Next Month:
Planning 2001, part one

Communications Technology

Official Trade Journal of the
Society of Cable Telecommunications Engineers

September 2000

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Cover

Design by Tamara A. Morris
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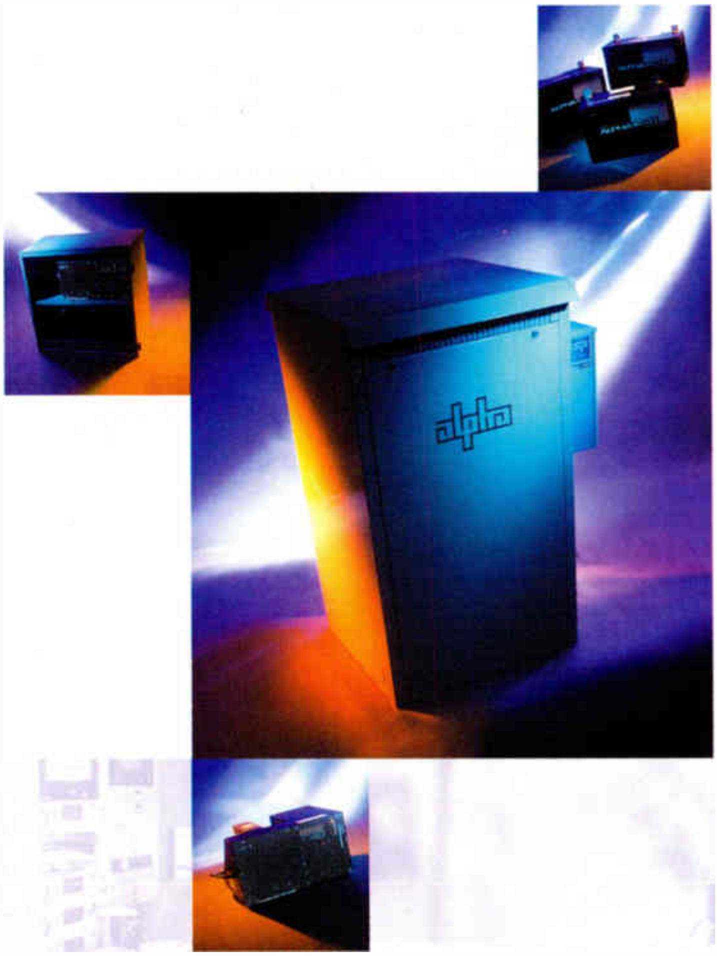
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September 2000 volume 17 number 9

For A Few Dollars—Less!

I enjoy television. I always have. Even though I have a wonderful digital video signal as a subscriber to a broadband network, I detest the audio service that comes with the picture. Each evening, following a hard day's work, I settle back onto my sofa and select my program of choice.

No matter which network, I adjust the volume of the program for pure enjoyment and then come the nine or 10 commercials with twice the volume of the program. I grab the remote and decrease the volume of one of the commercials only to find another advertiser screaming louder for me to come on down and buy a car or see the latest in wireless phones. Then, when these screamers give up and the program returns, I have to increase the volume.

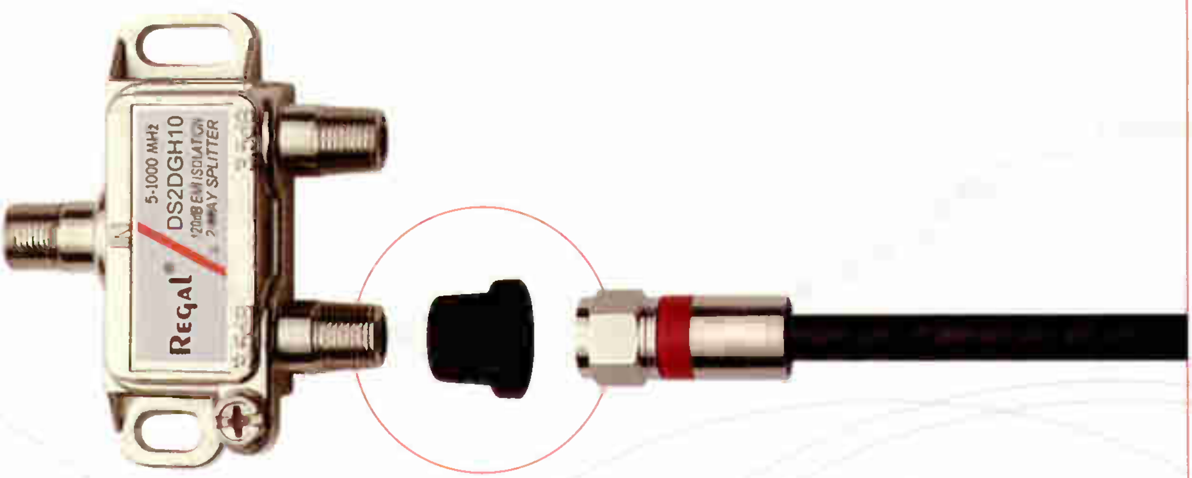
This scenario happens throughout the evening. I find myself wanting to scream also. Not at the television set, but at the cable system that touts its ability to bring a crisp clear picture in digital format. But nothing seemingly can be done about providing the subscriber with reasonably constant audio volume. I know there are threshold circuits which can maintain the audio volume of any cable channel. So I started asking questions about this problem that everyone detests but no one does anything about. I spoke to some manufacturers of headend processors. They readily admitted they could supply such audio threshold circuits in processors sold to broadband network owners. Then they stated that there seemed to be no interest in maintaining a reasonable volume of television audio. I know TV broadcasters allow their advertisers to blast viewers with ear-splitting noise. They feel it may help get the viewers attention. Sound weird? Not really.

TV advertising studies have shown that irritating commercials are often better than quality spots. The viewer often remembers the commercial because he detests its content. Sure, viewers might detest the extra noise but they will, at least, look at the commercial before breaking their leg trying to locate the remote.

So, viewer be damned. Surely they will simply blame the extra noise on the advertising company and its product—never the broadcaster that allows it to blast into the viewers ears. Surely the system people recognize the problem and would want to give their subscribers better audio service than the broadcasters or other providers? Are you kidding? The system operators wouldn't want to maintain audio volume of a network broadcast because, in doing that, they would have to maintain the same audio of commercials they insert onto non-network cable programming and might have a harder time selling local commercials for their own ad insertion.

Shame on us—we claim the customer is our first priority and yet we refuse to fix a problem that would complete the digital experience and prove our dedication to superior customer service!

REVOLUTION



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> What Do You Think? by Rex Porter

I am continually surprised to get all of the e-mails and phone calls from SCTE members who want to talk about the Society, their programs and meetings. These conversations run the gamut from positive to negative. When I recommend members call the SCTE directly for these discussions, there are lots of responses such as, "I wouldn't feel comfortable discussing this with them;" "I don't know the people back in Exton;" or "Well, I'm not sure they will listen to what I have to say."

I always ask if the caller has ever returned any of the numerous SCTE surveys asking for opinions and ideas from the general membership. The answer is usually "No." When I ask if the caller has spoken with their Regional Director, many times they respond they don't know the Director well enough.

The Board members, who are all volunteers, and the SCTE staff members need to know your thoughts and wishes. They need to know whether you are pleased or displeased. While I am both a Senior and Charter member of the Society, I am on neither the SCTE staff nor Board of Directors. *Communications Technology* is the Official Trade Journal of the Society, and this year we added a slate of new directors to the board. So, I am going to offer *CT* as an extra conduit for you to voice your opinions about how you perceive SCTE from the field. From conversations, it seems members are just hesitant to voice their opinions directly and are more comfortable chatting unofficially.

Feel free to write me or sending an e-mail to me at tvrex@earthlink.net. You can trust me not to publish a letter/message, or any part of them, without getting your approval beforehand. I will make SCTE aware of your opinions, however, although I will not identify you as the writer, unless you say otherwise. If you think SCTE is great, say so. If you think changes should be made, say so. The Society wants to serve your needs. But, if you don't let them know "what you think," they will only hear other voices. I have heard everything, from Expo registration costs being too high, to the need for new training programs, to changing the name of Cable Games to Cable Olympics. Perhaps you want to comment about MSOs supporting attendance at these meetings.

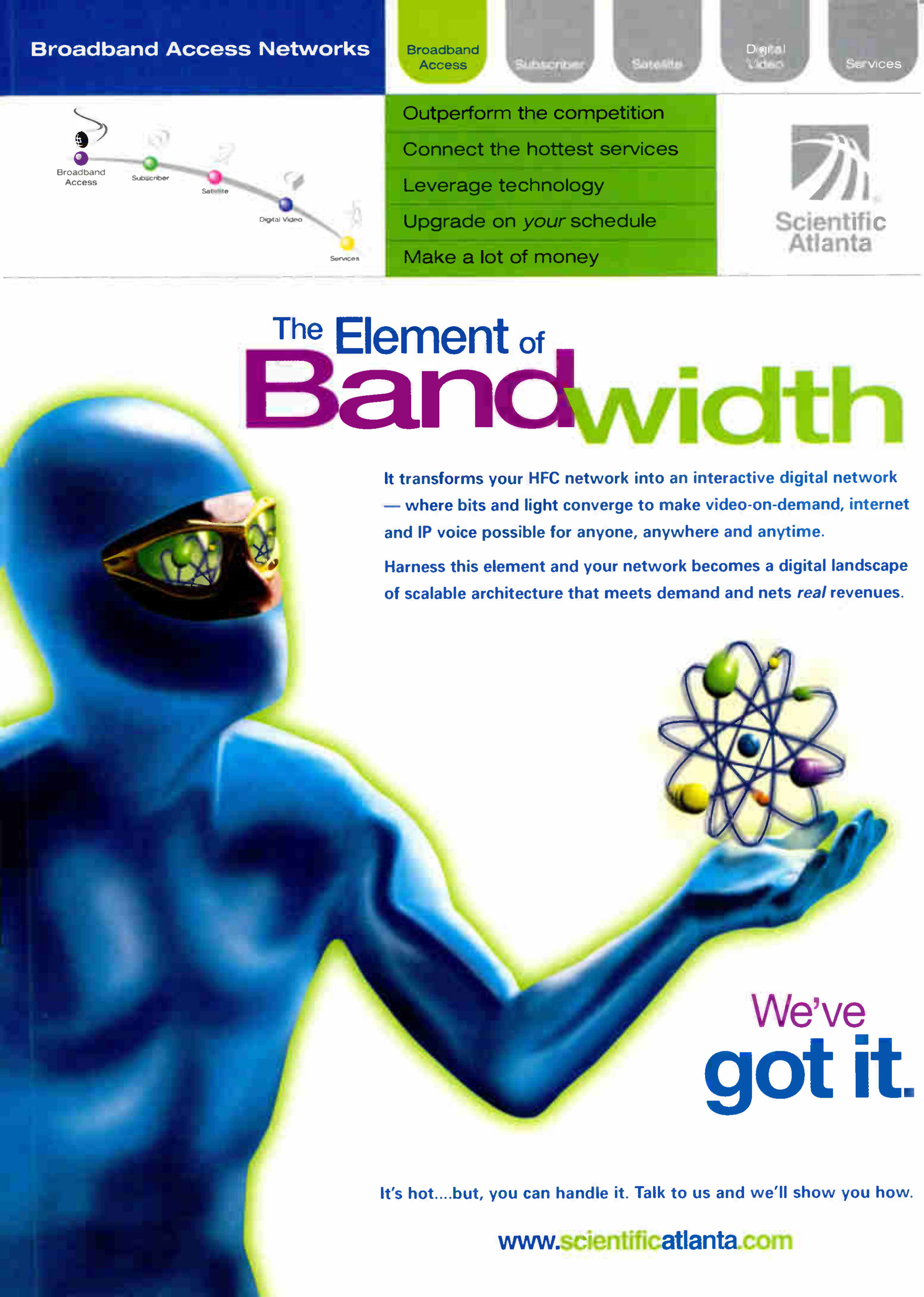
The ideal thing would be for all members to attend local chapter meetings, Vendor Appreciation Days, the Conference on Emerging Technologies and the Expo. At the Expo, you should attend the Annual Membership Meeting where members in the audience are heard. But since many of you cannot attend these meetings, or if you just want to speak your piece, write me a letter or send me an e-mail. I'm listening.

Hamming Around

CT:

I want to congratulate and thank Mr. Hranac for his excellent article "Signal Leakage & Harmful Interference: A Ham Radio Perspective" (July 2000, page 80). Like Mr. Hranac, I am a licensed amateur who is also involved in the cable television industry. The article is very well written, clear, and extremely informative. I look forward to reading more of Mr. Hranac's work in the future.

Dan Levin
Chief Technical Officer
ReplayTV



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Ron:
I enjoyed your article, "Signal Leakage & Harmful Interference: A Ham Radio Perspective." Some people will do anything to get pictures of their antenna farm and mobile installation in print. The caption is somewhat bothersome, however: "....plus a DBS dish." and "...plus a CB antenna." I knew about the DBS antenna but I'm worried about you going over the edge with CB.

P.S. Have you tried transmitting on your ferrite-rod 80 meter DF antenna?

Steve Johnson
Director, Engineering & Technology
Time Warner Cable Denver

Editor's Response: *The 80m DF antenna is for receive-only. Connecting it to your Alpha 87A or Heath SB-220 amplifier would result in instant smoke, but the ferrite might give off an interesting glow before it disappears.*

International Fans

Jim:
I was reading your digital compression articles (February 2000, page 66; April 2000, page 98; June 2000, page 156). I must say you do have the knack when it comes to writing good articles. Well done.

One of my areas of interest is home networking—video, audio, data and so on—using 1394 or any other technology. Have you written any articles in this area? Or do you know of one you could refer me to? Many thanks.

Dr. Ahmad Atefi
Project Manager
Independent Television Commission
UK

Editor's response: *Thank you so much for the compliment. As for home networking, unfortunately I am not working in that area and have not personally written on it. However, Communications Technology has done several recent articles on the topic. See "The Networked Home: Closer Than You Think" (May 2000, page 80) and "Home Networking 101" (February 2000, page 101). Also, stay tuned for a forthcoming article on wireless home networking in our November 2000 issue.—JF*

Ron:
I applaud you for your latest technical articles on subjects such as dB, dBmV, dBm—as well as "The Powers That Be" (June 2000, page 55), "The Numbers Behind Thermal Noise" (April 2000, page 45), "The Wireless Dilemma" (July 2000, page 36), "Signal Leakage & Harmful Interference" (July 2000, page 80), and so on—because you explain the fundamentals which must be refreshed continously for everybody to better understand the most recent advancements in our industry. Please continue in that vein because, in my opinion, the entire technical community needs and welcomes these essential concepts.

M. Antonio Huerta Carbajal
Communications/Electronics Engineer
ESIME
Mexico City, Mexico

> 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.

Juno Joins Time Warner Open-Access Trial

By Eric Ladley, Editor, ISP Business News

Soon after being aggressively probed by the Federal Communications Commission (FCC) on when it would open its cable systems to competing Internet service providers (ISPs), **Time Warner** agreed to let **Juno Online Services** offer access over its systems.

The deal is for a limited trial in Columbus, Ohio, however, and there is no sign it will soon result in consumer choice. The announcement came at the height of FCC scrutiny of the merger of Time Warner and **America Online**, the largest ISP in the world with 23 million subscribers.

Juno, with 3 million subscribers, and Time Warner will test how offering cable access from multiple ISPs would work. Time Warner will be in charge of installing the service, but there is no joint marketing agreement.

Time Warner says the open access trials started prior to announcing the Juno deal. Analysts, though, say the announcement was clearly motivated by the beating Time Warner took at a FCC merger hearing.

AOL is bigger than any other ISP by about 20 million subscribers, and the thought of it getting exclusive control of Time Warner's cable prompted concerns from other Internet companies and the FCC.

"It's cover-your-ass time," says Carl Garland, an analyst with Sterling, Va.-based **Current Analysis**. "Maybe this is a move by Time Warner to head off the FCC. There has been a lot of waffling going on, and maybe the FCC is signaling to them that here's an opportunity to take the initiative."

> "Maybe the FCC is signaling to them... to take the initiative"
>
> –Carl Garland

Time Warner director of communications Lynn Yaeger says there is no specific timetable on when open access would be offered and the tests would focus on the hardware and software that make up the cable network's infrastructure. The trials have started, and Yaeger tried to play up the fact that multiple ISPs are participating.

"The test is to a great extent for multiple ISPs," Yaeger says. "The hardware and software for provisioning the network for ISPs is new, and we must identify any implementation issues that must be resolved."

There are three other ISPs now participating in the trial: AOL, **CompuServe** (part of AOL), and **Road Runner** (partly owned by Time Warner). In other words, Juno is the only independent ISP involved. Yaeger says Time Warner is in discussions with other ISPs but cannot divulge their names.

"The purpose of the test is to determine how to deliver and offer services from multiple ISPs," Yaeger says. "Their affiliation does not matter."

In addition to any technical problems that need to be worked out before Juno can actually offer service, Time Warner has to restructure its relationship with its exclusive cable ISP Road Runner. Road Runner is being restructured as part of the **AT&T/MediaOne** deal.

A redone Road Runner could take shape by year's end, Yaeger says, and could clear the way for Juno to offer cable access through Time Warner.

NEWSBYTES

> ***Blonder Tongue Leases***

Blonder Tongue Laboratories is giving its customers leasing options through an agreement with Information Leasing Corporation, a unit of **Provident Financial Group**. Blonder Tongue says it aims to increase customer options, minimize paperwork, and reduce turn-around time.

> ***Comcast Surpasses Million***

Comcast has deployed over a million digital set-top boxes that deliver its Digital Cable service. Launched in July 1998, Comcast Digital Cable features enhanced picture quality, CD-quality sound, more than 40 channels of commercial free music and an interactive program guide.

> ***Anadigics Hits Milestone***

Anadigics has shipped over 100 million broadband radio frequency integrated circuits (RFICs) for cable systems and fiber optic networks. The company's product lines include integrated chips (ICs) and broadband amplifiers for cable TV, Internet and Internet protocol (IP) telephony systems.

> ***Thomson Gets Older***

AT&T Broadband plans to buy 700,000 **RCA**-brand, high-speed cable modems from **Thomson** Multimedia over the next two years. The deal could be worth as much as $140 million. Thomson also sells to **Comcast**, **Charter** and **Adelphia**, and says it is expanding 2001 cable modem production capacity to 1.5 million units.

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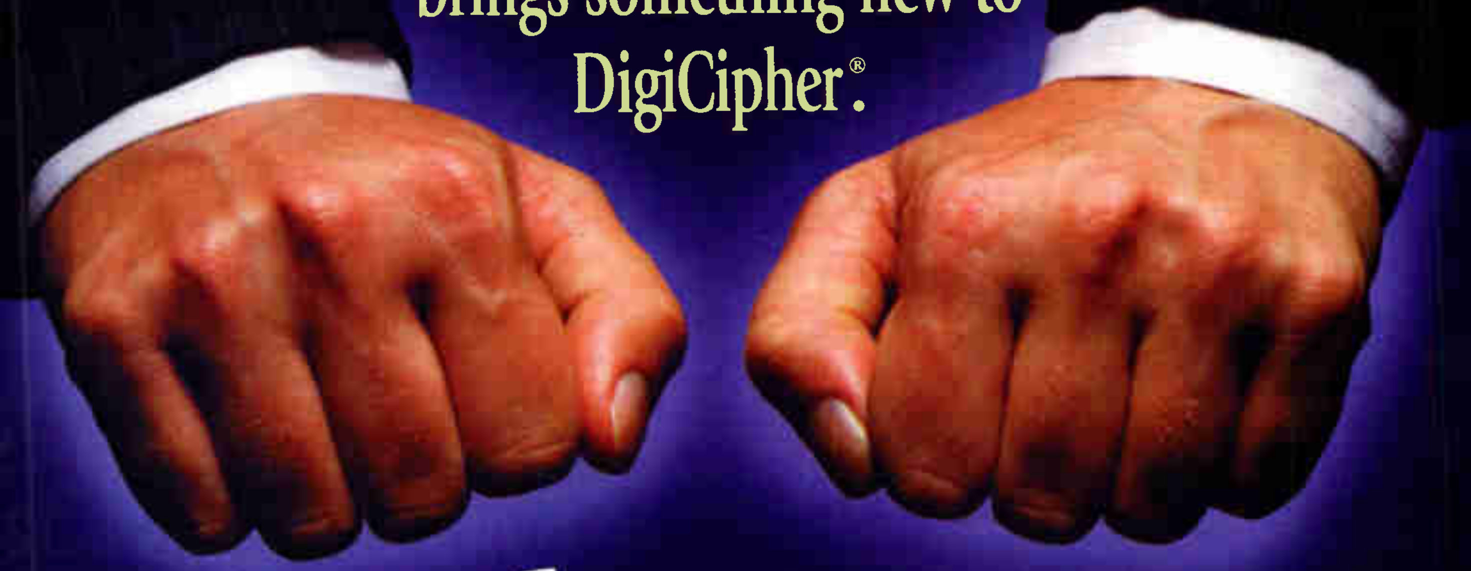

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Cox Trials Excite

By Arthur Cole, Contributing Editor

A new trial at **Cox Communications'** plant in San Diego can be seen as a new twist on an old theme. Rather than trying out the latest whiz-bang features on the newest equipment, Cox, along with **Excite@Home**, is interested in the mileage it can get out of existing equipment.

The two companies hope to gauge consumer receptivity to a number of innovations available on the **Scientific-Atlanta** Explorer 2010 set-top, a modified version of the 2000 box that is already in many consumers' homes but lacks the processing power and storage capabilities of the upcoming 3000 model.

With an installed base of more than 500,000 broadband users employing either the early generation S-A or **Motorola** boxes, Cox has a vested interest in ensuring that the technology offers enough bells and whistles to keep viewers interested until they decide to upgrade.

One of the features Cox wants to try out is Excite@Home's new TV portal, designed to bring sharp text and graphics to the television screen.

"There is a heavy focus here on leveraging our broadband content—audio, video, animation and games—for the living room," says Kent Libbey, Excite@Home director of set-top products. "We want to understand how far we can push today's set-top."

> **"There is a heavy focus here on leveraging our broadband content.... We want to understand how far we can push today's set-top."**
>
> **—Kent Libbey, Excite@Home.**

Trial participants will be able to access any and all information—news, weather, sports and so on—from the Web via their TV sets, and will have complete browsing capabilities to take advantage of shopping and other services. They will also be able to use Excite's personalization features, allowing them to customize the service to their specific needs.

Still, both Excite and Cox recognize that the current generation of set-tops cannot provide all of the potential services that broadband has to offer.

"We've made some design modifications and reformatted the default Web pages so that they fit on the TV screen. But in the end, it's still just text and graphics on the TV," Libbey said. "But maybe we'll be surprised and find that consumers want the Web on their TV, but not pay extra for it."

Once the more advanced boxes come out, Cox and Excite can start experimenting with more flashy offerings, such as personal video recorders, on-line gaming, enhanced DVD players and MP3 jukebox services.

"This is a learning experience, and it's important that we participate in this whole development effort," Libbey said. "Cox is a strategic partner, and this is the first step in a long journey."

Marconi Dazzles and Delivers

By Jonathan Tombes, Deployment Editor

The media room (pictured at left) for the Marconi Grand Prix (at right) in Cleveland, Ohio.

Let's take two looks at communications innovator **Marconi**, one at the races in Cleveland, Ohio, and the other in a Cox data network in Santa Barbara, Calif.

At the Marconi Grand Prix in Cleveland, a Champion Auto Racing Team (CART) event, the sponsor dazzled journalists with a newsroom that included nine separate plasma screens and workstations that enabled real-time personalized coverage.

The event required collaboration with CART officials, equipment vendors such as **Tandberg**, **ABC** camera crews and Marconi's own team. In technical terms, Marconi managed a dozen signals over a 5,000-foot stretch from the track to the media center.

"We digitized twelve separate sig-

nals using MPEG (Moving Picture Experts Group) compression equipment, and we then multiplexed them onto an ATM (asynchronous transfer mode) infrastructure," says Tom McDonnough, a director in Marconi's strategic industry solutions group.

At the other end, Marconi terminated the video streams at the wall of nine large plasma screens using MPEG II decoders and in the workstations using very-high-data-rate digital subscriber line (VDSL) technology.

At their monitors, journalists could scroll through channels and use hyperlinks. McDonnough says that two-way video conferencing between racing pits and media center was also a hit.

This was a limited demo, but imagine applying personalized coverage to events such as professional golfing or the Olympics on a mass-market basis.

Someone's mind is already reeling at the prospect of digital ad insertions alone.

PacketPath in Santa Barbara

Meanwhile, back to real deployments and current customers, Marconi is gaining a foothold in cable's burgeoning data business.

Cox Business Services, for instance, is using Marconi products exclusively in Lubbock, Texas, and Santa Barbara, Calif.

Cox Senior Data Engineer Rich Prohaska says that Marconi's OSR with PacketPath allows his customers in Santa Barbara to migrate from a local area network (LAN) into the metropolitan area network (MAN).

"Everybody is beginning to create equipment with Ethernet type interfaces, even for the MANs," says Prohaska. "Marconi led the charge."

Marconi's OSR optical access multiplexers is based on a synchronous optical network (SONET) platform, but with PacketPath, says Prohaska, Marconi made a "quantum leap."

A classic SONET architecture requires committing a segment of bandwidth to a customer, whether or not it's used.

"Packetpath takes (data) into the packet switching world...and allows you to drop off, using Ethernet 10BaseT interfaces or 100base, a circuit with a variable bit rate to the customer," he explains.

The result enables quality of service (QoS) and flexible offerings. "For instance, if a customer wanted a 10 Mbps pipe, but the rate for a solid 100 percent 10 Mbps is so out of his budget, I can sell one with a 50 percent CIR, (committed information rate); I can guarantee him 5 Mbps and let him burst to 10 Mbpsas long as the backbone can handle it."

At the same time, the Packetpath eliminates the need to commit as much bandwidth to backbone resources.

So how's business?

"Can't hold it down," says Prohaska, who notes the Santa Barbara's relative lack of commercial real estate may be leveraging the product. "Everybody wants to be connected."

"Everybody is beginning to create equipment with Ethernet type interfaces, even for the MANs. Marconi led the charge."

—Rich Prohaska, Cox Business Services

DEALS

> ***Broadcom Continues Spree***

Broadcom is acquiring **Altima Communications**, a supplier of integrated circuits (ICs) for the small-to-medium business networking market.

> ***Cisco Teams with Liberate, Comcast***

Cisco Systems announced separate deals to invest $100 million in **Liberate Technologies** and concluded a three-year agreement to provide **Comcast** with routers and other equipment for IP telephony, video-on-demand (VOD), high-speed Internet access plus other broadband cable services.

> ***Broadband Innovations Garners $11 million***

Scientific-Atlanta invested $6.8 million, and **Motorola**, **SBC Communications** and **Lauder Partners** made up the difference. The company will use the funding to augment manufacturing of current products and continue R&D efforts.

> ***Alloptic Gets S-A Funds***

Scientific-Atlanta is investing up to $8 million in passive optical network (PON) developer **Alloptic**. The two companies plan to co-develop and deliver advanced interactive services. S-A also plan to work with Alloptic on Gigabit Ethernet residential PON fiber access products over the next five years.

> ***Nortel Nabs Alteon***

Nortel Networks is acquiring **Alteon WebSystems**, a content-aware switching company, in an estimated $7.8 billion stock deal, thus boosting Nortel's position to deliver high-performance Internet data centers.

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Roving Reporter

Lucent's Automated Optoelectronics Plant

By Jonathan Tombes, Deployment Editor

Ten miles west of Allentown, Pa., on a hill with a commanding view of the countryside sits a 143,000 square-foot answer to the question of what drove **Herrmann Technologies** and **Ortel** into the arms of **Lucent**.

Wall Street analysts have their own explanations, but the automated technology on display in Lucent's optoelectronics "manufacturing realization center" (MRC) on Breinigsville's Clover Hill illustrates a point that executives of the involved companies themselves have made.

At the time of their respective acquisitions, both Herrmann Technology President Bill Herrmann and Ortel President Stephen Rizzone emphasized Lucent's "industry-leading automated packaging processes" .

On the floor of Lucent's MRC, that phrase jumps to life, as rows of mini-clean rooms housing precision robotic manufacturing tools quietly churn out trays of 50 optical sub-assemblies (OSAs) at a time.

The silence is nearly deafening. "I've had visitors ask me why we weren't producing anything," says Lucent microelectronics group director Jim Dormer, who drew up the business plan for the MRC. But producing they are.

Ground broke last summer and the $24 million expansion closed this April, 10 days before schedule. Moreover, while moving into the new facility, says Dormer, production actually increased. But, then again, Lucent expects to quadruple production by year's end as a result of the expansion.

"What we make in a week or two we made just a very few years ago in a year," says Dormer. But the process is not only faster, it's been miniaturized.

Manager of Product Marketing Brian Rothermel explained communications subsystems have evolved from a 11 inch-by-12 inch discrete board assembly that consumed 25 Watts in 1997 to a 2 inch-by-3 inch multi-chip module that uses a fifth as much power today.

Through the looking glass

Under magnification, Lucent's element management layer (EML) OSA resembled not so much the two-dimensional blueprint of a classic silicon chip as a veritable town, complete with intersecting streets, several-story buildings, strung wires and water tower.

All of this on a scale puts two dozen such units on a single penny.

On the MRC's floor, Lucent's photonic team technicians monitor a re-designed manufacturing process said to take 50 percent fewer steps and increase reliability by five-fold. Dormer says the role of engineers, who account for between one-third and one-half of the MRC's employees, is to improve the paperless process further, for instance, by reducing the number of tests required.

"What we make in a week or two we made just a very few years ago in a year." —
—Jim Dormer, Lucent

Lucent's Manufacturing Realization Center (MRC) in Breinigsville, Pa.

(Agilent, ILX Lightwave, and other test equipment manufacturers, take note.)

Spreading this technology around, in May Lucent announced a $40 million expansion of its Ortel-based manufacturing capacity in Southern California. It has pledged a three-year $1 billion investment in optoelectronics components R&D.

As analysts calculate the financial implications of Lucent's recently announced plans to spin-off its microelectronics group, demand continues unabated. Paul Coe Clark, editor of sister publication *Communications Today*, says that "the spin-off will be filling current orders until doomsday."

Filling them sometime before that date will require Lucent's engineers to figure out how to get this equipment to work at an even faster pace.

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MMDS Gets Boost from Communications Giants

By Natalia A. Feduschak, Senior Editor

Taking a cue from the cable industry in the need for standards, communications companies have forged two separate initiatives to promote Multichannel Multipoint Distribution Service (MMDS).

The first, dubbed the Wireless DSL Consortium, encompasses six leading communications and semiconductor companies who have joined together to accelerate deployment of wireless access solutions. The other, known as the Breckenridge Agreement, was initiated by **Sprint** and **MCI WorldCom**.

"There should be one set of standards," says Lamar Bishop, a consultant to the Wireless DSL Consortium. "What we want to do is to converge...so that the industry will not be as chaotic."

Comprised of **ADC**, **Conexant Systems**, **Gigabit Wireless**, **Intel**, **Nortel Systems** and **Vyyo**, the Wireless DSL consortium hopes to provide the industry with an open standard that will allow suppliers to make multi-vendor products for the broadband wireless access markets. The group says it will provide a forum to define, develop and implement a set of open interfaces for broadband wireless access products operating in the 2.5GHz MMDS band in the United States and Canada and the 3.5 GHz band internationally.

The solution will include non-line-of-sight (NLOS) operations in all regions of the world and access speeds that are faster than current broadband solutions. To accomplish its goal, the consortium is expected to pursue next-generation multifaceted standards that take advantage of recent technological advantages.

Residential, small office-home office (SOHO), telecommuters, as well as small-to-medium enterprise (SME) clients are the consortium's target audiences. The first product of the consortium will be the adoption of an air interface this year, based on the Data Over Cable Service Interface Specialization (DOCSIS).


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The Breckenridge Agreement

Coming on the heels of their failed merger, Sprint and MCI WorldCom have jumped on the MMDS bandwagon by unveiling the Breckenridge Agreement in early July. The companies introduced an industry-wide spectrum management plan which creates a set of standards, spectrum band plans and operating procedures necessary to build out new high-speed data services in markets across the U.S. that lack high-speed Internet connections.

"At the beginning of 1999, the industry was in trouble," says Robert Hoskins, director of corporate communications for Sprint's broadband wireless group. "People didn't want to work with each other, didn't want to see past each other."

Sprint determined it would be better to work together rather than separately.

"The problem is when you roll out a market, you have 33 frequencies," says Hoskins. "What we all agree on was which side of the road we're going to drive on.... We've agreed on using a certain number of channels for upstream, and others for downstream."

Determining a set of standards makes sense for an industry that is expected to see fixed wireless broadband revenues soar at a compound annual growth rate of 140 percent and reach revenues of $16.3 billion by the year 2004.

> "At the beginning of 1999, the industry was in trouble. People didn't want to work with each other, didn't want to see past each other."
> —Robert Hoskins, Sprint

"The year 2000 should be a catalyst year for fixed wireless growth in the following years," says James Mendelson, an analyst for the **Strategis Group** in Washington, DC, who co-authored a study on world wireless broadband.

While Hoskins says the market will boom, he admits the competing consortiums aren't planning to merge anytime soon, although his group has been asked to join the Wireless DSL Consortium.

"We're not part of that consortium yet," Hoskins said. "The whole thing is going through a giant learning curve."

NEWSBYTES

DSL To Overtake Cable

Allied Business Intelligence says digital subscriber line (DSL) technology will soon overtake cable modems as the leader in high-speed Internet access. At the end of 1999, cable Internet service had 2.1 million U.S. subscribers while DSL had only 500,000. But ABI predicts DSL will catch up with cable this year and that by 2005, it could surpass cable by about 10 million subs.

VeriSign Protects

VeriSign introduced authentication services for cable modem manufacturers to protect against service piracy on broadband networks. Terayon is the first cable modem manufacturer to deploy the service.

Charter and Cox Buy Modems

Charter Communications signed a volume purchase agreement with Com21 for DOXport 111 cable modems, and **Cox Communications** has a agreed to buy Best Data Smart One CMX110 cable modems.

PEOPLE

Lappington Named Broadcom Entrepreneur

Veteran entrepreneur John Lappington has been named "Broadcom Entrepreneur in Residence" at Georgia Tech's Advanced Technology Development Center.

D'Arcangelo Honored by SCTE

Paul D'Arcangelo was awarded the **SCTE** New England Chapter's seventh annual personal achievement award for his leadership and commitment to building and upgrading the Northeast Region's network. D'Arcangelo is vice president of engineering for **MediaOne/AT&T's** Northeast Region.

Olander, O'Hare Become East, West VPs

AT&T Broadband named John Olander, vice president, engineering for its East Group and Patrick O'Hare vice president, engineering for its West Group.

