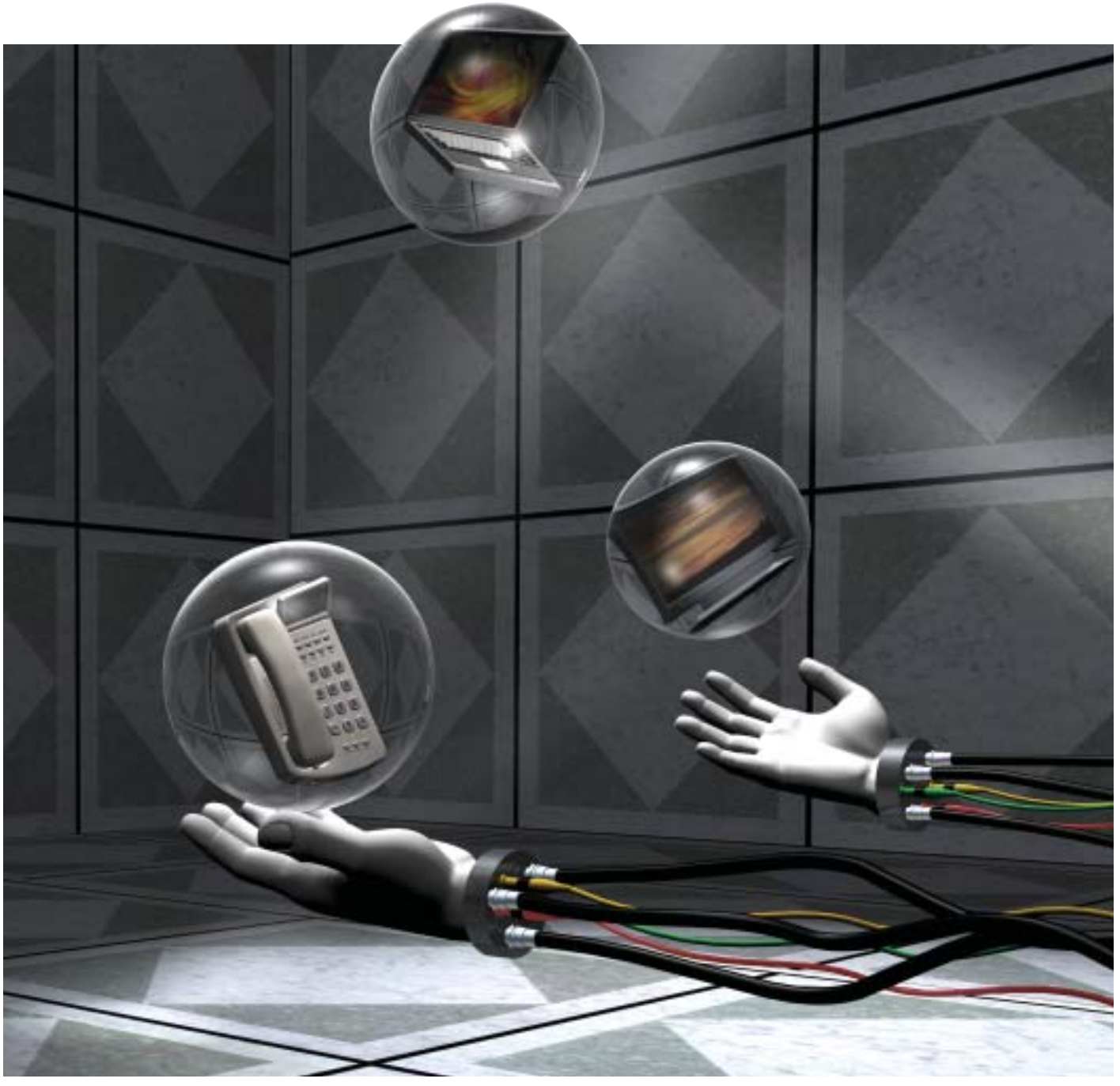


100-Mbps BROADBAND: HOW,

WHY, WHEN, AND WHERE?

A TRIPLE PLAY OF VOICE, VIDEO, AND DATA MOVES THE BANDWIDTH TARGET AS CONSUMERS ADOPT HDTV AND DVR TECHNOLOGIES AND DEMAND MORE CONTENT CHOICES.

