canada, cable operators wanted to improve over-the-air reception of several distant TV broadcast stations, including the four Buffalo networks and three or four Canadian stations, all greater than 50 miles away. In-city reception had proven to be problematic because of electrical interference and weak signals. Over a half million cable customers were being affected by this less-than-ideal reception.

A major building initiative was underway; the CN Tower, a structure reaching a height of 1,815 feet. Hey, a great cable TV antenna tower—and by being on the lake's edge, the antennas would not have interference-generating power lines in the foreground. We obtained permission to do a signal reception test at the top of the partly-completed structure in a doughnut-like canvas-covered radome, more than 1,000 feet up. The canvas radome form was maintained by air pressure overcoming deformation by wind. Inside the radome was a narrow annular platform around which one could walk, dodging microwave antennas and other antennae bolted to the structure.

Doug Young of Signal Technologies and Nick at Shannonville taking part in Formula 2000 racing.

Sammy Ting, a colleague, and I entered this radome with considerable trepidation—a false step would throw you off this tiny ledge onto the canvas, and we had no notion whether the canvas would hold our weight if we tripped. With a certain degree of adrenaline flowing, we assembled the test antennas, spectrum analyzers and chart plotters. Of course, we kept looking behind us at this drum skin tight canvas separating us from certain death.

Then, suddenly sirens and horns started to howl around us, signifying a failure in the radome air compression system. We immediately tried to get back inside the tower body, but the airtight doors were automatically locked by the alarm system. Oh, shit, what to do now? Air pressure was

building, ears started to pop and, without saying anything to each other, we could visualize a big bang and being ejected into space.

Suddenly, we found a new use for RG-6 cable. We stripped the cable off the test equipment, wrapped several turns around our waists and lashed ourselves onto the access ladder rungs and awaited what we thought would be the inevitable. However, after about 30 minutes, the sirens silenced and all returned to normal. We immediately went down to terra firma and had a bunch of stiff drinks, then laughed about it.

CT: How did Rogers get involved in franchising U.S. cities?

NHP: Early in 1977, CCL elected to have a go at franchising in major U.S. cities. Our pitch was that unlike the United States, cable TV in Canada started in the big cities rather than the rural or suburban areas, and that qualified us for big-city cable operators.

The initial foray was the hotly contested Syracuse, N.Y., franchise. I knew we had to make an excellent showing, being "aliens," and convinced our company to go in with a proposal for a fully operating two-way system with status monitoring and a company-designed low-cost security alarm system. The proprietary design used a combination of polled feeder disconnect switching and frequency division multiplexing (FDM). This enabled very low cost in home terminals—about $30, so widespread deployment was economically feasible.

We were awarded the franchise in April 1978 and not only built the network passing over 65,000 homes within just over a year, but actually implemented and made the two-way system, services and status monitoring fully operational based on the 300 megahertz Jerrold-GI Starline-300 amplifier platform.

The system proved itself very reliable in that we specified the amplifiers with "self" bypassing devices should they fail. We used this system as our base platform when contesting for other franchises.

Shortly after securing the Syracuse franchise, CCL was acquired by a smaller but very aggressive Canadian MSO under the leadership of Ted Rogers, probably one of Canada's best-known telecommunications entrepreneurs. Rogers had recognized the strengths in the CCL management team and put many of us into positions managing the combined operations, to the extent it displaced several of his original management folk.

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Rogers stepped up the pressure for growth in the United States, and we went on an aggressive franchising foray coast to coast. We won franchises passing 570,000 homes in Portland, Ore.; Minneapolis; the city suburbs south of Minneapolis; and a number of cities in Orange County, Calif. Building these kept me on the road nearly 52 weeks a year.

We also acquired a 51-percent share of the UA-Columbia systems in late 1981, with those properties passing an additional 1.1 million homes and many builds underway, including the mammoth San Antonio system. UA already had a strong engineering group under the leadership of Bob Luff, and he combined these forces with my engineering team, making the total a really hot technical group.

The real challenge of this merger was bringing a somewhat "folksy" company into alignment with the professional disciplines we had embedded within the corporation. This later resulted in the UA system cluster being split into two groups of systems, with Rogers acquiring 100-percent control of the southern U.S. group. The jewel from this acquisition, of course, was the franchise of San Antonio, a very fast and big build, that took a substantial portion of my time.

We actually built and made operational the "far out" promises offered during the franchise wars. All systems featured real-time two-way, standby power, sections of institutional trunks, addressable set-tops and status monitoring. Some technologies we introduced were very new, such as providing real-time responses from enhanced cable set-tops.

At that time, they were the Zenith ZTAC set-top with a proprietary external RF transponder unit providing the two-way operation. My engineering team did a number of innovations in that area, including setting up software for such services as gathering channel viewership statistics to help us negotiate more favorable programming fees, and opinion polling where we posed the question of the day on this or that issue and obtained the popular response.

My group also developed and introduced a service called Time-Shared-Telidon. We mounted a teletext-type decoder at different parts of the cable system so it could be accessed by a number of customers; then through the two-way set-tops, customers could access pages of information and graphics on a party-line basis. The Internet hadn't really been thought of at that time—it was still the National

Science Foundation Network used only by universities and researchers.

Through the '80s, I also led the advancement of status-monitoring, general network surveillance and management, and other initiatives to improve the operations of the various cable systems. I had quite a large engineering team involved in standards, practices, designs, equipment evaluations and project-managing builds in the various franchises we won. A hell of a time for activity, it was mostly life on the plane, living out of suitcases, walking every street in some of these towns to see the best cable routes and so on.

This is where some of the technical leaders of the industry developed their skills—people like Tony Werner, who eventually became my right hand engineering person, building, running and upgrading our various operations.

CT: And when did you first take a fling into the cellular world?

NHP: In the middle 1980s, our company decided to get into this newfangled thing called cellular. Rogers, ever the entrepreneur, said, "Hey, I think this cellular telephone is going to go somewhere." A lot of us thought he was crazy. "Who wants to talk to someone out of their car, on the telephone, all the time?" But we helped develop a Canadian coast-to-coast license application. It was a hot contest, but with some partners we won the national license, and the corporation formed a new company, Cantel, to focus on building this coast-to-coast cellular network.

Our cable activities went into a holding pattern as far as developments and major capital spending for the next few years, and to replenish company funds, we sold off our U.S. properties at a good price. Our company was now moving to being more of a telecommunications company than a traditional cable MSO.

My engineering team was given the challenge of developing an architecture that could be used in support of the cellular operation interconnecting cell sites and cities. Simultaneously, I had formed a small group to investigate whether we could lever our cable network for the provision of high-speed business connections. A small competitive access provider (CAP) we named Rogers Network Services was born. The very high transmission reliability required for both these initiatives required a rethink of the cable network architecture. This is where

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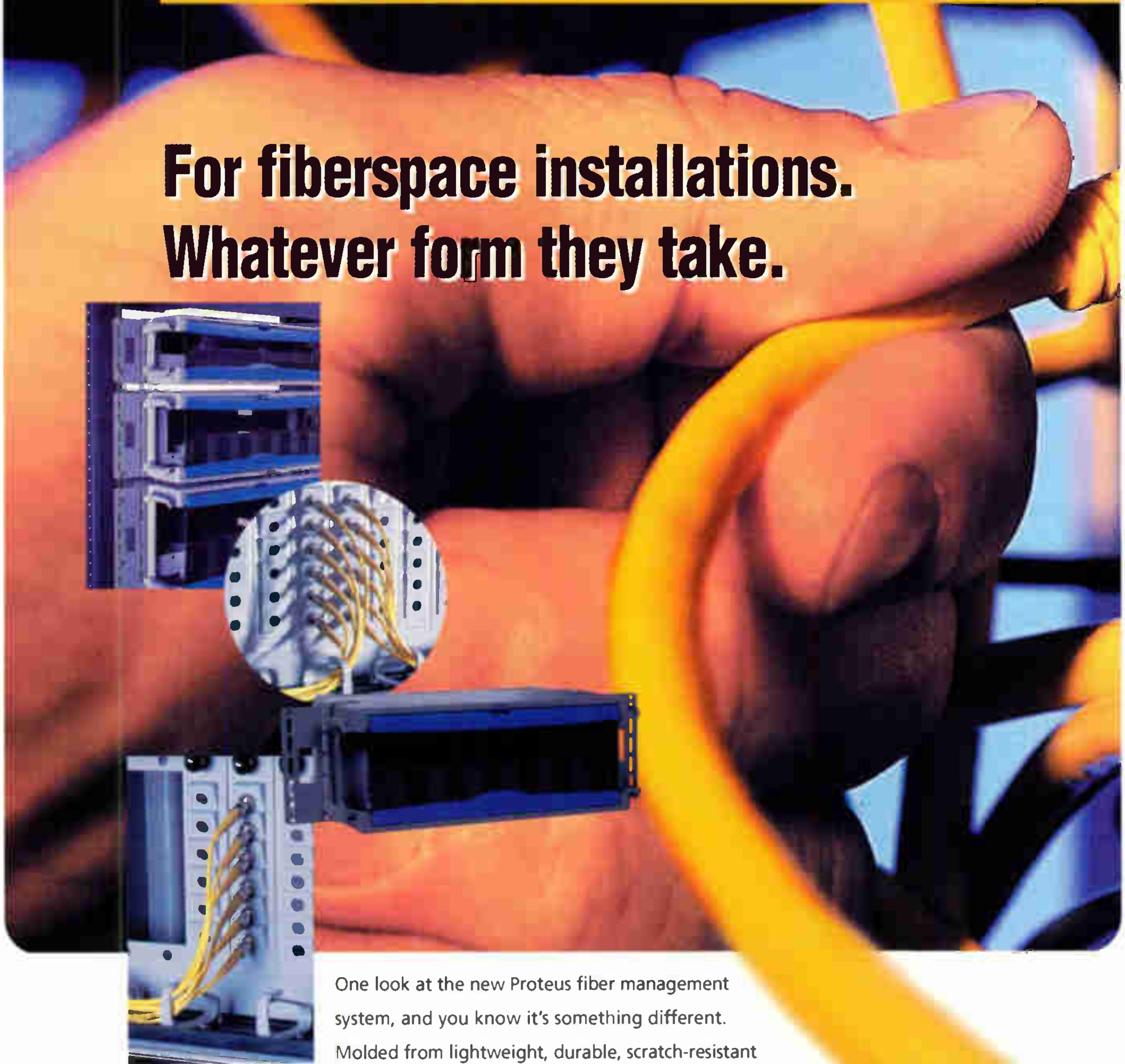

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DITEL

Managing fiberspace.

the Rogers Primary Ring/Secondary Ring architecture that garnered me the NCTA Science and Technology Vanguard recognition had its roots.

CT: Your company was one of the pioneers in introducing the Internet to cable, wasn't it?

NHP: Encouraged by our earlier Portland and RNS business communications, our team started dabbling in residential high-speed connections to a blossoming new area called the Internet. We used a version of the Zenith modems we had previously used in Portland. Our president, Cohn Watson, was super-supportive of this initiative and encouraged us to split off a business development team to bring the technology and service to commercial reality.

This 1993 initiative has now grown into Rogers@Home; at year-end, 185,000 customers were accessing this service, and thousands are being added weekly.

Mid-1990s, the company went through a major reorganization, recognizing it was now a telecommunications entity, with cable TV being but one application. Waves of consultants were engaged, and major restructuring followed. The company's focus moved our technical strengths to operations engineering rather than the developmental engineering of the previous 20 years.

My role was redirected to emerging technologies and their possible impact on company business, either as opportunities or threats. I was, and still am, responsible for assuring that our management is not blindsided by any of these new technologies.

CT: Finally, Nick, have you found time to slow down a little bit now?

NHP: I continue to be heavily involved in industry groups such as CableLabs where I chair the Technical Advisory Committee, participate in the NCTA and Society of Cable Telecommunications Engineers Engineering Committees and do whatever I can to help form the standards and whatever else is necessary for keeping this maturing industry out front as a leader—in other words, continue to contribute that "professional" touch wherever I can. CT

Rex Porter is editor-in-chief of "Communications Technology" magazine. He can be reached via e-mail at tvrex@earthlink.net.

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p Box Operating Systems • System Integration & Consultancy • Broadband Internet Systems • Interactive Applications • OpenCable™ Set-top Box a distance of one meter. The joule is a measure of a quantity of energy and equals one watt-second.

Power: The rate at which work is done, or energy per unit of time. One watt of power is equal to one volt causing a current of one ampere.

Volt: The potential difference between two points on a wire carrying one ampere of current when the power dissipated between the points is one watt.

Watt: The power required to do work at a rate of one joule per second. That is, a joule of work per second is one watt.

Ohm: A unit of resistance (R), where one ohm is defined as the resistance that allows one ampere of current to flow between two points that have a potential difference of one volt.

With regard to this latter definition, you might recognize it as the basis for Ohm's Law, which is $R = E/I$. Here R is resistance in ohms, E is electromotive force in volts, and I is current in amperes. This equation can be shuffled around a bit to give us some of the other variations of Ohm's Law: $E = IR$ and $I = E/R$.

Now go back to the definition of watt, a key subject of this month's column. If you think about it for a moment, one watt is simply the use or generation of one joule of energy per second. Other electrical units are in fact derived from the watt. As you've no doubt surmised by now, all of this stuff is related. For instance, one volt is one watt per ampere. Another definition of watt is one volt of potential (EMF) "pushing" one ampere of current through a resistance, or $P = EI$. As was the case with Ohm's Law, a bit of equation shuffling will give us $E = P/I$ and $I = P/E$.

"Have some really strong coffee before reading on."

Put it all to use

Now, using your trusty scientific calculator and some basic algebra, substitute the Ohm's Law equivalents for E and I into the formula $P = EI$, and you'll get a couple other common expressions of power: $P = E^2/R$ and $P = I^2R$.

Power calculations and measurements in direct current (DC) circuits and applications are relatively straightforward. For example, if you have a 1,000-ohm resistor with an applied voltage of 13.8 volts, the power dissipated by the resistor is 0.19 watt ($P = E^2/R$ or $0.19 = 13.8^2/1{,}000$). Current through the resistor will be 0.0138 ampere ($I = P/E$ or $0.0138 = 0.19/13.8$; as well, $I = E/R$ or $0.0138 = 13.8/1{,}000$). Because this example is a DC circuit, the voltage always will be 13.8 volts and the current 0.0138 ampere. As long as the resistor's value remains constant,

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it's easy to calculate dissipated power.

Alternating current (AC) circuits and applications are much more complicated because the instantaneous voltage and current are not constant. In order to equate the varying AC waveform to a DC equivalent component, one must work in the world of root mean square (RMS) voltage and current, where $P_{AVG} = E_{RMS} \times I_{RMS} \cos \varnothing$.

Consider an unmodulated RF carrier, which really is nothing more than a sinusoidal AC waveform. AC power measurement can be a bit tricky, though, because the product of voltage and current varies during the AC cycle by twice the frequency of the sine wave.

In other words, the output of a signal source such as an RF signal generator is a sinusoidal current at the desired frequency, but the *product* of the carrier's voltage and current has what amounts to an equivalent DC component along with a component at twice the original frequency. In most cases of RF power measurement, "power" refers to the equivalent DC component of the voltage and current product.

If you connect a thermocouple power meter to the output of an RF signal source, the power meter's power sensor will respond to the RF carrier's DC component by averaging. Of course, this averaging usually is done over many cycles, which, at RF, still can be a relatively short period of time.

Otherwise, if the power meter simply measured an instantaneous point of the sine wave, then measured that sine wave at another instantaneous point, the result would vary according to the instantaneous product of the voltage and current at each measurement point.

This is the primary reason why most RF carrier power measurements are expressed in average power.

Which is the point

This is certainly true with regard to the signal level measurements made in our cable TV networks. They are expressions, in one form or another, of the carrier's average power. CT

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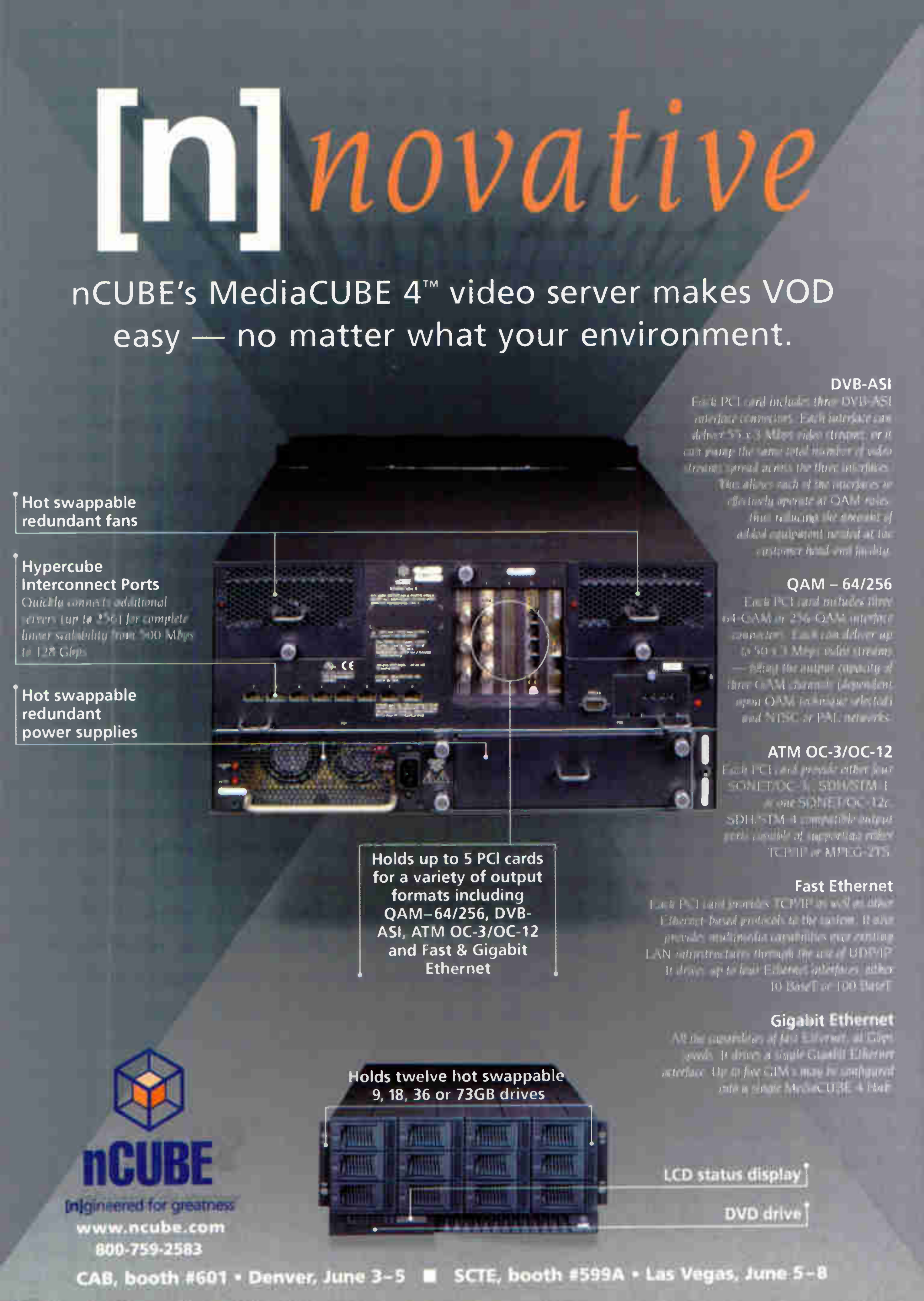
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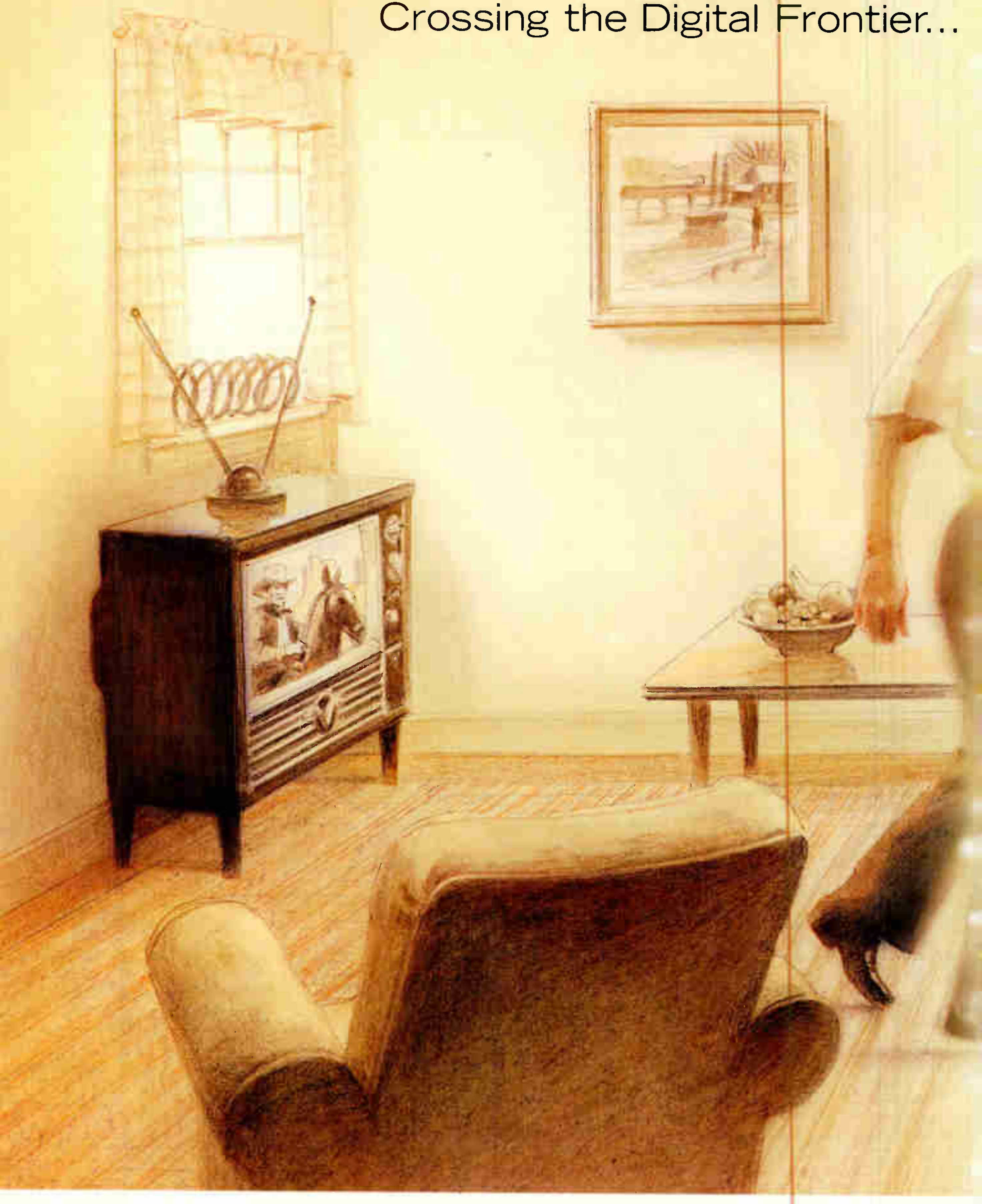

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"Carrier Grade:" More Than Just Reliability

"Carrier grade" sounds so much like a standard that you expect it to be one. Yet, as I noted earlier this year, this is a nebulous term in the Internet protocol (IP) telephony industry, bordering on buzzword status.

"Even before IP was invented, carrier grade implied not only reliability, but also better quality."

Almost everyone agrees that a carrier grade system should meet "5 nines of reliability"—that is, 99.999 percent availability. Reliability, however, is only part of what differentiates public switched telephone network (PSTN) telephony from the simple exchange of voice packets over the Internet.

If you want an example, just think about the differences between a packet telephony session between two personal computers (PCs) and a telephone conversation over the PSTN.

Where's my dictionary?

As an engineer, I believe that any word used as the criteria for a product's inclusion in a telecommunications system needs a more precise definition. To clarify this particular term, I asked some of the major vendors of telecommunications equipment to give their definition of the meaning of "carrier grade." This column contains their answers.

Given that my quest was for a definition of a term that includes the word "carrier," you might ask why I sought definitions from vendors, rather than carriers. The answer is that I have a feeling that the traditional telcos would define this metric by example, specifically their own. I don't believe that cable wants to live with a definition created by our competitors. Vendors, on the other hand, have to sell to many markets, so they need to formulate answers that meet the criteria of all of them. In this light, "carrier grade" becomes far more than a measure of reliability.

History

Dan Paone, the Antec vice president for the Arris Cornerstone product line, provided some historical perspectives on the origin of the term "carrier grade." He noted that it was early data applications that drove the requirement for something better than the quality of service provided for local voice calls.

"Carrier grade comes from the old days of telephony, actually from the early days of data," he said. "Back then, there was message grade service and carrier grade service. Message grade was good for normal voice conversations, but carrier grade was a requirement for data." Looking at it this way, even before IP was invented, carrier grade implied not only reliability, but also better quality transmission.

Dr. John Pickens, Com21's chief technical officer and a major contributor to the PacketCable standard, provided a modern refinement to the meaning of quality transmission. His definition of carrier grade includes "performance," which he explains is the minimization of latency and jitter in a network used to transport packets.

Pickens also adds scalability as a carrier grade requirement. He points out that scalability includes not only subscriber growth, but the ability to gracefully adjust for varying traffic loads.

Reliability

Lucent's Harrison Miles, director of CableConnect Solutions, focuses on both reliability and features as requirements for carrier grade systems. He provided some fine-tuning on the reliability factor by reminding me that a system can be called carrier grade, even though not all the components of the system have five nines of reliability.

"The definition of carrier grade comes from the Bellcore LSSGR document that set up failure group sizes. It gave guidelines beyond individual pieces of equipment and included the concept of a failure group."

Equipment outages in any failure group might cause a certain number of subscribers to lose service, but no one piece of equipment would cause a wide area failure. As individual

pieces of equipment become more critical to the health of the total system, however, the need for their reliability increases, and they are more closely tracked in terms of failure occurrences.

Records of failures caused by telephony switches, for example, are tracked by the Federal Communications Commission's ARMIS (Automatic Reporting and Management Information System) reports. Five minutes of switch downtime per year, which equates to 99.999 percent availability, is the accepted norm.

Harrison pointed out that service providers' expectations for carrier grade go beyond reliability.

"There is an industrywide feature set that provides revenue from business and residential customers. In addition, there are certain essential features, such as E911, that a carrier grade telephony system must be able to provide," Harrison said.

Dan Middleton, Nortel vice president of marketing and business development, stressed another important feature-related attribute of a carrier grade system in an IP telephony implementation.

"Carrier grade systems need to have a service creation capability, which allows a service provider to create new applications. These new capabilities can be made unique to each customer, with widely available JAVA programming tools."

For systems based on an IP platform, this capability is needed to take full advantage of the potential benefits from both future and present integrations of voice, data and video.

Middleton agreed with Harrison that reliability could vary between parts of a carrier grade system and added that both the application and the failure group size affect the need for network element fault tolerance. This in turn affects factors such as the need for equipment redundancy. He noted: "The system designer needs to figure out where the critical points are and protect them from failing."

"Maintain-ability"

In addition, Middleton affirmed that carrier grade systems must be scalable and include maintenance tools that allow system health checks and upgrades without taking subscribers out of service.

Mark Bakies, manager of cable communications solutions for Cisco Systems, expressed similar views regarding maintenance.

"Operators and vendors are usually not willing to make customer premise

equipment to six nines of reliability, when a failure will only affect one or two lines. On the other hand, at the UBR (Cisco's cable modem termination system, or CMTS), a failure could affect up to 3,200 simultaneous calls, and we need more reliability. This holds even more true in the network core, where a gigabit switch router may need route redundancy or multiple links to guarantee end-to-end reliability."

Maintenance work can cause downtime to exceed acceptable limits if the system is not designed to continue operation during maintenance. Part of Bakies' definition of carrier grade includes the concept of hot-swappable components and redundant network elements operating in a standby mode.

When network elements are required to be taken out of service for maintenance or upgrades, a standby unit has all the necessary call state and routing information and is prepared to kick into active service in a fraction of the time required for a full reboot.

But how do you know?

Finally, everyone agrees that none of these parameters are meaningful without a way to measure their attainment. A carrier grade system must, therefore, include tracking and measurement to ensure the system meets its service goals consistently over time.

To sum up, the working experts who are responsible for "carrier grade" IP telephony implementations require more than five or six nines of system reliability to define a carrier grade system.

Their definitions certainly include failure containment by constraining failures to noncritical failure group sizes, built-in redundancy, and fault tolerance where required. However, they also include scalability, revenue-generating features, nonservice-affecting maintenance, and quality of transmission measured by minimized jitter and latency.

Finally, they agree that carrier grade attributes need to be measurable and tracked over time. CT

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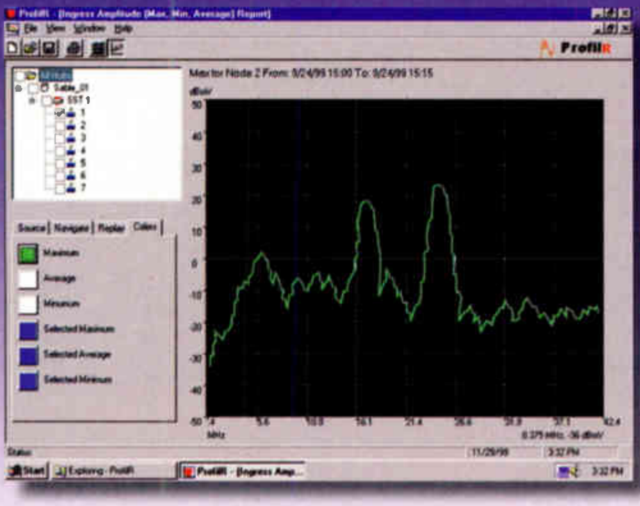

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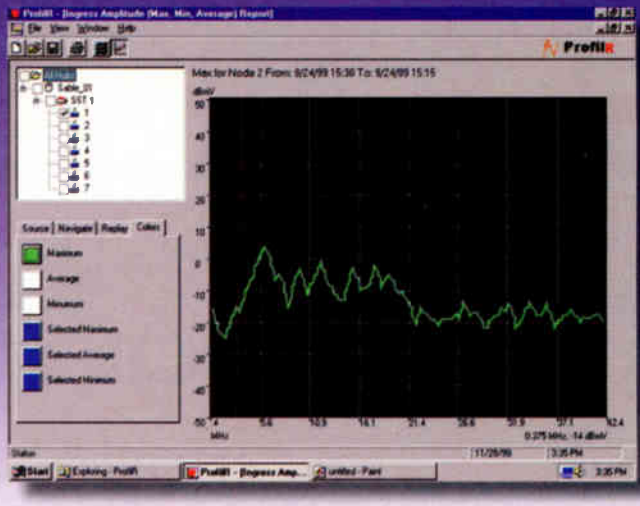

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HDTV: Big Bucks Or Simply Bravado?

Although the grumbling still lingers over broadcast formats, copy protection and must-carry rules, cable operators are well-positioned to make money from high definition TV (HDTV)—once consumers start buying the sets and the necessary decoders.

TABLE 1 HDTV-RELATED REVENUES (IN MILLIONS)

	2001	2002	2003	2004	2005
Subsidies	$5	$74	$324	$262	$57
Ad revenues (after subsidies)	$18	$133	$448	$1,191	$896
ITV	$16	$143	$714	$1,458	$2,718
Datacasting	$0	$1	$8	$31	$92
TOTAL	$39	$351	$1,494	$2,942	$3,763

Source: Forrester Research

Where's the money to come from? According to Forrester Research, advertisers and broadcasters will be waiting in line to spend big bucks on targeted advertising and equipment subsidies. What's more, datacasting and interactive services delivered via HDTV signals offer additional revenue potential for cable systems.

Growth and subsidies

In its new report "HDTV: High-Demographic TV," Forrester predicts that HDTV ad revenues will hit $133 million in 2002 and peak at $1.191 billion in 2004 (See Table 1). Why? Because advertisers are eager to target their message to affluent buyers of HDTV sets. If you haven't already geared up your digital insertion equipment to handle ads for your digital cable offerings, you may want to get started. The bean counters at your operation will surely want a piece of this revenue pie.

What's more, because broadcasters are anxious to increase penetration of HDTV sets and converters, Forrester believes they will offer equipment subsidies, much like cell phone makers, to lower the costs of HDTV modules for cable and satellite set-tops. These subsidies are expected to hit $74 million in 2002 and skyrocket to $324 million in 2003.

Subsidies, combined with falling prices, will drive HDTV penetration from an expected 530,000 sets this year to 3.24 million in 2003, according to Forrester projections. Because cable's HFC infrastructure offers the best means for delivering that bandwidth-hogging HDTV content, it's sure to garner the lion's share of these potential subsidies. (See "High Definition Holding Pattern," May 2000, page 91.) Eventually, HDTV will change the face of the digital converters you deploy. Enhancements in decoder chips and lower prices will enable vendors to integrate the decoders into sets-tops, TV sets, and other cable and satellite gear by the middle of the decade.

Where the bucks are

Of course, in order to get the subsidies you'll have to carry the HDTV content (there's that political hot potato again) and pass on some of the money to customers, predicts Forrester. Still, anticipating that high-bandwidth content is another reason to continue pushing ahead with your upgrades to 860 MHz.

In addition to money from advertising, it's worth paying attention to HDTV buyers because they are likely to purchase other services from you as well. Although HDTV demographics aren't available in the report, Forrester notes that 55 percent of buyers of projection TVs are online, and 26 percent of those have multiple set-tops in their houses. Plus, they spend more each month on their cable services. You've a ready-made market for up-selling data services and interactive TV.

In fact, if you think you've got a handle on all those interactive and Internet TV trials and platforms, get ready for a new wrinkle. Like all other digital media, HDTV is expected to sing the interactive tune. Broadcasters will want to include e-commerce opportunities with their programming, and those high-definition ads will have interactive components as well, predicts Forrester.

As the old saying goes, there's no rest for the weary. New applications such as HDTV and competitive threats will continue to fuel a relentless network upgrade pace.

(To purchase the report, contact Forrester Research at (617) 497-7090 or www.forrester.com.)

Jennifer Whalen is editor of "Communications Technology." What are your thoughts on this topic? Send e-mail to jwhalen@phillips.com.

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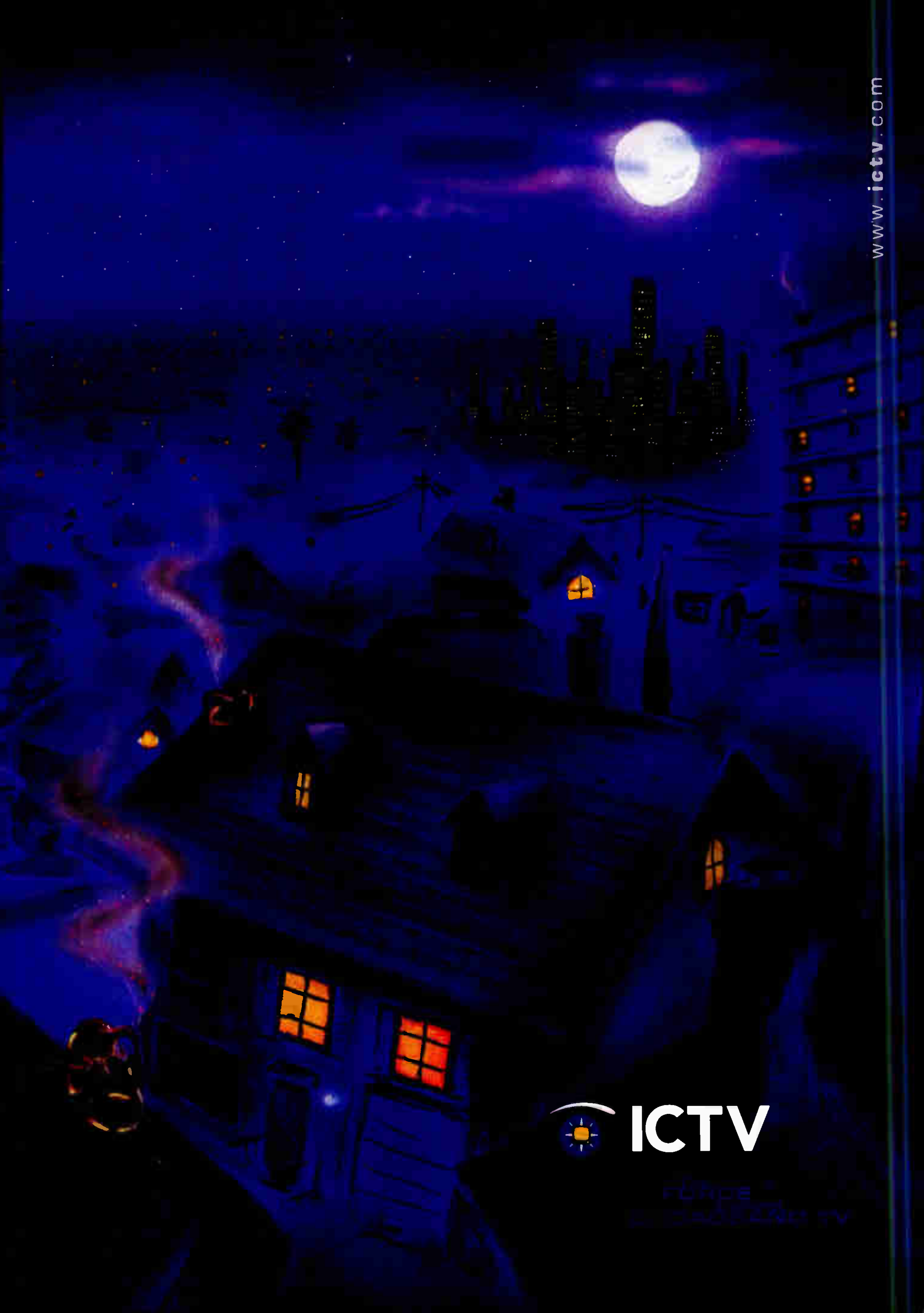
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Open Access and Multiple Service Providers

Has the open access/multiple service provider issue made it onto cable's radar screen? It's been a year since I explored this topic in detail (Cable '99 NCTA Technical Papers: "The Exposed Headend: Enabling a Strategically Defensible Posture for Broadband Telecommunications Services").

Now, with the pending acquisition of Time Warner by America Online, it appears that the Federal Communications Commission is willing to let the market create its own arrangements for how we let multiple external service providers deliver services on our networks.

Interest in this topic seems to be growing on some of the Internet lists, and for good reason. Not only is accommodating open access substantially more complex than deploying Internet service provider (ISP) services from a single provider, how we accommodate multiple service providers in an open access climate could profoundly affect our bottom lines.

Space does not permit me to simply incorporate the entire "Exposed Headend" paper in this month's column, so I'll try to incorporate the salient points.

Challenges involved

The fundamental challenges of accommodating multiple service providers on broadband cable networks are in the areas of services monitoring and management, subscriber billing, and service quality/guarantees. Multiple service providers include ISPs, application service providers (ASPs) and telephony service providers, among others.

Where external service providers are involved, service integrity (stability and consistency) and asset control complications crop up. This is because external service providers will want access to some aspects of the service delivery infrastructure, including quality of service (QoS) controls and perhaps even domain name services (DNSs).

These challenges and complications impose the need for an integrated services monitoring/ management system (ISMS). Such a system must, among other critical functions, enable operators to maintain control over their infrastructure to ensure the integrity of all concurrently delivered services.

An ISMS must perform four primary functions:

- Integrate back-office operational and support databases to accommodate billing interfaces and support functions such as external helpdesk and network operations functions
- Provide an infrastructure proxy to accommodate QoS and other configuration settings for external service providers
- Provide dynamic bandwidth management across the hybrid fiber/coax (HFC) network for QoS and other policy-based configuration settings
- Ensure proper (bidirectional) routing of subscriber data packets into, out of, and across the HFC network

These functions are critical to achieving a manageable multiple service provider environment where the cable operator maintains control over both its assets and the quality and consistency of services delivered. Starting at the end and working backward, let's examine some of the details of this list.

Routing

Popular thinking on routing subscriber packet traffic to and from external service provider environments is to utilize something called source-based routing (SBR). This technique, which essentially maps the source address in subscriber transmission control protocol/Internet protocol (TCP/IP) packets to an external service provider, should work well if subscribers choose only one service provider among several offering services over a given network.

But what about subscribers who opt for several accounts with several service providers available on the network? The SBR approach, in order to accommodate subscribers with multiple service provider accounts, must operate within a larger dynamic service envelope. I am not sold on the applicability of SBR to the multiple service provider challenge, but I am convinced that an ISMS must somehow address this need.

Bandwidth management

The need for dynamic bandwidth management is not well-understood. Several bandwidth/service management packages available on the market manage QoS from the head-

end out to the Internet. These packages basically elicit various bandwidth consumption behaviors on the HFC side by throttling Internet access for some classes of service.

In a multiple service provider climate, the need for more granular HFC-side bandwidth management will become acute because operators will want to maximize the efficiency of their networks to accommodate as many premium (higher QoS) services as possible and as many concurrently deliverable "best effort" services as possible. Instead of configuring QoS settings for cable modems once, the multiple service provider scenario will require dynamic QoS setting manipulation.

For example, a subscriber may have a low QoS setting with one particular service provider and a high one with another, switching between services at will. Without dynamic bandwidth management on the HFC side, it will be impossible for operators to maximize HFC bandwidth efficiency. The idea here is to "ensure" bandwidth (dynamically) for a given service upon invocation. Without such assurances, service performance will be inconsistent, leading to user (and external service provider) dissatisfaction. Dynamic bandwidth management is critical.

Infrastructure proxies

An infrastructure proxy is a fancy name for configuration "referee." It is a given that some external service providers will want to manipulate certain infrastructure configuration settings such as QoS. In a shared environment such as broadband, where subscribers are connected through a single cable modem for example, cable operators cannot afford to open up their networks to external service providers at the configuration level. Having more than one entity manipulating configuration settings would be a formula for disaster.

Nevertheless, external service providers' needs for some control over the service delivery infrastructure are legitimate and should be accommodated. The infrastructure proxy function should be closely integrated with dynamic bandwidth functions, providing external service providers a "virtual" capability to alter configurations on a subscriber session basis. It is critical that this ISMS function be owned by the cable operator, not an external service provider.

Databases

As the cable industry has evolved through acquisition and clustering, many back-office database functions have become less useful than originally intended, or at least have not been the target of integration efforts. As systems have been acquired, for example, they often use different graphical information systems (GIS) and billing packages. These typically remain in place.

As headends are eliminated through system joining, the value of legacy database and GIS packages often drops. Customer service representatives (CSRs) and construction personnel, for example, often are blind to certain aspects of the joined systems because of lack of integration with legacy database and GIS systems. An ISMS should be able to integrate these packages into legacy packages for smooth operation across all connected

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Integrated Billing

In an open access environment, billing is critical in a variety of ways. The techniques used to integrate billing functions with those of external service providers, if not carefully thought out, can impose unwanted changes on the entire service delivery paradigm.

For example, some external service providers will want metered billing. Metered billing is fine at the right time, but it can have undesirable consequences, especially if introduced too early in the game. For example, cable-based Internet access services in Holland (flat-fee based) enjoy 50+ percent penetration because of metered billing employed by the local telephone companies.

A form of metering known as tiered services is perhaps a better interim billing approach: Subscribers need not watch the clock or count packets, so they can be happily getting further hooked on your services. Perhaps a good compromise would be to impose metered charges on the external service provider for resources consumed by its subscribers. End-user billing would be up to the external service provider.

Get it right the first time

It will be interesting to see how "open access" accommodations evolve. An interesting point to consider as they do is that competition from digital subscriber line (DSL) providers and other broadband players will likely intensify at the same time. I doubt it would be a good time to experiment with anything other than the right approach. CT

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SCTE Standards Submitted to ITU-T

The Society of Cable Telecommunications Engineers' Data Standards Subcommittee has approved several standards to be submitted to the International Telecommunications Union-Telecommunications Study Group 9. These proposals were submitted in April. Here follow descriptions of each.

Audio codec requirements

Many cable operators are upgrading their facilities to provide two-way capability. They are using this capability to provide high-speed Internet protocol (IP) data services as per ITU-T Recommendation J.83 (04/97), "Digital Multi-Program Systems for Television, Sound and Data Services for Cable Distribution" and ITU-T Recommendation J.112 (03/98), "Transmission Systems for Interactive Cable Television Services." These operators now want to expand the capability of this delivery platform to include telephony.

The proposed Audio Codec Requirements for the Provision of Telephone Service Over Cable TV Networks Using Data Modems is one in a series of recommendations that is required to achieve this goal. It provides guidance on audio (voice) codec selection that will provide a high-quality interoperable service. It specifies the audio codecs that are to be used in the provisioning of telephone services over cable TV distribution networks using IP technology (that is, IP CablePhone service). It also addresses codec options and packetization issues.

Architectural Framework

Also on its way to ITU-T Study Group 9 is the proposed Architectural Framework for the Delivery of Time-Critical Services Over Cable TV Networks Using Cable Modems. At a very high level, the IP CablePhone architecture contains three networks: the cable modem hybrid fiber/coax (HFC) access network, the managed IP network and the public switched telephone network (PSTN). The cable modem termination system (CMTS) provides connectivity between the cable modem HFC access network and the managed IP network. Both the signaling gateway (SG) and the media gateway (MG) provide connectivity between the managed IP network and the PSTN.

"Embedded clients are not confined to residential use only; they may be used in a business as well."

The cable modem HFC access network provides high speed, reliable and secure transport between the customer premise and the cable headend. This access network may provide all cable modem capabilities, including quality of service (QoS). The cable modem HFC access network includes the following components: the cable modem, multimedia terminal adapter (MTA) and CMTS.

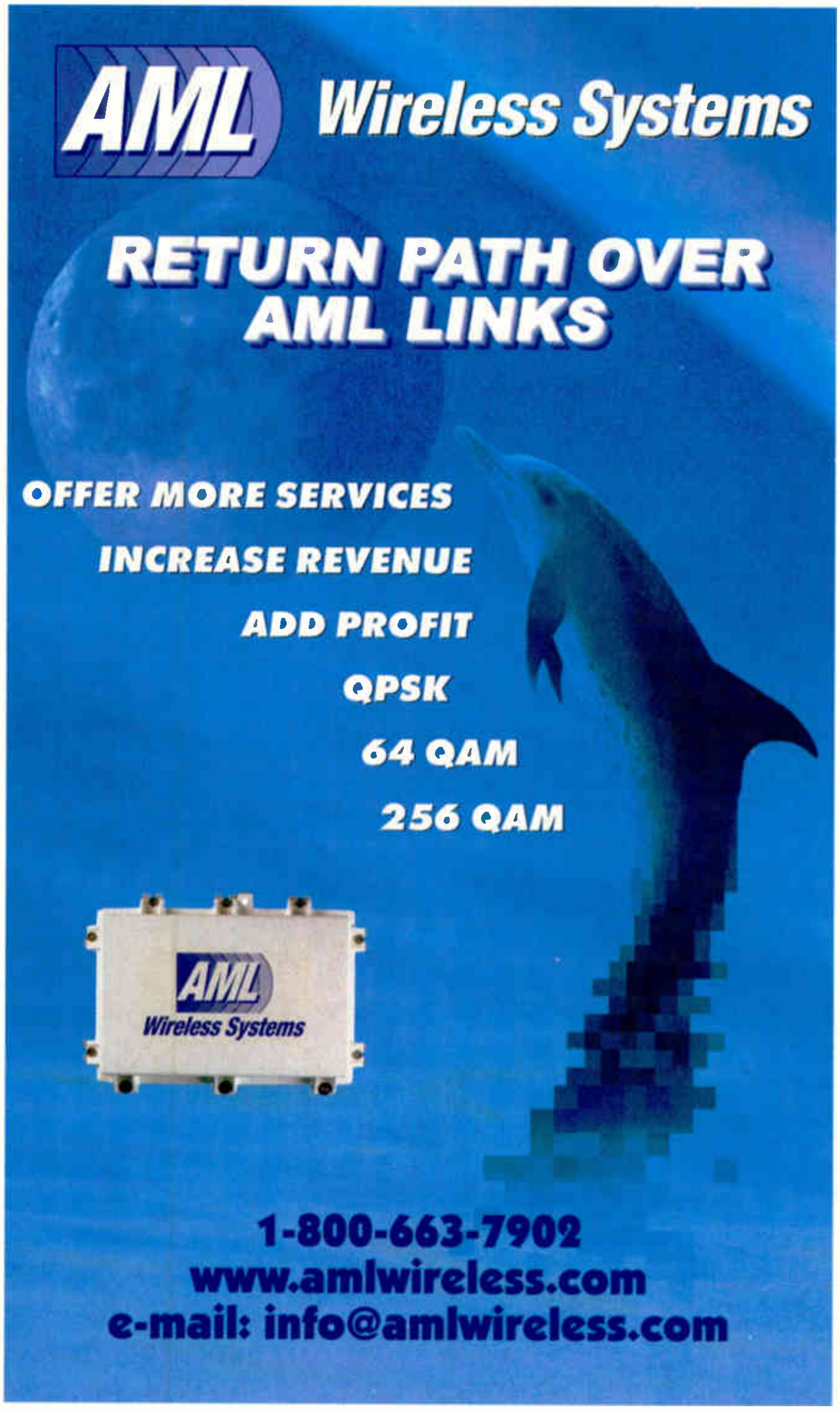
The managed IP network serves several functions. First, it provides interconnection between the basic IP CablePhone functional components responsible for signaling, messaging, provisioning and QoS establishment. In addition, the managed IP network provides long-haul IP connectivity between the other managed IP and cable modem HFC networks. The managed IP network includes the following functional components: call management server (CMS), announcement server (ANS), several operational support systems (OSS) back-office servers, SGs, MGs and media gateway controller (MGC).

Network call signaling

The proposed Network Call Signaling Protocol for the Delivery of Time-Critical Services Over Cable TV Networks Using Data Modems is based on the media gateway control protocol (MGCP) v1.0. It was the result of merging the simple gateway control protocol (SGCP) and the IP device control (IPDC) family of protocols, as well as input generated by the people who developed this profile. This recommendation provides a network-based call-signaling protocol necessary to establish connections.

This document describes a profile of an application programming inter-

face (API) called the media gateway control interface (MGCI) and a corresponding protocol called media gateway control protocol (MGCP) for controlling voice-over-IP (VoIP) embedded clients from external call control elements. The MGCP assumes a call-control architecture in which the call-control intelligence is outside the gateways and is handled by external call-control elements. The profile, as described in this document, is referred to as the network-based call-signaling (NCS) protocol.



An embedded client is a network element that provides two or more traditional analog access lines to a VoIP network, or possibly one or more video lines to a VoIP network. Embedded clients are not confined to residential use only; they may be used in a business as well.

Embedded clients are used for line-side access and are expected to have line-side equipment (such as analog access lines with conventional telephones associated with them, as opposed to trunk gateway).

The MGCP assumes a call-control architecture in which the call control intelligence is outside of the gateway and handled by external call-control elements referred to as call agents. The call agents will synchronize with each other to send coherent comments to the gateways under their control.

The MGCP defined in this particular document does not define a mechanism for synchronizing call agents, however, although future IP CablePhone specifications may specify such mechanisms.

Dynamic QoS

This proposal for Dynamic Quality of Service (QoS) for the Provision of Real-Time Services Over Cable TV Networks Using Data Modems requires a client device to obtain access to network resources. In particular, it specifies a comprehensive mechanism to enable a client device to request a specific QoS from the cable modem network. Extensive examples illustrate the use of the specification.

The scope of this specification is to define the QoS architecture for the access portion of the PacketCable network. CT

Ted Woo is director of standards for the Society of Cable Telecommunications Engineers. He can be reached via e-mail at twoo@scte.org.

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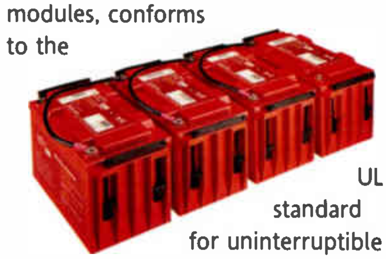

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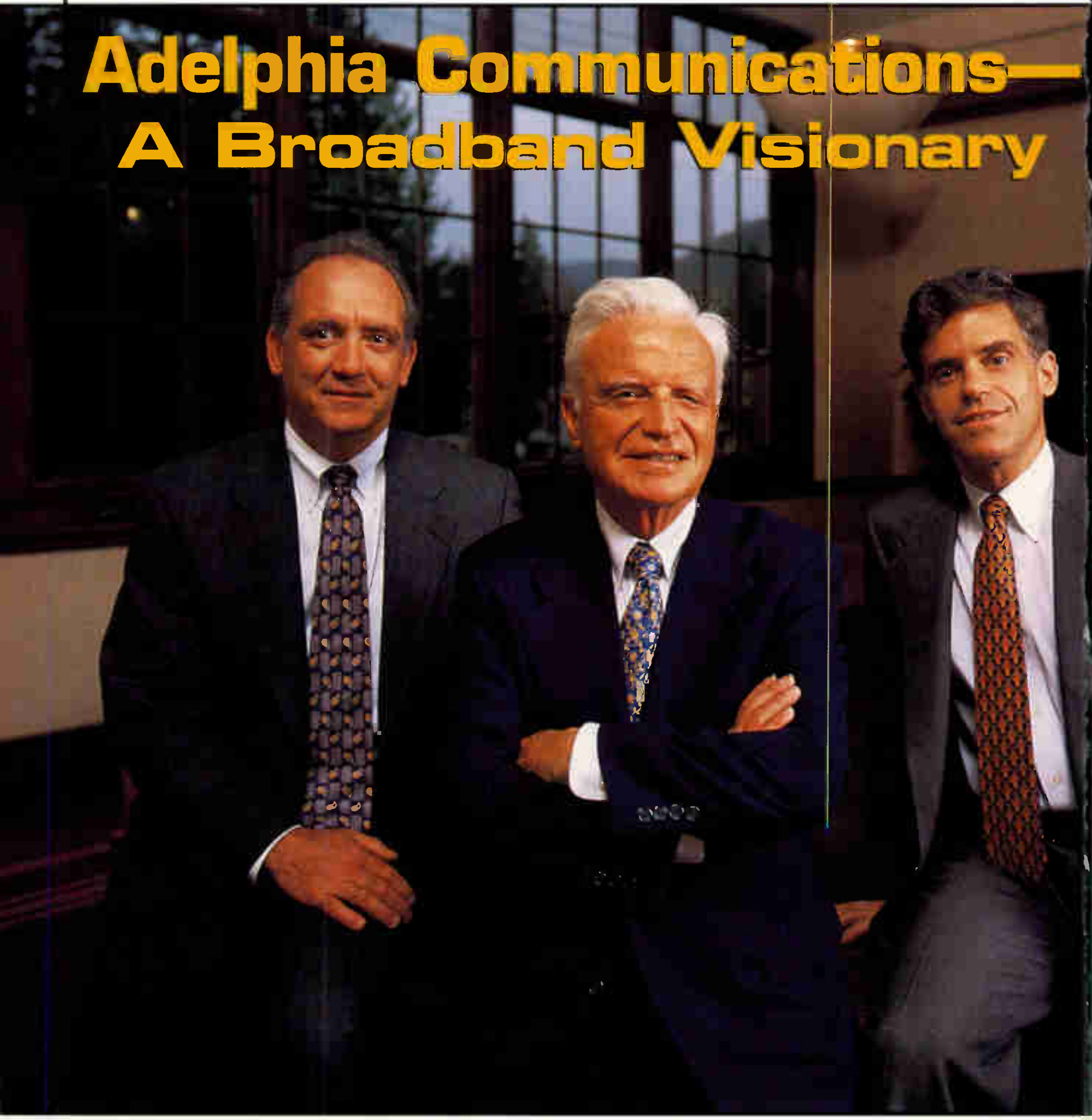


Adelphia Communications—A Broadband Visionary

Adelphia's Brain Trust: From left to right, Vice President of Engineering Dan Liberatore, Chairman and Chief Executive Officer John Rigas and Executive Vice President Michael Rigas. All photos courtesy of Adelphia Communications

nology Award

By Jennifer Whalen

It takes more than technology to make a great cable company. Rather, it's an innovative blend of technology, business acumen and foresight that will transform a cable system from a traditional supplier of entertainment fare to a nationwide broadband telecommunications provider. Adelphia Communications Corp. is such a company, and its achievements have earned it *Communications Technology's* 2000 Service in Technology award.

Recognizing that to survive in the 21st century means delivering a wide array of nationwide voice, video and data services to both businesses and consumers, John Rigas, Adelphia's chairman and chief executive officer, spearheaded an ambitious acquisition plan. In less than a year, the multiple system operator (MSO) doubled its basic cable subscriber base to roughly 5 million customers. Adelphia passed 7,722,933 homes as of December 1999, with additional acquisitions nearing completion.

What's more, the MSO's residential product offerings not only include basic cable, digital cable and high-speed data services, but also long-distance telephony, paging and home security. Local telephony and interactive TV aren't far behind.

On the business front, through its Adelphia Business Solutions subsidiary, the company offers local dial tone, integrated services digital network (ISDN), Centrex, long distance, calling cards, frame relay, asynchronous transfer mode (ATM), digital subscriber line (DSL), voice mail, Internet access and other services via its nationwide backbone.

Upgrades underway

Adelphia is well-positioned to leverage its ABS network to deliver still more services to both its residential and business customers and to continue to attract new customers. The MSO is in the midst of an aggressive upgrade of its cable plant and expansion of the ABS backbone, explains Mike Rigas, executive vice president of Adelphia.

"We believe that it's very important that we launch new products, and we can't do that until we get the plants upgraded and have the bandwidth for modems, digital converters and telephony," Rigas says. "We're also feeling the competition from (direct broadcast satellite, or DBS). We need the bandwidth so that we can compete effectively with DBS. We believe there's a window out there, and we need to hit that window in terms of launching new products and generating new revenue streams."

The MSO expects to spend about $1 billion on its upgrades over the next two years. Adelphia intends to upgrade about 83,000 miles of plant by the end of 2001, including 33,000 miles this year. Prior to the acquisitions, it had 44,250 miles of plant. About 52 percent of that had been upgraded to 550 or 750 MHz, and 26 percent was two-way active. Today, Adelphia has 115,000 miles of plant, 32 percent of which has been upgraded to 550 or 750 MHz, and 16 percent is two-way active. >

Node plus one architecture

Adelphia primarily is using 750 MHz and 860 MHz amps from C-Cor and General Instrument (now Motorola) in its upgrades. Projects started after Jan. 1, 1999, will be upgraded to 750 MHz, while those begun after Feb. 1, 2000, will get 860 MHz of bandwidth. The reverse path will be activated at the same time, Rigas adds.