Canal+ Gets Moss

Canal+ U.S. Technologies named David Moss vice president, sales. Moss was formerly senior director of national accounts with **Motorola's Broadband Communications Sector**. Canal+ provides interactive middleware for cable television.

Sloan Become CTO

Broadband communications provider **Cypress Communications, Inc.** has named Alistair A. Sloan as chief technology officer. He will co-ordinate the company's network strategy, oversee development and deployment of new technologies, plus manage strategic investor relations.

WorldGate Does Good and Well

By Jonathan Tombes, Deployment Editor

When talking about the "digital divide," **WorldGate** Chief Executive Officer Hal Krisbergh is a man on a public mission. The numbers show he understands private enterprise, too.

WorldGate's latest public service venture is called **Wish TV**, which aims to provide inexpensive Internet connection via the television.

Krisbergh deftly chose Capitol Hill as the venue for launching Wish TV's first program: providing fourth graders at 11 school in four states (Louisiana, Illinois, Ohio, and Connecticut) with a full year of in-home Internet access.

From left to right: FCC Chairman William Kennard; Congressman Billy Tauzin (R-LA), who is also chairman of the House Subcomittee on Telecommunications, Trade and Consumer Protection; Hal Krisbergh, chairman and CEO, WorldGate; Steve Schumm, executive vice presidnet, Charter Communications Inc.

"We really believe that the Wish TV initiative has all the right ingredients to really attack the problem for children who are growing up in the Internet world without equal access," said Krisbergh in a statement.

Local cable operators **Charter Communications**, **Buckeye CableSystem** and **Masillon Cable TV** agreed to install free cable access for participating students. **Motorola** and **Scientific Atlanta** are also supporting the program.

WorldGate's Internet on **Every TV** Service has also showcased the company's ability to connect consumers without personal computers (PCs) to the Web. (See CT, May 2000, p. 14.)

But Krisbergh appears to be doing both good and well. Its quarterly earnings rose to $3.6 million this quarter over $0.6 million a year ago, and the company is now closely aligned with four major multiple system operators (MSOs).

Adelphia, **Comcast**, and **Cox** joined Charter in agreeing to a predetermined number of digital deployments of Internet on Every TV service. The group also invested a total of $24.5 million into WorldGate, giving it about 7 percent aggregate ownership in the company.

The four MSOs and WorldGate have also formed a separate interactive TV joint venture, **TVGateway**. The venture will license WorldGate's Channel HyperLinkiing and Ultra-Thin Client technology, which provides back-office advertising and programming support for the MSO's digital set-tops, and WorldGate's Application Launcher, a middleware product.

Michael Christinziano, a cable infrastructure analyst with Gerald Klauer Mattison, says that the U.S. Department of Justice's approval of the **Gemstar/TV Guide** merger (arguably leaving program guide technology in one pair of hands) provides backdrop for MSO interest in WorldGate's alternative approach.

"There is no middleware with TV Guide in the thin-client box," he says.

Christinziano also says that WorldGate is benefiting from a lack of deployment for advanced digital boxes, where it had a weak presence. He says that WorldGate acquired **Digital Video Arts** in May to shore up its portfolio on the high end.

More typical was WorldGate's collaboration with Motorola on the lower-cost, Internet-enabled SURFview advanced analog set-top, which debuted last year and is beginning to pay off in domestic and international deployments, according to this year's second quarter report.

Ongoing acquisitions and overlapping alliances make the interactive television space notoriously tangled, but this joint venture and World Gate's accelerating revenues suggest that eh market is sorting itself out.

"You've heard that the proof is in the pudding," says Christinziano. "Well. the pudding is starting to cook."

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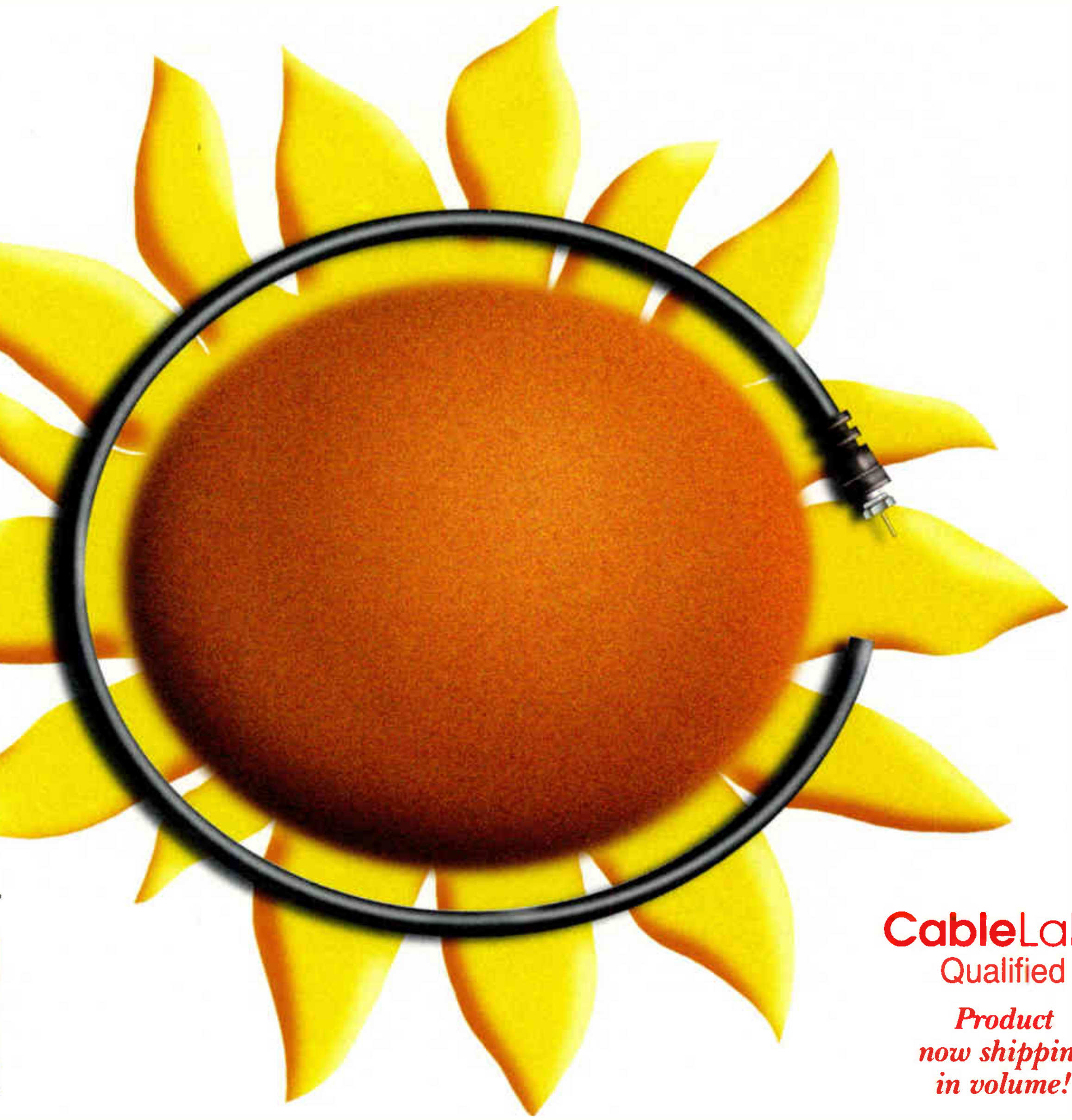

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Understanding Reverse Path RF Problems: Part 1

I'm frequently asked for suggestions about how to troubleshoot reverse path problems. My answer is usually prefaced with an obligatory, "It depends."

"On what?" you ask.

A lot of things, but first and foremost is understanding what the most common problems are. You can't troubleshoot what you don't understand. Allow me to make the assumption that your system's reverse path has already been activated and is operational. How well it operates is usually at the root of questioning how to troubleshoot reverse path problems. If it operated well, you probably wouldn't be asking.

That said, let's begin at the top of my list of most common problems.

"Of the reverse problems I've seen over the years, improper plant alignment almost always tops the list."

Improper plant alignment

I intentionally left "reverse" out of the first problem description because you must properly align the forward and reverse in order for the reverse to work. If the plant is not properly aligned, it's pretty much impossible to characterize any other problems, even the seemingly ubiquitous ingress. Indeed, of the reverse problems I've seen over the years, improper plant alignment almost always tops the list. You must—not should—sweep the forward and reverse actives, regardless of cascade length. Levels must be correct and frequency response must be flat. No ifs, ands, buts or shoulds. Must. Period.

Some might wonder why I've placed so much emphasis on forward path alignment in this discussion. Let me share a war story.

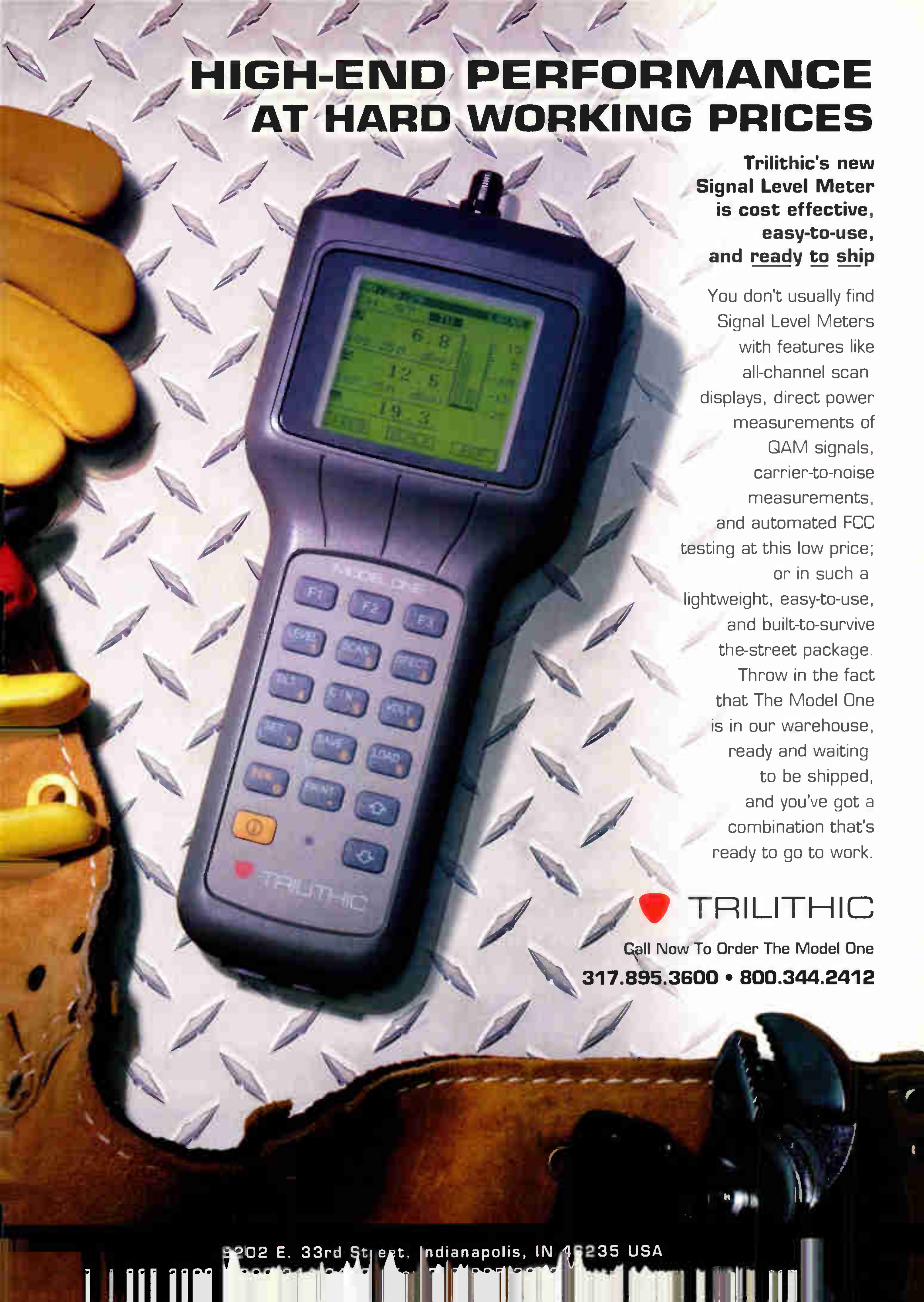
A few years ago, I was helping a cable operator set up an evaluation lab at the company's corporate headquarters. They had a fully operational headend, fiber links and even a dandy coax plant complete with a small cascade of two-way amplifiers, cable, line passives and taps. Most of the actives were of the multiple-output variety and we noticed, as we set up the cascade, what at first appeared to be common path distortion (CPD) in the reverse spectrum. A little troubleshooting suggested the first amp's output diplex filter was defective, exhibiting symptoms of what appeared to be insufficient isolation. To make a long story short, the problem turned out to be incorrect operating levels at the first amplifier's other downstream outputs. The main output was set correctly, but we discovered that each output had to be set separately. The other outputs were running wide open (whoops!), which was enough to overdrive that same amp's reverse module input. See what happens when you only read instruction manuals as a last resort?

Bottom line: Make sure the forward and reverse are properly aligned before doing anything else.

Ingress/impulse noise

This ranks a close second to improper plant alignment. While Data Over Cable Service Interface Specification (DOCSIS) modems and even some proprietary modems are fairly forgiving, robust modulation schemes are not a panacea for a noisy reverse spectrum. DOCSIS mandates minimum upstream carrier-to-noise, carrier-to-ingress power and carrier-to interference ratios of 25 dB. Good engineering practice says you should shoot for some headroom above any minimum spectrum. I'd recommend at least 30 dB carrier-to-anything.

Once again, the place to start is the downstream. If you want to clean up the reverse plant, first clean up the forward plant. Your system—headend, distribution network, and subscriber drops must be RF tight. Ideally this means no measurable downstream signal leakage, although a reasonable target is 5 microvolts/meter (µV/m), or less. If your downstream leakage just meets the Federal Communications Commission (FCC) 20 µV/m limit, the plant is not tight enough for two-way. If it's higher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than the FCC limit, re-read this paragraph—several times.

Got ingress? Narrow it down to a specific node, then use the divide-and-conquer method to find out where it is and where it isn't. Look for leakage while you're tracking down the ingress. Ingress and impulse noise have to get in somewhere—where there's ingress, there's almost always leakage.

High levels of ingress don't always equal high levels of leakage, so pay attention to low-level leakage. One of my favorite tools for tracking down low-level downstream leakage is a handheld VHF ham transceiver. The better ones have usable sensitivity in the 144 MHz-to-148 MHz ham band down to about 0.5 µV/m, and are almost as good at nearby midband frequencies. That's no typo—it really is half of a microvolt per meter!

"DOCSIS mandates minimum upstream carrier-to-noise, carrier-to-ingress power, and carrier-to-interference ratios of 25 dB."

Common path distortion

Once the plant has been properly aligned and the reverse path junk is cleaned up, you may find that common path distortion CPD is your real problem. In a nutshell, CPD is second- and third-order distortions that show up every 6 MHz in the reverse (every 8 MHz in PAL systems). The distortions are generated when downstream signals pass through a signal path that has diode-like characteristics. No diodes in your signal path? I'd be willing to bet otherwise. Things like corroded connectors, dissimilar metal interfaces and related critters are all candidates for CPD sources. The culprit is usually a microscopic oxide layer (sometimes only a few atoms thick) at the interface between two metals. This oxide layer can behave electrically like a diode, and distortions are generated when RF passes through what is essentially a non-linear "diode junction." For more information on CPD, I urge you to check out an excellent paper by by Barry Patel entitled, "Report on Dynamic CPD." It can be found on the Web at http://cable.doit.wisc.edu/cable_resources.html.

Identifing CPD is the easy part. Tracking it down is where the real fun begins. For instance, let's say the problem is a defective line terminator at the unused output of a directional coupler. You think you've narrowed your search down to the pole where the DC is located, but as soon as you put on your hooks and climb the pole, the CPD disappears. What happened? The vibration that occurred when you climbed the pole was enough to jiggle the thin oxide layer and allow decent metal-to-metal contact at the problem interface, so the diode disappeared along with the CPD. For a little while, anyway. Sure enough, a few days later the oxide layer has reformed and the diode is back. How many ways can you spell headache?

Improper headend combining

I could spend all day on this, but *CT*'s editors only allocate so much space for this column. Too many nodes combined at the headend or hub are a common problem, along with homebrew reverse combining/splitting networks. With regard to the latter, look at any of several available commercial solutions for more effective upstream combining and splitting.

Too many combined nodes aggravate the reverse funneling effect, which can result in an unacceptable overall combined C/N. After all, there was a reason why you segmented your system with that dandy hybrid fiber/coax (HFC) architecture. You've segmented the downstream, so why undo that thinking by excess upstream combining? Otherwise you might as well have left the old tree-and-branch plant in place.

As well, too many combined nodes can result in too many modems per cable modem termination system (CMTS) upstream port. I suggest you set an upper limit of around 150 modems per upstream port. More is doable, but data throughput slows appreciably.

Here's one that gets a lot of folks: Make sure you have the upstream signal paths connected to the appropriate CMTS upstream ports. Otherwise the CMTS and certain modems may have a tough time talking to each other. For instance, a modem may hear its downstream signal just fine, but when it attempts to transmit upstream to that same CMTS, it doesn't get heard because it's connected to either a different CMTS or the wrong upstream port. Not only do the affected modems not connect with the headend, but other modems experience a decrease in throughput because of unnecessary data collisions. Obvious, but not all that unusual.

One other thing pertaining to upstream combining is the importance of using dedicated headend or quad-shield cable and high-quality connectors. This is not the place to skimp on the good stuff.

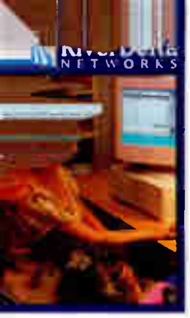
Next month, I'll cover a few more fun reverse path problems, including so-called babbling set-tops, defective modems, passive device intermod, signal path intermittent connections and other things guaranteed to keep you awake late at night. CT

RiverDelta NETWORKS

QoS: The Key to Maximizing Revenue

A Technical Guide for Cable Operators

Supplement to Communications Technology



Editor's Letter

Quality Of Service

What does Quality of Service (QoS) really mean to systems entering new and sophisticated deliveries of data and IP telephony?

Operations and engineering managers face a perplexing future as we digitize television entertainment while adding services that are also provided by "entrenched" businesses in our local communities and across the nation.

Although these entrenched companies are competing for the same customers via circuit-switched networks, satellites and wireless services, the broadband cable operator will want to keep all of his options open.

DOCSIS 1.1 specifications set the groundwork for delivery of IP services via hybrid-fiber coax (HFC) networks, whether data or telephony. However, DOCSIS 1.1 does not define QoS above and beyond the HFC position of the network. Innovative companies will provide multi-service platforms with rich QoS control from the cable modem to the backbone network. This will allow systems to reach out to new business customers as well as the traditional residences throughout their networks.

Business data, high-speed access for downtown offices, and IP telephony will require more sophistication than we have achieved in the past. Flexibility will be a key word as companies and equipment are approved for these services. We will be introducing differentiated data, voice, and multimedia services for both corporate (business) and residential subscribers.

Since IP telephony service will require 99.999 percent reliability, the network should provide the same 99.999 percent reliability for all of its other services. After all, the same HFC network and its network operation center (NOC)/headend/hub/node equipment will be providing the platforms and applications for all. The routers and switches must offer the highest density and lowest price-per-port possible. As we add more services throughout our networks, we must monitor the equipment's ability to "hand off" packets of data in the fastest and most intelligent manner possible. As NOCs, headends, hubs and nodes add more equipment, the size of each addition becomes important to both space and cooling.

Operators need to prepare for opportunities to deliver robust new content, data, voice, and multimedia services. Those operators that deploy next generation equipment with advanced QoS control will reap staggering financial benefits. •

Supplement to

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What Can QoS Do for You? Plenty

The infrastructure is in place, the headends are upgraded and the public is primed for broadband service. It's finally time to start reaping the rewards of your hard-earned investment.

If it wasn't for those pesky telephone companies, you'd have it made.

But the sad fact of the new broadband world is that it is filled with competition. Satellite providers, wireless companies, CLECs, ILECs, IXCs and an alphabet soup of communications firms are all gearing up to compete with your network in one way or another. That is why one of the most crucial aspects of broadband delivery—one that will either make or break your business—is Quality of Service (QoS).

Satisfying Customers

Let's face it. Customers don't really care how much fiber you have in the ground or what your switching capacity is at the headend. But they are looking for someone to provide a lower-cost, simpler solution to their communications needs. They want a single company to provide them with telephone and email, lightening-fast Web-surfing and streaming media, television programming and interactivity. And then there are the service and content providers—the AOLs and UUNETs and Amazon.coms—who want to ensure that users are able to take advantage of their broadband fare in the most user-friendly environment.

What many in the cable industry might not understand is that in the future, you will be cutting deals with these content and service providers almost as fast as you will sign up new subscribers. That's the beauty of open access. Rather than posing a threat to cable, it affords a tremendous opportunity because, with an agreement in hand, you will provide access to the existing AOL subscriber base in your area.

But to take advantage of this, you will need to provide QoS guarantees to your customers and third-party content providers. In effect, you must promise that you will provide them with adequate bandwidth for their needs regardless of how many users are on the network at the same time. This is opposed to the "best effort" approach that has been used for high-speed data deployments for the past few years.

At RiverDelta Networks, we take QoS seriously. By offering consumers and providers a guaranteed level of service, you can generate multiple revenue streams that will further support network infrastructure upgrades. That's why we've designed our underlying technology to allow cable operators to provide the highest level of service to each customer and business partner. This is particularly crucial for voice communications and high-bandwidth business applications. Calls must get through no matter what if you hope to compete with the entrenched telco providers. And high-bandwidth services such as media streaming and videoconferencing require low latency and a constant bit rate for the richest experience.

Defining QoS

When we refer to QoS, we mean end-to-end QoS. Not only must you maintain QoS within your access network, you must ensure that the service does not degrade below Service Level Agreement (SLA) requirements in the backbone. The cable operator must build intelligence at the edge of the HFC plant so it can communicate QoS requirements on the Metropolitan Area Network and to the core Wide Area Networks of numerous content providers and other network partners. More on this later.

The DOCSIS 1.1 standard has gone a long way toward enabling QoS levels throughout an HFC network (See "DOCSIS 1.1: No Guarantee of QoS," page 5). But the new specifications do not guarantee that any particular system will provide QoS in the same way or to the level that many customers will demand.

Per-Flow Queuing

There are a number of issues that need to be examined in order to ensure that QoS levels are optimal to deliver multiple services to subscribers as well as content and service provider partners. One of them is that the router/cable modem termination system (CMTS) in question uses hierarchical per-flow queuing. Under this

technique, each packet stream is assigned a queue in the router. Those packets with QoS reservations are given a guaranteed flow rate, while all others are assigned bandwidth in a round robin or fair share method.

In most cases, each flow will have its own queue. In this way, a network can support literally thousands of queues, as opposed to perhaps several dozen provided by other methods.

It is easy to see how hierarchical per-flow queuing is vastly superior to other forms of queuing, such as FIFO (First In First Out) and class-based queuing. Under FIFO, packets are assigned a queue based on when they entered the system, with no priority given to higher priority or time-sensitive data.

Class-based queuing addresses some of these problems, but leads to others. This approach requires the system operator to predetermine what portion of network capacity will be devoted to a particular use; say 30 percent to voice, 30 percent to Web surfing and 40 percent to streaming media. When real usage patterns set in and the network realizes maybe 50 percent for voice communications and only 10 percent for streaming media, a class-based system will start discarding voice packets, even though there is still available bandwidth on the network. Of course, the network operator can continually reconfigure the bandwidth, but it will never perfectly match a continually shifting network environment.

But one of the chief advantages to per-flow queuing is that it allows network operators to keep track of individual flows, allowing him to aggregate all the flows of a particular subscriber to ensure they are getting the full service they signed up for. Likewise, all the flows of a particular service provider may be aggregated, ensuring that the SLA is being met.

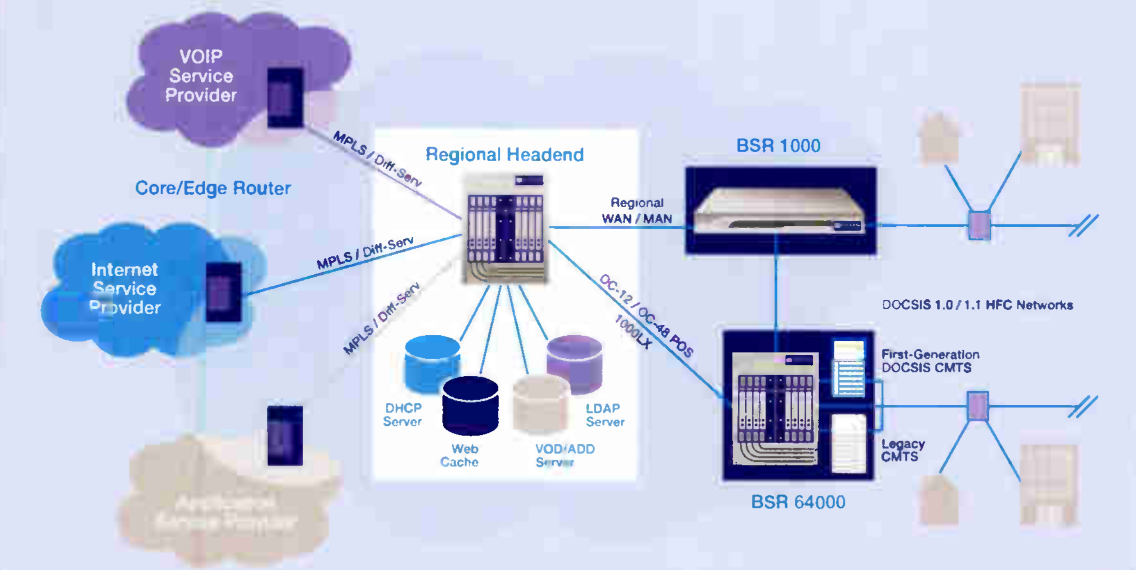
Providers will not be able to exceed their SLA or misuse your network in any way. Under congested conditions, traffic that exceeds the contracted bandwidth would be dropped first. Under non-congested conditions, the cable operator will be able to determine what to do with traffic that exceeds the contracted rate, either by allowing it to pass, charge extra for it or discard it. This latter option is done through packet-discard systems built into the network that in most cases will be unnoticeable to the user. Most other queuing methods provide random discard of packets that in some cases can undermine the service quality needs of revenue-sharing partners and subscribers.

Maximizing Bandwidth

This is all well-and-good for the HFC network. But what about the backbone? There are two ways to address this need: priority-based and connection-based QoS.

Under a priority-based scheme, each flow is labeled to ensure that it receives the proper bandwidth. At the edge of the HFC network, each flow is monitored and tagged with a specialized marker in the header. The marker conforms to the Diff-Serv (Differentiated Services) standard that was

Next-Generation CMTS/Router Platforms Can Deliver End-to-End QoS



devised to ensure that the packets are forwarded properly at each hop on the of a router network.

Diff-Serv essentially defines a number of per-hop behaviors (PHBs) that are applied to packets as they pass through Diff-Serv capable routers. One such behavior is expedited forwarding (EF) that tells the router that it must pass a particular packet along in a specified timeframe, usually with very low latency. Other PHBs establish priority levels between packets and assign other characteristics to tell the router exactly how to process the data.

In a connection-based method, each connection is made with defined QoS parameters. Edge routers connect to the backbone or service or content partner's networks—usually either by an ATM virtual circuit or a Multiprotocol Label Switching (MPLS) path—and the traffic is forwarded based on that connection. The only requirements are that forwarding must be maintained in a per-connection state and each router along the path must be QoS capable.

By maintaining QoS from the user to the content provider in either of the above two ways, cable operators will be able to maximize revenue-sharing profits from the service and content providers and also deliver quality service to residential and business subscribers. To effectively manage a revenue-sharing arrangement, the cable operators must be able to identify the source of any particular traffic flow and then match that flow to the designated service provider, all in real time. It is also crucial that this technology be placed at the edge of the network in order to act as the go-between for the HFC plant and the backbone.

Maintaining Flow

Monitoring and management of the different data flows is also necessary to ensure that no one exceeds their allocated bandwidth to the point where they begin to impact the service of others. Any overload must be contained within network resources assigned to a subscriber or to service or content providers to ensure a smooth ride for others on the network. This requires isolation for each flow. Subscriber traffic flows must be isolated from each other to ensure their SLAs are met, and service providers must be given the level of service they have contracted for as well. But it goes deeper than that. Individual applications such as voice, video, and data must be isolated to protect the higher priority ones and ensure SLA compliance.

As the cable industry begins to deploy multiple services and the potential for revenue-sharing agreements with a wide range of providers—from RoadRunner and Excite@Home to UUNET and AOL—broadens considerably, cable is in a unique position to take advantage of these market conditions because, quite frankly, it has the widest connection to the home. But managing all these users and service providers will take expertise and a rock-solid technical approach.

By ensuring QoS levels from the home or business through the headend and all the way to the service provider, cable operators will garner an increased share of the broadband market for residential and corporate services and will continue to lead the world in advanced communications. The revenues are out there. All it takes is a commitment to succeed and the right technology on your side. •

DOCSIS 1.1: No Guarantee of QoS

By Gerry White, CTO, RiverDelta Networks

One of the most significant advancements in the new DOCSIS 1.1 standard is its commitment to QoS levels for multiple services across an HFC network. The 1.0 specification simply called for "best effort" service, meaning that some users and some providers might not be getting all they paid for.

In DOCSIS 1.1, there are a number of enhancements to the Media Access Control (MAC) protocol in DOCSIS 1.0. The goal was to incorporate more advanced methods in which to access a network. Specifically, the new version offers the following upgrades:

- packets, and thus applications, are now classified into individual "service flows" based on their content;
- several new scheduling methods have been defined to organize upstream and downstream access requests on a per flow basis. The new methods include constant bit-rate, real-time polling, non-real-time polling and the best effort system included in the 1.0 spec;
- individual service flows can now be configured through new management applications. They can also be created or deleted as applications are launched and exited;
- large packets are now fragmented. This allows the lower latency services to reside on lower bandwidth upstream channels.

Continued page 7

Putting QoS to Work for You

There is no question that Quality of Service concerns should be at the top of every cable operator's list when it comes time to roll out new digital services. The question is, "what is the best way to accomplish true end-to-end QoS so that end users and third-party service providers receive all the benefits that broadband networks have to offer?"

As we have already discussed, DOCSIS 1.1 compliance does not guarantee sufficient QoS support, nor is it good enough to simply deploy QoS in the access portion of the network without paying heed to the backbone connection to content providers. What is needed is a fully integrated, platform that ensures end-to-end QoS support that provides top-quality service and satisfies your service-level agreements (SLAs) with subscribers and third-party content and service partners.

Routing Services

The key ingredient in the implementation process is the router. You need a carrier-class switching device with a built-in CMTS that allows you to rapidly deploy various types of data, voice, and multimedia services. It is also critical that the router be able to distinguish between different QoS requirements that are likely to arise according to the needs of subscribers and both service and content providers.

The Broadband Services Router (BSR 64000) from RiverDelta Networks is tailor-made for this application. It is an extremely flexible platform that supports multiservice operation at the IP level, allowing cable operators to quickly generate new revenue and then scale up as new users come on board.

What Makes It Work

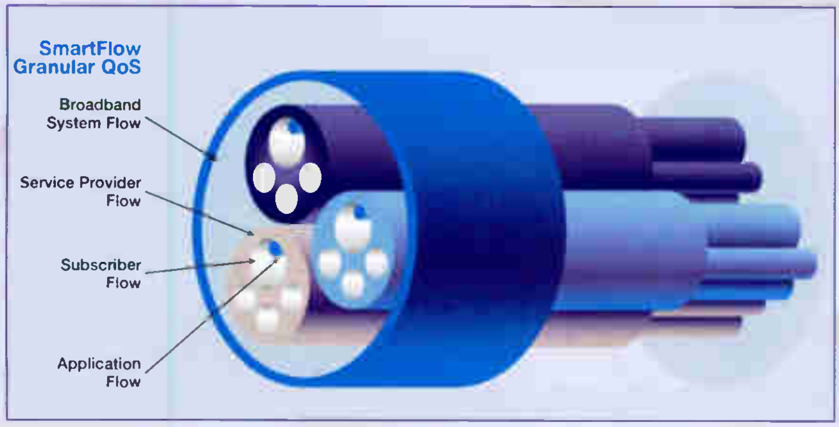
The key technology behind the BSR 64000 is the SmartFlow packet-classification system. With SmartFlow, operators can classify packets of data so they can be given the agreed-upon QoS level. The same technology that works on the DOCSIS 1.1 platform in the cable plant also works on the Diff-Serv or MPLS platforms of the backbone and regional networks. This system of classification allows the operator to provide the necessary isolation and segmentation to ensure that subscribers are receiving service commensurate with their SLAs and third party providers are not exceeding their contracted bandwidth.

Operators can also enforce any other network policy, such as admissions control and rate limits. What's more, the segmentation provided by SmartFlow allows different types of services to be delivered across the same network without interfering with other services. Voice communications can come from a voice service provider, Internet from any number of ISPs and business applications from revenue-sharing providers.

There are a number of other functions and features that are needed in order to provide rock-solid QoS. You'll need a carrier-class system that offers 99.999 percent reliability by incorporating fault detection, redundant components and switch-over mechanisms in case of a system outage.

The Benefits of the BSR Family

With such a system at the edge of the network, you can create and police QoS policies and profiles that can be used to manage and track individual customers or groups of customers. It will also simplify provisioning as many new users begin to purchase and install their own modems. Customer data can also be metered and mined and delivered to other computer systems using standards-based interfaces, such as eXtensible Markup Language (XML) or LDAP.



The carrier-class BSR 64000 and the space-saving BSR 1000 allow operators to swiftly deploy multiple services.

Network management and control is another area that should receive special attention. Because your staff may be relatively inexperienced when it comes to overseeing multiservice broadband networks, it's a good idea to select a system with a look and feel that is familiar. Easy-to-read LED displays and remote management capability for such things as provisioning, configuration and fault detection make it easier to monitor the network. What's more, you're going to want to offer your third-party service providers with partitioned management functionality so they can control their own service over the HFC network.

Again, open standards-based approaches are key here. Systems should support Simple Network Management Protocols (SNMP), and, for bulk transfers, the File Transfer Protocol. And for efficient network configuration and control, a Cisco-compatible Command Line Interface (CLI), which is well-known throughout the industry, would be a great benefit.

All of these features can be found on the BSR 64000. We've engineered it as a high-density platform that delivers four-times the performance in one-quarter the space at a lower cost. In fact, it has the highest density port capability in the industry for connecting to the HFC infrastructure.