BY MAURY WRIGHT • EDITOR IN CHIEF

Long the Holy Grail for telecom companies and MSOs (multiple-service operators), or cable companies, the triple play succinctly means serving consumers' voice, video, and data needs over a converged network. And without question, some telecom companies and MSOs are delivering today. But consumer desires are changing. Video has always been the most bandwidth-hungry part of the play, and that need for speed is skyrocketing. Consumers are increasingly enamored of DVRs that might record two or even more channels while yet another channel plays live. Combine DVR use with the escalating migration to HDTV quality, and the last mile is suddenly once again a huge obstacle just as it was for broadband data a decade ago. Purveyors of cable, DSL (digital-subscriber-line), and optical-network services all have plans to support the ramping bandwidth demand, but none of those plans is cheap or simple in deployment.

Next-generation broadband gates a number of services ranging from real-time and interactive TV to more compelling multiplayer gaming. And the impact and opportunity go far beyond the companies—the IC vendors, communication-equipment makers, set-top-box vendors, and service providers—that directly address the market. Next-generation broadband expands the market for home networking, entire new classes of consumer products, and content.

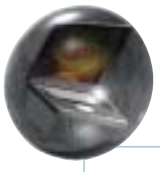
Consider the types of networks that now are or will soon be in deployment and the challenges the service provider face. Worldwide DSL is outpacing all types of broadband deployment. Optical is just getting started. In North America, cable may still be the market leader (see sidebar "DOCSIS moves ahead"). But Imran Hajimusa, director of marketing for communications-access ICs at Infineon, claims that three DSL lines are being deployed today for every cable line worldwide. DSL also faces perhaps the toughest challenge in the triple-play race.

THE DSL CHALLENGE

The challenge starts with the bandwidth requirement that telecom companies face with video-over-DSL services or IPTV (Internet Protocol television). In such a deployment, the telecom company sends only the video channels that the subscriber requests down the last-mile connection. Channel changes happen in the companies' remote terminal. IPTV software from companies such as Microsoft has progressed to the point that channel-change time is acceptable to consumers even though the channel request must go upstream to the telecom equipment.

But what can DSL data rates deliver? Starting in late 2004, many telecom companies moved to ADSL2+ (asymmetrical-digital-subscriber-line 2+) technology that boosted downstream data rates to 25 Mbps by doubling the transmission band to 2.2 MHz. Presumably, a telecom company can deliver one HDTV stream and two SDTV streams along with Internet service and VOIP (voice-over-Internet Protocol) phone service on an ADSL2+ line. But Infineon's Hajimusa claims that North American telecom companies have found such an offering insufficient. He claims that consumers are demanding six channels, two of which are HDTV. Hajimusa states, "Anything else is just rubbish. This is what the consumer is looking for."

Better video encoding can ease the video-bandwidth requirements. Originally, a typical MPEG-2-based HDTV stream needed close to 20 Mbps in bandwidth. Improved codecs get that number down to



AT A GLANCE

- DSL (digital-subscriber-line) deployments have passed cable on a worldwide basis, but DSL may face the toughest challenge of any option when it comes to video delivery.
- Consumers are demanding six channels, two of which must be of HDTV quality, in IPTV (Internet Protocol-television) applications. That demand translates to a minimum of 50-Mbps broadband services.
- PON (passive-optical-network) technology is taking off rapidly in Japan and to a lesser extent in North America. Aerially deploying the network on utility poles cuts cost and construction hassles.
- Hybrid-PON/DSL networks may offer the best bang for the buck in cities with copper-network installations.