Adelphia wants its architecture to be well equipped to handle an influx of new subscribers and service launches. "We decided that the key characteristic of our network should be reliability," explains Dan Liberatore, Adelphia's vice president of engineering. "So we are building a fiber node, and off of that fiber node is typically no more than one amplifier. In some cases, there's a second or third amp, but that's very rare. The network is not defined by how many homes in a service area, but by the amplifier cascade. Typically that comes out to about 100-plus homes, but we do have nodes that are in the tens of homes and nodes that are in the couple hundreds, depending on density."

The architecture leaves the company well-positioned to accommodate additional demand for bandwidth. "Because of the small nodes, a lot of the reconfiguration that we may have to do because of capacity gets done in the headend," Liberatore adds. "In the headend, these nodes are combined off of single lasers and single upstream equipment. If we need more capacity for video-on-demand (VOD), high-speed data and telephony, we can go in and reconfigure the headend only. We won't have to go back out and take 1,200-home nodes down to 500 homes nodes."

One head is better than two

The recent acquisitions, while increasing Adelphia's footprint and subscriber base, haven't made the upgrade process any easier.

"Some of the properties we purchased were behind our existing systems in terms of bandwidth and product launches. It did put a heavier burden on us in terms of the number of miles to upgrade," says Rigas. "Second, they had numerous headends. We're in the process of trying to eliminate many of them and connecting them to each other to get a little more manageable structure."

Top: Quick provisioning is essential to meet the needs of today's business customers. This state-of-the-art computer room enables agents at Adelphia Business Solutions to provision new services quickly.

Left: Technicians monitor the network around the clock in the map room of Adelphia Business Solutions network operations center in Coudersport, Pa.

"We have over 600 headends today, and at the end of the upgrade there will be about 100," added Liberatore.

Adelphia plans to interconnect most of the remaining headends with each other through its ABS backbone, so that it can offer those systems its telephony, digital cable and Power Link (high-speed data) services.

"We've been aggressive as far as connecting headends and putting the lion's share of the headend equipment for DOCSIS (Data Over Cable Service Interface Specification) modems or for digital converters in one place," Rigas says. Adelphia already has one

BOTTOMLINE

> Adelphia Goes the Extra Mile

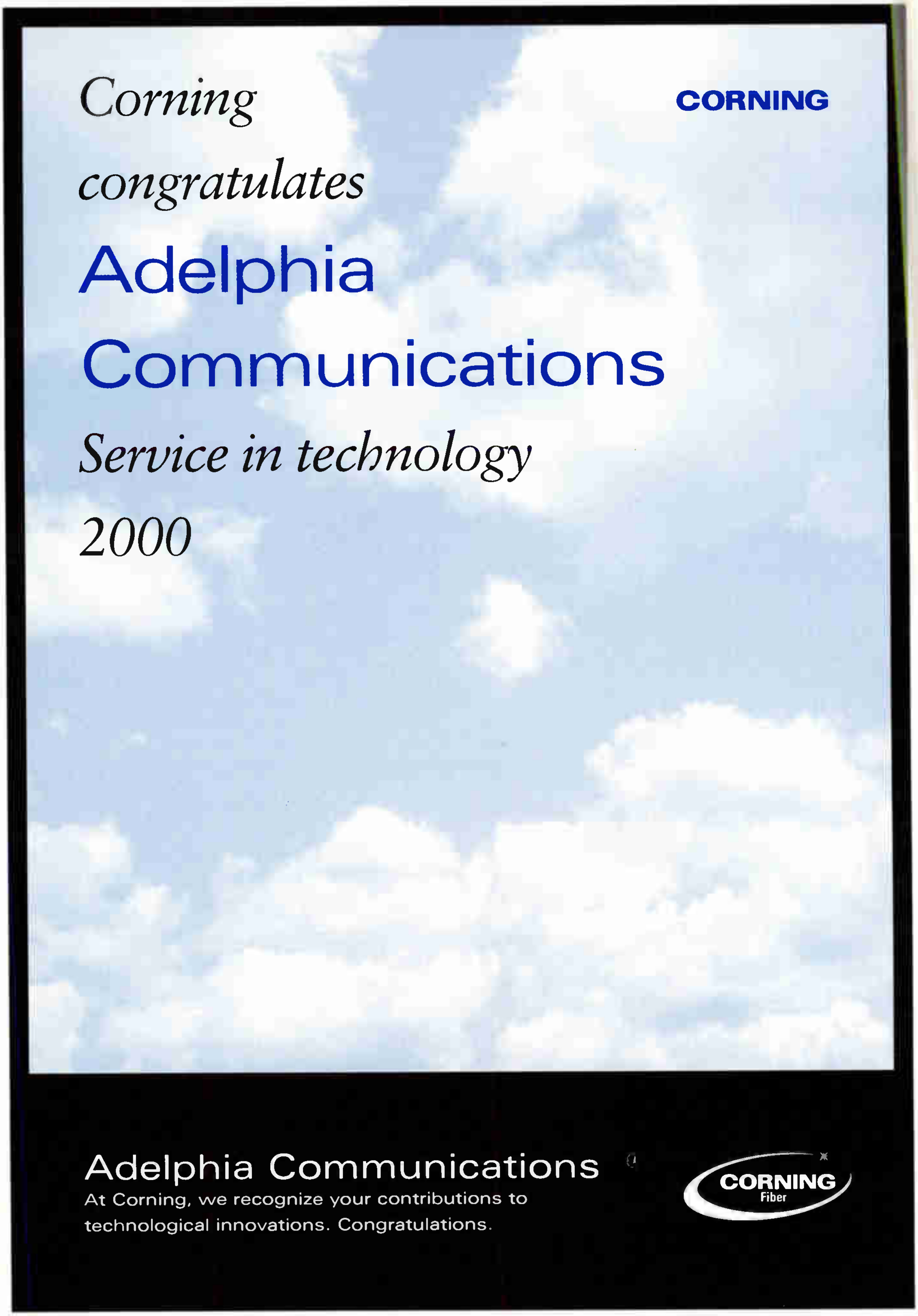
Adelphia Communications' aggressive construction of a nationwide fiber-optic backbone, its launch of advanced services, as well as its pursuit of both residential and business customers have garnered it *Communications Technology*'s 2000 Service in Technology Award.

In less than a year, Adelphia has doubled its subscriber base to nearly 5 million. The multiple system operator (MSO) has a very ambitious upgrade underway that it hopes to complete by the end of 2001. In addition, it's building a 33,000-mile long-haul fiber-optic backbone through its subsidiary Adelphia Business Solutions.

Adelphia is aggressively selling digital cable, high-speed data and long distance telephony services. It expects to have 800,000 digital cable subscribers by year's end, and 160,000 cable modem users. Paging and home security service are also available.

But that's not all. Adelphia will shortly launch an Internet protocol (IP) telephony trial in New York and will roll out commercial local phone service this fall. Interactive TV trials and commercial services are also planned for this year.

It's clear from these initiatives that Adelphia's top executives and engineers are well underway in transforming the company into a premier supplier of broadband telecommunications services.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Technicians Dave Marshall and Doug Moore keep the headend running smoothly in Adelphia's Longview, Wash., system.

Scientific-Atlanta digital converter super-headend in Vermont, which serves most of the state. Another S-A headend is running in Buffalo, N.Y., which serves the systems in western New York and western Pennsylvania.

The headend consolidation offers Adelphia economies of scale for purchasing equipment and launching products. Maintenance is also easier, explains Rigas.

"When we consolidated all the addressable controllers in one place and the other things we did to centralize equipment, that gave us flexibility to react to the marketplace quicker than if the equipment had been scattered out all over the company," adds Liberatore.

The centralization effort and ABS interconnection also enables Adelphia to offer advanced services to its smaller systems.

"If you have a 5,000- or 10,000-subscriber system, it's expensive to launch a major headend for digital, for modems and for telephony. If you have that system tied into a major headend somewhere else that also serves a number of other small systems, it becomes much more cost-effective," Rigas continues.

Connecting the headends also enables Adelphia to share programming between its systems.

"If we can't pick up a broadcast signal in a particular area, we can run it over fiber and improve reception. The ability to share programming will be important down the road," Rigas adds.

Nationwide footprint

In addition to its acquisition and upgrade initiatives, Adelphia had the foresight to recognize the importance of owning and building its own long-haul fiber backbone. By the end of 2001, Adelphia Business Solutions (formerly Hyperion Communications) expects to complete construction of a fully redundant 33,000-mile, long-haul fiber network as well as an additional 15,000 local fiber route miles.

ABS already has sold more than 360,000 access lines to business customers and recently spearheaded a consortium that landed a $228 million, five-year contract to provide voice, data, video, basic digital transport and Internet services to all three branches of Pennsylvania's state government.

The ABS backbone plays a critical roll in Adelphia's strategy to expand its cable modem coverage and launch residential telephony services.

"The main advantage we get from ABS is that it gives us the backbone to connect our systems and connect our headends. This allows us to move data and voice services across the network," explains Rigas. "We can leverage the installed switches, and it also gives us some expertise. We've been able to get our feet wet on the business side, and we can use some of the same knowledge on the residential side."

ABS currently has 22 Lucent 5ESS voice switches or remote switching modules installed for local telephony, and another nine are planned for operation during the first half of this year.

IP telephony underway

Telephony plays an important role in Adelphia's residential strategy as well as its offerings to business customers. The company already resells long distance service to its cable customers and has nearly 60,000 subscribers. But it has retail ambitions of its own and is poised to launch an Internet protocol (IP) telephony trial.

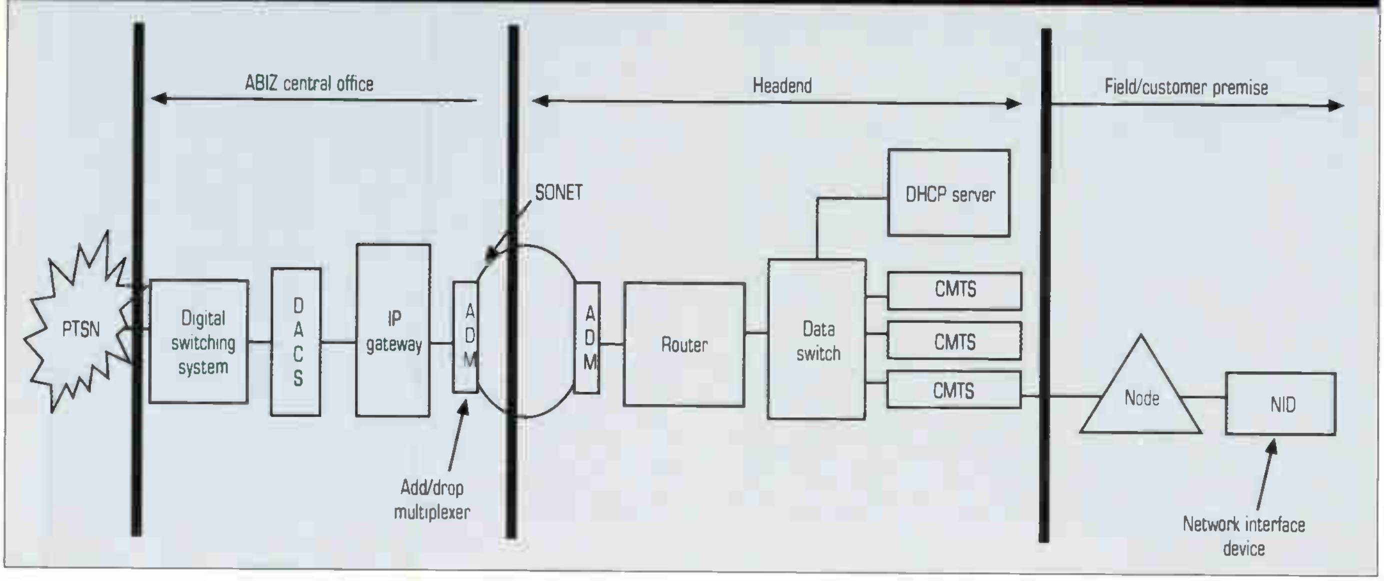
"We think there is a great potential with telephony to generate revenues, compete with the telephone companies and take part of the pie. We feel that our platform allows us to get in the business easily. And we also have the contact with the customers, which would allow us to market the services and package what we have," says Rigas.

"We all feel that we're in a good position to offer residential telephony because of the ABS infrastructure that's in place—the switches, the processes, the operations center. All of that has been in place for awhile, so by leveraging off of that, we feel there's only a little more to do to get to the residential piece," adds Liberatore.

Adelphia hopes to have its IP telephony trial up and running this month in the suburbs of Buffalo, N.Y. It plans to offer commercial service later this summer or in the fall, Rigas says. The MSO also has been testing circuit-switched telephony with 30 friendly users since 1996.

So why the interest in an IP solution? "We chose IP technology

FIGURE 1 | ADELPHIA'S RESIDENTIAL IP TELEPHONY TRIAL NETWORK



because we believe, in the long run, it's the most efficient way of doing telephony," says Liberatore. "The world seems to be moving from circuit-switched to packet-switched technology. Rather than take an interim step with circuit-switched, we will get there with packet-switched and get there as quickly as we can."

But that doesn't mean Adelphia won't use its investment in all of those 5ESS switches. "From a technical standpoint, we put an IP gateway in front of the existing switches. So that capital is already in place. And DOCSIS 1.1 is coming along. With those two things, we believe we're in good shape to take the IP route." >

In the trial, traffic will run from the network interface unit (NIU) at the customer's home over the hybrid fiber/coax (HFC) network to the headend. From there, the ABS network carries traffic to the IP gateway and telephony switch via either a metropolitan synchronous optical network (SONET) ring or the long-haul backbone. The switch then sends the IP calls out to the public switched telephone network (PSTN). (See Figure 1 on page 90.)

Adelphia is testing IP gateways from Cisco and other vendors, but has not made a definitive vendor selection yet. In the trial, it will use NIUs from Motorola, ADC and Nortel. Rigas added that the company expects to launch commercial service first in Buffalo followed by (not necessarily in this order), Pittsburgh and its suburbs, Florida, Colorado Springs, Southern California, and other areas served such as Vermont, Virginia and Ohio. >

A cable technician hones his skills at Adelphia's corporate technical learning center in Coudersport, Pa.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DOCSIS Spec:

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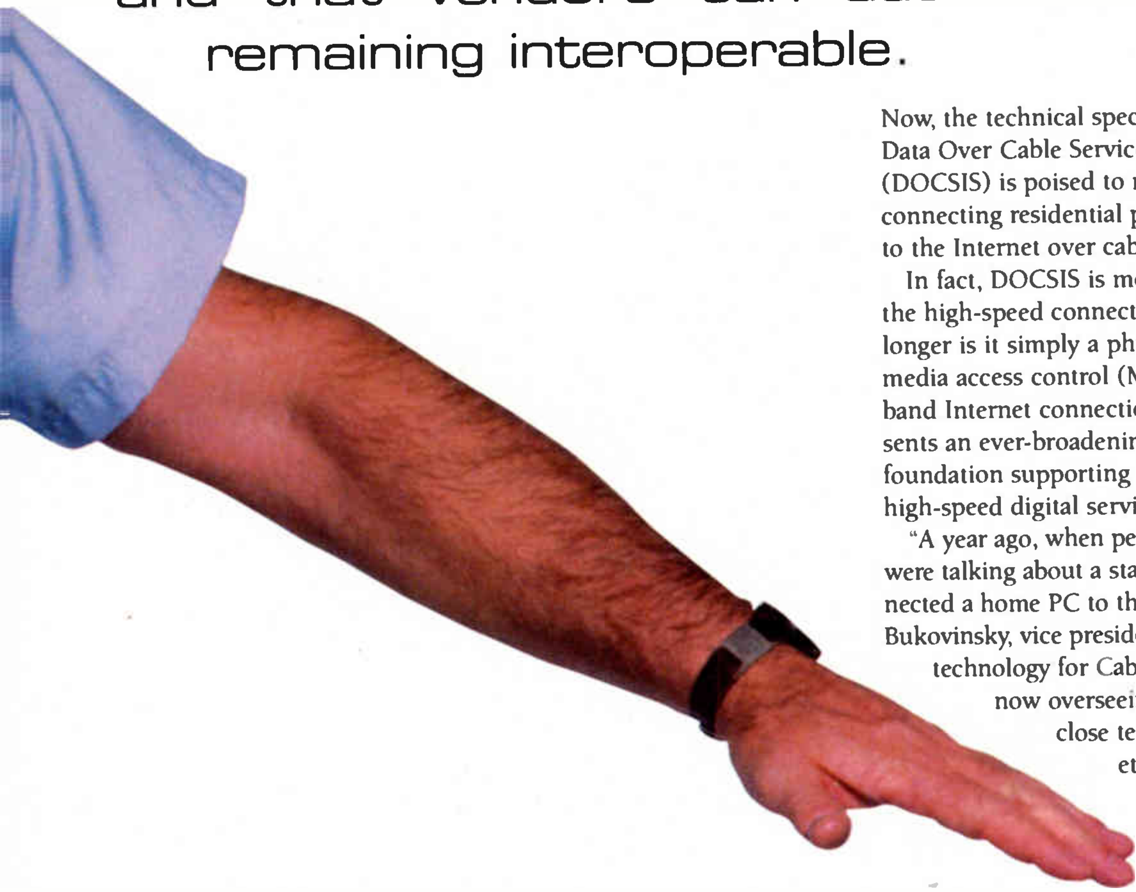
Baseline for Bundles

Industry Slugger Bats 1,000

By the CableLabs Staff

Last month marked the 12th certification wave at CableLabs, proof that the process is stable and that vendors can add features while remaining interoperable.



Now, the technical specification known as the Data Over Cable Service Interface Specification (DOCSIS) is poised to move well beyond just connecting residential personal computers (PCs) to the Internet over cable's broadband pipes.

In fact, DOCSIS is morphing right along with the high-speed connectivity that it enables. No longer is it simply a physical layer (PHY) and media access control (MAC) protocol for broadband Internet connections. Now, DOCSIS represents an ever-broadening and deepening foundation supporting an expanding array of high-speed digital services.

"A year ago, when people said 'DOCSIS,' they were talking about a stand-alone device that connected a home PC to the Internet," says David Bukovinsky, vice president of broadband services technology for CableLabs and the executive now overseeing both DOCSIS and its close technological partner, PacketCable. "Now, and especially with (DOCSIS) 1.1, the spec becomes a core enabler of higher level services."

What constitutes "higher level" services? Anything that works better at a higher speed that can be reasonably guaranteed through quality of service (QOS) extensions in forthcoming DOCSIS 1.1 equipment. Examples include in-home networking, streaming media including Internet protocol (IP) telephony, and "twitch"-style games.

DOCSIS 1.0 tally: 38 Modems, 3 CMTSs

"We've far surpassed high-speed data," Bukovinsky says.

That's saying a lot, when looking at the momentum around what can now almost be called "plain old" DOCSIS, or DOCSIS 1.0. That's the generation of equipment in the field now—to the tune of 3 qualified CMTS systems, and 38 certified cable modems from 17 different manufacturers. (See sidebar "CableLabs Certified Products" on page 108.)

In the most recent round, which concluded in early March, the vendor community submitted 38 modems and 2 headend/CMTS systems. It was one of the largest showings yet, Bukovinsky says, noting that the certification process is stable enough to probably begin moving toward vendor "self-certification" for DOCSIS 1.0 products by the end of this year.

But it's not just the strong showing from the vendor community that's important. So are the types of equipment submitted—including several feature-enhanced versions that prove that manufacturers can and will differentiate their gear while remaining interoperable.

Among the submissions:

- A modem that included a 4-port Ethernet hub, built-in firewall and network address translator (NAT), useful for cable operators who want to provide technological options for small businesses. Status check: One submission, not yet certified.
- A modem that connects to the PC with a universal serial bus (USB) connector, important because the device can be installed without having to open the PC. Status check: 3 submissions, 3 certified.
- Internally installable modem cards, for the nascent but promising original equipment manufacturer (OEM) segment, meaning PC manufacturers who build-in cable modems while assembling a PC system. Although no cable modem cards passed in Certification Wave No. 12, Bukovinsky says it's simply a matter of time until they do—which will likely give an important boost to the industry's weekly installation rates. Bukovinsky says CableLabs needs to remain vigilant about the hostile RF environment inside the PC housing, to ensure that it doesn't adversely affect cable modem data. Status check: Several submissions, none yet certified.
- Home networking gateways, or devices configured such that the cable modem becomes a backdrop for any number of in-home networking techniques (HomePNA, HomeRF, BlueTooth and so on). The idea: to extend cable's external two-way plant to a two-way home, where in-home electronics are linked together to communicate with cable-delivered data, at speeds of up to 10 Mbps. The gateways, already in development by a growing list of vendors, could let cable operators remotely provision IP telephony, high-speed data and digital services over units that either mount on the side of the home or are designed for in-home use. Status check: One submitted and certified.

> **"Now, and especially with (DOCSIS) 1.1, the spec becomes a core enabler of higher level services."**
> **-David Bukovinsky, CableLabs**

The potential benefits to cable are enormous.

"Picture a cable modem integrated with an MTA (multimedia terminal adapter)," Bukovinsky says, sketching out a vision that clarifies CableLabs' decision, last fall, to blend the DOCSIS and PacketCable projects. "Then add in-home networking, so that cable operators can connect the electronics in the home. It's whole-house broadband, and it's something only cable can do right now."

Plus, gateways, once strapped onto the sides of homes, serve as a convenient way to upsell existing customers to advanced services as they become available, without having to schedule a service call.

"Our member companies love the idea because it simplifies matters for them and their customers," Bukovinsky explains, outlining a future service scenario where cable CSRs "can say: 'You take basic and digital, and now you want to try phone? No problem. And while I have you on the line, let me point out that you get an even

BOTTOMLINE

> Data's Future

The Data Over Cable Service Interface Specification (DOCSIS) is more than just a way to connect residential personal computers (PCs) to the Internet over cable. DOCSIS 1.0 now supports an expanding array of high-speed digital services.

Version 1.1 features quality of service (QoS) parameters that let cable operators guarantee different bit rates—a precursor to tiered data services. The immediate impact is more efficient use of bandwidth and enhanced security. DOCSIS 1.1 also is ground zero for the PacketCable specification, which is focused on voice-over-IP (VoIP) and multimedia services.

The industry ended 1999 with nearly 2 million high-speed data subscribers, hooking up 17,500 customers a week, even before the retail modem availability. With DOCSIS-certified cable modems widely available at retail outlets, cable-delivered high-speed broadband services will expand, which is good for cable operators and customers alike.

> **CableLabs Certified Products**

The following companies all have CableLabs Certified products, either modems or cable modem termination systems (CMTSs), and in some cases both. Companies with more than one product certified have the number listed in parentheses after the company name.

Modems

3Com (2)
www.3com.com

Arris Interactive (3)
www.arris-i.com

Askey (2)
www.askey.com

Best Data
www.bestdata.com

Cisco
www.cisco.com

Com21 (5)
www.com21.com

Dassault
www.dassault-at.com

DX Antenna
www.dx-trading.co.jp.com

Motorola, including the former General Instrument (5)
www.motorola.com

Philips
www.be.philips.com

Samsung
www.samsungtelecom.com

Sony
www.sony.com

Terayon (3)
www.terayon.com

Thomson Consumer Electronics (6)
www.thomson-broadband.com

Toshiba (4)
www.toshiba.com/taisnpd

Turbocomm
www.turbocomm.com.tw

Cable modem Termination systems

Arris Interactive
www.arris-i.com

Cisco
www.cisco.com

Motorola
www.motorola.com
www.sharewave.com

deeper discount if you try our cable modem service, too.'"

And consider the power, Bukovinsky says, of a cable modem configured as an internal PC card, coupled with an in-progress "service locator" project at CableLabs called G2B, short for "Go2Broadband," that links retailers and PC manufacturers with information about areas of the United States where high-speed service is available.

It's the sort of stuff that could add significant firepower to weekly cable modem install rates: computer manufacturers build DOCSIS modems into PCs (just as dial-up modems are a standard feature of today's PCs), then close the sales gap by knowing when and where high-speed cable modem service is available.

The next certification round for DOCSIS gear is in full swing as of this writing, with results expected in late May.

Enter DOCSIS 1.1

And that's just "plain old" DOCSIS. The next version of the spec is well underway, too. Bukovinsky and multiple system operators (MSOs) familiar with the technology are quick to point out that most 1.0-version modems shipping now include silicon that is upgradable to the newer 1.1 spec through a software download.

What makes 1.1 different? The short answer: QoS parameters. With QoS, cable operators will be able to guarantee different bit rates—an important precursor to tiered data services. The immediate impact is more efficient use of available upstream and downstream bandwidth, important for services such as IP multicasts and enhanced security.

Perhaps more importantly, DOCSIS 1.1 is ground zero for the PacketCable specification, which is focused on voice-over-IP (VoIP) and multimedia services. That means gateways and MTAs will start to emerge in lockstep with the DOCSIS 1.1 specification.

Bukovinsky explains that the specification was released for vendor review in segments last year; already, 1.1-based gear has gone through the paces at three interoperability trials at CableLabs. Depending on vendor performance, 1.1-based gear could go into certification testing as early as this month. On that schedule, products could emerge as certified by the end of this year.

Also part of the 1.1 product mix: a computer controlled cable modem, where portions of the cable modem's processing load are handled by the onboard chips of the PC itself. The benefit: A huge potential cost savings, to the tune of a sub-$50 cable modem that gets deployed with each outfitted PC. Prototype gear is expected to emerge from the vendor community in the second quarter of this year, with certification submissions by year-end.

And the security with 1.1 becomes more robust, with the use of digital certificates and a stronger encryption format, Bukovinsky says. "The existing (1.0) equipment uses link-layer security, but 1.1 builds on it significantly," starting with a baseline privacy spec.

"DOCSIS is morphing right along with the high-speed connectivity that it enables."

"It means that if a 1.1-based cable modem wants to download a new image, there's a digital certificate that verifies that the code layer is valid,

and that it came from the MSO," Bukovinsky says, adding: "It's an MSO control point."

Future ready

With all the advancements, it's easy to lose sight of what gave way to the need for DOCSIS in the first place. Recall that four years ago it seemed quite unlikely that a long list of cable modem manufacturers, all making interoperable equipment, would reduce their prices and add a new, retail pipeline to speed penetration rates for high-speed data services.

Clearly, that's starting to happen. Analysts who cover cable say the industry ended 1999 with nearly 2 million high-speed data subscribers, hooking up customers at an aggregate rate of 17,500 per week.

All of that happened before the retail engine engaged. And that will only speed the rate at which cable adds high-speed subscribers. And with telephone companies' digital subscriber line (DSL) technology right on its heels, every advancement helps. With the wide availability of DOCSIS-certified cable modems at the likes of Circuit City, Best Buy and other consumer electronic outlets, the pace of cable-delivered high-speed broadband services will accelerate, resulting in a ubiquitous deployment of feature-rich advanced services to the consumer.

That's why the addition of advanced feature sets, such as those coming in both 1.0 and 1.1 versions of the DOCSIS spec, are important. Not only do they prove that interoperability doesn't necessarily mean sameness—they also serve as a future-ready way to anticipate and roll out complete digital bundles of voice, video and data to subscribers. It's how cable keeps a lock on "broadband," as the only high-bandwidth provider that can provide a total service bundle. CT

Cable Television Laboratories Inc. is in Louisville, Colo. You can check out their Web site at www.cablelabs.com.

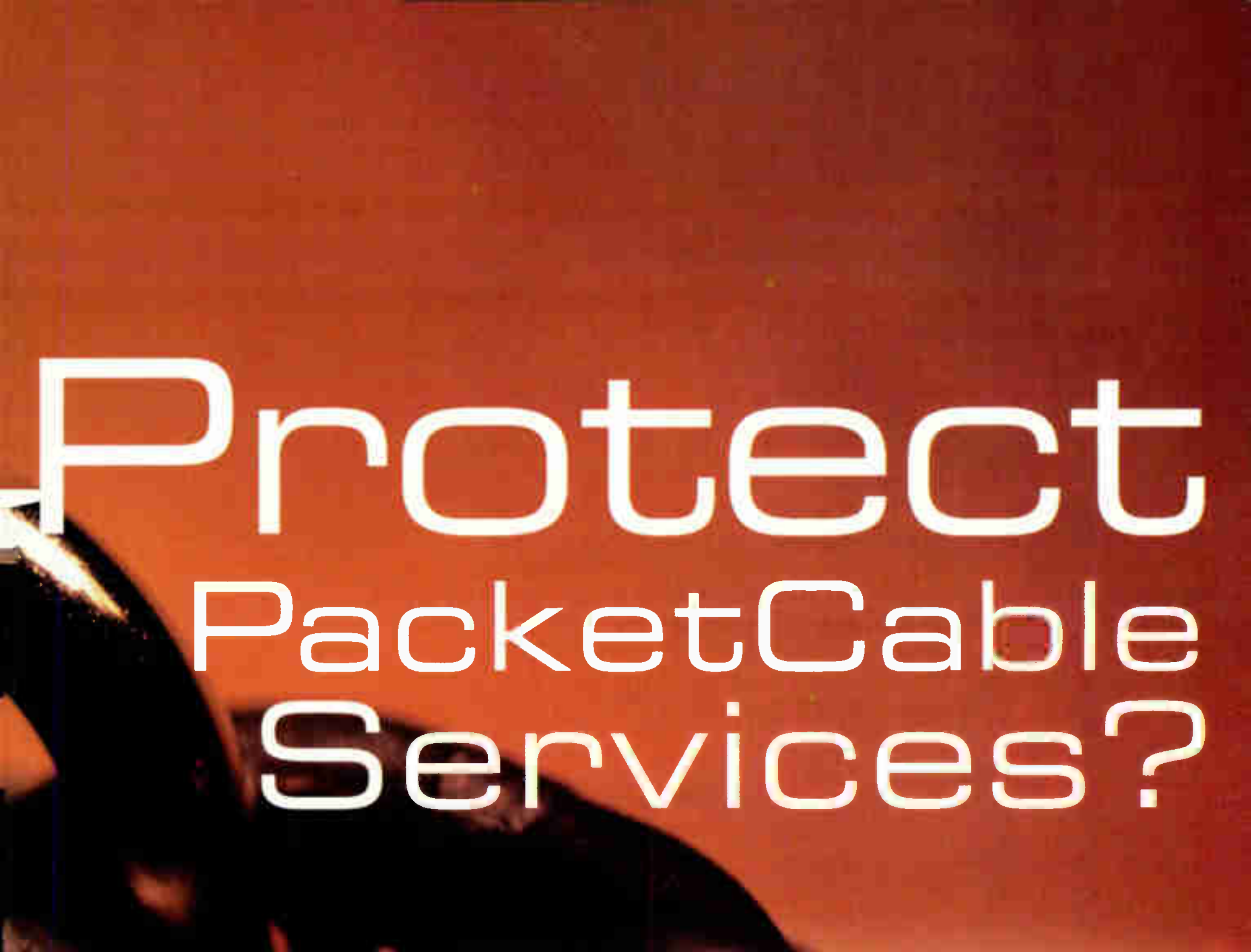
Did this article help you? Let us know your thoughts. Send an e-mail to jwhalen@phillips.com.

Can You

Tips for Locking Out Security Threats

By Doug Jones

Everyone is eagerly anticipating the new services made possible by PacketCable, including telephony and videoconferencing over cable networks and the Internet. But before jumping in head first, beware that it comes with complex security concerns that you'll need to guard against.



Protect PacketCable Services?

[illegible] ication, [illegible] by [illegible]ableLabs, uses Data Over Cable Service Interface Specification (DOCSIS) security, but it has many additional security requirements. The purpose of any security technology is to protect value, whether it is a revenue stream or a purchasable information asset. The proper engineering task is to employ a reasonably priced security technology to force any user with the intent to steal or disrupt network services to spend an unreasonable amount of money to circumvent it.

A PacketCable Internet protocol (IP) telephony network must be at least as secure as today's public switched telephone networks (PSTNs). Much of the PSTN security depends on the fact that each telephone is connected to a dedicated line. To provide the same level of privacy and resistance to denial-of-service attacks in a PacketCable IP telephony network, where both voice and signaling data are transmitted over a shared cable network and an IP backbone, appropriate cryptography-based security mechanisms are available.

What's at stake

The potential loss of revenue from security breaches is huge. Telecommunications fraud was estimated to be $4 billion in 1997. The amount of long distance charges stolen through customer premise equipment (CPE) in the United States was $1.5 billion. Average losses caused by CPE phone fraud were about $16,500 per incident. The cost to users in "800" line charges was estimated at $205 million.

PacketCable is vulnerable to a variety of security threats, including:

- Theft of service
- Bearer channel information threats
- Signaling channel information threats >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Service disruption threats
Repudiation

heft of service

IP telephony network services may stolen from either the network or om the media terminal adapter ITA). The MTA is on the subiber's premises and is essentially the lephone handset" used for attach; to an IP phone network.

One or more MTAs masquerades as other MTA by duplicating its peranent identity and cryptographic ys. The secret cryptographic keys n be obtained by either breaking the ysical security of the MTA or by nploying cryptoanalysis. When an MTA is broken into, the perpetrator can steal telephone service and charge it all to the owner. The feasibility of such an attack depends on where an MTA is located.

The MTA is an untrusted network element. It is operating inside the customer premises. An adversary has the ability to open up the MTA and make software and even hardware modifications to fit his or her needs. And this could be done in the privacy of the customer's home. In addition, an MTA communicates with the cable modem termination system (CMTS) over the shared DOCSIS path and has access to downstream and upstream messages from other MTAs within the same hybrid fiber/coax (HFC) segment.

An MTA is responsible for initiating and receiving telephone calls to and from another MTA or the PSTN and negotiating quality of service (QoS).

Compromising an MTA can result in:

- MTA clones capable of charging phone calls to someone else's account, violating privacy, perpetrating identity fraud and downloading a code image that illegally enables enhanced features within the MTA
- An MTA running a bad code image that disrupts telephone calls made by other MTAs or degrades network performance

In addition to cloning of the permanent cryptographic keys, temporary (usually symmetric) keys also may be cloned. Such an attack is more complex because the temporary keys expire more often and have to be redistributed frequently. The only reason someone would attempt this attack is if the permanent cryptographic keys are more protected, or if the temporary keys are particularly easy to steal or discover with cryptoanalysis.

Services are at risk of being stolen include:

- Long distance phone calls
- Local (subscription) telephone service
- Video conferencing
- Network-based three-way calling
- QoS

Services such as the support for multiple MTA ports, three-way calling and call waiting may be implemented entirely in the MTA, without any interaction with the network.

MTA code to support these services may be downloaded illegally by an MTA clone, in which case the clone has to interact with the network to get the download. This threat is no different from network service theft.

Alternatively, downloading an illegal code image using some illegal out-of-band (OOB) means also can enable these services. Such service theft is much harder to prevent—a secure software environment within the MTA may be required. But in order for an adversary to go through this trouble, the price for these MTA-based services has to make the theft worthwhile.

As a result, valuable services cannot be implemented entirely inside the MTA without a secure software environment in addition to tamper-proof protection for the cryptographic keys. While a secure software environment within an MTA adds significant complexity, it is an achievable task.

Threats to the bearer channel

Bearer channel information threats involve the breaking of privacy of voice communications over the IP telephony bearer channel. Threats against non-voice-over-IP (VoIP) communications require additional security at the application layer. >

"Internet communications are inherently insecure ... so sophisticated security methods are necessary."

BOTTOMLINE

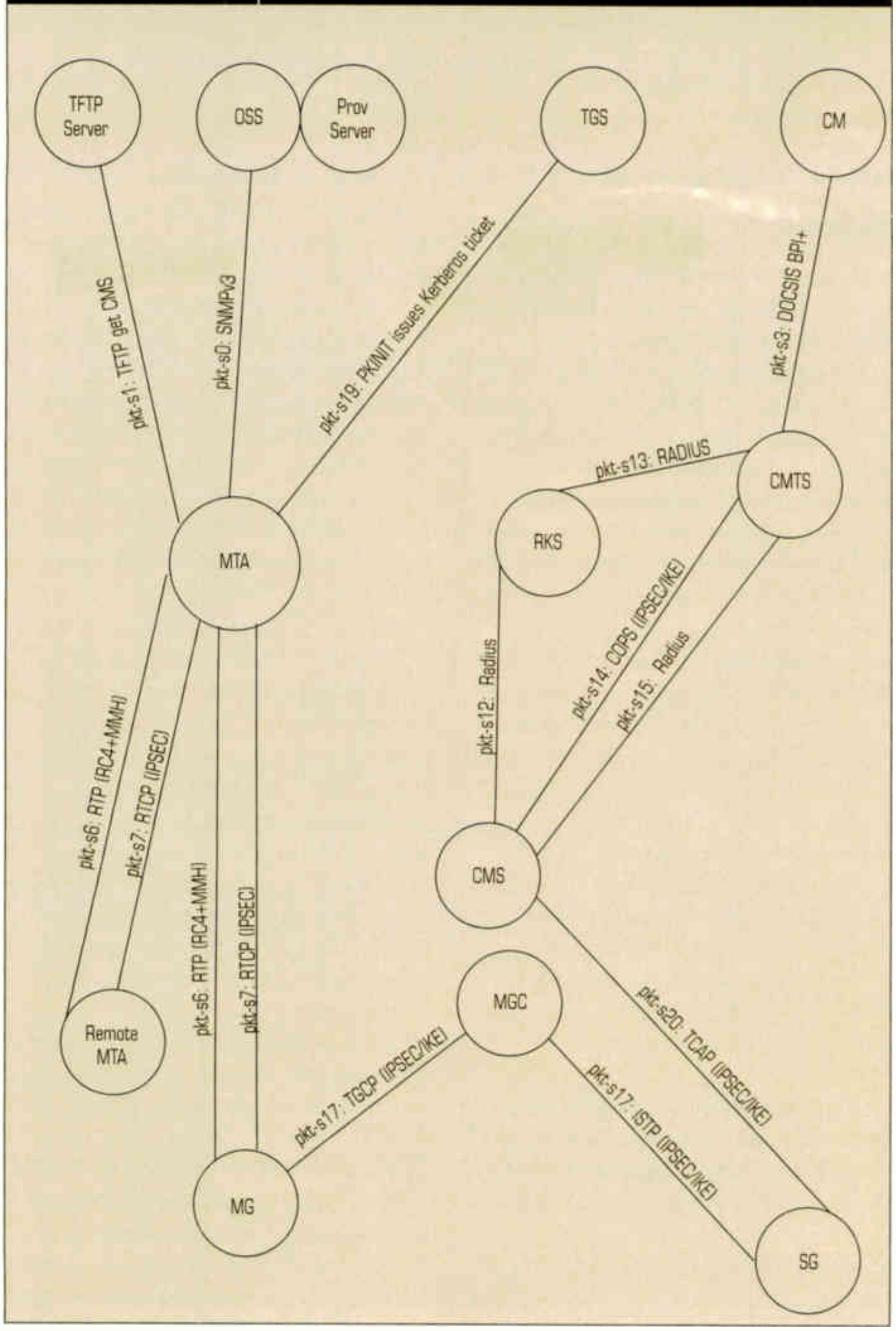
Sec rity To Even the Score

As a end-to-end application, Pac tCable uses Data Over Cab Service Interface Specificati (DOCSIS) security, but it has any additional security req ements.

he purpose of any security technology is to protect value, whether it is a revenue stream or a purchasable information asset. The proper engineering task is to employ a reasonably priced security technology to force any user with the intent to steal or disrupt network services to spend an unreasonable amount of money to circumvent it.

A PacketCable IP telephony network must be at least as secure as today's public switched telephone networks (PSTNs). Much of PSTN security depends on the fact that each telephone is connected to a dedicated line. In order to provide the same level of privacy and resistance to denial-of-service attacks in a PacketCable Internet protocol (IP) telephony network, where both voice and signaling data are transmitted over a shared cable network and an IP backbone, appropriate cryptography-based security mechanisms must be implemented.

FIGURE 1 Security architecture



Clones of MTAs and other network elements, as well as protocol manipulation attacks, also apply in the case of the bearer channel information threats. MTA cloning attacks mounted by the owner of the MTA are less likely in this case, but not completely inapplicable. An owner of an MTA may distribute clones to the unsuspecting victims, so that he or she can later spy on them.

Bearer channel information may be recorded and analyzed over a period of time until the encryption keys are discovered with cryptoanalysis. The discovered information may be valuable for some time.

Signaling channel information threats

Telephony signaling information, such as caller identity and the services to which each customer subscribes, may be collected for marketing purposes. The caller identity also may be used illegally to locate a customer who wishes to keep his or her location private. Clones of MTAs and other network elements, as well as protocol manipulation attacks, also apply in the case of the signaling channel information threats.

MTA cloning attacks mounted by the owner of the MTA theoretically a possible. An owner of an MTA may distribute clones to the unsuspecting victims, so that he or she can monit their signaling messages for information with marketing value. The poter tial benefits of such an attack seem unjustified, however.

A caller ID can be revealed, even though a phone number is unlisted and the owner of that phone numbe enabled caller ID blocking. Dialed phone numbers and the type of phone service customers use may be gathered for marketing purposes by other corporations.

Disrupting service

Service disruption threats are aim at interrupting the normal operation of the IP telephony network. The m tives for denial-of-service attacks ma be malicious intent against a particu lar individual or against the telephoı company. Or it even can be a competitor who wants to degrade the pe formance of another service provide and use that information in an adver tising campaign.

A perpetrator could manipulate th protocol to close down current telephone connections. This might be achieved by masquerading as an MT that is involved in a telephone conversation. The same effect may be achieved if the perpetrator impersonates another network element, such as a gate controller or an edge route during either call setup or voice packet routing.

Depending on the signaling protoc security, it might be possible for the perpetrator to mount this attack from the MTA, in the privacy of his or her own home. Clones of MTAs and other network elements, as well as protocol manipulation attacks, also apply in the case of the service disruption threats.

MTA cloning attacks mounted by the owner of the MTA theoretically can be used in service disruption against unsuspecting clone owners. >

However, since there are so many other ways to cause service disruption, such an attack is unlikely.

The threat of repudiation

In a network where masquerade is common or is easily achievable, a customer also could repudiate a particular telephone call.

In addition, unless public key-based digital signatures are employed on each message, the source of each message cannot be absolutely proven. If a signature over a message that originated at an MTA is based on a symmetric key shared between that MTA and a network server, it is unclear if the owner can claim that the service provider somehow falsified the message.

However, even if each message were to carry a public key-based digital signature and if each MTA were to employ stringent physical security, the customer still can claim in court that someone else made that phone call without his or her knowledge. Thus, the benefits of nonrepudiation services seem dubious at best and do not appear to justify the performance penalty of carrying a public key-based digital signature on every message.

The security architecture

Unlike the PSTNs, the PacketCable architecture (see Figure 1 on page 116) defines almost a dozen networked components and the protocol interfaces between them. These networked components include the MTA, call management server, signaling gateway, media gateway and a variety of operational support systems (OSSs) and other servers. The PacketCable security specification addresses the security requirements of each constituent protocol interface by:

- Identifying the threat model specific to each constituent protocol interface
- Identifying the security services (authentication, authorization, confidentiality, integrity, nonrepudiation) required to address the identified threats
- Specifying the particular security mechanism providing the required security services for each constituent protocol interface

There are a variety of techniques used to secure these interfaces. In addition, the individual network elements must physically be protected from attack.

BPI+

All MTAs must use DOCSIS v1.1-compliant cable modems and must implement baseline privacy plus (BPI+). BPI+ provides security services to the DOCSIS v1.1 data link layer traffic flows running across the cable network, including between computer modem and CMTS. The BPI+ security services operating in conjunction with DOCSIS v1.1 provide cable modem users with data privacy across the cable network and protect cable operators from theft of service.

BPI+ has two component protocols:

- An encapsulation protocol for encrypting packet data across the cable network. This protocol defines:
  1) The frame format for carrying encrypted packet data within DOCSIS media access control (MAC) frames
  2) A set of supported cryptographic suites, including pairings of data encryption and authentication algorithms
  3) The rules for applying those algorithms to a DOCSIS MAC frame's packet data
- A key management protocol, baseline privacy key management (BPKM), provides the secure distribution of keying data from CMTS to modems. Through this key management protocol, the modem and CMTS synchronize keying data; in addition, the CMTS uses the protocol to enforce conditional access (CA) to network services.

BPI+ does not provide any security services beyond the DOCSIS v1.1 cable access network. The majority of PacketCable's signaling and media traffic flows, however, traverse the managed IP "back-haul" networks, which lie behind CMTSs.

Because DOCSIS and PacketCable service providers typically will not guarantee the security of managed IP back-haul networks, the PacketCable security architecture defines end-to-end security mechanisms for all these flows.

End-to-end security is provided at the network layer through security architecture for IP, or, in the case of MTA media flows, at the application/transport layer through real-time protocol (RTP) application layer security. Thus, PacketCable does not rely on BPI+ to provide security services to its component protocol interfaces.

Security at the IP layer

Security architecture for the Internet protocol (IPsec) provides security services at the IP layer by enabling a system to select security protocols, determine the algorithms for the services, and put in place any cryptographic keys required to provide the requested services. IPsec can be used to protect one or more "paths" between a pair of hosts, between a pair of security gateways, or between a security gateway and a host.

IPsec can provide some security services, including access control, connectionless integrity, data origin authentication, rejection of replayed packets (a form of partial sequence integrity), confidentiality (encryption) and limited traffic flow confidentiality. Because these services are provided at the IP layer, they can be used by any higher layer protocol, such as transmission control protocol (TCP), user datagram protocol (UDP) and RTP, all used by PacketCable.

IPsec is used on a number of different interfaces with varying security and performance requirements, so several different key management protocols have been chosen for different PacketCable interfaces. On some interfaces it is Internet key exchange (IKE), and on others it is Kerberos.

Internet key exchange

PacketCable uses IKE as one of the main management protocols for IPsec. It is used on the interfaces where there is not a very large number of connections (on the order of 100,000 or above) and the endpoints on each connection know about each other in advance. >

Eye on the Competition

A typical VOD order screen as it would appear to a customer.
Image courtesy of nCube

In addition, content providers want to control how copies of their material—especially copies that might be produced in a customer's home—can be made. PVR and caching strategies complicate copy-protection. Is a copy stored on a set-top disk an authorized copy? In a caching scheme, how does the operator certify that every copy of a given title has been purged once outside the content's authorized window?

One more consideration: Because of their mechanical nature, vibration and heat generated, disk drives are the most likely items to fail in a video server. That said, does an operator want disks located in customer set-tops, where failures are likely to cause service and support issues, or at a central location, where they are much easier to maintain?

Recommendations

Where does this leave today's cable operator seeking the most cost-effective, but flexible VOD solution? A few guidelines may help ease the decision-making process.

- Value simplicity: Look for straightforward, simple-to-execute, standards-based solutions.
- Prepare for success: Don't lock into a solution for small-scale residential deployments that fail to be economical with the inevitable growth of a successful service.
- Consider price vs. cost: A thorough understanding of a vendor's technology will help an operator find an efficient solution whose underlying costs are less, and, therefore, more likely to be offered for a better price in later large-volume purchases.
- Watch operational costs: Generally speaking, the deployment of fewer centralized video servers, which will need fewer copies of content, will result in lower operational, or people-related, costs.

By following these simple guidelines, MSOs can deploy a video server architecture that will scale to help them reap the new revenue streams promised by VOD. CT

Greg Thompson is chief technical officer for nCUBE. He can be reached at gregt@ncube.com.

Did this article help you? Let us know your thoughts. Send an e-mail to jwhalen@phillips.com.

A hybrid approach?

Looking at the larger picture, a hybrid approach using centralized and distributed video servers might work for an operator under certain circumstances. Video servers in the hubs could provide "hot" content delivery locally, while a centralized video server would be used for archival content delivery. Rebalancing content between the servers would take place in the background or during off-peak hours. This approach can reduce the on-demand bandwidth needed from the headend to hubs, but at a higher risk of not having the bandwidth to stream a requested title from the central server.

The hybrid solution has advantages and disadvantages. Video servers must be located at both the headends and hubs, but the headend backs up the hub. Hot titles still must be duplicated, but not the whole content library at each hub. Content management is much more complex, but not impossible. Dedicated streaming bandwidth still is needed from the headends to the hubs, but not to the extent of a pure centralized approach.

"TWC is deploying a hybrid solution in some locations because it also has distinct advantages," Adams says. "One is reliability. The hub-based and headend-based servers spare each other. Another is that some hubs are too small to justify a video server, while others are too large not to. The fact is that some headends serve fewer customers than do some hubs. The distance-bandwidth equation has to be factored in according to individual circumstance."

Disks in set-tops?

Set-top boxes that offer disk storage include TiVo, ReplayTV and PACE/NDS XTV. They can act as a personal video recorder (PVR) that lets the user explicitly capture a program by hitting the pause button or preselecting something he or she wants to watch in the future. Alternatively, the storage could be used as a local disk cache in which the headend determines the titles automatically prestaged in the set-top.

PVRs suffer from several problems. First, users must remember to set up their units to capture programs, just as they do with today's VCRs. That, in turn, makes the system much less user-friendly than true VOD services. Second, the user or cable system must manage the limited local storage capacity. With automated caching, it is difficult to predict what a customer will want to watch.

So is the set-top the most cost-effective location for storage in the network? The disk significantly adds to the set-top's cost, and while each subscriber needs a set-top, video servers in hubs or headends only need to support subscribers concurrently using the VOD service. One copy of the content centrally located that supports 10,000 users takes a lot less storage than staging it to 10,000 set-tops in homes. >

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Using DWDM, 1,550 nm amplitude modulated (AM) fiber-based technologies can provide remote narrowcast delivery of VOD channels for each service area off each hub. One can either RF combine the VOD channels with other digital channels in the hub, or remote the entire digital spectrum in a passive optical hub design with all services and RF mappings originating in the headend.

Various SONET/synchronous digital hierarchy (SDH) digital fiber approaches, which also can leverage DWDM, include traditional intermediate frequency (IF) transport over SONET, MPEG-2 single program transport stream (TS) over asynchronous transfer mode (ATM), MPEG-2 multiple program TS over ATM, and MPEG-2 transport over Internet protocol (IP) networking with quality of service (QoS) support. Depending on the approach, MPEG-2 multiplexing, quadrature amplitude modulation (QAM), conditional access (CA) scrambling or RF upconversion may or may not be required in the hub.

U.K.-based Telewest is one cable operator using a centralized approach. Telewest is placing video servers in regional headends and using Harmonic's DWDM technology to deliver VOD streams through hubs to the customer's service area.

"VOD has already been delivered with this technology, and future extensions are under development," says Sal Kabay of Imagine Broadband Ltd., which helps Telewest design and deploy its digital services. "The first deployment of the service in the U.K. is in successful commercial trials, and the subscriber base will be ramped up to support 35,000 digital customers with a view to national rollout covering almost 200,000 subscribers in the very near future."

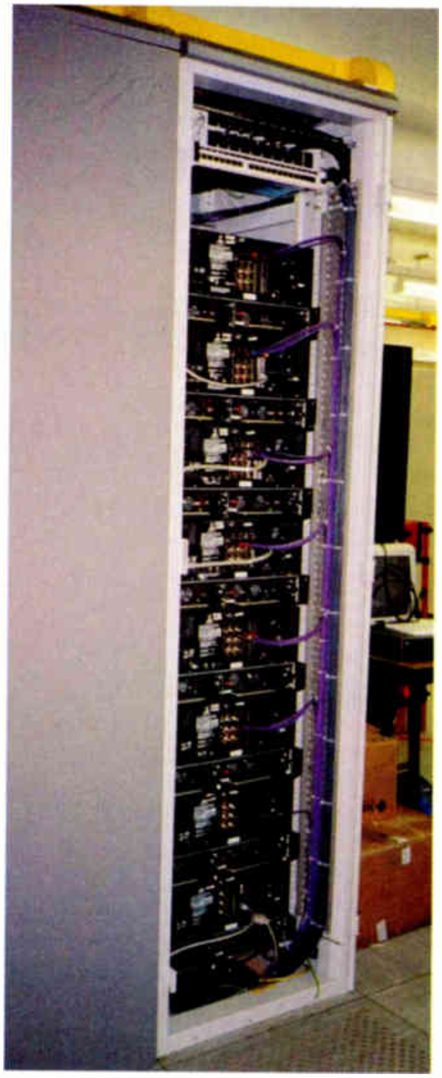
Distributed architectures

The alternative to putting video servers in the headend is to put them in each hub and stream MPEG-2 content from the local hub. This approach does not impact the headend-to-hub network, other than creating some additional reporting and management traffic. While this alternative calls for duplicating content in each hub, it can save headend-to-hub network upgrade costs if the environment has little fiber or if DWDM hasn't been deployed. (See Figure 2 on page 219.)

DWDM, the key technology that can provide the network bandwidth to enable a centralized approach, is relatively new and, in general, not yet widely deployed by cable operators.

"To my knowledge, no MSOs have deployed DWDM to support VOD, so the cost of DWDM is completely incremental," says Michael Adams, principal network architect of Time Warner Cable. "The fiber count is typically high—36- to 48-count per ring, containing three to four hubs—but without DWDM, it would be exhausted very quickly."

Adams' primary concern regarding the centralized approach is cost.



A video-on-demand (VOD) server in a regional headend belonging to UK-based Telewest. Telewest uses a centralized server approach. Photo courtesy of nCube

"I think a fundamental weakness of the argument for centralized servers is the lack of discussion of the very real costs of DWDM," he says. "Currently, TWC places servers at the hubs primarily to reduce transport costs. It requires much less transport bandwidth to trickle 20 movies a month to distributed servers than to stream thousands of movies simultaneously to individual set-tops."

Complex content issues

Content distribution to the hubs typically is done using a real-time broadcast capture, faster-than-real-time Internet file transfer protocol (FTP) or multicast distribution over an IP network. Tape distribution using periodic truck rolls also is possible, although more labor-intensive. Because each title is sent to each hub, the number of copies that must be created and stored for each title greatly increases. That, in turn, raises the risk of theft and complicates the auditing requirements imposed by content providers for protecting and accounting for each digital copy of their content.

Distributed video servers can be managed centrally via an IP-based network. But truck rolls to the hubs still are required for such maintenance tasks as replacing failed disks, fans, power supplies or other equipment. Another key consideration is that many hubs have limited available rack space, power and cooling capacity. That, in time, could limit the scalability needed to meet increased demand.

The choice is primarily about the trade-off between video server storage and network bandwidth costs. From my perspective, more and more networking vendors are offering DWDM solutions at lower prices. Eventually, DWDM's bandwidth multiplying capabilities will drive down the cost of network bandwidth. Therefore, over time, the centralized video server architecture will become the clear preference, especially with a passive optical hub design. >

ized video server, but also creates the need for additional network bandwidth to deliver the video from the headends to the correct optical nodes.

Scalability allows cost-effective, seamless expansion of a system to meet growing demand, without radical changes in architecture or unnecessary duplication of components. Without a scalable solution, it may not be possible to accommodate the demand for successful services.

Today's scalable video-server designs allow single copies of content to be shared across all streams supported by the video server. This is achieved by striping content across all the server's disk drives. Combined with a scalable internal interconnect, this enables the server to deliver whatever stripe of video is needed for each video pump's output, while automatically balancing each stream's input and output load across the entire server.

Reducing storage space

By requiring only a single copy of redundant array of independent discs (RAID)-protected content, storage costs are greatly reduced, rack space is saved, content-management is simplified, and security is increased. For the same number of disk drives, as compared with distributed architectures that need many disks to duplicate content, much larger online content libraries can be supported.

Video rental stores' buy rates increase with the number of titles on hand. More products translate into more revenue. But they also create the need for more shelf space. Along these same lines, large movie libraries and advanced VOD services—such as online broadcast, distance-learning content, network-based videocassette recorders (VCRs) and video-enhanced Web pages—dramatically increase the need for video-storage shelf space. The ability to support large, centralized libraries of content can provide significant business advantages that would not be feasible if the content had to be duplicated on multiple distributed video servers.

All video streamed to the network originates from the disk drive. As a server grows to support more simultaneous streams, the number of disk drives needed to support the delivered bandwidth must expand as well—independent of the number of online titles. That, in turn, provides plenty of online content storage for advanced VOD applications and the growing customer base.

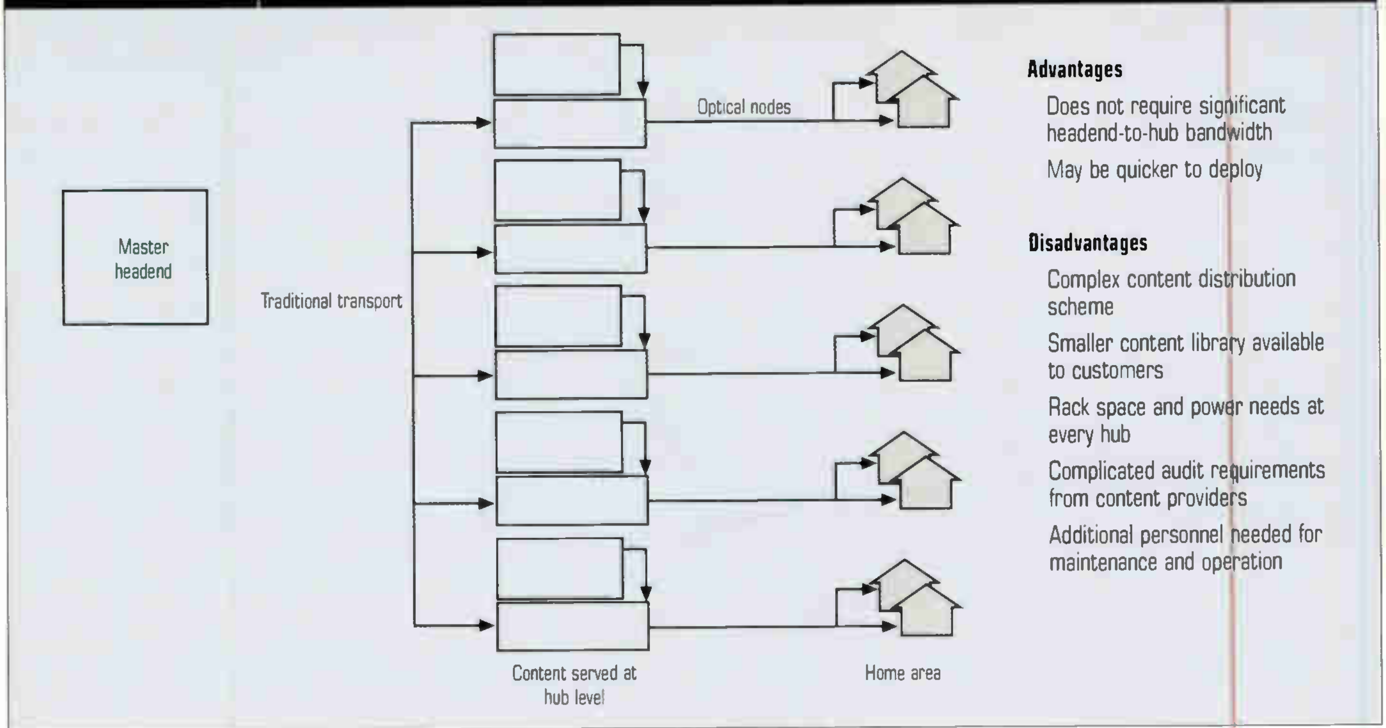
With video-server, networking and technology costs continuing to fall, operational—or people-related—costs eventually will dominate. Centralized video server approaches call for far fewer servers requiring fewer disks. Furthermore, these servers are located in headends, where they are much easier to support. This translates into lower operational costs.