Offering Flexibility

Our design utilizes centralized routing and distributed forwarding. Each line card features its own forwarding engine, so the system is highly scalable. It can be utilized in the distribution hub, providing a link between the regional fiber network and the cable plant, or it can go into the regional headend as en edge router that connects to the backbone and local content servers. What's more, each interface module can handle more than 3 million packets-per-second, for a total of 42 million packets-per-second for each chassis.

The BSR 64000 can be installed in a range of configurations, including OC3/12 with POS or ATM interfaces and an OC-48 module with an add/drop multiplexer (ADM). There is also a high-density 10/100 Ethernet interface card to connect local servers and legacy CMTS equipment, and a Gigabit Ethernet interface module for backbone or local connections.

You've poured a lot of time and money in your network, and now is the time to start cashing in on that investment. The one thing that could absolutely kill your business is not providing the level of quality that consumers or service providers expect.

Selecting your router/CMTS platform is one of the most crucial decisions you will have to make going forward. You simply cannot afford to be caught flat-footed in this age of technological innovation and cut-throat competition. Quality of Service is not just an option for those with the deepest pockets. It's an absolute necessity.

And now, it is completely affordable. •

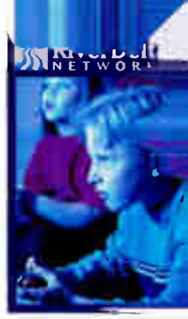
Continued from page 5

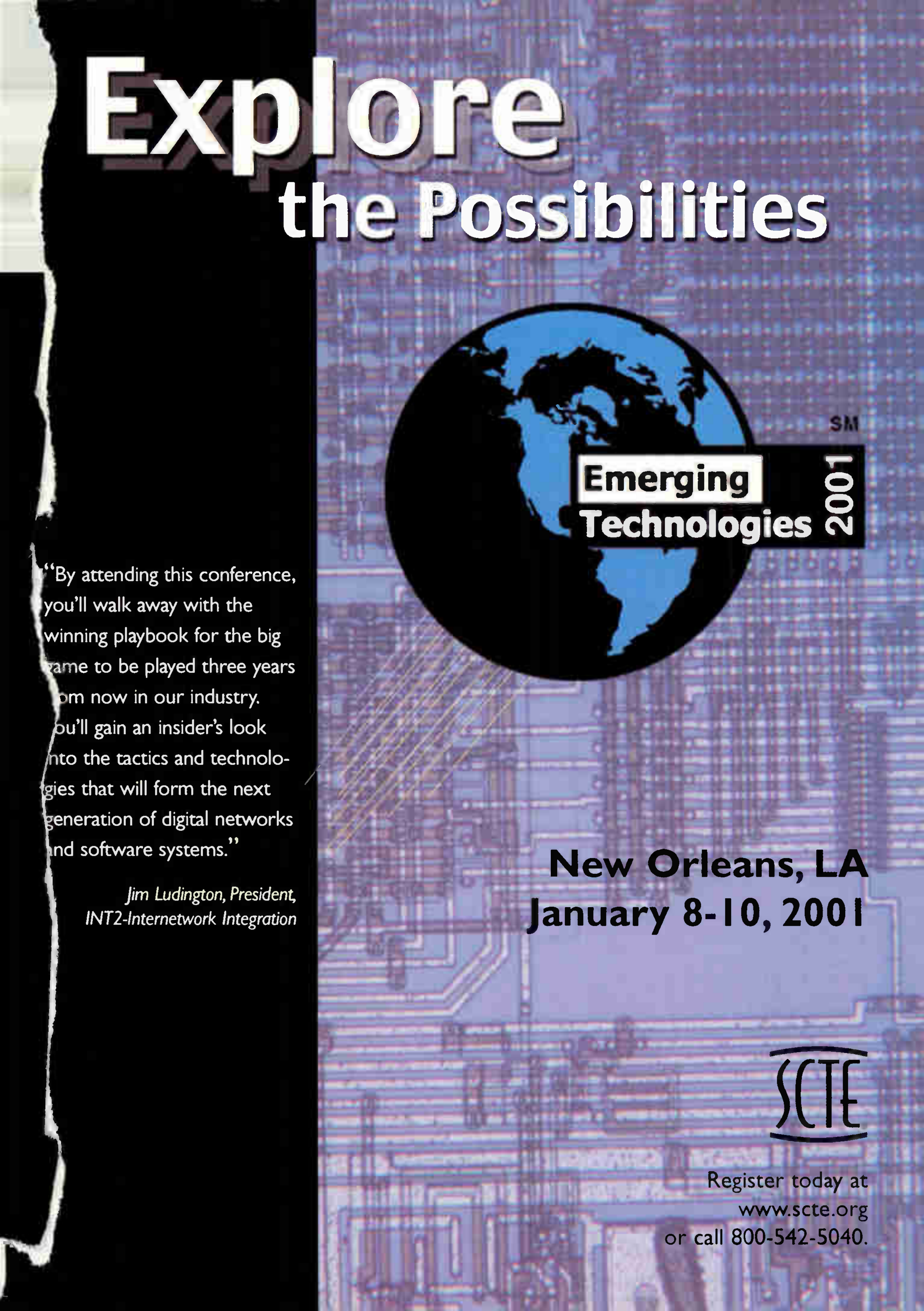
But while 1.1 goes a long way toward defining what QoS means, it must be remembered that DOCSIS is an interface specification and therefore does not describe exactly how vendors are to implement QoS.

One of the chief aspects of DOCSIS 1.1, of course, is that it only applies to the cable portion of the network. To ensure that subscribers and content providers and service providers are receiving adequate bandwidth, QoS must be provided end-to-end. That means the cable system's edge router has to provide QoS-enabled traffic through the regional and/or backbone networks. Therefore, it must have the capability to deliver QoS mechanisms, such as Diff-Serv, MPLS and ATM, on these outer networks.

The edge router must also provide sophisticated traffic management and policing capabilities in order to inspect the individual traffic flows and ensure that adequate QoS is being delivered from the cable modem to the service provider.

DOCSIS 1.1 goes a long way toward ensuring Quality of Service in HFC networks, but it does not guarantee that every DOCSIS-compliant platform out there is offering the maximum QoS level that will be needed, especially for critical services such as voice communications. Only by adequately ensuring that each device in your network performs to maximum QoS requirements will you be able to get the most out of your system.

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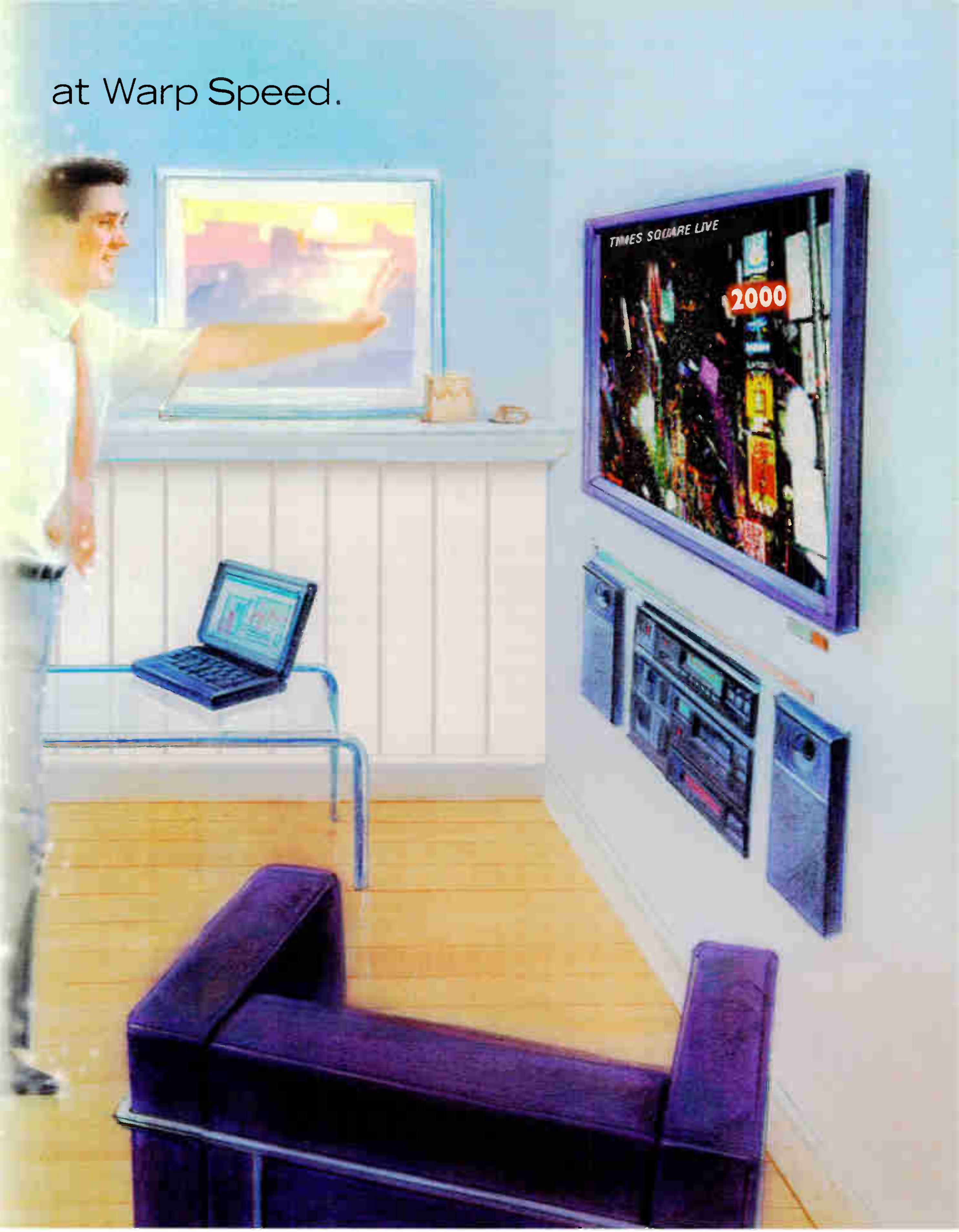
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Installer Tools for Turning Up IP Telephony Service

I promised last month to discuss the operations systems support of IP network interface devices (NIDs). As I dug deeper into this topic, I realized that operations support systems (OSS) for IP NIDs has two facets—one is the installer's interface while service is being turned up, and the other is the back-office component that includes billing and maintaining customer records. This month, we will look at the OSS tools installers can expect to use during IP telephony installation.

"The extent that tools and troubleshooting skills are really necessary depends on the integrity of the IP telephony NID, the operator's network and the back-office processes."

I'm not the only student of this topic that came to the conclusion operations support is two subjects. CableLabs expresses a similar thought in its PacketCable Specification PKT-TR-OSS-D01-990730 for OSS.

The document reads, "Strictly speaking, the terms OSS and BSS refer to different types of management systems. The term OSS refers to facilities management or network management functions and typically includes fault management, performance management and security management. BSS refers to business management functions and typically includes accounting management and configuration management."

OSS and IP telephony

The authors of the PacketCable OSS specification chose not to separate both components. Their reasoning is good—the back-office processes are intimately tied to operations. If you have any doubts about this, remember that you can't bill a customer for the service you just installed when you don't have a record of the customer's request for, or use of, that service.

On the other hand, parts of OSS are closely linked to the telephony installer's job—for example, the indications on an IP telephony NID that tell the installer a unit is operational. To find out if I was right, I talked to several vendors about what they provide installers as installation aids at the NID.

I though it might be interesting to ask 3Com this question first, since they don't offer an NID, but do have a cable modem termination system (CMTS) that will have to interact with IP telephony NIDs. Their response was in tune with their product strategy.

"The industry needs to shift to retail customer premise equipment (CPE), which will be self-provisioning," Todd Landry, 3Com's vice president of product management, carrier networks business, says. Under this philosophy, the customer would purchase a cable modem, or a device containing a cable modem, at a retail outlet the same way consumers today purchase dial-up data modems. This retail unit would alleviate the need for a house-mounted NID installed by the cable company. The cable modem would have the ability to connect to the operator's network—essentially a plug-and-play connection between PC and network—with a minimal configuration for initial provisioning only. The customer would then use a Web interface to enable services, including IP telephony, corresponding to his needs and willingness to pay. At the same time, a customer record would be established.

The end-user would be responsible for troubleshooting any problems with installation, and returning faulty modems to the retailer. Installation progress indicators would be limited to those found on any Data Over Cable Service Interface Specification (DOCSIS) cable modem used for high-speed data service. Obviously, the retail device containing the cable modem would need to have a standard RJ-11 telephone jack and embedded media terminal adapter (MTA) to work with existing telephone sets. >

Landry doesn't eliminate the pos-

sibility of his company's CMTS working with an outside-mounted IP telephony NID. "3Com will be compatible with both. Functionality is one thing. Packaging is another," he states. In this scenario, however, the installer would treat the NID as a cable modem from the perspective of any visual indicators or installation procedures, albeit one installed on the side of the house, instead of being next to the customer's PC.

"Plug-and-play" philosophy

I checked with vendors who have displayed IP telephony NIDs at cable trade shows to see if they agreed that a simple plug-and-play philosophy could be extended to a cable company installation of an externally mounted IP telephony NID.

Eric Hartford, ADC's HomeWorx telephony marketing director wouldn't go so far as to imply external NIDs would become user self-install items, but suggested the installer's task would not change much from installing a circuit-switched cable NID. "There will still be basic indications that confirm the presence of power to the NID, synchronization, ranging, the completion of frequency assignments and the fact that provisioning has linked the NID to the rest of the system."

ADC uses a combination of red, amber and green LEDs in their circuit-switched product to convey these states to an installer. Eric mentioned, however, that having a 10BaseT port on the IP NID allows for attaching a laptop or other data interface to access status and troubleshooting screens if required.

Motorola's CentriQ systems engineer Lou Bifano pointed out this could add a different dimension to installer troubleshooting, which would require a whole new set of skills. He notes that any new troubleshooting aids most likely will be addressing the data capabilities of the cable modem in the IP telephony NID. "You can have data service at the NID without telephony being operational. It's then possible to receive diagnostic messages from the CMTS, and perform pings to verify Internet connectivity," Bifano told me. "Specific to telephony, you might also want to also verify that the NID could interact with call agents in the IP network by verifying correct host names."

The approach used by Arris in their PacketPort is a compromise between the expanded capabilities of a separate data interface and keeping the troubleshooting tools contained in the NID. Quintin Boe, product line manager for Arris, explained that his company has replaced flashing or colored LEDs with a seven-segment LED display which provides feedback of completion of stages of operational readiness. When the unit is capable of acting as a cable modem for data, for example, it will display a "D," while a "7" indicates it has registered with a call server for IP telephony. Of course, the option of attaching a laptop to the Ethernet port is still available.

The extent that any of these tools or troubleshooting skills are really necessary depends on the integrity of the IP telephony NID design, the design and implementation of the operator's network and the proper implementation of the back-office processes tied to provisioning the NID. We'll leave the tasks of verifying equipment design integrity and network functionality to the IP telephony trials. The next column in this series will look at back-office support systems. CT

Justin J. Junkus is president of KnowledgeLink, Inc., and applications engineering director for ANTEC, Inc. To discuss this topic further, e-mail him at jjunkus@knowledgelinkinc.com.

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IP Telephony
Circuit-Switched

IP Telephony vs. Circuit-Switched:

THE GREAT DEBATE

By Natalia A. Feduschak

It appears inevitable that most systems will make a move into cable telephony. Those that have already done so explain their technology choice, or why they've hedged their bets.

Francois Laflamme is so convinced about the future of Internet protocol (IP) telephony and its benefits over circuit-switched telephony that he has turned off his residential telephone service and relies entirely on the new technology.

"Circuit-switched is dead," announces Laflamme, vice president for IP telephony at Montreal-based Videotron, a communications company that is sponsoring the first large-scale IP telephony trial in North America. "All the multiple system operators (MSOs) ...are looking at soft switch (digital). We're way ahead of those folks."

Laflamme hopes that by the end of this year, IP telephony will be widely available in the Canadian province of Quebec. Once the merger between his company and MSO Rogers Communications is complete—expected shortly—IP telephony may be well on its way toward extensive deployment in North America.

Yet while the Videotron trial is being watched with interest by many MSOs, others are firmly convinced that despite IP's touted potential, circuit-switched will be the name of the game in the world of cable telephony for a long time. The application is proven, and while IP telephony is likely to become the standard within the next two decades, today it is still more a dream than a reality.

What's certain is that cable operators want to create additional revenue streams and telephony appears to be one of the ways to do that. The idea is to bundle cable service with telephony, data, video streaming and video-on-demand, and to send the customer a single bill in the mail. To meet those demands, operators are having to decide whether they want to jump into cable telephony now using existing technology, which is circuit-switched, or wait until IP telephony begins to prove itself.

As they debate which direction to take and when, Mike Paxton, an analyst with Cahners In-Stat, says North American MSOs are broken into two camps. One says in order to get to IP telephony, circuit-switched needs to be deployed first. AT&T, MediaOne and Cox Communications are in this group. The other camp, which consists of Videotron, Time Warner Cable and Comcast, says why bother implementing cir-

"The general consensus is that he or she who can bundle the most services wins."
—Alex Best, Cox Communications

cuit-switched if IP telephony is the wave of the future.

"I think the first group, because they're gaining a lot of experience from billing to powering to quality of service (QoS), and some of the hardware they have already put in place, supposedly think they can make the leap to IP without really having any type of expensive retrofit," Paxton says. "But the jury's still out on that one. We'll have to wait and see who's right."

Telephony still an infant market

For all the fervor surrounding cable telephony, today's market remains small. With more than 70 million cable subscribers in the United States, only four of the top MSOs are commercially deploying cable telephony, serving some 280,000 customers in the first quarter of 2000, according to Keith Kennebeck, a cable analyst with The Strategis Group, a Washington, D.C.-based research firm, and an author of a recent report on U.S. cable telephony.

Kennebeck estimates that by 2005, the United States will have more than 12.5 million cable telephony users. Circuit-switched will serve more than half of all subscribers.

Lifeline IP cable telephony will account for nearly one-quarter of all cable telephony subscribers by the end of 2005, according to Kennebeck's report. Lifeline service means customers can use their phone at any time, even during a power outage.

Non-lifeline IP will be available commercially next year, facilitated by a phone-jack installation in cable modems, thus increasing the number of users from 100,000 in 2001 to more than 2.8 million by the end of 2005. The widespread commercial launch of IP telephony is expected in 2002.

Revenues from cable telephony services will grow from $293 million in 1999 to more than $7 billion in 2004, according to Paxton.

The benefits of circuit-switched...

With 170,00 subscribers, Cox Communications is the biggest player in circuit-switch telephony in the United States. Until IP telephony can prove itself, both economics- and technology-wise, the company will continue using circuit-switched, Alex Best, the company's senior vice president of engineering, says.

"It's a tried and proven technology," Best says in outlining the benefits of circuit-switched.

Circuit-switched provides a lifeline service and all the attributes, such as call waiting and three-way conferencing, that come with local exchange carrier (LEC) service.

"It's as good in reliability as the Bell companies," he says.

One major benefit of circuit-switched technology is that circuits are used domestically and abroad.

"When the telephone customer makes a call, chances are they are going to call someone who has a circuit-switched line," Best says. "Therefore, somewhere along the way...even if they are an IP customer, the call will have to be converted back to circuit-switched...If you want to be in competition with the telephone companies, you have to do circuit-switched. Some day IP telephony will offer the same technology, but not initially."

...and the drawbacks

To be sure, circuit-switched has its own set of problems, Best admits that to provide lifeline service, powering was an expensive proposition because cable power boxes had to be placed on the sides of homes and generators installed throughout neighborhoods, something residents generally do not want to see dotting their landscapes.

"That's capital intensive and problematic," Best explains.

In addition, cable companies find themselves dealing with a number of organizations they never had to before, giving up a degree of control over how their operations work.

"You have to interconnect with all the long-distance and Bell companies," Best says. Cox has had to negotiate with long-distance carriers, emergency services and other organizations to ensure that the phone service it provides works around the world.

These are necessary growing pains if a company is to compete in the new technology marketplace, however. "The general consensus is that he or

BOTTOMLINE

> Making the Choice

As cable companies look to the future, telephony is becoming increasingly important in developing their businesses. The choice facing MSOs is: do they go with the tried circuit-switched technology and begin to see incremental revenues now, or wait for IP—the technology touted as the wave of the future—to fully prove itself before jumping into the telephony game. Companies like Cox are betting on circuit-switched until IP can prove itself, both technologically and economically. Canada's Videotron, however, has taken the plunge into IP and expects the application's wide deployment in the fall. Other MSOs are conducting test trials to determine which solution suits them best.

Both circuit-switched and IP telephony, however, have their problems. Powering remains an obstacle. Voice quality can be problematic. And MSOs suddenly find themselves having to deal with a host of other issues, like drawing up long-distance contracts.

she who can bundle the most services wins," Best says.

Sean Parham, director of product management for General Bandwidth, says a major drawback in circuit-switched is that the technology is already getting old.

"The con...is that it's really not upgradeable," he says. "It's based on technology which is in the end of its tech lifecycle and is being replaced by packet-based systems. Its efficiency, speed, performance improvements and deployment improvements are not quite a dead-end, but it's really not the type of system that service providers or MSOs can grow into the future."

Parham's view is consistent with his company's business: building applications to help MSOs make the transition from circuit-switched telephony to IP telephony by packetizing and compressing circuit-switched voice from the public switched telephone network (PSTN) and delivering it over broadband data networks. That sort of technology could make it easier for companies to make the transition from circuit-switched to IP, he says.

Conversion costs

One drawback in implementing IP telephony is the cost involved in conversion (from circuit-switched to IP telephony), particularly when the technology still hasn't proven itself.

"In order to get the quickest returns, we need as many value-added services as possible," Best says. "The more services, the quicker we'll replace the cost of network upgrades."

To spend money on IP upgrades makes no sense until Cox sees a return on its investment, he says. Cox has put in incremental costs in the area of $700 per telephone customer for telephony with $60 a month in revenue.

Circuit-switched is likely to remain part of cable telephony for the next two to three decades, according to industry insiders and analysts. However, it is the promise of IP telephony that is beginning to generate significant enthusiasm among MSOs. While Cox has held off on the technology, other operators, such as Time Warner, are watching the Videotron trial with interest, simultaneously dipping their toes into the IP world.

After conducting a successful circuit-switched trial in Syracuse, N.Y., two years ago, Time Warner has started an IP trial in Portland, Maine, Paul Gemme, the company's vice president, plant engineering, says.

"When you look at circuit-switched, it is an expensive proposition," Gemme says. "It is an older technology. The notion that you need to be primary line and lifeline ... we found it very costly."

Although Time Warner considered its circuit-switched trial in Syracuse a success, for now the company is opting to offer IP telephony in the Portland trial as a second line to the home.

"Having a line from the cable company and a line from the phone company offers redundancy," Gemme says. "If the primary line fails, you still have the second line."

Gemme says IP telephony is still one-and-a-half to two years away from being used as a primary line and it will take even longer for customers to be aware that they can get the service.

All eyes on Videotron

While companies like Time Warner are just beginning IP telephony trials, it is Videotron's experiment in Quebec that is being closely watched by MSOs because it is a case study in what IP telephony can and cannot do.

The Canadian company, which uses Telcordia Technologies' software, was launched last summer with 200 users, and is up to 2,000 customers now. It expects to implement full-scale IP telephony service this fall.

"We don't want to explode, we want to be careful," Laflamme says.

After weighing the pros and cons of circuit-switched, Videotron decided to move forward with IP telephony because the company saw it as the technology of the future. Laflamme said Videotron is able to provide the full range of services offered by phone companies, like emergency service, call waiting and three-way calling.

But because it is a new and largely untested technology, IP telephony has shown that it has more than a few kinks to iron out.

Noise on the line is one such issue. Power remains problematic, although Videotron is also providing energy via home powering. Functionality, along with finding the right software to tie together all the necessary components of regular phone service, are also stumbling blocks.

"All the software had to be built," Laflamme says. "This is a new technology, especially on the CPE [customer premises equipment] side of things."

Yet once the software is in place, Laflamme says, "functionality is amazing. In some areas, it's ahead of telcos."

Laflamme is so enthusiatic about IP telephony that he already thinks about the future. "The next big wave is wireless broadband," he says. >

Laflamme predicts Canada will be at least two years ahead of its southern neighbor in implementing IP telephony on a massive scale. Some industry observers, however, say the United States could be further along in realizing IP telephony if CableLabs moved faster.

CableLabs is currently looking at specifications for Data Over Cable Service Interface Specifications (DOCSIS) 1.1 cable modems and PacketCable, both of which would enable IP telephony via cable modems.

"Do we want to use IP telephony?" asks J.R. Anderson, vice president of voice services for High Speed Access Corp., an Internet service provider. "I would love to order that equipment, but it gets bogged down in the standards process."

Despite the delays, most cable operators would agree that standards, even if they may slow the implementation process, are better than none at all. After years of being bogged down by that lack of standards, the wireless industry recently unveiled details of an industry-wide spectrum management plan, which created a common set of standards, spectrum band plans and operating procedures needed to build out new high-speed data services.

Meanwhile, as MSOs decide which application they want, people like Nancy Goguen, vice president of marketing for Telogy Networks, will continue to dream about future possibilities.

"Within three years, most of the gateway market will be moving to IP-based gear," she said. "By 2005, most of the long distance internationally and within geographic regions will be over IP networks ... we will see a significant penetration in the communications infrastructure and that will make it much better for everybody." CT

Natalia A. Feduschak is senior editor for Communications Technology. She can be reached at nfeduschak@phillips.com.

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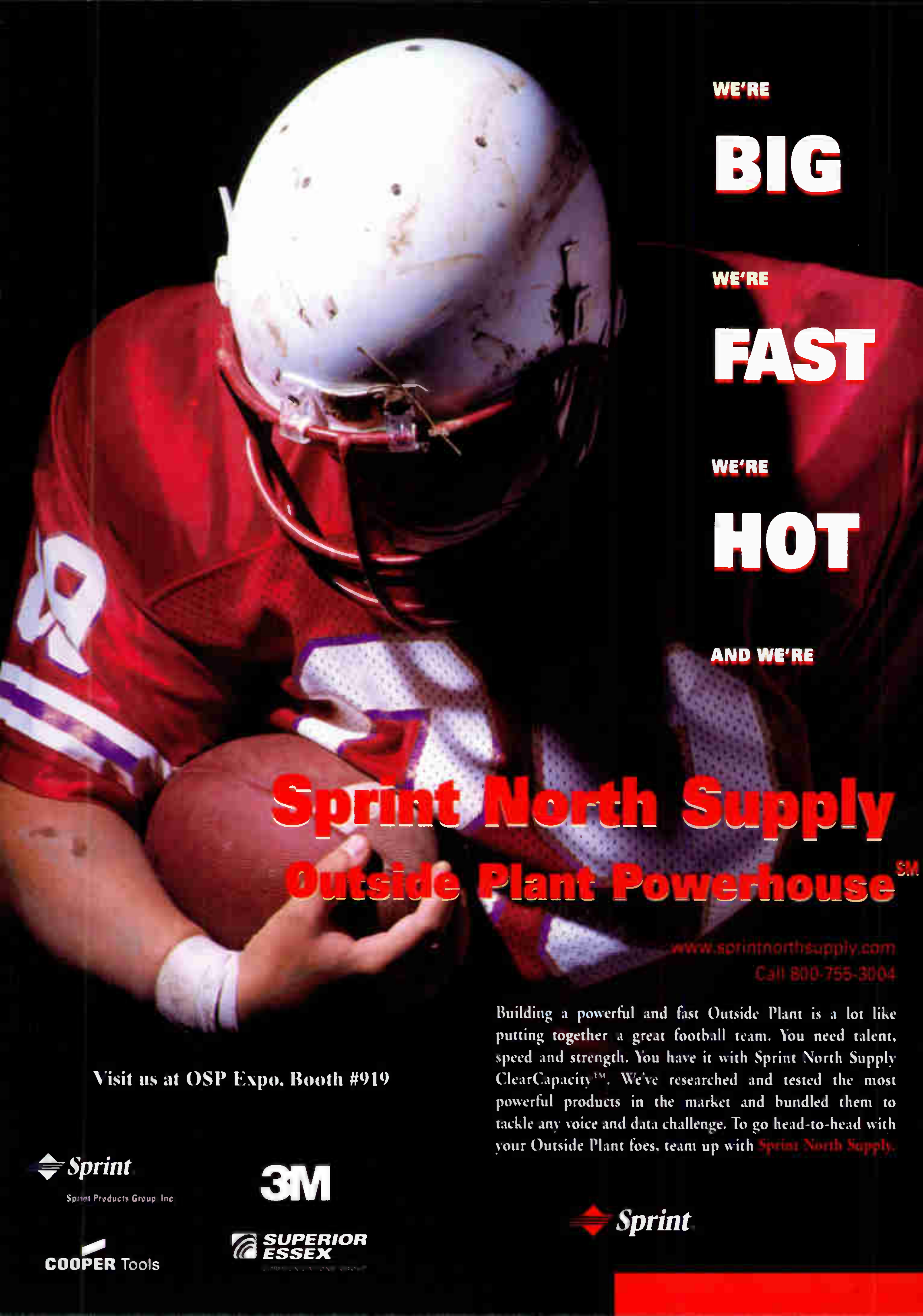

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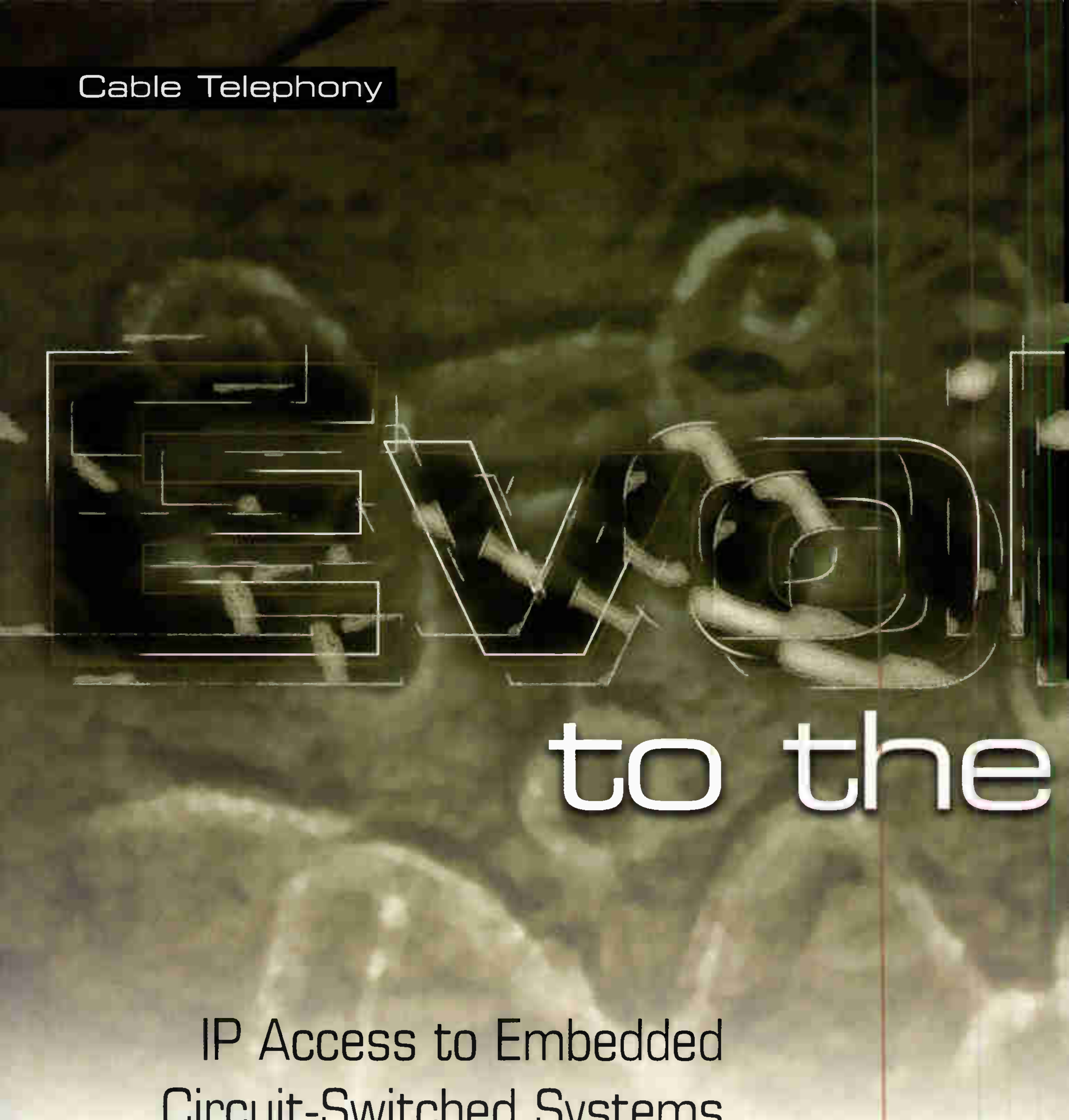


Evol to the

IP Access to Embedded Circuit-Switched Systems

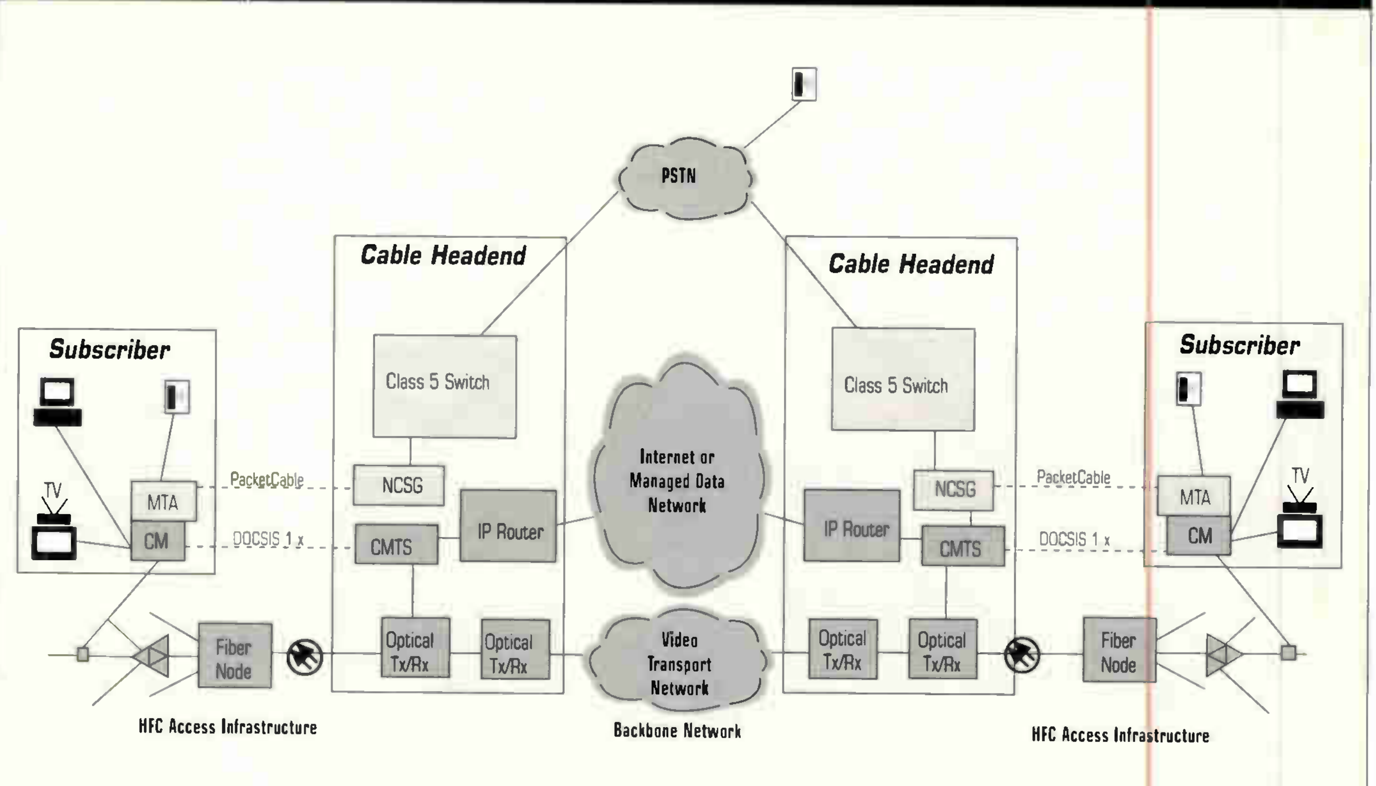
By J.C. Proano and Jane Gambill

Wiring IP Solution

If you have deployed some circuit-switched technology but want to migrate to Internet protocol (IP), consider a hybrid solution that provides IP access to circuit-switched headend equipment.