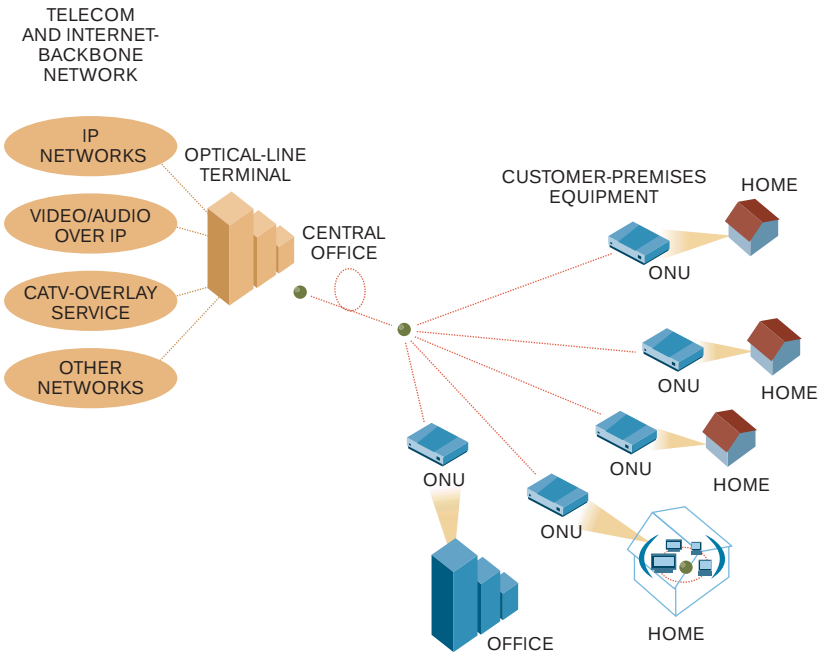


Figure 1 In a PON, an OLT (optical-line terminal) at the service provider connects to a fiber segment that is passively split, and the resultant fibers connect to either ONUs (optical-network units) or ONTs (optical-network terminals) at each subscriber premise.

approximately 12 Mbps. MPEG-4 helps even more. Cyrus Namazi, vice president of marketing at Conexant, claims, "Three HD streams require only 20 Mbps total with MPEG-4." Still, ADSL2+ can't meet Hajimusa's six-channel scenario.

The answer, according to DSL proponents, is VDSL2 (very-high-bit-rate DSL 2). The original VDSL standard offered higher data rates than ADSL, but QAM (quadrature-amplitude-modulation)-based VDSL was largely incompatible with DMT (discrete-multitone)-based ADSL. VDSL pioneer Ikanos had some limited success with VDSL, but telecom companies couldn't seamlessly migrate their customers to the faster technology. VDSL2 was completed a little more than a year ago and is both DMT-based and backward-compatible with ADSL2+.

Today, telecom companies can deploy VDSL2 chips in their remote terminals and support legacy ADSL clients, ADSL2/2+ clients, and VDSL2 clients. Hajimusa claims that Infineon can support 100-Mbps symmetrical VDSL2 service over distances as far as 3500 ft, using 30 MHz of bandwidth, or 50-Mbps symmetrical service over distances as far

TOO MANY PONs?

What would our industry be without competing standards, and why should we expect anything different in optical networking? Like skirmishes in the wireless-LAN- and ultrawideband-standards efforts, competing standards bodies have promulgated different versions of PON (passive-optical-network) technology, and vendors are deploying it in different scenarios around the world. Here's a quick guide to the PON flavor of alphabet soup.

The ITU-T (International Telecommunications Union-Telecommunications Standardization Sector) standard G.983 defines BPON (broadband PON). BPON is largely a follow-on to APON (asynchronous-transfer-mode PON), which still relies on ATM-transport protocols but at higher data rates. BPON offers asymmetrical service with 622-Mbps downstream transmission and 155-Mbps upstream transmission.

The IEEE-802.3ah standard defines EPON (Ethernet PON), or GE-PON (Gigabit Ethernet PON). As the name implies, EPON, or Ethernet in the first mile, carries native Ethernet traffic and offers symmetrical 1-Gbps service.

ITU-T standard G.984 defines GPON (Gigabit PON), which can support a variety of Layer 2 protocols, including ATM, TDM (time-division multiplexing), and Ethernet using the GEM (Generic Encapsulation Method) translation layer that the standard defines. GPON offers asymmetrical service with 2.5-Gbps downstream and 1.25-Gbps upstream transmission.

as 5000 ft using 17 MHz of bandwidth. So telecom companies that deploy VDSL2+ on the service-provider side of the link can supply the six-channel IPTV example to customers with relatively short loops and still offer slower services for customers with longer local loops.

Today, Infineon, Conexant, Ikanos, and Broadcom are shipping VDSL2 ICs, and Texas Instruments has announced support through its Uni-DSL (Universal DSL) family. Still, debate is ongoing about how quickly VDSL2 support will proliferate. Hajimusa states, "There are some loops that will never get below 10,000 ft." Those loops wouldn't benefit from VDSL2 but would benefit from ADSL-2+. Supporting VDSL2 adds to the complexity of the silicon. "There is a premium to process 30 MHz of bandwidth," he says.