Centralized servers also are better able to provision and load-balance requests because they serve a larger, more statistically significant population sharing a larger pool of resources. This enables them to better avoid insufficient capacity for any one location because of localized hot spots of users, over-requested titles or failed components.

Higher bandwidth demands

The primary disadvantage of the centralized approach is that it requires more network bandwidth from the headends to the hubs to target delivery to each customer's service area. With the increased use of fiber, dense wave division multiplexing (DWDM) and synchronous optical network (SONET) technologies, bandwidth limitations can be mitigated in several different ways. >

FIGURE 2 DISTRIBUTED ARCHITECTURE



Deciding where to put the servers to store that content gold mine is an issue plaguing cable operators today.

VOD deployment has been accelerated by many technological developments already in place to support other new services. Broadcast digital TV (DTV) based on Moving Picture Experts Group (MPEG)-2 standards has contributed to advances in encoding and efficient delivery of video streams over the cable plant. Today's broadband hybrid fiber/coax (HFC) architecture supports interactive services by providing separate bandwidth to each optical node. New Data Over Cable Service Interface Specification (DOCSIS)-certified modems enable high-speed Internet access. By combining these modems with modern Web-browser technologies, we can create rich, cross-media, interactive user experiences.

Perhaps most important for cable operators, however, is the fact that the cost of deploying VOD has fallen to the point that VOD applications can become major money-makers going forward. Instead of requiring an operator to build the system from the ground up, VOD can leverage the Web capabilities of interactive TV, the efficiencies of digital video, the new cable standards and the modern hybrid fiber/coax (HFC) infrastructure.

The falling cost and increased capabilities of video servers also are accelerating the deployment of VOD. The video server, with its disk storage, is the new component that must be added to the HFC architecture to support VOD applications. Yet, it can be difficult for a cable operator to decide where in the architecture to place the servers to provide a cost-effective and scalable VOD system.

BOTTOMLINE

> To Centralize or Distribute: That Is the Server Question

Video-on-demand (VOD) is emerging as a technologically and economically viable video delivery system. Can you say, "At last?"

VOD has gone through a profound evolution in the past six years. No longer defined by just movies, it now encompasses myriad advanced applications that can be supported by technology already in place. The infrastructure is there, allowing the costs of deployment to fall to the point that VOD is ready to become the revenue generator it originally was envisioned to be.

But what about the VOD architecture? How will you most efficiently, and cost-effectively, structure your on-demand delivery system?

If you centralize your servers at the headend, you reduce storage costs by requiring only single copies of content, thereby supporting larger online libraries. A centralized architecture means fewer servers, requiring less maintenance and reducing truck rolls.

However, if you centralize, you need more bandwidth to get from the headends through the hubs to the target customer service areas. Put the servers at the hubs, and you don't significantly affect the headend-to-hub network. But it does call for a duplication of content in each hub.

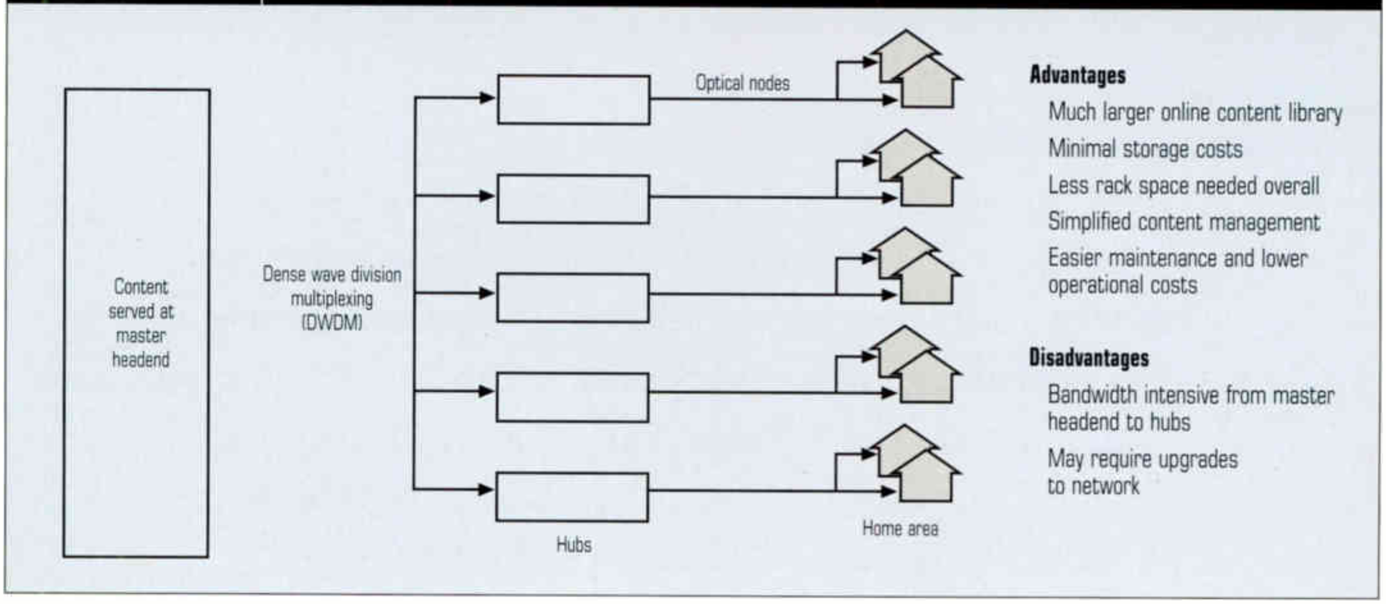
You could combine the two in a hybrid approach, rebalancing content between servers during off-peak hours to reduce bandwidth requirements, but then you would risk not having the bandwidth you need to stream a specific title from the central server.

What's a cable operator to do? Consider simplicity, scalability, operational needs and total cost when making your decision.

Centralized architectures

In a centralized server architecture, video servers are located in the regional or master headend, and content is sent over the network through the hubs to the requesting service areas. (See Figure 1.) This approach provides the many benefits of a central-

FIGURE 1 CENTRALIZED ARCHITECTURE



Distributed VOD Servers

How Is This Tug of War Impacting Your Architecture?

By Greg Thompson

As cable operators seek new revenue, video-on-demand (VOD) means more than just movies. Today it includes on-demand post-broadcast video delivery, "personal TV," Internet video, distance learning, video caching, targeted ads, video libraries and video mail. >

Centralized

vs.

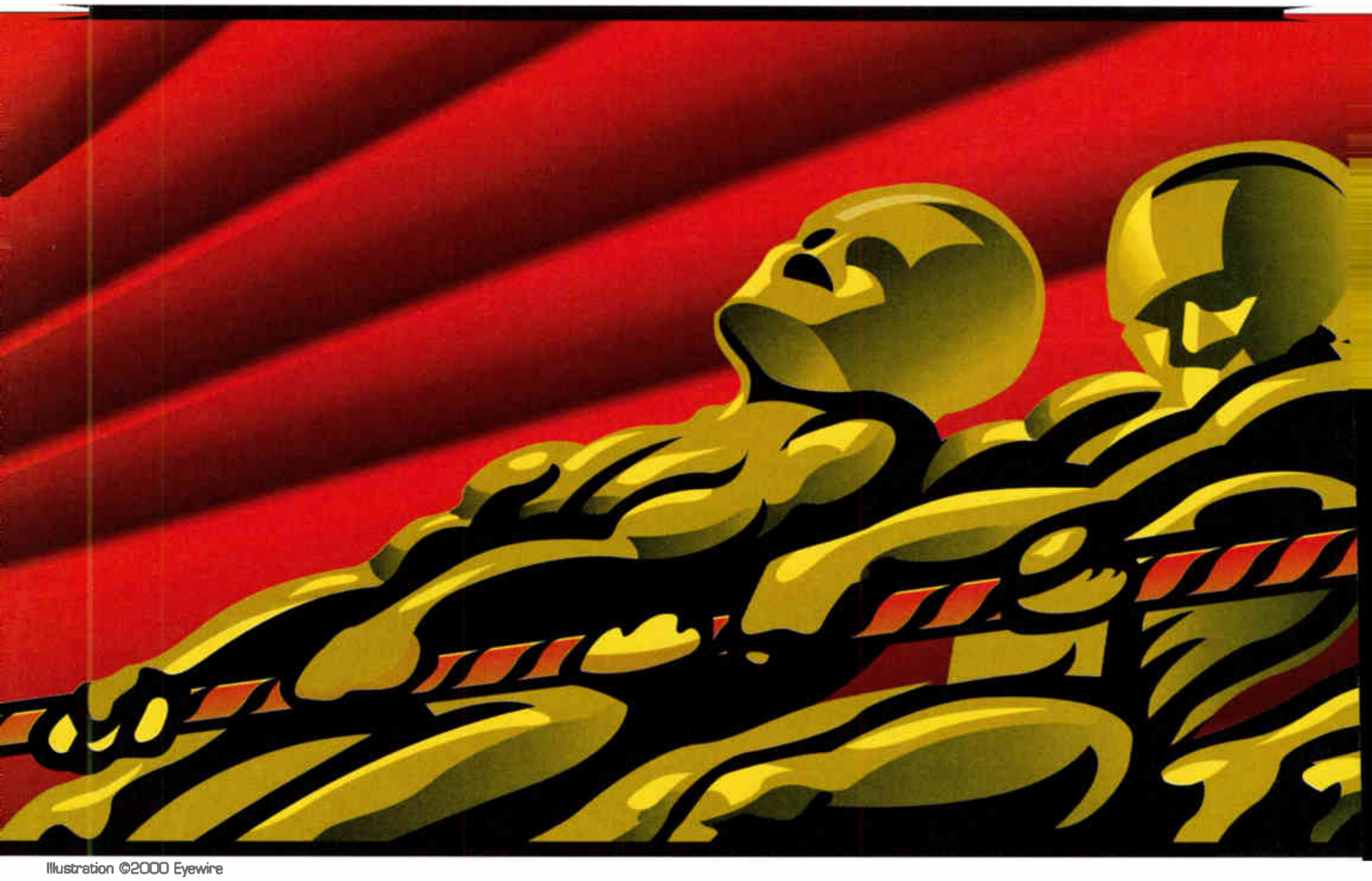


Illustration ©2000 Eyewire

> Add Local Ads To Digital Channels

Digital program transport streams insertion (TSI), also known as Moving Picture Experts Group (MPEG) splicing, digital program insertion and digital-into-digital, gives you the ability to insert local ads into channels carried on digital cable.

TSI works as an extension of existing digital ad insertion systems. Insertion into digital networks becomes transparent in operations that use video server-based insertion systems to insert into analog channels.

Key equipment for TSI may already be present in your system. It requires two components at the headend: An ad inserter and a transport stream remultiplexer. In many cases, the remultiplexer is already installed and functioning as a channel grooming device. Enabling the remultiplexer to function as an ad insertion switch requires only a software upgrade.

TSI functions much like digital-into-analog ad insertion systems. However, for TSI configurations, the remultiplexer takes the place of the video switch, and ads are delivered as digital video broadcast/asynchronous serial interface (DVB/ASI) instead of composite video.

While a digital cue tone specification (DVS 253) has been evolved and approved by the Society of Cable Telecommunications Engineers, it has not yet been implemented by any of the major encoder manufacturers. This means that feeds such as Headend In The Sky (HITS) arrive at the local headends with no cue information whatsoever.

Analog cues still can be used with this system, and to date, every insertion system installed has used analog cues to get the job done. Some digital networks such as ESPN NEWS and ESPN Classic Sports have analog cues embedded within their signals. These cues are separated out by the receiver and forwarded to the ad inserter directly. CT

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Did this article help you? Let us know your thoughts. Send an e-mail to jwhalen@phillips.com.

> Case study: Cox Communications Phoenix

The majority of the top 25 U.S. cable markets see revenues of more than $25 million from local ad insertion. The robust advertising programs in these markets will likely be the first to launch digital transport streams insertion (TSI), following on the obvious trend of digital service roll-outs to large and demographically diverse populations of subscribers. Since December 1999, Cox's Phoenix system, in partnership with ESPN and SeaChange International, has been testing TSI insertions alongside analog.

Cox's existing SeaChange Spot Moving Picture Experts Group (MPEG)-2 ad insertion system, originally installed for insertions into analog channels, is integrated with a Terayon CherryPicker 7000 for insertions into a direct satellite-to-headend digital video broadcast (DVB) feed of ESPN NEWS, which includes cue tones to automatically signal the switch. Here, Cox has deployed Scientific Atlanta's Explorer digital set-top box. Just behind the addition of a substantial digital channel line-up and the digital set-top deployments, the operator plans to deploy TSI in its normal course of advertising business by early summer.

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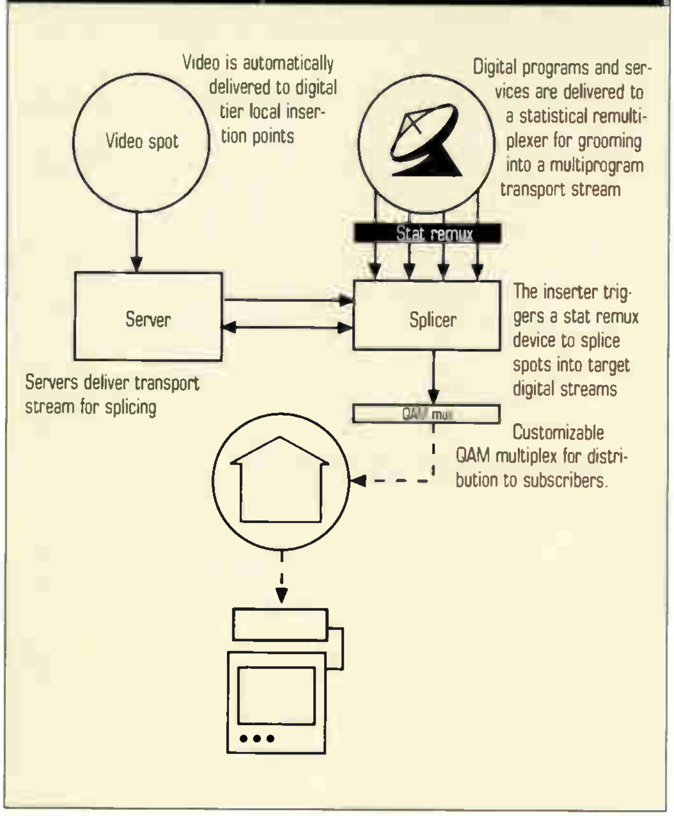
FIGURE 1 VIDEO SERVER-BASED INSERTION



a TSI ad inserter can be connected, and the system is up and running in less than five rack units of space.

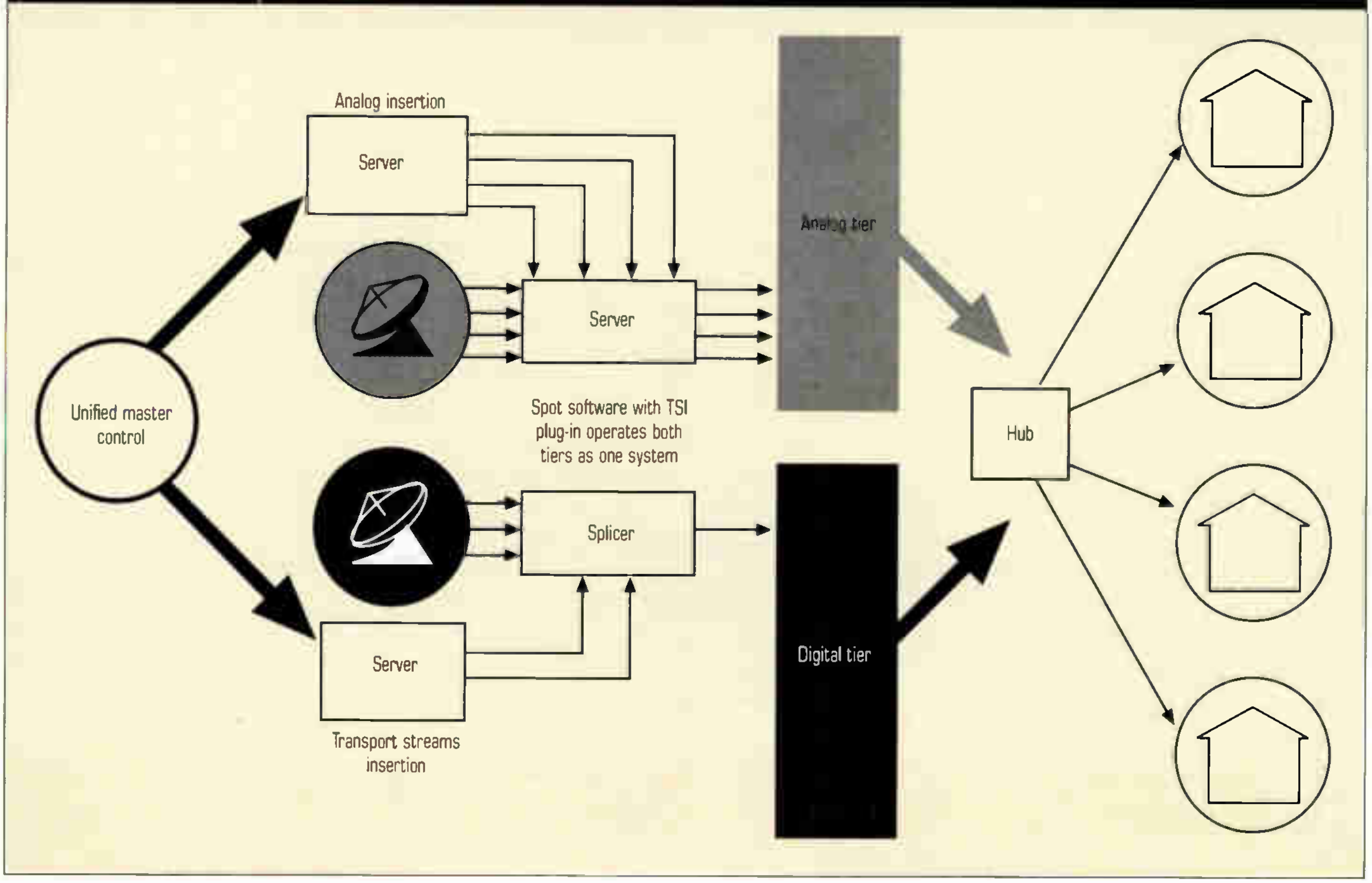
TSI functions in a manner very similar to that of the existing digital-into-analog ad insertion systems. (See Figure 2.) However, for TSI configurations, the remultiplexer takes the place of the video switch, and ads are delivered as digital video broadcast/asynchronous serial interface (DVB/ASI) instead of composite video.

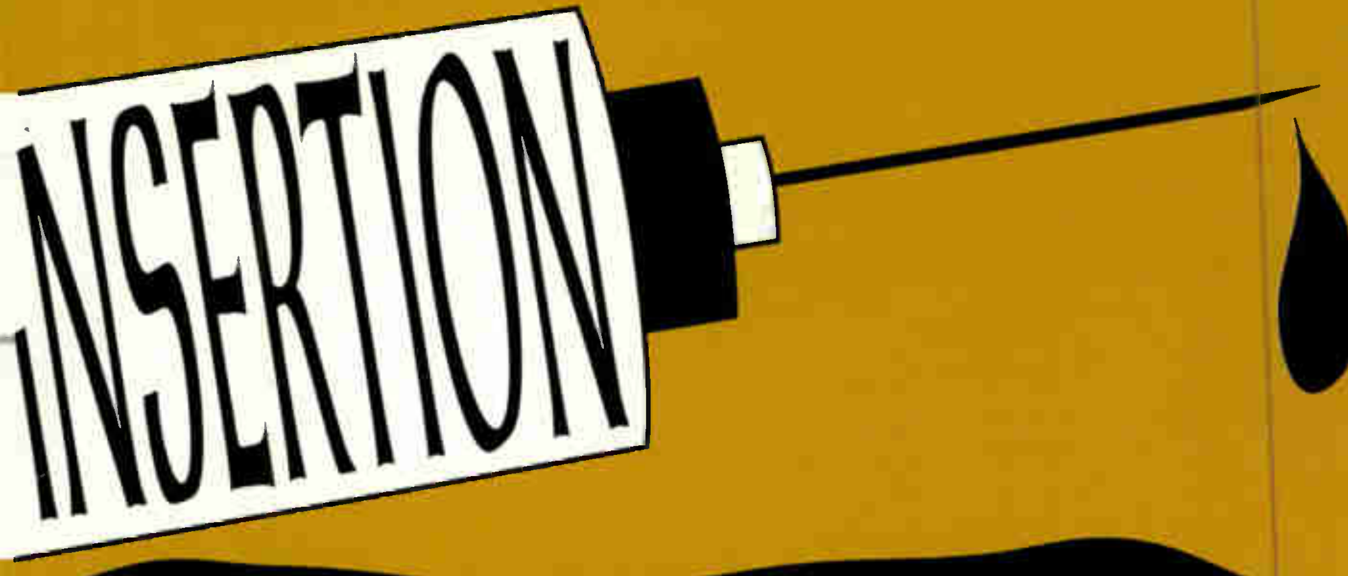
In addition to the DVB/ASI connection, the remultiplexer is connected to the TSI ad server via an Ethernet network for command and control. An industry standard application program interface (API) operates over the Ethernet connection, providing digital cues from the remultiplexer to the inserter and carrying switch commands back from the inserter to the remultiplexer. Video arrives over the DVB connection and is spliced into the digital stream by command of the ad inserter. While this all sounds simple, the work going on inside the ad inserter and the remultiplexer is quite complex. The task is akin to unwrapping a present under the Christmas tree, sticking in a larger present, and then rewrapping it with the same paper—without anyone noticing and leaving no clues.

Final hurdles: network cue tones

There is still work that remains to be done to enable cable to take full advantage of TSI, with improvement in the current cue tone system being the most urgent. >

FIGURE 2 MPEG SPLICING





It's Not Just for Ads Any More

By R. James Kelso

The ability to insert local ads into channels carried almost entirely on digital cable, such as ESPN NEWS and ESPN Classic Sports, presents a major advance toward adding new advertising revenue streams to the local analog cable ad insertion business, as well as powerful motivation for getting those digital channels into the local line-ups. Digital program transport streams insertion (TSI), also known as Moving Picture Experts Group (MPEG) splicing, digital program insertion and digital-into-digital, has already proven successful in cable system testing in the United States.

This year cable operators will kick off with the capability to drop local video—ads as well as programming—into the cable networks delivered to headends via satellite in single or multiplexed program transport streams and on to subscribers via digital cable. This is a tremendous opportunity—not just for marketing messages to high-end customers, but also as TSI is a revenue stream for the local ad business. The development of TSI is every bit as exciting as the widespread arrival of automated multichannel ad insertion was.

TSI goes to work

The opportunities of many new digital cable services, such as digital telephone and cable modems, bear the encumbrances of technical staff training and increased maintenance issues, and exacerbate the land rush that current technology already imposes on cable headends. Conversely, TSI can make its home without excess baggage.

TSI has been implemented by most manufacturers as a seamless extension of existing digital ad insertion systems. From video encoding to scheduling to delivery, insertion into digital networks becomes transparent to cable advertising operations that are already leveraging video server-based insertion systems to insert into analog channels. This means that no operational changes are introduced, and very little additional training is required, for operators who undertake the TSI expansion.

TSI does not significantly expand the headend footprint of an insertion system. In fact, the key equipment for TSI may already be present. TSI requires two components at the headend: An ad inserter and a transport stream remultiplexer. (See Figure 1 on page 212.) In many cases, the remultiplexer is already installed and functioning as a channel grooming device. Enabling the remultiplexer to function as an ad insertion switch requires only a software upgrade. Once this upgrade is complete,

Digital services promise to arrive with gale-force impact on local cable systems, demonstrably with more spending on upgrades than immediate revenue gains. However, the arrival of cable channels with specific demographic appeal presents an opportunity to bolt another booster rocket onto the relatively young $3-billion local advertising industry and help offset the costs of bringing digital home.

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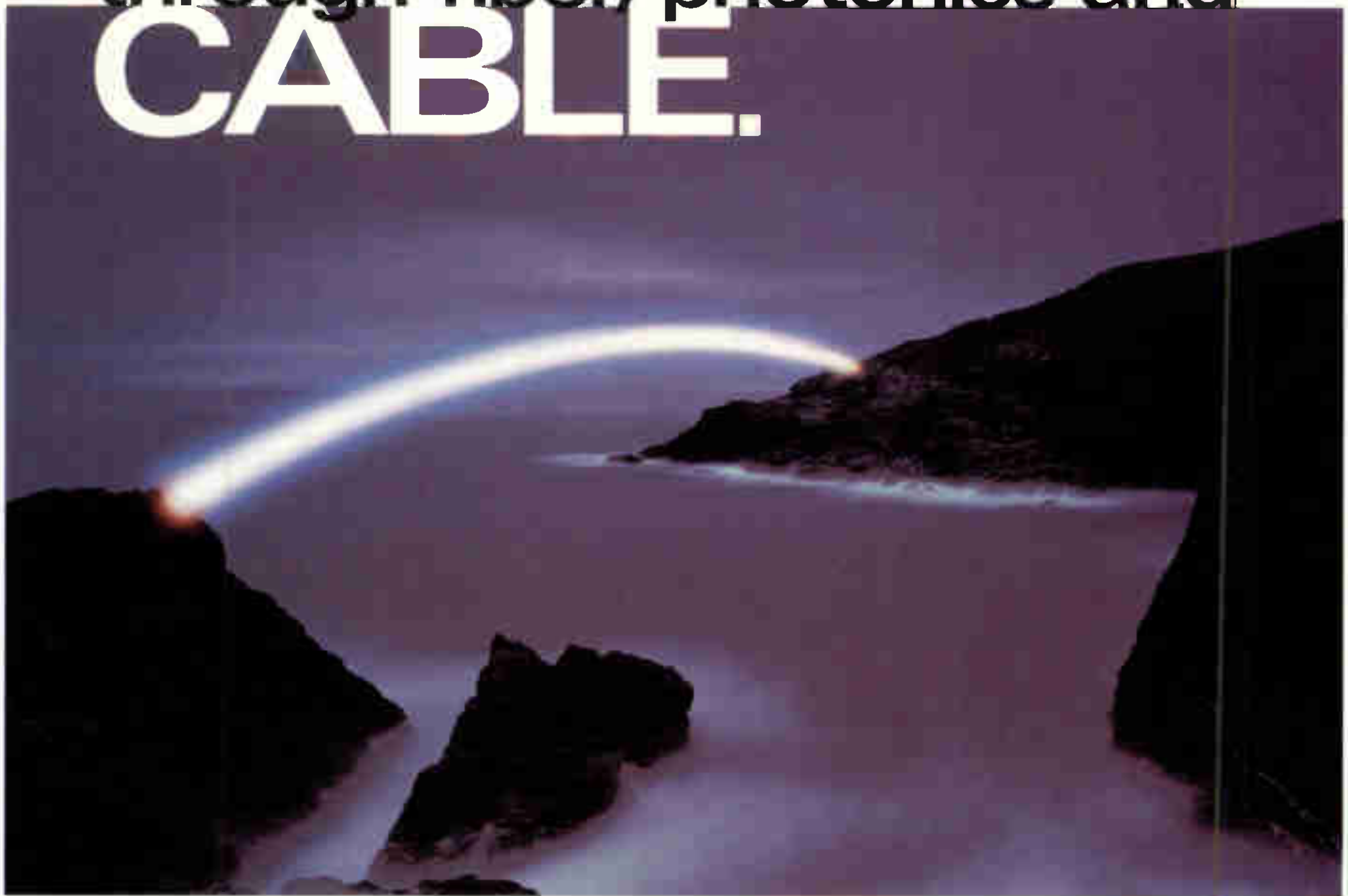

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the same almost across the board, but in different priority orders. What we found was in order to do the OSS right, you couldn't have an end-to-end, one major OSS. What you had to do was allow for modular and flexible kinds of arrangements because a lot of these people are very new in the software world. A lot of them don't provision."

"If cable telephony is to take off, consumers must recognize the technology's benefits."

General Instrument's NETsentry management system will integrate with Lucent's CableConnect OSS, enabling cable operators to use the combined network management systems to provision, manage and monitor the end-to-end network. Lucent also is working with Mobile Data Solutions Inc. to integrate workforce management capability into the CableConnect OSS.

"Something that most people haven't really gotten their arms around is the looming IP address provisioning and management crisis with the proliferation of these IP addresses," Nye says. "That's done with the QIP we announced at the Western show."

QIP Broadband Services is an IP address management platform marketed toward service providers, including cable operators, CLECs, long distance carriers, and Internet service providers (ISPs) who need to assign and track subscribers' IP addresses. The platform combines Lucent's dynamic host configuration protocol (DHCP) server with an integrated management suite enabling network administrators to match and track a subscriber's user profile with IP address information.

QIP Broadband Services is available now and has a list price starting at $3 per IP address in 1,000-user configurations and $0.25 per IP address in 1 million-user configurations.

The acquisition of 60-employee DeltaKabel gives Lucent suppliers of both proprietary and standards-based cable modems and CMTSs. DeltaKabel's products include telephony-enabled cable modem systems that connect to telephones and computers.

Where does that leave us?

If cable telephony is to take off, consumers must recognize the technology's benefits. Arris Interactive sums up those differences as capacity, quality and reliability, and competition.

Capacity: Cable telephony travels on an HFC network that not only offers telephone and cable TV service, but many other broadband applications.

Quality and reliability: All of this is now available with a reliability equal to current telephone service.

Competition: Competition is a major driver behind this technology. Until recently, people had no choice in their local telephone service. Now, those same customers have other options, and history has proven that competition lowers the cost to the consumer. Also, an HFC network is less expensive for the operator to run than the traditional copper wiring systems of the telephone world.

Why miss out on the potential revenues to be generated from cable telephony? Vendors are working hard to upgrade their products to support both circuit-switched and IP approaches as well as increase the capacity and performance of those systems. Maybe there's a solution that's right for you. CT

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Did this article help you? Let us know your thoughts. Send an e-mail to jwhalen@phillips.com.

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cable operators are not able to take advantage of this theoretical benefit."

Lucent rolls on

Since announcing its CableConnect product at NCTA in Chicago last June, Murray Hill, N.J.-based Lucent Technologies has been trying to build on its momentum.

At the Western Cable Show in Los Angeles in December, Lucent announced IP Telephony in a Box and CableConnect operational support system (OSS) solutions, including QIP broadband and network care broadband services. Then in March, Lucent acquired DeltaKabel, a cable modem and IP telephony systems developer which has about 22 percent share of the Netherlands market.

"We are very happy with the number of solutions we have and the kind of backbone products and edge products we can offer, as well as the IP telephony," says Rosemarie "Dee Dee" Nye, general manager and vice president of Lucent's cable communications group.

IP Telephony in a Box leverages Lucent's similar preconfigured, rapid deployment products, such as its Central Office in a Box, and is targeted to cable operators that are expanding or upgrading their networks but have limited space for new equipment in existing headends. It uses a standard concrete controlled environment cabinet that Lucent can preconfigure with the exact equipment a cable operator needs for the services they plan to deploy in that area, including IP switches and routers, CMTSs and synchronous optical network (SONET) equipment.

The key to IP Telephony in a Box is the PathStar access server compact data shelf. Geared for cable environments, the compact data shelf delivers the same features of the data shelf contained in the larger PathStar access server, but from a rack-mounted 19-inch shelf. Up to three of these shelves can be mounted in a cable operator's standard seven-foot rack. As service demand grows in that area, a single PathStar shelf will be able to grow from one cable telephone line to more than 10,000 lines.

The CableConnect OSS is a full network operations support solution that supports cable operators who expand their service offerings from only video to voice, video and data. The software provides billing for integrated services, flow-through provisioning, and fault management and trouble isolation. It also is designed to comply with PacketCable requirements to ensure interoperability in multivendor environments. The CableConnect OSS is modular, so cable operators can add new systems and functionality over time.

That modularity was essential, Nye says, after Lucent analyzed the results of more than 160 interviews about requirements for what's needed from the OSS technology.

"The No. 1 item was the same on everybody's list—provisioning and billing," Nye says. "Nos. 2 to 5 were


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As for what's coming up in cable telephony, Schorsch says that depends on the faith of the public.

"There's a lot of skepticism around whether these things are really ready for prime time in the packet world," Schorsch says. "I think you're going to see more trials and more customer references saying, 'This thing is here, and it's real.'"

While phone companies might have trouble reworking their switch technology to accommodate new technology, cable companies have nothing to lose by deploying this technology right away, Schorsch says.

"Those people that are going to wait and see more are going to be the incumbent telephone companies," Schorsch says. "They can't just run out and buy this thing that just came out yesterday and stick it on their network. They've got a huge embedded investment in telephony switches.

"You're going to see CLECs (competitive local exchange carriers) and other companies starting out saying it makes no sense to build a network with TDM switches when you're going to have a lot of data as the primary force driving your traffic. You're going to stick everything on one network, and it's not going to be circuit-switched—it's going to be a data network with voice on it."

Tellabs gets denser

Realizing that scalability is critical for cable telephony, Tellabs has recently released an upgrade to its Cablespan 2300 Universal Telephony Distribution system, increasing its density by nearly 500 percent.

The upgrade, Feature Package 4.0, lets broadband service providers support nearly 4,000 voice lines from the same HDT, giving Tellabs the industry's highest available density, says Tom Ruvarac.

"This puts Tellabs in the forefront of HFC telephony," Ruvarac says. "It is the most highly dense system that is out there at this point in time. When you compare that to traditional circuit-switching systems, I believe we're about eight times as dense as traditional telephony switches."

The feature package enables the Cablespan system to support 7,920 voice lines from one seven-foot rack within the customer's headend. It also has enhanced alarm and traffic monitoring capabilities that alert service providers when the network is approaching capacity. In addition, Ruvarac says Tellabs' EXPRESS/path feature allows service providers to offer data services up to 30 times faster than analog modems without using additional RF spectrum.

The feature package is compatible with the Cablespan Element Management System, which has a graphical user interface (GUI) to let operators remotely diagnose service failures at the subscriber site, thus often eliminating the need for truck rolls.

Ruvarac says plans are in the works eventually to cram enough capacity for 12,000 lines into a seven-foot rack, but that's down the road a ways.

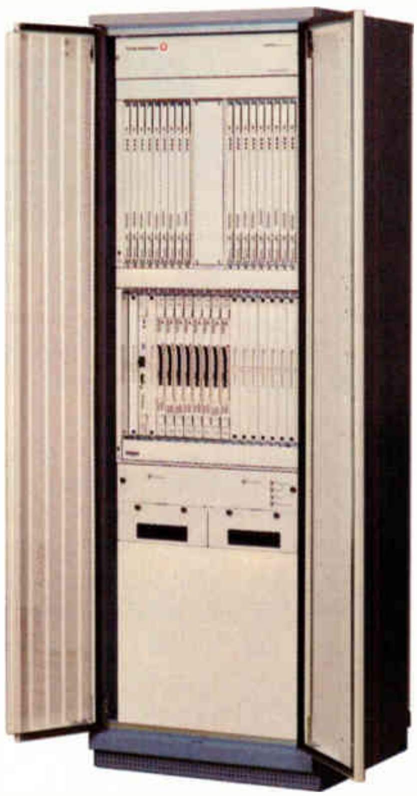
"The density may increase over time, Ruvarac says. "But I think for now, we're at a level where companies that want to do large roll-outs like AT&T see an advantage in the Cablespan system in that they're going to use up less floor space to serve the number of customers they want to serve. Now it's going to be some time as they build out their systems and get penetration of subscribers before they're going to be begging for more density in the system."

Ruvarac says Tellabs has 150,000 revenue-generating lines installed on the Cablespan system. Enough Cablespan equipment has been deployed to support up to 7 million customers worldwide. The system is suited for the deployment of telephone and data services to residential and small-business customers.

Two major Cablespan customers are MediaOne and its parent, AT&T. In January, MediaOne launched digital telephone service in six New Hampshire communities over its HFC network using Cablespan. MediaOne plans eventually to offer local telephone service to more than a million households in New England using Cablespan.

Then in March, Tellabs signed a contract to become an approved vendor and participant in AT&T Broadband's HFC broadband network buildout. AT&T Broadband will use Cablespan to leverage existing HFC networks to provide residential consumers and business customers integrated telephony, data and video services.

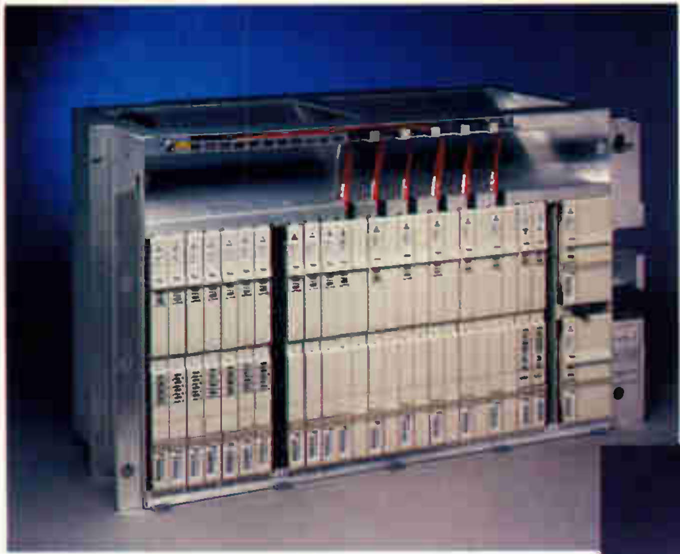
AT&T, which has worked with Tellabs for more than two years, began deploying Cablespan in the fourth quarter of 1999 in the Portland, Ore. area.



Lucent's PathStar for IP telephony.

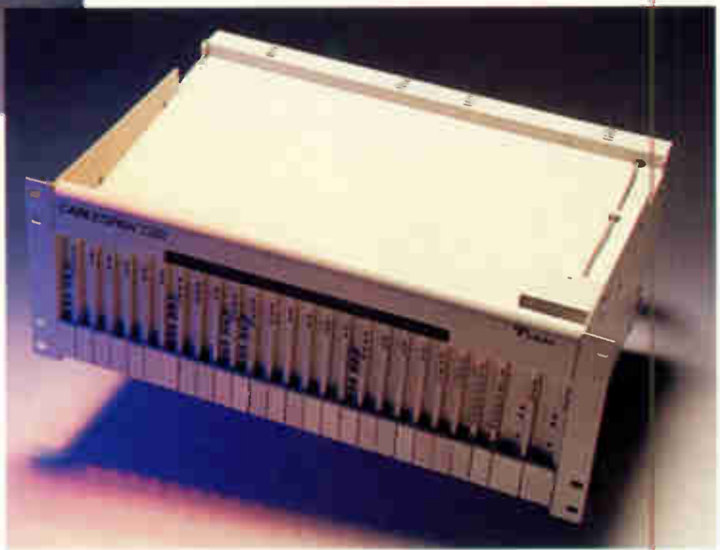
As for how Cablespan stacks up against technology from Tellabs' main competitor ADC Telecommunications, Ruvarac acknowledges that ADC's OFDN technology has some advantages, but says it isn't practical to deploy today.

"OFDN theoretically provides more density per megahertz of bandwidth," Ruvarac says. "The requirements to get to that level are so stringent that many



Left: ADC's Homeworx Host Digital Terminal

Below: Tellabs' Cablespan



"That's a real caveat because as we all know today, in general, IP does not have the same level of services going across the network," Horton says. "You can duplicate many of the CLASS services internally in your network if you're treating it as a (virtual private network, or VPN). But once you try to go cross-network and you try to integrate in with the Bell systems and everybody else in the world, there are some standards that are still being worked out."

But Horton says Arris has the ability today in beta formats to show high-quality voice phone calls.

"We're promoting this to our customers who are not trying to implement primary line because it's not quite primary line yet," Horton says, "because you can't put all the CLASS services on it if you're going cross-network. It's a services issue, not an equipment issue."

The module provides a strong migration story for existing Cornerstone HDT groups, Horton says.

"I have a saying that really fits our industry," Horton says. "'Let's not make our subscribers fit our network; let's make our network fit our subscribers.' This is really what this does. You can meet your subscriber needs and protect your investment in the network."

Telcordia touts Call Agent

The main cable telephony offering from Telcordia Technologies (formerly Bellcore) is Call Agent, a circuit-switch replacement.

A local Class 5 switch replacement, Call Agent operates on packet network to deliver voice-over-IP (VoIP) with the same PSTN quality a customer would expect from Bell Atlantic or anywhere else, says Peter Schorsch, Telcordia director of marketing for next generation network solutions.

"The only difference is it's in packets instead of TDM (time division multiplexing)," Schorsch says. "There have been garage-shop VoIP technologies, but they've really never been to the point where you could really say they're 24/7 type of switches. So this is really geared toward evolving from today a VoIP Class 5 switch to probably a multimedia 'fission' manager."

"In a packet world, the architecture's open, such that application program interfaces (APIs) become more real in the industry. I think you'll see the capabilities of a call agent vs. a switch that will provide for multimedia—data, e-commerce—whereas a switch wouldn't do that today. It's really controlling all aspects of the network, regardless of the transport layer or the application."

So the Call Agent software acts like a local office "virtual" switch. It supports intelligent call control features and end-to-end signaling for IP gateways using media gateway control protocol (MGCP). The Call Agent also is transport layer independent. It conducts the set-up and tear-down of a call with "look ahead" capabilities, through a Signaling System 7 (SS-7) gateway.

Call Agent is deployed by Groupe Vidéotron, a top cable TV operator in Quebec, with 1.5 million subscribers.

"They have several hundred live customers up in the Montreal area using Call Agent to provide VoIP over HFC," Schorsch says.

The software provides full SS-7 connectivity, allowing service providers, such as Groupe Vidéotron, to connect with existing PSTN service control points and SS-7 trunks. The software provides telephony features such as E-911, 411, local number portability, toll-free service and operator service capabilities.

Call Agent is priced on a right-to-use seat per line basis, and that can vary greatly depending on the size of the contract. But typically the cost is between $15-$40 per seat, Schorsch says. >

that it would in a clean plant," Mathews says. "That's why we're coming out with Dual Constellation OFDM in which you can provide either 32-QAM or 4-QAM."

The Homeworx AM Transport System consists of a family of products designed to provide high quality transmission of analog and digital signals over hybrid fiber/coax (HFC) networks. The equipment is available for installation in both indoor and outdoor environments. The Homeworx system has full two-way capability and provides multiple options for carrying different types of upstream signals. The signal feed points in a fiber network serve as interface locations for multiplexing, status monitoring, local origination video and data signals.

ADC has been working on 4-QAM for nine months and expects to begin beta testing this month. This platform enables customers to provide telephony service regardless of the state of their plant.

"If you have a high noise floor, you can get in the business and offer telephony," Mathews says. "But you also get the immunity against impairments that OFDM offers: multipath, group delay, common mode distortion. Now you have a lot of capacity; you're growing your system like most of the MSOs (multiple system operators) out there. You could either add a bunch more headend equipment, or you could convert the system over to 32-QAM."

Mathews says ADC is the first company to offer 4-QAM for improved performance, even better than QPSK on low signal-to-noise ratio (S/N) plant, and extremely high capacity for clean systems.

"You can decide how you want to engineer the network, whether you want to provide a clean upgrade and get a lot of capacity or do an average upgrade and just get telephony up and running," Mathews says. "It finally gets you a one-size-fits-all piece of equipment. Before, you could get the robust product that got low S/N, or you could get the high-capacity system. Now you could get the whole thing in one system."

Mathews considers ADC's main competition for circuit-switched telephony in the United States to come from Nortel Networks and Tellabs.

"They have the QPSK systems, so they will function almost as well as 4-QAM," Mathews says, "but not quite as well in low S/N plant. They don't have the capacity we have. Our product continues to evolve in the circuit-switched world because we really believe that circuit-switched will eventually migrate to IP (Internet protocol) telephony."

However, there are still several technical obstacles hindering the deployment of IP telephony. One of the big hold-ups is the fact that Class 5 switch features such as call waiting, caller ID and transfer/drop are not widely available on IP telephony, Mathews says.

"Consumers expect those things," he says. "So the IP telephony side of our product will mostly be focused on trials, while the circuit-switched side will be focused on actual deployment."

Arris debuts IP module

Arris Interactive has been lying low in the cable telephony space since last June, when it announced upgrades to its Cornerstone product line. But the company got back in the news at NCTA this year with the introduction of a new IP migration strategy for Cornerstone.

Arris' Cornerstone system provides telephony and data solutions for transmission over a cable operator's HFC plant. The system consists of a host digital terminal (HDT) or a cable modem termination system (CMTS), located at the cable headend, connected to voice ports or cable modems respectively, located at homes or businesses.

The new product, called the Advanced IP Module, should be ready for the market in the first quarter of 2001.

"This will enable Cornerstone to let an operator take its system into the IP arena so it can have voice and high-speed data on there," says Mike Horton, Arris director of marketing. "This will be a major advancement for the industry, since Cornerstone is the most installed base of any system and has the most potential of any system."

With 20 operators deploying, or planning to deploy, Cornerstone Voice in more than 40 cities, and more than 300,000 lines shipped to date, Arris claims to supply the most widely used cable telephony system in the world. Arris has shipped the Cornerstone CM 100s and CMTS 1000s to more than 38 different sites globally for detailed field evaluations and deployments.

The Cornerstone system allows operators to provide telephone services, including custom calling features, custom local area signaling services (CLASS), screen-based telephony and Centrex, to a subscriber's home or office over an HFC network. The new module will enable Cornerstone operators to take advantage of IP as that technology becomes ready for their subscriber space.

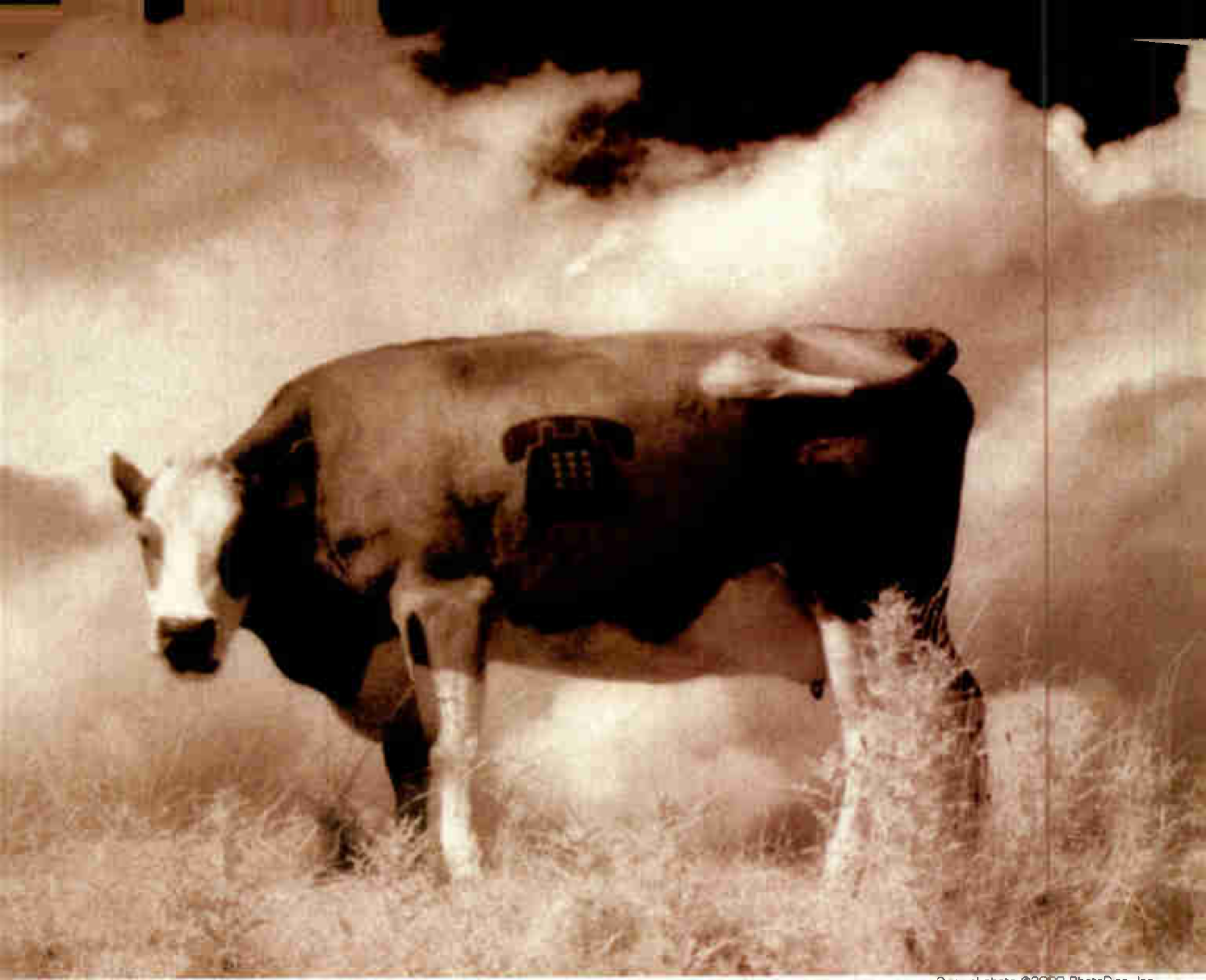
BOTTOMLINE

> Vendors Tout Telephony Enhancements

With an eye toward encouraging cable operators to take the telephony plunge, vendors are adding a variety of enhancements to their platforms.

ADC Telecommunications, Arris Interactive, Lucent Technologies, Telcordia Technologies, and Tellabs are all placing new emphasis on both their circuit-switched and Internet protocol (IP) telephony solutions. Many of the products shown at the National Cable Television Association's Cable 2000 show were more scalable, robust and feature-rich than earlier releases. What's more, some of the circuit-switched leaders are developing a migration strategy for IP telephony.

Wherever you fall in the IP vs. circuit switched debate, it's clear that vendors are convinced that their telephony products are ready for deployment in your hybrid fiber coax (HFC) network today.



Original photo ©2000 PhotoDisc, Inc.

ADC's Homeworx

ADC Telecommunications recently upgraded its Homeworx product, announcing a next-generation platform at the National Cable Television Association's Cable 2000 show in May.

"We call this carrier-class cable telephony," says Ham Mathews, ADC director of marketing. "We provide pretty much the building blocks that allow you to offer carrier-class service. For instance, in terms of reliability, every critical component of our system is redundant. That allows the operator to offer uninterrupted service, whether there's a power outage or a fiber cut."

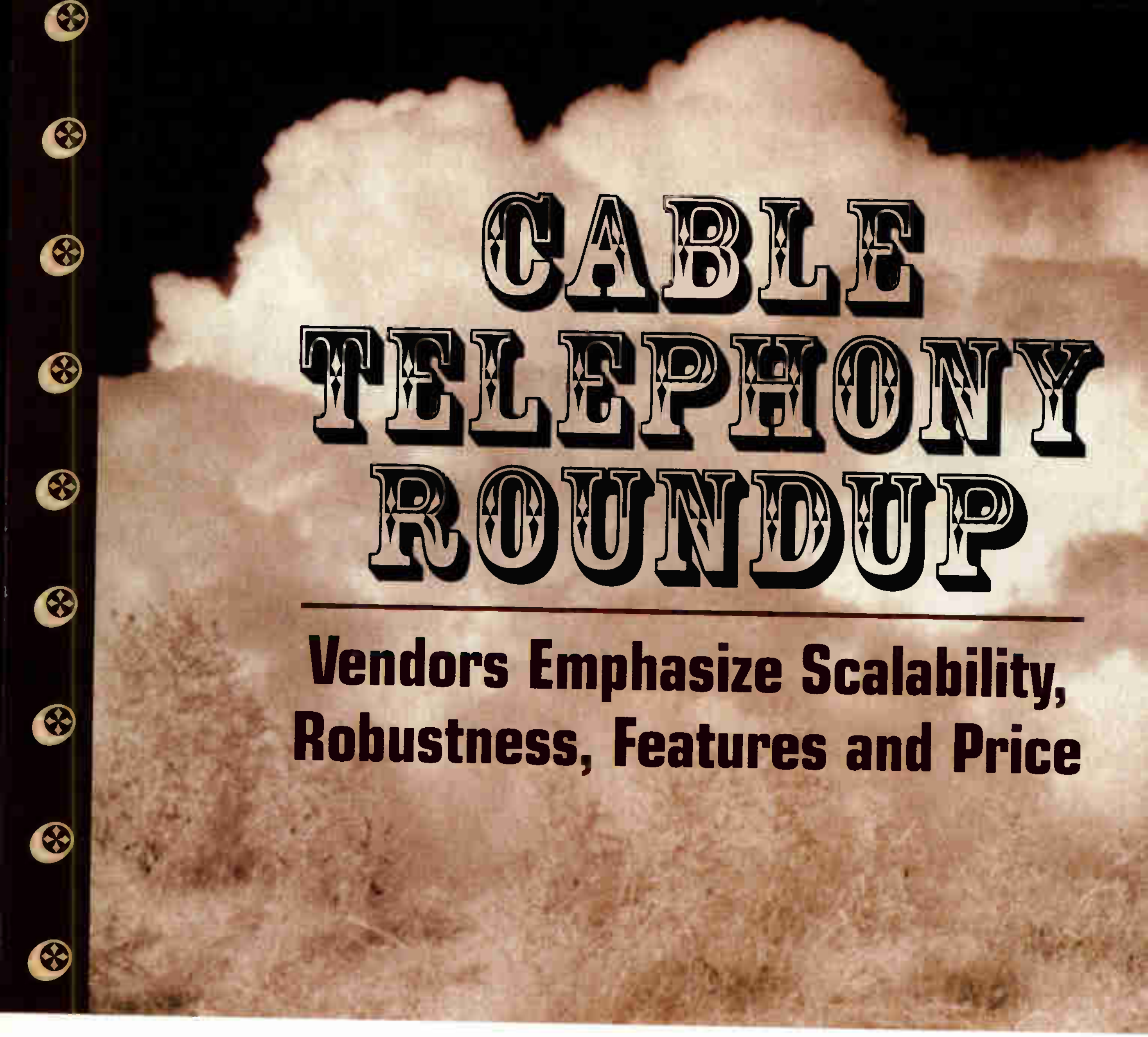
Mathews says primary line service is key to offering telephony that will make subscribers convert from incumbent local exchange carriers (ILECs) to cable. The second part of the hook is deployment flexibility.

"Homeworx is based on orthogonal frequency division multiplexing (OFDM)," Mathews says. "The OFDM access scheme allows you to have resistance to quite a few of the common analog impairments. In addition to that, the actual modulation is done using quadrature amplitude modulation (QAM)-32."

OFDM technology permits 240 digital service level zero (DS0) lines to be carried in each 6-MHz channel. Each digital voice or data subchannel is complex modulated using 32-QAM. This multilevel modulation method maps five bits of information per symbol period, as opposed to the two bits per symbol of quadrature phase shift keying (QPSK).

The resulting information density is nearly four bits/Hz for ADC's OFDM/QAM product. The QAM subcarriers, or tones, are then upconverted to an RF carrier with amplitude modulation (AM) for transmission over the cable plant. A DS0 payload byte is delivered via two tones in the RF channel, which has a total capacity of 480 tones, providing the capability to transmit 240 DS0s within 6 MHz.

"But if you have a plant that has a high noise floor, the 32-QAM modulation doesn't provide all the advantages



CABLE TELEPHONY ROUNDUP

Vendors Emphasize Scalability, Robustness, Features and Price

As cable telephony becomes more real, vendors are racing to get systems to market. Debates still rage over circuit-switched vs. Internet protocol (IP). But it's clear that no matter the platform, products are becoming more scalable, reliable and feature-rich. Let's check the progress of five vendors: Lucent, Telcordia, Arris Interactive, ADC and Tellabs.

tween 18 months and two years. Some of the larger systems required as much as three years.

Once the service is up and running, it can be a challenge switching customers over from their existing service without interruption, especially if the customer wants the same telephone number.

> **"Circuit switches have a rich feature set. IP telephony would need a reasonable set of those services."**
> **—Albert Young, Cox**

"Our biggest problem is in local-number portability," Sharpe reports. "We set up an install time with the customer and try to coordinate with PacBell. But they might turn service off at 10 a.m., and the customer might not have service for a few hours. They might perceive it as a Cox problem."

There is also a challenge as to what areas should be switched on first. Naturally, you want to power up the regions that have the earliest adopters, but it takes market research to determine where those areas are.