With a broadband-ready network connected to millions of U.S. homes, multiple system operators (MSOs) continue to explore ways to increase their income by adding new services beyond traditional entertainment video. High-speed Internet access and residential telephony service are two good examples. Built on the existing video distribution network, these services offer new revenue streams that leverage the MSO's existing network investment. >

FIGURE 2 Hybrid Telephony Solution



"Circuit-switched technology requires only an overlay—the same coax goes to the home but the operator separates voice and data bandwidth over the cable."

Among its disadvantages:

- It is an overlay network incompatible with packet-switching technology, so it cannot take advantage of the IP backbone network without expensive multiplexer and conversion systems;
- The evolution to packet-based telecommunications can be limited or null (forklift upgrades are required); and
- It is a costly solution because it essentially creates "two" networks, one for voice and one for data, that need separate equipment and separate network management.

Deploying IP access to existing equipment

An emerging solution for cable operators is IP telephony, which offers the ability to deploy telephone service over IP networks. IP telephony offers efficiency in the use of cable spectrum, and in the use of cable network infrastructure, particularly in networks that include IP access to Internet service providers (ISPs). Many of the features used in residential telephony service are available in IP telephony implementations. For service providers who have Class 5 circuit switches available, it's possible to upgrade the access to those switches from an overlay circuit-switched network to an integrated IP telephony access network as a first step toward providing full IP telephony.

BOTTOMLINE

> **Cable Telephony Migration to IP**

In an effort to offer a complete set of communications services to customers, cable operators have pursued the ability to offer telephone service over cable networks. Most deployments to date have used circuit-switched equipment, essentially creating a separate "overlay" network to the cable operators' existing IP-based network for cable-modem service. Ideally, cable operators want to converge voice and data service onto one, converged IP network. An interim step for cable operators that have purchased circuit-switched equipment but want to head toward an all-IP network is a hybrid IP-circuit solution.

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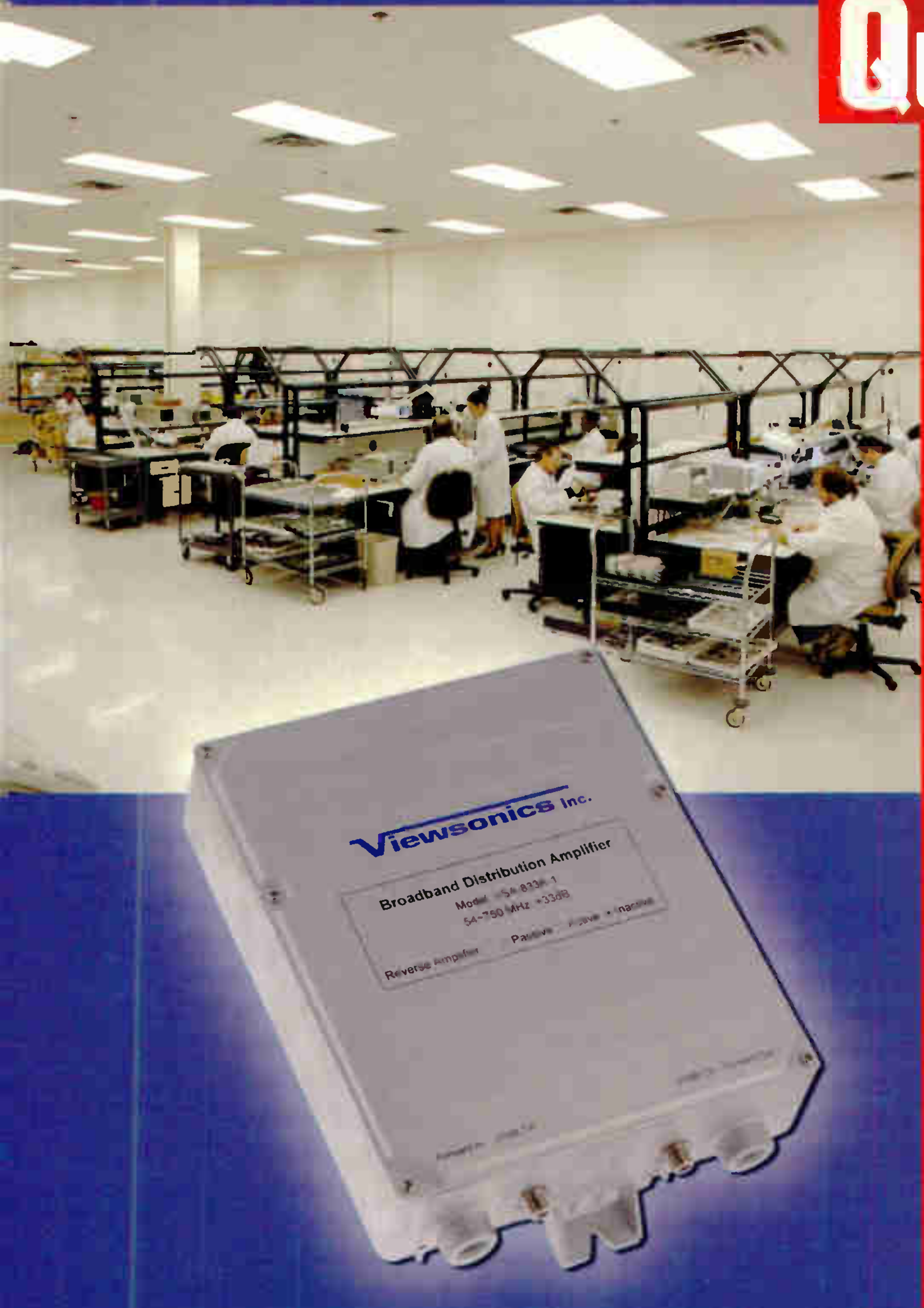

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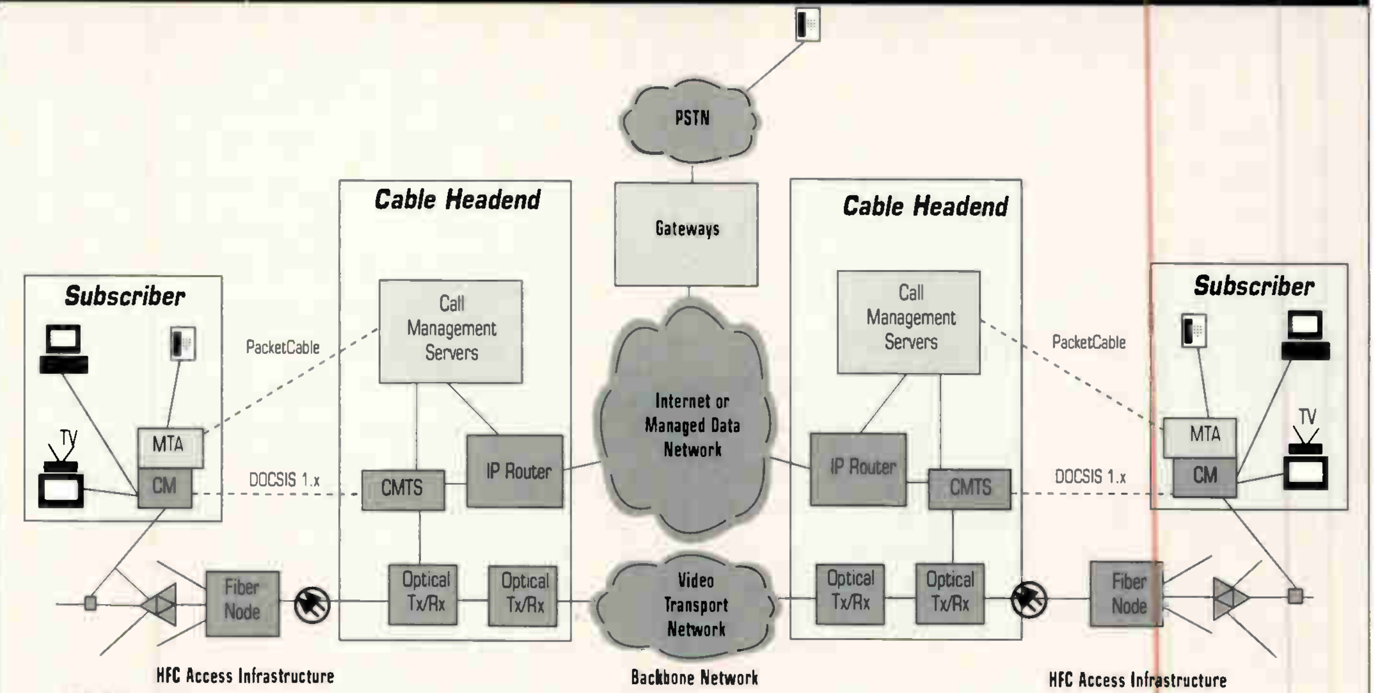
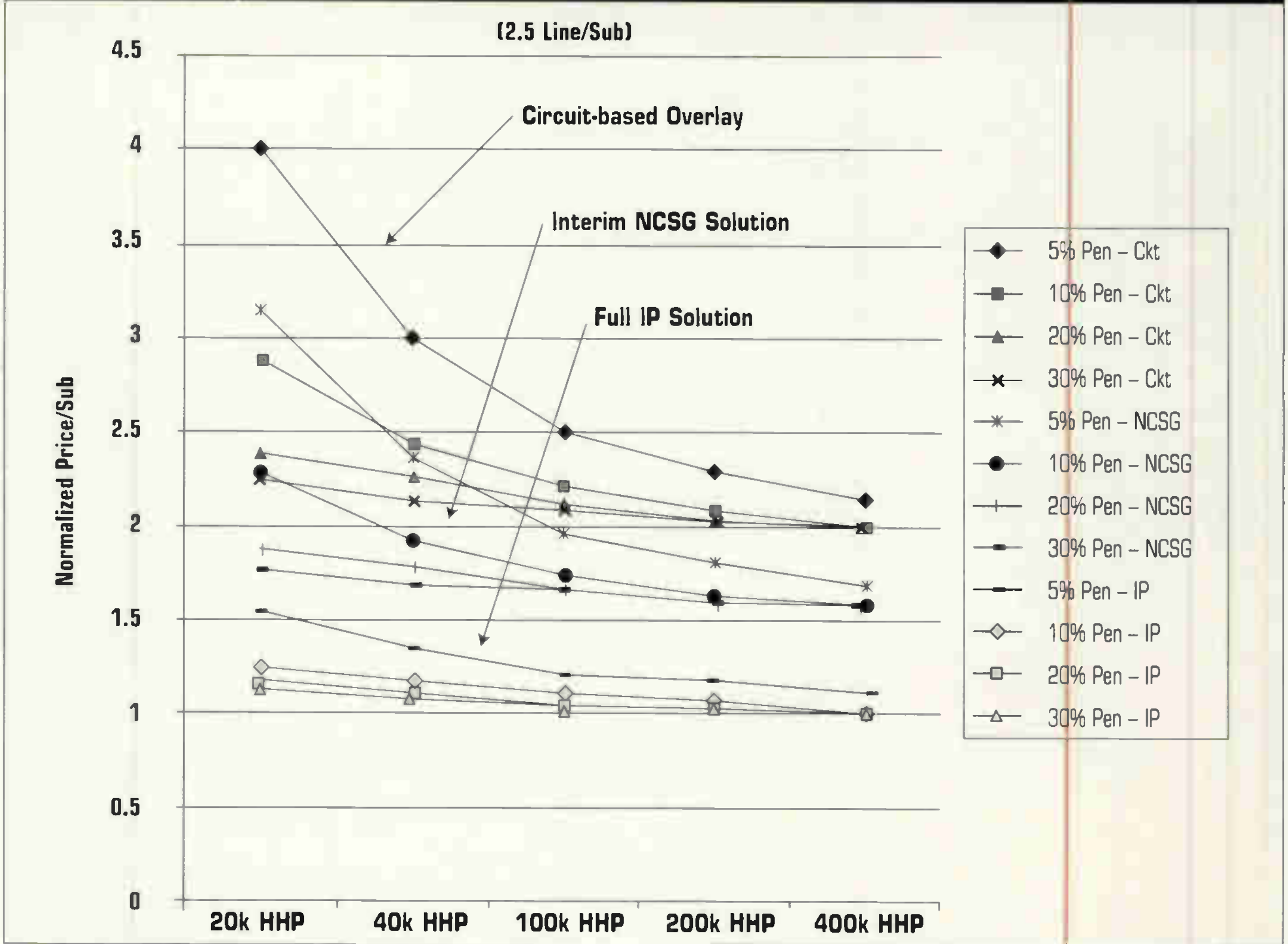
FIGURE 3 | IP TELEPHONY



CM: Cable Modem
CMTS: Cable Modem Termination System
Calling Feature Servers & Gateways—Provide call processing and logic features

FIGURE 4 Normalized Price/Subscriber



This hybrid solution is characterized by efficiently providing high-quality telephony and the full set of telephony features—call waiting, caller ID and so on—via IP access to circuit equipment.

Figure 2 (page 56) shows one possible implementation of the hybrid solution. This solution is appealing because it does not disrupt the video entertainment nor the packet data services infrastructure. This hybrid solution takes advantage of the deployed IP access and backbone networks to carry the voice traffic, in packetized form, to the network-based call signaling gateway (NCSG), or packet-circuit gateway, at the edge of the network.

From an engineering point-of-view this hybrid solution has the following characteristics:

* It provides significant capital cost savings;
* It minimizes the development of new operations systems while improving the performance and cost effectiveness of an MSO's cable network flow-through provisioning; and
* It leverages the continued use of existing Class 5 switches and operations support systems (OSS) infrastructure.

The hybrid solution represents a major step toward the realization of the strategy of most MSOs for a converged broadband network capable of delivering any distance, any service to customers. As CableLabs' PacketCable specifications mature and new technologies emerge, the cable network will become ready to go from a hybrid (IP and circuit) to the full end-to-end IP telephony solution.

As the cable network evolves to a full packet-based network, the Class 5 switch evolves functionally to a full packet-based switch. This transition provides key technologies and capabilities necessary to evolve today's circuit-switched networks into the cost-efficient packet network of tomorrow, while protecting the cable operator's investment in their embedded base of network elements and revenue-generating services.

As the gateway between the cable network and the Class 5 switch, the NCSG translates the functionality of the Class 5 switch into the IP access network. Call processing and any associated functions are performed in the circuit-switched environment using the MSO's embedded base of Class 5 switches. The NCSG interfaces with the NIU equipment at the subscriber premises—a multimedia terminal adapter or broadband telephony interface, for example—via the cable modem termination system (CMTS) over the cable plant (an HFC network), and sends and receives calls

over the IP access networks using voice over IP packet technology.

The NCSG is supported by network management systems that leverage current OSS systems. In this solution, all network provisioning is done at the Class 5 switch through existing interfaces, and billing information flows are done over the current paths.

The proposed hybrid solution assumes that an appropriate infrastructure made of data routers, optical systems, data servers and so on, already are in place in the MSO's network.

Deploying IP access to IP equipment

Figure 3 (page 58) shows the architecture for end-to-end IP telephony over cable. This architecture has no circuit-based equipment and the transition to full packet-based (IP) telephony has taken effect. Notice that the transition includes an evolution of the NCSG system to a call-management server and gateway implementation.

> "Many of the features used in residential telephony service are available in IP telephony implementations."

Call-management servers and gateways shown in the diagram are PacketCable compliant. The overall effect of providing IP access to the telephony system on the Internet access network is to raise the level of the network shared among the services to the IP level. This allows the maximum re-use of deployed equipment and applications.

Cost comparison

Figure 4 (page 60) shows a comparison between the circuit-based telephony overlay network architecture, the hybrid solution using NCSG gateway and the full end-to-end converged IP telephony network solution, using normalized price-per-subscriber.

Notice that even for large deployments (optimal scenarios for the overlay solution), the circuit-based telephony overlay network is twice as expensive as the full IP solution. The reason behind this is the duplication of equipment throughout the network in the case of a circuit-based network overlay. The hybrid solution appears to be significantly less expensive than the circuit-based overlay solution.

Up until recently, the comparison has been shown on equipment alone. If we consider that the circuit-based overlay network solution has two full networks to operate, maintain and provision, the cost of the network increases significantly. In this architecture, two independent and complete networks exist, for which two sets of specialized personnel, training, procedures and so on are required. The operation cost is significantly higher in the circuit-based solution than the other two architectures.

IP technology for cable telephone service provides enhanced use of Internet access networks, so an MSO expecting to provide both Internet access and telephone service should consider the use of IP telephony equipment for telephone service. If the MSO has invested in circuit-switched telephone equipment as well as an Internet access network, a hybrid solution like the one described here can provide an excellent method for leveraging existing investments as well as evolving the network to a converged multi-service network in the future. CT

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Cable Telephony

CABLE TELEPHONY:

Applying Circuit-Switched Experience to VoIP

By Alan S. Nakamoto
and Kenneth G. Craft

HFC networks provide an ideal medium for advanced services delivery, including packet voice and data, but how feasible is it for MSOs to make the transition to a VoIP solution, and what lessons can they learn from circuit-switched?

As the communications revolution continues, the demand for high-performance networks has grown exponentially. Hybrid fiber/coax (HFC) networks inherently provide an ideal medium for the delivery of advanced services between the cable TV headend and the residence.

In order to take advantage of HFC networks, equipment vendors must first develop a reliable, multi-purpose digital transport system. There has been a great deal of discussion about the importance of getting increased performance (in terms of digital bit rate) from an HFC system. However, the most important factors in determining the success of an HFC service are contained in the user experience, quality and availability of service, operational characteristics and overall service reliability.

Since the early 1990s, telecommunications equipment manufacturers have been developing systems to provide lifeline telephony service over HFC plant. One manufacturer offers a system that concurrently supports telephony and Internet protocol (IP) data services via a single remote service unit. We'll outline the basics of these systems and specific product developments that have enabled the successful offering of local telephony and high-speed data services over HFC networks.

In addition, we include a discussion of how other "advanced services," such as packet voice and data, can be layered onto the same HFC transport for even greater return on an HFC investment—such as integrated delivery of lifeline telephony, IP data and voice-over-IP (VoIP) telephony via systems that provide all of these services over a single modem.

HFC vs. traditional PSTN access networks

HFC access networks are inherently different from traditional public switched telephone network (PSTN) access networks. The HFC network is designed to broadcast video programming to a large serving area. Each home in the serving area has access to all of the programming. Entertainment channels and services are enabled to the subscriber location per the customers' subscription package. (See Figure 1, page 66.)

Conversely, the traditional PSTN access network has been designed for analog voice service and dedicates separate or individual connections for each telephony line. PSTN local loops provide individual complete paths between the subscriber location and the telephone company central office. (See Figure 2, page 66.)

Digital HFC systems utilize traditional telco access technology to provide a standard interface to telephony end office switches, as well as providing multi-services over a shared (across many homes) high-speed digital medium. (See Figure 3, page 68.) Subscribers are given shared access to the digital network for their services, but only use bandwidth when they actually need it. Powering for the typical plain old telephone service (POTS) line is accomplished over the cable plant and includes battery backup for quality of service (QoS) objectives.

The result is a multi-purpose digital access platform designed for telco grade lifeline services with the capability to deliver other services such as IP data.

At the headend or hub, a host digital terminal (HDT) interfaces the PSTN and IP data network to the broadband HFC cable network. The HDT effectively manages telephone conversations and data traffic, and provides full interoperability with the appropriate backbone networks (PSTN or data network).

Today, most HDT modems utilize quadrature phase shift keying (QPSK) technology to modulate the digital signals onto narrowband RF carriers for both downstream and upstream channels. Quadrature amplitude modulation (QAM) schemes are anticipated in the near future to increase digital throughput and system capacity.

Circuit-switched time slots (64 Kbps) and IP data packets are multiplexed into a single multi-megabit digital stream and modulated onto a 1.5 MHz wide RF carrier for straightforward insertion in the downstream path. The RF carrier is normally set between 10 dB 16 dB below the visual carriers and requires no special downstream engineering in the HFC plant. Digital HFC systems typically support downstream carriers in the 470 MHz to 862 MHz range.

Remote service units (RSUs)

A remote service unit (RSU) at the subscriber location receives all of the downstream signals via standard coaxial drop cable. The RSU locates its assigned telephony RF carrier for demodulation and passes the downstream RF to other devices, such as a set-top box or television set. The RSU shares the digital bandwidth with other RSUs on the same RF carrier frequency. The digital bandwidth is used only when telephones are "off hook" or data packets are being transmitted.

For circuit-switched cable telephony services, 64 Kbps is used for connectivity between standard telephony line interfaces in the RSU and the local telephony switch. Data services can utilize the remaining unused bandwidth, providing very efficient use of the digital pipe. Traffic engineering for each individual service establishes the QoS for both the voice and data application that share the same digital bandwidth; this will apply to a combined VoIP and IP data service as well.

The RSU comes in many line capacities and is available in both indoor and outdoor versions. The RSU provides a standard two-wire telephony interface and can be connected to in-house wiring in the same manner that telephone lines have been installed for years.

Traditional customer premise equipment (CPE) devices, such as analog telephones, fax and answering ma-

FIGURE 1 HFC Access Network

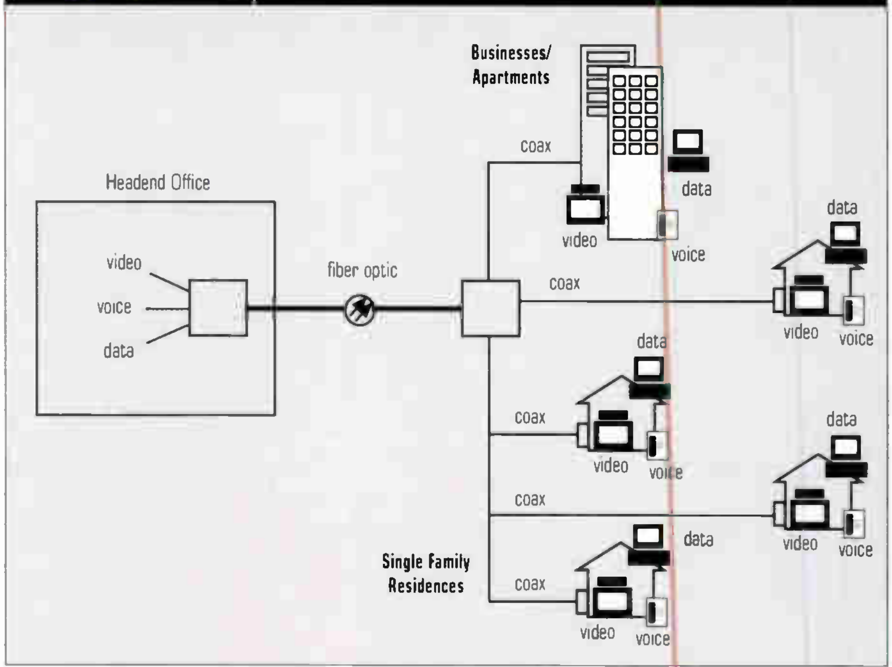


FIGURE 2 Local Loop Access Network

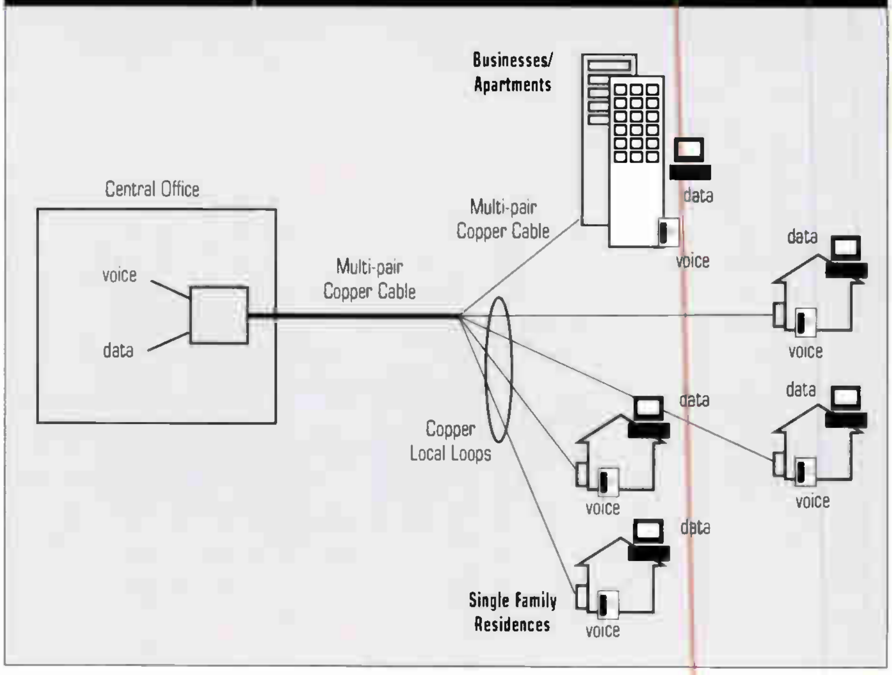
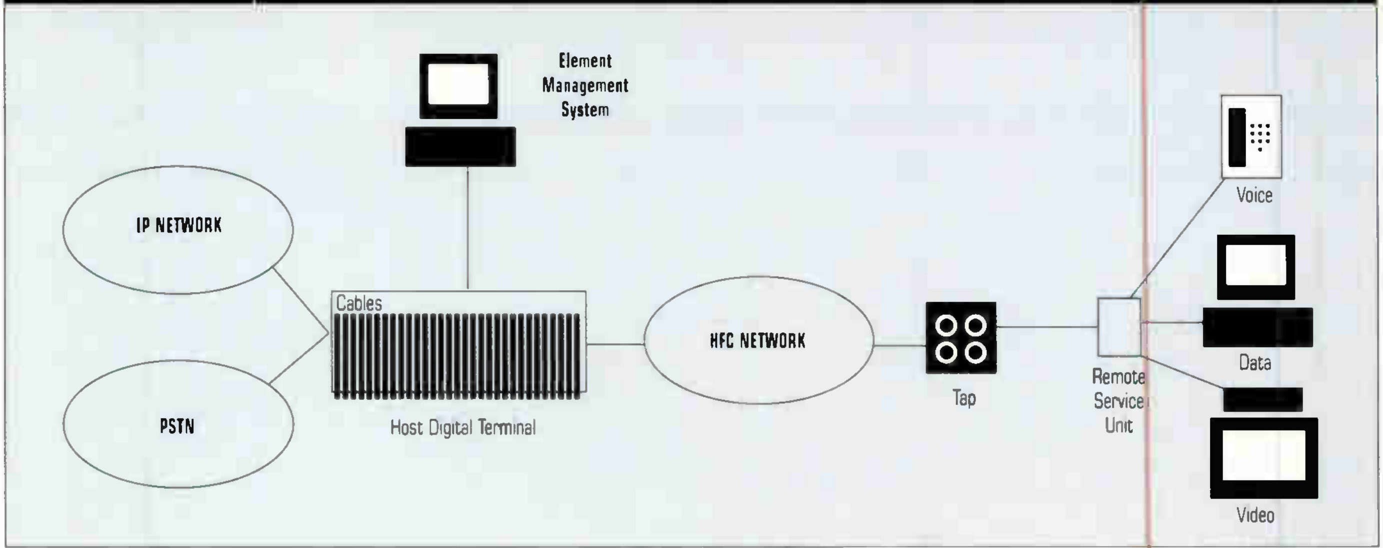


FIGURE 3 Digital HFC Access System



chines, analog modems and cordless phones, are compatible with the RSU. Furthermore, there are no differences in how a user makes telephone calls or accesses custom calling features such as voice mail, call waiting or caller ID. For the data service, the RSU provides a standard 10BaseT interface (RJ45) for connection into the PC network interface card.

In the upstream direction, the RSU transmits digital voice and data signals to the HDT via narrowband RF carriers (typically between 5 MHz and 42 MHz) using QPSK modulation and time division multiple access (TDMA) multiplexing. The digital bursts from multiple RSU transmitters are received by a modem in the HDT, creating a shared multi-megabit two-way transmission path. The HDT modem manages each RSU's packet transmission timing and transmit levels to account for the different distances between the headend and subscribers and variations in the plant over time and temperature.

End-user service objectives drive product development

For many years, cable telephony equipment manufacturers have been working with cable operators to understand their service and business objectives and using this information to drive product development. The resulting products are allowing multiple system operators (MSOs) to enter the telephony market by enabling the offering of local telephony services over HFC networks.

Three fundamental objectives were used in developing cable telephony equipment:

1. The end-user experience with the telephony service must be equal to or better than the service provided by the incumbent local telephony company.
2. The reliability and QoS of the service must also be equal to or better than the incumbent provider's service.
3. The ongoing operations and maintenance expenses of providing the service must be minimized.

These objectives are identical to those driving the development of IP-based access equipment to deliver VoIP and other new IP-based services. By leveraging the proven capabilities of digital HFC systems, manufacturers are now migrating to IP and standards-based systems compliant with Data Over Cable Service Interface Specification (DOCSIS) and PacketCable systems to support new services. >

BOTTOMLINE

> On the Road to VoIP

Hybrid fiber/coax (HFC) networks are the right medium for the delivery of advanced services between the cable TV headend and the residence, but a reliable, multipurpose digital transport system is still needed. However, recent advances have enabled the successful offering of local telephony and high-speed data services over HFC networks. Packet voice and data can be layered onto the same HFC transport for even greater return on an HFC investment, so that systems could provide lifeline telephony, Internet protocol (IP) data and voice-over-IP (VoIP) telephony over a single modem.

Cable telephony equipment manufacturers, meanwhile, have come up with products allowing multiple system operators (MSOs) to enter the market by enabling local telephony services over HFC networks. Their objectives are to enhance end-user experience, improve reliability and minimize operations and maintenance expenses. Similar goals are driving the development of IP-based access equipment to deliver VoIP and other new IP-based services.

By leveraging the proven capabilities of digital HFC systems, manufacturers are now migrating to IP and standards-based Data Over Cable Service Interface Specification (DOCSIS)- and PacketCable-compliant systems to also support new services. The digital HFC system supports global lifeline telephony and data services today and is a viable access vehicle to migrate to tomorrow's IP-based services.

Their improvements have enhanced the following:

- **End-User Experience:** There are many ways to measure the end-user telephony experience, but there are two primary categories in which the service is judged. These categories include: "Does the user interact with the new service in the same manner as the incumbent service?" and "Is there a difference in the perceived quality of the service?"

Digital HFC systems have been developed to provide the same user interaction as provided by any local telephone company. These systems leverage the customer local area signaling services (CLASS) and custom calling features provided by telephony end office switches. The results are the end user originates calls, answers calls and initiates custom features (such as call-waiting), using the same keypad and hook switch on standard telephone sets. Cable telephony RSUs are also designed to support the different kinds of customer equipment attached to the standard two-wire telephony interface.

Although a "standard" is published for the telephony interface, some answering machines, cordless telephones and other electronic devices function slightly different than a typical telephone set. In addition, cable telephony manufacturers have developed RSUs to conserve power consumption causing a slight variation in the telephony interface as well. Cable telephony manufacturers have worked to balance these incompatibilities along with power consumption over the last few years. In the future, a VoIP service will benefit greatly from these CPE circuit-switched experiences.

The quality of telephony service provided over digital HFC systems is generally higher than service provided over traditional copper local loops. Digital HFC systems use digital signals to transport services directly to the home. This provides immunity to audible noise frequently heard on copper local loops.

- **Reliability:** Telephony service in the United States is one of the most reliable in the world. Users take the service for granted and expect that the service will work during extreme weather conditions and during power outages. Digital HFC systems have been designed to meet these end-user expectations.

The RSUs are designed for outdoor installation for easy maintenance by service providers. Outdoor installation requires the use of high-quality components designed to withstand extreme temperature and humidity conditions. The mechanical packaging of RSUs also is designed to protect the electronics from snow, rain, sand, dust, insects, animals and other potentially harmful intrusions.

The RSUs are designed for low-power consumption to be economically network-powered. Network powering for single-family residential applications has become the U.S. norm for providing telephone service over HFC networks. The RSUs also are capable of local powering with battery backup for multi-dwelling applications or where network powering is unavailable. Battery back-up configurations for situations requiring the use of locally powered RSUs can be deployed with 8 hours or more reserve power.

The HDT also is designed for high reliability. Modules are designed with background diagnostic routines to detect failures and the system is designed to automatically switch to standby modules in the event of a primary module failure.

The ability for digital HFC systems to automatically avoid ingress noise is a technique used to minimize service disruptions and maintain audible service quality. Frequency agility, such as frequency hopping, detects service degradation due to plant noise and changes frequencies without interrupting active conversations.

- **Ease of Operations and Maintenance:** Customer care is critical to the successful deployment of new services. Customers expect minimal telephone service outages, and cable telephony equipment provides both remote surveillance and diagnostic capabilities to maintain high service quality. The RSU provides local and remote operations, administration, maintenance and provisioning (OAM&P) capabilities that cannot be implemented over standard copper local loops.

These capabilities, which generally identify and isolate problems before customers notice them, include:

* Real-time detection of connectivity disruptions between the subscriber and the headend;
* Performance monitoring of the connection (QoS) between the subscriber and headend, such as the RF carrier in the HFC access network;
* Diagnostic testing of in-house wiring; and
* Extensive system diagnostics and status monitoring of local power and battery reserve when implemented.