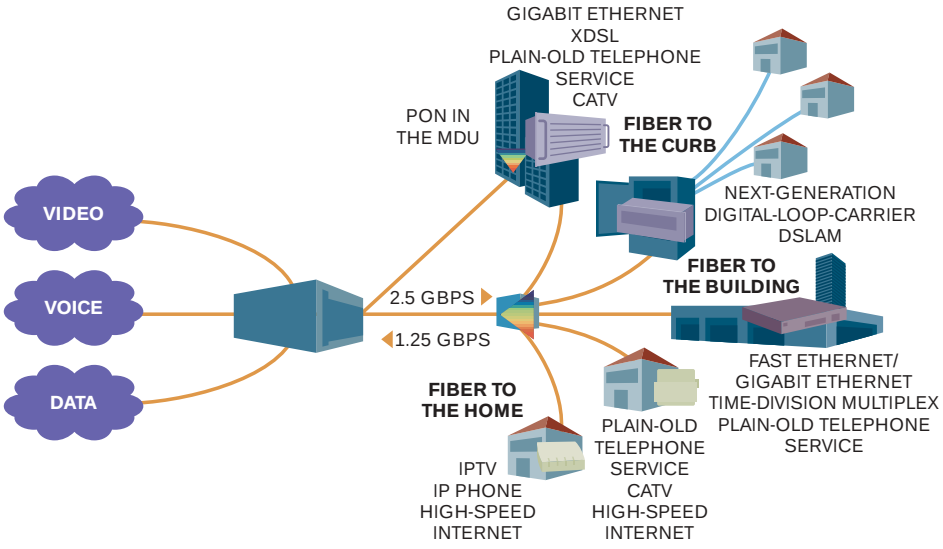


Figure 2 The variety of flavors of FTTx allows carriers to deploy fiber to individual homes or to deploy hybrid networks in which some flavor of DSL or another technology provides the final link to the subscriber.

Kurt Eckles, director of marketing for residential gateways at Texas Instruments, is more bullish on broad VDSL2 deployment. "The WAN interface is only 25% of our silicon costs, and a new process node will take care of that," he says. Eckles point is that power supplies, packaging, and other silicon dominate the cost of access cards in the remote terminal and in the CPE (customer-premises equipment). VDSL2 requires a relatively small premium to "future-proof" a network on the service-provider side, he says.

PONs DELIVER FTTH

But do technologies such as VDSL2 make sense with optical networks poised

MUNICIPALITIES ADOPT ACTIVE ETHERNET

Much of the optical-network deployment in North America today is in the form of the Active Ethernet switched network. The word "active" differentiates this type of network from PON (passive optical network). Unlike PON, in which a number of subscribers share the bandwidth of a single fiber segment, Active Ethernet is more like the typical office network in which each node connects to a central switch. And, whereas PON relies on passive splitters that provide the fiber drops to each subscriber, Active Ethernet requires a dedicated fiber to each subscriber.

Without question, Active Ethernet is superior to PON in the amount of bandwidth it dedicates to each user. PON proponents, however, believe that it would be cheaper to deploy the passive topology. PON requires only one set of optics on the service-provider side of the link, and its shared-media fiber plant is simpler. So, most large service providers worldwide are now pursuing some flavor of PON technology.

Active Ethernet proponents claim that the cost difference between the two has narrowed considerably as the price of optics has dropped. And Active Ethernet is winning business among new home communities that have FTTH (fiber-to-the-home) deployments, municipalities that deploy an FTTH network, and even some CLECs (competitive local-exchange carriers) that are deploying FTTH networks in competition with the major telecom companies.

In the case of small municipalities, the Active Ethernet deployment both serves the local residents and generates revenue. A typical municipality allows third parties to offer phone, video, and Internet service over the FTTH network. And the municipality gets a percentage of the revenue that the third parties generate. In such a scenario, Active Ethernet is more attractive to third-party service providers than PON would be because Active Ethernet provides dedicated and guaranteed bandwidth to each subscriber.

to reach the home? Whether it's FTTH/C/P/N/B (fiber to the home/curb/premises/node/basement) or some other flavor of deployment, PONs (passive optical networks) are poised to push fiber nearer to the subscriber (see sidebar "Too many PONs?").