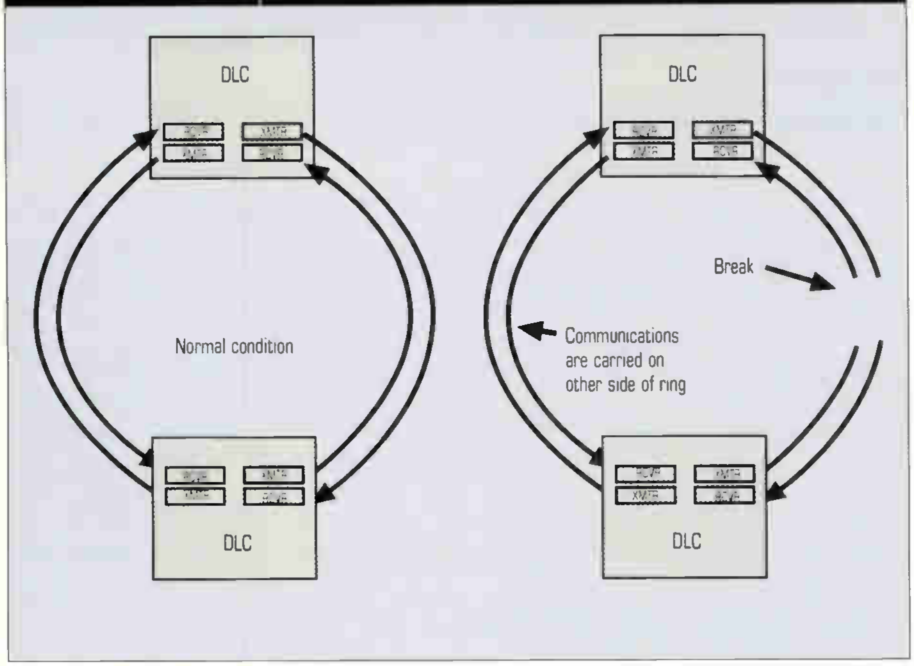
And more to come

Because Cox is hungry for market share, the company is planning an aggressive rollout of telephony service across the country. That means the company will continue to be on the cutting edge of HFC telephony technology for some years to come. CT

Art Cole is contributing editor to "Communications Technology." He can be reached via e-mail at acol602@aol.com.

Did this article help you? Let us know your thoughts. Send an e-mail to jwhalen@phillips.com.

FIGURE 2 | A TWO-FIBER BIOIRECTIONAL RING



try because it would take too long to train cable engineers on the intricacies of telephony.

"You've got to get the right people," says Sheri Sharpe, vice president of new product operations at Cox San Diego. "We hired a switch manager and technicians and a backbone SONET (synchronous optical network) manager and technicians who can work on that type of network. We also needed operations people to work with local portability, 911, 411 and other services."

At the moment, Cox is deploying only time division multiplexing (TDM)-based telephony, not Internet protocol (IP), across all of its systems. Young says Cox most likely will wait a few years to see which vendors and architectures will win out in the IP telephony race.

"There are a lot of IP boxes out there right now, but they don't scale very large," he says. "Circuit switches have a rich feature set. IP telephony would need a reasonable set of those services."

From start to finish, the process of upgrading a typical section of Cox plant to two-way and getting telephony services up and running took be-

> Development of Cornerstone

The Cornerstone telephony system developed by Arris Interactive consists of two main components: the host digital terminal (HDT) and the modem shelf.

The HDT contains an access bandwidth manager that connects to the public switched telephone network (PSTN) switch, and a time interconnect switch, a nonblocking switch that connects individual calls between the trunk side of the plant and the line side. The modem shelf is where the T1 connections are converted to RF and transmitted to cable.

The most innovative aspect of the system is the time interconnect.

"Because we have a time-space switch in the unit, we can serve more than 10 times the number of subscribers than we have actual trunk paths," says Jim Lakin, chief marketing officer at Arris. "It allows operators to spread the cost of telephony service over many subscribers."

For the home, Cornerstone is available in two-, four- and 12-line versions, and the company is close to releasing a 24-line unit for apartments and small businesses.

The company also is working on a double-density HDT, which will cut in half the amount of footprint that each call requires. Current HDTs measure 23 x 24 inches, serving about 7,000 subscribers.

BOTTOM LINE

> Lessons Learned From The Field

Cox Communications is one of the leaders, if not the leader, in the cable telephony market. The company has eight systems up and running with more than 101,000 telephone subscribers.

Although Cox engineers don't characterize their drive to deliver telephony as a struggle, it did require a good amount of technical innovation and plain old-fashioned elbow grease. New architectures had to be put in place, and headends had to be strengthened to protect the new equipment. And the networks had to be made more robust so as to provide highly reliable service.

That latter requirement led to the adoption of "ring-in-ring" architecture, a method of running multiple fibers through each node to provide alternate paths to and from the headend.

But even after the networks and systems are in place, there are still the problems of connecting to the worldwide telephone network and enticing people to switch from the incumbent telephone provider.

With all of these challenges, it's no wonder that Cox engineers went into telephony with their heads up and their eyes open. All that remains to be seen is how much market share the company can amass.

> Connecting to the Outside World

Probably the most complex task in setting up telephony service is getting interconnect agreements in place with the outside world. Most telephone carriers have interconnect agreements in place, and federal law forbids them from striking anticompetitive deals with rival carriers.

However, the deals involve a host of concerns, including pricing and technical issues.

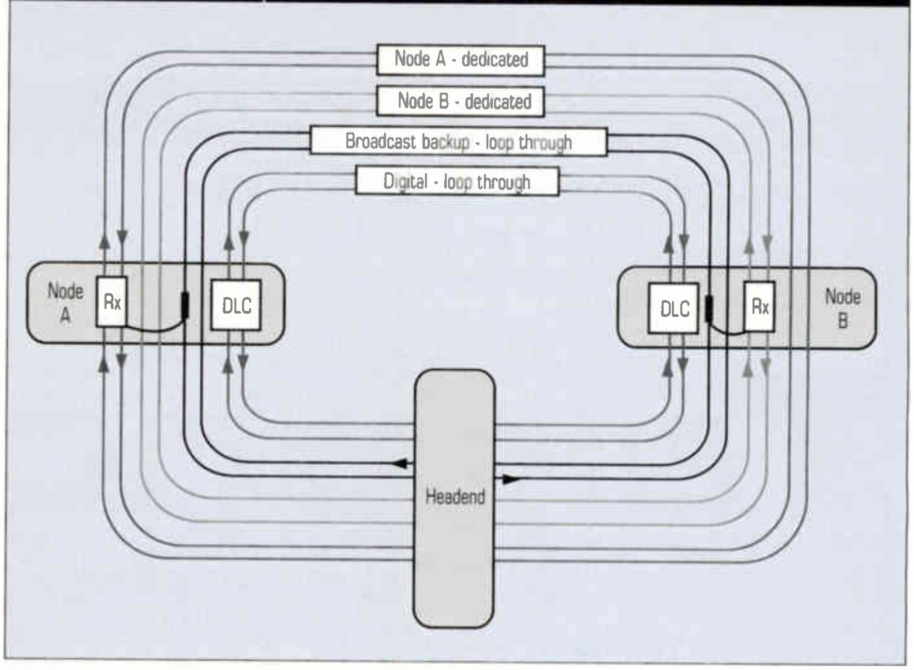
Once the agreements are reached, cable operators must provide a transport facility between the headend switch and the local exchange carrier (LEC) and an interexchange carrier (IXC) if long distance service is provided. Almost all public switched telephone networks (PSTNs) use a packet data network called Signaling System 7 (SS-7), an extremely dynamic standard that has the intelligence to communicate with all circuit switches throughout the world.

A company called IXC controls nearly all SS-7 infrastructure in the United States, so most cable companies will have to purchase access from that company. But according to Albert Young, vice president of engineering for telephony technology at Cox, IXC is very strict as to who gains access. Purchasers must show a high degree of technical know-how and have the financial resources to prove that their telephony service will be reliable.

The only other option is to maintain your own SS-7 signaling. But this requires a lot of experience in switched telephone technology, and few vendors sell the equipment because the market is so limited.

"It's a question of the economic model between running your own (SS-7 network) or buying it from a provider," Young says.

FIGURE 1 TWO-NODE RING-RING SCHEMATIC



"ring-in-ring" architecture while building the network. (See Figure 1.) The style was deployed specifically for telephony because it adds a layer of redundancy, which is vital for reliability in critical communications applications such as lifeline telephony. Simply put, the design calls for dual routes to each fiber node. The nodes are outfitted with duplicate transmitters and receivers and an RF switch. (See Figure 2.)

"We did a little analysis on the investment in those buildings," Young says. "Not only was the equipment investment large in itself, but what would happen if we lost the whole building? How long would it take to get back online? What inconvenience would it be to customers, and what would be our revenue loss?"

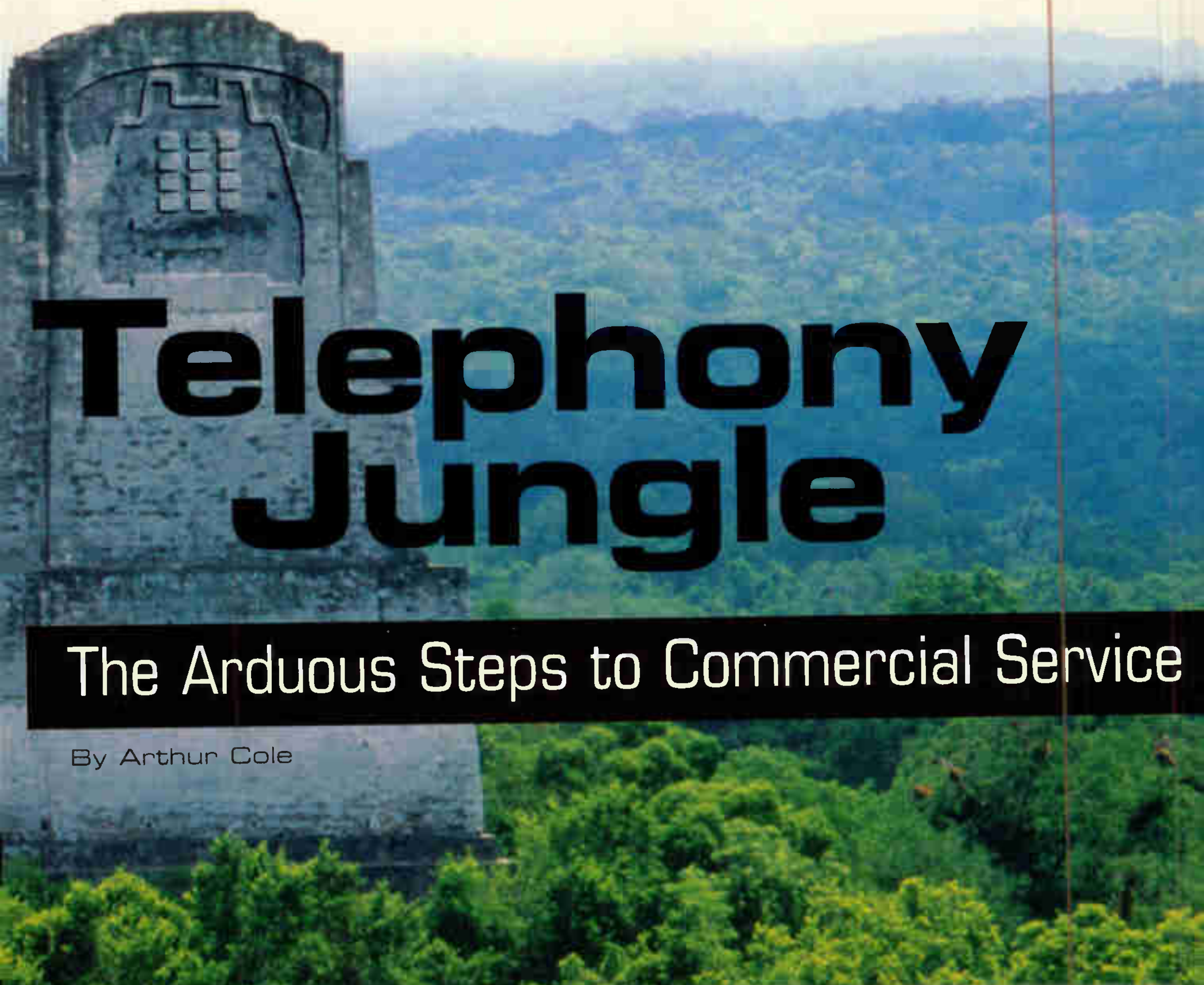
Cox also increased the size of several headends to accommodate the new equipment. Prior to the addition of telephony and modem services, most headends used a single laser to feed multiple hubs and nodes. Now, the company employs one laser per node, which means more space and more power needed at the headend. The result, of course, is greater bandwidth to the customer.

"Our biggest problem is in local-number portability."
—Sherri Sharpe, Cox San Diego

"If you lose one fiber, the RF switch will select another fiber path," Young says. "We put additional sets of fibers in those rings that can be shared among node-serving areas, which can be used for other technologies deployed by fiber."

Changes also had to be made to the headends of each system. Most importantly, the company decided to "harden" the exterior buildings themselves with additional steel and concrete and install state-of-the-art fire suppression equipment.

Then there was the question of finding enough qualified personnel. In many cases, it became necessary to hire additional engineers and technicians away from the telephone indus-



Telephony Jungle

The Arduous Steps to Commercial Service

By Arthur Cole

how it wanted to set up its new digital network and how to provide the most reliable, feature-laden telephone service. It's fairly obvious that any cable company looking to compete with incumbent telephony providers must provide a service that is equal to or better than that of the incumbent. That means a lot of groundwork had to be done to the physical plant and the headends before service could be switched on.

Upgrading the plant

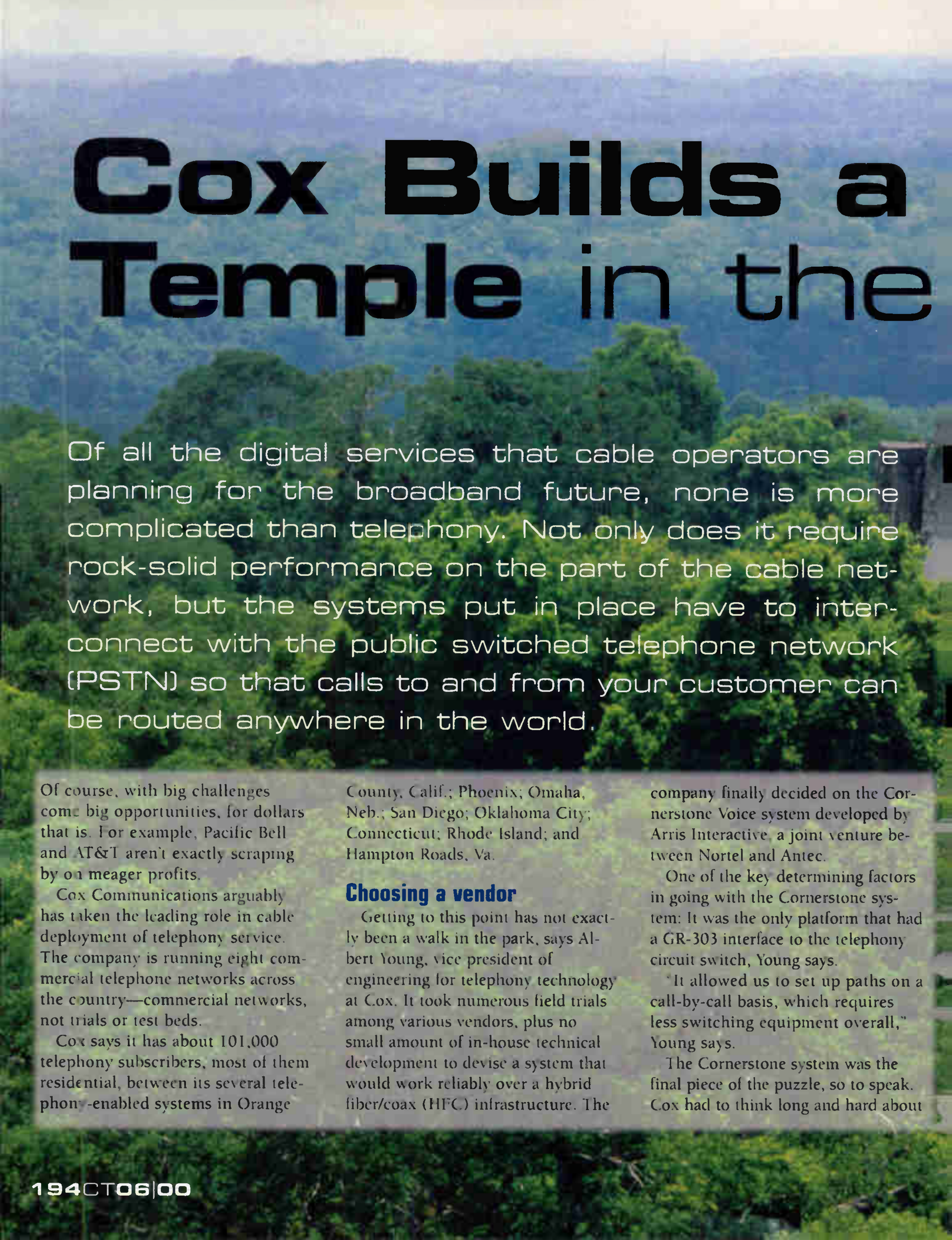
Obviously, the first thing to be done was to convert the one-way cable plant to two-way. That required careful alignment of both the upstream and downstream actives. But because digital signals have their power spread out over the bandwidth of the carrier, the company had to adopt a new approach to calculate power density.

"There's a 6-MHz video channel in traditional cable," Young says. "Now, we use power per hertz, so we can normalize the telephony signals to the video signals to the set-top signals. We come up with an amount of power in each signal per 1 Hz of frequency."

This is important because the new devices in interactive systems—not just telephone, but modems and other gadgets—all have an active RF setting, not a static version as in the video realm. When upstream signals enter the headend, monitoring equipment measures the incoming power levels and can send a downstream signal to adjust that power if need be. For all this to work, Cox engineers had to calculate acceptable power target levels for each type of device in the home.

The power of rings

The company also undertook the innovative adoption of the so-called



Cox Builds a Temple in the

Of all the digital services that cable operators are planning for the broadband future, none is more complicated than telephony. Not only does it require rock-solid performance on the part of the cable network, but the systems put in place have to interconnect with the public switched telephone network (PSTN) so that calls to and from your customer can be routed anywhere in the world.

Of course, with big challenges come big opportunities, for dollars that is. For example, Pacific Bell and AT&T aren't exactly scraping by on meager profits.

Cox Communications arguably has taken the leading role in cable deployment of telephony service. The company is running eight commercial telephone networks across the country—commercial networks, not trials or test beds.

Cox says it has about 101,000 telephony subscribers, most of them residential, between its several telephony-enabled systems in Orange County, Calif.; Phoenix; Omaha, Neb.; San Diego; Oklahoma City; Connecticut; Rhode Island; and Hampton Roads, Va.

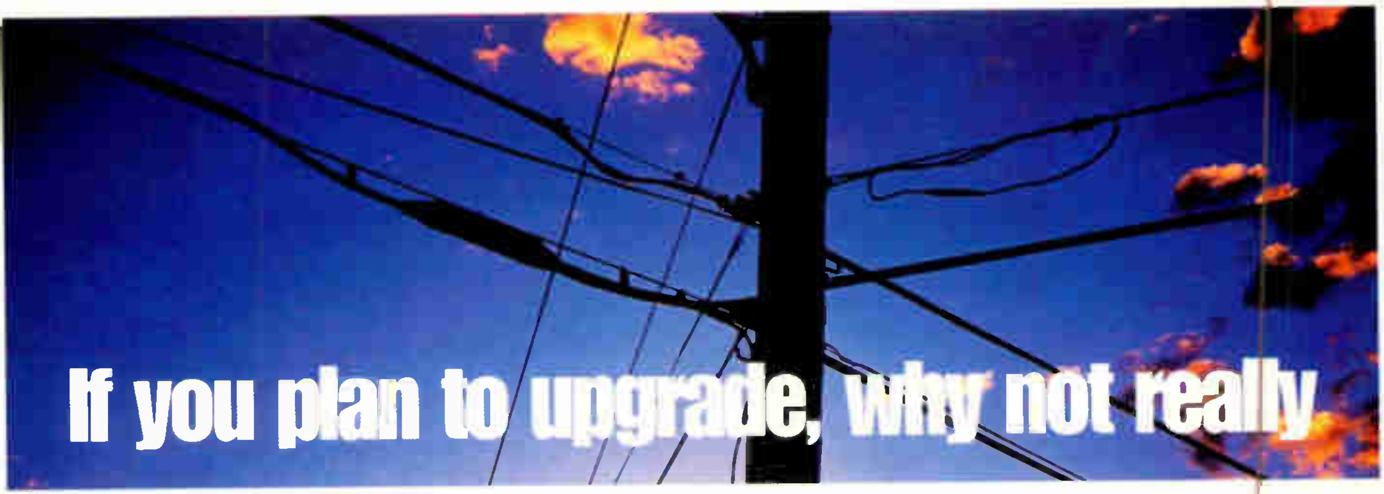
Choosing a vendor

Getting to this point has not exactly been a walk in the park, says Albert Young, vice president of engineering for telephony technology at Cox. It took numerous field trials among various vendors, plus no small amount of in-house technical development to devise a system that would work reliably over a hybrid fiber/coax (HFC) infrastructure. The company finally decided on the Cornerstone Voice system developed by Arris Interactive, a joint venture between Nortel and Antec.

One of the key determining factors in going with the Cornerstone system: It was the only platform that had a GR-303 interface to the telephony circuit switch, Young says.

"It allowed us to set up paths on a call-by-call basis, which requires less switching equipment overall," Young says.

The Cornerstone system was the final piece of the puzzle, so to speak. Cox had to think long and hard about



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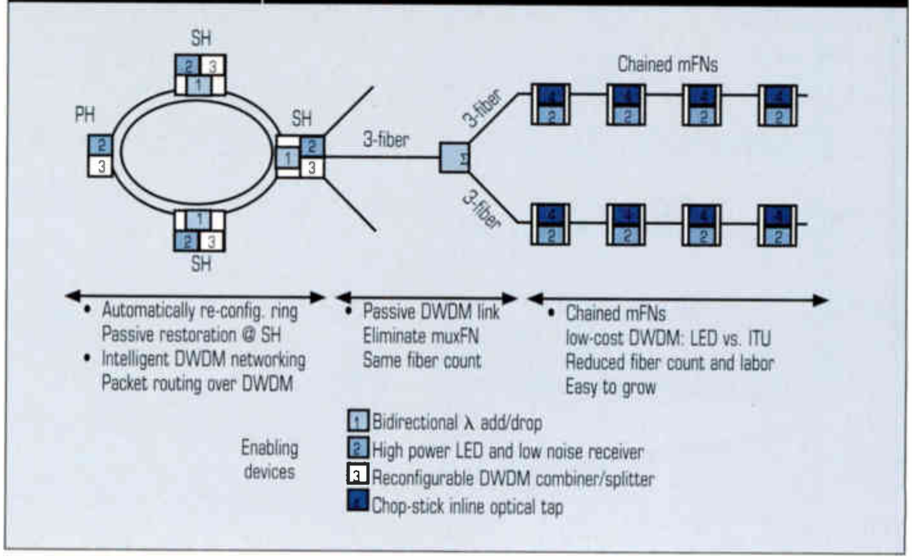
distributed processing approaches provide migration paths for replacing RF links with digital baseband links.

These paths also can be merged to support both the legacy system operation and distributed processing platform. For example, digitized reverse signals can be interleaved with digital baseband signals (information bits) from the distributed processing platform that demodulate the reverse signals from customer premise equipment at the mFN.

Simultaneously, forward digital baseband signals can be received in the mFN, modulated and injected into the forward path.

Any of the digital solutions presented earlier can be modified to eliminate muxNodes. This elimination may bring significant savings in both equipment and labor. Basically, the muxNode components are distributed among mFNs that are daisy-chained with one fiber and have only a single dedicated fiber for broadcast and some narrowcast services.

FIGURE 5 LightWire-II: Making it more passive



Advanced DWDM

The progress in digital technology has been accompanied for the last several years by accelerating progress in passive optical components. These components allow for fiber-optic networking and make DWDM-based passive optical networks practical. These components can be helpful in further simplification of the LightWire architecture and additional cost savings. (See Figure 5.) This new architecture is achieved by deploying new fiber-optic components.

Low-cost and low-loss optical splitters and DWDM filters allow for further simplification of the network, especially when combined with the fact that digital baseband signals allow for significantly larger loss budgets. Moreover, the new components simplify redundancy switching at secondary hubs and allow for moving optical switches to primary hubs.

"The progress in digital technology has been accompanied for the last several years by accelerating progress in passive optical components."

A fiber-rich future

The future of HFC networks for the next two years most likely will lie in digital technology proliferation and in wider deployment of passive optical networks. These two trends will allow for lowering cost of fiber-deep architectures. The digital technology will evolve toward distributed network terminals, and the signals from nodes and mFNs will be transported in their native baseband rates to the locations where muxing, routing and switching provides the most benefits.

Progress in fiber-optic technology is more exciting as it happens in several directions simultaneously. However, this progress will further bring prices down and make the fiber-deep architectures more cost-effective.

The fiber depth in the HFC networks that can be readily upgraded will not increase significantly beyond the penetration proposed in the LightWire architecture. In this case, the coaxial cable already deployed in the feeder section of the HFC plant will be fully leveraged to provide the telecommunications services.

However, in many new network builds and rebuilds where labor in coaxial plant can be exchanged for labor in optical plant, deeper fiber deployment can bring additional benefits of higher reliability, easier manageability of the reverse path, and simplified mFN design.

The time when FTTC or fiber-to-the-home (FTTH) architectures become economically viable alternatives in these areas is within the next decade.

This article originally appeared in the *Proceedings Manual* for the Society of Cable Telecommunications Engineers' 2000 Conference on Emerging Technologies. CT

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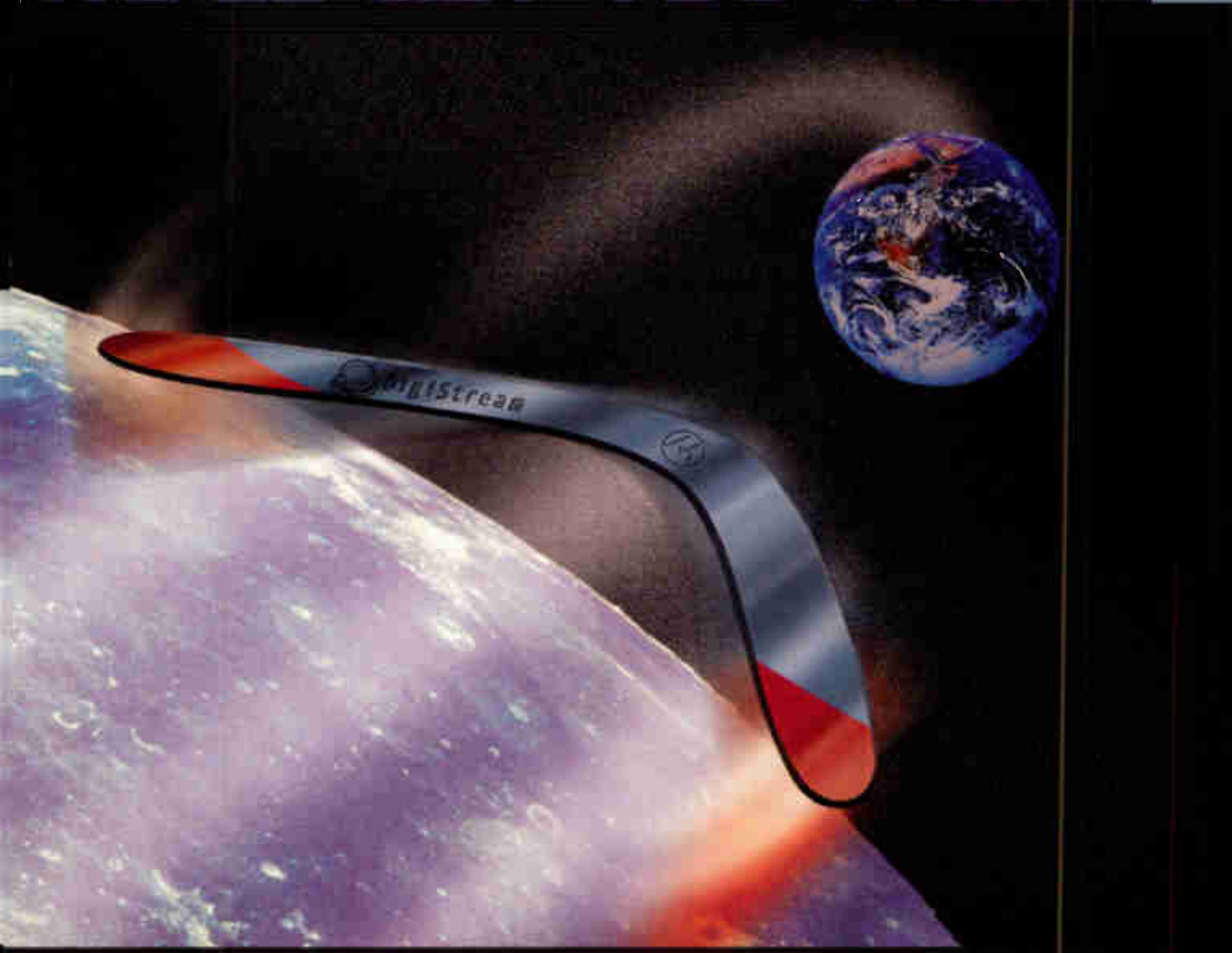

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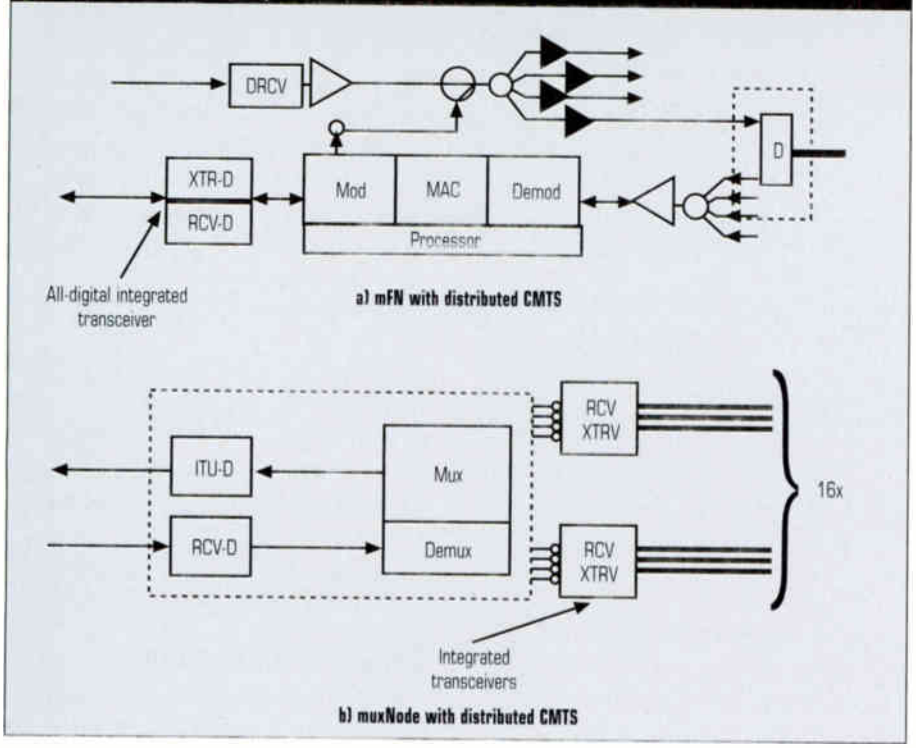
FIGURE 4 LIGHTWIRE WITH DISTRIBUTED PROCESSING



accomplish the following objectives.

- Establish a future-proof network
- Reduce operating cost
- Significantly improve network reliability

All these considerations resulted in our defining architectural solutions for HFC networks that capture the ever-changing landscape of service demand and affordability (cost/benefit ratio) of new technological solutions.

What is LightWire?

To resolve those issues and to establish a platform that improves performance of the embedded system, evolves to meet future needs and simplifies operations across the entire network, we at AT&T Broadband proposed a new architecture called LightWire.

In this architecture, mini fiber nodes (mFNs) eliminate all the coax amplifiers. (See Figure 1 on page 188.) Between each mFN and the customers, we use passive coax plant to carry both the current and new services.

We terminate fibers connecting multiple mFNs at the "multiplexing fiber node" (muxNode). The muxNode performs concentration and distribution functions. It "multiplexes" the upstream signals and sends them to the primary hub (PH) through the secondary hubs (SH). It also "demultiplexes" the downstream signals received from the PH-SH fiber trunks and distributes them to mFNs.

It is very important to notice that despite increased fiber penetration from 5 percent (fiber backbone) to 30 percent (LightWire) through the years, the most important portion of the coaxial network, feeder and drops, has been fully utilized in all architectures, and the trunk portion has been used for RF signal transport and for network powering.

LightWire's cost implications

Although there was an incremental cost related to upgrading a system to the fiber-deep architecture (see Figure 2 on page 189), the significant operational savings, cost distribution and declining price trends helped us decide that this architecture was very appealing. For rebuilds and green-field scenarios, the cost comparison will be more advantageous for LightWire.

More than half of these costs were related to the equipment, and most of that was related to the fiber-optic electronics and fiber-optic cable. When we were looking at labor costs, we found that a significant portion was related to fiber placement and fiber splicing, and any simplification greatly affects total cost. Falling prices for fiber-optic electronics and cable also will continue to reduce our total costs.

What will the future bring?

The progress in RF active devices and in optical technology was helped by progress in digital technology. A/D conversion, signal compression, signal processing and advanced modulation techniques allowed for significant advances in increasing bandwidth efficiency.

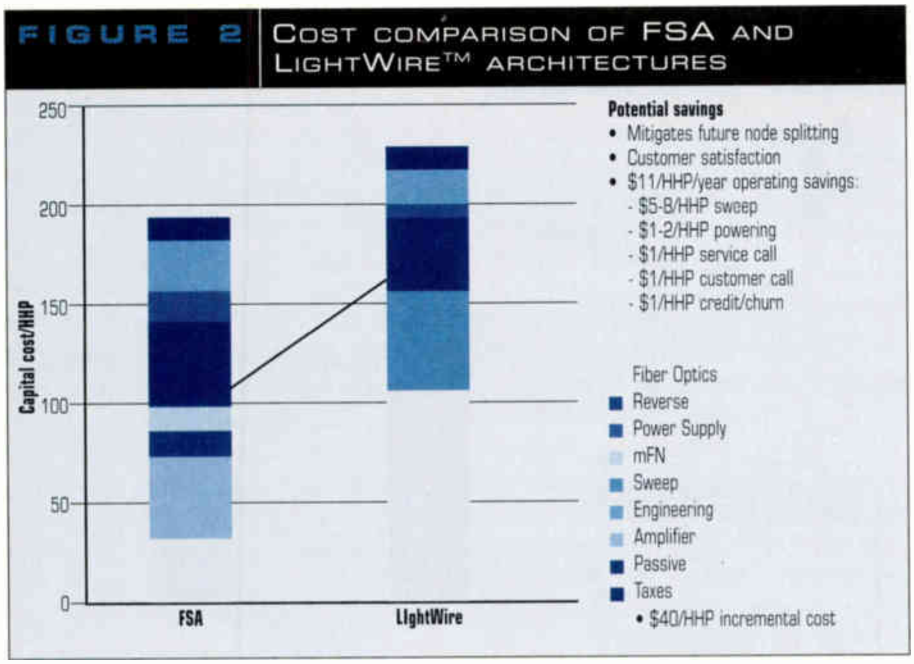
At the same time, the proliferation of digital technology resulted in availability of low cost, high quality A/D converters and TDMs complying with the standard data rate hierarchies. These components are available now, highly integrated and low in cost. These technologies have penetrated the HFC network and can be expected to further expand their presence over the next few years.

Distributed processing

The unique position of each mFN enables considerable simplification in defining media access control (MAC) protocols. Each mFN can do local policing and resolve upstream contention within its serving area without involving other parts of the networks. Therefore, cable modem termination system (CMTS)-like headend equipment can be distributed into the network.

For example (see Figures 3 and 4 on page 189 and above), the RF interface (modulator and demodulator) and MAC functions can be placed at mFNs, and the multiplexing and demultiplexing functions can be placed at the muxNode. This approach further simplifies the transport network, reduces its cost, improves service performance, and enhances network flexibility and scalability.

Depending on the operators' upgrade status and service provisioning, both reverse digitization and



multiplexing (DWDM) technology and its affordability.

Although known and applied in the early '90s, DWDM technology achieved the level of performance required for analog frequency division multiplexing (FDM) distribution systems and became affordable and price-competitive with other technologies used for architectural solutions only in 1997 and 1998.

Fiber's growing role

Engineers optimized the traditional cable TV networks for broadcast signal distribution in a tree-and-branch coaxial architecture (point to multipoint). Under pressure for bandwidth expansion and larger areas served from a single headend, it became apparent that the industry needed some long-reach technology to shorten the cascades and reach remote pockets of subscribers. Engineers achieved this by applying fiber-optic links in the fiber backbone configuration pioneered by ATC (part of today's Time Warner). This technology replaced amplitude modulated link (AML) microwave distribution.

With the requirements for further bandwidth expansion as well as for two-way communication, the coaxial networks with fiber backbone evolved into HFC networks with fiber node segmentation. This topology is deployed today by most operators of HFC networks. The main characteristics of this topology are:

- Node sizes of 600 to 1,200 homes passed
- Nodes segmented into up to four 300-homes-passed buses
- Between four and six fibers from secondary hub to the node
- Between five and eight amplifiers in cascade
- Upstream bandwidth of 5-40 MHz, and downstream of 50-750 MHz

Secondary hub ring

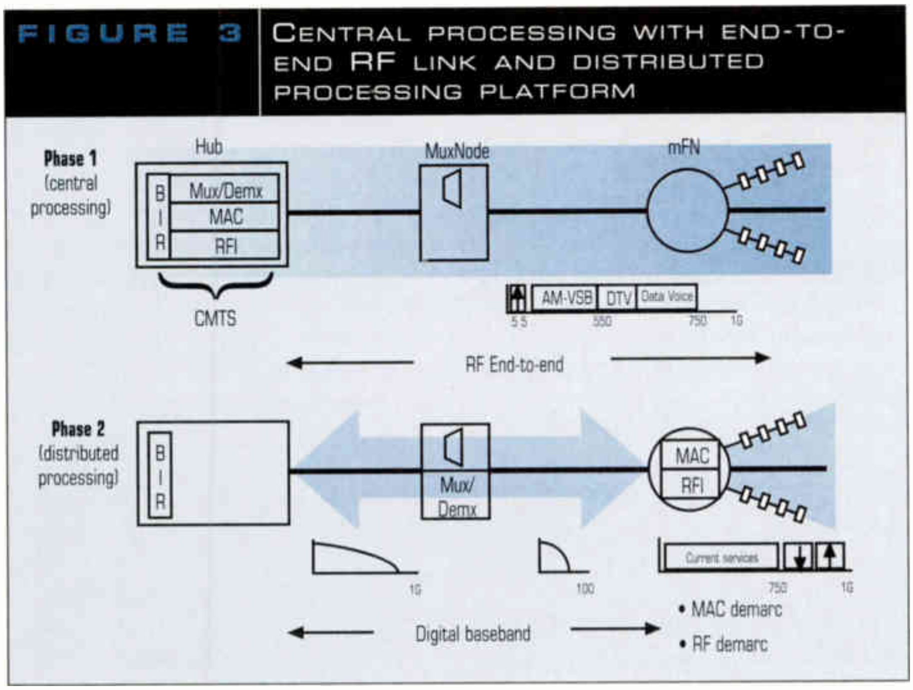
In parallel to segmentation, Rogers introduced a secondary hub concept to provide route redundancy and lower the fiber counts in a single fiber-optic cable route. Since then, secondary hubs have evolved into facilities used for multiplexing of signals in the forward and reverse directions.

Multiplexing technologies range from standard time division multiplexing (TDM) of data streams for target service delivery, through frequency conversion (practical in the reverse direction) and WDM, including DWDM.

TDM can be deployed in different ways: by using data transport systems between primary and secondary hubs for delivery of target service signals or using analog-to-digital (A/D) conversion of the reverse signal and multiplexing them to lower the cost of other technologies and lower the fiber count.

Fiber-deep architectures

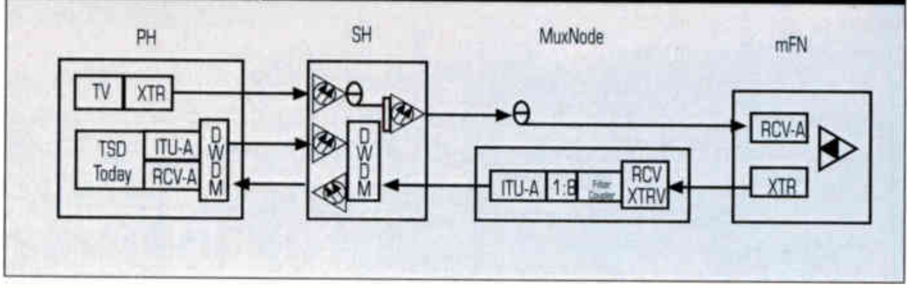
Although cost-competitive in comparison to the upgrades of other access networks to the same level of capacity and performance, upgrading from tree-and-branch coax plant to an HFC network requires significant financial effort from cable operators. Therefore, it is critical that the upgrades



- Dedicated medium (dedicated copper pair): traditional telephony networks
- Shared medium broadband networks: used for one-way broadcast signal distribution

The traditional telephony network began using shared medium in its backbone applications initially and only most recently in its access network. However, these shared-medium access networks have been limited to a handful of fiber-to-the-curb (FTTC) and passive optical network (PON) deployments. The economics of these architectures still are questioned by most network providers.

FIGURE 1 LightWire Architecture



The initial objective of the traditional cable TV network was to provide TV service in areas with limited or no over-the-air broadcast signals. Eventually, other entrepreneurs realized the potential of the coaxial networks and created new programming sources that successfully competed with traditional broadcasters. These new programming networks required additional bandwidth that was delivered by the traditional broadband technologies that evolved from vacuum tube-based actives to silicon-based discrete and hybrid amplifiers.

Forward bandwidth Expansion

To meet the demand for a richer entertainment offering, bandwidth in the coaxial networks has expanded exponentially over the last 35 years, increasing from 200 MHz in the 1960s to 860 MHz today.

This bandwidth expansion was facilitated by the progress in RF active device technology. Although this progress was significant, the technological advances in RF actives alone without changes in coaxial system architectures would not result in matching the increased demand for bandwidth. If not for the fiber-optic transport systems, the expansion of the areas served by the same headend, as well as the increased number of actives per mile of plant, would lead to extremely long cascades of active and passive components (detrimental to the network reliability).

The progress in optical components allowed for the first wide application of this technology in analog frequency division multiplexing (FDM) cable TV systems in late '80s. It was used to shorten amplifier cascades in the optical backbone configuration. Over the years, the performance of the technology improved from:

- Carrier-to-noise ratio (C/N) of 51 dB, composite triple beat (CTB) of -65 dBc, and composite second order (CSO) of -65 dBc for 5-7 dB fiber loss in 1,310 nm window, to
- C/N of 54 dB, CTB of -71 dBc and CSO of -66 dBc for fiber links of 10-13 dB loss in 1,310 or 1,550 nm wavelength windows.

This improvement in reach and performance allowed for feeding small pockets of subscribers and for headend consolidation without performance compromise.

Despite all of these advantages, the deployment of this technology increased significantly only after the growing demand for two-way and interactive services forced a segmentation of the broadcast tree-and-branch architecture into smaller pockets of customers. These customers then shared the same medium and bandwidth in the forward and reverse directions.

Although shortened cascades and smaller failure groups in the coaxial section of the new hybrid fiber/coax (HFC) network improved its reliability, the headend consolidation led to large groups of subscribers being fed by long runs of high-count fiber-optic cables.

Engineers remedied this situation by designing redundant routes and deploying equipment deeply into the network. This requirement for redundancy has been fulfilled by the progress in dense wavelength division

BOTTOMLINE

> It's a Fiber World

The amount of fiber in the hybrid fiber coax (HFC) network has been increasing continuously over the last 12 years from 5 percent in fiber backbone architectures to 30 percent in AT&T Broadband & Internet Service's LightWire architecture. On the other hand, most if not all coaxial cable is being utilized for RF signal distribution to our customers or for powering network components.

This march of the fiber-optic cable deployment is aided by progress in digital and fiber-optic component technologies as well as by declining costs of these technologies. We have chosen to take advantage of these new opportunities.

While the fiber's penetration in system upgrades may not increase much beyond what's been achieved through LightWire, there are opportunities in new builds and rebuilds. If labor in coaxial plant can be exchanged for labor in optical plant, deeper fiber deployment can bring additional benefits of higher reliability, easier manageability of the reverse path, and simplified mini node fiber design. Fiber-to-the-curb (FTTC) or fiber-to-the-home (FTTH) architectures could become economically viable alternatives in these areas within the next decade.

"C" in HFC?

Deep Fiber Reduces Costs

Oleh Sniezko and Xiaolin Lu

The main goal of the upgrades has been to evolve the infrastructure from a broadcast-type tree-and-branch plant to a bidirectional, high-capacity, and reliable network ready to deliver advanced telecommunications services. This type of upgrade would not be possible without fiber-optic technology. Fiber optics enabled engineers to:

- Simplify the architecture by shortening cascades of active and passive components in the coaxial network
- Provide route and equipment redundancy deep into the network
- Provide substantial bandwidth expansion for emerging two-way services

Where we started

Modern telecommunications networks evolved from two different directions: >

How Much "F" &

There is little doubt that the cable TV industry has become a telecommunications industry. However, to support new services, the coaxial networks had to be upgraded to increase their forward bandwidth, improve their reliability and provide two-way capability. Fiber-optic technology has been essential in this transformation and will continue to play an increasingly important role.

for a consortium known as OpenCAS. "We thought it could benefit the industry by a number of vendors getting together and working to create interfaces that increased the level of interoperability, as well as make sure that those interfaces are well targeted for the new services that are rolling out," he says. In particular, DiviCom is exploring video-on-demand (VOD) applications.

Carlucci describes OpenCAS as complementary to OpenCable. In November, OpenCAS submitted a set of open cable standards to the SCTE. The OpenCAS specifications are based on DVB SimulCrypt technology, but modified for North America.

In that light, DiviCom's partnerships in the interops make sense. For instance, Mindport's Director of Marketing Joe Zaller says his company helped create SimulCrypt, even contributing key intellectual property.

"We consider ourselves an open systems player," says Henry Walton, NagraVision's vice president for marketing in North America. "So anyone who operates in the DVB space, we can plug and play with those providers."

"We are working with DiviCom because they are the perfect partner," says SCM's Vantalone. "They are providing something open to everybody on the headend, and we are providing a module platform open to everybody on the client side."

Down to the wire—And beyond

Only OpenCable participants with digital systems deployed are bound by the July 1 deadline. Absent such deployment, the market entrants can weigh first-mover advantage against technical design goals. "If this module is ready in July, that's OK, but if I need one more month or two more months to finish it, I'd prefer to take the time and hit the market with the right product," says Vantalone.

As for the established players, will they meet the July 1 deadline? As of this writing in April, In-Stat's Paxton expects some big announcements, perhaps to explain partial compliance, at the National Cable Television Association's annual convention in New Orleans in May.

"They can hardly ignore the issue, and that's as good a time as any," he explains.

Others are less skeptical. "PODs have been ordered by all the major MSOs, and hosts are probably going to be ordered pretty soon," says Motorola's Sakuma. Retail availability "just depends on where the first systems are that start supporting the POD-host deployment."

"We'll be there," says S-A's Bagley, who already is looking beyond the July deadline toward the new competitive landscape. "Obviously, there's still a long way to go even once we make it because we'll have minimal functionality to what we've agreed to within the OpenCable process, and so that will have to be built over time."

OpenCable manager Zimmerman also takes a long-range view.

"Certification waves will continue indefinitely for OpenCable, similar to what DOCSIS has done," he explains. "The first two waves will be prior to the July 1 date, but then we'll have another wave beginning in July and a couple more through the year."

In other words, it's just another milestone.

Forrester analyst Rhinelander, the under-whelmed set-top prophet, puts OpenCable in perspective this way: "It's kind of a baby step for the industry, but it's an important baby step." By implication, the cable industry is moving beyond crawling to walking, and may eventually reach running speed. CT

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Did this article help you? Let us know your thoughts. Send an e-mail to jwhalen@phillips.com.

are promising products that enable those new services. Until then, however, the mere presence of new manufacturers is perhaps OpenCable's most striking outcome.

"The markets were enormous as long as you didn't focus on the U.S.," says Zenith's Nowakowski, describing life before OpenCable. Zenith participated in the second interop as a host device manufacturer. Apart from incumbent players S-A and Motorola, other host manufacturers that participated in the interops are Philips, Samsung, Microsoft and Panasonic.

Jeroen Brouwer, product manager for Philips' digital set-top box, says his firm has focused in the interops on ensuring that Philips' set-tops can work with S-A's PowerKEY and Motorola's DigiCypher POD modules. Philips also has its own POD module in the works.

"We have a lot of experience in Europe with digital video broadcasting (DVB) systems, and within DVB you have, of course, the DVB common interface," says Brouwer. "That concept is quite similar to the POD module."

SCM Microsystems, an international provider of conditional access (CA) for digital services, has partnered with Mindport, NagraVision and NDS to provide form factors for their CA technology. "With 90 percent of the European market, we know very well what is a renewable conditional access module," says Luc Vontalone, SCM vice president for worldwide business development.

Mindport's play into this market comes through Irdeto Access, traditionally the R&D lab of parent company MIH, a global pay media operator. NagraVision is a Swiss-based company with more than 11 million digital smart cards in use worldwide. NDS is headquartered in the United Kingdom, where some 15 million viewers of pay TV use its technologies. They all use the DVB open SimulCrypt standard.

> Getting the Gear

For more information on point of deployment (POD) modules, contact the following manufacturers:

Motorola
(215) 323-1492
www.motorola.com

Mindport
(858) 618-4878
www.mindportusa.com

NagraVision
(310) 967-7770
www.nagra.com

Scientific-Atlanta
(770) 236-5866
www.sciatl.com

NDS
(949) 725-2500
www.ndsworld.com.

SCM Microsytems
(408) 370-4888
www.scmmicro.com

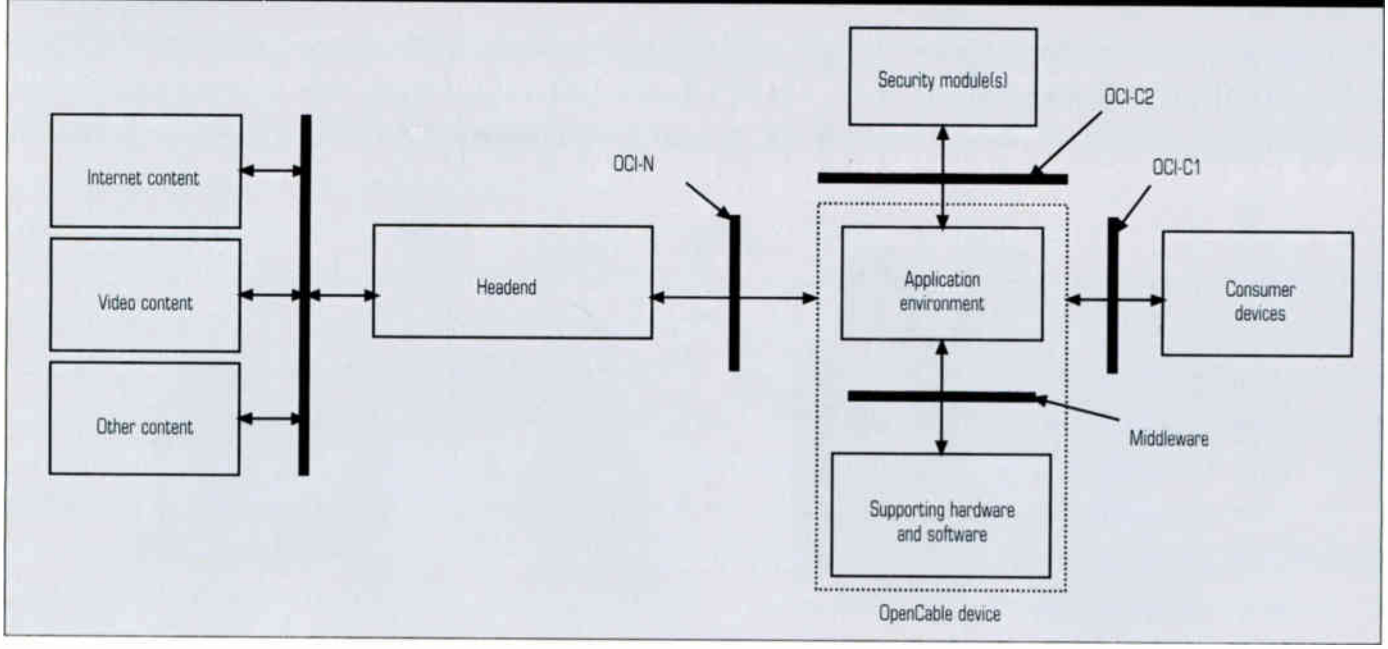
Headend maneuvers

While Motorola and S-A are developing complete CA systems, including POD module and headend solution, Mindport, NagraVision and NDS are taking another approach. In the interops, they have demonstrated CA via a common interface on a DiviCom (soon to become part of Harmonic) headend.

DiviCom is a leading advocate for open CA at the headend. In December in Jacksonville, Fla., MediaOne launched the first U.S. open cable platform, using DiviCom digital headends, Philips set-tops and Canal+ middleware. The open-access architecture allows operators to mix and match components and potentially deliver more innovative services.

John Carlucci, a principal engineer for DiviCom, says that the Jacksonville project became the seed

FIGURE 1 OpenCable architecture



im specifications for hardware elements. The middleware solution will be released in OpenCable's second phase, during the second half of this year.

The interim specs include unidirectional functional requirements, bidirectional functional requirements, unidirectional terminal requirements, OpenCable network interface (OCI-N) and host POD module interface (OCI-C2). The interface between host and digital consumer device (OCI-C1) is referenced in the functional requirements and defined according to DVS194, a Society of Cable Telecommunications Engineers standard.

Interops to certification

To date, CableLabs has organized three "interops," where vendors come together to test equipment. The first was in August at CableLabs' headquarters in Louisville, Colo., the second in December in Los Angeles (coinciding with the Western Cable show), and the third in March, again in Louisville.

"Basically, we've had the requirements out, and people were building to requirements," says Paul Zimmerman, CableLabs systems integration manager. "As everybody is building in parallel, the goal of CableLabs is to facilitate these Interop events, to bring everyone together, to make sure that as people build and interpret these specs, everyone is doing it the same way."

At the December interop, there were reportedly differences of interpretations in the use of address lines, bit rates and some commands. The latest Interop raised new questions, but Zimmerman says that over the first quarter, participants made "considerable progress." Besides, he adds, "The whole purpose of the interop is to identify issues like this, so frankly, it would be a failure if we didn't."

Work has extended outside the interops, such as in weekly phone conferences among the participating engineers. "We're reviewing the specs and writing Engineering Change Requests (ECRs), basically a change notice to reflect those new understandings as we develop them in this process," says S-A's Bagley. In this process, an ECR becomes an Engineering Change Order (ECO), and then an Engineering Change Notice (ECN) once approved by the entire organization.

So what's left to discuss? "I would say that in general that the one big issue that's still left up in the air has been copy protection," says Bagley, "but I think we've pretty much gotten that nailed."

Ready or not, the first of two six-week certification waves began on April 10. The second began on May 22, scheduled to close just prior to July 1. Modeled after CableLabs' Data Over Cable Service Interface Specification (DOCSIS) project, the waves consist of three phases: a one-week dry run of informal testing, four weeks of official testing, and a final week in which the certification board reviews the test results.

Another outcome: New players

CableLabs Senior Vice President of Advanced Platforms and Services Don Dulchinos says that the OpenCable effort has three goals: diversify equipment supply, enable retail distribution, and extend the cable platform to enable new services.

Dulchinos says the FCC mandate explains only part of the retail goal—the other reason being to meet competition that is already in the market. He emphasizes the goal of extending cable, especially the TV platform.

"That's really where the upside is in all this," he says. "Without OpenCable, we would still have an active digital video deployment, and that is going on and will continue to go on, but what OpenCable gives you in terms of upside is this new layer of services that we've never done before."

To some extent, these three goals are interrelated. Manufacturers entering the cable space, for instance,

Reasons for concern

One reason for continuing concern over the schedule is that OpenCable participants initially set a September 2000 deadline. The FCC's June 1998 Report and Order (R&O), which implemented section 304 of the 1996 Telecommunications Act, moved that goal up by three months, but included the original interim milestones.

The accelerated schedule has made compliance a closer call, leading some to doubt that industry participants will make it. "They're up against a deadline that, in my opinion as an analyst, they're not going to meet," says Mike Paxton, a senior analyst with Cahner's In-Stat.

"And this isn't just a deadline—it's law," Paxton adds. "They're going to have to be very sensitive about how to handle this whole situation so they don't get in trouble with the FCC and with Congress."

Meeting the deadline may become a matter of interpretation. "The technology vendors have a bit of a different definition perhaps than the MSOs of compliance," says Bedgood. The key word, says Paxton, will be "availability," which could denote either retail shelves or demo model.

OpenCable participants say that nontechnical issues complicate the picture. "There are huge revenues involved," says Victor Nowakowski, director of strategic planning and advanced development engineering for Zenith. "There are MSOs that don't want to change their headends. There's a couple of major vendors here in the U.S. that really have deployed an awful lot of equipment. An open standard just increases expenses and costs for certain MSOs."

The perception that momentum is battling inertia lingers. Forrester Senior Analyst Tom Rhinelander, who foresees digital set-tops defining the TV space over the next three to five years, calls the current OpenCable initiative "a first and half-hearted effort."

"The whole purpose of the interop is to identify issues like this, so frankly, it would be a failure if we didn't."

—Paul Zimmerman, CableLabs

Legal and technical Background

The 1996 Telecommunications Act stipulated that cable subscribers be able to purchase their own equipment. Competition in the set-top market, in turn, required making equipment that could work in systems using different security mechanisms and signaling protocols. POD modules became the conceptual solution to the problem of separating a set-top's security from nonsecurity functions.

The FCC's R&O initially required operators to separate the security functions in digital devices and the analog portion in both analog-only and hybrid boxes. On reconsideration, the FCC dropped the requirement on analog-only set-tops. CableLabs has issued an optional specification for an analog interface for hybrid boxes, but has focused on digital set-tops.

A relatively easy issue was settling on the Personal Computer Memory Card International Association (PCMCIA) form factor as the module's physical shape. That form, of course, also determines design for set-tops, or host devices. OpenCable refers to host devices because the POD module could go into a set-top box or something else, such as an integrated TV set.