HFC element management systems (EMSs) also play a major role in providing and maintaining lifeline services. These systems simplify service provisioning, identify and isolate network faults as they occur and enable corrective actions to be quickly performed. Overall, these operations and maintenance capabilities provide HFC network operators with the tools to maintain a superior level of customer satisfaction. Most EMSs are GUI-based (graphical user interface) and are easily mastered by personnel with basic computer skills.

These systems also readily connect to a higher level network management system (NMS) for total network control from a centralized network operations center.

Beyond traditional telephony service

The basic digital HFC system provides the same lifeline voice services that are offered through traditional voice switches. These services include CLASS and customer calling features (such as calling number delivery and call waiting), calling card, pre-subscribed long distance, emergency (911) and operator services. Multiple lines also may be offered over the same coaxial drop to serve a single-family home or a multi-dwelling unit. Circuit concentration ratios as high as 8:1 can be supported with some systems.

High-speed data service capabilities are now offered through digital

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HFC systems. These services, targeted for Internet access and remote office branch office (ROBO) applications, use the high bit rate digital pipe that is available at the RSU. The data services can be offered in the same spectrum allocated to telephony, since peak traffic periods for telephone service are different than peak periods for Internet access. Many successful deployments are generating revenues today by offering both circuit-switched telephony and IP data over the same RSU, HDT and HFC digital bandwidth.

VoIP and other future IP services are being defined today for tomorrow's new enhanced services. Digital HFC systems will be leveraged to begin offering packet-based services in the HFC access network before the packet-based service infrastructure is built. When VoIP equipment matures, end-to-end IP telephony services will be carried by digital HFC systems.

Digital HFC systems support global lifeline telco and data services today, and are a viable access vehicle to migrate to tomorrow's IP-based services.

Key lessons learned in circuit-switched apply to VoIP

Regardless of the technology, there are many lessons learned during the deployment of HFC circuit-switched telephony that apply to VoIP, or for that matter any follow-on technology.

First and foremost is that customers expect a replacement telephony service to be at least equal to or better than the incumbent in all aspects, such as available features, operation, reliability and quality of service. Unless the new telephony service is marketed as a complementary service to the existing local service (such as a second line), the MSO must transition the customer to a complete transparent service offering.

Although this sounds simple, replicating a complete transparent local service offering is a significant challenge for an end-to-end VoIP solution, not to mention tending to all the OAM&P systems. Therefore, we expect VoIP solutions to roll out in phases and over time gradually build into an overall end-to-end network solution with multi-vendor interoperability.

VoIP solutions will start in the HFC access network and build-out toward the core transport and next generation switching areas over time. Early VoIP service solutions will continue to use local telephony switches to replicate the many features available to customers today, and until call control standards are well defined for multi-vendor interoperability.

Customers also expect their investment in various CPE equipment to be fully compatible with any new VoIP service. There have been many valuable experiences learned through the deployment and interconnection of low-powered, circuit-switched RSU

products with a variety of CPE equipment that will continue to apply to any new VoIP RSU solution as well.

In terms of reliability and QoS, HFC networks will continue to evolve towards smaller homes passed serving areas, pushing fiber even closer to the subscriber; including diverse fiber routing to the fiber nodes. Uninterruptible power supply (UPS) and battery back-up solutions will become common practice to power the RSU-type products. This will increase bandwidth availability to the customer, reduce or eliminate actives in the feeder, and increase reliability and overall network quality. Performance monitoring and key diagnostic and maintenance features available today in the RSU and HDT will continue to be needed in a VoIP product. These features not only improve QoS and reliability, but also keep the MSO operations cost at a minimum and maintain a high level of customer satisfaction. Both the RSU and HDT will need to be designed to meet carrier-class specifications, similar to circuit-switched products today.

In the future, some circuit-switched telephony manufacturers will introduce new HDT modems to allow MSOs to more gracefully migrate from a circuit-switched service to a VoIP service. These new VoIP modems will co-exist in the same HDT as the circuit-switched modems and continue to provide carrier-class service.

By allowing for a co-existence of both technologies, MSOs can deploy a circuit-switched solution today, and then migrate to the VoIP solution as the technology matures and the standards evolve for interoperability. This provides investment protection, and allows the MSO to begin offering an equivalent local telephony service immediately. These new VoIP modems will be DOCSIS- and PacketCable-compliant and be software upgradable to the new standards for interoperability.

In light of the above, plus increasing competitive pressures, it makes sound business sense for MSOs to begin deploying proven circuit-switched solutions today, and migrate that investment to a VoIP solution in the future. "Time is the enemy!" CT

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SPEED MEANS NOTHING

IF THEY CAN'T GET ONLINE

And Every Second Counts.

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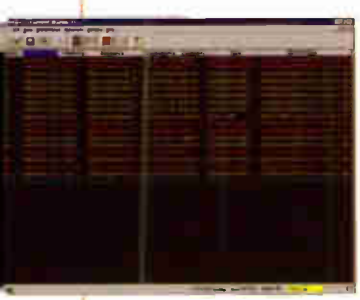

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DWDM: Doing More With Less?

By Jonathan Tombes

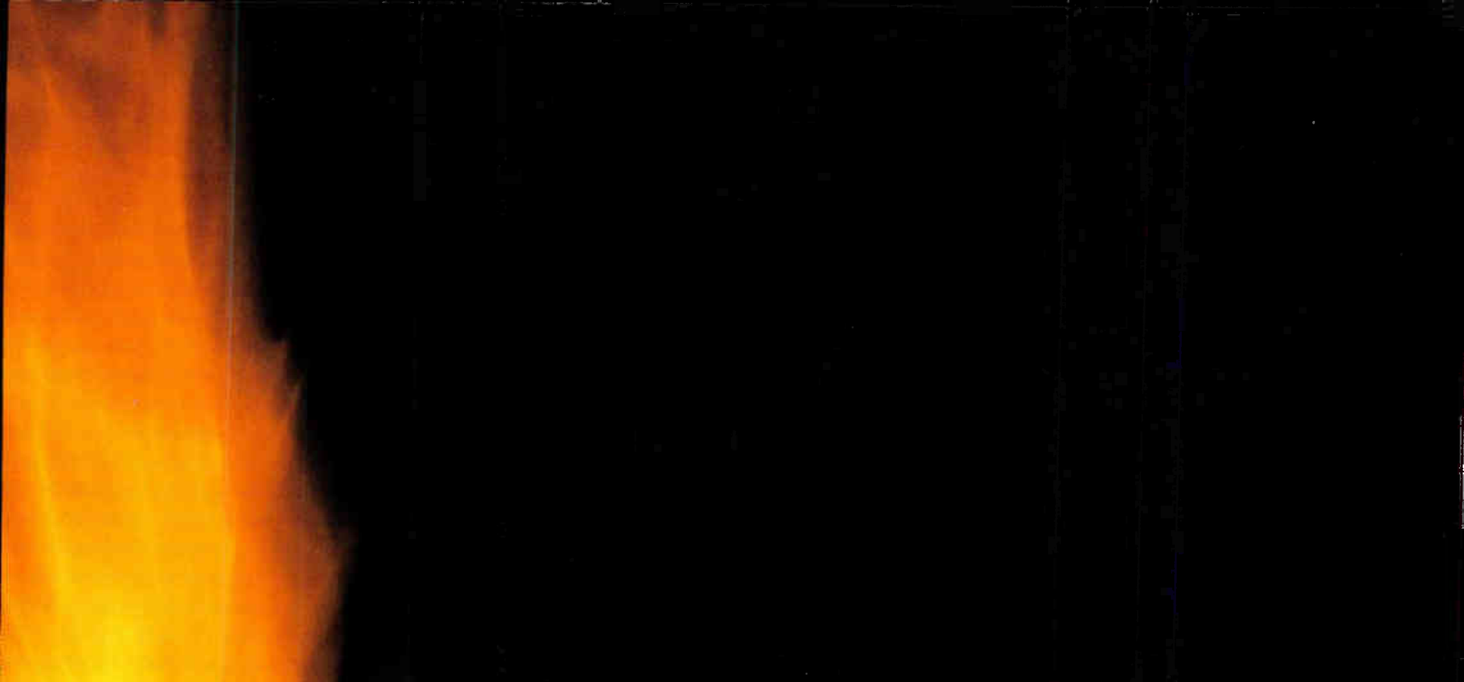
Dense wavelength division multiplexing (DWDM) is a hot technology, but is its promise too good to be true?

Analysts foresee dense wavelength division multiplexing (DWDM)'s compound annual growth rates in the range of 30 percent to 50 percent. The DWDM niche of the cable industry is also humming.

Vendors are selling light-filtering, channel-spacing and related DWDM transmission equipment, even as they fine-tune their approaches, explore new technologies and cope with market entrants, ranging from nimble start-ups to telco-equipment giants. Operators are testing gear, adjusting network architectures, running economic models and actually deploying.

The basis of this activity is what one investment bank calls cable's "manifest destiny"—to grow more network bandwidth and provide more services. DWDM's promise is to increase network capacity over fewer fibers and presumably at lower cost—in other words, to do more with less. Is that promise too good to be true?

Let's see where cable's latest optical gambit now stands.



From telco to cable

Popularized in long-distance telecom networks by Ciena in the 1990s, wavelength division multiplexing (WDM) works by combining multiple wavelengths (or colors) of light onto a single optical fiber. The original or "broad" WDM mixed 1310 nm and 1550 nm wavelengths. Dense WDM is associated with 1550 nm transmitters and a greater number of wavelengths.

"It's basically just the notion of putting more bandwidth over a small number of fibers," says Paul Connolly, vice president of marketing and network architecture for Scientific-Atlanta. The technology debuted in cable networks in 1998, but DWDM remains largely a telco phenomenon.

In "DWDM Systems: The Bright Future of Networking," Cahners puts the total market for DWDM systems in 1999 at $4 billion and attributes all to long-haul applications. Cable's piece of this pie is tiny. On the component level, for instance, Stephen Montgomery, president of market research firm Electronicast, estimates that cable TV had only 0.4 percent of total DWDM filter modules in 1999.

But growth is the key. Analysts are predicting compound annual growth rates of between 36 percent and 51 percent for the overall DWDM industry between 1999 and 2004. Montgomery predicts that cable's global consumption of DWDM components will grow from $24 million to $165 million over that period. (See Table 1, page 84.)

In terms of the broader WDM category, cable is a larger presence and should grow even more quickly. Investment bank CIBC World Markets says cable's WDM revenues were about $90 million in 1999 and will grow to more than $400 million by 2004.

Connolly says cable's ongoing adoption of DWDM has two parts. "The first application is what I would call pure transport: you want to move voice, data or video information between network points, not access out to users, but rather between headends, or headends to hubs," he says. "The second application, which is a more recent one, is basically the notion of using WDM ...(for) both the broadcast and the narrowcast information."

Case in point: Rogers

The case of Rogers Cable demonstrates Connolly's first point. Using the Linear product from Ericcson's optical networking (ERION) family, Rogers applied DWDM to the fiber interconnects between the large urban centers and the digital headend that serves all of Ontario. Another application rose from Rogers' affiliation with @Home.

Left: Synchronous' Agena ITU Return Path Transmission System, used for DWDM analog return services.

Right: Synchronous' Corvus Dynamic Digital Return Path System, for use in DWDM operations.

Left: Synchronous' ITU-OMUX/ODMUX Dense Wave Division Multiplexer/De-multiplexer (8 and 16 wavelength units), the hearts of its DWDM system.

"On that backbone (between Toronto and Buffalo), we have deployed DWDM, and that was to turn up OC48 capacity for Internet service," says Dermot O'Carroll, senior vice president of engineering and network operations for Rogers Cable.

"The economics of that are good in routes where you don't have spare fiber, but you need the capacity," says O'Carroll.

As for its primary and secondary hub architecture, Rogers is considering having two large hubs use DWDM in a situation now involving 13 small nodes. Non-economic issues, such as right-of-way or timing, also impact a decision to go with DWDM.

"We are using it where it makes economic sense," O'Carroll states. He says on narrowcast the company is looking at companies like Synchronous, but adds that the equipment remains pricey.

Hold the epoxy

The economics from the other side of the fence may look different, especially to vendors who already play to deep-pocketed telcos.

"There is so much demand shortage in terms of WDM components that there's no incentive on the part of the vendors to find a new market that offers lower pricing," says Synchronous Chief Technical Officer Mani Ramachandian.

A full-service DWDM provider to cable, Synchronous offers muxes, demuxes, add/drop multiplexers, transmitters, receivers and erbium-doped fiber amplifers (EDFAs). "Everything but the fiber," says Ramachandian. The Synchronous value proposition also includes an alternative approach to such common practices as epoxy-bound optical filters.

"This is a definite 'no-no' in the telco industry, but cable TV is not even aware that vendors are using this," he says.

Ramachandian says the problem with epoxy is "creep," very slight mechanical movements that occur as the epoxy either hardens or goes through its life cycle. "The best way to build any optical component is by laser welding, and that is the only type of component that we use."

Among this apparent minority of non-epoxy DWDM vendors is Gould Fiber Optics, which claims it pio-

BOTTOMLINE

> Does DWDM Deliver?

The promise of dense wavelength division multiplexing (DWDM) is to deliver more bandwidth over a smaller number of fibers, presumably at a lower cost. Its initial application in cable resembles its long-haul function in the telco world where it predominates. For cable networks, that translates to transport between headends, or headends to hubs. Narrowcasting or broadcasting is a more recent DWDM cable application.

Product differentiation in DWDM technology includes optical filters (thin-film, laser-welded, Fiber Bragg Grating, planar-waveguide), approaches to channel expansion (interleaving, reduced channel sizes, greater bandwidth), modulation techniques (direct or indirect) and compatibility with other transmission streams (QAM modulated traffic, WDM streams). Many of these features have price/performance tradeoffs, which helps explain the appeal of less costly, un-cooled coarse WDM gear.

DWDM makes sense on a backbone applications for some operators. An upgraded plant poses higher hurdles than a relatively greenfield case. Operators with deep fiber architectures are likely to be significant DWDM consumers. Prices are falling, but remain a concern.

neered the fused biconical taper process. Both Gould and Synchronous also tout low optical insertion loss, of 4 dB and 6 dB, respectively, for eight-channel muxes/demuxes.

Synchronous also takes a contrary stand on the question of channel expansion. Instead of jumping from eight to 16 wavelengths, Ramachandian advocates interleaving technology, a way of filling up vacant intermediate space.

Does this take you off the International Telecommunications Union (ITU) grid? "The ITU itself does not specify which wavelength people use," he counters. But is cable ready for interleaving?

WaveSplitter, one of many cutting-edge optical start-ups, plans to deliver a device this fall that interleaves sets of 100GHz or 200 GHz-spaced channels into one set of 50 GHz channels. But WaveSplitter Director of Marketing Bob Shine is aiming that product at telcos.

For the cable space, WaveSplitter is offering its WavePump 980 nm pump laser combiners as a way to build bigger amplifiers, and its WaveMetro Narrow WDM product as an alternative to the dual-channel WDM and the relatively more expensive DWDM.

Right: Finisar's Opticity 3000, a metro WDM optical transport platform geared toward providers and enterprises building backbone architecture.

Left: Scientific-Atlanta's Prisma II DWDM Opto Platform, part of a family offering "carrier-class" performance.

Left: Scientific-Atlanta's Prisma II Reverse Data Module

More filter techniques

Contrarians and fiber-optic start-ups aren't the only ones exploring filter technology. ADC's photonics unit combines fused biconic taper technology with Fiber Bragg Gratings (tiny grooves that work as a reflector). The impact is again on insertion loss.

"We get much lower loss typically than thin film, especially in higher channel count," ADC's Photonics Program Manager Eric Campbell says. He says that instead of eight filters for eight channels, with grating you need only three filters. Doubling to 16 channels requires only four.

ADC's tree architecture also helps eliminate the need for signals to pass through every filter when being split, Campbell says. The technology can potentially deliver tighter channel spacing, as well.

Scientific-Atlanta is entering the filter fray, albeit through a strategic partner,

> Getting the Gear

From backbone transport to reverse path aggregation, wavelength division multiplexing (in its dense and other flavors) covers a lot of territory. To learn more about companies mentioned in this article, visit the following Web sites:

* ADC: www.adc.com
* Antec: www.antec.com
* Artel: www.artel.com
* Bookham Technologies: www.bookham.com
* C-COR.net: www.c-cor.net
* Chromatis (now part of Lucent): www.lucent.com
* Ericsson: www.ericsson.se
* Finisar: www.finisar.com
* Gould Fiber Optics: www.gouldfo.com
* Harmonic: www.harmonicinc.com
* Herrmann Technology: (now part of Lucent): www.lucent.com
* Motorola: www.motorola.com
* Ortel (now part of Lucent): www.lucent.com
* Philips: www.philips.com
* Scientific Atlanta: www.scientificatlanta.com
* Synchronous: www.syngroup.com
* WaveSplitter: www.wavesplitter.com

Above: Antec's DWDM modules, part of its Transplex system. Right: Antec's Lightplex Optical Wavelength Router developed with Lighchip, Inc.

Bookham Technologies. S-A's Connolly says that Bookham's work in optical integrated circuits marks "a radical improvement in costs, versus today's filter technology-based products."

> **"(Epoxy) is a definite 'no-no' in the telco industry, but cable TV is not even aware that vendors are using this."**
>
> **—Mani Ramachandian, Synchronous**

Bookham's planar or arrayed wave guide technology simply writes the signal paths onto a piece of silicon. Japan's Nippon Telephone & Telegraph Corp. adopted an early product from Bookham. Potential cable applications include fiber-rich networks such as AT&T's LightWire architecture, in which mini-fiber nodes eliminate the need for all coax amplifiers.

AT&T's LightWire trials began last year in Salt Lake City and now include Miami, Dallas and Pittsburgh. Equipment vendors include S-A, Harmonic and C-COR.net.

Fighting words

Because DWDM covers a lot of network territory, getting a handle on who's got market share is tricky. But Antec Vice President for Marketing Emmanuel Vela has a quick answer: "It's us and Harmonic." Lawrence Harris, telecommunications equipment analyst for Josephthal & Co., agrees that those two companies are DWDM market leaders for cable.

Antec's DWDM Transplex system is based on its Laserlink platform and includes transmitters, EDFAs, upstream/downstream directly modulated 1550 nm lasers and muxing equipment.

Vela, and Antec's Senior Director for Product Management Harj Ghuman, tout such features as gain-locking, which ensures constant power level of wavelengths in the event of a drop in one wavelength's power.

Antec also has a novel approach to channel expansion. "The traditional cable TV DWDM architectures are based on 200 GHz spacing," Ghuman explains. "What we have done, if you want to go from 20 to 40 wavelengths, we have kept it at 200 GHz, but we have expanded the bandwidth from what we call a C-band to an L-band."

In other words, Antec expands the architecture's overall spectrum. While the spacing could also decrease, cable's continued transmission of analog signals argues for retaining 200 GHz, Ghuman says.

Antec has worked with a company named Lightchip, Inc. to launch a DWDM passive device based on defraction grating, achieving a fixed, low-insertion loss, and enabling lightwave monitoring. "With it you can add 20, 40 channels, whatever, but insertion loss doesn't change because it's based on a different technology altogether," Ghuman says.

Another Antec deal with optical upstart Chromatis Networks earlier this year suggests its leadership position. (See July *CT*, page 16.) Antec made an equity investment and received exclusive rights to sell the Metropolis optical transport system to the cable industry. Soon after, Lucent snapped up Chromatis in a stock deal worth $4.5 billion.

A Lucent spokesperson confirmed suspicions that the exclusive rights may lapse. (After all, Lucent has distribution channels of its own.) However that plays out, the deal highlights the role of network bridge devices and helps define the cable transmission space.

Metropolis (to be renamed Chromatis) was designed to integrate data, voice and video services using selective wave division multiplexing (SWDM), a related technology that gives network providers choice in the


SIZE MATTERS
Now there's a closure to handle any size cable in the industry. Bigger is better.
The FOSC 600™ Platform
with the GelSeal Closure System
tyco
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gel.

C.COR-net's Mini Fiber Node (left) and MuxNode (below) support fiber-rich architectures using "coarse" wavelength division multiplexing.

deployment of optical wavelengths.

Vela says Antec is happy to leave metro and long-haul applications to "people like Lucent and Nortel and others." What about the threat they may pose in the traditional cable network?

"Bring 'em on," Vela says. "We'll happily go toe-to-toe with them."

Return path activity

Lucent is certainly on the radar screen. Its microelectronics unit now includes cable TV optoelectronic components manufacturer Ortel and DWDM thin-film processing leader Herrmann Technology. Stay tuned as this Lucent unit spins itself off next year and the cable share of the DWDM industry grows.

For now, however, the threat to a company such as Antec comes not from Lucent but from Harmonic—an equipment manufacturer that is riding several industry trends.

"There's still a lot of interest in the analog forward DWDM for use in narrowcasting and for video-on-demand systems," says Harmonic's Director of Product Line Management John Trail. "In the return path, I would say that there's much more movement towards converging the return signal toward a baseband format signal and then using DWDM to transmit that signal back up to the headend location."

> **"Remove one of the QAM transmitters, replace it with a baseband digital transmitter, and the DWDM network will work just fine."**
>
> **—John Trail, Harmonic**

Harmonic's menu of transmission products includes the METROLink series of distributed feedback (DFB) laser forward and return transmitters. Unlike Antec, Harmonic's transmitters use direct modulation, which Trail says entails a "price/performance tradeoff." In other words, it brings some distortion terms but is less expensive.

Also in the lineup are its PWRBlazer scalable optical nodes. AT&T has used Harmonic's multiplexer nodes in its deep-fiber LightWire trials.

Trail anticipates a growing role for DWDM in the return path. He says products from both Harmonic and S-A take the 5 MHz to 45 MHz spectrum of the return path and digitize it through sampling techniques, effectively converting a 40 MHz bandwidth into a gigabit signal.

Harmonic's prospective NODEcmts is the next-generation way to handle this path, Trail says, because it looks at the signals coming in, and interprets and recodes them. The result? "The same information in 100 Mbps worth of baseband digital, as opposed to a gigabit that you have in brute force digitization."

The flexibility of a DWDM network, which can also be used for quadature amplitude modulation (QAM) traffic, recommends it for upstream aggregation. "You can just remove one of the QAM transmitters, replace it with a baseband digital transmitter, and the DWDM network will work just fine," Trail says.

Options from S-A

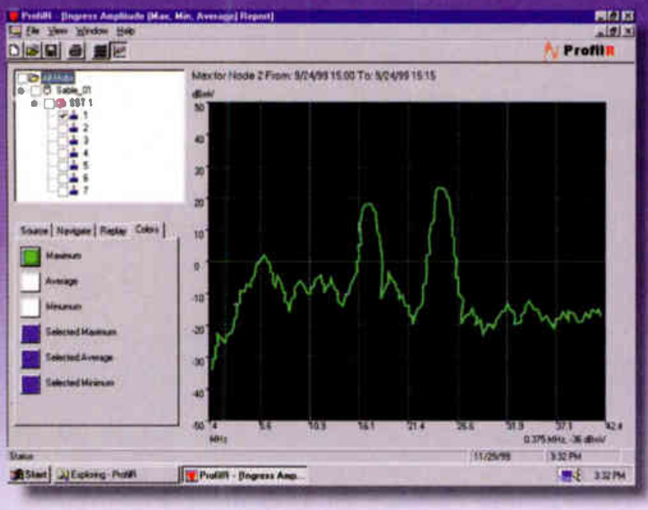
"We pioneered the notion of digitizing the upstream and using both time division multiplexing (TDM) to combine multiple streams together, as well as DWDM," S-A's Paul Connolly says.

Introduced in its second-generation version at the Cable-Tec Expo, S-A's baseband digital return (bdr) products support greater reverse path transmissions and features several reverse path options. Its 1310 nm single channel node provides the capability of an uncooled DFB transmitter, and a 1550 nm single channel DWDM-compliant transmitter is capable of scaling using TDM.

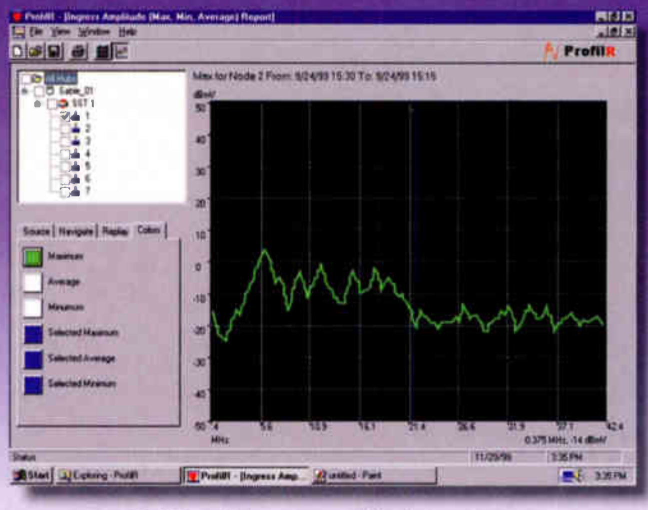
Increasing the number of upstreams combined using TDM from two to four results in being able to aggregate traffic from up to 64 fiber nodes. The upshot compares with a pure DWDM play.

"We could reach from the farthest

Crisis. Management.



Without TraffiControl™, ingress events remain hidden under return traffic



TraffiControl™ measures and plots ingress spectra of bands fully occupied by return traffic

New *TraffiControl™* lets you see the ingress inside your system's return traffic

TraffiControl™ Now Available On Trilithic's Guardian™ 9580 SST Return Path Analyzer

No doubt about it: where the return path is concerned, ingress is a big problem. Left unchecked, ingress outbreaks can prevent your system from delivering the Internet and other premium services your subscribers have come to expect. It's tough enough now to catch ingress outbreaks and fix them before the phone starts ringing. It'll be even tougher as new services fill your return spectrum, because the majority of ingress will be hidden by the increased return "traffic."

How will you detect ingress when it's hiding in your occupied bandwidths? Fortunately Trilithic, the leader in digital return path maintenance technology, has engineered a solution – a solution that will quite literally change the way you look at ingress. It's called *TraffiControl™* and it's a new feature of the Trilithic Guardian 9580 SST Return Path Analyzer.

TraffiControl is an advanced Digital Signal Processing (DSP) technology that identifies and removes all the legitimate signals from your scanned return spectrum. What remains is the once elusive ingress spectrum of your entire return band, which the system analyzes against user-set ingress limits. The best part is that *TraffiControl* can be programmed to work automatically. Then, when ingress occurs, the system will tell you about it, giving you time to respond before it causes problems.

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TraffiControl is the newest addition to the Trilithic Guardian System, the only fully-integrated, fully-digital family of return path maintenance products on the market. With the addition of *TraffiControl*, the Guardian System takes you from the subscriber, through the distribution system, all the way to the headend for complete ingress detection and, most importantly, resolution.

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node in a deep fiber (120-mile) deployment all the way back to the central headend without any need for intermediate processing," Connolly says.

At Cable-Tec Expo, S-A also debuted a 24-wavelength (up from 16) DWDM forward product. Connolly says technology would allow even more. "We think that at 24 channels, we can hit the right price points and get that balance between capacity and overall system costs," Connolly says.

Make that cooled

Motorola recently introduced several enhancements to its SpectraStar optical headend platform, including a directly modulated DWDM 870 MHz transmitter designed for targeted delivery of services.

Motorola has also been busy on the return path. As with S-A, Motorola is employing something other than pure DWDM. Its DigiStream digital return receiver is designed to receive a TDM optical signal at a rate of 2.5 Gbps from the DigiStream optical node digital return transmitter.

DigiStream supports what Motorola Manager of Optics Engineering Tim Brophy calls "coarse WDM," in this case a mixing of wavelengths at 20 nm intervals between about 1510 nm and 1570 nm.

"This allows you to make transmitters now that don't have be cooled to maintain their ultra-wavelength stability, which is something you need on the ITU grid, and yet you can still get them back to the system," says Brophy.

C-COR.net also has a mixed strategy. "We're developing components that work at 1310 nm and work at 1550 nm coarse wavelength and also are developing products that work at 1550 nm dense wavelength," says Mike Kelly, C-COR.net's vice president of sales engineering.

Economics is driving the un-cooled option. Kelly says a DWDM-capable 1550 nm tranmsmitter in the return type component costs the customer

around $1,700 to $1,800, whereas a coarse wavelength unit sells for around $800. C-COR.net expects to be shipping such "transceivers" in August.

Chromatis revisited

Kelly hinted that C-COR.net has other transmission news in the works.

"We're in development stages with some partners to potentially use coarse and dense wavelength for some other approaches," he says, alluding to Antec's deal with Chromatis.

The idea is to offer the AT&Ts and Time Warners an alternative to costly synchronous optical network (SONET)-type architectures for their burgeoning cable modem termination system (CMTS) traffic. Kelly suggests that the capability to do 1 Gbps or 10 Gbps WDM signaling on a set of fibers around a network with redundant self-healing rings will come from not only Chromatis but also C.COR-net partner named Finisar. More precisely: Finisar's Opticity line.

Kelly says that offering closed and secure networks to business customers at one-tenth the cost of commercial DSL naturally intrigues MSO executives.

Operators speak

As mentioned previously, Rogers has deployed DWDM technology from Ericsson to increase capacity on its backbone fiber. Its economic models currently identify two projects for narrowcasting.

"If the price comes down we would make a whole lot more use of it," says Rogers' O'Carroll.

AOL is another of Ericsson's recent DWDM customers, but on the cable side of AOL/Time Warner, it's another story. Time Warner Cable Vice President of Engineering Paul Gemme says that a good guess on fiber count and luck on technological advances has left his upgraded network in pretty good shape.

Gemme characterizes Time Warner Cable's DWDM deployments as "limited." One such application involves Philips DT-210 series ITU return transmitters for high-speed data service to subscribers served by ten rural hubs in northern New York. These hubs feed reverse signals to three regional headends.

In that case (which entailed concentrating equipment in a rural territory), the numbers worked. But given a robust plant and more pressing opportunities, Time Warner has reason to postpone large DWDM deployments.

"We're looking at our capital and saying, 'Well, we're better off spending our capital on deploying new services right now, rather than having stranded investment out in the plant,'" says Gemme. In part, Time Warner is wait-

TABLE 1 Global Cable TV Consumption of DWDM Components*

1999	$24.0 million
2000	$51.5 million**
2004	$164.9 million**

Source: Stephen Montgomery, president, Electronicast, San Mateo, Calif.

* DWDM components include DWDM filter modules, transmitters, receivers, (DWDM-capable) optical amplifiers, integrated optoelectronics, tunable filters and miscellaneous components used in the production of DWDM systems

** Projected

ing to see where demand arises.

For others, the time and the price are right. "We're kind of thankful to the telecom guys because their very strong push ... has brought prices down and made it a very simple decision for us to utilize a lot of those technologies," says Charter Communications Vice President of Engineering Larry Schutz. "With the same number of dollars you're getting a lot more pushed through that glass pipe."

Let there be LightWire

Then there is AT&T Broadband, which is driving much of the demand in this niche. In the third quarter of last year, for instance,

"It's really becoming a Moore's Law-type thing with optics. With the same number of dollars you're getting a lot more pushed through that glass pipe."

—Larry Schutz, Charter Communications

Charter is in the midst of what Schutz calls "rather breakneck" migration to digital. Charter's DWDM equipment comes from Harmonic and Synchronous, he says, and its baseband digital returns from S-A and Harmonic.

"It's really becoming a Moore's-law type of thing with optics," says

AT&T accounted for 50 percent of Harmonic's sales. This was an untenable position, but nonetheless illustrative of recent supply and demand.

Since then, AT&T has adjusted its vendor line-up and expanded its LightWire project from Salt Lake City to Miami and Dallas, and now to what it calls the OXiom phase in Philadelphia. At this stage, the architecture calls for "daisy-chaining" mini-nodes via a two-fiber strand.

"The nice part of that is it gives us the ability to expand the network," says AT&T Vice President of Strategic Engineering Xialin Lu. "We're basically down to the fiber node location." (For more on Lightwire, see June *CT*, pages 186-192)

Aggressive deployments attract market entrants and the pitch from DWDM vendors with strong broadcasting expertise may be increasingly compelling as video-on-demand gains speed. Artel, for instance, has its MegaWave DWDM transport and DigiLink video transmission systems that together promise delivery of more than 1,000 channels of Moving Picture Experts Group 2 (MPEG-2) TV-quality video across 120 km on one fiber.

Harmonic would seem similarly poised with its DiviCom unit.

But DWDM's future is not quite as clear as the glass pipes that carry these mixed signals. Ramachandian, who says Synchronous is not supplying much gear to AT&T these days, offers an insider's critique.

"DWDM has several technologies that have been promised but not delivered," says Ramachandian. "Some of them work for digital, some of them work with a narrow pathband, and some of them are too expensive."

In other words, everyone likes a hot technology, but not if its applications are limited or entails burning through money.

"There are lots of technologies doing all this, but cost is a big driver in the cable TV industry," Ramachandian says. "Unless the cost of some of these technologies comes down and they are proven in the real world, people are really hesitant to use them." CT

Jonathan Tombes is deployment editor for Communications Technology. He can be reached at jtombes@phillips.com.