Generally, a PON in an FTTH deployment is more akin to a cable plant than a DSL plant (Figure 1). A typical segment of fiber serves 16 to 64 subscribers with passive splitters that create the fiber run to each subscriber. Downstream data rides one wavelength, and upstream data rides another. Even with the shared-media approach, a PON can provide a guarantee of 50-Mbps or faster services to a subscriber as long as the service provider manages the number of subscribers on each PON segment.

PON appears to be the choice of major service providers worldwide for optical deployment, although some smaller carriers and municipalities are installing Active Ethernet (see sidebar "Municipalities adopt Active Ethernet"). Considerable disagreement exists about which PON flavor will ultimately dominate. Carriers in North America and Europe prefer GPON (Gigabit PON) because it matches the carrier-class quality that the legacy carriers have always designed into their networks. Rich Moran, director of product management at NEC's Optical Network System Division, states, "GPON is well-suited to carriers because of its ability to tightly manage traffic and service." NEC is betting on GPON both in Moran's equipment division and in NEC Fiber Optek, which makes lasers and optical interfaces.

GPON is also the fastest flavor of PON, although speed to the subscriber depends on how many subscribers share an optical segment. EPON (Ethernet PON) proponents claim that EPON is cheaper and that the 1-Gbps rate allows EPON to use some components developed for 1-Gbps Ethernet. GPON advocates counter that, even though GPON is marginally more expensive, a GPON segment can serve double the subscribers of an EPON segment.

It would be nice if you could draw some conclusion by looking at early deployments of VDSL2 and PON, but it may be too early to judge those deployments. Moreover, hybrid PON/DSL networks enter the equation, as well. In North America, Verizon has the largest PON deployment; its FiOS (fiber-optic service) uses BPON (broadband-PON) technology to offer the triple play. BPON was a precursor to GPON, and Verizon will presumably migrate its network to GPON as chips and equipment become available. NEC's Moran believes that Verizon will make the GPON transition next year.

BroadLight supplies much of the BPON silicon that Verizon uses and is also the first company with broadly available GPON chips. "If it's just Internet, you can get away with BPON," says Dan Parsons, the company's director of marketing. Verizon now offers Internet and phone services over the broadband link on the FiOS deployment. The company offers the video services essentially through a cable-TV-like multicast service on an overlay network—a wavelength separate from the broadband service. Service providers in the future will have the

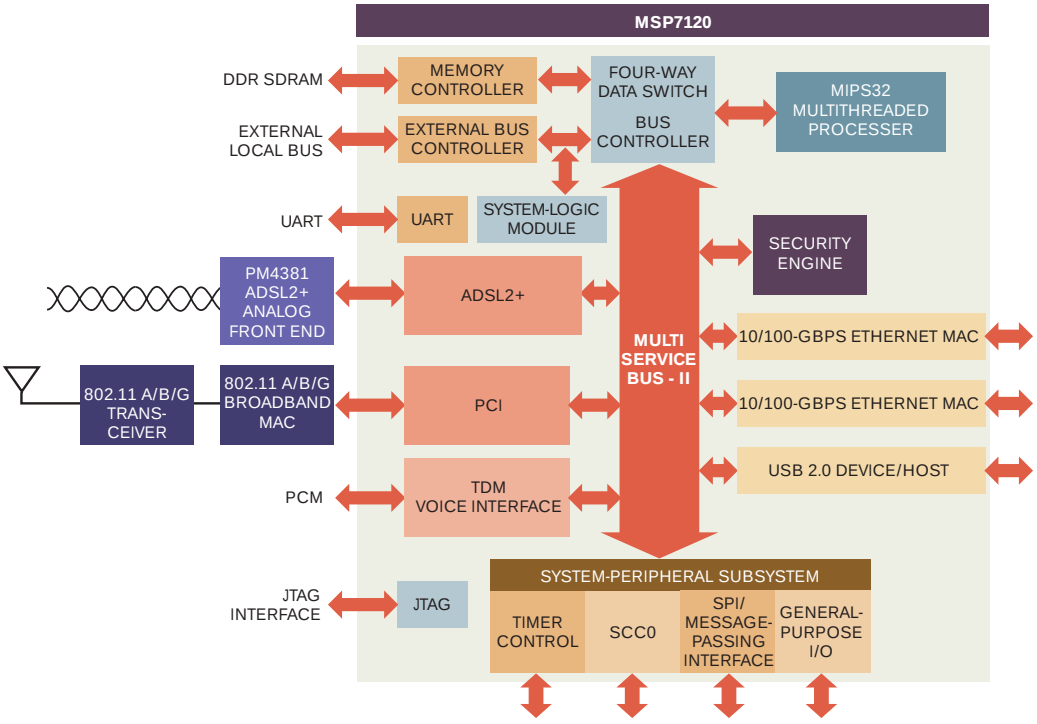


Figure 3 A family of chips for residential gateways, the PMC-Sierra MSP7100 gateway platform integrates ADSL and VOIP functions and can connect to home-network technologies, such as 802.11.