More difficult has been specifying how set-top portability will work. The OpenCable Interop (OCI) process identifies interfaces as being needed at four points: between the POD module and host (OCI-C2); between an OpenCable-compatible headend and host (OCI-N); between the host and a digital consumer device (OCI-C1); and within the host between applications and any operating platform or system software (middleware). (See Figure 1 on page 180.)

At press time, CableLabs had released five POD-related OpenCable 1.0 Inter-

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BOTTOMLINE

> Methodical, Inclusive and Roughly On-Schedule

The Federal Communications Commission mandated that cable operators with digital systems deployed make removable security devices available to customers who want to buy retail set-top boxes by July 1.

CableLabs' OpenCable initiative decided upon a point of deployment (POD) module using a Personal Computer Memory Card International Association (PCMCIA) form factor, issued hardware specifications to enable manufacturing, and has overseen a series of interop events designed ensure common interpretations of specifications and interoperability of POD modules, host devices (set-tops and integrated TV sets), and headends. In April, OpenCable began the first of two six-week certification waves, the second of which is scheduled to end June 30.

Multiple systems operators (MSOs) covered by the mandate have placed orders with their key vendors, Motorola and S-A, and expect delivery within the required timeframe. Meanwhile, other manufacturers are entering the emerging U.S. POD module market. These include SCM Microsystems, Mindport, NagraVision, and NDS. DiviCom is providing them open conditional access (CA) at the headend.

Whether OpenCable proves to be as revolutionary as some predict will take time to tell. For now, the process itself appears methodical, inclusive, and roughly on (if not quite ahead of) schedule. Compliance with the July 1 deadline may become matter for interpretation.

Make Way for PODs

The July 1 Deadline Approaches

By Jonathan Tombes

Operators are expectant, manufacturers cautiously optimistic, and some analysts skeptical about whether CableLabs' OpenCable project can meet the July 1 retail market deadline for point of deployment (POD) modules. CableLabs itself says the schedule holds. Meanwhile, the initiative continues to transform the industry, especially by opening it to new players.

The deadline comes from the Federal Communications Commission, which mandated that cable operators with deployed digital systems make removable security devices available to customers who want to buy retail set-top boxes. As such, the mandate affects numerous multiple systems operators (MSOs) and vendors of cable equipment.

Cautious optimism

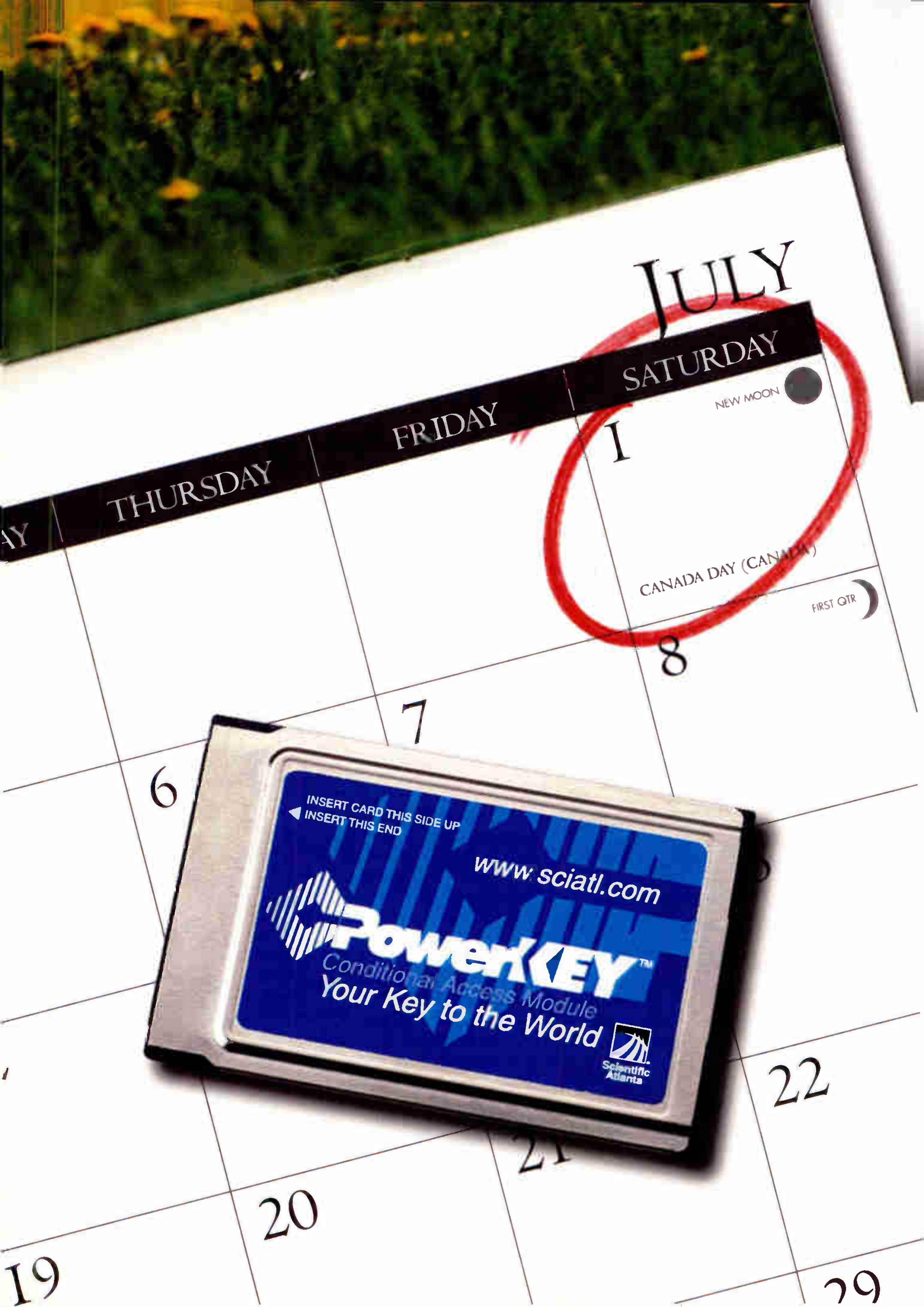
"We'll have PODs available from Scientific-Atlanta and General Instrument (now Motorola), and expect a few before July 1," says Jim Chiddix, Time Warner Cable's senior vice president for engineering.

"I can tell you that we're working very closely with both of our technology vendors to determine if that's going to be the case," says Charter Communications Vice President of Digital Services Powell Bedgood. "We know that there are still some hurdles and obstacles that we have to get through, as far as resources and equipment management, but our goal is to be compliant by July 1."

Manufacturers are measuring their words. After all, OpenCable has only just begun the certification process. While not directly under the FCC mandate, manufacturers are linked to the deadline by purchase orders and what Bedgood calls "a lot of scheduling interface."

"The customers have placed orders for PODs, and that's the key thing," says Julius Bagley, senior engineer for S-A. "We'll be delivering against those orders, or at least some of those orders, in July."

"It's tight, but we're hitting all our milestones," says Dwight Sakuma, a marketing manager for Motorola. "At this point, we have no problems seeing we will have POD modules ready for the July 2000 rollout." >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THURSDAY
FRIDAY
SATURDAY
NEW MOON
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System to system	± 0.5 dB	± 3 to 7 dB	± 2 to 4 dB
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NTSC	Yes	Maybe	Up to you
CENELEC	Yes		
PAL-A, PAL-B, PAL-I, PAL-G	Yes		
SECAM	Yes		
... or any other frequency scheme	Yes		
Windows interface	Yes	No	Up to you
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1. All seven tests (CTB, 4 CSOs, C/N, and XMOD) performed on any nine channels.

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sweep transmitter's front panel display. So, when you make an adjustment in the field, you can see what's going on at your headend "X level" test point—while you're in the field.

I'm familiar with equipment from Calan (Agilent), Trilithic and Wavetek Wandel Goltermann that does this. Some of the available equipment has forward sweep capability, so the forward and reverse plant can be swept at the same time. Furthermore, headend units from the three manufacturers mentioned support multiple field units for use in larger systems where several sweep technicians are doing reverse alignment simultaneously.

When you've performed your initial reverse alignment, it's time to evaluate the severity of ingress reaching the headend. This is impossible to do in an improperly aligned system because what you see in the headend doesn't necessarily reflect what's really going on in the field. After alignment has been completed, then and only then can you make a decision about whether tools such as high-pass filters will be necessary to combat drop-related ingress problems.

Ongoing system reverse sweeping will keep frequency response-related problems under control, minimizing the possibility of group delay affecting upstream data carrier bit error rate (BER). Proper system alignment also will ensure optimum operation of two-way technology such as impulse pay-per-view (IPPV), cable modems, telephony and status monitoring.

The section of this article about understanding unity gain was adapted from an article that originally appeared in the June 1999 issue of sister publication *International Cable*. CT

Ron Hranac is consulting systems engineer for Cisco Systems' Service Provider Engineering group. He also is senior technical editor for "Communications Technology." He can be reached via e-mail at rhranac@aol.com.

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point is at or near the diplex filter or downstream output port, then the amp's "Output test point" loss is all that must be added to the desired input to determine the sweep transmitter level. If the reverse test signal insertion point is at, say, the reverse gain stage input, you definitely will need to know the amp's internal losses.

Set your reverse sweep transmitter to the correct level for the particular amplifier being aligned (amplifier A in Figure 4) and connect it to the amp's reverse test signal insertion point. If unity gain exists, this should result in the correct reverse amp output level, and the correct input level at the node, which will yield the correct output level at the headend reverse receiver, and, of course, the same level at your "X level" test point as when you aligned your optical path. If the "X level" test point signal level is wrong, install the appropriate pad and equalizer at reverse amp A's output. This will give you the correct level at the node input, which will provide the correct "X level" test point signal level.

Lather, rinse, repeat

Now move on to amplifier B (Figure 4) and repeat the process used for amplifier A. Depending on your system design, the amplifiers may not be identical. Many systems use a combination of single output amplifiers such as line extenders and multiple output amplifiers. Multiple output amplifiers have higher internal losses than single output amplifiers, a consideration when setting reverse sweep transmitter levels to accommodate an internal unity gain reference point. If you use an external unity gain reference point, this may or may not be an issue, depending on where the reverse test signal insertion point is located.

Set up your reverse sweep transmitter for amplifier B's configuration and connect it to the amp's reverse test signal insertion point. If unity gain exists, this will result in the correct reverse output from amplifier B, the correct input and output at amplifier A, the correct input at the node and output at the headend upstream receiver, and the proper headend "X level" test point signal level. If not, install the appropriate value pad and equalizer at the reverse output of amplifier B. This will give you the correct levels back through the system to the headend. Now go to amplifier C and do the same thing and continue working your way out from the node toward the end-of-line.

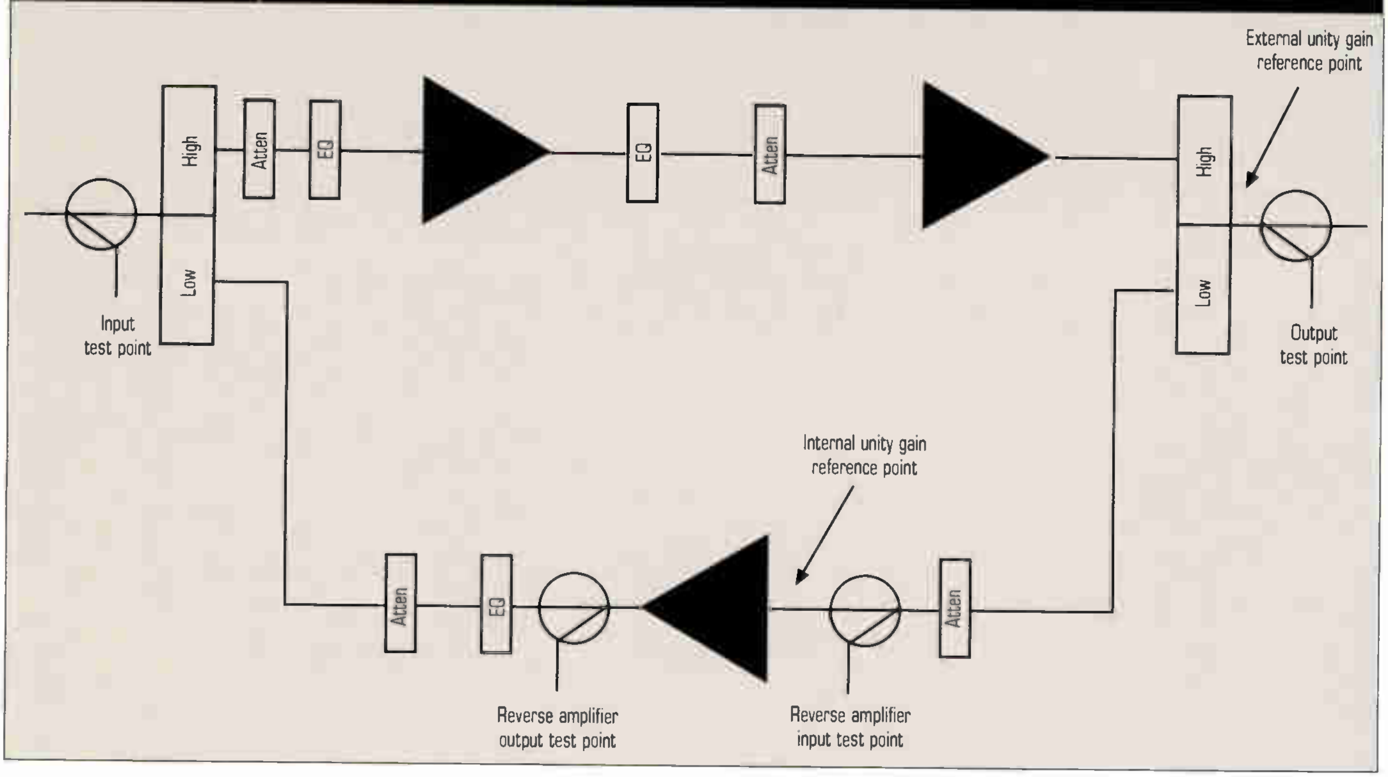
Staying in touch

Reverse alignment is a fairly straightforward process. But how can you know what the "X level" test point signal level is when you're out in the field? There are several ways. One tried and true method is to place a TV camera in front of the headend sweep receiver display and transmit the video from the camera downstream on an unused channel. You can carry a portable TV set tuned to the unused channel, where you can monitor in real time what effect your reverse amp adjustments have back at the headend. If you're using a multiple-carrier generator as your reverse test signal source, the headend equipment can be a spectrum analyzer. This will allow you to see your test signals along with ingress and other interference from the field.

The TV camera/spare channel method is cumbersome but effective, and has been successfully used for a long time. But what if you don't have a spare channel available to transmit the camera's video? Well, you could station another tech in the headend to describe via two-way radio or cellular phone what the sweep receiver or spectrum analyzer display looks like, but this method really doesn't work well and isn't recommended.

The best way is to use test equipment designed for one-person operation. The headend sweep receiver takes what's shown on its front panel display, digitizes it and sends it downstream on a narrow-band telemetry carrier. The reverse sweep transmitter receives the downstream telemetry carrier and shows the headend information on the

FIGURE 1 AMPLIFIER BLOCK DIAGRAM



directional coupler's tap leg to the diplex filter and through the low-pass section of the diplex filter to the input of the reverse amp.

Refer to the manufacturer's documentation to determine the total loss from the "Output test point" to the input of the reverse amp. If the amp has a 20 dB test point, then your sweep signal will have to overcome the test point's 20 dB of loss, plus 0.5 dB to 1 dB diplex filter insertion loss, another 1 dB for the "Reverse amplifier input test point" coupler through-loss, and any loss associated with the reverse amp input attenuator.

(A quick side note on reverse amp input attenuators: Many contemporary reverse amplifiers have this feature, which is used for design purposes and to assist troubleshooting, but not for reverse sweep alignment.)

In this particular example, the total loss from the "Output test point" to the reverse amp input is about 22 dB. In order to get +10 dBmV at the reverse amp input, your sweep transmitter needs to be set to +32 dBmV. Keep in mind that I'm using hypothetical numbers in these examples. Make sure that you use the actual numbers applicable to your system's amplifiers and test equipment.

If your system policy is to use what I've marked as the external unity gain reference point, setting the reverse sweep transmitter requires knowing where in the amp's signal path the reverse test signal insertion point is. Depending on its location relative to the external unity gain reference point, you may or may not have to consider the amp's internal losses.

If the reverse test signal insertion

BOTTOM LINE

> Align the Return

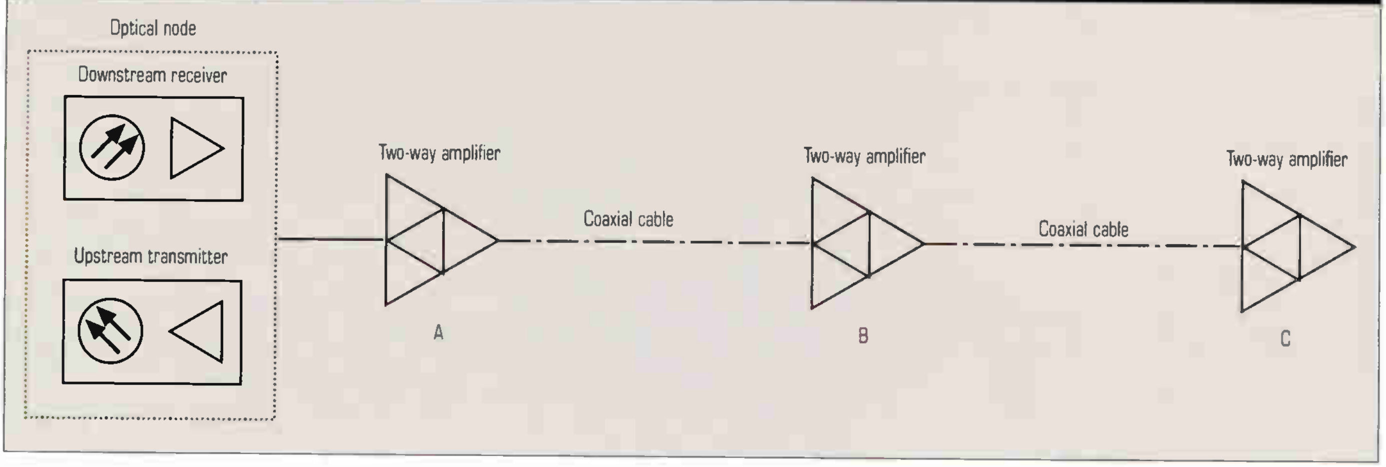
You've just completed alignment of your upstream fiber links and are ready to tackle the coax plant. You've got your sweep gear ready to go, have a handy selection of pads and equalizers, a couple replacement reverse amplifier modules just in case, and are headed out to begin tweaking the system's amplifiers.

Before you pop open the first amplifier's cover, make sure you have a firm grasp of one of the most important fundamentals of coax plant operation: unity gain. This concept is critical to the proper operation of both the forward and reverse path.

As with fiber link alignment, proper coax plant alignment requires a good working relationship with the amplifier manufacturer and access to equipment documentation. The latter will help you determine how to set reverse sweep transmitter operating levels relative to either internal or external unity gain reference points.

Starting at the first amplifier out of the node, make appropriate adjustments to get correct levels at the headend "X level" test point. Move to the next downstream amplifier location and repeat this process, then continue working downstream to the end-of-line amplifier. Reverse alignment is fairly straightforward, and using test equipment available from one of several manufacturers can in many cases make this a one-person process.

FIGURE 4 COAXIAL PLANT ALIGNMENT



span BD did not exist and the directional coupler were not there, then an input attenuator and equalizer could be used at amplifier B to compensate for span BC. However, because the input to amplifier B gets its signals from both spans BC and BD, it's necessary to install attenuators and equalizers at the outputs of amplifiers C and D in order to get the correct input levels at amplifier B. Otherwise, you could install an attenuator and equalizer at amplifier B's input to compensate only for span BC or BD, but not both.

Unity gain is an important concept that applies to the forward and reverse paths of every properly operating cable system. Without it, network performance will be marginal at best. Unity gain starts in the network design process and continues through equipment installation, alignment, and ongoing operation and maintenance.

Step by step

As I mentioned in the March article, proper alignment of the reverse coax plant begins at the node. Once the optical path has been set up and a headend or hub site "X level" test point established, then it's time to tackle the amplifiers in the distribution network. (If you're confused about the "X level" test point, refer to the previously mentioned March 2000 *CT* article.) Assuming you've got the node itself correctly aligned, the next place you go is to the first downstream amplifier location out of the node.

In some systems, this amplifier may be located adjacent to the node and is sometimes referred to as the launch amplifier (amplifier "A" in Figure 4). Other systems may use nodes that have the launch amplifier built into the same housing as the node. In either case, the launch amp is where you begin when setting up the coax plant's reverse path.

As was the case with optical equipment alignment, you'll need to have a good working relationship with the amplifier manufacturer and have applicable documentation on hand. In particular, you'll need detailed block diagrams that show amplifier signal flow. (See Figure 5 on page 170.) This will help you establish the necessary reverse test signal input levels for each type of amplifier used in the network and determine the amp's reverse test signal insertion point.

Aligning return amps

When it comes to aligning a system's reverse amps, there are two schools of thought on setting reverse test signal levels. One method defines the reverse path unity gain reference point as the input to the reverse amplifier module or gain stage. This is marked "internal unity gain reference point" in Figure 5. The other has the unity gain reference point at either the reverse input to the amp housing (the downstream output connector) or perhaps the diplex filter and is marked "external unity gain reference point" in Figure 5.

There are pros and cons to each method, but the latter method is recommended by several amplifier manufacturers. Make sure you understand which one is preferred in your system and stick with it throughout the amplifier alignment process.

Let's first look at the use of an internal unity gain reference point. Assume you want your reverse test signal level to be +10 dBmV at that point. At what level should your reverse test signal source (that is, reverse sweep transmitter) be set in order to get +10 dBmV at the input to the reverse gain stage? For that matter, where do you connect your reverse sweep transmitter to the amp?

Study Figure 5 for a moment. At first glance, you might be tempted to connect your reverse sweep transmitter to the "Reverse amplifier input test point." If you look closely at the figure, though, you'll see that that particular test point is a directional coupler-type test point. In that example, the directional coupler test point is for measuring the input level to the reverse gain stage, not for reverse sweep injection. If that particular test point were a resistive-type rather than a directional coupler-type, then it could be used for reverse sweep injection. See the value in having good documentation? Had you connected your reverse sweep transmitter there, the sweep signal would have gone downstream, not into the reverse amp.

In this instance, a far better place to connect your reverse sweep transmitter is the amplifier's "Output test point" shown on the far right side of Figure 5. Inserted there, the reverse sweep signal will pass through the

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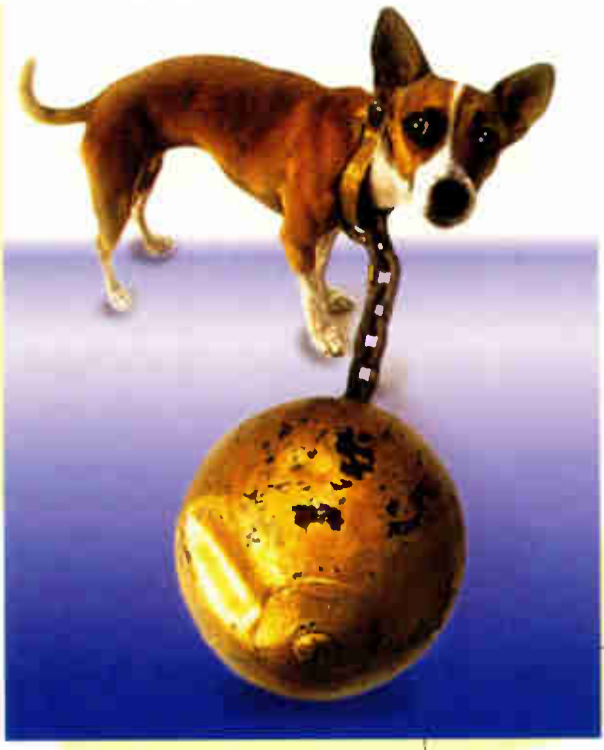

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Figure 2 | Forward path unity gain

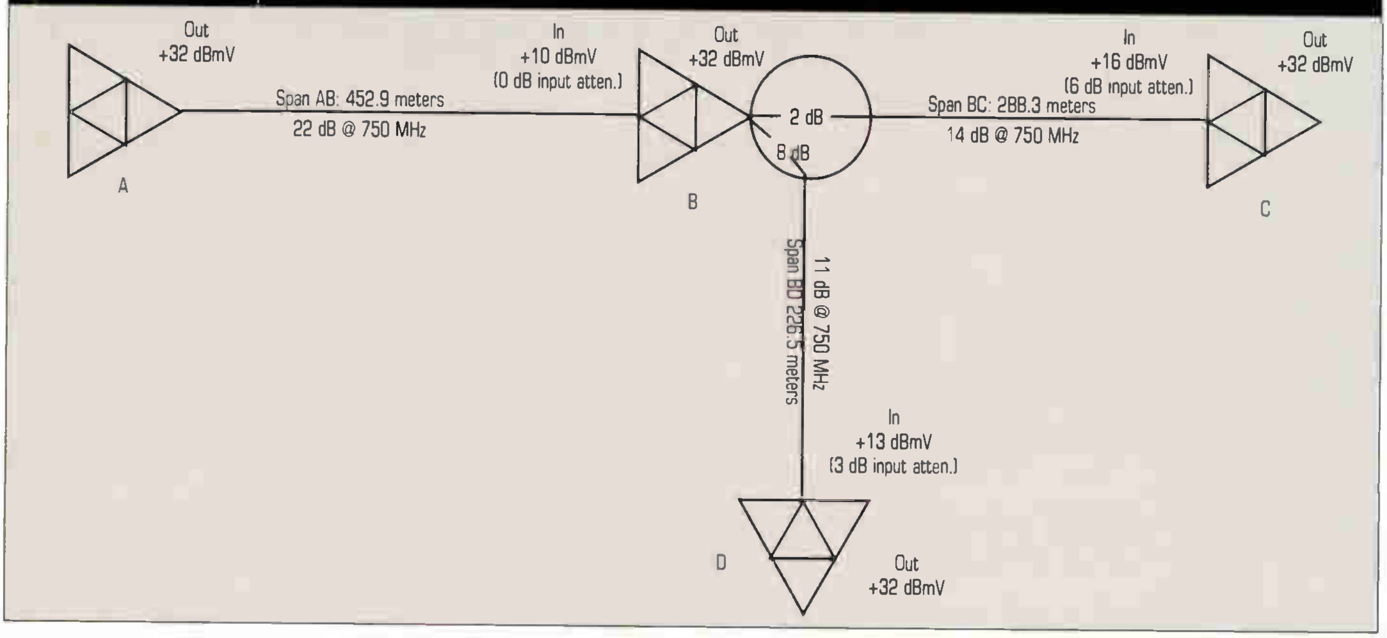
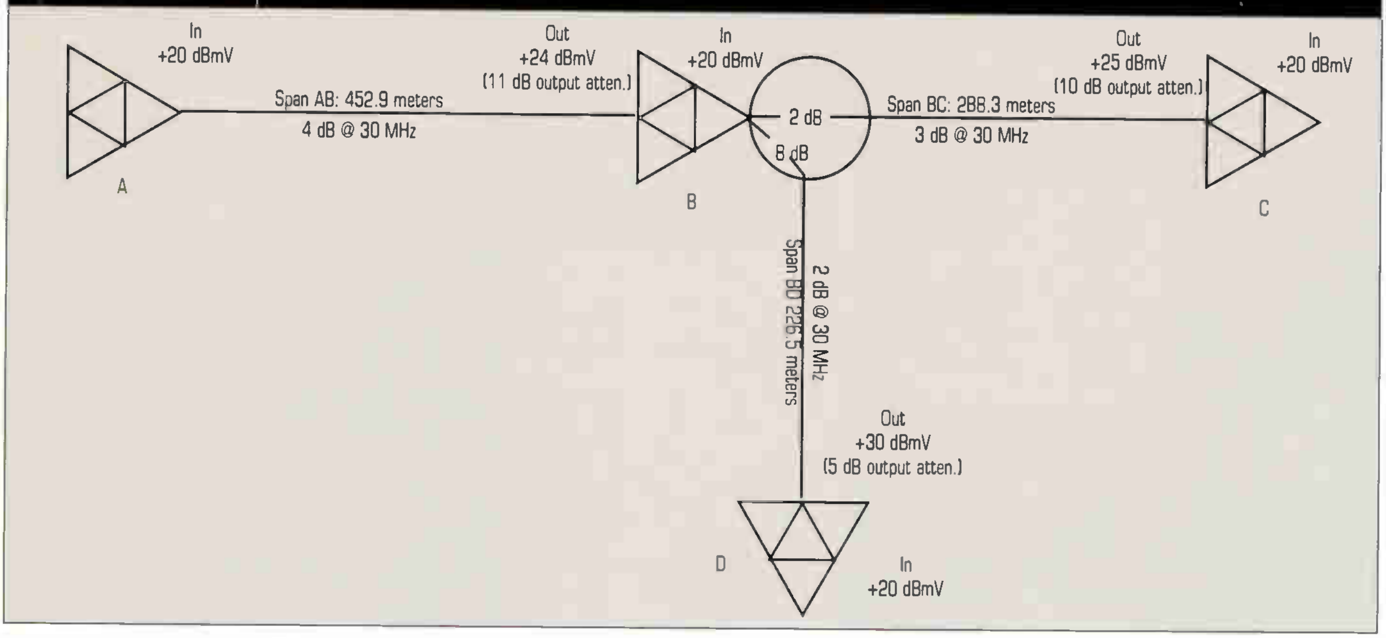


Figure 3 | Reverse path unity gain



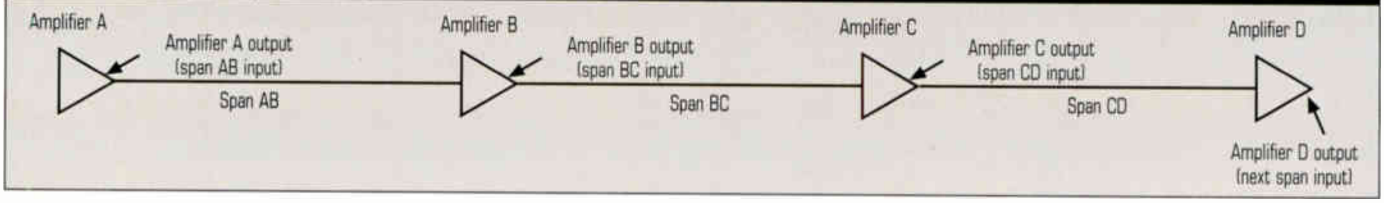
only 4 dB of loss at 30 MHz, requiring an 11 dB output attenuator at amplifier B. (Yes, modern reverse amplifiers have the attenuators and equalizers installed at the amplifier outputs; read on to see why.) This will provide 15 dB of total loss in span AB, which is numerically equal to amplifier B's 15 dB of gain. Thus, amplifier B's +20 dBmV input is equal to the +20 dBmV upstream output of span AB, which is also the input to amplifier A. Here, unity gain exists for the combination of span AB and amplifier B.

Span BC includes a combination of cable and passive loss totaling 5 dB. This requires a 10 dB output attenuator at amplifier C to give the desired overall 15 dB of loss. Now the gain of amplifier C and loss of span BC are numerically equal, and amplifier C's +20 dBmV input is equal to span BC's +20 dBmV upstream output.

Span BD has 8 dB of passive device loss and only 2 dB of cable loss, requiring a 5 dB output attenuator at amplifier D. This makes the gain of amplifier D and loss of span BD numerically equal (15 dB), and amplifier D's +20 dBmV input equal to span BD's +20 dBmV output. Here, too, unity gain exists. For all of the reverse amplifiers shown in Figure 3, one objective is identical signal levels at the unity gain reference points, in this case the amplifier inputs.

Why are attenuators and equalizers located at the reverse amplifiers' outputs? Well, they could be at the inputs if there were no network splits or branching. An input attenuator and equalizer would work just fine at amplifier A instead of the output of amplifier B because of the direct signal path from amplifier B to A. Likewise, if

FIGURE 1 FUNDAMENTAL FORWARD PATH UNITY GAIN



equal to the total loss of the cable and passive devices immediately upstream from that amplifier. This concept is known as unity gain, and is still a critical parameter in modern cable system design and operation.

The term unity gain is based on the fact that in a properly designed system, the loss in the cable and passive devices comprising the span immediately upstream from an amplifier is exactly offset by the gain of the amplifier, resulting in unity or no net gain.

When forward path unity gain exists, the input signal level to a given span of cable will equal the output signal level of the amplifier immediately following that span of cable. (There are occasional exceptions—for instance, the transition from a bridger to a derated line extender.) Figure 1 shows a cascade of four identical amplifiers. In that example, unity gain exists when the input to span AB equals the output of amplifier B, the input to span BC equals the output of amplifier C, the input to span CD equals the output of amplifier D, and so on. This also defines a system's unity gain reference point, something I'll get back to in a moment. The bottom line: If unity gain is not observed, performance will quickly deteriorate to unacceptable conditions. This is especially true in long amp cascades.

For example

Just to emphasize the importance of unity gain, imagine a cascade of 10 identical amplifiers, each with 22 dB of gain. However, let's assume the loss between each amplifier is 23 dB. If the output of the first amplifier is +32 dBmV, then the input to the second one will be +9 dBmV. The second amplifier's output will be +31 dBmV. The input to the third amplifier will be +8 dBmV, and its output +30 dBmV. By the time we get to the 10th amplifier in cascade, the input level will be +1 dBmV and the output +23 dBmV. C/N performance will be quite bad in this hypothetical system.

Figure 2 (on page 166) shows a detailed example of forward path unity gain, and assumes a cascade of identical amplifiers, each with 22 dB of gain. The output of amplifier A, which also is the input to cable span AB, is +32 dBmV. Span AB has 22 dB of loss at 750 MHz, which results in +10 dBmV input to amplifier B. Because amplifier B has 22 dB of gain, its output will be +32 dBmV if a 0 dB input attenuator is used. (I'm leaving equalizers out of this discussion to keep things simple.) Here we clearly can see that unity gain exists because amplifier B's 22 dB of gain is numerically equal to span AB's 22 dB of loss. As well, the +32 dBmV input to span AB is equal to amplifier B's +32 dBmV output. So far, so good.

"Cable TV network performance is a delicate balance between noise and distortion."

Span BC has a combination of cable and passive loss. The directional coupler's insertion loss is 2 dB, and the cable loss is 14 dB, for a total of 16 dB. Span BC's loss obviously does not equal the gain of amplifier C, so it's necessary to install a 6 dB input attenuator at amplifier C. Now the total loss does equal 22 dB, which is offset by the 22 dB gain of amplifier C, and the +32 dBmV input to span BC equals amplifier C's +32 dBmV output. Unity gain exists.

Span BD also has a combination of cable and passive loss, but here the total is 19 dB. This means a 3 dB input attenuator is required at amplifier D. Here, too, unity gain exists because the 22 dB loss in span BD equals the amplifier D's 22 dB of gain, and span BD's +32 dBmV input equals amplifier D's +32 dBmV output.

Not only does this show an example of forward path unity gain, but it also shows the forward path unity gain reference point. That reference point is the downstream amplifier output. In a cascade of identical amplifiers, one objective is to achieve identical signal levels at the unity gain reference points.

And in the return?

But what about the reverse path? Is unity gain important there, too? The answer is an unequivocal yes. In order for the reverse path to operate properly, unity gain must exist there as well.

Figure 3 (on page 166) shows a detailed example of reverse path unity gain. The layout is the same as Figure 2, except that losses are shown for 30 MHz instead of 750 MHz. The reverse amplifiers are identical to one another, each with 15 dB of gain. As is the case with forward path unity gain, the numerical gain of a reverse amplifier must equal the loss of the cable and passive devices in the span immediately upstream from the amplifier. The reverse path unity gain reference point is the same physical location as the forward path unity gain reference point, but from a signal flow perspective, it's at each amplifier's input rather than the output. When reverse path unity gain exists, the signal level input to a given amplifier will equal the output from the span immediately upstream from that amplifier.

In this particular example, we need 15 dB of loss to compensate for each amplifier's 15 dB of gain. Span AB has

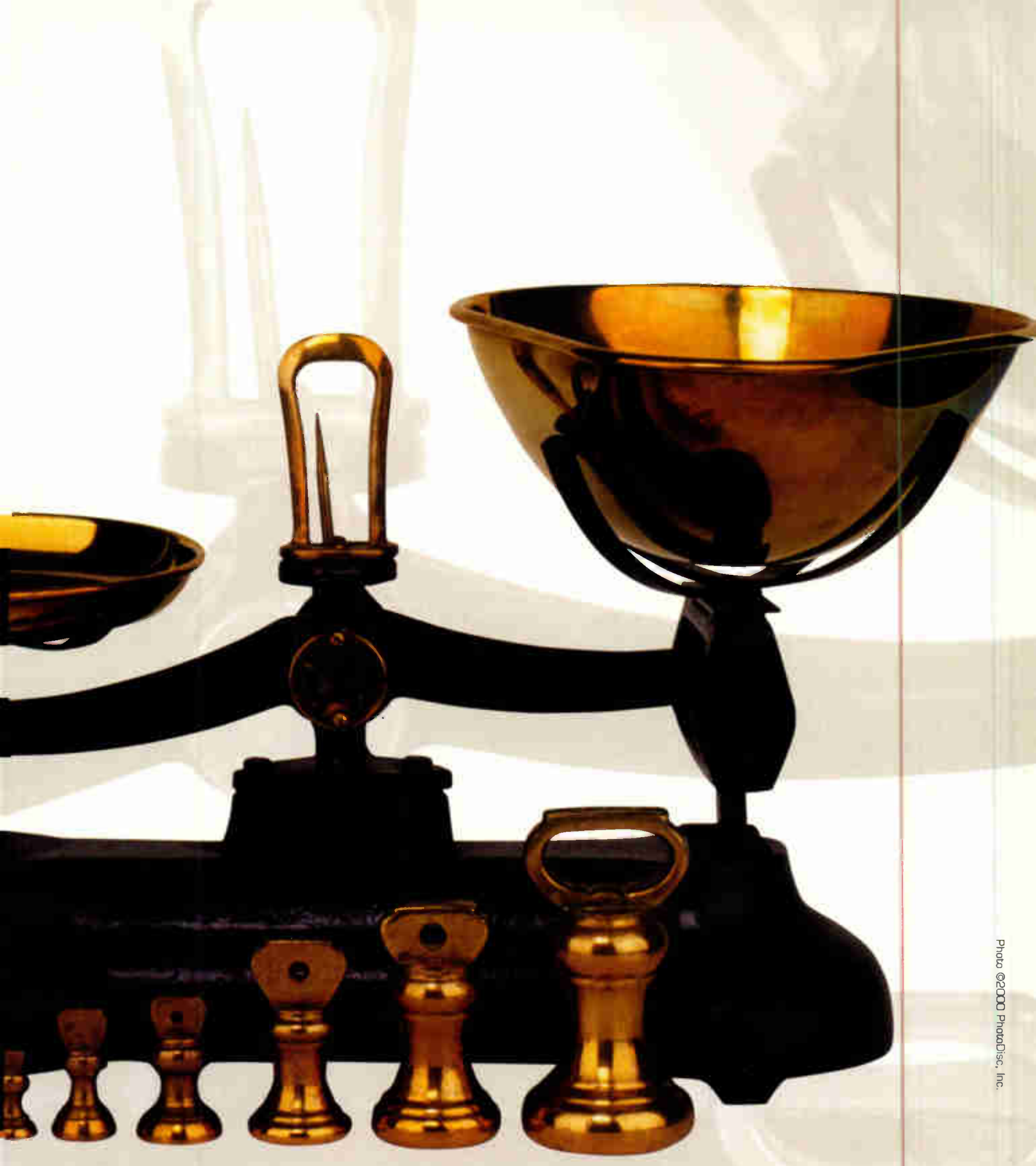


Photo ©2000 PhotoDisc, Inc.

Hold on a second. Before you pop the cover open on the first amplifier, make sure you have a firm grasp of one of the most important fundamentals of coax plant operation: unity gain. This concept is critical to the proper operation of both the forward and reverse path.

Understanding unity gain

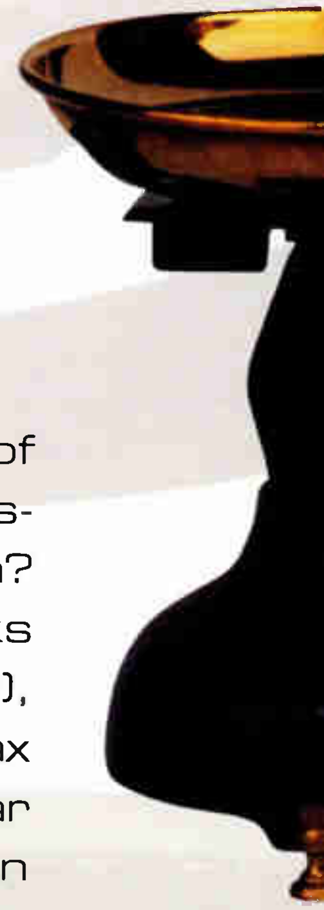
Cable TV network performance is a delicate balance between noise and distortion. If the network's RF levels are too low, the carrier-to-noise (C/N) ratio will degrade, and if RF levels are too high, the carrier-to-distortion ratio will suffer. This means network operating levels must be confined to a moderate window that becomes smaller as the signals pass through more and more active devices.

Very early in cable's history, engineers discovered that for optimum cascaded amplifier performance, each amplifier ought to have its station gain

SEEK BALANCE in All Things

A Look at Unity Gain in the Upstream Coax Plant

By Ron Hranac



You've just completed alignment of your upstream fiber links (see "Mystified by Return Path Activation? Get Your Upstream Fiber Links Aligned," March 2000, page 40), and are ready to tackle the coax plant. You've got your sweep gear ready to go, have a handy selection of pads and equalizers, a couple replacement amplifier modules just in case, and are headed out to begin tweaking the system's amps.

FIGURE 3 | DCT FOR SMOOTH BLACK-TO-LIGHT-GRAY TRANSITION

10	20	30	40	50	60	70	80
10	20	30	40	50	60	70	80
10	20	30	40	50	60	70	80
10	20	30	40	50	60	70	80
10	20	30	40	50	60	70	80
10	20	30	40	50	60	70	80
10	20	30	40	50	60	70	80
10	20	30	40	50	60	70	80

a. Real pixel image data for horizontal black-to-light-gray transition

Transform →

Zig-zag scan →

360	-182	-.2	-19	-.2	-5.7	-.1	-1.5
.1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
.1	0	0	0	0	0	0	0
-.1	0	0	0	0	0	0	0
.1	0	0	0	0	0	0	0
-.1	0	0	0	0	0	0	0
-.1	0	0	0	0	0	0	0

b. DCT transformed image data

expressed the pixels in terms of all possible spatial frequencies. What have I accomplished to this point in terms of reducing the number of bits I need? Absolutely nothing. It will take me about the same number of bits to represent the pixels in the frequency domain as it does to represent them in the "spatial domain." Further, I can exactly reproduce the picture from this information.

To get some serious data reduction, I'm going to have to get good at throwing away information I don't need. In the process of doing this, I will introduce errors or "artifacts" into the picture, so I'd better do it in ways that the eye cannot detect.

To see how I can use the DCT to reduce the data in the picture, pretend that we have a series of increasingly light pixels progressing from left to right, with all pixels in each column of the same brightness, or value. Figure 3a shows an 8 x 8 block, as is really used in MPEG compression, with the values of the pixels assumed. The corresponding DCT block is shown in Figure 3b. Note that almost all of the values are zero, so I don't need to transmit them. As I follow the zig-zag scan pattern, I encounter long runs of zero value, so rather than transmit them, I simply will transmit a code that says the next so many values are all zero.

In fact, it is even better than that: There is an optional second zig-zag pattern here that would cover all nonzero values quickly in this case, leaving a lot of zeros that don't need to be transmitted.

Effectively losing Picture information

So this is the first way I save bits: I use the DCT to identify zero weightings that I don't have to transmit. Now I have saved a few bits with typical video patterns, but I have a long way to go. Where I have very small weighting values, or coefficients, I can choose to treat them as zero and not transmit them, a process called "truncation." This will lose picture information (that is, it is a "lossy" process), but if I do it intelligently, I will not create visible artifacts.

The next thing I can do is to look at the higher frequency components and maybe represent them by fewer bits. This is called "quantization." Picture information is destroyed, but if I do it well, you won't be able to see the difference.

I will illustrate the losses inherent in truncation and quantization in the August issue. CT

Jim Farmer is chief technical officer for Antec. He can be reached via e-mail at jofarmer@mindspring.com.

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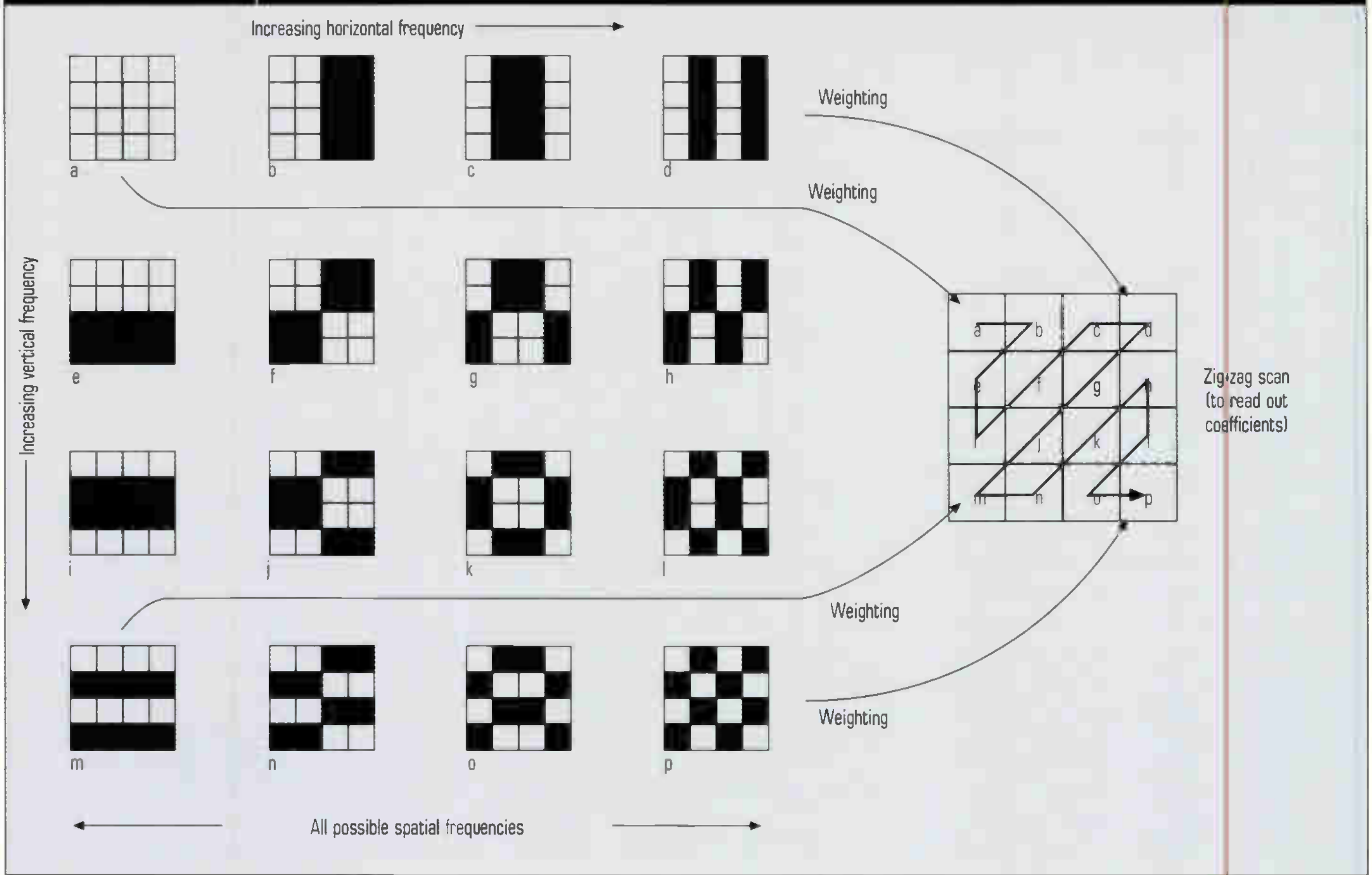
FIGURE 2 Composition of the DCT transform



would figure out what the average value of the video is in the real picture block and assign the appropriate weighting factor to block A. This weighting goes in the DCT block shown at the right of Figure 2, at location A. This DCT block is nothing more than a way to keep track of the appropriate weightings for each of the 16 patterns in the left part of Figure 2. Just so you know, in the real world of Moving Picture Experts Group (MPEG) compression, the block is 8 x 8 and has 64 unique patterns.

The other blocks to the left of Figure 2 represent other patterns that may or may not be needed to make up a particular block. These patterns may take on weighting values from -1 to 1, where negative weighting values represent the opposite pattern of light and dark. Look at the top row of blocks (A-D) in Figure 2. The left block has no change in brightness as we move horizontally across the block. (It has no vertical pattern either, but I'll get to that in a moment.) So it has zero spatial frequency horizontally. The next block, B, has a light-light-dark-dark pattern, and block C has the equivalent light-dark-dark-light pattern. This is the same spatial frequency because we make the artificial assumption that the blocks will repeat. Finally, block D has a light-dark-light-dark pattern horizontally, so it has the highest horizontal spatial frequency.

Look now at blocks A, E, I and M, which represent increasing spatial frequency in the vertical direction. The other blocks progressing to the right in any row have the same horizontal frequency as all other blocks in that column, and the same as we go top to bottom.

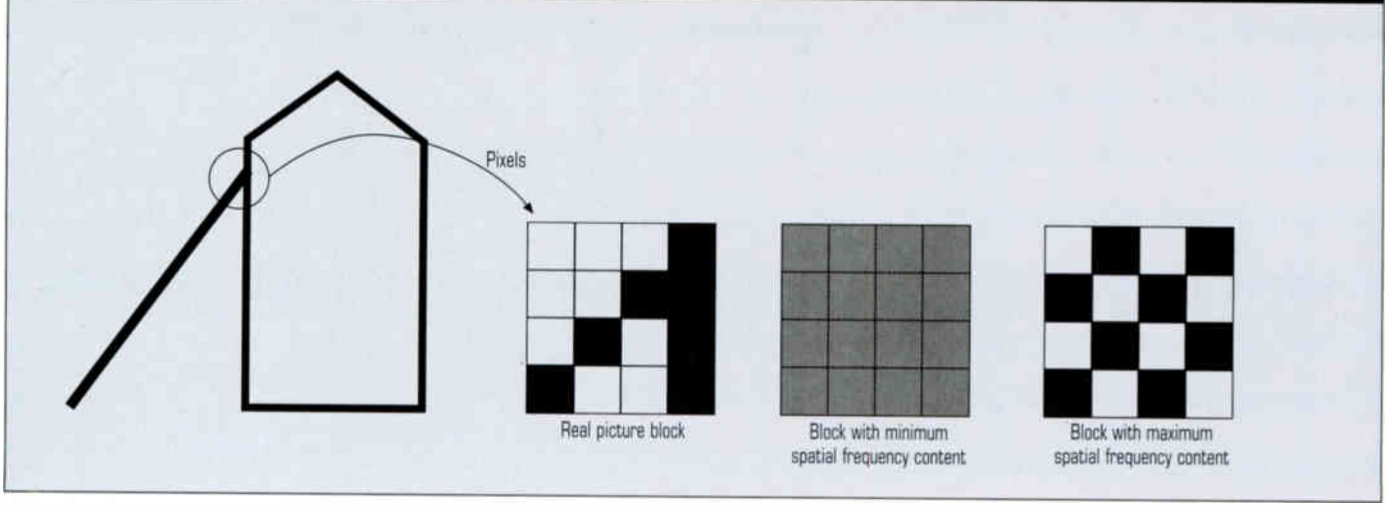
In performing the DCT, I figure out the weighting of each pattern, and I put it in the appropriate place in the DCT block of Figure 2. I can represent the real picture block as shown in Figure 1, or I can represent it as a series of DCT weighting factors as in the DCT block of Figure 2. I then read out (transmit or send for further processing) the weightings I have put in the DCT block, normally using the zig-zag pattern shown, where I first read out the dc value, A, then I read out the lowest spatial frequency values, B and E, then go to the next higher spatial frequency values I, F, and C, and so on until I have read out all weightings.

"Picture information is destroyed, but if I do it well, you won't be able to see the difference."

Wait, the bits aren't Reduced ... yet

OK, so now I have represented the block of pixels in the "frequency domain," called that because I have

FIGURE 1 AN EXAMPLE OF SPATIAL REDUNDANCY



transitions per unit of time, but it is equally valid to think of frequency as the number of cycles or transitions per unit of distance. Furthermore, we don't need to restrict ourselves to thinking of frequency along just one axis: We can think of frequency along two axes, horizontal and vertical (and I sure hope I don't get them mixed up again).

If I have a block of pixels that are all the same, I say that block has minimum spatial frequency content—in fact, it only has a constant, or "dc," value. By contrast, if a block has a different value for each pixel, as represented at the extreme right, it has maximum spatial frequency content.

So in order to reduce the amount of data I have to transmit, I'd really like to get rid of spatial redundancy by identifying all pixels of the same value, and only transmitting that value once, with information as to which pixels that value applies.

Reducing spatial redundancy

There are many ways of doing the calculations to reduce spatial redundancy; the one chosen for digital TV (DTV) is called the discrete cosine transform (DCT). This technique is not a perfect way to eliminate spatial redundancy, but it works pretty well. DCT is a mathematical operation that derives from Fourier transform theory. Fourier transform theory says that any repetitive waveform may be represented by a series of sinusoidal waveforms at multiples of some fundamental frequency, and it offers the mathematics to compute the series of sinusoids for any repetitive waveform.

We are going to take an intuitive, nonmathematical approach to the subject here, though. So if you really like the math, you are probably going to be offended. Sorry about that. If you don't like the math, or if you want an intuitive introduction, read on, but don't feel this makes you an expert on DCT. It doesn't.

The DCT

Assume we have values for the video in every pixel shown in Figure 1. Maybe these values range from zero for a black pixel to 100 for white. In the real world, we'd usually have more values. I want to operate on these pixels so that I can identify which of them are redundant, meaning they have the same value as adjacent pixels. One way to do this is to use the DCT.

Figure 2 shows how we would apply the DCT transform to the real picture. In the real world of compression, we use 8 x 8 pixel blocks to transform the picture. Here we are using 4 x 4 blocks for simplicity.

As shown to the left of Figure 2, I can express all possible patterns in any block with combinations of the 16 blocks shown. Think of each block as a pattern in the real picture block of Figure 1. I can form the Figure 1 real picture block by combining several of the patterns at the left of Figure 2, using different weightings (or coefficients) for each block.

Notice that the block in the upper left of Figure 2, block A, is all the same luminance. Let's say it is white, but we will take a weighting factor (that is, choose a coefficient for its value) between zero and one, depending on the shade of gray we want. So I

BOTTOMLINE

> **The DCT Two-Step: Reducing Picture Bits**

This month we introduced the discrete cosine transform (DCT), the first step in reducing the number of bits it takes to transmit a picture. The DCT converts the "spatial domain" pixels into "frequency domain" coefficients.

In real pictures, most of the coefficients will be zero or near zero, so we don't need to transmit them, which means it takes less bandwidth to transmit the picture. We can apply several tricks to the nonzero coefficients, but doing so will introduce picture artifacts. We must make sure the artifacts are not noticeable to the viewer. The most common operations are to truncate the block description by not transmitting small coefficients. Another common trick is quantization, in which we reduce the number of bits representing a particular coefficient.

The DCT

"Department of Redundancy Department"

By Jim Farmer

You've heard of people who zig when they should zag. Well, in the February column, I "H"ed when I should have "V"ed. I made the statement that 21 or 22 lines of a picture are taken by the horizontal blanking interval (HBI). Several of you have let me know that 21 or 22 lines are taken by the vertical, not horizontal, blanking interval. Must have been something wrong with my computer when I typed that part.

I also caught it for saying that the best way to display a 16:9 picture on a 4:3 display was to use pan-and-scan. I have since been told that videophiles don't change the artistic judgment of the scene's creator, so they prefer letterbox format. Hey, you are reading the column, and I appreciate it. And watch me: I'm going to zig and zag this time.

In the last issue, I made the point that if you just digitize a picture, you wind up with much too much data to transmit, so you have to compress. There is a standard used by TV broadcasters where they handle digital video at 270 Mbps and another at about half that rate, so there's a long way to go to get it down to something that can be transmitted. Previously, I mentioned several of the compression techniques used, and this time I'll go into one of those techniques in more detail.

Saving bits by cutting pixels

I need to start with a TV picture, but I'm a lousy artist, so bear with me if I come up with a poor example. Consider a picture of a ladder leaning up against a house, as shown to the left of Figure 1 (on page 158). Take the area where the ladder meets the house, which I have circled.

When we digitize the picture, we wind up with pixels in the horizontal and vertical directions that represent the picture. To the right of the house we show a 4 x 4 block of such pixels. Of course, real video would have a much larger number of pixels, but I need something simple. If the ladder were about one pixel wide (real ladders would be much wider in order to show up on the screen), then maybe the block in the circle would look something like I have illustrated in the real picture block. The darkened pixels represent the ladder and the side of the house.

Note that a number of the pixels have the same level (or value), either light or dark in this example. (We treat the color and luminance information separately, but we treat them the same way.) Several of the adjacent pixels have the same value, and this represents spatial redundancy in the picture. That is, we normally transmit each pixel even if it is the same as several of its neighbors. If we can eliminate this redundancy, we can save bits.

This gets us into the concept of spatial frequency. We normally think of frequency as the number of cycles or

Video Compression 3:

Save Bandwidth in the


e-mail

If a modem manufacturer decides to introduce tamper-proof key storage, this process can be validated with the public key certificate signed by the manufacturer and installed in the factory. Pirates will not have access to the manufacturer's certificate signing key and thus will be unable to purposely manufacture their own units in order to bypass the tamper-proof key storage.

Regardless of how well hidden, an attacker will eventually find the decryption key.

When security is used in a personal computer (PC), however, the keys usually are generated later, based on a consumer-initiated application. For example, Web browsers usually have an interface that allows a PC client to generate a public/private key pair that can be used to authenticate a secure sockets layer (SSL) session with a Web server. A corresponding public key certificate can be obtained over the Internet, from an online certification authority, such as Verisign.