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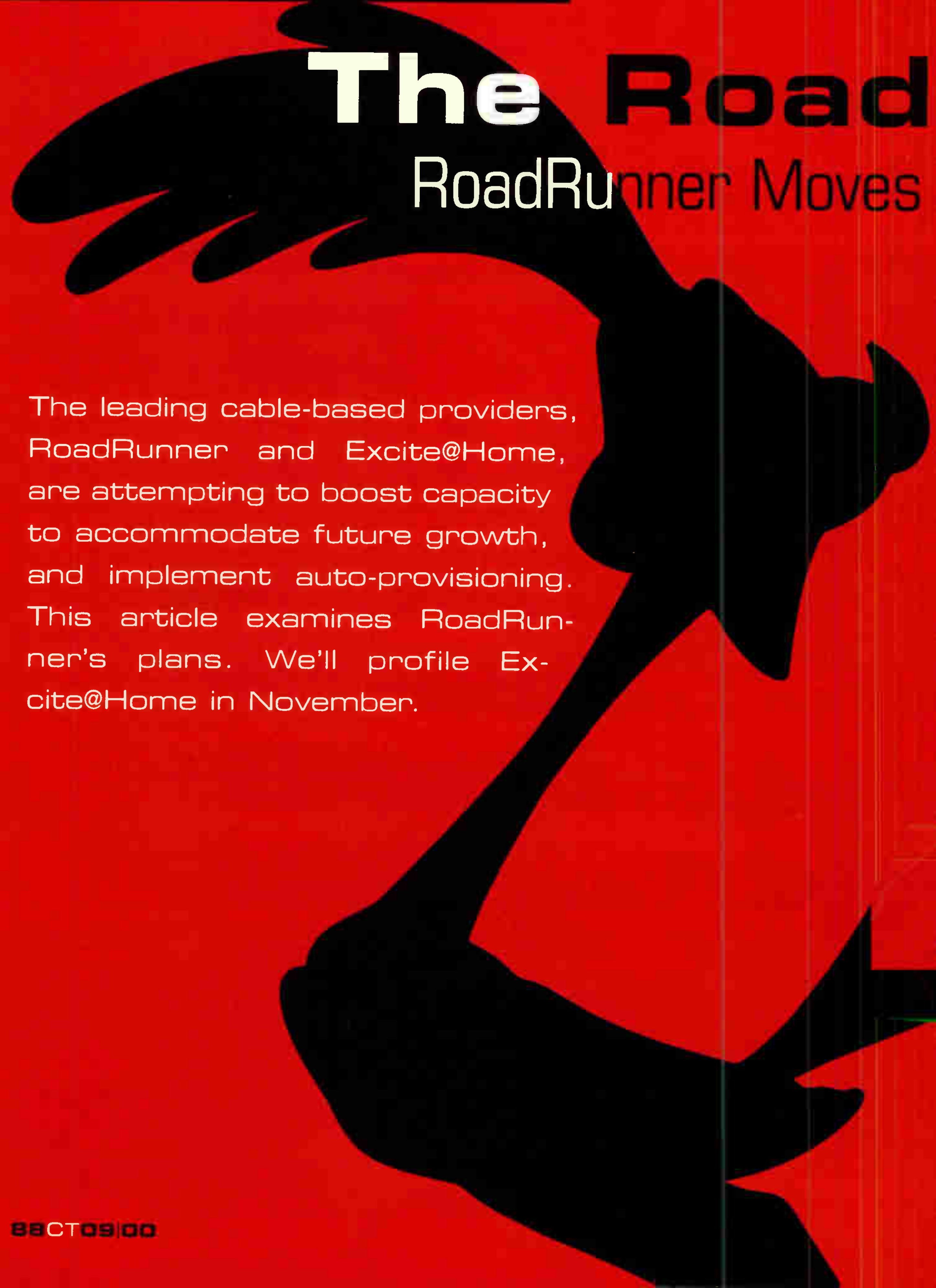
The Road

RoadRunner Moves



The leading cable-based providers, RoadRunner and Excite@Home, are attempting to boost capacity to accommodate future growth, and implement auto-provisioning. This article examines RoadRunner's plans. We'll profile Excite@Home in November.

Ahead: into the Future

By Arthur Cole

Now that high-speed data services have been rolled out and are starting to reach beyond the early-adopter crowd, service providers are unleashing a flood of new consumer features and network solutions designed to make the services faster and more convenient.

Since customers demand high speed, RoadRunner is putting a lot of effort into boosting carrying capacity.

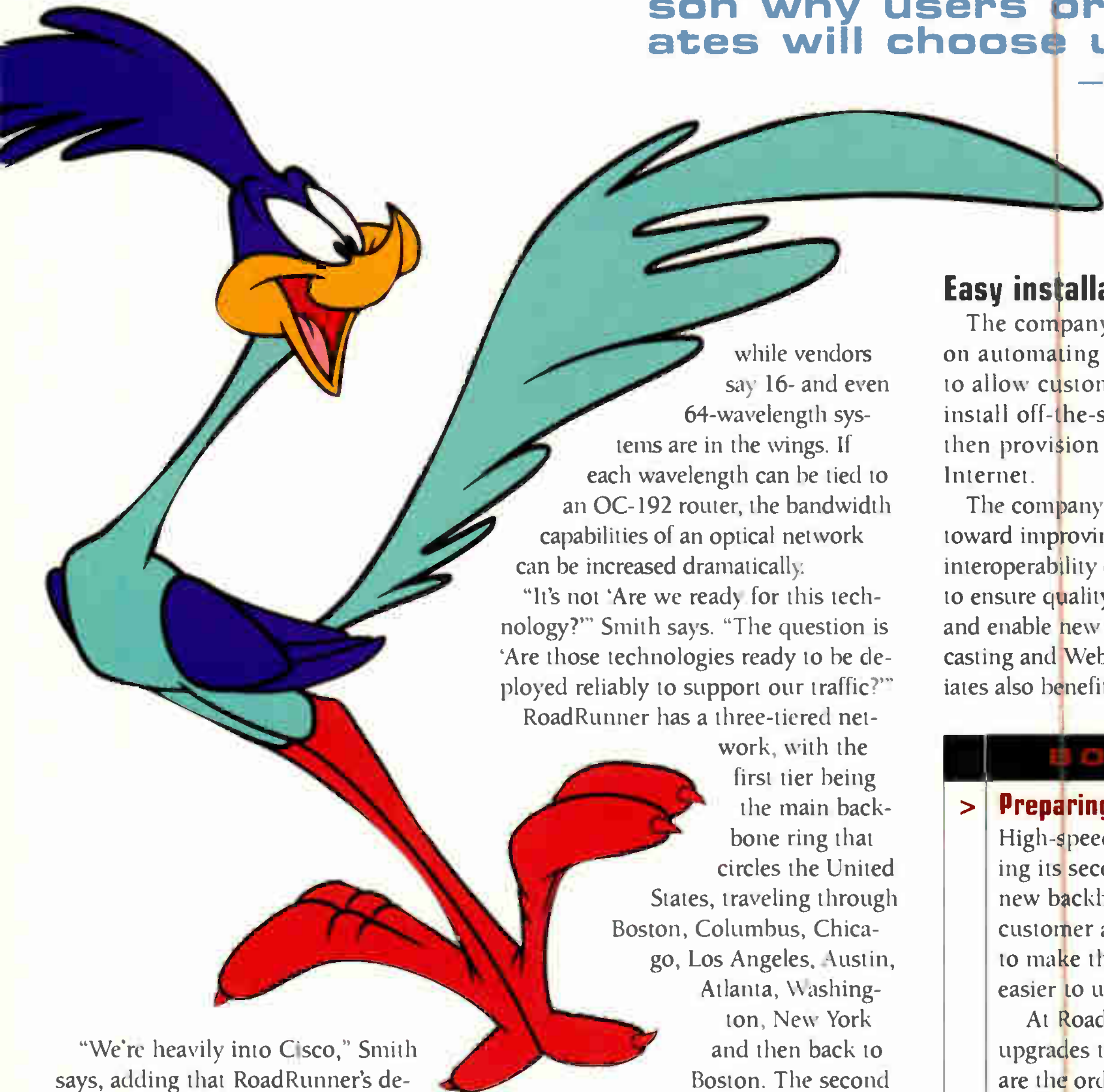
"Like everything on the Internet, we are going through lots of upgrades," Terry Smith, chief technology officer and senior vice president of engineering at RoadRunner, says. "You're going to see very significant upgrades to our Internet protocol (IP) backbone and networking centers in the next two years."

On the backbone, the ultimate goal—for the moment anyway—is OC-192. The process will be gradual, though, with this year's effort aimed at moving main trunk lines to OC-48. Smith said the network typically peaks at 2.5 Gbps to 3 Gbps during the busiest hours, which will still push the limits of an OC-48 connection that provides a maximum throughput of about 2.4 Gbps. Thus the anticipation for OC-192, which is rated at up to 10 Gbps, is high.

Fortunately, fiber being fiber, the upgrades require new equipment only at the switching centers and not on the backbone itself. Smith said the chief links in the RoadRunner network are Los Angeles to Kansas City, Kansas City to New York, and New York to Washington, making these centers the first in line for new gear. More than likely, the new equipment will be in the form of Cisco routers. >

"We want customer care to be the key reason why users or affiliates will choose us."

—David Temlak, RoadRunner



"We're heavily into Cisco," Smith says, adding that RoadRunner's deployments give Cisco "a chance to see how (its technology) works in a real broadband environment."

'I'm not going to pay a lot for that transmission'

RoadRunner is also experimenting with new transmission schemes, such as DWDM, but as Smith puts it: "It's not there yet." The main stumbling block is the price/performance ratio. The upgrade from DS-3 to OC-3 saw price/performance improve by an order of magnitude. The jury is still out on the price of DWDM, but the potential performance is astounding. Two- and four-wavelength DWDM systems are already seeing limited use in the cable industry, while vendors say 16- and even 64-wavelength systems are in the wings. If each wavelength can be tied to an OC-192 router, the bandwidth capabilities of an optical network can be increased dramatically.

"It's not 'Are we ready for this technology?'" Smith says. "The question is 'Are those technologies ready to be deployed reliably to support our traffic?'"

RoadRunner has a three-tiered network, with the first tier being the main backbone ring that circles the United States, traveling through Boston, Columbus, Chicago, Los Angeles, Austin, Atlanta, Washington, New York and then back to Boston. The second tier consists of regional rings off of the main broadband ring. There's the New York ring, the Carolina ring, the midwest regional ring, the West Coast ring and so on. The final ring is the local distribution networks between cable headends and homes (except, of course, my home here in rural Rhode Island).

In addition to the backbone upgrades, RoadRunner is pouring a lot of its resources into the network's data centers, not only to shore up existing ones, but to add new ones.

"Now is the time to scale them up and provide the capability for all the new broadband applications and services that are coming," Smith says.

Easy installation

The company is setting its sights on automating the sign-up process to allow customers to purchase and install off-the-shelf hardware and then provision their service over the Internet.

The company is also working heavily toward improving the integration and interoperability of its network systems to ensure quality of service to all users and enable new applications like multicasting and Web streaming. Cable affiliates also benefit, with things like

BOTTOMLINE

> Preparing for Growth

High-speed data is now entering its second generation, with new backbone technologies and customer applications designed to make the service faster and easier to use.

At RoadRunner, backbone upgrades to OC-48 and OC-192 are the order of the day, while new self-provisioning and diagnostic applications make it possible for customers to set up and maintain service without ever having to see a cable technician.

The name of the game in the crowded broadband space is customer loyalty and RoadRunner aims to play the game with system speed, system reliability and ease of use.

Broadband is clearly the wave of the Internet future. High-speed, always-on access is what the public is clamoring for, and the cable industry is at the front of the curve.

back-office automation for billing, service provisioning and other features. >

This concentration on customer care is one of the key initiatives as RoadRunner moves forward. The company recently launched RoadRunner Connect, a CD-ROM package for end users and professional installers that simplifies and speeds up the installation process. The package not only scans the users' computer to verify that it is capable of running RoadRunner, it also installs and configures the software, verifies that the connection has been successfully established and files customer data to the backend RoadRunner data ledger. >

> Cable and DSL: Can There Ever Be One World?

A major myth about the communications revolution is that it is inevitably moving toward a single, global, interactive network. Sad to say, it just isn't so. Not yet anyway.

The fact is that in the broadband world, there will be two distinct network architectures vying for dominance, cable modem vs. DSL. And it doesn't look like the twain shall ever meet.

At just about every step of the communications pipeline, from the customer premise equipment to the central office, telephone and cable companies are installing incompatible technology, virtually ensuring that the two technologies will not be interoperable for the foreseeable future.

Part of the reason is that the cable and telephone companies had different networks to begin with: cable's coaxial environment offers nearly 1 GHz of bandwidth and extensive RF shielding while the telephone companies have to contend with twisted-pair bundles that require compression and a host of other technological sleights of hand to provide broadband data.

"Engineering-wise, they are fundamentally different from cable," says RoadRunner's Terry Smith. "There is a different modem, different access technology, a different physical plant, different layers. It's going to be different for a while."

Does this mean cable-modem users won't be able to access a Web page that is hosted at a home or business served by a DSL line? No. Once the data hits the Internet, it can be captured and converted to whatever technology the viewer is using. But it does mean that there is a lot of conversion and encoding and multiplexing equipment out there that in a perfect world would not be necessary. The cost, of course, is passed onto the users.

Such is the price we pay for competition.

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The IsoMeter™. Now there is a fast and easy way to test the home cabling for resistance to signal ingress. The RSVP generates a special 28 MHz test signal. The installer uses the IsoMeter to track down leaks in the cabling. Moving in the direction of the leak causes a rise in pitch, quickly pinpointing its location.

The 9580-SST™. The SST headend unit collects balancing and ingress measurement data from one to eight test points, and transmits updated measurements to the SSR field units, the second component of the 9580 system. The SST operates as an ingress monitor, receiving 80 ingress samples per test point, per second.

The 9580-SSR™. Up to six SSR field units can communicate with one SST simultaneously. The SSR displays ingress and reverse sweep information. The 9580 and GUARDIAN products are a complete return path maintenance system designed to test and service the entire return path.

The 9580-TPX™. The 9580-TPX offers a very attractive alternative for monitoring a large number of return test points for ingress at a relatively low cost. The TPX is fully compatible with the 9580-SST, expanding capacity up to 64 test points.

Ingress Management Software. Allows the operator to set up a powerful ingress monitoring system for hundreds of reverse path test points. IngressManagR™ compares the ingress spectra measured at each test point to its own user-settable limits, logs data, sounds alarms, calls pagers and initiates other programmed responses if the ingress exceeds those limits.

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David Temlak, vice president of customer care at RoadRunner, said the goal is to provide a uniform sign-up process regardless of whether the customer self-installs or has a cable technician at the home.

"Eventually, we will do auto-provisioning where customers can activate the service and pay via credit card," Temlak says. "Auto-provisioning is nice, but without self-installation, it's meaningless."

Self-installation is just one of the applications that RoadRunner has coming down the pike. Another is RoadRunner Medic, a client-based diagnostic tool that offers constant monitoring of the system and connection. The package offers a desktop indicator that shows a green light if all systems are go, a yellow if the connection is still active but some applications are missing, and red if the connection is lost. It also provides tools to repair any damage and has the ability to restore the desktop to its last known working state. If that doesn't fix the problem, there are tools to connect to a national help desk.

Be on the lookout for a flood of e-mail, chat and electronic self-help applications as well, not to mention voice over IP. For the cable operator, there will be new messaging tools that communicate with single users, subsets of users or an entire customer base, even if there is a network outage.

The goal of this development is to build customer loyalty. As new broadband providers and technologies join the market, competition is going to increase. Price will be one determining factor when it comes to acquiring and retaining customers, but another will be whether users feels they are getting their money's worth.

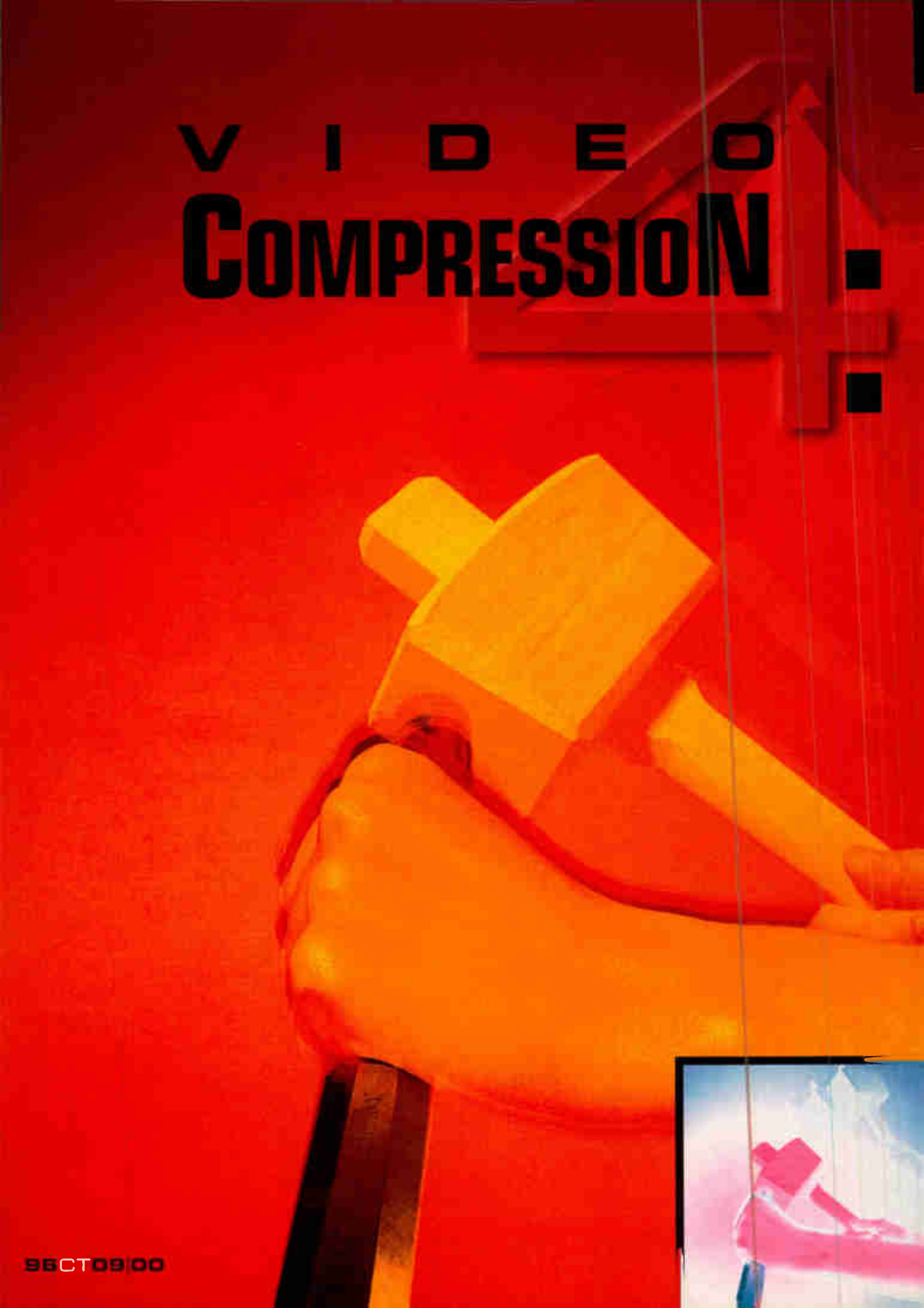
"We want to offer as many options as possible," Temlak says. "We want to differentiate ourselves so that when open access moves down the pike, we want customer care to be the key reason why users or affiliates will choose us." CT

> The Numbers

While broadband providers look for innovative features to make their services more attractive, at least they will not need to worry about demand. U.S. broadband subscribership will jump from 2.3 million in 1999 to 42 million in 2005, representing an annual growth rate of about 162 percent, according to a market forecast by Allied Business Intelligence of Oyster Bay, N.Y.

RoadRunner serves about 1 million subscribers in 22 states. It has a strong presence in all major U.S. cities and in many cases, RoadRunner service is interleaved with @Home, so the two do not compete directly to a great extent.

VIDEO COMPRESSION



SAVING DCT BITS

By Jim Farmer

In the June 2000 issue of *Communications Technology*, we described how to transform a block of picture information into the spatial frequency domain by using the discrete cosine transform (DCT). The DCT is analogous to the Fourier transform used to compute the frequency spectra of a continuous signal, expressing it in the frequency domain. In this issue, we will use a Fourier transform to illustrate some approximation techniques we can use with the DCT.

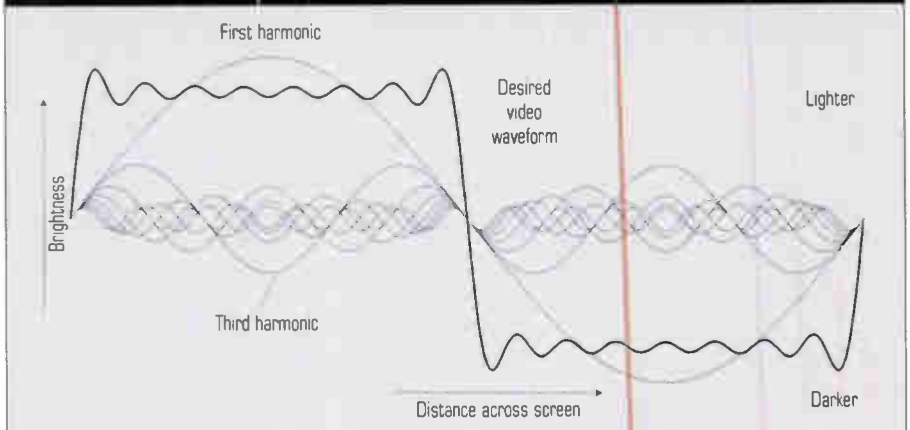
The DCT is a way of representing a block of picture information in the frequency domain. If we are lucky, the block does not contain all possible frequencies, so we don't have to transmit the amplitude of all harmonics. In general, though, we are not that lucky. Most real video will contain information at all possible frequencies, so we have to make intelligent choices in what we throw away. If we do that job right, we can get rid of information unseen by the eye, but keep information that is seen. If we do the job poorly, we will create visible errors in the picture. We call these errors "artifacts." Let's illustrate using a one-dimensional representation, which is easier to visualize.

Fourier transform: One-dimensional, infinite DCT

Let's return to the Fourier transform for an idea of what we can do with the discrete cosine transformed picture information. Pretend that we are displaying a picture of a white vertical line followed by a black vertical line. Not very interesting, granted, but it is easy to do the transform.

Figure 1 (above) illustrates the white-black waveform as a thick line. The video waveform for a pair of white and black lines would be one cycle of a square wave. You undoubtedly recognize this thick line as a poor approximation of a square wave. Those who have studied the Fourier transform know that a square wave is composed of an infinite series of sine waves at odd harmonics of the fundamental frequency, with each harmonic having an amplitude inversely proportional to the harmonic number. In this picture, we only used harmonics up through the 15th, not enough to accurately portray the square wave. For our present purposes, pretend that the waveform shown is the desired one—it keeps the illustration simpler.

FIGURE 1 WHITE-BLACK TRANSITION AND FOURIER TRANSFORM



distance	fund	3rd har	5th har	7th har	9th har	11th har	13th har	15th har	sum
0	0	0	0	0	0	0	0	0	0
0.05	0.0196337	0.0196236	0.0196034	0.0195732	0.0195329	0.0194827	0.0194224	0.0193523	0.1562242
0.1	0.0392598	0.0391791	0.0390181	0.0387772	0.0384575	0.03806	0.0375862	0.037038	0.3073759
0.15	0.0588708	0.0585988	0.0580569	0.0572498	0.0561842	0.0548687	0.0533144	0.051534	0.4486776

The bottom of Figure 1 shows the first four table entries for the waveform graph. This partial table tabulates the instantaneous magnitude of each harmonic at the first four positions across the screen. We have divided the waveform into 321 discrete "pixels." The fundamental sinusoid has a peak amplitude of one, with the other harmonics in their proper proportional amplitude. As we work through certain approximations, compare the tabulation at the bottom of this figure to the next two.

This graph illustrates several important observations. Electrical engineers are accustomed to thinking of graphing something against time, and to thinking of frequency as being temporal. That is, we think in terms of amplitude vs. time, and frequency as the number of cycles per second. However, it is not necessary to plot a waveform with a time axis. In thinking of digital video, the time axis tends not to be a consideration, and we think of amplitude vs. distance, either vertically or horizontally. We can plot a waveform against distance just as easily as we can plot it against time. The Fourier transform is just as valid if the horizontal axis is distance and not time.

Truncating the spectrum

In our last installment (June 2000, page 156), we pointed out that it is possible to convert a spatial-amplitude signal into a spatial-frequency signal

BOTTOM LINE

> **Refining The Picture**
>
> We can use the DCT to represent a block of a picture in the spatial frequency domain rather than in a spatial amplitude domain. But the goal is to reduce the amount of data transmitted, and to do this we must throw away some information. One method is to truncate the transmitted data simply by not transmitting those components with a small value. Another method is to round off, or quantize, the data so that we transmit a frequency, but we don't represent the amplitude of those components with as much resolution. Different encoding strategies work better or worse depending on the content of a particular block of a picture.


KODAK 5053 TMY
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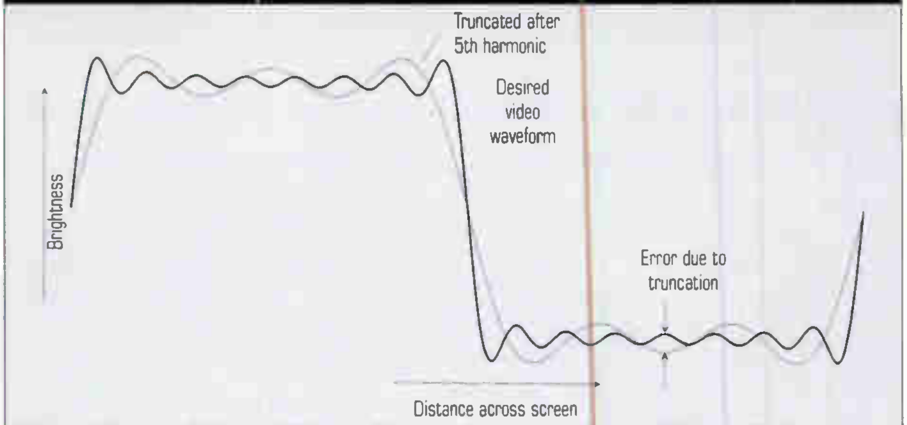
FIGURE 2 HARMONIC SERIES TRUNCATED AFTER THE 5TH HARMONIC



distance	fund.	3rd har	5th har	7th har	9th har	11th har	13th har	15th har	sum
0	0	0	0					0	
0 05	0 0196337	0 0196236	0 0196034						0 0588607
0 1	0 0392598	0 0391791	0 0390181						0 117457
0 15	0 0588708	0 0585988	0 0580569						0 1755265

using the DCT. The Fourier transform we are playing with now serves the same function as the DCT, but in a continuous sense. We now are using the Fourier transform to illustrate what happens when we try to compress a picture by eliminating information from it. Simply transforming the video using the DCT does not give us any compression (unless the picture contains large sections of the same luminance and chrominance value). We come out ahead when we use the transformed signal to intelligently eliminate unneeded information.

In Figure 2 (above), we show the same desired waveform as in Figure 1. The difference here is that we have truncated the harmonic series after the 5th harmonic, as shown in the table at the bottom of the figure. This means that we made a decision not to transmit amplitude data about any harmonics above the 5th.

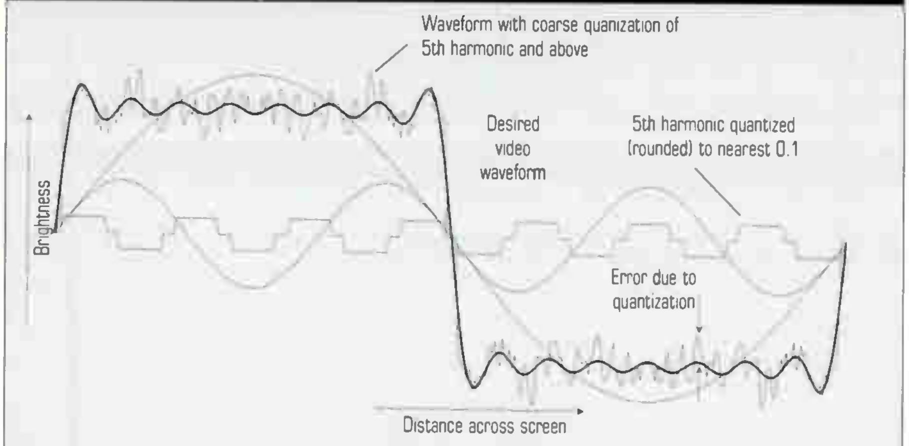
Compare the tabulation at the bottom of Figure 2 with that in Figure 1. There is much less data to be transmitted. For each video block we need only transmit amplitude data for three harmonics (the 1st or fundamental, 3rd and 5th) rather than for eight harmonics. The penalty we pay is that we transmit a distorted signal, where the distortion arises from the difference between the two waveforms shown. This distortion shows up as artifacts in the picture. However, if we are careful about what we transmit and do not transmit, we can throw away information that the eye doesn't notice, and we are none the worse off. On the other hand, if we don't do a good job of deciding what to throw away, we create visible artifacts.

Saving data through quantization

We have established that one way to save data is to truncate the spectrum by throwing away higher harmonics of the waveform if they don't make that much difference. Another method is to quantize the data. That is, we transmit all harmonics of the signal, but choose to transmit some with less resolution than others.

Figure 3 (on page 102) illustrates a situation in which we have transmitted all harmonics, but we have reduced the data transmitted by quantizing (rounding) the data to the closest 0.1. That is, we have rounded the value of the 5th harmonic and above to the nearest 0.1. We graphed the fundamental, 3rd and 5th harmonics, as well as the desired waveform (heavy line) and the resultant. We rounded the 5th and higher harmonics to the nearest 0.1. The table at the bottom shows what we transmit in this case. Note that when we come to a long series of zeros, we don't need to transmit anything. Where we have a value for harmonics 5 and up, we need only transmit one

FIGURE 3 HARMONICS ABOVE 3RD QUANTIZED TO 0.1



distance	fund	3rd har	5th har	7th har	9th har	11th har	13th har	15th har	sum
0	0	0	0	0	0	0	0	0	0
0.05	0.0196337	0.0196236	0	0	0	0	0	0	0.0392573
0.1	0.0392598	0.0391791	0	0	0	0	0	0	0.0784389
0.15	0.0588708	0.0585988	0.1	0.1	0.1	0.1	0.1	0.1	0.7174696

> The Gibbs Ringing Phenomenon

We can learn something about analog transmissions from Figures 1 (on page 98) and 2 (on page 100). Note in Figure 1 the 15 low amplitude cycles contained within the approximated square wave (it is easiest to count cycles at their positive-going center crossing). If you play with different numbers of harmonics, you will see that the number of cycles of ripple per cycle of the fundamental waveform is always equal to the highest frequency component used in building the waveform. This illustrates a phenomenon we see sometimes in analog video transmission and also in data transmission, called Gibbs ringing. Gibbs ringing occurs when a transmission channel is too narrow to accommodate all significant harmonics of a signal. The frequency of the Gibbs ringing is equal to the maximum bandwidth of the channel. This shows the effect of the highest frequency transmitted, which cannot possibly fill in the waveform with any data at a higher frequency than itself. Note that the truncated waveform in Figure 2 has five cycles per cycle of the fundamental, rather than the 15 cycles of the nontruncated signal. Also note that the amplitude of the ripples is larger than that of the nontruncated waveform, because each harmonic is of lower amplitude than the next lower harmonic.

digit rather than maybe 7 as we have done for the other values.

This may be a more satisfactory strategy for encoding this piece of picture than the strategy shown in Figure 2. Note that the artifact would be higher in spatial frequency in Figure 3, and thus could be less visible to the eye. If, however, the scene were of a flat surface so that over the distance we were considering, the scene were all of the same luminance (or chrominance when we are encoding chrominance) value, then the strategy of Figure 2 might yield less visible artifacts.

Encoding strategy

There can be a number of strategies for encoding a picture, and one must make decisions on a scene-by-scene basis. It is possible to have an encoder work in real-time and make the best decisions it can when encoding each scene. However, you get better quality and lower data rates by manually going through a program and directing the encoder to use different encoding strategies on each scene, or even on each part of a picture.

This illustrates one of the ingenious properties of moving picture experts group (MPEG) compression—the decoder must be able to support multiple decoding strategies (for example, truncation or quantization), but encoders may be built with differing levels of capability. Any MPEG decoder will work like any other MPEG decoder, but not all encoders work with each other. It is possible for the encoder manufacturers to differentiate their products by encoding strategy, quality and bit rate trade-off of the encoded picture.

On the other hand, encoding requires a lot more computing power than does decoding. To properly apportion the tasks in a broadcast situation, put the computing power at the transmission end where you only have to do it once. You can control costs by keeping the decoding as simple as possible.

More data-reduction strategies

DCT is only one of the data-reduction strategies used in MPEG. We will move on to some others in our next installment. CT

Jim Farmer is chief technical officer of ANTEC, Inc. He can be reached at jofarmer@mindspring.com.