choice of offering video through a FiOS-like overlay, IPTV over the broadband link, or both. They could offer multicast video over an overlay and video-on-demand programs through IPTV.

The largest 1-Gbps PON deployment is the NTT (Nippon Telegraph & Telephone) EPON in Japan. Most experts predict that Japan, China, and Korea will drive PON deployment. In the case of NTT, the Japanese government has largely funded the EPON deployment that provides 100-Mbps services. The bandwidth may not be necessary today, but observers believe that it is important for Japan to lead the world in PON. Conexant's Namazi states, "In Japan, the claim that 'mine is faster than yours' carries a lot of weight. There is a lot of pride involved." Infineon's Hajimusa points out that some subscribers in Japan use 10- to 15-Mbps upstream rates for Internet gaming.

NTT based its deployment on ICs from PMC-Sierra through its acquisition of Passave. "The NTT new-PON-subscriber rate has passed DSL additions in Japan," says Babak Samimi, FTTH-product-line manager at PMC-Sierra. He claims that NTT is adding 400,000 to 500,000 PON subscribers per quarter. He also claims the number will reach 30 million subscribers by 2010 out of a worldwide PON deployment of 50 million to 60 million in 2010.

NTT aerially deployed most of its network on utility poles rather than burying it underground. The same situation is true of the Verizon BPON deployment. The combination of falling component prices and aerial deployment has decreased the cost of PON. Samimi claims that it can be as cheap as $600 to $700 to deploy service to a new subscriber. Others place the figure a bit north of $1000 but still far cheaper than the $6500 per subscriber it cost just a few years ago. However, many communities in North America don't allow overhead utilities, limiting the benefits of aerial deployment. Surprisingly, aerial optical plants are cheaper to maintain and more reliable that aerial copper plants.

Despite the success of PMC-Sierra in Japan, GPON proponents plan a major push across Asia. Presumably, NTT chose EPON because it was available and despite the fact that PMC-Sierra has been a sole source as an IC supplier. GPON proponents claim that the EPON standard leaves options, especially in areas such as security, that limit robust interoperability between chips from various vendors. Companies such as BroadLight believe that GPON interoperability will be key to ultimately winning a portion of the Japanese market, as well as in regions such as China.

Samimi counters that NTT added security provisions that make its EPON suitable for interoperability and that China can do the same thing. Recently, China held an EPON-interoperability test. Conexant is playing in both the GPON and EPON markets and participated in the Chinese tests. Conexant's Namazi states, "We have successfully interoperated with a number of companies in the EPON space."

Texas Instruments has yet to announce a PON play but is closely watching the market. TI's Eckles believes that China will focus on low cost and will ultimately choose a technology in which multiple vendors will compete and drive down component prices.

HYBRID-PON/DSL NETWORKS

Meanwhile, across the globe, hybrid networks will compete with PON FTTH deployments (Figure 2). For example, an FTTB or FTTN deployment might connect to the basement of an MDU (multiple-dwelling unit), such as a high-rise apartment building. Inside the building, VDSL2 might provide the link to subscribers over existing copper wires. Similar FTTN developments will serve individual homes. For example, Deutsche Telekom is using such an approach with VDSL2 to roll out a triple-play network in 10 major German cities. AT&T in North America is taking a similar approach. It could be that companies are deploying VDSL2 more in such hybrid networks than in pure-copper networks.

The hybrid-deployment concept eliminates the concept of a video-overlay network, such as the one that Verizon is using in its pure-optical BPON. If VDSL2 bridges the final link to the subscriber, then IPTV is the only option for video services.

A move of gear inside the home is another deployment trend to watch. As TI's Eckles points out, "The telco network has traditionally ended with the line pair. The telcos now want to move the demarcation point to CPE in the house. The cable industry always had that philosophy with the way they developed DOCSIS [Data Over Cable Service Interface Specification]." Conexant's Namazi agrees. "The service providers have wanted to sell the consumer more, but they have been afraid of the support issues," he says.