Where keys are generated in the field, cloning attacks cannot be prevented. Even if the required procedure is to generate the keys inside a tamper-proof smart card, there really can be no assurance that this actually happens.

A pirate can easily hack a program (such as a streaming media player) that is supposed to generate keys on a smart card and instead generate them within the PC. The hacked program would then store the keys in a file that can later be easily distributed to other PCs, which will then be able to decrypt the same media streams for free.

BPI+ security architecture allows the use of tamper-proof key storage as an effective deterrent against passive cloning attacks. This differentiates BPI+ security from a PC-based security model that allows consumers to generate their own keys.

The last word

Although BPI+ security itself doesn't require tamper-proof protection for cryptographic keys and does not specify how intrusion detection should be performed, the DOCSIS 1.1/BPI+ architecture provides the hooks for both. Because intrusion detection normally is done centrally, at the cable headend, it can be deferred until a later time, when cloning attacks against unicast services become a problem.

When streaming multicast services, such as Internet TV, become more popular and service providers start charging substantial fees for these services, cloning attacks are likely to become of greater concern than they are today. In that case, tamper-proof key storage coupled with BPI+ would serve as an effective deterrent.

If a service provider starts deploying cable modems with tamper-proof key storage today, before cloning is a major concern, it would likely save the operator money in the future when streaming multicast services will be widely deployed.

This article originally appeared in the *Proceedings Manual* for the Society of Cable Telecommunications Engineers' 2000 Conference on Emerging Technologies. CT

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Did this article help you? Let us know your thoughts. Send an e-mail to jwhalen@phillips.com.

In the case of DOCSIS, tamper-proof key storage is most applicable for protecting multicast services, but also can be used on unicast services. One of the biggest advantages to tamper-proof key storage is that there are no recurring network costs, only the initial investment per modem. This is in contrast with the intrusion detection systems that have to be upgraded as the system configuration changes.

In general, there is no such thing as fully tamper-proof key storage. It is always possible to extract keys. The goal of tamper-proof key storage is to force the pirate to apply a lot of effort and money to extract the keys from just one box.

In the context of DOCSIS multicast services and BPI+, the following keys could be protected:

- RSA private key. If only this one key is protected, a cloned unit will be unable to decrypt authorization reply messages containing the authorization key. The modem needs the authorization key to derive the KEK, in turn used to deliver TEKs. If a pirate still wants to clone boxes, each time the original modem receives an authorization reply and extracts the authorization key, it somehow has to distribute the authorization key to cloned units. Thus, protecting the RSA private key may provide sufficient protection against cloning attacks.
- RSA private key, authorization key and KEK. If cloning schemes where the authorization key is distributed (as described earlier) is a concern, protection of additional keys may be provided. The KEK is protected so that a clone will be unable to decrypt key reply messages, containing a TEK. Because the authorization key is used to derive a KEK, it would have to be protected at the same time. Now, if a pirate still wants to attempt cloning, whenever a TEK is delivered to an original cable modem, it has to redistribute it to clones. Because TEKs are delivered more frequently than authorization keys, such a cloning attack would be even more complicated and more easily detectable.
- RSA private key, authorization key, KEK and TEK. If one wants to protect against all possible cloning schemes, each TEK also is kept in tamper-proof key storage. Such a protection scheme is more expensive, as each modem may possess many valid TEKs, but only one KEK. However, a pirate would have to break the tamper-proof key storage for a cloning scheme to succeed.

Loading keys into modems

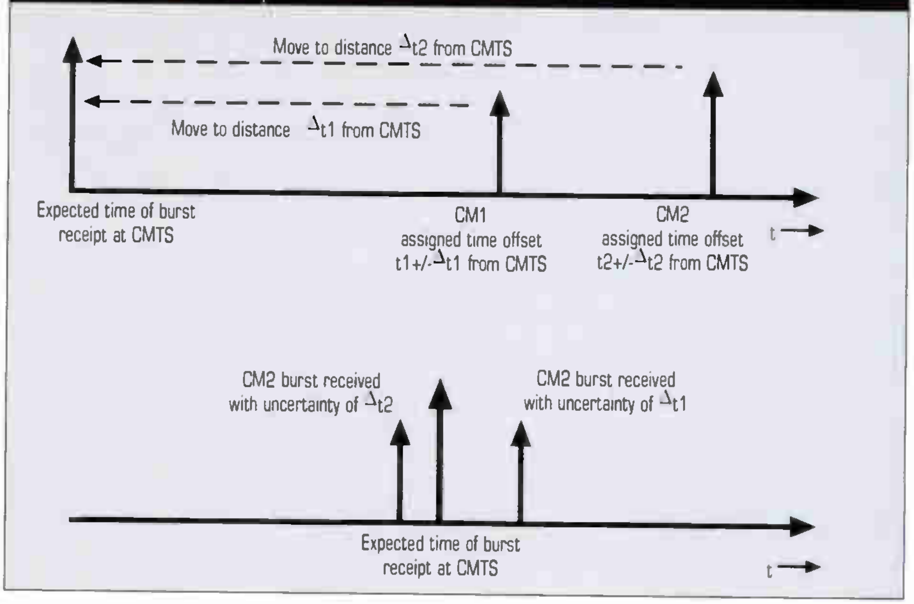
The BPI+ security model, where RSA public/private key pairs and the corresponding public key certificates are installed in modems during manufacture, allows for introduction of tamper-proof key storage. >

the measurement resolution would still be 100 feet. However, this would force a greater variance between received bursts because cloned modems would not be aware of other cloned modems' offsets, unless each clone monitored all of the other clones' initial ranging response messages. This method means sacrificing bandwidth.

It is important to note that with this improved clone detection scheme, the CMTS needs to check for fine grained time offset differences only during regular transmissions, protected with BPI+. It should not attempt to flag time offset differences during ranging because these messages are not authenticated, and flagging them could result in a denial of service attack.

This detection process is not perfect because the units are statistically distributed across the 800-1,600 foot uncertainty window. Units could appear to be located at the same position in the network. However, this does provide an additional method for detecting duplicate units.

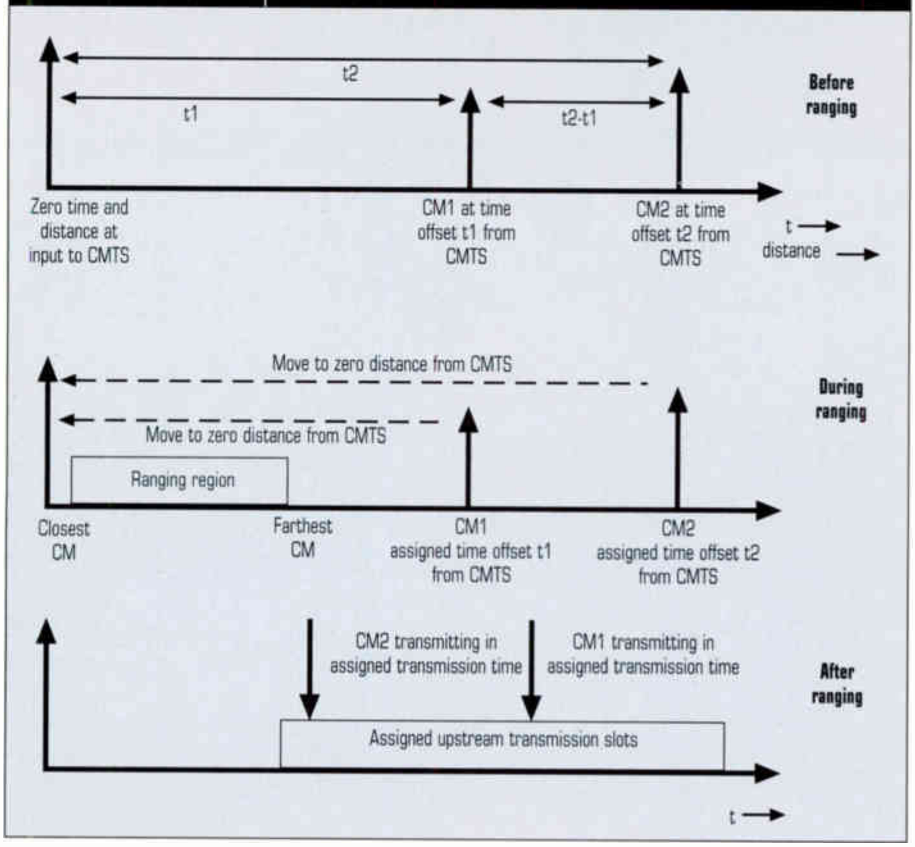
FIGURE 3 EXPECTED TRANSMISSION RECEIPT TIME



Tamper-proof key storage

Tamper-proof key storage is designed to prevent unauthorized extraction and redistribution of secret keys. The protection of the keys that enable the use or reception of high value services is a reasonable pre-emptive design goal, rather than waiting for theft to occur. >

FIGURE 2 DOCSIS 1.1 CABLE MODEM RANGING



tion techniques described earlier will not catch this clone because it is not using its MAC address. In fact, if the clone uses a MAC address of another valid cable modem, an attempt at intrusion detection could result in deauthorization of a valid cable modem—a denial of service attack.

After this initial ranging, the clone ranges again with the cloned MAC address. The steps are as follows:

1) CM2 (the cable modem clone) performs initial ranging using a random, but valid, MAC address to get its ranging offset t2 from the CMTS (as illustrated earlier, in Figure 2).
2) CM2, which has the identity (including the MAC address) of the legitimate clone master (CM1), listens for CM1's initial ranging information. Based on snooping the initial ranging response from the CMTS to the clone master (or through some OOB method), CM2 now knows the value of t1.
3) CM2 then calculates the difference between its time offset (t2) and CM1's time offset (t1).
4) CM2 can now perform subsequent initial ranging using the CM1 ID and appear to the CMTS as if it were at the same location as CM1. CM2 can do this by sending a ranging request t2-t1 seconds earlier than it is supposed to.
5) CM2 can now sniff the downstream to note any use of CM1 (or through OOB methods), and if clear, CM2 can request upstream transmission slots using CM1's identity
6) The headend sees the transmission in the correct assignment with the correct time offset and cannot tell the difference without more sophisticated transmission arrival time detection.

An advantage of this method (if you can call it that) is that the CMTS only sees one transient ranging request with an ID that is not subscribed. All subsequent initial ranging will be performed by one of the cloned modems that are using the clone master's identity.

Obviously, there are additional firmware modifications required in the clone master unit and the cloned client unit to facilitate this method of getting around the intrusion detection, but for the most part they are straightforward. The more difficult task is the design of a reliable and undetectable OOB coordination of clones and clone masters.

While this type of timing attack can get around any timing-based intrusion detection, it has limited scalability. In addition, the design of a reliable and undetectable OOB mechanism for the coordination of clones and clone masters may be quite difficult. And even further, any sharing of services would result in loss of privacy for anyone subscribing to the pirate service. All pirate subscribers would be able to snoop on each other's traffic because all of the encryption keys must be shared. In spite of all of these difficulties, it may still be tried and successfully implemented.

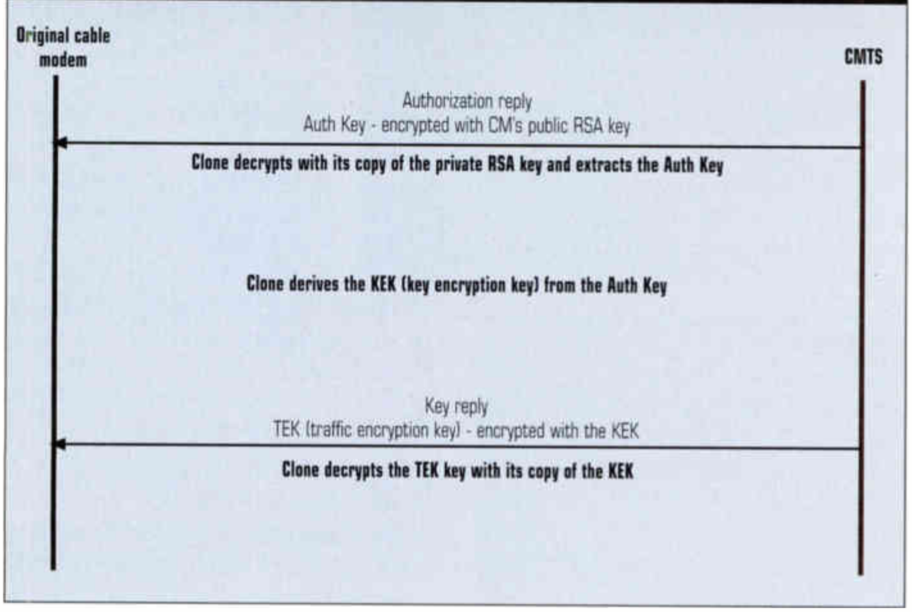
Improved intrusion detection

As mentioned, the CMTS normalizes all of the modems to appear as if they were zero virtual distance from the CMTS. The resolution of the CMTS sampling clock is nominally 10.24 MHz and gives a resolution of approximately 100 feet as to the modems' actual physical distance from the CMTS.

Because modems are only ranged to within 100 feet, the CMTS could sample at a greater granularity and provide additional ranging resolution such that cloned units that are grabbing clone master bandwidth could be detected. This Δt is shown in Figure 3 (on page 150). There may be variations from temperature or individual modem characteristics that may add uncertainty to this measurement. Be sure to recognize these at the CMTS to obtain an acceptable false alarm rate.

A second method would be to introduce a random offset sent to each cable modem in the ranging response message, but continue to measure with the current resolution. For example, if the least significant 3 or 4 bits of the initial ranging response messages were randomized, the measurement uncertainty (Δt) would be increased to somewhere in the range of 800-1,600 feet. The sampling frequency would remain the same, so

FIGURE 1 PASSIVE THEFT OF BPI+ KEYS BY A CLONE



ceivers. This is directly opposite to normal unicast services, where usually a receiver would not want to share its keys with others, both for privacy and to prevent unwanted charges to the subscriber account.

Regardless of how well any design attempts to hide the key that decrypts the media, an attacker will eventually find this key. A more effective approach is physically to secure the key inside tamper-proof storage, such as a specialized microprocessor or a smart card.

The problem is much harder to solve for media that has persistent value. The recent hack of the key decryption key for digital video disks (DVDs) is a powerful example of how quickly key hiding schemes can be compromised. In this case, the requirement is for the key encryption keys, the media encryption keys and the media content itself never to be seen in an unencrypted form. This can be effectively accomplished only when both the keys and the content are never exposed outside of a tamper-proof environment.

Fortunately, media content protection has a simpler solution if the content does not need to remain encrypted once the access to the content is granted (such as with broadcast TV). In this scenario, only the cryptographic keys need to be kept in a tamper-proof area. This requires a relatively small amount of tamper-proof storage, which can be achieved with reasonable cost.

Beyond BPI+: intrusion Detection

The ability to operate undetected is essential for any pirate unit. If there were any detectable characteristics that distinguish the unit, the network could identify that a cloned ID were being used.

In general, characteristics associated with a cable modem include: distance from the CMTS, transmission power level, transmission frequency and equalization coefficients. Other intrusion detection techniques also are possible.

Different clone units' transmissions do not take the same path back to the CMTS, which results in a different distance between each clone and the CMTS, usually measured as a time offset. These differences may be used to identify units that attempt to appear identical to the CMTS and network.

Ranging detects intrusion

To understand how the CMTS could use the time offset to spot cloned units, one needs to understand the DOCSIS process called ranging. DOCSIS defines a network-wide 32-bit timestamp that is broadcast to all units that are part of the network domain. The client unit uses this timestamp to both synchronize an internal reference clock and define the exact time to transmit on the upstream channel.

Because all of the client units in the network are different distances from the receiver in the CMTS, there must be some mechanism to normalize all of the individual client unit's transmitted burst arrival times. This process is called ranging, shown in Figure 2 (on page 148). There is a ranging region defined within the upstream bandwidth assignment that is wide enough to accommodate the closest and farthest cable modem from the CMTS receiver at the headend. The receiver measures the arrival time of the ranging burst and calculates the difference of the arrival time of the burst to the time that the burst was expected. This difference is then sent to the modem and used as an offset.

The effect of this process on the modems is that they all appear to be the same distance from the CMTS receiver. The resolution of this measurement (worst case) is approximately 100 feet.

A CMTS can perform physical layer (PHY) intrusion detection based on the timing offsets obtained during ranging. The CMTS can keep a record of each MAC address and the time offset that represents that modem's physical location in the network. Any time a single MAC address is associated with two or more time delays, the CMTS would flag this MAC address as being a potential cloned modem.

Defeating detection

If one could spoof the system into believing that client units located at different distances from the CMTS receiver were really located at the same distance, the time offset check at the CMTS would no longer reveal cloned units. A clone first performs ranging as described in the previous section. However, instead of its own MAC address, the clone uses a MAC address of some other valid cable modem, or a random MAC address, if the CMTS will accept it.

After this initial ranging, the clone will know its time offset from the CMTS—known as t2. Intrusion detec-

While the DOCSIS retail model has great benefits, it also means the possibility that unscrupulous users could buy modems at retail and then use them to pirate services. Fortunately, DOCSIS provides hooks for detecting and combating such piracy. DOCSIS-certified modems such as these will work with several privacy and security mechanisms built into the specification.

These coordination messages would be encrypted with BPI+. To decrypt those messages, all clones could snoop on the key management messages, which also results in loss of privacy.

Though it is possible for clones automatically to coordinate network access times, it is complicated and restricts each active clone to certain hours of operation—thus limiting the value of active clones and their usefulness for stealing unicast services.

Partially active Cloning attacks

With partially active attacks, a clone does not authenticate itself to the CMTS. It listens for the original modem with that MAC address and steals the traffic encryption key (TEK) that is being delivered to it. Once the clone has the key, it begins to transmit upstream and listen to the downstream.

The process used by the clone to steal the traffic encryption key is illustrated in Figure 1 (on page 146).

The clone only listens to downstream messages from the CMTS. Therefore, upstream messages that are normally present in BPIKM are not shown in Figure 1. After receiving and decrypting two downstream messages, a clone will share a TEK with both the original cable modem and the CMTS.

Passive cloning attacks

As with partially active cloning, a passive clone does not authenticate itself to the CMTS. It waits until the legitimate modem authenticates itself and then steals its TEK. A passive clone, however, never transmits upstream packets. It is limited to snooping on downstream packets. Because this clone never transmits, it cannot be detected at the CMTS. Thus, intrusion detection techniques cannot be used against passive cloning attacks.

A larger scale attack would have a pirate distribute keys into passive clones and at the same time subscribe for premium multicast services. A common type of multicast service would be the delivery of streaming video and audio. By snooping, each clone could steal multicast services for free—analogous to cloning attacks on set-top boxes.

The only practical thing to reduce the risk of passive clones is to add tamper-proof key storage into the modems.

One-to-many multicast

Multicast IP allows a single source to send packets to multiple receivers using a common IP address in either a one-to-many or many-to-many distribution model.

The first multicast distribution model represents multicast from a single transmitter to many receivers. This is very similar to the existing TV broadcast model.

The second multicast distribution model is multicast from numerous transmitters to many receivers. The receivers may be participating in the control of the content. An example of this type of a multicast environment would be a multicast videoconference. Members may communicate with all of the other members of the group simultaneously.

Theft of multicast services

The focus of security for the many-to-many distribution model is authentication of each participant to the rest of the group, while the focus for the one-to-many distribution model is access control.

The very nature of a multicast service implies that the original information must be distributed to many receivers as a single transmission. If the content is protected cryptographically, in general, there must be a single unique key that allows access to the data.

In the case of the one-to-many multicast, a likely application would be Internet TV. In this case, a receiver possessing the key to decrypt the data might be financially encouraged to illegally share this key with other re-prove its identity to the CMTS with the help of a Rivest Shamir Adelmann (RSA) public/private key pair and an X.509 certificate. Both the RSA key pair and certificate are installed into the cable modem at the time of manufacture.

- Access control. The CMTS maintains authorization information for all registered cable modems. Unauthorized modems are denied access to the network. Further, authorized modems are restricted to specific service flows. The CMTS will not deliver a decryption key for a multicast flow to a particular modem unless it is authorized for that service.

BOTTOMLINE

> **Can You Prevent Cloning?**
> The Data Over Cable Service Interface Specification (DOCSIS) 1.1 standard includes the security specification Baseline Privacy Plus (BPI+) that cryptographically prevents unauthorized cable modems from operating as clones.
>
> BPI+ does not require a modem to use tamperproof key storage, nor does it specify intrusion detection techniques—automated detection and prevention of illegal behavior. While BPI+ security is adequate for unicast data services, it may be augmented with intrusion detection to identify duplicate units. BPI+ also may be augmented with tamper-proof key storage to provide additional protection for higher value multicast services.
>
> When streaming multicast services, such as Internet TV, become more popular and service providers start charging substantial fees for these services, cable modem cloning attacks are likely to become of greater concern than they are today. When that happens, tamper-proof key storage coupled with BPI+ can serve as an effective deterrent against cloning.

- Key management. BPI+ defines the BPI key management (BPIKM) protocol, where the CMTS periodically generates symmetric encryption keys for different service flows and delivers them to the cable modems. BPIKM supports both unicast and multicast service flows.

As a result of the BPIKM protocol, the cable headend is not required to manually maintain a set of encryption keys for modems. Encryption keys are generated and refreshed automatically.

All of the cryptographic services provided by BPI+ are based on the fact that each modem contains a unique public/private RSA key pair and an X.509 certificate. These cryptographic services could be bypassed if the RSA key pair and certificate were copied into duplicate cable modem units, called clones.

It was determined that because of the limited scalability of such attacks, protection against them is unnecessary. Still, the possibility of cloning exists, and it is prudent to plan for additional security that would discourage such attacks on DOCSIS-based services.

Cloning attacks

A clone is any unit where the duplication of any of the permanent keys allows it to imitate the identity of a legitimate original unit. A clone may be created by stealing the keys from another modem. Alternatively, a pirate might purposely register a cable modem under a fraudulent account and then copy the keys into cloned units. A pirate would then sell those clones. This attack is most interesting whenever data network access is offered at a flat rate, where clones are sold to circumvent the $30-$50 monthly charge for service.

Under DOCSIS 1.1 and BPI+, such a permanent key would be the 1,024 bit private RSA key of the cable modem. Duplication of this key and the corresponding public key certificate would be enough to authenticate a clone to the CMTS.

There are several types of cloning attacks. Each clone could authenticate itself to the CMTS. Alternatively, a clone might wait until the legitimate unit with the same identity has authenticated itself and then start transmitting. Further, a clone may be completely passive and be limited to snooping.

Active cloning attacks

In this type of attack, each clone individually authenticates itself to the CMTS. Normally, a single cable modem MAC address is restricted to one RF domain in the CMTS. A single RF channel is limited to about 500 cable modems. Thus, this attack is not easily scalable. To scale this attack, a pirate would have to clone a modem in multiple RF channels.

To steal service, multiple clones of the same MAC address have to coordinate the times at which they access the network—manually or possibly by snooping the downstream to see if this MAC address is already active. Otherwise, if the same MAC address appears in the same RF channel twice, they probably will interfere with each other and can be detected by the CMTS.

If a clone were created without the owner's consent, it could be used in denial of service attacks. The clone could purposely transmit at the same time as the original modem. But, once the original modem were off the network, the clone could steal service.

Coordinating clones

Active cloning attacks require out-of-band (OOB) coordination between clones to make sure that they do not access the network at the same time. This coordination could be done via some manual means, such as e-mail.

More efficient coordination also is possible. The cloned cable modem could be designated to distribute the schedule of when each clone can transmit. One possibility would be for a cloned modem to send to its own MAC and Internet protocol (IP) addresses. Such messages would be reflected back down by the CMTS and received by all the clones. Alternatively, these messages could be addressed to an IP multicast group consisting of the IP addresses of the cloned units.

Your
Be Cloned

fication also protects the link between the cable modems and the cable modem termination system (CMTS). BPI+ provides privacy on this link, as well as authentication of the cable modems to the CMTS.

BPI+ does not address cloning attacks on this link, where all cryptographic keys within a cable modem are duplicated into another unit, called a clone. This is not a serious problem because this attack is limited in scalability, as we'll discuss later.

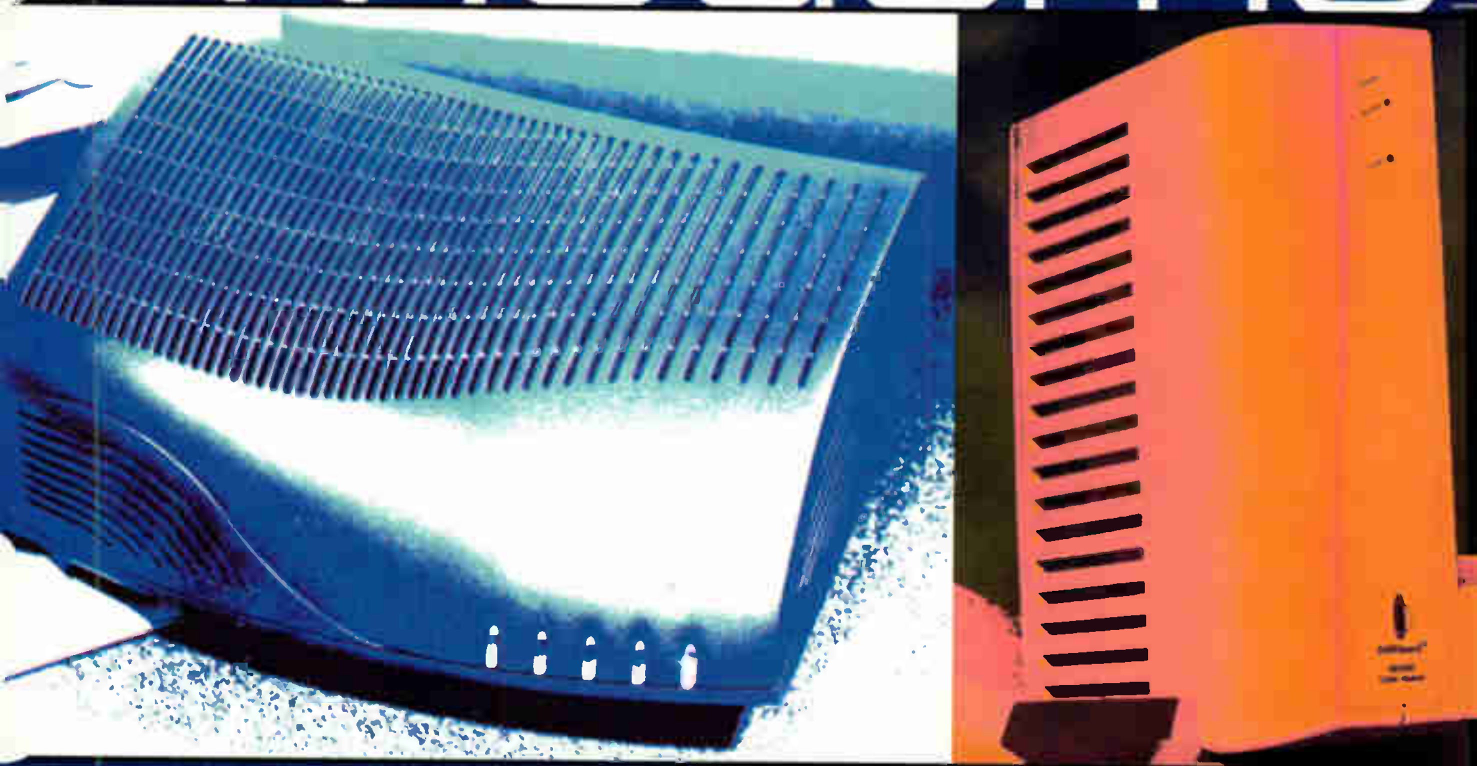
Nevertheless, DOCSIS 1.1 provides hooks that allow for additional security measures that along with BPI+ would reduce the risk of cloning attacks. These measures include intrusion detection and tamperproof storage of cryptographic keys.

Overview of BPI+

BPI+ provides the following security services:

- Media access control (MAC)-layer privacy. Privacy for all downstream and upstream data packets is achieved through encryption with a symmetric key. Currently, only data encryption standard (DES) encryption is provided for data packets. However, BPI+ provides mechanisms for negotiating additional encryption algorithms in the future.
- Cable modem authentication. Each cable modem has to periodically

Don't Let Modems



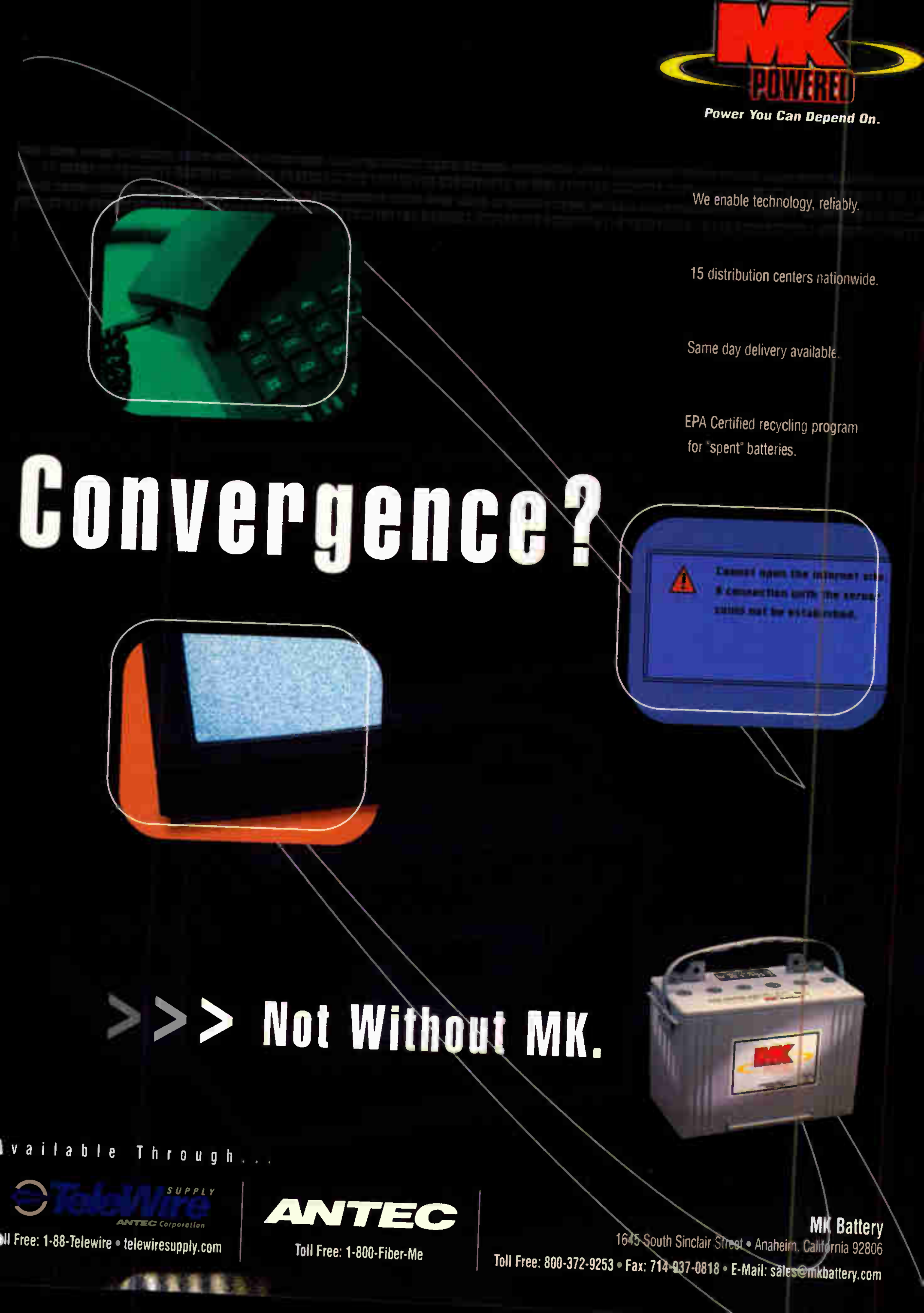
DOCSIS Security Protects Your System

By Sasha Medvinsky
and Steven Anderson

Cable modem services are hot. And, unfortunately, with any hot new service comes the opportunity for theft. Still, that doesn't mean engineers will have to stay up all night worrying about fraud.

CableLabs has built security provisions into Data Over Cable Service Interface Specification (DOCSIS) 1.1 to help engineers thwart would-be thieves. By being aware of the risks and augmenting the CableLabs procedures, engineers can sleep better.

DOCSIS 1.1 includes the Baseline Privacy Plus (BPI+) security specification, which cryptographically protects against unauthorized cable modems posing as authorized units. The speci-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phase, qualification of the customer's residence and desired service. Because broadband wasn't (and still isn't) available everywhere instantly, it was necessary to determine where the customer lived. The system pictured in Figure 2 (on page 136) was our first attempt at resolving this problem. This can't be based on a state or ZIP code because it's necessary to ensure that high-speed data is available for the particular customer's dwelling.

Selection of the state and service options enabled the system qualifier to begin a detailed system check. The results of this check are displayed in Figure 3 (on page 138). This phase determined if the customer's PC met minimum requirements needed for high-speed data service.

Once these checks were complete, the last phase of this process evaluated whether the customer's PC was capable of supporting MediaOne high-speed data. If it was capable, the system gave the customer a code to provide to MediaOne during signup. (See Figure 4 on page 138.) This code would speed MediaOne's data entry during the signup conversation. If it did not pass, the customer was allowed to view the results in more detail, which indicated where discrepancies existed.

MediaOne supported the concept of an application that could make high-speed installations more efficient. However, the system qualifier provided only a small piece of what high-speed data customers need in terms of self-help applications. What actually is needed is a suite of tools or a self-help toolkit.

Self-help toolkit

The need to expand the customer base along with the need to cut expenses and reduce the number of service calls requires better-equipped customers. Self-help tools abound on the Internet. Many Internet sites, such as www.computingcentral.com/topics/bandwidth/speedtest.asp, are providing a growing number of free services, from Internet protocol (IP)-switchers to speed checkers.

PCs also are becoming more broadband-friendly. For example, new PCs come with simple wizards to configure Internet services along with the ability to save and restore multiple configurations. As a result, the PC is better able to adapt to the type of broadband access available in the customers' area. Short of full-fledged broadband-ready PCs that completely set up a network interface and IP address settings, these improvements represent significant progress toward a more efficient and trouble-free Internet installation. CT

Bruce Bahlmann is senior systems engineer for MediaOne's Internet Services Group. He can be reached via e-mail at bahlmann@bigfoot.com.

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FIGURE 3
MEDIAONE SYSTEM QUALIFIER PROTOTYPE CHECKS

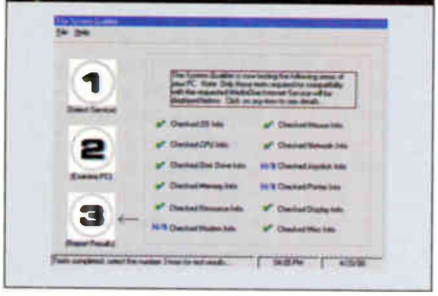
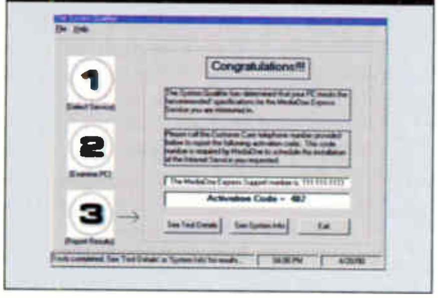


FIGURE 4
SUCCESSFUL QUALIFICATION SCREEN



capable of running the MediaOne high-speed data product. The end result would be one of three possibilities:

1) The computer "passed" the test, so an install can proceed.
2) The computer "passed with a warning." In this case, the system met the minimum requirements for service, but not the recommended requirements (such as in the case of free hard disk space). The install could proceed, but the user and MediaOne staff (sales, support and field service teams) would know that a potential problem exists. Knowing this in advance allows teams to schedule additional time for the install.
3) The computer "failed" the test. In this case, the application would state why (lack of memory, disk space and so on) and make recommendations as to what the user could do to remedy the problem and eventually have the product installed successfully.

In the case of the first two results ("passed" or "passed with a warning"), MediaOne provides the customer with a result code. This result code contains the serial number of the PC's hard drive and an indicator of any potential problems that could be occurring.

In the case of the third result ("failed"), a local computer supplier could help the customer resolve the problem. This was done to demonstrate that, if desired, the eventual application could potentially generate revenue. This could be accomplished by selling this "advertising space" to suppliers.

The prototype MediaOne developed divided the problem of system qualification into four phases. The first phase (see Figure 1 on page 136) mainly explained to the customer what this application does and how to use it.

Customers would like to know what the system qualifier does and what they can expect to see once it is complete. This directly led into the next

1998 (a conservative estimate), and we assumed the same 5 percent (1,500 additional subscribers) would be affected by PC minimum requirements. We further assumed that these lost 1,500 customers were spread out over the year. Using these numbers, the math comes out as follows:

Lost 1998 revenue = 1,500 x 5 x $39.95 = $ 299,625

1998 expense = 1,500 x $125 = $187,500

Total 1998 impact = $ 487,125

However, the impact numbers do not take certain elements into account. One is time lost by sales representatives when they have to walk a customer through the prequalification process. Today the sales representative must take time to manually determine if a customer's PC meets the minimum specifications. This means longer talk times and less time available to close additional sales calls. Another is negative customer satisfaction and press received when installations do not go according to plan. Finally, there's lost revenue from additional customers gained year-to-year by having implemented this program.

The result of a 5-percent increase in installation efficiency would amount to a savings of $16,237.50 per 1,000 projected additional customers for the year. Each 1 percent increase in installation efficiency would amount to a savings of $3.25 per additional projected customer for the year.

BOTTOMLINE

> Self-Help for Cable Modems

Armed with a self-help toolkit, customers can do such things as determine whether their personal computer (PC) can support broadband services, check the speed of their Internet connection, send and receive test e-mails, run system and diagnostic tests, and even troubleshoot localized problems. By having customers prequalify their PCs, cable operators can reduce the number of failed installs, saving both time and money.

MediaOne's System Qualifier prototype demonstrated the potential for selling advertising space within self-help tools. The availability of this "customizable" advertising space along with the growing number of self-help tools will enable these tools to reach an increasing number of broadband customers. While a number of companies offer self-help tools for a fee, this service should likely be free to take advantage of the definite advertising opportunities. The good news: A vast majority of these self-help tools can be operated via an Internet connection. The industry only has scratched the surface of what is to come in this area.

Possible solutions

To reduce potentially expensive installations and failure rates, self-help tools are needed. Currently there are a few different approaches to providing self-help tools.

Stand-alone application: self-help products that can be executed on a customer's PC. This approach is capable of performing detailed diagnostics of the computer; however, its usefulness is limited because it isn't able to change with the times (new operating systems, advertisers, requirements and so forth). Typically it is suited for only one type of broadband access (integrated services digital network, digital subscriber line, or high-speed data via cable) and must be updated manually.

Internet-based approach: self-help products that are accessible via a Web site. This approach is less capable of performing detailed diagnostics on computers to the point where it may not be able to prequalify the computer. However, it is extremely flexible, able to work with all types of broadband access, and is able to keep up with changes in software, hardware and advertisers.

Combination: self-help products that attempt to leverage advantages of stand-alone and Internet-based approaches. This approach can be extremely effective in offering a wide variety of self-help tools to customers; however, it typically comes with a price tag and does not allow the user to reap the benefits of making deals with vendors that want to advertise with customers.

FIGURE 1 MEDIAONE SYSTEM QUALIFIER PROTOTYPE INSTRUCTIONS

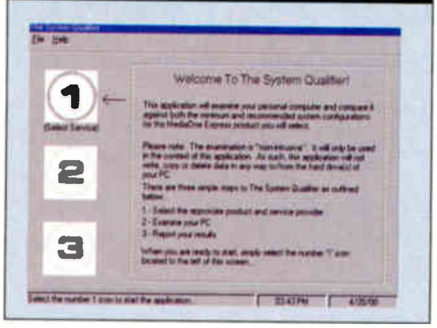
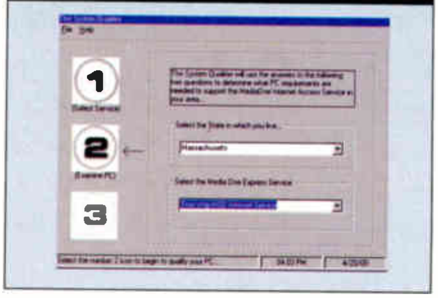


FIGURE 2 MEDIAONE SYSTEM QUALIFIER PROTOTYPE RESIDENCE AND SERVICE SELECTION



User initiative

Another way to address this dilemma would be to allow a potential customer to automatically prequalify his or her own PC. This application would examine the user's PC in a non-intrusive fashion and then compare the results against the known requirements of the various MediaOne high-speed data product offerings for an applicable region. This application eventually could be delivered to customers via the Internet, e-mail or through promotional media.

Before rolling out a truck for installation or a service call, the customer could run a simple, easy-to-use application. This application (currently known as The System Qualifier) clearly would state if the computer were

the Art of Self-Diagnostics

Tips for Reducing Installation Failures

By Bruce Bahlmann

Cable operators installing high-speed data services on subscribers' computers are experiencing significant setup failures, a time-sensitive and expensive problem.

But the failure rates are preventable.

In 1997, MediaOne began examining installation and service metrics for its high-speed data product. It soon became clear that its high-speed data business was seeing a larger installation failure rate than its core business counterparts. The failure represented between 3 percent and 9 percent (depending on the region and the month) of all high-speed data install attempts.

The problem was because high-speed data installations deal with the unknown of the subscriber's personal computer (PC). Specifically, the failure rate was high because we were trying to install service on PCs that did not meet the minimum system requirements for high-speed data service.

By eliminating the wasted time and effort on failed installs, and allowing personnel to roll trucks only to qualified systems, the number of successful high-speed data installs can be increased by more than 5 percent.

Do the math

These types of improvements are difficult to realize or translate into a number that is meaningful for any multiple system operator (MSO). However, certain assumptions can be used by any MSO to determine a reasonably accurate assessment of high-speed data installation costs on non-qualified personal computers:

- Assume you could increase your yearly customer base by an average of 5 percent.
- Assume lost customers (5 percent) were spread out over the year. (Only five months are used to calculate the lost revenue because a majority of customers typically join up late in the year.)
- Assume each failed truck roll costs $125.
- Assume you charge $39.95 for high-speed data service.

Based on these assumptions, some simple calculations are all that's needed:

Potential customers = 5 percent x projected customer adds for year

Lost revenue = potential customers x 5 x $39.95

Expense = potential customers x $125

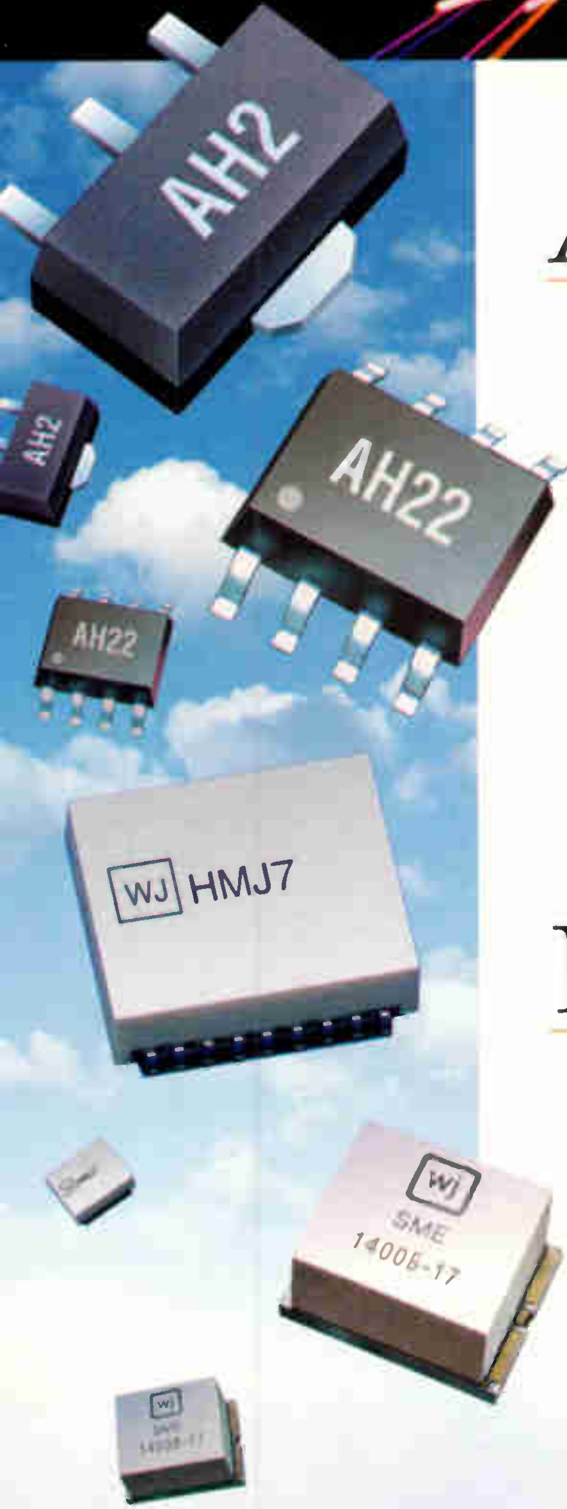
Total annual impact = lost revenue + expense

Just a 5-percent increase in installation efficiency can have a significant impact on a company. MediaOne's projected 1998 numbers, for example, added up to hundreds of thousands of dollars.

MediaOne planned to add 30,000 high-speed data two-way customers in

Perfecting

Cable Performers:



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CTB	-75*	-61**	dBc
IP2	48	70	dBm
IP3	38	41	dBm
Gain	16.5	11.7	dB
NF	3.0	4.5	dB
DC voltage	5	5	volts
Package	SOT89	SOIC8 (Thermally enhanced)	

*Measured at 30 dBmV output/channel, 83 channels.
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return path with actual data and measure the performance. Packets that are lost or contain errors can be attributed directly to the return path performance, assuming the forward path performance shows good MER and BER.

Once a problem is identified on either the forward or return path, the technician can quickly isolate its location using standard troubleshooting techniques, testing at the tap, ground block or modem input. (See Figure 3 on page 130.) By measuring the performance at the tap, he or she can determine if the problem is with the network or the wiring. If it's the wiring, standard troubleshooting techniques of checking the various locations in the installation for performance quickly will isolate the source of the problem so it can be repaired or replaced.

"Modems that are continually resending can hog system bandwidth."

Wrap-up

By testing cable modem installation using a system analyzer, technicians can find problems quickly, making them much more efficient. This saves money because more installations can be done with the same number of people, and because the performance of the network is checked, there will be fewer service calls stemming from installations with poor margin for error. The network throughput will be better because of fewer errors resulting in fewer resends. Ultimately, this makes more money for the operator and results in happier subs. CT

Rick Jaworski is vice president of marketing for Hukk Engineering. He can be reached at rick.jaworski@ hukk.com.

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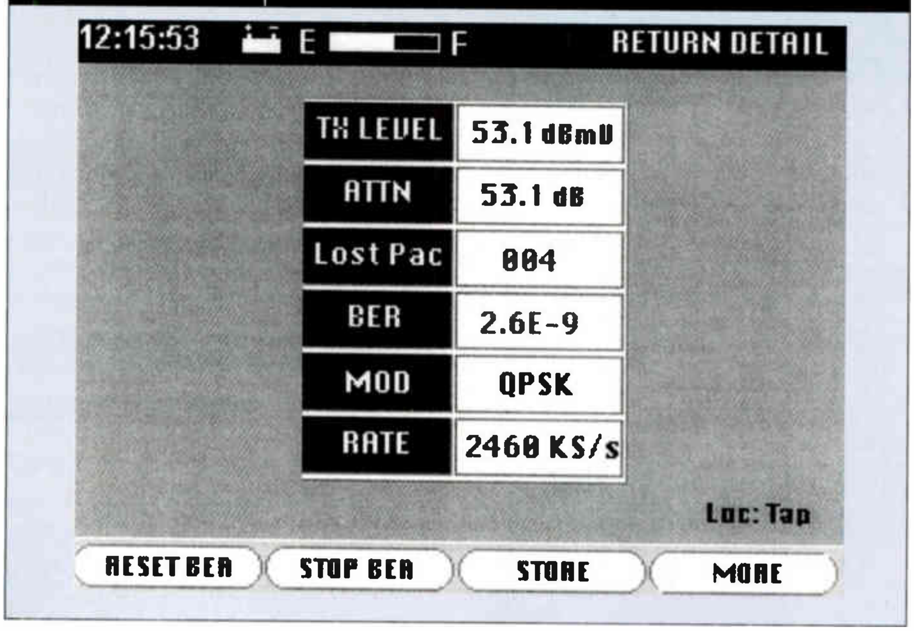
FIGURE 2 RETURN PATH TEST MEASUREMENT SCREEN



handle any additional errors should the system degrade in the future.

Once you determine that there is a poor MER or BER, the technician can use the constellation display and automatic constellation diagnosis to determine the type of impairment affecting the signal to help find the problem.

Return path measurements

On the return path, the system analyzer is transmitting to the CMTS, so some measurements need to be inferred based on information received on the forward path from the CMTS. The key measurements on the return path are path attenuation, BER and lost packets. (See Figure2.)

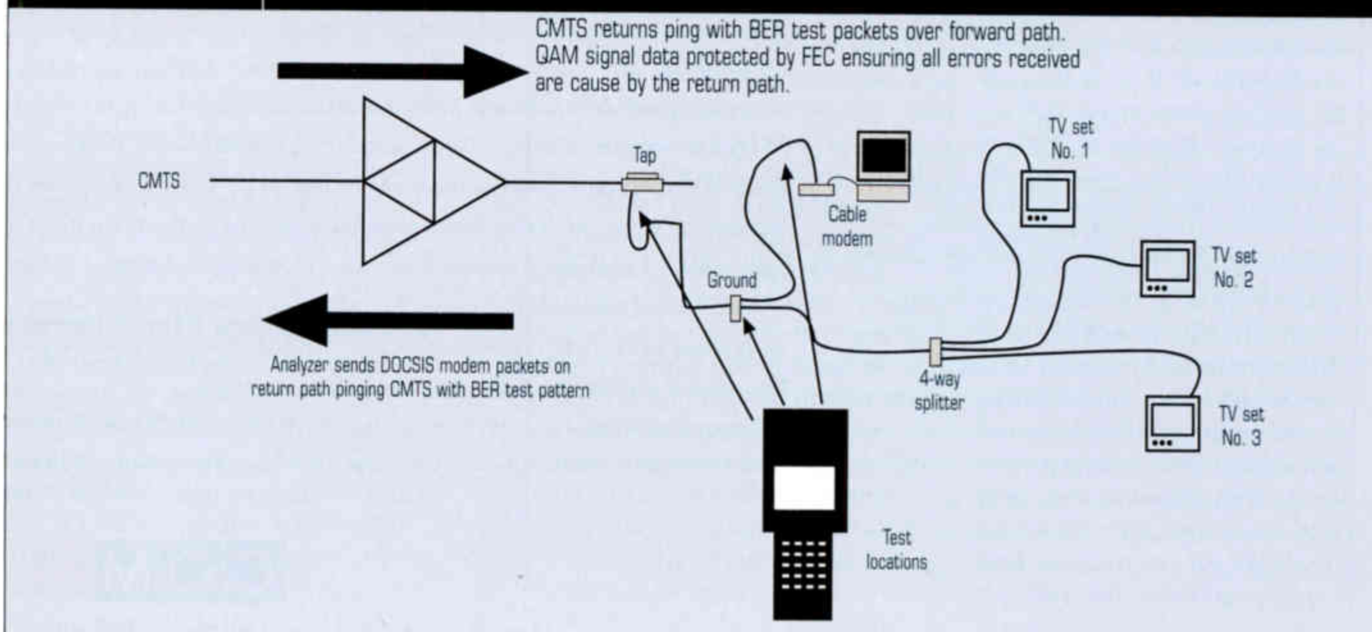
The Data Over Cable Service Interface Specification (DOCSIS) calls for a maximum power output of +58 dBmV using QPSK modulation and +55 dBmV using 16-QAM modulation. Typically, the receive level of the CMTS is 0 dBmV, so the output level of the modem is the same number as the attention in dB. If the attenuation is so large that the modem must operate close to the maximum level, there won't be enough margin for future degradations. Thus, the technician needs to try to reduce the amount of loss in the drop to allow for margin.

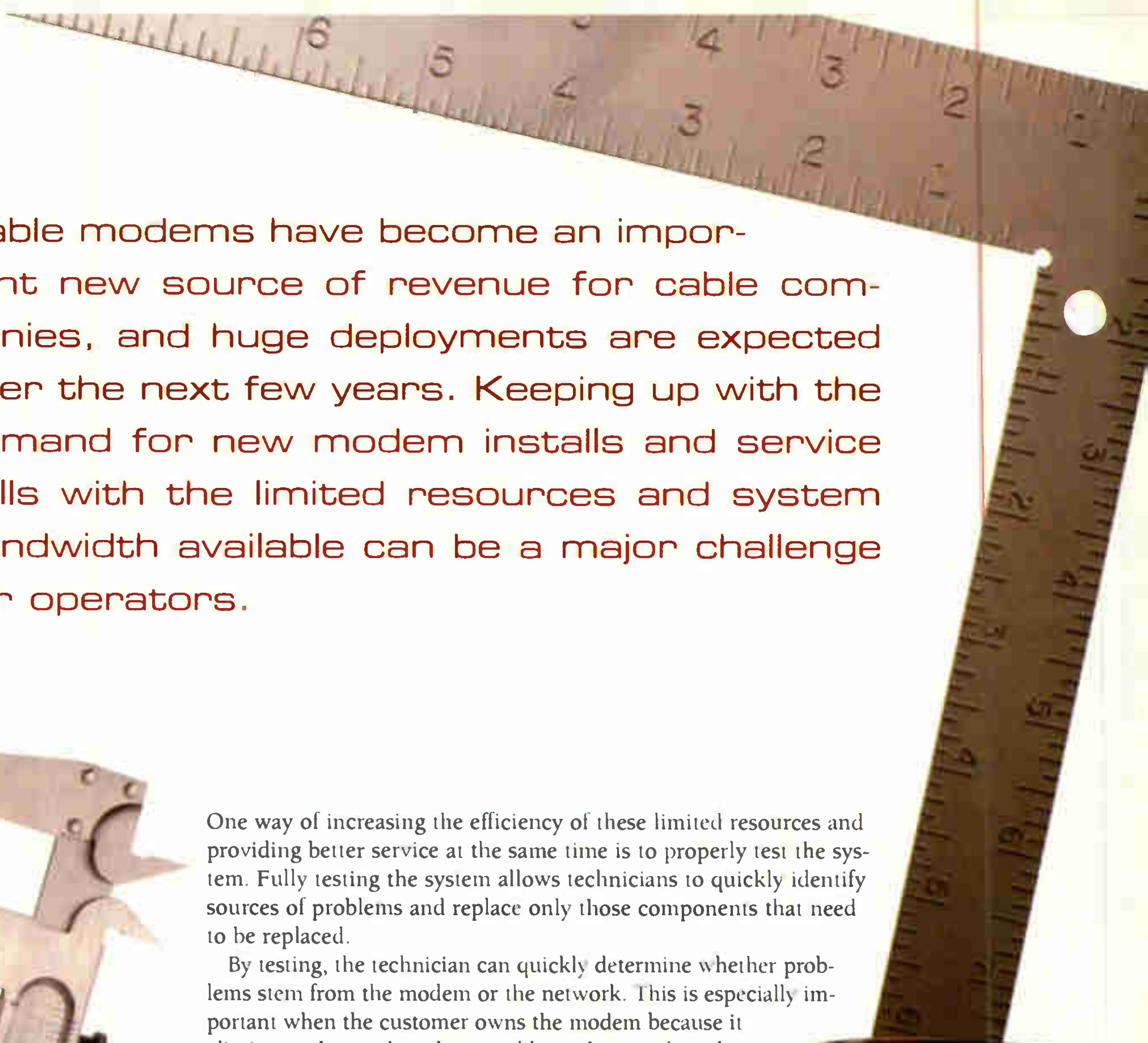
To test BER on the return path, the analyzer can ping the CMTS with a packet of known data. The ping command will return the packet to the analyzer from the CMTS on the forward path. To be sure the packet does not go any further than the CMTS port, the analyzer can use a trace route command to the dynamic host configuration protocol (DHCP) server to determine the route. The first Internet protocol (IP) address in the route to server is the CMTS port.

Because the ping command simply returns the packet to the sender without error checking, any errors to the payload caused by transmission on the return path come back intact to the field instrument on the forward path. Because the forward path has FEC, any errors caused by the return path will be protected by the FEC on the forward path. That way, the instrument can measure the performance of the return path, without being at the headend to receive the signal.

With the return BER function, the technician can completely exercise the

FIGURE 3 RETURN PATH BER TEST





Cable modems have become an important new source of revenue for cable companies, and huge deployments are expected over the next few years. Keeping up with the demand for new modem installs and service calls with the limited resources and system bandwidth available can be a major challenge for operators.

One way of increasing the efficiency of these limited resources and providing better service at the same time is to properly test the system. Fully testing the system allows technicians to quickly identify sources of problems and replace only those components that need to be replaced.

By testing, the technician can quickly determine whether problems stem from the modem or the network. This is especially important when the customer owns the modem because it eliminates the need to chase problems that are the subscriber's responsibility. By testing the system, more service calls and installations can be accomplished in less time, allowing systems to roll out modems quicker and save money. It also ensures that the subscriber has enough margin to maintain long-term reliability.

In addition, testing can help increase the throughput of the network. Cable modems will resend packets until they get through error-free. Modems that are continually resending can hog system bandwidth. Although this may not be noticeable initially while there are only a few subscribers online, once the numbers of modems increase, the bandwidth may not be able to handle all of the resends, and the system grinds to a halt. Determining the cable modem system performance and troubleshooting the problems will be crucial once traffic becomes heavy.

Divide and conquer

Testing of cable modem systems can be broken into two parts, the forward path and the return path. Forward path testing is identical to testing digital video and has been common over the past couple years. Tests

Testing and Measuring DOCSIS Cable Modem Systems

Today's Tools Simplify the Task

By Rick Jaworski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Internet. RC4 is a proprietary cipher and is owned by RSA Data Security.