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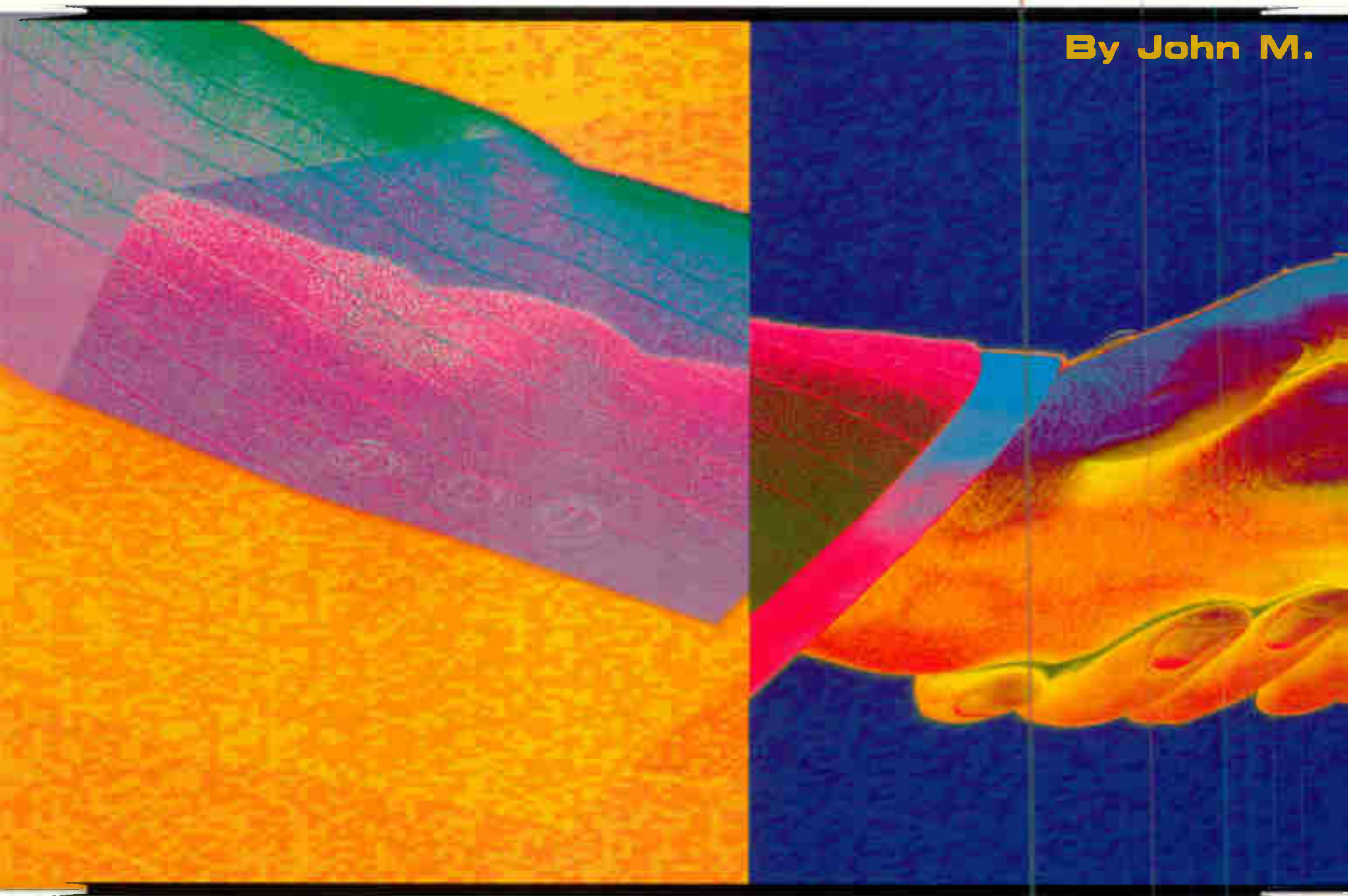
Improving Contra

New Challenges, > > > >



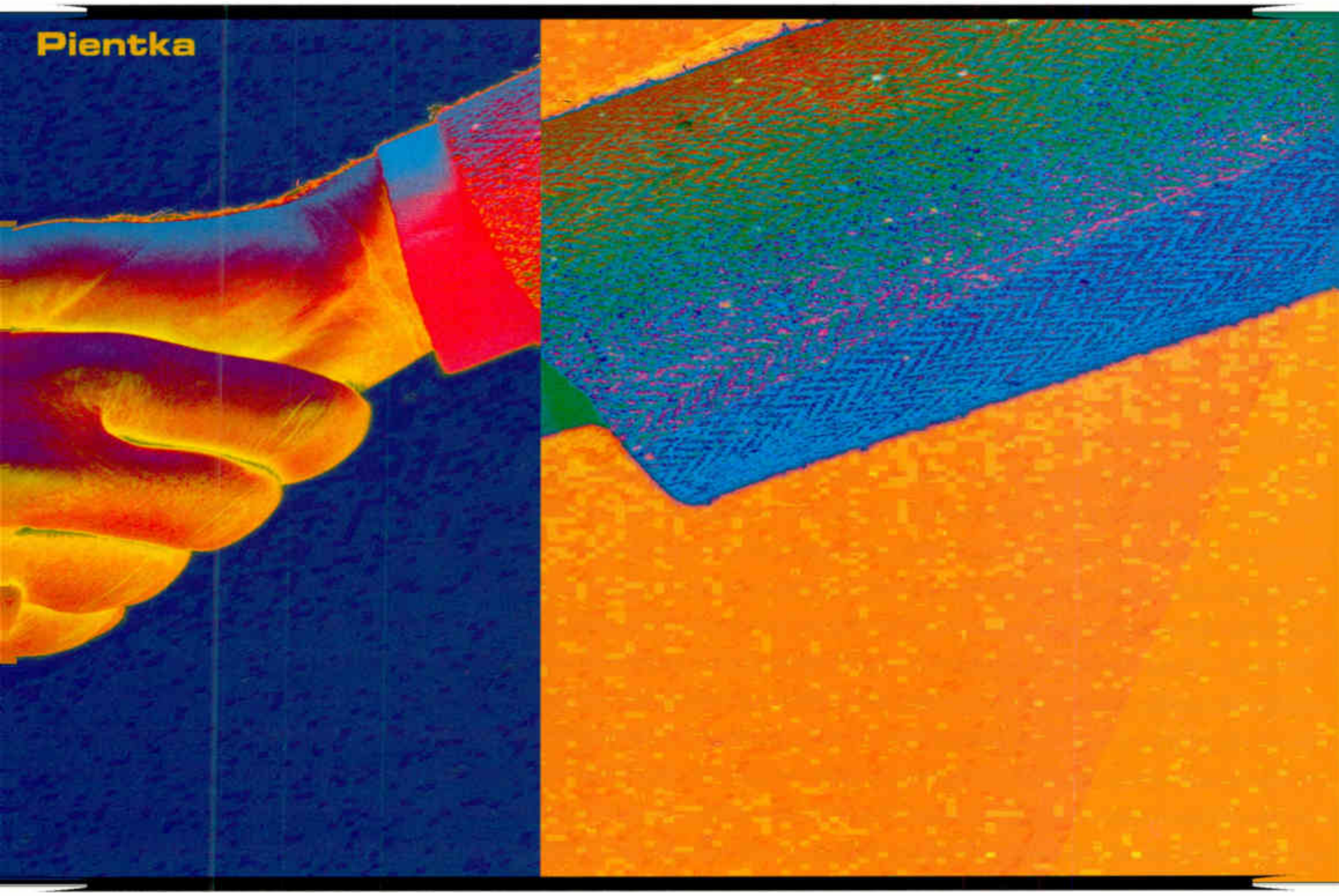
By John M.

Cable operators and other broadband providers increasingly face the challenge of providing more customers with high-quality advanced services. Can outsourcing help ease the load?

Not so long ago, both cable and telephony were monopolistic, satellite and wireless were either non-existent or in the early stages of development, and the premise-network environment couldn't keep pace with new technologies. Today, cable companies have consolidated and merged, telephony carriers are deregulated, satellite providers have led the charge towards local access,

ctor Relations

> > > > > New Solutions



and premise networking has migrated from a purely business environment to now include fully connected home local access networks.

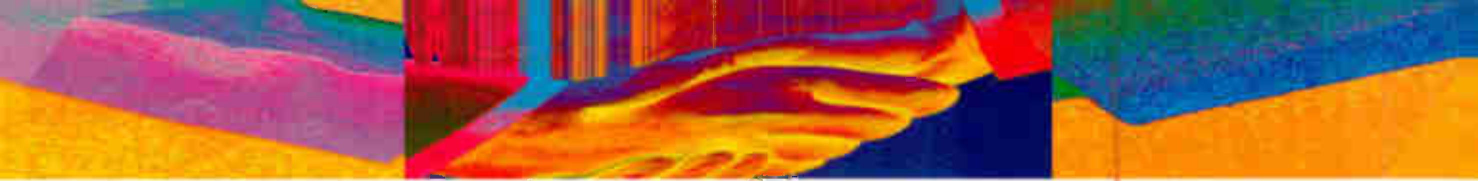
With these changes has come the necessity for the outsourcer to evolve from the "guy in the beat-up pick-up truck" to today's model of professionalism and quality assurance. Now that the need has been acknowledged, fulfillment providers, once considered a marginal if not unprofessional business, have been called upon to step up to the plate and become an important player in today's broadband world.

The need

As technology advances, consumers have more choices, and the deliverers of broadband services have more challenges.

The new demand requires companies to provide customers with new products on a timely basis, often while they are handicapped by issues such as modem and digital-box shortages. Companies also find it difficult and costly to develop and maintain branded fleets and a well-trained work force with the volume fluctuation associated with rapid product deployment.

Churn is also a big factor in determining work volume. In the high-stakes race to bring new services to customers, broadband providers are finding a core of new customers creating stepped-up demands, while other customers are switching products. It is estimated that the cable industry alone churns at approximately 35 per-

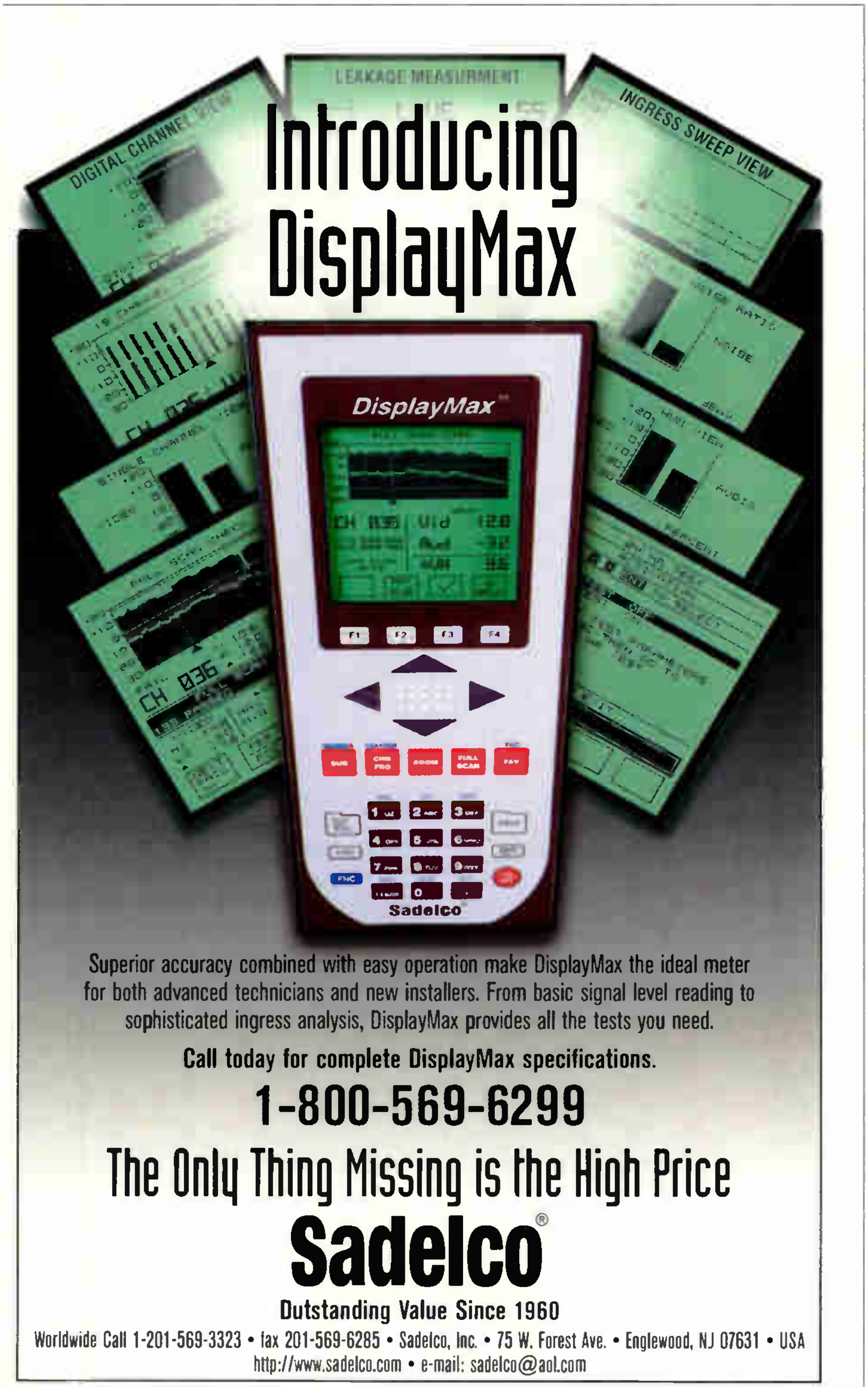


cent per year, and the satellite industry at half that. Besides new adds, upgrades, service calls and long-term warranty work, churn alone presents a tremendous volume of work.

Even as the customer base increases, numbers are offset by the ebb and flow of customer demands, which in turn affects fulfillment. Customer loyalty will vacillate, as they tend to migrate to whatever provider offers them the best product, deployed quickly and professionally, and at a competitive price.

The total estimated market for telecommunications outsourcing services, excluding construction, in the United States is $110.7 billion. Total U.S. TV households are projected to be 107,733 million by 2009. Digital cable service is expected to reach 33.6 million by 2004, representing penetration of 47.3 percent basic subscribers. Cable telephony consumers are expected to reach 23.9 million homes by 2008, representing penetration of 36 percent. DBS subscribers are expected to grow to 21.1 million by 2003.

And with the explosive growth of telecommunications and networking technologies—telephony, video conferencing and advanced home-wiring



BOTTOMLINE

> The Outsourcing Option

The new landscape in the world of broadband delivery results from the speed in which the marketplace is evolving—and growing. In the new world order, providers must look for outsourcers who can quickly and professionally provide scalable, quality solutions that don't compromise their standards. In addition to addressing issues such as professionally trained workforces in branded fleets, outsourcers should also provide a high level of quality assurance that includes meeting federal employee guidelines and safety performance standards. Training has taken on a more critical role. Companies need to creatively seek out potential trainees from a variety of sources, offer product diversity and build the company around a solid constituent base serving three major groups—the provider, the end-user and their own employees.

systems—there is a growing demand for independent providers of premise networking services.

"Partnering with a national outsourcing company affords us the luxury of knowing we have a national base of skilled technicians certified in the installation and maintenance of our product," Gary Brand, vice president of Sales/Channel Development, says. "One-source shopping ensures we deliver the same uncompromising, consistent product nationally."

Employee training

At no time in the history of telecommunications has there been so much excitement and so many opportunities. A fulfillment provider must be focused and must invest heavily in employee training, emphasizing career paths that offer both cutting-edge technical and management opportunities. Employees are representatives wherever they go, and they are the messengers of the mission. A well-trained work force reflects the company's goals and provides quality assurance for end-users

> **"Enablers of broadband services need to consider the entire customer experience."**
> **—John Pascarelli, Mediacom Comm.**

as well as clients. And a well-trained work force projects an air of confidence and professionalism that is key to successfully continuing relationships with clients.

A company's ability to attract a competent workforce is always a challenge. Companies need to creatively seek out potential trainees from a variety of sources—technical schools, the military, high school graduates and building trades—as well as from other telecommunications disciplines. The company that offers all levels of technical training, from entry-level to advanced services, becomes an important resource for clients.

On-the-job training and experiential learning are two common approaches used to train new employees. The two together ensure employee and company success.

A series of controlled-environment training labs that simulate actual work places help trainees learn firsthand not only all of the technical aspects of the job, but also how to interact with clients and home customers in real situations. Then can-

Viasource trainees learn (at left) how to install Digital Service Line modems in computers during an advanced services experiential learning class, and (below) how to splice wire using correct safety uniforms and procedures.

didates armed with real knowledge are ready to go into the field, but even then should remain under the watchful eye of the field trainer. This emphasis provides clients with the quality assurance guaranteed by a professionally trained workforce.

Viasource's own installer program "is 15 percent lecture by the trainer, 15 percent demonstration by the trainer, and 70 percent practical performance by the trainee," Tan Paolino, a Viasource senior regional trainer, says. "Safety, quality, production and customer service are concepts presented as equally important, and are presented in an enjoyable and interactive environment in which the trainee is encouraged to attain his or her potential quickly."

During the training period, a trainer should take on an almost paternal role in guiding trainees through their exercises, which provides the opportunity to observe the potential exhibited by candidates on various levels of competency. Each trainee should be thoroughly versed in basic wiring before moving on to the more advanced technologies.

Building relationships

Forging client relationships that are strategic and long-term, creating a national footprint, product diversity and an understanding of their core area of expertise and opportunity are key elements to building a successful company. In addition to product diversity, the outsourcer needs to build the company around a solid constituent base that serves three major groups—the provider, the end-user and their own employees. The interaction among these three groups is paramount to the creation of a successful outsourcing company.

"Enablers of broadband services need to consider the entire customer experience," John Pascarelli, Mediacom Communications Corp.'s senior vice president, marketing and consumer services, says. "Those compa-

nies that have the scalable resources, provide a well-managed workforce, and can combine technical expertise with customer service, will help operators in building long-term relationships with their customers."

Traditional provider companies that have attempted to provide all facets of service in their industry have given birth to the outsourcing industry. These companies need to be able to provide services faster, better and less costly than they can do themselves. Addressing the providers' needs effectively allows providers to devote their efforts to other phases of their business. This represents a major step in the provider/fulfillment solution.

The end-user has historically been the least represented audience in the mix, but this group provides the real financial return to the provider. End-users expect an exceptional fulfillment experience, completed on time with quality personnel. As technical complexities and greater dependence upon interactive media escalates, it's crucial for the outsourcing company to help create long-term customers with its role in the customer experience. Quality national branding creates an environment of recognition, confidence and a comfort level among end-users, similar to the FedEx or UPS delivery experience.

The third key group completing the critical triangle is employees who should be considered the revenue-generating soul of the company. In addition to plant deployment, content delivery and customer acquisition, employees are finally being recognized the prominent component linking the successful relationship between provider and end-user. CT

John M. Pientka is chief operating officer of Viasource Communications, Inc. He can be reached via e-mail at jpientka@viasource.net.

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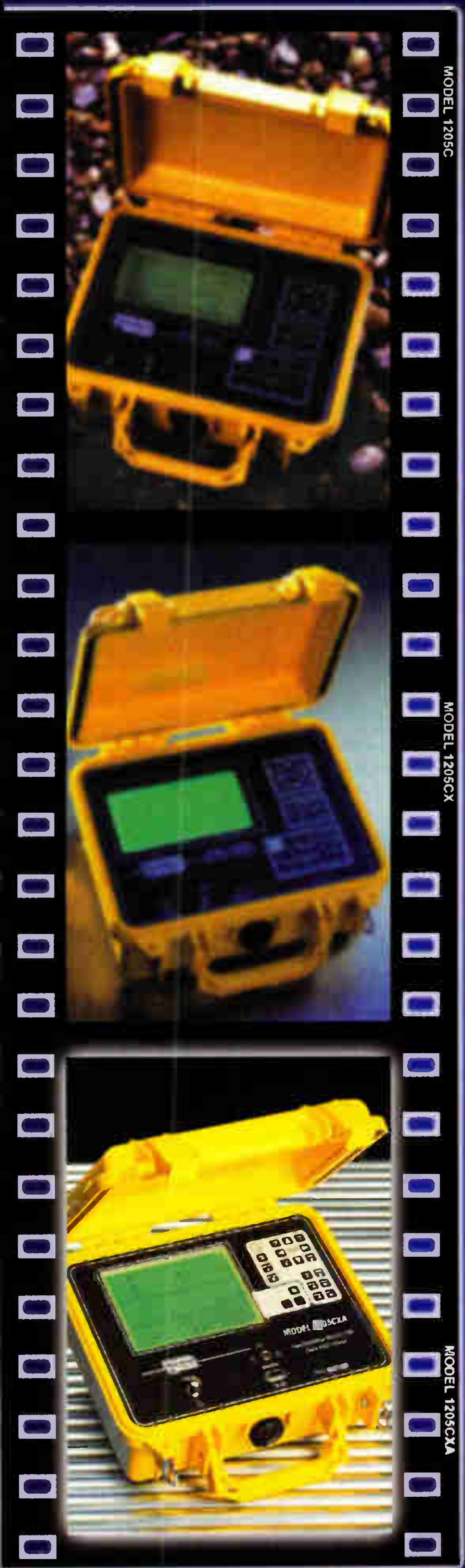

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Watts Up Doc?

BY RON HRANAC AND MARK MILLET

RE

S:

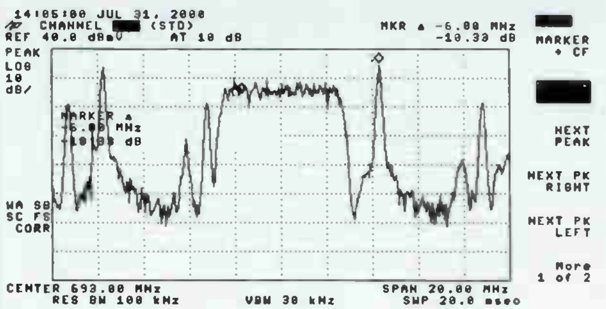
Accurately measuring 64-QAM (quadrature amplitude modulation) and 256-QAM digitally modulated carriers can be a bit tricky, but here's how you do it right.

Proper operation of cable modems and even digital video set-tops require, among other things, that downstream RF operating levels be set correctly. Most of us are intimately familiar with measuring and adjusting analog TV channels. Spectrum analyzers and signal level meters (SLMs) make this an easy task. But accurate measurement of 64-QAM and 256-QAM digitally modulated carriers can be a bit tricky.

First, the amplitude of these types of carriers is characterized in terms of total average power of the entire 6 MHz-wide signal. Second, digitally modulated carriers resemble noise across the channel bandwidth. These two factors complicate the measurement process. When it's all said and done, amplitude measurements of digitally modulated carriers should closely correlate with what a thermocouple power would indicate.

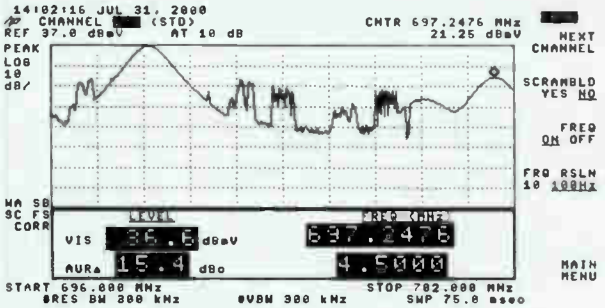
Contrast this with amplitude measurement of old-fashioned analog TV channels. With modulated TV channels, we're interested in the root-mean-square (RMS) amplitude of the visual carriers' instantaneous sync peaks. That's why signal level me-

FIGURE 1



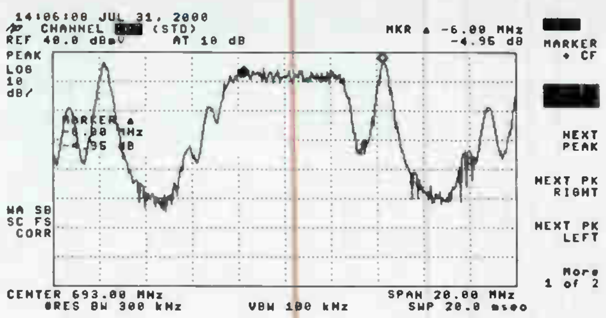
At the spectrum analyzer settings shown, the digitally modulated carrier appears to be +25 dBmV or so, which is 10 dB below the adjacent visual carrier levels.

FIGURE 2



This measurement confirms that adjacent visual carrier levels are actually about +36 dBmV.

FIGURE 3



When the spectrum analyzer resolution bandwidth is changed from 100 kHz to 300 kHz the apparent amplitude of the digitally modulated carrier increased to +32 dBmV.

ters have peak detector circuits—so the meter can determine the instantaneous sync peak and display the carrier's RMS amplitude. SLM peak detector circuits are optimized for video, not noise or noise-like signals.

So when you attempt to measure noise with a conventional SLM, you must apply detector correction factors to the measurement. As well, SLMs perform measurements over a relatively narrow bandwidth, something else that's optimized for TV channel visual carriers. A 6 MHz-wide digitally modulated carrier measurement must take into account the average power in the entire channel bandwidth, which is significantly greater than the SLM's measurement bandwidth.

Fortunately, the manufacturers of SLMs and spectrum analyzers have in recent years added digital carrier average power measurement functionality to many of the products available today. You should use this option if it's available. If it's not, contact the test equipment manufacturer and see if there is a software or firmware upgrade that will enable this feature.

Spectrum analyzers provide a convenient way to measure the amplitude of digitally modulated carriers, but if you're not careful about what you're doing, it's very easy to make mistakes.

Figure 1 is a spectrum analyzer plot of a typical headend output, and shows a digitally modulated carrier in addition to adjacent analog TV channels. The TV channel visual carriers appear to be about +34 dBmV to +35 dBmV (their actual amplitude is a bit more than +36 dBmV as shown in **Figure 2**). The digitally modulated carrier is 10 dB below the visual carrier levels, a level difference that is fairly typical. But is it really 10 dB below visual carrier levels?

Let's switch the analyzer's resolution bandwidth (RBW) from 100 kHz to 300 kHz. The video bandwidth (VBW) is in autocouple, so it changes from 30 kHz to 100 kHz when the RBW is changed from 100 kHz to 300 kHz. Look at **Figure 3**. The visual carriers are much closer to an indicated +36 dBmV (they changed only a dB or so), but look what happened to the digitally modulated carrier's amplitude. It's now only 5 dB below the visual carriers. So, which is right? Figure 1 or Figure 3?

The easiest way to answer this question is to use the spectrum analyzer's built-in digital channel power measurement function. **Figure 4** (on page 118) shows the measurement result. The carrier's total power actually is +40.2 dBmV, nearly 4 dB higher than the visual carriers, and 14 dB higher than the desired level!

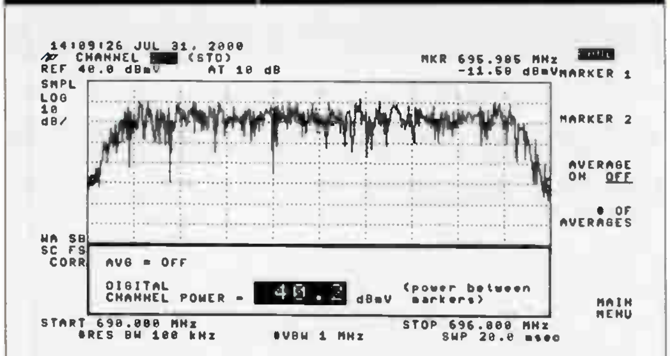
We need to attenuate the cable modem termination system (CMTS) upconverter output to achieve the proper

BOTTOMLINE

> **Power Measuring Simplified**

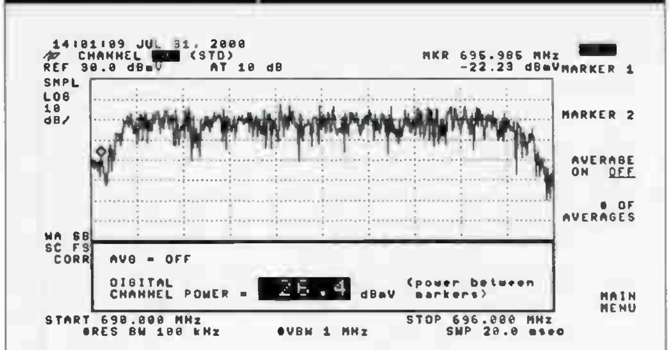
Proper operation of cable modems and even digital video set-tops require, among other things, that downstream RF operating levels be set correctly. But accurate measurement of 64-QAM (quadrature amplitude modulation) and 256-QAM digitally modulated carriers can be tricky. Fortunately, the manufacturers of signal level meters and spectrum analyzers have in recent years added digital carrier average power measurement functionality to many of the products available today. You should use this feature, or consider obtaining test equipment that includes it. This is especially important because manual measurements of digitally modulated carriers, if not done correctly, can easily result in performance-degrading errors.

FIGURE 4



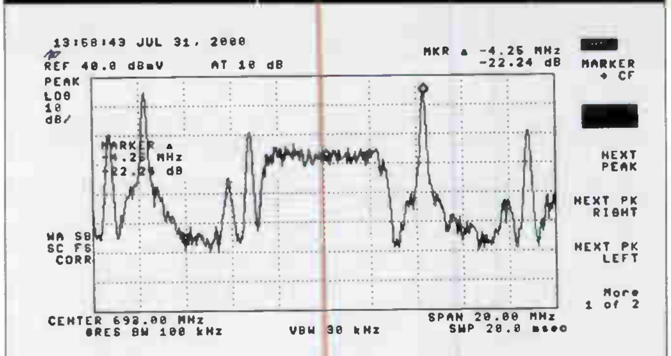
A digital channel power measurement indicates the actual amplitude of the digitally modulated carrier is +40.2 dBmV.

FIGURE 5



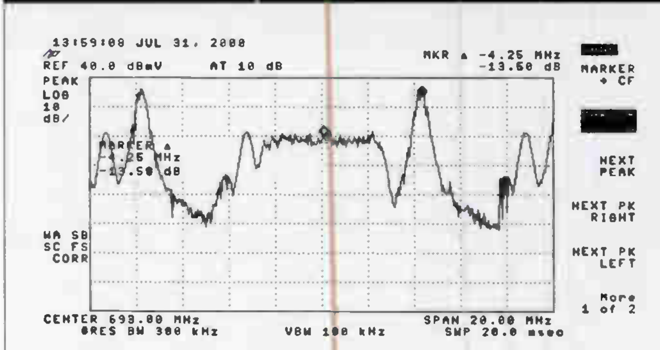
The digitally modulated carrier amplitude has been set to the correct level (+26 dBmV total power), which is 10 dB below the adjacent channel visual carrier levels.

FIGURE 6



Going back to the original instrument settings used in Figure 1, the apparent amplitude of the digitally modulated carrier is now about +12 dBmV. The total power is correct, but the displayed amplitude does not seem to be.

FIGURE 7



Changing the analyzer resolution bandwidth setting to 300 kHz once again shows a higher apparent amplitude for the digitally modulated carrier.

level. (A quick side note: It's better to operate the CMTS and upconverter at their optimum output levels, and if necessary, add external attenuation to the upconverter output to reduce the digitally modulated carrier to the desired level.) In order for the digitally modulated carrier's total power to be 10 dB below the visual carrier levels, about 14 dB of attenuation should do the trick. Start with a 10 dB and a 3 dB attenuator coupled together; the additional 1 dB can be obtained by a slight upconverter output level adjustment.

Figure 5 is the digital channel power measurement result after installing the required amount of attenuation. Here you can see the digitally modulated carrier's total average power is now +26.4 dBmV, which is just about perfect relative to the +36.6 dBmV visual carrier levels.

Reset the spectrum analyzer controls to duplicate the measurement performed in Figure 1. This will give you a display similar to **Figure 6**. The indicated amplitude of the digitally modulated carrier appears to be more than 22 dB below the visual carrier levels. If you switch the analyzer's RBW to 300 kHz (as mentioned previously, the VBW changes too, when auto-coupled to RBW), the digitally modulated carrier's indicated amplitude increases and appears to be 13.5 db below the visual carrier levels.

Which is right? Figure 6 or **Figure 7**? Technically both of them are, but if you didn't know that the carrier's total power was already correctly set, you might be tempted to get out the ol' tweaker and turn the digitally modulated carrier's level up several dB. That would clearly be the wrong thing to do. Furthermore, don't try to duplicate the particular analyzer set-up used to produce the plots for this article, because your own analyzer's RBW and VBW filters may be different from the analyzer we used and could produce a different amplitude reading. Don't use video averaging; it will affect the accuracy of your measurement.

A far better and more consistent approach is to set your analog TV channels as you always have, but use your test equipment's digital channel power measurement function for measuring and setting digitally modulated carrier levels. CT

Ron Hranac is a consulting systems engineer for Cisco Systems, and senior technical editor for Communications Technology. You can reach him at rhranac@aol.com. Mark Millet is a consulting systems engineer for Cisco Systems, and is SCTE's Member of the Year. You can reach him at mmillet@cisco.com.

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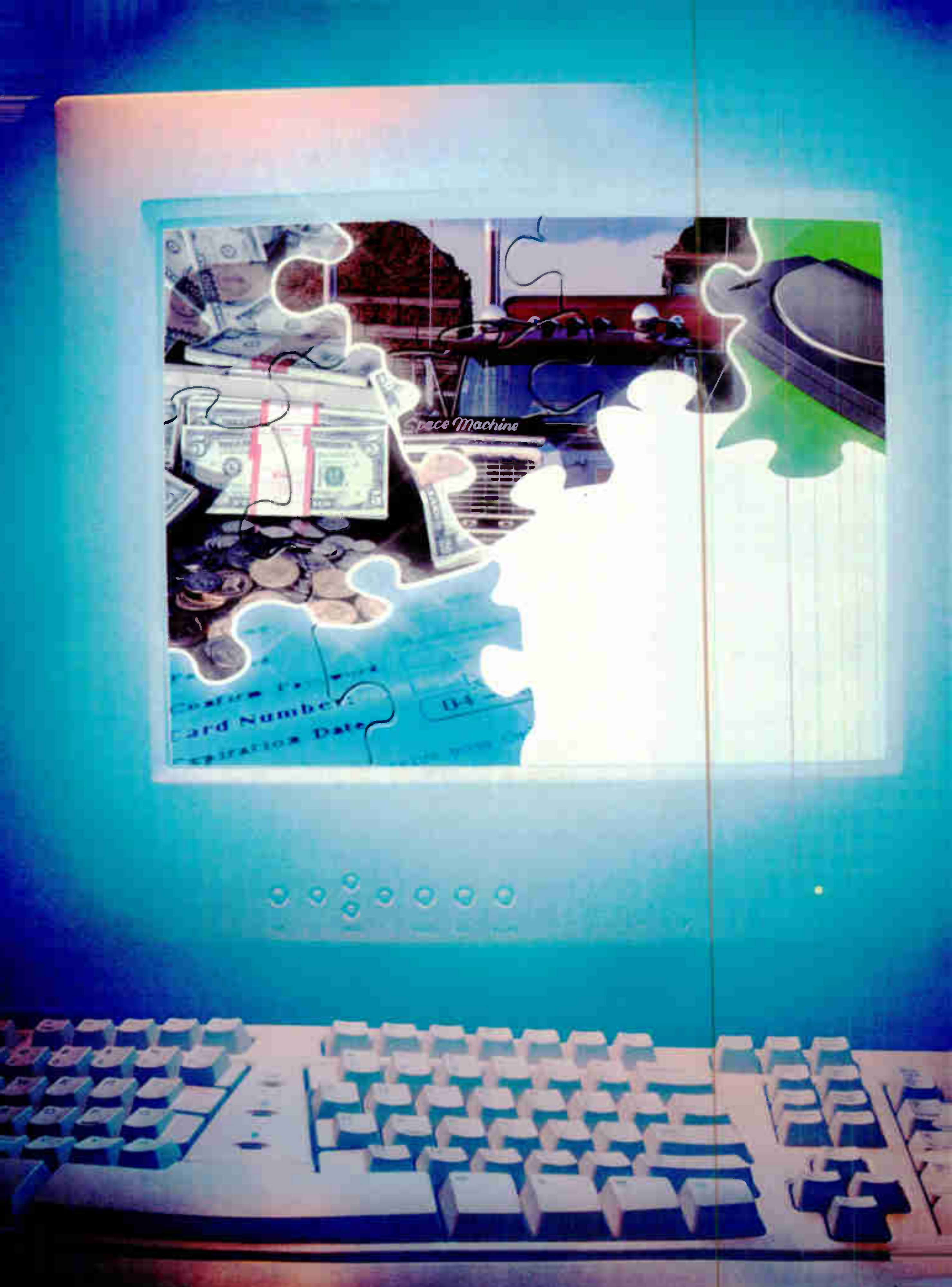


CT

Streamlining Transactions:

Can Systems Integration Software Help?

By Bruce Bahlmann

Cable-modem installers are working late hours, upgrades cost a fortune, and billing is getting out of hand. Some vendors are creating software to ease these headaches and make systems integration a breeze. Are they worth your investment?

It's a challenge multiple system operators (MSOs) face with nearly every product and service they offer: the need to integrate various billing and provisioning systems, while ensuring these divergent systems can communicate with one another. And systems integrators have to be mindful of existing applications.

Products that serve the purpose of systems integration fall into a category known as operational support systems (OSS). They are the glue that binds a mixture of vendor products to form a working system.

The OSS product area is riddled with acronyms such as application programming interfaces (API), remote procedure calls (RPC) and strange terms such as hooks, triggers, script layers and scripting points.

These acronyms and terms represent traditional OSS practices that have become commonplace through rigorous commercial and industrial use. Although these traditional OSS products are still in use by many MSOs, new OSS products are challenging their foothold. With features such as the ability to re-try, or repeat a transaction until it succeeds, new OSS products are trying to address key MSO selling points, such as not impacting operations during temporary outages. However, a lesser-known fact is that these features only apply to a minority of the overall types of transactions. The new products cannot address all types of transactions, though.