Both Eckles and Namazi are referring to the telecom companies' plan to move to a residential gateway. Both see the service providers providing consumers with a box that integrates 802.11 wireless-LAN technology or other home-networking technology for video distribution, VOIP telephony, and other services. The service provider might charge the consumer a premium for such CPE, but, realistically, the avenue to more services will generate revenue.

Still, such a plan opens the service provider to the support risk. But Namazi claims that implementing a gateway on an SOC (system on chip) would mitigate some of the support risks. "A gateway

DOCSIS MOVES AHEAD

At first glance, you might think the cable MSOs (multiple-service operators) have solved the triple-play issue of voice, video, and data and can count their money. In North America, where cable still dominates, the major players are offering the triple play, including HDTV and DVRs. But the MSOs will have their own set of problems as they continue to add intelligence to their network, push intelligence deeper into the network, and offer more HDTV content. For example, CableLabs is promulgating new DOCSIS (Data Over Cable Service Interface Specification) 2.0 and 3.0 standards.

The MSO industry has widely deployed DOCSIS 1.1 cable modems that added quality-of-service features to earlier products. The next move is under way to DOCSIS 2.0 and adds support for faster upstream data rates for applications such as Internet gaming. DOCSIS 3.0, meanwhile, will add channel bonding, thereby providing MSOs flexibility in even further increasing both upstream and downstream rates.

Among the biggest trends in cable-modem design, EMTAs (embedded multimedia-terminal adapters) add an application processor and VOIP (voice-over-Internet Protocol) support to the traditional cable-modem function, thereby supporting voice calls in a standard manner. Broadcom and Texas Instruments are leaders in the cable-modem market, although TI claims to be pulling ahead in EMTA deployments, and MSOs that want to offer voice services are also targeting such deployments.

Kurt Eckles, TI's director of marketing for residential gateways, believes that growth in the cable side of broadband will come as DOCSIS pervades everything on the network. "Demand for a DOCSIS function in all set-top boxes will drive cable growth," he says. Eckles also believes the DSG (DOCSIS-set-top-gateway) initiative will be key for next-generation conditional access.

The big obstacle ahead, however, is how to handle more content—specifically, more HDTV content. As the telecom companies move to IPTV (Internet Protocol television), so could the MSOs. But making such a move would render the DOCSIS CableCards obsolete—at least in terms of receiving the IPTV channels. Consumers can add CableCard modules to TVs or even Media PCs to integrate digital-TV tuning over cable networks. Converting analog channels is another way that the MSOs could add digital channels. But a move to IPTV or a reduction in analog channels will surely anger some segment of the subscriber base.

with tightly integrated features is the only way you can get acceptable quality of service," he says. A networking-literate consumer can now cobble together home LANs with VOIP phone service. Namazi's point is that vendors will basically guarantee that the integrated functions in a residential-gateway chip will work as consumers expect.

As you might expect, CPE-chip vendors are moving toward the gateway trend. Texas Instruments has long offered such gateway reference designs. Recently, Broadcom, Conexant, and PMC-Sierra joined the market. Conexant introduced the CX9461x IC with an ADSL2+ modem, integrated 802.11a/b/g support, and VOIP features. Meanwhile, PMC-Sierra's MSP7100 gateway platform includes models for ADSL2+, VDSL2, and PON CPE, although the chips lack integrated 802.11 support (Figure 3). Similarly, Broadcom offers the BCM6358 with no integrated 802.11 support but pairs it with a new Intensi-fi 802.11 chip that the company claims is 802.11n-draft-compatible.

PATIENCE

In any event, the players in the PON and even the VDSL2 markets will need patience to realize a return on their R&D dollars. GPON hopeful AMCC (Applied Micro Circuits Corp) is working on a PowerPC-based MAC (media-access-controller) chip and now offers a PHY (physical)-layer chip. Neal Neslusan, director of marketing for the company's Transport Group, states, "From the time we kick off a program until we get a production part, it's 18 months to three years. Then, you get design wins, and that takes a couple of more years." Neslusan doesn't mention the need to guess right on the technology. And he isn't the only one looking at protracted deployment scenarios. For example, Conexant's Namazi states, "China is modifying the spec for encryption. That leads me to believe that massive deployment is a little way off."EDN

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