MMH: The multilinear modular hash (MMH) function is a message authentication code. The original message is run through the hash (with a secret key), and the code is the result. The code is sent along with the original message. The receiver of the message calculates the hash over the original message (also with the secret key) and compares the final message authentication code with the code sent with the message. If the two codes match, the receiver can be assured that the original message is authentic.

RADIUS: The remote authentication dial-in user service (RADIUS) provides authentication, authorization and accounting services. In PacketCable, RADIUS is used at the record-keeping server to gather billing events from both the CMTS and call management server. RADIUS authentication keys are hard-coded to zero. IPsec is used for message integrity, as well as privacy. Its key management is IKE.

DNSsec: The domain name service (DNS) originally was designed to support queries of a statically configured database. While the data was expected to change, the frequency of those changes was expected to be fairly low, and updates could be made manually or through a static provisioning system. With PacketCable, DNS updates are expected to occur dynamically and hence are subject to attack.

DNSsec, the DNS security protocol, authenticates dynamic exchanges between the call management server (CMS) and the DNS server as DNS entries are updated. The DNS client contains a pre-published public key for a DNS server, and the DNS server signs all DNS entries.

What's it mean for you?

All Internet communications are inherently insecure and subject to attack because of both distributed processing and open communications. PacketCable is no exception, so sophisticated security methods are necessary.

Within the PacketCable architecture are many interconnected network elements, distributed across both the public Internet and private IP networks. The interfaces between these devices must be protected based on the threats to these interfaces. In addition, bearer channel communications must be protected from eavesdropping.

This article has been reprinted with permission from the *Proceedings Manual* of the Society of Cable Telecommunications Engineers' Conference on Emerging Technologies 2000. CT

Doug Jones is a member of the technical staff at MediaOne Labs. He can be reached at dxjones@MediaOne.com.

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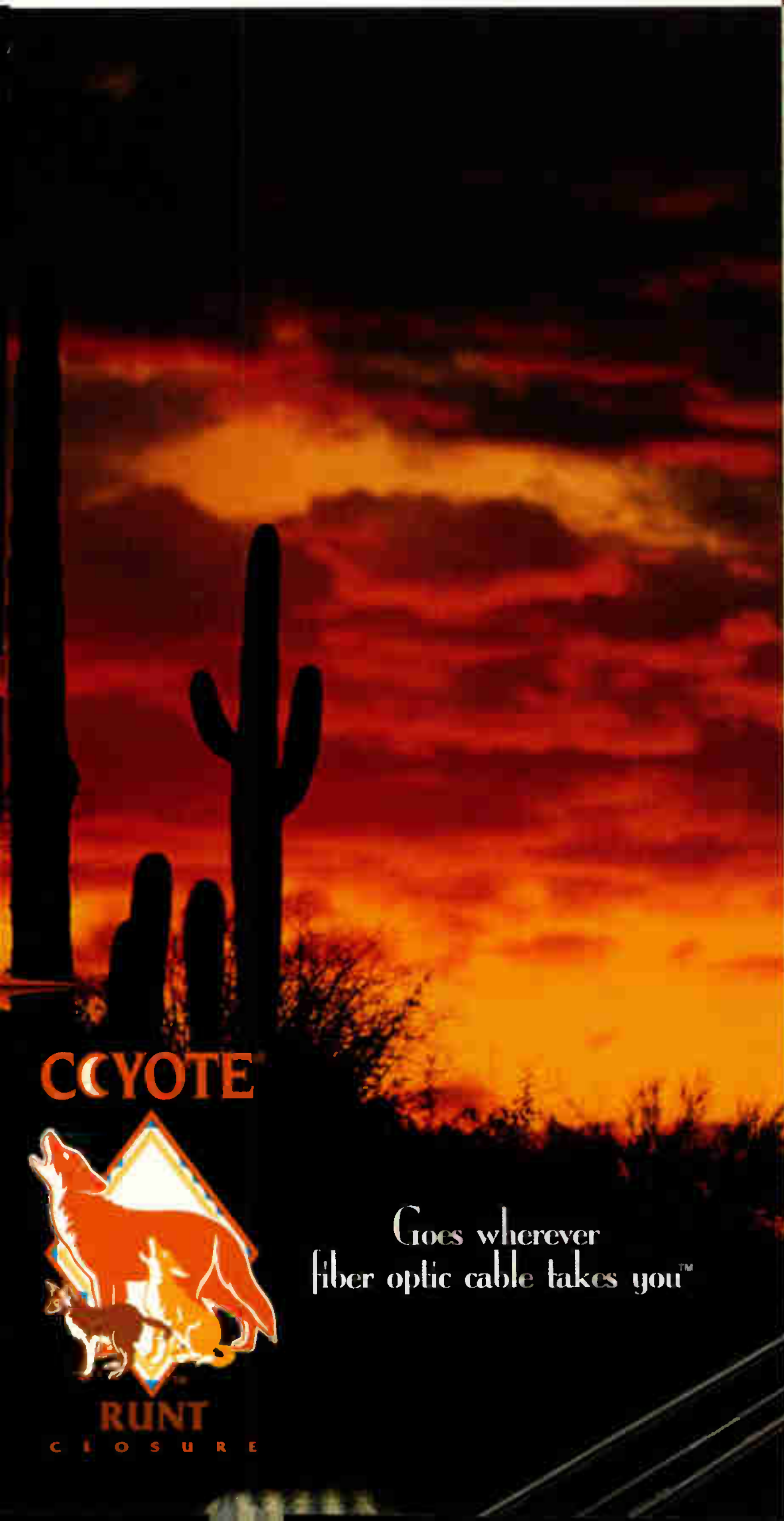

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PREFORMED LINE PRODUCTS

or two calls to the Kerberos library directly or through the generic security services application programming interface (GSSAPI). These calls result in the transmission of the necessary messages to achieve authentication.

End-to-end security for RTP

RTP, the real-time transport protocol, is used to encapsulate PacketCable media streams such as voice and video. RTP uses the real-time transport control protocol (RTCP)

RTP provides end-to-end delivery services for data with real-time characteristics, such as interactive audio and video. Those services include payload-type identification, sequence numbering, time stamping and delivery monitoring. PacketCable runs RTP on top of UDP/IP to make use of its multiplexing and check-sum services; both protocols contribute parts of the transport protocol functionality. RTP supports data transfer to multiple destinations using multicast distribution if provided by the underlying network.

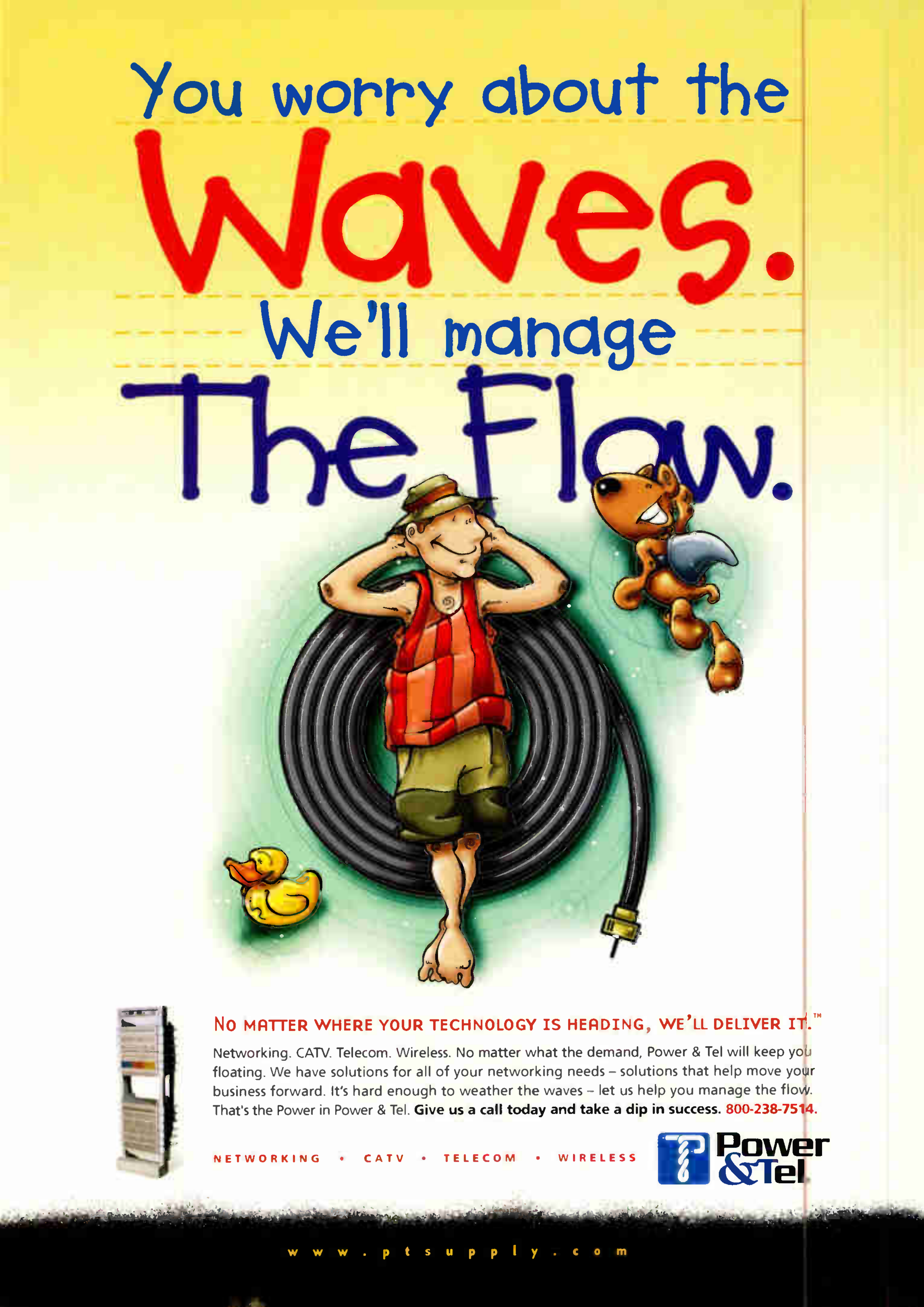
RTP does not provide any mechanism to ensure timely delivery or provide other QoS guarantees, but relies on other PacketCable services to do so. It does not guarantee delivery or prevent out-of-order delivery, nor does it assume that the underlying network is reliable and delivers packets in sequence. The sequence numbers allow the receiver to reconstruct the sender's packet sequence, but they also might be used to determine the proper location of a packet, for example, in video decoding, without necessarily decoding packets in sequence.

While RTP primarily is designed to satisfy the needs of multiparticipant multimedia conferences, it is not limited to that application. Storage of continuous data, interactive distributed simulation, active badge, and control and measurement applications also may use RTP.

The protocol is the basis for encoding real-time data streams in PacketCable; hence, encryption is available at this layer. The PacketCable security specification allows for end-to-end ciphersuite negotiation, so that the caller and the callee can choose their preferred encryption and authentication algorithms for the call. Although the current version of the PacketCable security specification only defines RC4 for RTP packet encryption and only the multilinear modular hash (MMH)/message authentication code for packet authentication, additional cryptographic algorithms will be defined as needed to meet future PacketCable application requirements.

Additional security methods

RC4: This secret key encryption algorithm is used in, among other things, the secure sockets layer protocol used by Netscape and other Web browsers to transmit encrypted information (such as banking transactions) over the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Within PacketCable, IKE management is completely asynchronous to call signaling messages and does not contribute to any delays during call setup. The only exception would be some unexpected error, where IPsec is lost by one of the endpoints.

IKE is a peer-to-peer key management protocol. It consists of two phases. In the first phase, a shared secret is negotiated via a Diffie-Hellman key exchange, which then is used to authenticate the second IKE phase. The second phase negotiates another secret, used to derive keys for the IPsec protocol.

Kerberos

Kerberos provides a means of verifying the identities of principals (an MTA or a network server) on an open, or unprotected, network. This is accomplished without relying on assertions by the host, without basing trust on host addresses, without requiring physical security of all the hosts on the network, and under the assumption that packets traveling along the network can be read, modified and inserted at will.

Kerberos performs authentication under these conditions as a trusted third-party authentication service by using conventional shared secret key cryptography. Kerberos extensions provide for the use of public key cryptography during certain phases of the authentication protocol. These extensions provide for authentication of users registered with public key certification authorities and allow the system to provide certain benefits of public key cryptography in situations where they are needed.

The basic Kerberos authentication process includes:

- A client sends a request to the authentication server (AS) requesting "credentials" for a server.
- The AS responds with these credentials, encrypted in the client's key. The credentials consist of a "ticket" for the server and a temporary encryption key (often called a "session key").
- The client transmits the ticket, which contains the client's identity and a copy of the session key, all encrypted in the server's key, to the server.
- The session key (now shared by the client and server) is used to authenticate the client and optionally may be used to authenticate the server. It also may be used to encrypt further communication between the two parties or to exchange a separate sub-session key.

Implementation of the basic protocol consists of one or more authentication servers running on physically secure hosts. The authentication servers maintain a database of principals, users and servers, and their secret keys. Code libraries provide encryption and implement the Kerberos protocol. To add authentication to its transactions, a typical network application adds one

CABLE operators face air raid

Broadband Wireless Sweeps the Nation Cable Must Decide: "Beat 'Em or Join 'Em?"

By Elisa Modugno

Like it or not, telecom carriers have found a way to sell data, phone service and even television to cable companies' bread-and-butter customers—the average American citizen.

Swooping from the sky, thanks to Federal Communications Commission wireless broadband spectrum auctions (and in the case of MCI WorldCom and Sprint, massive acquisitions), telecom companies such as incumbent local exchange carrier (ILEC) BellSouth are developing business strategies that involve broadband wireless. The intent behind much of this strategy is to beat cable companies at their own game—especially now that the cable pipe is being used to carry data, Internet and basic phone service.

Telecom carriers, en masse, are falling in love with broadband wireless for two reasons: its ability to circumvent the need for agreements with competing carriers at the local loop level, and the fact that it can do just about everything cable can for individual consumers—though at a higher cost per sub, at least for now.

Telcos' potent weapon

Broadband wireless has many faces. That's because a multitude of spectrum options are available, from the unlicensed spectrum (such as 2.4 GHz and 5 GHz) to local multipoint distribution system (LMDS) in the 28 GHz range, to the 38 GHz and 24 GHz spectrum used by WinStar and Teligent, respectively.

Probably the most direct threat to cable will come from operators such as MCI and Sprint, which own multichannel multipoint distribution system (MMDS) spectrum (2.5 GHz and 2.7 GHz), also known as wireless cable.

Though MCI and Sprint (soon to be one mega-carrier) officials say they plan not to offer TV services, the reason MMDS came into existence was the FCC's desire to promote competition in the cable industry. Needless to say, that tactic failed, and one by one the independent wireless cable operators declared bankruptcy—and became ripe for the telco picking. Cable operators are barred from buying

MMDS licenses. (See Table 1.)

Also, unlike LMDS and the frequencies used by Teligent and WinStar, MMDS is well-suited for individual households—though analysts say fixed wireless equipment still is too expensive for most carriers to justify deployment at that level.

Fixed wireless will most likely thrive in the small business and home office market, says James Mendelson, a telecom analyst at Washington, D.C.-based consulting firm Strategis Group. "Obviously, cable can also play there," he adds.

Mendelson estimates MMDS customer premise equipment alone currently costs carriers about $500 per household. "We expect this (price) to drop soon," he says.

MMDS operators' best bet, he continues, will be to target the multiple dwelling unit (MDU) market. "That'll be their sweet spot," Mendelson says.

However, Sprint and MCI have ambitious plans for the consumer market with their freshly acquired MMDS network. And, says Mike Levin, director of marketing for Sprint's Broadband Wireless Group, the battle between telecom carriers and cable companies is still in the early stages, so who'll win is anybody's guess. (See Figure 1.)

"The battle for the appropriate bundle is really down the road a ways," Levin says. "It's really a fair fight right now (concerning AT&T's cable strategy). The market is open. We're so early in the product life cycle here, I think it's an open field."

To win this "battle of the bundle" with cable, Levin says, Sprint will have to offer TV service at some point.

As for the high cost of MMDS customer premise equipment, Levin says Sprint is not daunted, though execs would definitely like to see the price move down to be comparable with digital subscriber line (DSL) and cable modem technology. But for now, Sprint wants consumers to know it's serious about connecting them via wireless cable. "If that means we'll have to absorb some losses early on, so be it," Levin says.

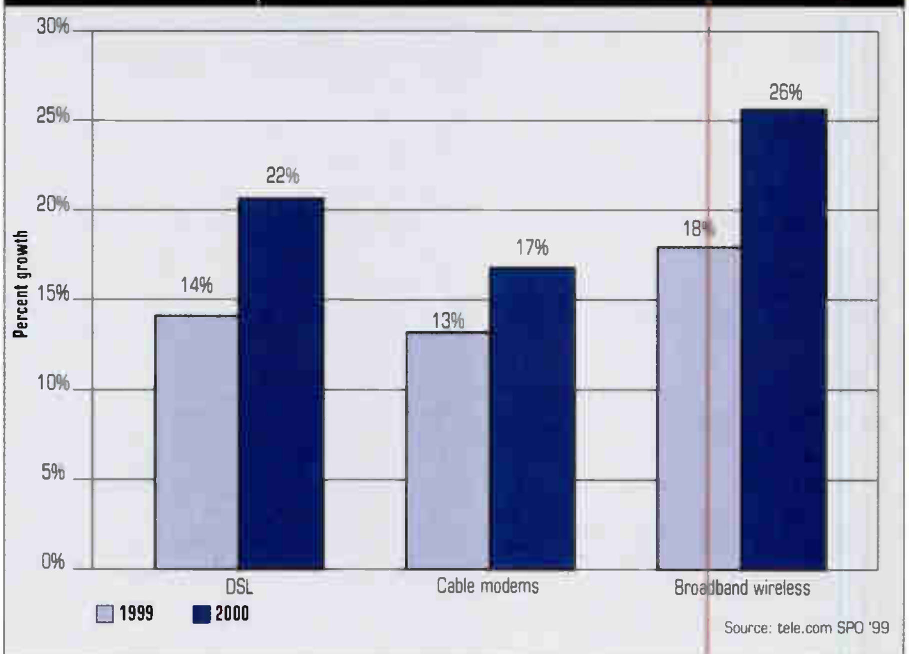
Other telcos, such as NextLink, are turning to higher frequency spectra such as LMDS or 38 GHz to hop over the tangle of local bottlenecks so commonly faced by competitive carriers.

TABLE 1 Top U.S. broadband wireless carriers

Telecom carrier	Type of spectrum	Markets/number of licenses
Advanced Radio Telecom	39 GHz	100 markets/352 licenses
MCI WorldCom/Sprint	MMDS (2.5 GHz and 2.7 GHz)	Combined MMDS licenses will pass 54 million U.S. homes
Winstar Communications	38 GHz, LMDS (28 GHz)	60 markets/315 38 GHz licenses, 16 LMDS licenses
NextLink Communications	LMDS (28 GHz)	Covers 95 percent of top 30 markets/ 40 LMDS licenses, which include 114 million points of presence
US West	LMDS (28 GHz)	Eight markets

Source: *Communications Technology*

FIGURE 1 High speed service revenue growth 1999/2000

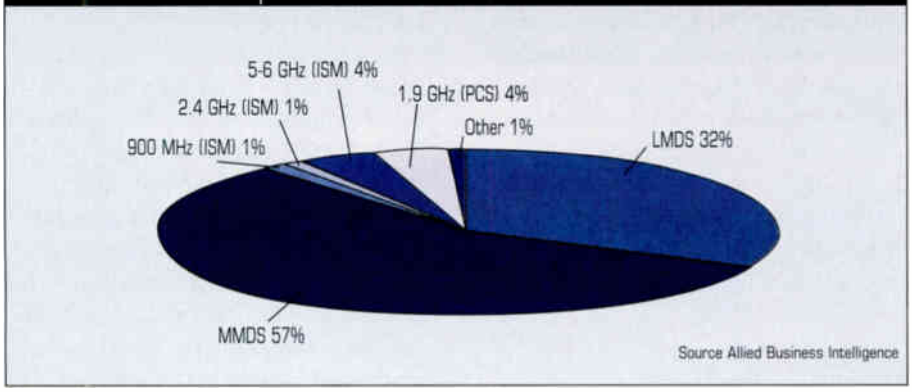


Source: tele.com SPO '99

BOTTOM LINE

> **Wireless Broadband: Friend or Foe?**
>
> Telecom carriers are opting for broadband wireless because it circumvents the local loop and is nearly as versatile as cable, if more expensive. The multichannel, multipoint distribution system (MMDS) poses the most direct threat; opportunities for cable may lie with unlicensed spectrum.
>
> MCI and Sprint own MMDS (or wireless cable) licenses, which at a relatively low spectrum can service homes within a 25- to 30-mile radius. Customer premise equipment costs carriers about $500 per household, but that could drop soon. It should do well in the multiple dwelling unit (MDU) market. At a higher frequency, local multipoint distribution system (LMDS) has a range of two to three miles. The spectra used by such companies as Teligent and WinStar are also relatively high.
>
> Telecom vendor Proxim sells transceivers and antennae that extend T-1 links up to seven miles over the unlicensed 2.4 GHz and 5 GHz spectrum. Comcast Internet Service ran trials of Proxim products for customers in Pennsylvania and New Jersey in February.

FIGURE 2 WIRELESS BROADBAND MARKET SHARE IN 2000



But the higher the frequency, the less likely it is for carriers to put their spectrum to use for business customers. The reason is scope of reach: LMDS and higher frequencies have a more limited range than MMDS. LMDS, for example, has a radio range of two to three miles, while MMDS has a 25- to 30-mile radius.

And for that reason, says Levin, Sprint isn't worried about NextLink, Teligent, and WinStar.

"The LMDS spectrum is not particularly well-suited for residential," Levin says. "We don't see that as a threat to the consumer market at all."

Mendelson of Strategis Group agrees. "(With MMDS) you get more bang for your buck," he says. But, he cautions, MMDS is a lower-bandwidth application. Its bandwidths are competitive with DSL and cable modems.

It's a well-heeled market

According to the latest figures from Strategis Group, the LMDS and MMDS markets combined will generate $3.4 billion by 2003, compared to $3.3 million for LMDS and $5.6 million for MMDS in 1999.

These figures do not include whatever gains in the broadband wireless market will be made by Teligent, WinStar, AT&T (which holds a very small amount of 38 GHz spectrum) and Advanced Radio Telecom, Mendelson says. The figures also don't take into account NextLink, which operates in the 28 GHz spectrum. "They really haven't begun rolling out services," Mendelson says.

The Strategis Group predicts that by 2003, no less than 34 percent of U.S. households and 45 percent of U.S. businesses will be serviceable by broadband wireless networks—a fairly substantial finding considering that in 1997, fewer than five vendors had the ability to produce an operating LMDS system. (See Figures 2 and 3.)

Now, big-time vendors such as Cisco, Lucent and Nortel can deliver carriers working broadband wireless systems for all spectrums that are capable of transmitting voice, data, Internet and video services.

Will cable join in?

Lots of smaller vendors are getting into the broadband wireless game as well, seeking to capitalize on carriers' lust for everything broadband wireless these days.

Sunnyvale, Calif.-based Proxim produces equipment that can be used in the unlicensed spectrum—2.4 GHz and 5 GHz. The company sells wireless local area network (LAN) adapters, Ethernet bridges, wireless LAN connectivity for Windows CE devices and two-radio wireless bridges to original equipment manufacturers (OEMs) and the end user. One advantage for Proxim is that it makes wireless broadband products that can be used by telecom carriers and cable operators alike.

> **"We touch the very edge of the broadband delivery facility. We don't care whether it's DSL or cable—it matters not."**
> **—Kurt Bauer, Proxim**

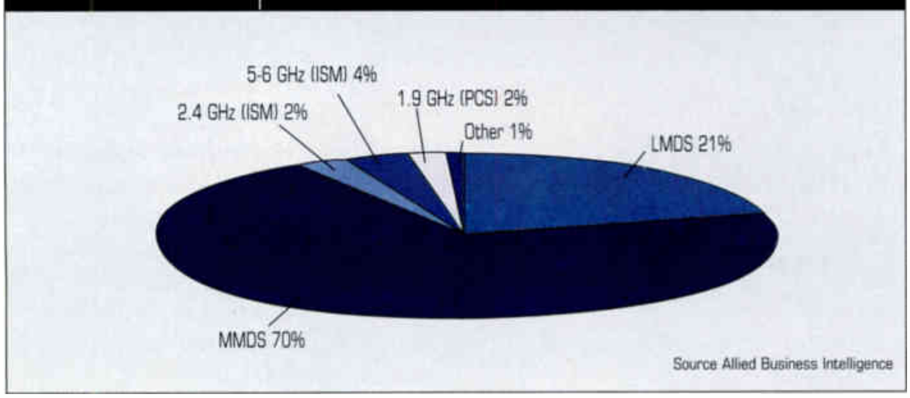
"We touch the very edge of the broadband delivery facility," says Kurt Bauer, Proxim vice president of marketing. "We don't care whether it's DSL or cable—it matters not."

Proxim sells service providers equipment for the 5 GHz unlicensed spectrum that is used to connect buildings so providers don't have to use fiber or cable. This equipment includes a transceiver and antennae that are bolted onto the sides of buildings, and extends T-1 links across the air.

"It's an extension of the LAN environment," Bauer says.

This type of equipment shoots data,

FIGURE 3 WIRELESS BROADBAND MARKET SHARE IN 2005



voice or video a distance of seven miles, and can be placed at the central office or an Internet service provider (ISP) point-of-presence (POP), making it ideal for rural use.

While cable companies could use this equipment, Proxim's primary customers are ISPs and enterprises. "We don't vigorously approach (cable companies)," Bauer says.

Nonetheless, cable companies, if they so choose, could use Proxim's products anywhere they find themselves in need of a point-to-point 100 Mbps link within their infrastructure or backbone. This would be ideal for cable companies trying to sell Internet service.

"Voice service can be included in that, in our case," Bauer adds.

Within the next six to nine months, Proxim plans to begin marketing its products heavily to cable companies.

"Right now, we're talking to cable companies about specific opportunities," Bauer says.

In fact, Comcast Corp. in February trialed Proxim's RangeLAN and Symphony products, which both operate in the 2.4 GHz range, for subscribers to its Comcast Commercial Internet service in Pennsylvania and New Jersey. The trial participants, however, were from the small business market, rather than the consumer arena. Comcast execs wanted to see how customers would respond to a service where they would not have to go through the "hassle and expense" of installing their own Ethernet wiring, says Matt Fanning, Comcast vice president of sales and marketing.

Friend or foe?

While cable players mostly view broadband wireless as a threat, not an ally, there could indeed be many opportunities for cable players to take advantage of the wireless world—and perhaps be better able to compete with its telco counterparts.

In fact, for AT&T it was a close draw between buying up the MMDS spectrum now owned by MCI/Sprint and acquiring TCI's cable plant, says Robert Rini, a managing attorney with the Washington, D.C.-based law firm Rini, Coran and Lancellotta.

Rini, who represents wireless broadband companies such as Sprint, Teligent and BellSouth, as well as "small mom-and-pop" cable companies, suggests cable companies would benefit from operating a combined wireline and wireless platform.

"I don't think (cable companies) are very interested at all—and that surprises me," Rini says. "At the moment, I think (broadband wireless) is more competitive (with cable) than complementary." CT

Elisa Modugno is assistant managing editor, The Phillips Group-Telecom. She can be reached via e-mail at emodugno@phillips.com.

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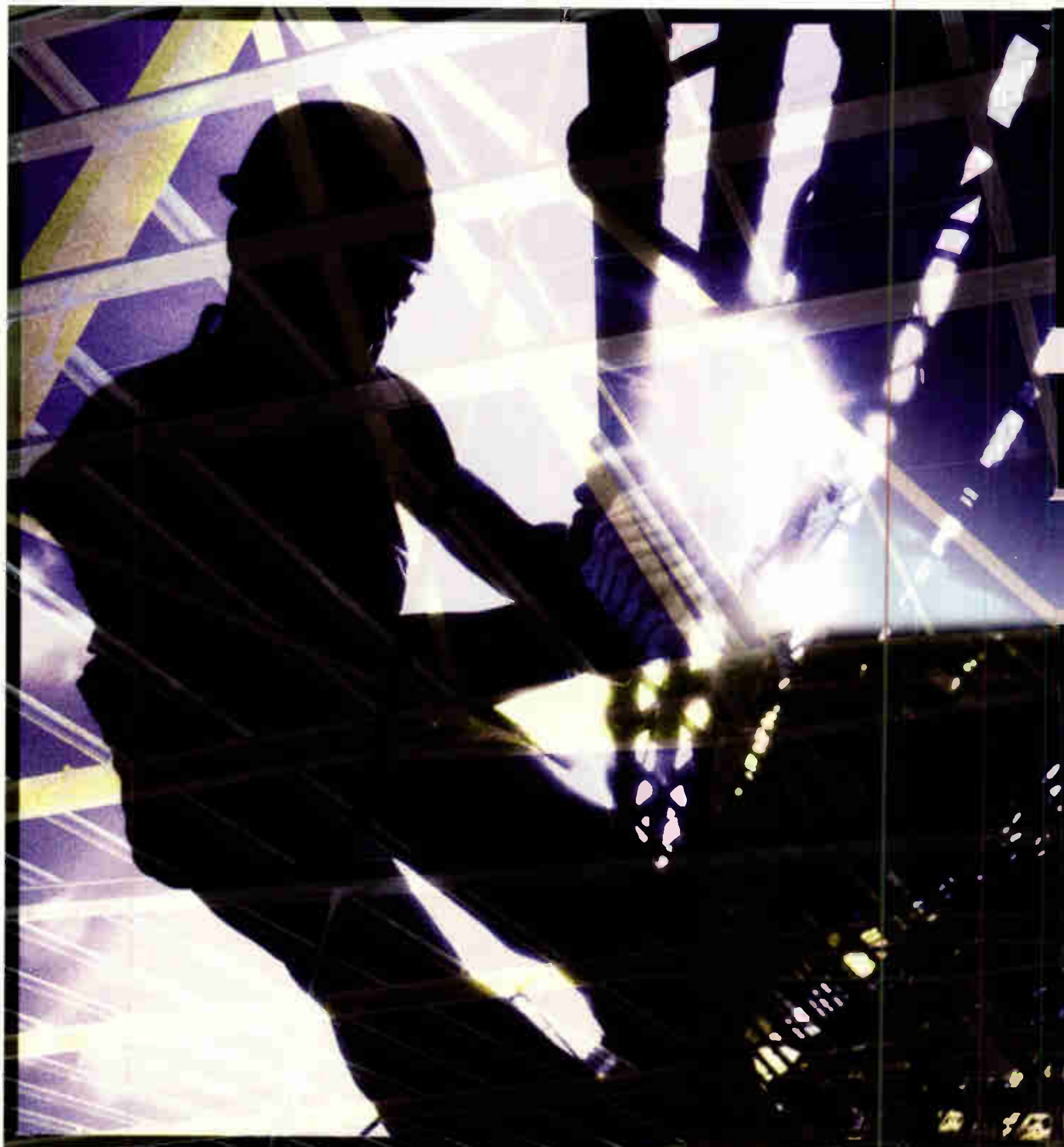
Aerial Safety
Fall Protectior



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Practices and

Reduce Your "Elevated" Risks

By Kevin McDevitt and John Young

Aerial safety practices are becoming more important as telecommunications plant upgrades continue to increase. Full-time employees, contractors, subcontractors and temporary hires are all working somewhere in your franchise's plant. Each work area has its own problems and personality regarding safe practices and fall protection.

As illustrated by this past winter's extremes, the weather is an additional factor that affects safety on a day-to-day basis. Low temperatures combined with moisture and high winds can have crews, in effect, working on ice skating rinks every time they put their feet down. Below-freezing temperatures make equipment unreliable with brittle and unyielding panels, door hooks and so on. Work slows as crews bundle up and have to take breaks from work in subzero temperatures.

Stress is always present in construction projects. Deadlines do not change because of unfavorable weather conditions or because there is a labor shortage. Straining to meet goals for customers passed, project deadline and budget can mean adding more contractors with little concern for their training or equipment.

Aerial safety

Aerial safety and fall protection is only one of many areas we need to carefully evaluate under these circumstances. If training, equipment and supervisory enforcement of safety rules are being neglected to "get the job done," putting an employee 20 or more feet in the air is very likely to lead to an accident or serious injury.

Occupational Safety and Health Administration (OSHA) regulations 29 CFR 1910.268 and 1926.502 and 503 cover many of the telecommunications requirements for aerial safety. These requirements are very specific

Though it looks simple, working with bucket trucks carries numerous risks, from getting "bounced" out of the bucket by an impact with another vehicle to ripping down a restaurant's drive-through awning.

regarding climbing gear and ladders. They are less clear when it comes to buckets on aerial lift trucks.

Once you get more than four feet off the ground, personal fall protection is mandated by 1926.501 (a)(1) and (b)(1). Do we put an employee in a body belt and lifeline or a full body harness and six-foot lanyard under these circumstances? As long as the employee cannot fall farther than two feet, the belt and lifeline are acceptable. If the employee could fall farther than two feet, a full body harness and lanyard are required.

In a bucket, any lines or lanyards must be tied off to the boom arm and not to the bucket. If we restrict the employee's fall to two feet, then the line cannot be more than two feet long and we restrict movement in the bucket, which is not always feasible when performing construction and upgrades. As a consequence, most of us in the industry have adopted full body harnesses and six-foot lanyards to meet 29 CFR 1926.501 and 502 requirements. While it is rare for an employee to fall out of a bucket, it is more common that one will bounce out when another vehicle hits the aerial lift truck. The harness and lanyard have saved life and limb on more than one occasion.

1910.268 further mandates that "safety straps and body belts shall be used while working on elevated work platforms," including ladders. Section 8 also mandates their use on poles, towers and similar structures that do not have adequately guarded work areas. Section (g)(1) puts all the responsibility on the shoulders of the employer, stating that the "employer shall ensure their use when work is performed at positions more than four feet above the ground." It further requires that every piece of equipment be inspected by a competent person prior to each day of use to determine that it is in safe working condition.

Pole climbing, ladders and Aerial lift trucks

Poles, ladders and lift trucks all have one thing in common: They can be used as modes of transportation to get you from Point A (ground level) to Point B (the height at which you need to work).

Years ago, when I taught pole climbing and aerial safety classes, I would start off the class with a simple statement. "Some people work behind a

BOTTOMLINE

> **Safety in the Air**
>
> As work piles up and deadlines approach, it's tempting to cut corners on safety. But busy schedules make safety training, equipment maintenance, and enforcement of rules all the more necessary.
>
> Falling is a significant cause of occupational death. Ladder safety is important for that reason, as well as for the hazards of simply handling the equipment. A pole farm is the best place to learn, practice, and gain confidence pole climbing. Aerial lift trucks also require training, both for driving and operating the bucket.
>
> To preserve life, limb and property, set up and maintain a comprehensive aerial safety program. It's an essential part of our business.

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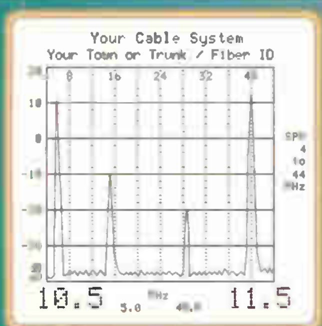
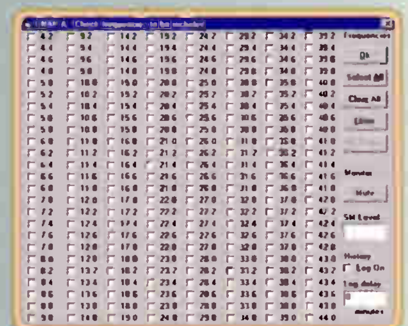
- Integrated RF Switching
- Automatic Test Carrier Levels
- I-NAN© Maintenance Monitoring
- Displays Impulse Noise and CPD



Video Output with Test Carrier Levels

Monitor Screen; Impulse Noise Present



I-NAN© Monitoring Parameters

The RDU© is a new type of return test system. You "see" the live condition of the return spectrum and RF level in dBmV at the HE, from any subscriber's terminal, amplifier, tap or fiber node.

The RDU© provides a "live" visual display of Carriers and Level, Ingress, Noise, Impulse Noise and Common Path Distortion.

With integrated RF switches, you select and monitor, a single node, a group of nodes or all the nodes in a Hub.

Node configurations are created by you, insuring an intuitive, easy to implement Return Management System.

RDU©'s monitor the noise floor, where you designate, by frequency. The RDU© averages the energy and displays your benchmark I-NAN© number.

You gauge the noise floor's condition from a simple, trackable number!

I-NAN© numbers judge return performance over time by node or group. I-NAN© is a flexible, cost effective tool for proactive maintenance of return networks.

The RDU© provides frequency agile level cursors with a Delta in dBmV and a time/date stamp for cost effective engineering test operations.

Poll your nodes, isolating the problems for immediate attention. The RDU© is a tool for effective plant maintenance.

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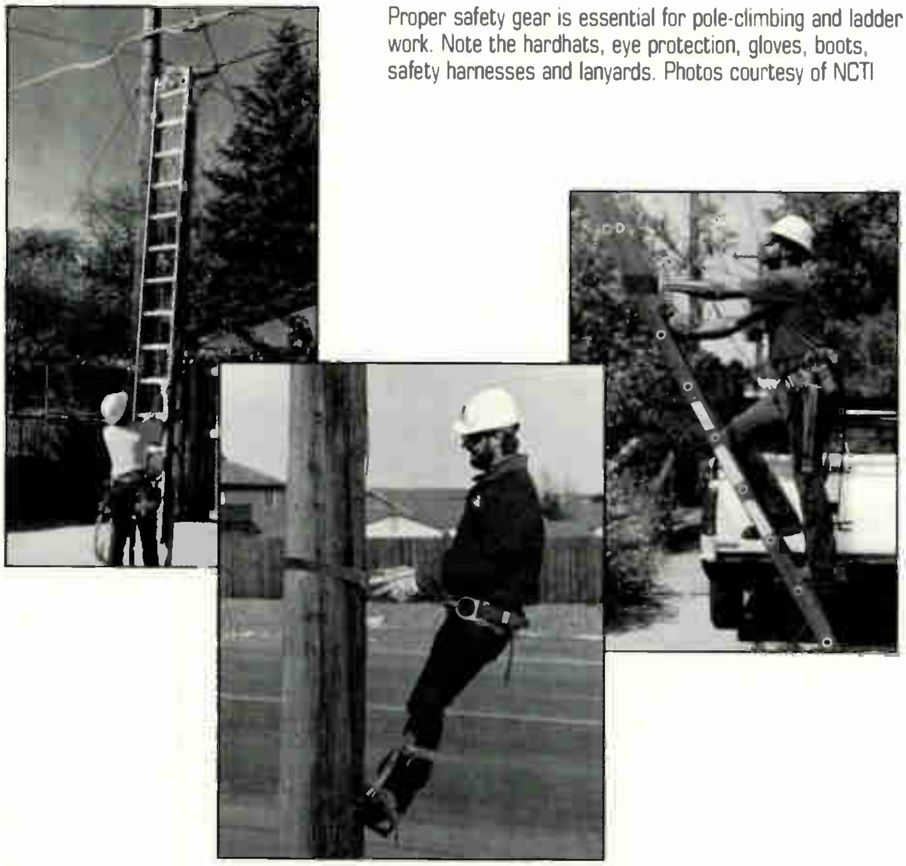


Proper safety gear is essential for pole-climbing and ladder work. Note the hardhats, eye protection, gloves, boots, safety harnesses and lanyards. Photos courtesy of NCTI

desk; you work 20 feet up in the air. If that is not where you want to work, you might want to go back to being a bank president."

Training required

Each of these modes of transportation has distinct advantages and disadvantages. All three share a mandatory requirement: training and certification.

OSHA clearly defines training requirements in 29 CFR 1910.268. The regulation says, "(c) Training. Employers shall provide training in the various precautions and safe practices described in this section and shall ensure that employees do not engage in the activities to which this section applies until such employees have received proper training in the various precautions and safe practices required by this section."

To translate this into English: If you are not trained and qualified in a certain mode of transportation,

> Fall Protection Checklist

The following items will help you evaluate your program. Keep in mind that no checklist is a substitute for a good safety program.

❑ yes ❑ no 1. Is there a designated, qualified person responsible for safety and health issues as well as corrective actions for your area?

❑ yes ❑ no 2. Is this person knowledgeable about fall protection and jobsite issues?

❑ yes ❑ no 3. Are contractors and subs required to have written safety programs, safety training and a person responsible for safety on site?

❑ yes ❑ no 4. Are field safety inspections performed regularly on all site work?

❑ yes ❑ no 5. Is management actively committed to providing a safe work environment? Does this include training?

❑ yes ❑ no 6. Is the work area inspected in advance for hazards that can cause a fall from elevation?

❑ yes ❑ no 7. Are the work areas surveyed on a regular basis for OSHA compliance and changing work conditions that may create fall hazards?

❑ yes ❑ no 8. Are tools and equipment properly inspected prior to use and damaged or hazardous equipment taken out of service and repaired or destroyed?

❑ yes ❑ no 9. Are ladders made of appropriate materials for the work being performed with them?

❑ yes ❑ no 10. Are ladders tied off properly when necessary? Do they extend the proper distance beyond roof lines?

❑ yes ❑ no 11. Do employees wear proper footwear for ladders or climbing gear?

❑ yes ❑ no 12. Is the level of lighting adequate for safe employee movement and the work being performed?

❑ yes ❑ no 13. Do contractors and their subcontractors use proper equipment in a safe manner?

❑ yes ❑ no 14. Are aerial lifts, ladders and climbing gear properly inspected prior to use?

❑ yes ❑ no 15. Is climbing gear maintained in accordance with Occupational Safety and Health Administration and American National Standards Institute standards?

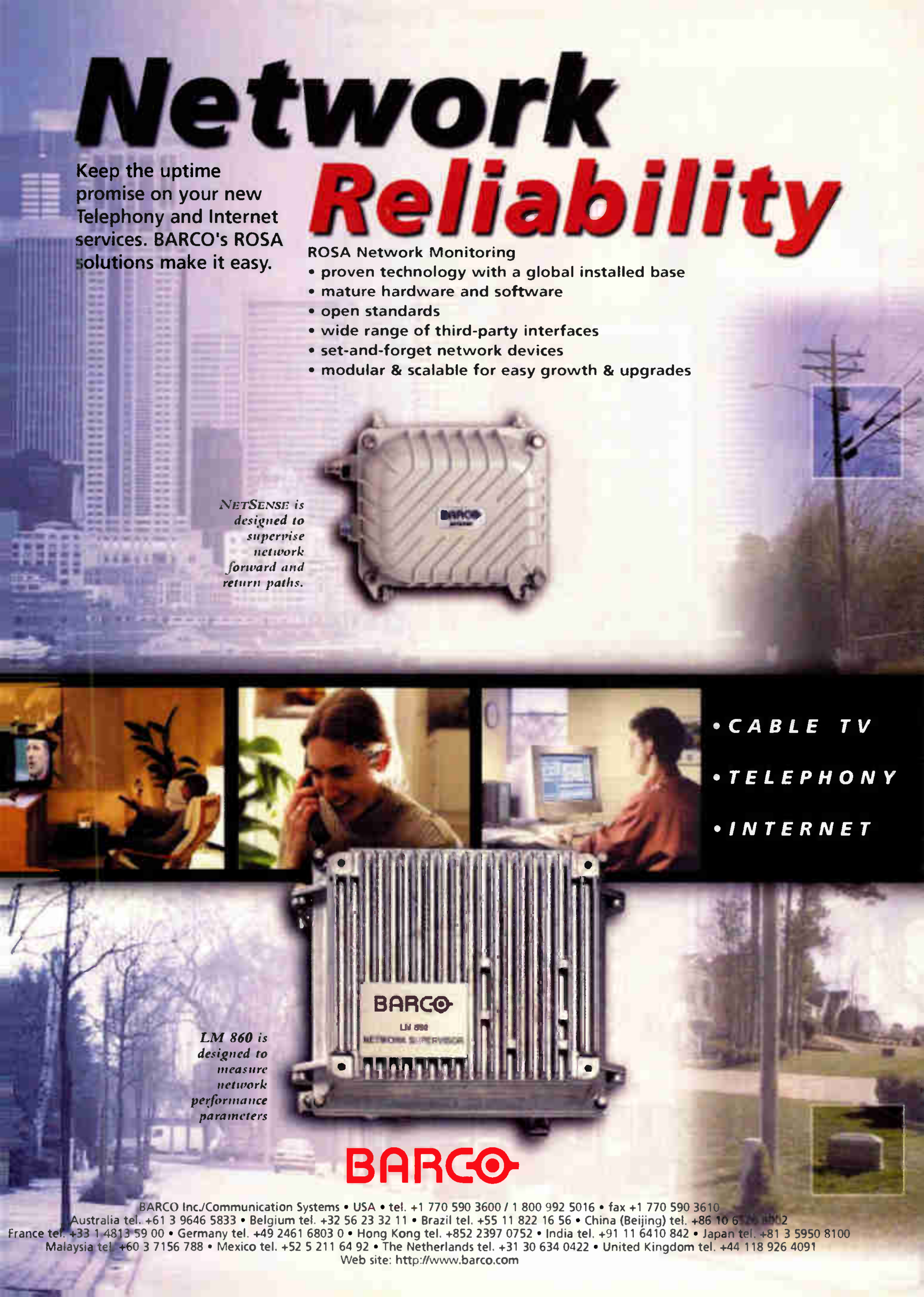
❑ yes ❑ no 16. Do all aerial lifts have personal fall protection available for operators?

❑ yes ❑ no 17. Are all employees properly trained in the operation and use of equipment?

❑ yes ❑ no 18. Have all employees been advised as to how to report unsafe conditions at their jobsite and who to contact?

❑ yes ❑ no 19. Are emergency numbers posted as required?

❑ yes ❑ no 20. Are reported items or unsafe conditions documented and corrected?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You are not Tarzan· While tree work generally is to be avoided, sometimes it can't be helped when trimming branches away from your cables. If you have no choice but to climb a tree, proceed with great caution—climbing trees takes the dangers of pole-climbing to a whole new level.

you should not use that mode. Sending out unqualified workers may carry great risks, such as medical costs, lost worktime, lower production and liability.

Ladders

Some workers may think: "Why do I have to be qualified to use a ladder? I can just throw it against a building and climb up; what's the big deal?" Falling is the big deal. According to the Bureau of Labor Statistics' 1994 Census of Fatal Occupational Injuries, 8.8 percent of occupational deaths are related to falling. Section 1910.268 (h) outlines ladder rules.

Falling isn't the only hazard involved with using a ladder. Lifting the ladder itself also is a major cause of injuries. Using improper technique while lifting a ladder can lead to lower back injuries so severe that they may cause an employee to miss work or even suffer a lifetime of pain. Maneuvering a 100-pound ladder off the truck and through a typical yard, around obstacles such as lawn chairs and toys, can be challenging, to say the least.

Anyone who works with a ladder needs to know a few basic fundamentals:

- How to inspect a ladder
- How to survey the area
- How to lift a ladder properly and where its balance points are located
- How to properly set-up of a ladder
- How to properly climb
- How to secure one's body while working
- How to work properly

Pole climbing

One clear advantage of pole climbing over ladder use is the weight of the equipment. An average set of hooks (climbers, gaffs and so on) weighs approximately seven pounds. Compare this to a 100-pound, 28-foot extension ladder, and the benefits are obvious. Section 1910.268(g) covers pole climbing.

Remember, only qualified workers should climb poles. The best way to become qualified is to go through a formal pole-climbing course, in a controlled environment such as a pole farm. The pole farm does not have to be elaborate; it can have just one or two poles. The advantage of a pole farm is that it provides a place to practice in the presence of a qualified trainer. This is essential because, as the saying goes, "Practice doesn't make perfect; practicing perfect makes perfect."

The pole climber should learn the fundamentals listed here. A formal class will teach much more, but the most important lesson for a pole climber is confidence.

- Correct use of personal protective equipment
- Techniques for surveying the pole and surrounding area
- Testing, shaping and sharpening gaffs
- Ascending and descending the pole
- Belting off

Aerial lift trucks

The aerial lift truck, more commonly called a bucket truck, is by far the most complex form of aerial transportation. In fact, OSHA has developed its own standards for aerial lift truck operation (29 CFR 1910.67). You may be thinking that operating a bucket truck is simple: All you have to do is jump in the bucket and hit a few switches, and you're there. Well, I have yet to see an accident report come across my desk in which someone hooking a pole has ripped the awning off a McDonald's drive-through.

Sometimes, just getting a bucket truck to the work area is a job in itself. An average bucket truck weighs 10,000 pounds and cannot stop on a dime. This is why the trucks are notorious for hitting other vehicles in rear-impact accidents. They are also known for getting stuck in off-road situations, especially in wet conditions. In addition, bucket trucks have poor visibility and should not be

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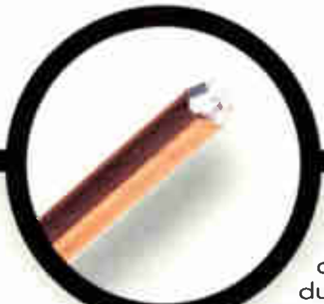

As a manufacturer of cable installation tools, Ben Hughes/Cable Prep was approached by technicians and linemen throughout the industry to produce a center conductor cleaner. The prevailing factor was the need to eliminate cleaning the bonded dielectric from center conductors with knives or other scraping methods without causing installation problems. By listening carefully to the comments and suggestions offered, Cable Prep has responded with the Cable Gator.™

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backed up unless the driver finds it absolutely necessary or has someone else to act as a guide.

In short, no one should work in a bucket truck without proper training. Operating a bucket truck requires a specific qualification, which includes instruction in the following:

- Workplace set-up
- Performing an inspection
- Understanding hydraulics
- Correct use of fall arrest equipment
- Clearances
- Boom operation
- Emergency procedures

"According to the Bureau of Labor Statistics... 8.8 percent of occupational deaths are related to falling."

We have just touched the surface on Aerial Safety Practices. An in-depth look at any of these modes of transportation would require an article in itself. Basic skill level, though, comes down to this: Employees need to be formally trained and qualified in aerial safety practices and equipment. This is not only our opinion; it's also OSHA's opinion. C+

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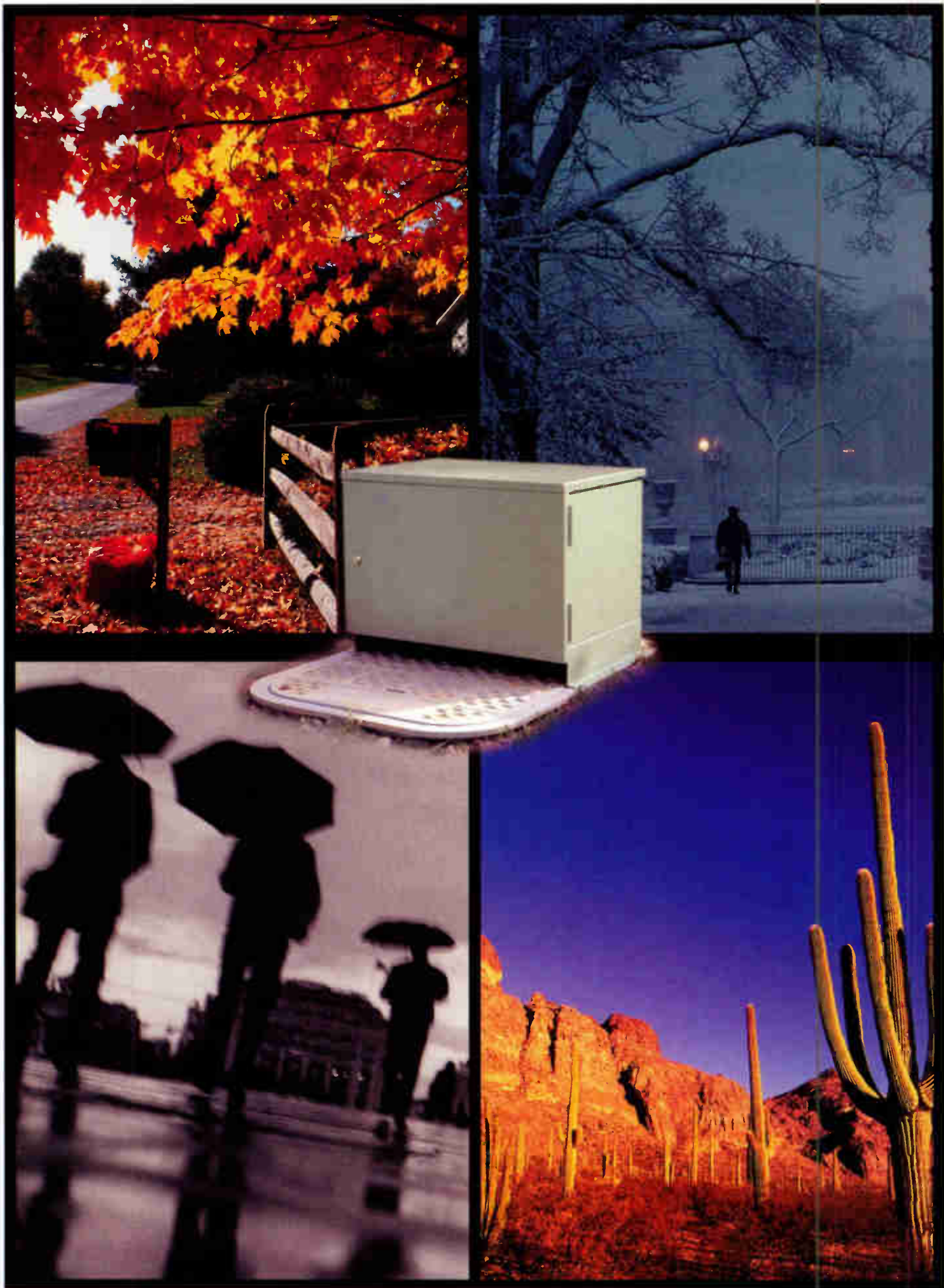
Did this article help you? Let us know your thoughts. Send an e-mail to jwhalen@phillips.com.



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PROTECT YOUR EQUIPMENT

Pick the Right Enclosure

By Ruth Suarez Zane

The boom in advanced services is forcing operators to pay more attention to the enclosures that help guarantee the quality of those services. More services mean more cables and equipment, plus fielding technicians to pop enclosures open and upgrade equipment. The days are long gone when operators could say, "Out of sight, out of mind."

With the expansion of communications services such as data, voice and video, structures are growing larger to hold more. Environmental impact on the structures has always been a concern for operators, but that is increasing because more services mean higher loss to the operator if the structure is breached. The threat of vandalism and theft also is pushing manufacturers to improve security with tough materials and locks. The bottom line: Enclosures need to be bigger and stronger than in the past.

Despite the obvious importance of quality structures, manufacturers warn, operators often neglect to research products properly and pinch a penny here and there, which ultimately may damage services. Veteran enclosure manufacturers, along with newer players, give operators tips on where to cut corners and where not to.

"The biggest challenge is developing the best products to deal with the convergence of service applications," says Jon Pickrell, vice president of sales for Carson Industries. "It's, 'How can we design the best enclosure product that takes into account the delivery of the service set, brings in telephony, video, data, mixes cable types'—we want to do that most efficiently and effectively."

More services, now!

The high public demand for communications services not only is requiring additional equipment in neighborhoods—it also is requiring operators to work faster. A customer who once subscribed to only cable, now might be adding telephony or high-speed Internet access. These new sources of revenue carry more reliability concerns than those traditionally associated with plain old cable TV service.

The additional equipment required ranges from battery packs to cables. In the past, two hours of batteries might have sufficed for emergency situations. However, added services may require four hours or more worth of batteries, requiring more space.

The tendency to move to larger equipment goes against the grain of a communications world where semiconductors, as well as telephones and other products, are shrinking in size. With vaults and enclosures, manufacturers are working to contain the expansion of the structures by building racks and shelving within the unit to pack in more equipment.

But size still is increasing—sometimes almost doubling, says Pete Kelly, vice president of Oldcastle Precast.

Andy Burgraff, vice president of sales for Newbasis, an enclosure manufacturer, agrees. "We went through a period where everything was downsized. Now we are seeing larger cable, larger enclosures; transformers are larger."

Despite their increasing size, many enclosures come ready to install.

"The product has to be installed quickly and easily because rollouts are happening very fast," Pickrell says. "A lot of products are already assembled. You just put them in the ground."

In addition, enclosures are becoming more complex. Some operators need to mix cable types and sizes in a single enclosure: fiber, coax and copper twisted-pair.

"The way these manufacturers package the enclosures is very important," says Jim Davis, regional director of construction for Time Warner. "You want it with trays and re-entry kits. That's very important vs. some that have four to five parts to add to get one station ready to go. It becomes an inventory nightmare."

Keep it friendly

Another reason operators are looking for enclosures that install easily is that the industry no longer has a plethora of technicians. Having a product that doesn't have 25 separate pieces to be assembled minimizes construction costs for operators and doesn't require heavy investment in training technicians.

BOTTOMLINE

> Choosing the Right Enclosures

The boom in telecommunications services has led operators to move equipment into the field, underscoring the need to enclose that equipment safely and efficiently.

Manufacturers are providing enclosures that, regardless of size, can be set up in a day. Labor constraints increase the value of simple installations. Preloading equipment also helps. The increased use of thermal plastic covers shows how enclosures have been redesigned in light of environmental factors. Other redesigns cover security, aesthetics, strength and ducts.

Choosing the right enclosure means taking all these factors and your own situation into consideration. Greater options could lead to a better fit, but also require doing more homework.

Left and bottom: Internal and external views of Lucent's Telephony in a Box

Responding to customer demand, vendors are making enclosures as complete as possible.

"One of the things we hadn't seen before is end users wanting to have their total equipment package, including content, preinstalled 100 percent," Kelly says. "In the past, we would install environmental controls, and they would install the racking and stacking. In some cases, after the permit gets squared away, they want to be able to turn the power on and provide the service."

In response to that demand, Oldcastle is introducing a new and larger enclosure–the 40 x 12 foot Maxi-Mode modular building. Twenty percent bigger than Oldcastle's previous largest structure, it will have the structural ability to be preloaded with the operator's content.

Lucent Technology also has come up with a twist on enclosures. Its IP Telephony in a Box enclosure targets cable operators that want to add telephony but have limited space for new equipment in existing headends.

The "Box" is portable and easier to maintain than a central office, says Paul Barth, Lucent network engineer. With its 8-foot height, 6-foot width and 8.6-foot length, operators can dodge building permits in some zones.