Cable-modem transactions

Look at the transactions associated with a cable modem (see Table 1, page 122). Each transaction can be associated with a priority along with a possible means of communication (see Table 2, page 124). Here the priority identifies the importance of each transaction. Those with a 'HIGH' priority typically require immediate execution while transactions with a 'LOW' priority can be executed at the next available opportunity. The last two columns in Table 2 represent communications that can be associated with each type of transaction.

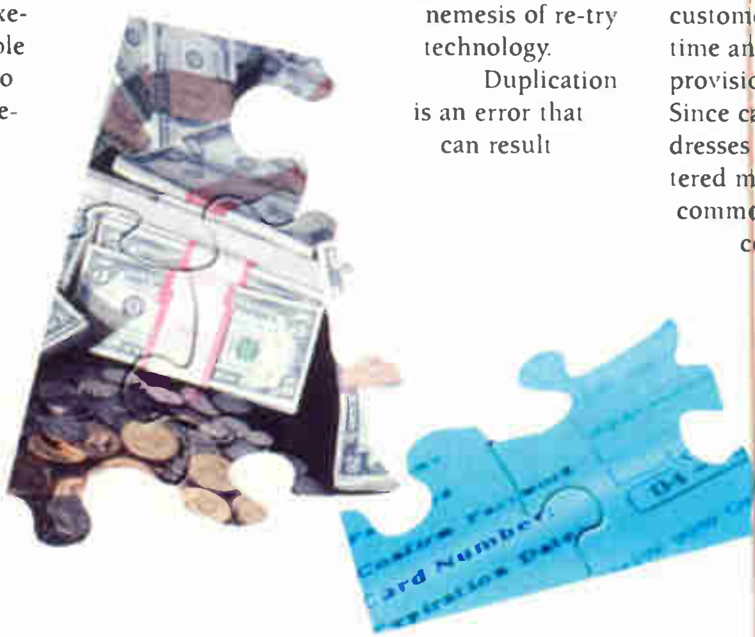
Ideally, one would like all transactions executed immediately, because they provide instant gratification to installers and customer service representatives, eliminating confusion (either it works or it doesn't). As well, customers enjoy instant changes to their account. Indeed, traditional OSS products are designed only for immediate execution. If something prevents immediate execution, such as a server or network problem, an error condition prevents the completion of the transaction. In these cases, all service modifications are down until the problem is corrected.

New OSS products provide the capability to re-try, which may benefit some transactions when problems prevent immediate execution. These products boast the ability to queue service requests during outages and then execute them at the next available opportunity once the problem is resolved. However, the nature of many high priority transactions prevents most, if not all, from being properly executed at the next available opportunity.

The nemesis of re-try technology

The single largest factor preventing most transactions from being carried out at the next available opportunity is duplication—the nemesis of re-try technology.

Duplication is an error that can result



when a transaction must create or modify a field that is supposed to be unique. Unique fields include such information as customer identifications, cable-modem Ethernet addresses and customer telephone numbers. Adding or modifying these fields requires previous checks to ensure the changes to be made are valid. The checks must also be passed for uniqueness. Any error condition preventing uniqueness checks prior to execution will prevent unique transactions from being executed at the next available opportunity.

In the cable-modem case (see Table 1, below) only 25 percent of the transactions may be successfully handled using the next available opportunity method of execution.

Re-try technology faces other challenges as well.

Race conditions, where two transactions are trying to add or modify the same record, is one such challenge. For example, one person attempts to provision a new customer's cable modem at the same time another person is incorrectly provisioning another cable modem. Since cable-modem Ethernet addresses are long and typically entered manually, it is extremely common that they are entered incorrectly. This creates problems for re-try technology. Even if the system were able to somehow ensure a transaction was unique, it is unlikely to accommodate a race such as two "unique" Ethernet addresses being provisioned at the same time. As a result, both transactions would confirm being accepted and processed.

However, a scary result occurs when one transaction fails. In this case, the re-try technology must go

TABLE 1 — CABLE-MODEM TRANSACTIONS

Transaction Type	Description
Register cable modem	Registers the cable modem with the provisioning server permitting it to activate
Unregister cable modem	Unregisters the cable modem with the provisioning server whereby disabling the service
Change level of service	Modifies the level of service maintained by the cable modem
Swap cable modem	Unregister existing cable modem and register new cable modem

BOTTOMLINE

> **Improving Your Transactions**

Operational support systems (OSS) are the glue holding system components together. But if your system components are fragile, no glue will be strong enough to overcome the shortcomings of faulty components. New OSS vendors are trying to solve problems in information technology (IT) infrastructure with software and hardware reliant on an already shaky framework. Improving the reliability of transactions begins with revisiting the health and resilience of an IT foundation rather than buying software that only places a bandage on the real problem.

TABLE 2	TRANSACTION BREAKDOWN		
Transaction Type	**Priority**	**Immediate Execution**	**Next Available Opportunity**
Register cable modem	HIGH	YES	NO
Unregister cable modem	HIGH	YES	NO
Change level of service	LOW	YES	YES
Swap cable modem	HIGH	YES	NO

back and change the state of one of the accounts to un-registered as the transaction that was previously indicated as successful has now failed. If this happens to be the account with the correctly entered Ethernet address, confusion arises as to why or how this could happen. It also could mean that the cable modem you thought was registered has not been registered after all. Correcting a race may mean a re-write of the OSS software or worse, setting different transactions in immediate execution mode.

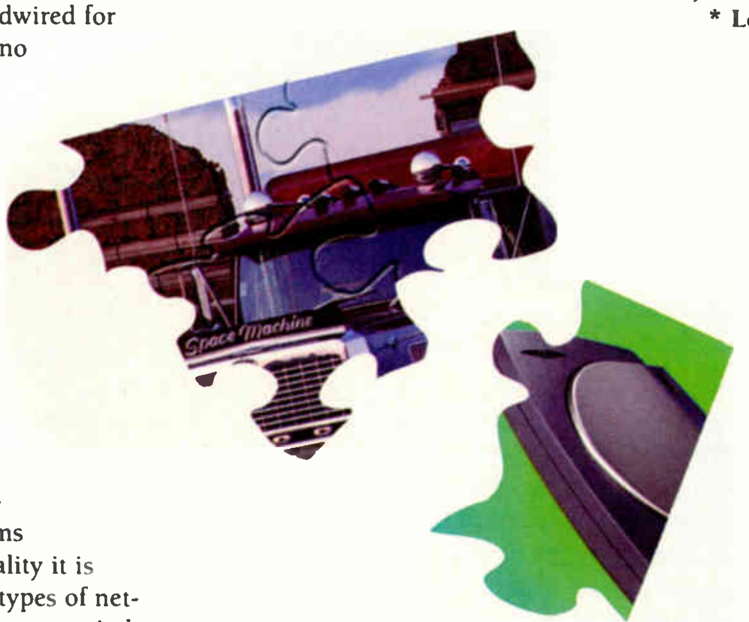
Re-try technology hardwired for immediate execution is no better than traditional OSS technology due to the added complexity it brings to the overall system as well as additional requirements it places on other necessary components of the system.

Traditional OSS merely requires connectivity from the host application to the provisioning server. This seems easy in theory, but in reality it is not, as several different types of networking gear—hubs, routers, switches, and/or firewalls, for example—may exist between the two. Each of these components must operate correctly in order for the system, and the OSS, to work properly.

New OSS products often require other components, such as clients, server applications and additional hardware, to the mix. The more components added to the system, the more complex the overall system becomes. Once more, any new additional hardware becomes even more dependent on the network to operate correctly. If this was a source of problems for the previous OSS, it will certainly present a problem for the new OSS.

Consolidation concerns

As new OSS products claim to support interfaces to multiple provisioning services such as e-mail, dynamic host configuration protocol (DHCP), telephony and digital video, we should think about problems that can arise from such consolidation. From an integration standpoint, one-stop shopping for a complete OSS solution looks attractive on the outside. However, consolidation is not always a good thing as a single OSS solution can be costly in other ways.



Consider the following when selecting a new OSS vendor:

* **Single point of failure**—Having a consolidated OSS means placing all your service interfaces under one roof. If that roof caves in, all your services are hurt. Exposure in this case could be costly—especially should the cave-in require code fixes or worse, if it requires the failure condition to be repeated so the error condition can be understood. Traditional OSS products are typically not consolidated and so are not interdependent, allowing new services to be developed in parallel without any service interruption.
* **Unproven**—Many new OSS vendors lack the track record of vendors of traditional OSS products. Newcomers breaking into the market sometimes use products developed in a lab that may not perform well in production. The journey of going from a concept to proven product can be very difficult and riddled with road kill. Being one of the first customers could place your business at unknown risks.
* **Longevity**—Many new OSS vendors have been around only a few years. Consider how long your existing vendors have been around. Also, consider where you want to go with your business, where the technology is going, as well as the problems you face with your existing OSS.

If the services you are considering for a new OSS are in their infancy, think about the maintenance costs you could incur.

Somewhere among these thoughts lies an OSS comfort level—or threshold of pain—in which your business can thrive in concert with your ability to add new technology to your system. CT

Bruce Bahlmann is senior systems engineer for MediaOne's Internet Services Group. He can be reached via e-mail at bahlmann@bigfoot.com.

Do you agree with the author? Let us know your thoughts. Send an e-mail to snayalkar@phillips.com.

Installing Cable Modems, Part 1

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.

Installing and setting up a cable modem requires a knowledge base broader than that required for cable drop installation and troubleshooting. Installing cable modems requires a working knowledge of and an ability to install, modify and troubleshoot the cable modem, the network system, the personal computer operating system, all computer components and the associated software for cable Internet access and service, in addition to the cable drop system.

The previous four installments provide an introduction to cable modems, covering equipment locations, drop system reliability and cabling configurations. This portion of the series begins installing hardware in the customer's computer.

Installing hardware in customer's computer

Sometimes a computer requires items installed internally to permit a network connection. To add these items you need to know how to prepare the computer, locate an available expansion slot, and install the network interface card (NIC) and/or the Personal Computer Memory Card International Association (PCMCIA) card.

For all full-size computers, use the same card installation method whether for a sound, small computer system interface (SCSI), or NIC-type. Many new top-end Windows PC computers and all new Macintosh G3, G4, and iMac computers have an internal NIC with RJ-45 connectors. Other Windows PC computers have integrated universal serial bus (USB) interface cards and ports.

Preparing the computer

After confirming the computer operates correctly (remember, always have the customer turn it on), shut it down properly. Then, unplug and disconnect all cables necessary to move the computer to an adequate working space for installing a network interface card. This installation will require removal of the computer case cover.

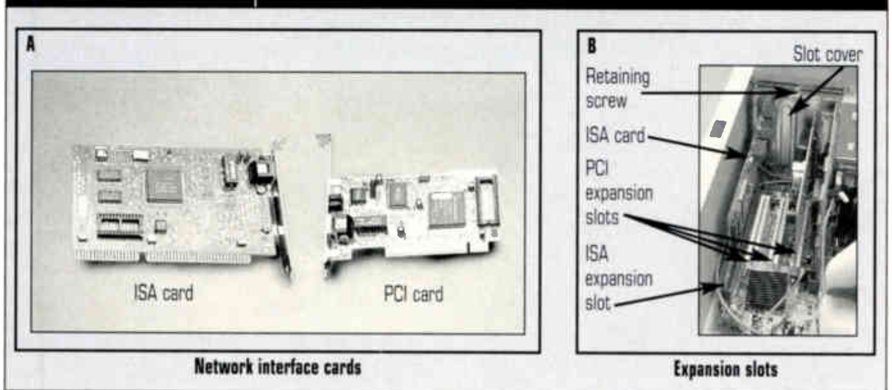
Unlimited design combinations and methods exist for opening computer cases. Typically, you need to remove a few screws on the back of the case along the top edge. The cover should slide back, then up and off. If you find an unusual cover attachment scheme, do not hesitate to ask if the customer is familiar with its removal or ask for the owner's manual detailing the removal process.

"An expansion slot is the designated plug-in location electrically connecting the selected NIC to the computer circuitry."

Locating available expansion slot

After you remove the cover, you must find the appropriate expansion slot for the NIC. An expansion slot is the designated plug-in location that electrically connects the selected interface card to the computer circuitry. The primary NIC is the industry standard architecture (ISA) NIC, because it costs less with negligible functional difference than the peripheral component interface (PCI) NIC (Figure 1A). However, available expansion slots (ISA or PCI) often dictate the card selection. After locating the desired expansion slot, remove the slot cover at the back of the case by removing its retaining screw and lifting the slot cover out of the computer (Figure 1B). CT

FIGURE 1 LOCATING AVAILABLE EXPANSION SLOT TO INSTALL NIC



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CALENDAR

September

7: SCTE Board of Directors Meeting, Orlando, Fla. Contact SCTE headquarters, (610) 363-6888.

7: Rocky Mountain Chapter Technical Seminar, Data Over Cable, NCTI, Littleton Colo. Contact Dave Robinson, (303) 722-8920.

13: Bluegrass Chapter Technical Seminar, Powering and Telephony, Frankfort, Ky. Contact Max Henry, (270) 435-4433.

12-14: East Coast Cable 2000, Baltimore, Md Convention Center. Contact Dobson & Assoc., (202) 460-7905.

15: Hill Country Chapter Vendor Show, Live Oak, Texas. Contact Sherry Hefner, (210) 352-4211.

19-21: SCTE Seminar, Broadband Technology for Technicians, Adam's Mark, Kansas City, Mo. Contact Jessica Dattis, (610) 363-6888.

20: Piedmont Chapter Vendor Show, Winston-Salem. Contact Mark Eagle, mark.eagle@twcable.com.

21: New Jersey Chapter Technical Seminar, "Digital Television." Contact Jim Kearney (732) 420-5936.

21: Old Dominion Chapter Technical Seminar, "Return Path Basics," Roanoke, Va. Contact Maggie Fitzgerald, scteodc@aol.com.

21-22: SCTE Seminar, DOCSIS Deployment, Kenilworth Inn, Kenilworth, NJ. Contact Jessica Dattis (610) 363-6888.

28: Central California Chapter Technical Seminar, "Baseband Signal Processing, Servers and Routers," MediaOne L & D Center, Fresno, Calif. Contact Roger Paul, (559) 253-4685.

27-29: Great Lakes Cable Expo, Chicago. Contact Great Lakes Cable TV Assocation, (317) 845-8100.

PLANNING AHEAD

> **Oct. 12: SCTE Seminar, Cable 101**
Atlanta. Contact Jessica Dattis, (610) 363-6888.

> **Nov. 28-Dec. 1: Western Show**
Los Angeles. Contact California Cable TV Assoc. (510) 428-2225

> **Dec. 12: SCTE Seminar, Cable 101**
Chicago. Contact Jessica Dattis, (610) 363-6888

> **Jan. 8-10: Emerging Technologies Conference**
New Orleans. Contact SCTE, (800) 542-5040.

> **Feb. 28-Mar. 1: Texas Show 2001,**
San Antonio. Contact Jessica Dattis, (610) 363-6888

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COAXIAL CABLE

Trilogy Communications is announcing its Perfectbonded 10 line of coaxial cables. Intended for system upgrades, the series of trunk and feeder cables is designed to be universally compatible with existing cables and connectors and to eliminate cold weather suckouts and water migration. The cables also are designed to exceed the mechanical properties of existing cables while matching their electrical properties.

For more information, contact Trilogy and (601) 932-4461 or on the Web at www.trilogycoax.com. *(Readers note: the contact information for Trilogy in the August issue of CT was incorrect.)*

DIGITAL TRANSMITTER

Communications Specialties makes sending analog video, audio and data signals in either one or two directions digitally over one fiber cable possible with its Math Fiber Optics Pure Digital, One Fiber transmission system. The Pure Digital, One Fiber converts incoming analog signals to a digital bitstream, transmits that stream optically over a single fiber, then converting the signals back to analog form. The all-digital process and transmissions minimizes distortion, delivers a uniform signal and eliminates crosstalk.

For more information, contact Communications Specialties at (631) 273-0404 or on the Web at www.comm-special.com.

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For more information, contact Strongwell at (540) 646-8000 or on the Web at www.strongwell.com.

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North American Cable Equipment's Cable Tronix CTARM modulators integrate up to four video devices such as VCRs, satellites, surveillance cameras and/or DVD players. The units have non-volatile memory and a phase lock loop (PLL) digital circuit that stabilizes video output and can assign TV channels to any piece of video output equipment. By creating a separate channel for each device, CTARM modulators combine new channels with cable or broadcast channels and can route output to all home TV sets via existing cable outlets.

For more information, contact North American Cable Equipment, Inc. at (800) 688-9282, or on the Web at www.cabletronix.com.

BATTERY-FREE UPS

Caterpillar Inc. is offering a flywheel-based uninterruptible power supply (UPS) that protects electrical loads from power disturbances and provides uninterrupted transition to a standby generator set. The Cat UPS is battery-free, offers unlimited cycle life, boasts a 98 percent efficiency, and uses energy stored in a clean, safe and environmentally friendly flywheel. When the Cat UPS senses a power disturbance, the flywheel instantaneously supplies power in place of the utility. A standby engine-generator can be used for long-term power backup.

For more information, contact Caterpillar at (309) 578-6444 or on the Web at www.cat.com.

CABLE MODEM LINE DRIVERS

Analog Devices' two broadband cable TV line drivers are optimized for reverse-path data transmission in interactive digital cable terminals. The AD8322 and AD8323 are designed to interface with leading industry chipsets to help original equipment manufacturers (OEMs) exceed performance requirements of Multimedia Cable Network System Partners/Data Over Cable Service Interface Specifications (MCNS/DOCSIS).

For more information, contact Analog Devices at (781) 461-3732 or on the Web at www.analog.com.

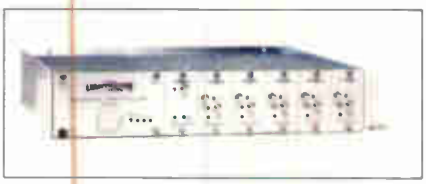
DIGITAL FIBER LINK

Force, Incorporated's HDTV Linx model 2953 transports digitized video and audio using high definition, serial digital fiber optic link. The transmitter meets Society of Motion Picture and Television Engineers (SMPTE) 292M standards and incorporates 1310 nm or 1550 nm optics. The device can be used for studio-to-post production links, studio-to-transmitter links or switched digital networks between studios.

For more information, contact Force, Inc. at (800) 732-5252 or on the Web at www.forceinc.com.

AC/DC HEADEND CONTROLLER

Tollgrade's Lighthouse Headend Controller (HEC) Model 360MPS offers a choice of either AC or DC power. The HEC can be configured for AC power or -48V for the DC powered networks, depending on the selection made by the cable operator upon ordering. The device has a modular power supply, which is accessible and replaceable. Power configurations can be made upon ordering the product.



For more information, contact Tollgrade at (412) 820-1400 or on the Web at www.tollgrade.com.

NODE CLOSURE

Preformed Line Products Coyote Runt closure is designed for node applications in low-fiber distribution networks. Its 12-count slice tray kits are compatible with the Coyote Pup closure and allow upward expansion with larger closures in the Coyote family.

The Runt measures 8.5 x 14.75 inches and can be used in aerial, buried and underground applications. Its fiber management system is molded into the bottom shell half, providing separate areas for routing and protecting buffer tubes from loose cables or bare fibers from unitube type cables and allows for the splicing of loose-tube and unitube cables in the same closure.

For more information, contact PLP at (440) 461-5200 or on the Web at www.preformed.com.

DWDM MODULES

Alliance Fiber Optic Product's 100 GHz and 200 GHz multiplexer and demultiplexer modules incorporate the company's MICS filter-DWDM technology. They are designed for International Telecommunications Union (ITU) channel spacing applications, such as DWDM transport and access, optical add/drop multiplexing, and broadband DWDM systems. AFOP's MICS technology uses proprietary thin film filter components to achieve superior performance in terms of isolation, stability, and low insertion loss. The modules are available in 4, 8 and 16 channel configurations.

For more information, contact AFOP at (408) 736-6900 or on the Web at www.AFOP.com.

HEADEND BANDSPLITTER

Microwave Filter Company offers cable headend bandsplitters that separate the frequency spectrum into high and low bands to a common output. This series includes a model for most cable TV or local area network (LAN) applications and reflect a design capability that spans from baseband (4.2 MHz) to UHF (890 MHz). Model 3329-42/54, typical of this series, splits the low passband at 5-42 MHz and the high passband at 54-1000 MHz, with typical insertion loss of 1.0 dB (3.0 dB at 42 and 54 MHz). Mutual isolation is 30 dB, with standard 75 ohm, type "F" connectors.

For more information, contact MFC at (800) 448-1666 or on the Web at www.microwavefilter.com.

CABLE TIES

Panduit's Dura-Ty cable ties, made from extruded Delrin, are designed to withstand outdoor weather conditions for up to 20 years. Their tensile strength and chemical and moisture resistance makes them suitable for outdoor messenger strand applications. The tip of the cable tie has a lead-in allowing for quick assembly

even with gloved hands. These ties are available in 13.5 and 27.0 inch sizes and come with strap bodies and cable tie heads.

For more information, contact Panduit at (888) 506-5400 or on the Web at www.panduit.com.

CABINET PACKAGE

Hoffman's Pro-line Voice/Data Cabinet package includes a frame with frame feet, window door, louvered rear door, and two side covers with quick release latches. The package also includes a cable entry top, vented shelf, power strip, front/rear 19-inch mounting rails, frame reducing brackets and two sets of grid straps. The unit measures 2000 x 700 x 800 mm, is modular in design and carries a range of optional accessories.

For more information, contact Hoffman at (800) 355-3560 or on the Web at www.ehoffman.com.

PULSE SUPPRESSOR BOX

EXFO's Pulse Suppressor Box enables optical time domain reflectometer (OTDR) operators to measure the loss of the first connectorized port of an optical fiber network patch panel. The product offers singlemode or multimode fiber, three different fiber lengths (500 m and 1500 m for singlemode and 300 m for multimode) and a variety of connectors.

For more information, contact EXFO at (418) 683-0211 or on the Web at www.exfo.com.

RAID STORAGE SUBSYSTEM

Advantech's RAID 500U2 1/4 Terabyte data storage subsystem features data transfer speeds up to 80 Mbps and up to 128 MB dynamic random access memory (DRAM) data cache. Advantech's on-line capacity expansion enables the RAID 500U2 to stay "live" during high bandwidth demands without shutting down. Users can designate specific hard disk drives (HDDs) as spares. The 8.75-inch high unit can support six expansion chassis, increasing to system's capacity from 8 to 56 HDDs.

For more information, contact Advantech at (858) 623-0838 or on the Web at www.advantech.com.

INVERTER/CHARGER

Xantrex Technology's PROsine 2.5/3.0 inverter/charger delivers to fleets and vehicles the same grid power that all AC-powered equipment is designed to use. The inverter/charger delivers 87 percent efficiency at its continuous rated output power, put out 2,500 watts of continuous output with a surge rating (5 seconds) of 4,000 watts. The unit provides a maximum battery charge rate of 100 amps. It features a remote display/control panel, weighs 30 lbs. and measures 20 x 15 x 5.5 inches.

For more information, contact Xantrex at (800) 667-8422 or on the Web at www.xantrex.com.

POWER MONITORING SYSTEM

Dranetz-BMI and Electrotek Concepts power monitoring and management system is completely Web-based, enabling multiple users to view data simultaneously in real time from any location. The Signature System's features include alarming and notification, smart reports, enhanced data nodes, system-wide time synchronization, enterprise-wide management, enhanced visualization tools and answer modules.

For more information contact the WPT Group at (732) 248-4482 or view the system live at www.signaturesystem.com.

DIGITAL OSCILLOSCOPES

LeCroy's LC series of digital oscilloscopes offer 2 Gbps sampling rate on all four channels and the ability to interleave to 4 Gbps when using two (or one) inputs. Both the LC564DL and LC554DL offer 1 MB of acquisition memory per channel, which interleaves to 2 MB when using two (or one) channels. They also include a range of triggers for troubleshooting and incorporate LeCroy's 10.4-inch flat panel color display.

For more information, contact LeCroy at (914) 425-2000 or on the Web at www.lecroy.com.

COMPRESSION ASSEMBLY TOOL

Ripley's "Universal" compression assembly tool (CAT) works with series 59 and 6 compression connectors. This CAT uses a plunger tip that is compatible with five industry connectors. Ripley's CAT tool body features an all-aluminum body and four-sided plunger enclosure that provide long-lasting use without requiring adjustment.

For more information, contact Ripley at (800) 528-8665 or on the Web at www.ripley-tools.com.

DIGITAL REMOTE

Contec's CheckMate IV digital remote control is a four-device universal model for digital cable converters, TV sets, video devices (VCR/DVD), and audio (stereo amplifiers, CD players, etc.). The CheckMate IV supports digital converters from Scientific-Atlanta, Pioneer and Motorola. It features Contec's Point and Press Programming method; Memory Guard capability, which retains programming after battery changes; and SmartKeys, which enable transmission of multiple functions with one user-defined button.

For more information, contact Contec at (800) 382-2723 or on the Web at www.gocontec.com.

MINIATURE TRANSFORMERS

Pulse's line of small, surface-mount radio frequency (RF) transformers, the CX2039, CX2040, and CX2047, is used to match impedances, step-up/step-down voltages, create DC isolation as well as convert the circuit from balanced to single-ended. Each transformer operates within a frequency bandwidth from 500 KHz to 1.5 GHz, and the family is available with 1:1 and 1:4 impedence ratios. Their miniature (.15 x .15 inches) package makes them suited for space-constrained RF applications, such as cable modems, set-top boxes, and wireless and cable network infrastructure equipment.

For more information, contact Pulse at (858) 674-8215 or on the Web at www.pulseeng.com.

OPTICAL POWER METER

The **RIFOCS** 522B-HP optical power meter is capable of measuring levels of optical power up to +27dBm. The power meter is calibrated traceable to National Institute of Standards and Technology (NIST) with 980nm, 1310nm, 1480nm, 1550nm and 1625nm. With a dynamic range of 80dB, this hand-held instrument is suited for qualification and testing of communication systems, optical amplifiers and other high output devices. It features a backlit liquid crystal display (LCD), color-coded keypad, and intuitive controls and can store up to 1,000 separate data records.

For more information, contact RIFOCS at (805) 389-9800 or on the Web at www.rifocs.com.

BUTT-IN TEST SET

Greenlee's GTS all-weather butt-in test set offers a lifetime limited warranty and features a waterproof Nautilus plastic case that is completely submersible and drop-tested from 20 feet. The GTS series also features 10-number speed dialing, last-number re-dial and selectable tone electronic ringer; DigAlert, to detect inaudible T1 or ISDN transmissions; surge protection and alligator clips and leads.

For more information, contact Greenlee at (815) 397-7070 or on the Web at www.greenlee.textron.com.

MPEG-2 TESTER

Tektronix's MTS300 MPEG Test System is built for engineers who design or evaluate digital video products such as encoders, decoders and multiplexers. The MTS300's design enables it to test to 140 Mbs and its rugged chassis allows it to be transported to remote locations. A new interface improves access to the system's diagnostic capabilities.

For more information, contact Tektronix at (503) 627-6849 or on the Web at www.tektronix.com.

GARY SELWITZ

Recap of certification and the new installer rules

Certification—a word that strikes fear in many hearts. The reality is if you are properly prepared, it should be much less stressful and certainly rewarding. The rewards for certification in peer recognition, company recognition and self-satisfaction are numerous.

A new, improved program

The installer certification program has undergone extensive changes. In the past, the training portion and the certification portion was combined into one program. This posed problems to system trainers needing to keep the two entities together. Greater flexibility can be accomplished if training is separated from the test-taking certification process.

The installer certification rules were also changed significantly to create a more well-rounded installer. Starting with those applying last April, the practical exam was changed from installing an "F" connector and reading a signal-level meter to performing a complete installation to the satisfaction of your supervisor or designated person. The installation must be observed and checked off using an official installation checklist developed by the SCTE and following the guidelines of the *Installer Certification Manual.*

After applying to the program, a candidate is required to complete six months of work experience in cable before performing the complete installation practical exam. The written exam is still required, but may be taken any time after enrollment.

Certification departments are releasing results quickly. Headquarters typically mails results within two to three days after receipt from the proctors.

Overview

Following is a recap of the new installer rules and advice to proctors to speed up the grading process. We're shipping these recaps, along with other pertinent information, to proctors with the exams. We hope this will put to rest any concerns about the certification programs, and we welcome comments.

> **"Installer certification rules were changed significantly to create a more well-rounded installer."**

Proctors represent the key to success of individual certification. Many thanks for all of your efforts.

The SCTE Installer Program consists of two components—the installer training program and the installer certification program. Training information is available through SCTE installer manual and leader guides, which are available at SCTE's bookstore (www.scte.org) for $25 each.

To become certified, you must be an SCTE member, and submit a written application using the official form (the application fee is $15).

Certification consists of two exams. The first is a closed-book written exam of 50 multiple choice questions within a two-hour time limit (the fee is $10). The second part is a practical exam that requires the candidate to perform a complete installation using an official installation check list in the presence of an exam supervisor (no fee for this exam). The application and written exam may be submitted by anyone, regardless of the amount of industry experience. The practical exam may only be performed by candidates with at least six months of experience in the cable industry.

Proctoring is open to chapter presidents, SCTE staff, SCTE Board of Directors and individuals completing an approved proctor form and obtaining SCTE approval. When administering exams within your own company, the proctor should be at least one grade above the candidate. Fourteen days advanced notice of exam date and number of installer exams required must be given to SCTE prior to shipment of exams.

Those who entered the program prior to April will continue to enjoy full benefits until their current membership expires. This will include the first take on the written exam. CT

Gary Selwitz is director of certification, SCTE. For more information about proctoring and certification, e-mail him at gselwitz@scte.org.

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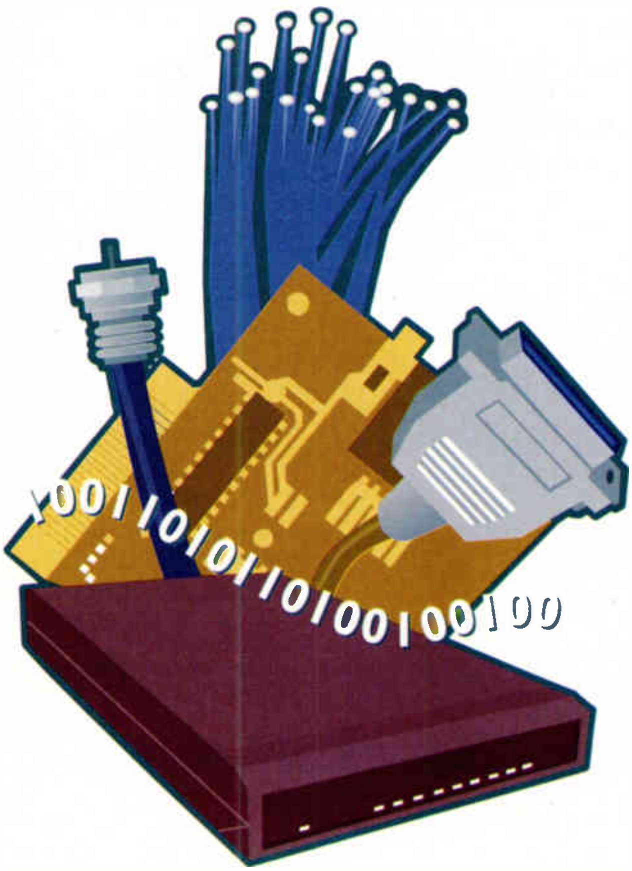

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Oct. 12	Atlanta, GA	Cable 101
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Nov. 7-9	Columbus, OH	Train the Trainer
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System Engineer-Network

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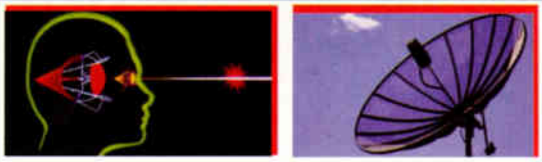

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Digital Video Standards Goes through DVS

SCTE standards document #DVS 313 Revision 2, entitled "Digital Cable Network Interface Standard" and dated April 27, 2000, passed via consensus ballot in May. This standard defines the characteristics and specifications for the network interface between a cable TV plant and commercially available consumer equipment that is used to access multichannel television programming.

The interface is also compatible with existing set-top terminal equipment owned by cable operators and with terminal equipment developed via the OpenCable specification process (see www.opencable.com). In this standard, the Cable Network Interface is defined in FCC 76.605 as the interface between the cable network and the input terminals of the first subscriber device connected to the network. A coaxial-based broadband access network is assumed in this demarcation.

This may take the form of either an all-coax or hybrid fiber/coax (HFC) network. The generic term "cable network" is used here to cover all cases. Cable networks typically use a shared-medium, tree-and-branch architecture with analog and/or digital transmission. The key functional characteristics assumed in this document are:

- Two-way transmission.
- The maximum optical/electrical spacing between the cable headend and the most distant deployed terminal equipment of 100 miles, although typical maximum separation may be 10-15 miles.
- A maximum differential optical/electrical spacing between the cable headend and the closest and most distant deployed terminal equipment of 100 miles, although this would typically be limited to 15 miles.

The cable network provides services utilizing 6 MHz in-band channel(s), out-of-band forward data channel(s), and out-of-band reverse data channel(s). The 6 MHz in-band channels are used to transport digital services, as well as analog services. These services may be either in-the-clear or scrambled. A typical channel plan for cable network places analog services (NTSC AM-VSB channels) in the 54 MHz-to-450/550 MHz range; and digital services [quadrative amplitude modulation (QAM) moving pictures expert group (MPEG)-2 multiplex channels] in the 450/550 MHz-to-864 MHz range. These channels shall comply with the ANSI/EIA-542 channel-tuning plan. However, the frequency location may change over time so that analog and digital channels may be located anywhere in the downstream operating range.

SCTE DVS 208 Revision 6, entitled "Emergency Alert Message for Cable," an SCTE/CEMA joint standards document dated October 1, 1999, is being balloted currently by the DVS standards consensus body.

This standard defines an Emergency Alert (EA) signaling method for use by cable TV systems to signal emergencies to digital "cable-ready" devices. Use of the EA signaling method defined in this standard is designed for cable systems that support devices offered for retail sale and certified as "cable-ready." Such devices include digital set-top boxes that are sold to consumers at retail, cable-ready digital TV receivers and cable-ready digital VCRs. Cable terminals owned by cable operators may use this or other proprietary methods for EA signaling.

The EA signaling scheme defined in this standard allows a cable operator to disseminate EA information related to state- and local-level emergencies and warnings in a cost-effective and efficient way, while minimizing disruption to programming. While it is possible for a cable operator to comply with Emergency Alert System (EAS) requirements by simply replacing the source signal for all programs with an emergency information channel, such switching is disruptive to viewing, is overly intrusive for many kinds of local warnings, and is expensive and complex for the cable operator to implement in a digital cable environment where each transport stream may carry many programs that would have to be individually interrupted. To handle the rare case of a national-level EAS event, the EA message instructs a cable-ready device to force-tune to a designated emergency broadcast channel.

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