"We deliver it to the customer site power tested and having conducted integration testing," he says. "Just pick it up and deploy." Barth estimates an operator can have IP Telephony in a Box on site and running within 30 days of purchase.

Not only do operators want enclosures ready to plug in, they want them simplified for re-entry. With the boom in communications services, technicians are increasingly re-entering enclosures to upgrade equipment.

"(Manufacturers) definitely have shifted to more user-friendly models than back in the mid-'90s," Davis says. "Before, they just filled up the enclosure, and fiber would lay in there for years. But as we move from point to point, we know we'll have to be back in there. A user-friendly type of enclosure is critical."

"As more and more equipment is out there, operators are asking for ease of installment," says Thomas Sloan, vice president of corporate technology for Alpha Technologies. In his 20 years in the enclosure market, Sloan

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This 30'x96' headend building was installed for a cable operator in northern Ohio in two days. Interior finish work was completed in four days. Photo courtesy of Oldcastle Precast.

says underground structures are becoming more and more important.

"The more services, the more critical is it for these operators to get these services delivered. Acceptance by local communities is even more critical to them."

While the enclosure business is changing, it's not as fast paced as the rest of the communications industry. Mark Howard, director of marketing for TeleWire Supply, a supplier of broadband hybrid fiber/coax (HFC) products, sees changes as evolutionary rather than dramatic.

Because the enclosures market isn't a quickly changing one, pricing across the industry is more or less standard, and there aren't a lot of new market entrants. Thus, quality is the big differentiator. Sloan says operators are more interested in buying vaults from vendors that provide various construction pieces.

"You'll have a competitor saying they sell a better vault," Sloan says. "The real proof in the pudding is experience—having done it a million times."

The elements

Along with assuring the function of a pedestal or vault, operators are buying pedestal, vault and enclosure covers. This protects the structure and its contents from environmental damage while it is awaiting repair or service. For instance, Napco's product, Bag-It, is an orange cover that protects a damaged enclosure's contents until field technicians get to them.

Although leaking is not as much a problem today in enclosures as it was in the past, operators' concerns that the elements could ruin expensive equipment are leading to much research and development in the materials used to protect the structures.

One of the changes the environment is having on enclosures is the increased use of thermal plastic instead of metal. Thermal plastic is more conducive to heat dissipation, Pickrell says. The plastic does not require fans or an active cooling system. The plastic acts as an insulator, a type of solar shield for heat buildup from the sun. Pickrell estimates thermal plastic can extend service life of integrated circuits (ICs) and hybrids by up to 50 percent. >

> Enclosure Buyer's Tips

- To protect investment in batteries, choose an enclosure that moderates heat extremes.
- Understand the size of cable and of the electronics you'll be using ahead of time in order to select the right enclosure and cable storage facility.
- Be neighborhood-friendly. For instance, put enclosures in back yards instead of front yards.
- Consider using an enclosure that is fully assembled at the factory, with hardware and bracketry so you don't have to assemble it in the field.
- Choose a material best suited to the region's weather conditions.
- Make sure the enclosure material is chemically resistant to acidic and petroleum-based products such as fertilizers and bug sprays if the region is subject to those treatments.
- Choose an enclosure with adequate venting for heat dissipation.
- Keep the design simple, and ensure full access to all internal components.
- Choose a convenient and secure locking mechanism, preferably self-locking.
- Work with a company that gives you technical field support on site.

Napco's Bag-It protects an enclosure's contents until a field technician can get to it for service or repair.

Inside the enclosure, metal components often are used to hang cables, making a type of metal framework. However, plastics are taking over here, too. Thus, this year Carson began using a thermoplastic laminated coating which chemically bonds to metal and provides long-term protection against corrosion.

Lock 'em up

Customers also have been asking enclosure manufacturers to step up security on the structures. Popular safety methods are self-lock mechanisms that require special keys to get back in.

Security has become a big issue with operators, as vandals break into them to destroy them or steal services. "Operators will pay big money to keep people out of pedestals," Pickrell says.

TeleWire Supply also is turning its attention to increasing security in the structures. The company uses a self-lock and locking "hat" or lid. The self-lock provides ease of locking, so the technician has no additional parts, simply placing the top on the enclosure. The additional lock makes the structure look more secure, and in case a vandal were to attempt to break the self-lock, the padlock would give it an additional level of security.

Looking good

In addition to mechanical changes in enclosures, consumers are asking for more aesthetically pleasing structures, especially as they increase in size. Carson has eliminated sharp edges from its enclosures, giving them curves for a European look, Pickrell says. The manufacturer offers customers nine colors ranging from light green to beige.

TeleWire Supply's Howard agrees beautification of enclosures is becoming more of an issue for customers. Preferred colors vary—with sandstone being popular across the board and terra cotta being popular in Arizona, for instance.

While many neighborhoods want to disguise enclosures as best they can, for operators, doing too good a job can make it difficult to locate enclosures later. Often in areas that experience heavy snowfall, operators place an orange flag on the enclosure to make it easier to find.

Rock look-alike pedestals have caught on in the communications market, although not in all regions. Time Warner's Davis says the company uses these structures where aesthetics are most important and cable customers have complained about "ugly" pedestals. Time Warner installed 4,500 in Bakersfield, Calif. last year.

But California is California, explains Davis. And without environmental factors such as heavy snow, which can bury low-profile pedestals, customers have the luxury of putting more weight on aesthetics.

Materials science

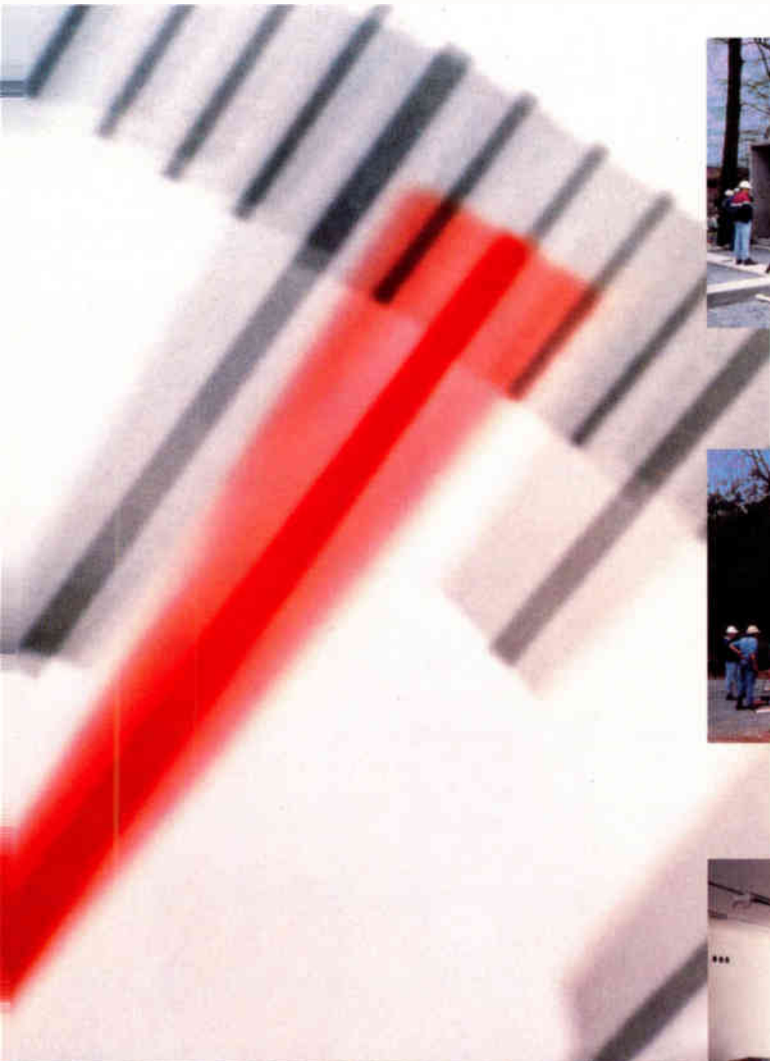
Aside from whether an enclosure is good-looking, materials also vary from region to region. Concrete is the most durable; it requires little maintenance and keeps water out, and pumps can be installed in case water does get in. The downside to concrete is its weight. As a result, operators tend to buy this regionally vs. buying it from a national manufacturer and having it shipped.

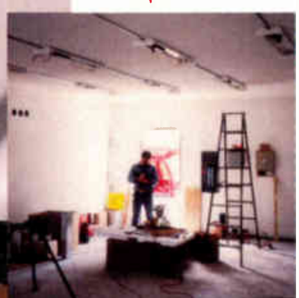
Vaults that are partially above ground often are made of polymer concrete, used in highly corrosive environments. The material is impervious to freeze-thaw cycles where expansion and contraction can crack other materials. The downside to this material is that it could be damaged by mechanical devices, cracking the cement. It also is sensitive to sunlight and tends to change chemical formulations, which can make the structure brittle and shortens its lifespan. Avoid this material in regions with wide variations in temperature. The material is commonly used in Washington and Oregon.

Plastic high-density polyethylene generally is used in grassy areas, where there is no traffic. In locations where there is no threat of snowplows or vehicles ramming into the structures, this plastic is preferred. >

Built for speed.

[OF DEPLOYMENT]





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Alpha's "Pedestal Support" system provides a one-step solution for ground mount enclosure installations.

While some operators still choose fiberglass for vaults and enclosures because it weighs less than concrete, it is becoming less popular because it isn't as strong.

Duct specs

Another factor is the quality of ducts, which often can affect the price of the enclosure.

The best kind of duct available is prime spec duct, which is pipe grade, says John Bradley, TeleWire Supply manufacturing specialist for Monarch products. Duct quality is important because it is often exposed to the sun, so if it doesn't have the correct additives, it can crack.

The other type of duct often used is wide spec, which is a less expensive version of prime spec. While it may hold up well, three years down the road it could crack. "You could certainly have success with duct from wide spec, but it's a crapshoot," Bradley says.

While the price difference is merely a few cents, with prime spec often costing 50 cents a foot, and wide spec costing 36 cents a foot, the cost, of course, impacts customers when purchased in large volumes.

"Sometimes these things are decided on price. A duct is a duct is a duct. Customers have a good understanding of plastics and materials, but once that thing is in the ground, you don't know. If you have a problem, it's a big problem," Howard says.

Wrap up

Demand for advanced services has led operators to rethink their enclosure needs. While more services often mean more equipment and larger enclosures, those enclosures also need better security and environmental protection.

Both traditional and and new manufacturers are meeting these difficult demands. Many enclosures can be set up in a day, offer excellent security and weatherproofing, and even have a certain aesthetic appeal.

Choosing the right enclosure means taking all these factors and your own situation into account. Greater options can lead to a better fit, but also require doing more homework. CT

Ruth Suarez Zane is editor of sister publication "Intelligent Network News." She can be reached via e-mail at ruthzane@yahoo.com.

Did this article help you? Let us know your thoughts. Send an e-mail to jwhalen@phillips.com.

> Getting The Gear: Pedestals, Vaults, and Enclosures

Here's a sampling of some of the vendors providing pedestals and vaults these days.

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Alpha Technologies
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American Power Conversion
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Armorcast
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www.associated-plastics.com
(501) 776.0684

Carson Industries Inc.
www.carsonind.com
(800) 735-5566

CDR Systems
www.cdrsystems.com
(904) 615-9510

Channell Commercial Corp.
www.channellcom.com
(909) 694-9160

Marconi Communications
www.marconicomms.com
(440) 460-3728

ICM Corp.
www.icmcorp.net
(800) 222-2142

Liebert Corporation
www.leibert.com
(216) 621-5133

Lucent Technologies
www.lucent.com/cableconnect
(877) 534-9182

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www.mooredp.com
(800) 769-1441

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(888) 707-4878

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www.precast-concrete.com
253-833-2777

Petro Comm Industries
www.petrocomm-osp.com
(888) 441-5724

TeleWire Supply
www.telewiresupply.com
(888) 353-9473

Trend Technologies Inc.
www.trendtechnologies.com
(408) 895-6450

What if I told you that the best way to move your safe driving program forward would be to spend more time going backwards? The technical staffs of most cable companies, which number hundreds of drivers, put millions of miles a year on the road. That's a lot of windshield time and a lot of exposure. And let's face it: Driving can be a dangerous thing.

Backing accidents are responsible for nearly one-third of the total number of accidents in most companies. Here is an opportunity to reduce that driving exposure.

What we teach

The driving program at Jones Communications has relied on a combination of three sources: the expertise of our insurance company (Liberty Mutual), the Smith System (originator of the "five keys to space cushion driving") and the company's internal program. This training allowed our drivers to heighten their awareness to the exposures of moving forward and helped them make good decisions. The basis of all this training can be best summed up in five steps.

1) **Expand your look-ahead capacity**: Most drivers look four seconds ahead, but they need to look 12 seconds ahead.
2) **Size up the whole scene**: Shift your attention every two seconds and check your mirrors every five to 10 seconds.
3) **Signal your intentions early**: Drivers make 100 decisions every mile they drive. Let others know your intentions.
4) **Plan an escape route**: Constantly ask yourself, "What if?"
5) **Take decisive action**: How much of your best thinking can you do in, say, three seconds? In three seconds you don't think, you react. Your reaction must be the right one. Reactions are putting prior thinking in motion. Prepare yourself to do the right thing.

There is much more that goes into a strong and effective safe driving program—quarterly commentary drives, driver recognition, a strong and clear disciplinary action program, to name a

BACKUP Rodeo

Embrace Your Fears of Backing Up

By Dennis Sullivan

few. But nothing is more important than attitude.

The attitude of both the driver and the company sets the tone. Our company has a very positive attitude toward training, recognition and discipline. But as far as backing up vehicles was concerned, we had a negative attitude. Because we were not very good at it, we discouraged it, and we told our associates to avoid it whenever possible. Instead, we focused on all the other exposures, such as weather, stopping and following distances, intersections, and railroad crossings. And our number of accidents went down in every category we focused on.

What we didn't teach

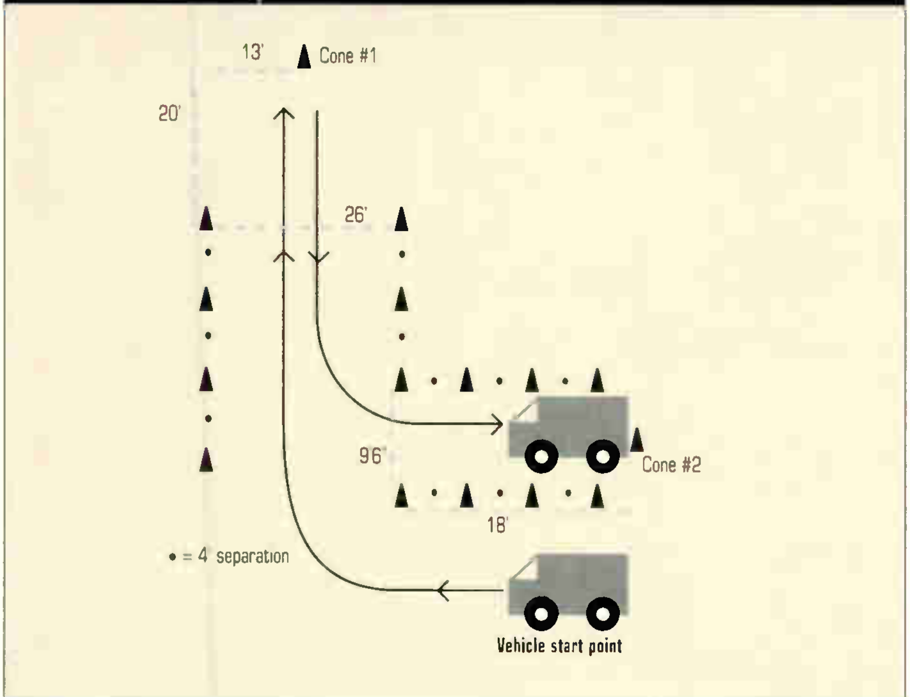
We viewed backing up as something we'd better not do, when we should have looked at it as something we needed to do better. Again, attitude came into play. It took us five years to change ours from one that said, "Don't back up—we don't do it very well," to, "To do it well, we need to focus more on it."

We were frozen in fear, afraid to back up. Some people even suggested taking reverse out of the vehicles. But the problem, of course, is not reverse; it's the person putting the vehicle in reverse.

Before you can improve, you need to admit there is room to do better. Most drivers probably feel that they drive well. Very rarely do drivers involved in accidents feel they were at fault. But the statistics paint a different picture.

Research indicates that 98 percent of all accidents are avoidable, and 95 percent are because of human error. These numbers would lead most people to believe that there may be some opportunity to improve their skills. But these are just numbers, and measuring does not mean controlling or

FIGURE 1 Backup rodeo course #1



convincing. Most people are like Doubting Thomas: They refuse to believe until it happens to them. With prevention as our goal, this kind of training was going to be challenging. How do you learn the lesson without paying the price?

Lectures and videos alone won't get it done. Confucius has a good answer: "I hear, and I forget. I see, and I remember. I do, and I understand."

A backing rodeo

Backing up is a part of our job. Knowing when to back up can be learned in the classroom. Knowing how to back up can only be learned by doing it. For the last five years, we were not spending time teaching the skills necessary to back up better. We invested in special mirrors and mirror stations. We invested in sonar backing alarms. In retrospect, investing more time and money into the vehicles was

> ### Rodeo Rules

We developed two different courses to test both parking and backup skills. Every one of the rodeo participants drove a 1998 Ford full-size long wheel base van from our fleet. Each driver started out with 100 points, from which we make deductions. We prohibited coaching and spotting from bystanders.

Course 1: Parking

First, see Figure 1. Running time limit is three minutes. Time will be stopped and started as necessary to allow for measurement from numbered cones.

From the starting point, the driver will pull forward as close to and as centered as possible to Cone No. 1. The driver will then back up into the coned-off space and get as close to and as centered as possible to Cone No. 2.

Point deductions are as follows:

- One-point deduction for every inch outside the center of the license plate area.
- One-point deduction for every inch away from the numbered cones
- 10-point deduction for every cone touched
- 30-point deduction for each egg knocked off a numbered cone
- 30-point deduction for any cone knocked over
- 20-point deduction for no seat belt or other safety infraction
- One-point deducted for each second past the three-minute time limit

Course 2: Five Point Star

First, see Figure 2. Running time limit is 10 minutes. Time will be stopped and started as necessary to allow for measurement from numbered cones.

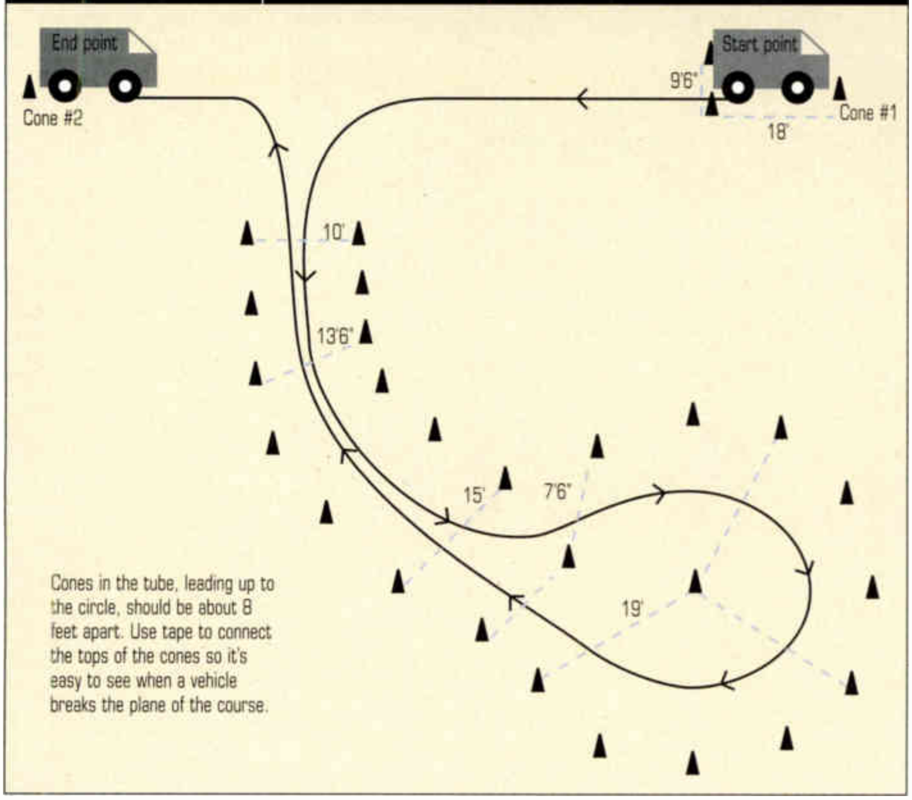
The driver will enter the coned-off space and pull forward as close to and as centered as possible to Cone No. 1. The driver will then back up and into the tube leading into the coned-off circle. Maneuvering around the center cone, the driver will turn the vehicle completely around and back out of the tube. Once out of the tube, the driver will then back up as close to and as centered as possible to Cone No. 2.

Point deductions are as follows:

- One-point deduction for every inch outside the center of the license plate area
- One-point deduction for every inch away from the numbered cones
- 10-point deduction for every cone touched
- 30-point deduction for each egg knocked off a numbered cone
- 30-point deduction for any cone knocked over
- 10-point deduction each time Tera-Tape is touched
- 20-point deduction for no seat belt or other safety infraction
- One-point deduction for each second past the 10-minute time limit

Once each driver finishes the course, record the scores on a scoring sheet (such as the one on page 256), and go over the results with the driver. Be sure to take note of areas for improvement and adjust training accordingly.

FIGURE 2 BACKUP RODEO COURSE #2



Above: A driver negotiates the backing rodeo course.

Right: Given the size and complexity of some vehicles (such as this one) commonly used in cable systems, skill in backing is a must.

not the entire solution. We also needed to invest more in the driver.

So how do we make our drivers understand their current skill level and the need to improve? The answer is to test them in a controlled environment, in what we call a backing rodeo. The idea here is not just to bring a new awareness to this old problem, but to bring new skills to combat it.

We developed our backing rodeo using a simple, five-step process:

1) Design your course: We had two courses that took about 15 minutes total to complete. (You will need about 40 square yards to set up the course.)
2) Develop a scoring system: We based ours on contact with and distance from cones lining the course.
3) Educate your drivers: We explained how they would be scored, how the course was laid out, and advised them to take all the time they needed and to think about the course before starting.
4) Set a schedule: We had our drivers arrive in 15-minute intervals throughout the day.
5) Educate on the spot: We pointed out to the drivers the extra precautions they took when they felt they were being tested. It's this feeling of being tested we need them to have every time they drive. We videotaped a few contestants for follow-up training.

In our region alone, we have close to 400 drivers, so rolling out the backing rodeo was no small task. But very seldom do you create change without disturbing the norm. We scheduled times for drivers of all "logo'd" vehicles to run the course, and we invited everyone else to participate.

The results of any training take time to assess. Our initial results from the backing rodeo thus far have been excellent. The drivers have given us feedback that supports our need to continue to train in this area. A common statement throughout the rodeo was, "I can't see," or, "I can't tell how far away I am." This further supported our need to continue training and stressed the need to better survey the backing area. Mostly, we challenged the

BOTTOM LINE

> **Avoid Backing, But Be Ready For It**

Typical defensive driver training neglects a major source of accidents: backing. But while backing is best avoided, sometimes it cannot be. In those cases, it is best to be prepared.

Give your drivers practice in backing with a backup rodeo. Use this five-step process:

1) Design your course
2) Develop a scoring system
3) Educate your drivers
4) Set a schedule
5) Use on-the-spot training

Such practice reinforces the goal of avoiding the need to back up, by underscoring the difficulty of seeing and judging distances. But it also prepares drivers for those occasions when backing cannot be avoided.

drivers to consider the need to back up. The best method of prevention is still to avoid backing whenever possible.

Our backing policy states that we should avoid backing whenever possible. This means that we avoid driveways and park on the street. It also means that when we park in a lot, we drive a little further so as to pull in, enabling us to then pull through. A successful backing policy would be to drive as if you didn't have reverse, but when you must back up, be ready.

To better prepare your drivers for backing, consider a backup rodeo. We all win when we have better drivers. And remember that the safest device ever put in a vehicle is an educated driver. CT

Dennis Sullivan is the former Washington, D.C., regional safety manager at Jones Communications. He is currently national safety manager for Prince Telecom. He can be reached via e-mail at dsullivan@princetelecom.com.

Did this article help you? Let us know your thoughts. Send an e-mail to jwhalen@phillips.com.

Large vehicles such as this truck-mounted crane underscore the need for well-trained drivers. Backing such a rig should be avoided if possible, but a skilled driver should be able to do so safely if necessary.

Safe Driver's Rodeo

Driver's Name ____________________ Date: ____________________

Parking Exercise

TOTAL

1) Vehicle Centered
(deduct 1pt per inch outside license plate area)

2) Vehicle's Forward stopping Distance
(deduct 1pt per inch, 10pts if touched cone, 30pts knocked egg off)

3) Remaining in Area
(deduct 10pts each time a cone is touched, 30pts if knocked over)

4) Vehicle Backing Stopping Distance
(deduct 1pt per inch, 10pts touch a cone, 30pts knock egg off)

5) Seat Belt or other Safety Violations
(deduct 20pts for each violation)

Time ________

Five Point Star

1) Vehicle Centered
(deduct 1pt per inch outside license plate area)

2) Vehicle's Forward stopping Distance
(deduct 1pt per inch, 10pts if touched cone 30pts knocked egg off)

3) Remaining in Area
(deduct 10pts each time a cone is touched, 30pts if knocked over, 10 pts each time tape is touched)

4) Vehicle Backing Stopping Distance
(deduct 1pt per inch, 10pts touch a cone, 30pts knock egg off)

5) Seat Belt or other Safety Violations
(deduct 20pts for each violation)

Time ________

Total Deduction
Time Deduction

Total Time ________

Final Score

Sample backing rodeo score sheet

Introducing Cable Modems, Part 2

This month's installment continues a series on cable modem installation. The material is adapted from a lesson in NCTI's new Digital Installer Course. © NCTI.

The first installment covered the considerations encountered when determining equipment locations and provided a checklist for certifying drop system reliability. This part provides two options for connecting cables to a stand-alone cable modem and computer. A cable modem can either be located next to the computer or at a central cable splitter or network distribution location.

Cable modem next to computer

The most common configuration is installing the cable modem at the same location as the customer's computer system (Figure 1). This cable configuration generally has a longer coaxial drop cable and a shorter CAT-5 network cable. This configuration also allows the customer to easily check the modem status lights.

Cable modem at distribution location

A less common configuration involves installing the cable modem at a central cable splitter or network distribution location (Figure 2). This generally reduces the necessary coaxial cable but increases the length of the CAT-5 network cable. If the customer has existing network cable, configuring the modem at the distribution location can decrease installation time. (Many new homes have a network system installed throughout using CAT-5 cable as a new enhanced technology-capable home selling feature. This is called "The Wired Home.")

Network cable is usually easier to install in and around rooms and furnishings than drop cable. Because of the very low frequencies of the data signal carried, it is not nearly as affected by ingress problems as RF frequencies carried on the drop cable. However, network cable can have interference problems if routed too closely to electrically noisy devices such as florescent lights, power transformers, motors and so forth. CT

Next month's installment will continue with considerations for connecting a telephone line to a cable modem using a phone return.

FIGURE 1 Configuring Cable Modem Next to Computer

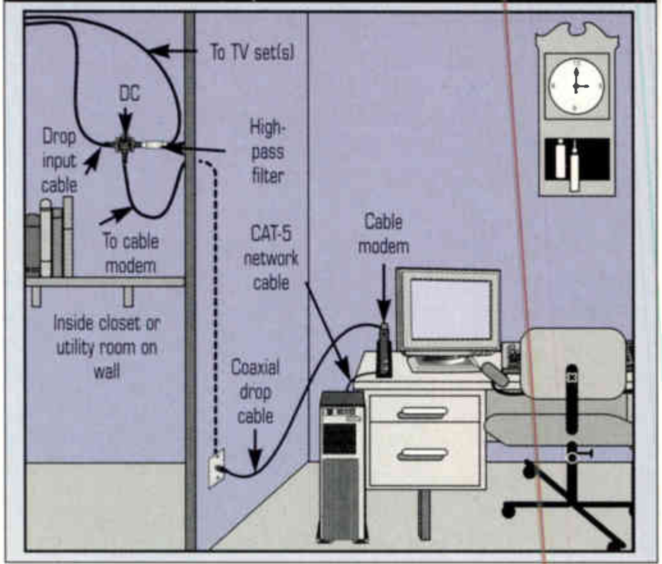
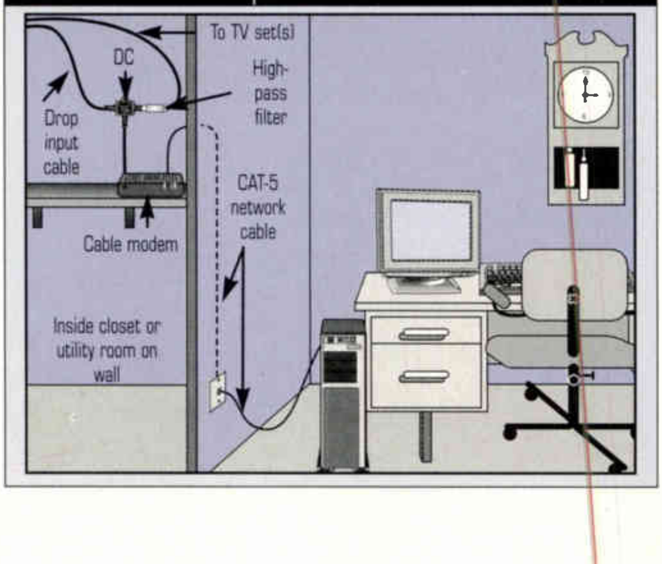


FIGURE 2 Configuring Cable Modem at Distribution Location



MARKETPLACE

POWERPLANT

C&D Technologies' PowerCom division has introduced the AGM 45 compact bulk power plant. The AGM 45 requires three rack spaces and can be configured from 7.5 amps to 45 amps using C&D's –48 VDC 7.5 amp advanced switchmode rectifiers. Using the AGM 45 and other C&D power board panels, a complete system can be configured to meet various telecommunications needs. The unit is designed for applications where space is limited and flexibility is mandatory.

For more information, contact C&D at (215) 619-2700 or on the Web at www.cdpowercom.com.

FAULT LOCATOR

Rycom Instruments has expanded its 8850 Path Finder series to include the 8858 cable pipe and fault locator. A handheld locator, the receiver locates two active frequencies, 815 Hz and 82 kHz, and passive frequencies of 50/60 Hz. The unit receives signals at waist level and can transmit by direct connection, coupler induction and transmitter induction. By attaching to an optional ground return probe, the 8858 becomes a fault-locating unit.

For more information, contact Rycom at (800) 851-7347 or on the Web at ww.rycom instruments.com.

COMPACT OSCILLOSCOPE

LeCroy's LP142 Literunner is a digital oscilloscope with 500 Mbps sampling, 100k memory, and 100 MHz memory, vertical accuracy within 2 percent and horizontal accuracy of 50 parts per million. It comes with various data storage and output interfaces—including 3.5-inch floppy disk drive, Personal Computer Memory Card International Association (PCMCIA) card slot, RS-232C interface—a menu selection format including help, event trigger, hardware five-digit frequency counter, and various automatic measurements. With built-in printer, it measures 8.25 x 7 x 6.5 inches and weighs about six pounds.

For more information, contact LeCroy at (914) 425-2000 or on the Web at www.lecroy.com.

COLLISION AVOIDANCE

Superior Signals' SuperSight collision avoidance system allows the driver of a vehicle to view objects that are behind and out of sight from the vehicle's rear view window. The SuperSight's camera is mounted to the back of the vehicle, and the monitor is positioned in the cab for the driver's viewing. The SuperSight is available at three levels of technology and price. Models include a standard black-and-white monitor or deluxe color liquid crystal display (LCD) monitor. The system is designed to reduce costs from accidents.

For more information, contact Superior Signals at (800) 447-3693 or on the Web at www.superiorsignals.com.

CABLE STRIPPER ENHANCEMENT

Trompeter Electronic's battery charger/conditioner enhancement enables the company's BWS battery-powered cable stripper to be discharged and recharged in 1.5 hours. The battery charger/conditioner is designated product BWCC-NSA; the complete cable stripping tool, with cutterhead, and the charger/conditioner is product BCWS-kit.

For more information, contact Trompeter at (800) 982-2629 or on the Web at www.trompeter.com.

CABLE MARKERS

VIP Division's Grabber cable markers identify fiber-optic cables. The markers are bright orange with black lettering that reads "Caution Fiber Optic Cable." The legend is repeated in alternative directions for 360-degree readability. Other stock legends are available. Grabbers are offered in lengths from 4-8 inches and widths to fit cables with outside diameters of 3/8-2 inches. They are constructed of a specially-developed vinyl that will not lose its color or uncurl, even after years of harsh field environments and long-term ultraviolet (UV) exposures.

For more information, contact VIP at (800) 950-4921 or on the Web at www.vipdivision.com.

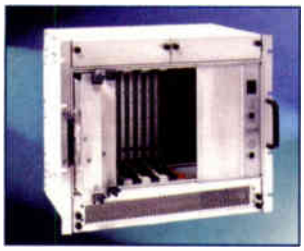
INDOOR PASSIVES AND POWER TAPS

PCT's Genesys line of indoor passive splitters and taps is designed for systems using digital, two-way services. Features include a –60 dBmV spurious signal and second order harmonic with a +55 dBmV return input carrier, designed to handle the high output levels of cable modems. Within a 15-40 MHz return path, PCT guarantees 35 dB tap-to-tap isolation and 30 dB return loss.

PCT's protocol data unit (PDU) faceplates are installed in existing housings to offer network powering for telephony upgrades. These modular, power distribution taps allow operators to upgrade from a coax cable to twisted-pair powering unit.

For more information, contact PCT at (800) 315-2253 or on the Web at www.pctusa.net.

CHASSIS



The Titan Chassis from APW Electronics Solutions is geared toward enclosures for CompactPCI. The enclosure features a plug-in power supply combination to be used in a high availability environment where withstanding excessive shock and vibration is critical. Reverse impeller-style fan modules are located in the top of the unit. The two pluggable modules are accessible from the front and can be removed for repair or maintenance. A microcontroller based on the Ultra-Smart Module option monitors voltage and temperature and controls fan speed.

For more information, contact APW at (858) 679-4550 or on the Web at www.apw1.com.

NOISE GENERATOR

Noise Com's dual-band VX19000 series programmable noise generator is able to switch between two bands within one instrument, providing dual frequency capabilities. Options on the VX119000 series include signal and noise combiner, 0.1 dB precision attenuation steps for both the signal and the noise path, and custom noise filtering. Frequency ranges are available from 10 Hz to 40 GHz.

For more information, contact Noise Com at (201) 261-8797 or on the web at www.noisecom.com.

CABLE CONNECTORS

> RF Connecters' expanded 7-16 DIN connector line includes the RFD-1631-2L2, designed for optimum performance with LMR-600 and LMR-600 Ultraflex cables from Times Microwave and DWC-600 and DWC-600R cables from CommScope. Other 7-16 DIN styles developed for these .60-inch diameter cables include straight or combo versions of male clamp or crimp plugs, and female clamp or crimp jacks in straight or combo configurations. All connectors feature machined brass bodies and Teflon insulation.

For more information, contact RF at (800) 233-1728 or on the Web at www.rfindustries.com.

POWER INVERTERS

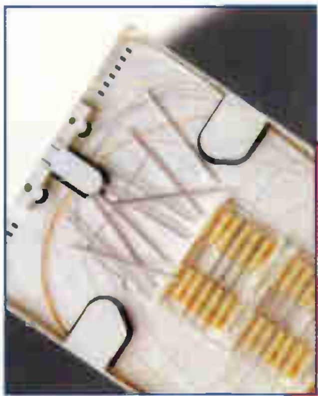
Statpower's PROsine series of power inverters convert DC power from batteries into sine-wave AC power for powering tools and equipment from convenient locations. Statpower's high frequency switching technology enables reductions in size and weight. Both the 100 (14.5 pounds) and 1,800 (16.5 pounds) watt models are housed in the same chassis measuring 15.4 x 11 x 4.5 inches. The units come with detachable liquid crystal display (LCD) on/off control panel and display for battery status. A power output scale informs the user on how much power the load is drawing.

For more information, contact Statpower at (604) 415-4613 or on the Web at www.statpower.com.

SPLICE PROTECTORS

DSG-Canusa's heat-shrinkable Fiber Optic Splice Protectors can accommodate single and ribbon fiber configurations. The Canusa CFSP (single fiber product) enables installers to protect single fiber fusion splices commonly used in fiber-optic networks. The Canusa CRFP is for ribbon fiber configurations and accommodates up to 12 fibers. Both products feature a clear heat-shrinkable sleeve that permits inspection of the fusion splice, a steel (CFSP) or polycarbonate (CRFP) reinforcing member, and a low temperature, meltable adhesive for protecting and sealing.

For more information, contact DSG-Canusa at (800) 422-6872 or on the Web at www.dsgcanusa.com.



SURFACE MOUNT POWER

Lambda Electronics has introduced a 30 W DC-DC converter that can be handled by pick-and-place equipment. Using 64-pin leadframe attach and regulating heat dissipation through a special board material with 10 times the thermal transfer of FR-4, the manufacturer has eliminated thermal encapsulation and the two-step potting process. By adding a 30 W module to its SM series, Lambada has expanded its line of converters to include 36 models with single and dual output configuration ranging from 10-30 W.

For more information, contact Lambda at (631) 694-4200 or on the Web at www.lambdapower.com.

RADIATING CABLE

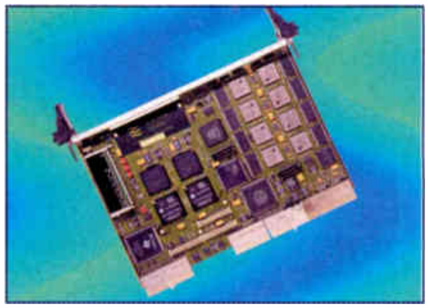
Andrew Corp.'s Radiax RCT series radiating mode cable is designed for in-building and tunnel-type RF communications systems. The cable can be tuned to radiate signals at the terrestrial trunk radio (TETRA)/UHF band, cellular/global system for mobile communication (GSM) bands, personal communications network/personal communications services (PCN/PCS) bands, and universal mobile telecommunications system (UMTS) and 3G bands.

The series has a foil outer conductor with specific slot dimensions. The cable uses the same foam dielectric and center conductor as other Andrew-manufactured coaxial cables.

For more information, contact Andrew at (708) 349-3300 or on the Web at www.andrew.com.

DIGITAL SIGNAL PROCESSOR

BlueWave has added another platform to its line of ComStruct digital signal processing (DSP) resource boards. Its CompactPCI board provides a flexible, scalable, single-slot DSP platform for the development of a wide range of wireline and wireless voice and data applications, including 2.5G and 3G transcoding, general packet ratio service (GPRS) encryption, packet applications, voice recording and archival systems, and communications test equipment. Model CPCI/C6402-3 employs eight Texas Instruments TMS320C6203 processors, making the board's processing power equivalent to that of three ComStruct CPCI/C640 boards.



For more information, contact BlueWave at (972) 277-4625 or on the Web at www.bluews.com.

BATTERY CABINETS

Pentair Electronic Packaging's battery cabinet features a louver-ventilated design that uses natural convection and forced ventilation to ensure proper air exchange and prevent hydrogen gas buildup. It can accommodate up to six strings of four batteries each in vertical or horizontal mounting configurations. External cable entry points enable entry from any side. The welded aluminum cabinets have outdoor-rated polyester powder-coat finish, heavy-duty continuous door hinge, and a seamless door gasket.

For more information, contact Pentair at (888) 550-9543 or on the Web at www.pentair-ep.com.

BROADBAND PROVISIONING

CAIS Software's IPORT Broadband Provisioning System (BPS), version 4.4, helps service providers offer enhanced high-speed Internet access to hotels, office buildings and multiple dwelling units (MDUs). The IPORT BPS provides subscriber session management for building centric networks, including automated online activation, limited free access and portal marketing capabilities. Version 4.4 features IPORT SelectSpeed, which enables tiered bandwidth offerings; IPORT OneTouch, a "customizable" tool bar; and IPORT Event!, a tool for managing network access in meeting rooms or conference centers.

For more information, contact CAIS at (858) 362-4054 or on the Web at www.atcominfo.com.

LINUX SERVER

The Linux Communications Server (LNX7000) from Enerdyne Technologies is a stand-alone, high-speed data server using Linux as the embedded operating system (OS). These units multiplex and demultiplex video, voice and data and stream the combined information over networks using Internet protocol (IP) transport. The LNX7000 is designed to service a single video and stereo audio channel as well as three bidirectional user data channels and allows it to communicate via 10/100Base-T Ethernet or DS1-based local area networks (LANs) or wide area networks (WANs). Supporting applications based on the Linux OS and a range of Personal Computer Memory Card International Association (PCMCIA)-compatible internal peripherals, the LNX7000 product line offers users the ability to customize products to their own applications.

For more information, contact Enderdyne, a unit of Advanced Remote Communications Solutions, at (858) 450-7600 or on the Web at www.arcoms.com.

CABLE BLOCKS

> Cast aluminum construction makes Condux International's cable blocks lightweight and durable. Designed for aerial cable installation, the blocks are available in various configurations including single roller, multiple roller, pole mounted and overlash models. Condux offers cable blocks in all combinations of cast or plastic frames and cast or plastic rollers.

For more information, contact Condux at (800) 533-2077 or on the Web at www.condux.com.

SCTE

Women in Cable & Telecommunications

Communications Technology
Official trade journal of the Society of Cable Telecommunications Engineers

2000 WOMEN IN TECHNOLOGY

AWARD NOMINATION FORM

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Objective:

The annual **Women in Technology Award** recognizes and honors leading women in technology positions within the cable and telecommunications community and creates visibility for all women in technical careers. Each year it identifies and acknowledges the achievements of one woman who has demonstrated outstanding personal and professional growth and has contributed significantly to the industry.

To Be Eligible:

- Open to all women in a technical field of cable television, broadband, and telecommunications.
- Current national SCTE member.
- Current national WICT member.

Factors of Consideration:

- Demonstrates meaningful contribution to the industry.
- Exhibits high level of knowledge, skills, and professionalism.
- Committed to community and/or professional activities that enhance the perception of the cable and telecommunications industry in general, and women in technology specifically.
- Broadband Communications Technician/Engineer (BCT/E) Certification.
- Exhibits commitment to professional development and continuing education.
- Attends SCTE and WICT conferences.

To nominate someone for this award, please provide the following information:

Name of Nominee: ______

Company: ______ Title: ______

Address: ______

Telephone: ______

Why are you nominating this person? (attach additional sheets if necessary.)

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Name of Nominating Person: ______

Company: ______

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Mail or fax to be received by August 25, 2000 to:

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Antronix	92
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Aurora Instruments	263
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Broadband Access Systems	75
Broadband Services Inc.	60-61
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Cable AML	30
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Cable Resources Inc.	235
Cabletek	74
Canal+ Technologies	81
C-COR.net	27
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Diva Systems	39
DST Innovis	225
DX Communications	23
Electroline	283
Ericsson	241
Fiber Instrument Sales	174
Fiber Optic Network Solutions	100, 185
GE Americom	33
Harmonic	199
HUKK Engineering	19
ICTV	70-71
Invensys Energy Systems North America	Insert
ISC Datacom	161
JFW Industries	138
Klungness Electronic Supply	150
Leaming	213
Lemco	14, 132
LINC.NET	155
Lindsay Electronics	58
Lode Data	42
Lucent Technologies	78-79
Mainline Equipment	131
Mega Hertz	270
Mega Hertz	160, 172, 182
Mega Hertz	184, 198, 208
Mega Hertz	214, 240, 264
Mega Hertz	66, 110, 154
Mindport	47-54

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ADVERTISER ACCESS

Advertiser	Page #
MK Battery	141
MMG North America	247
MobileForce	57
Moore Diversified Products	117
Motorola Broadband Communications Sector	191
Multicom	262
Multilink	284
NCTC	64
NCTI	110
nCube	59
NEPTCO	222
Noise/Com	245
Oldcastle	249
Pace Micro Technology plc	183
Passive Devices	25
PBI Customer Service	240, 262
PBI List Sales	198
PCI Technologies	Insert, 114
Pico Macom	137
Pioneer	149
Power & Telephone Supply	89, 121
Precision Valley Communications	91
Preformed Line Products	100, 123
Pyramid Industries	46
Quality RF Services	171
Quintech	124
R. L. Drake	223
Radiant Communications	221
RDL Inc.	175
Rifocs Corporation	10
Ripley Company	152
Riser Bond Instruments	181
RiverDelta Networks	101, 119

Advertiser	Page #
Rycom	251
Sadelco	230
Scientific Atlanta	13, 97
SCTE	103, 269, 271
SeaChange	257
Sencore	165
Signal Vision	77
SpanPro	122
Sprint North Supply	65
Standard Communications	11
Synchronous	69
TAS	167
Telecrafter Products	8,12
Tellabs	139
Tempo Research	120
Terayon Communication Systems	7
Thomas & Betts	37
Thomson Consumer Electronics	151
Times Fiber Communications	111
Tollgrade	179
Toner Cable Equipment	205
Toshiba	21
Trilithic	41, 67, 96, 259
Trilogy Communications	193
Tulsat	83, 215
TVC	40, 43, 44
U.S. Electronics	93
Viewsonics	147
Watkins-Johnson	133
Wavetek Wandel Goltermann	gatefold cover, 15
Wireless Communications Association	281
Women In Technology	265
Worldgate	95

Merchandise/Back Issues(800) 877-5188 Editorial(303) 839-1565, ext. 43 Advertising(301) 340-7788, ext. 2004

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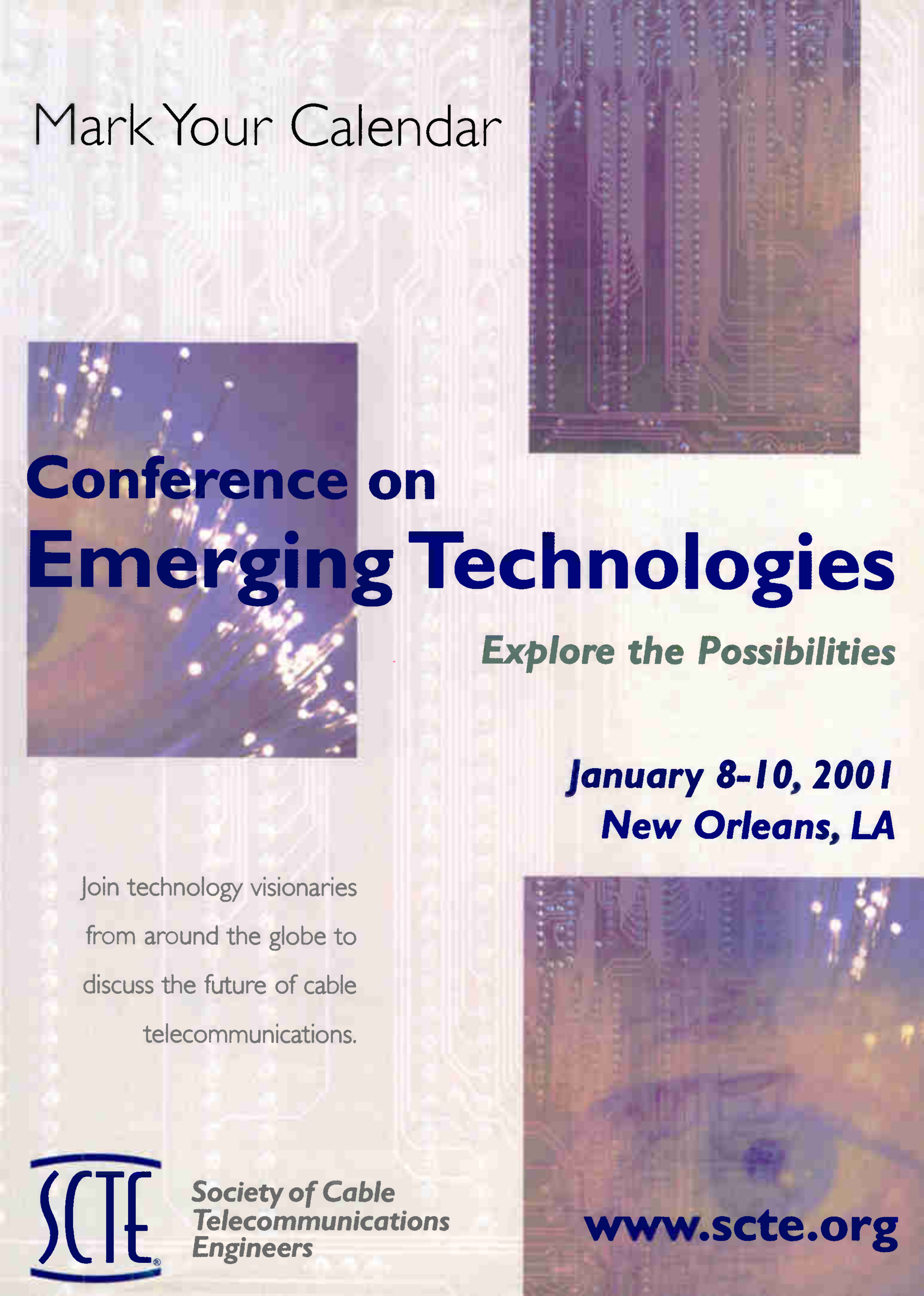

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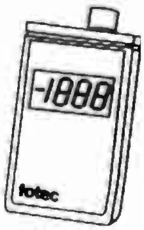

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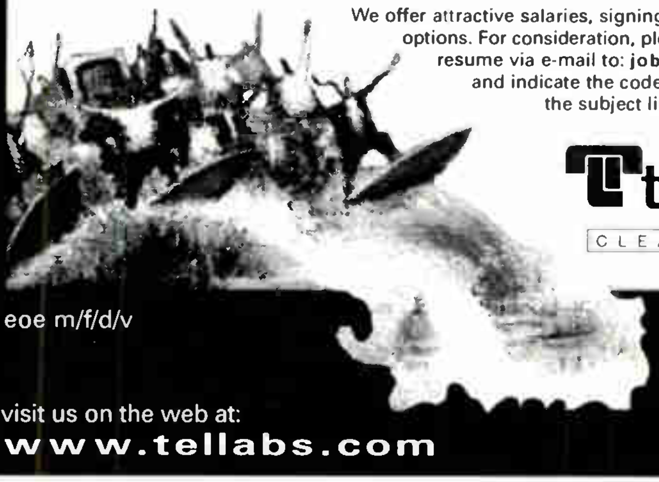

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Director of Training

SCTE seeks a Director of Training to oversee the development and delivery of training for the cable telecommunications industry. Duties will include:

- Identifying new training programs needed by the industry
- Designing new training programs and materials
- Developing and publishing training materials
- Representing the Society at industry events as a speaker and/or exhibitor
- Overseeing the budget for the training development
- Supervision of training staff and contractors
- Working closely with other departments to accomplish the goals of the Society

Qualifications: The successful candidate will have an extensive background in developing training programs & have demonstrated the ability to manage projects & staff. Basic tech. Knowledge of cable telecommunications indus. is helpful, but not req. Candidate should be willing to travel and relocate to the Exton, PA area. Creative innovation is a must. Demonstrated ability w/ structured training design, writing and project management, as well as exp. w/ stand-up delivery of training. Candidate must be self –starter w/ ability to work w/ little supervision & able to work well w/ others on various teams. Please send resume inc. salary req. to Society of Cable Telecommunications Engineers, Human Resources, 140 Philips Rd., Exton, PA 19341-1318, or Fax to 610-363-5898.

SCTE—What's In It for You

Never in the history of the Society of Cable Telecommunications Engineers has the organization's growth matched its current level. In February, SCTE membership reached an all-time record-high number with 16,850 members. In March, 1,018 technical professionals in the telecommunications industry joined SCTE, allowing the organization to break the 17,000 mark and announce a new record of 17,258 members.

While the expanding influence of the Society is incredibly exciting, it's also cause for reflection and action. Just as the industry has evolved to embrace the advances in technology while meeting the changing demands of the marketplace, SCTE continues to expand its educational programs, professional development resources and services to cater to the shifting needs of its members.

"SCTE hasn't just survived several periods of industry transition—it has thrived."

What's new

SCTE's recent advances include:

- The ongoing expansion of SCTE Online's resources, including online lectures, bookstore, seminar registration and more, to provide educational resources 24/7 at www.scte.org
- Partnerships with human resources and training directors at various systems to customize SCTE-developed training to meet their companies' unique needs
- The development of an international chapter program
- The expansion of SCTE's standards activities to include Data Over Cable Service Interface Specification (DOCSIS) standards maintenance and development
- The introduction of two new member benefits that enable members to advance their professional knowledge: SCTE-List and *Pipeline*.

Two resources

Started in 1994 by David Devereaux-Weber, network engineer at the University of Wisconsin-Madison, SCTE-List is an e-mail discussion forum that provides quick access to peer feedback and ideas regarding today's pressing technical issues. SCTE and Devereaux-Weber have partnered to make this valuable service available to all SCTE members.

"SCTE-List is like a virtual technical 'think tank,' with a group of subscribers from around the world who have a vast pool of knowledge and experience," Devereaux-Weber said. "By posting questions to the group, this resource can save you countless hours of trial and error in your career."

SCTE's additional new member benefit, *Pipeline*, is *Communications Technology*'s newsletter on broadband product news, applications and new service deployment. Society members receive the latest issues of *Pipeline* via e-mail twice a month.

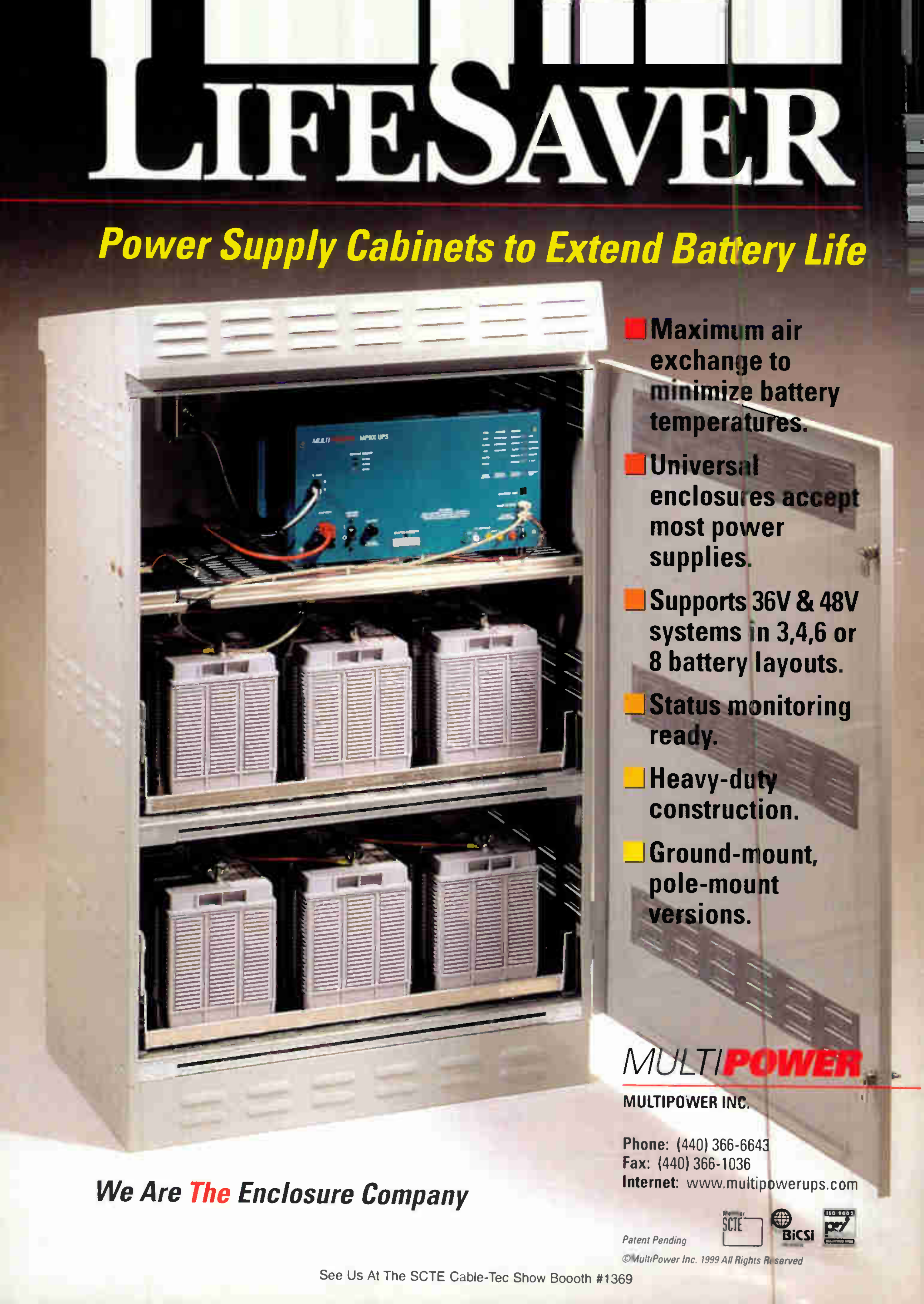
New logo for new times

Returning to the topic of diversity among the technical professionals served by SCTE, in March, SCTE's Board of Directors made the decision to update the SCTE logo to better reflect the association's membership. Created in 1969, the original logo emphasized the dominance of television in the cable industry. Who would have imagined the vast array of services provided via cable today? The updated version of the logo signifies SCTE's efforts to embrace and serve a multifaceted industry.

What accomplishment and fulfillment SCTE's charter members must feel 30 years after the inception of the organization. SCTE hasn't just survived several periods of industry transition—it has thrived. The number of telecommunications professionals who depend on SCTE to advance their careers and serve their industry through technological training, certification and standards is a testament to SCTE's sustained value and impact. SCTE's record-breaking growth indicates good things to come.

For more information on SCTE's member benefits and services or to join SCTE, call (800) 542-5040 or e-mail membership@scte.org. CT

Melissa Hicks is director of membership services for the Society of Cable Telecommunications Engineers. She can be reached via e-mail at mhicks@scte.org. Did this article help you? Let us know your thoughts. Send an e-mail to jwhalen@phillips.com.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