Swimming Upstream: The Case for Higher Speeds

By Piyush Sevalia, Director of Product Marketing at Ikanos Communications

Introduction

Business and residential subscribers are constantly demanding more bandwidth. With the Internet, where a wealth of content resides on the World Wide Web, most of this demand has historically been in the downstream direction. And that will certainly continue. But what has changed is that users are now accumulating and generating copious amounts of content of their own.

Digital electronics (cameras, camcorders, MP3 players, DVD recorders, etc.) is expanding the creation of this user content. Increased globalization (diasporas, outsourcing, economic liberalization and more) and basic human communication needs are driving the sharing of this content. Witness the surging popularity of peer-to-peer (P2P). This demand-driven phenomenon also has a supply side angle. Carriers, especially those in industrial, developed nations, are experiencing minimal revenue growth due to saturation in wireline and wireless adoption. They are also experiencing pressure from satellite and cable providers, who are venturing into wireline and wireless offerings with new technologies, such as Voice over IP (VoIP). To effectively enhance their revenues and stave off competitive pressures, carriers are announcing video services, such as IPTV, video-on-demand (VoD), interactive video and more.

Accompanying the trend in content creation and storage are changes in network utilization and new applications that are now demanding greater bandwidth upstream—forcing carriers to swim against competitive currents in this same direction. Video serves as a good example. To compete with cable and satellite providers, many carriers are now (or soon will be) offering IPTV, VoD and digital video recording services, as well as additional value-added services for videoconferencing, video monitoring, surveillance and interactive video gaming. All of these services require greater upstream bandwidth. And soon the need for services will grow to include video-mail (v-mail), video messaging/blogging and many other bandwidth-hungry applications that are certain to debut in the foreseeable future.

The leading technology for delivering higher bi-directional bandwidth is Very-high-bit-rate Digital Subscriber Line (VDSL). VDSL was designed to take full advantage of a carrier's broadband infrastructure with its increasing fiber optic capacity to the node, curb or building/basement. And unlike other technologies, VDSL has the ability to deliver 100 Mbps symmetrical broadband bandwidth, which puts carrier services on par with LAN switching to the desktop. Significantly, no mass-market local loop technology has ever done that before.

Carriers around the world are already experiencing tremendous success with their initial VDSL service offerings. The take-up rates are high, likely because these premium services can be provisioned profitably with a monthly fee comparable to other DSL services. As a result, most of these carriers are planning to add new or enhanced services

to generate additional revenue streams, potentially as an upgrade to existing (and increasingly inadequate) legacy services. This early success helps explain why industry analysts are so enthusiastic about VDSL, with forecasts of deployments doubling every year over the planning horizon.

The material in this document is intended for a business management audience, primarily at incumbent and competitive carriers. The content is organized into three main sections followed by a brief conclusion. The first section, *The Need for Speed*, lists nine emerging applications that will require increased bandwidth in the upstream direction. The next section provides a high-level (and non-technical) overview of *Bi-directional Broadband with VDSL and VDSL2*. Section three, *VDSL Today… and Tomorrow*, offers some real-world examples of carrier experiences and highlights two pertinent analyst forecasts. Additional information on VDSL is available on the Web at www.ikanos.com.

The Need for Speed

Users, carriers and equipment vendors alike have a long history of underestimating the need for speed. The root cause is innocent enough: keeping costs under control. But the inevitable "forklift" upgrades are disruptive and costly,which is quite ironic considering the original impetus involved cost savings.

Consider what has occurred in the local loop over the past couple of decades. Data communications in the Public Switched Telephone Network (PSTN) began with 300 BAUD modems. As welcome as these were in the marketplace, users soon demanded more. So the 300 BAUD modem infrastructure was replaced with one that supported 1200 bps… then 2400 … then 9600. A major breakthrough came with the advent of the 14.4 Kbps modem and then the really "fast" 28K modem. After a tweak to 33.6 Kbps, the modem reached its maximum potential with 56K technology. But even here, too, the initial asymmetrical V.90 standard was quickly replaced with a symmetrical version: V.92.

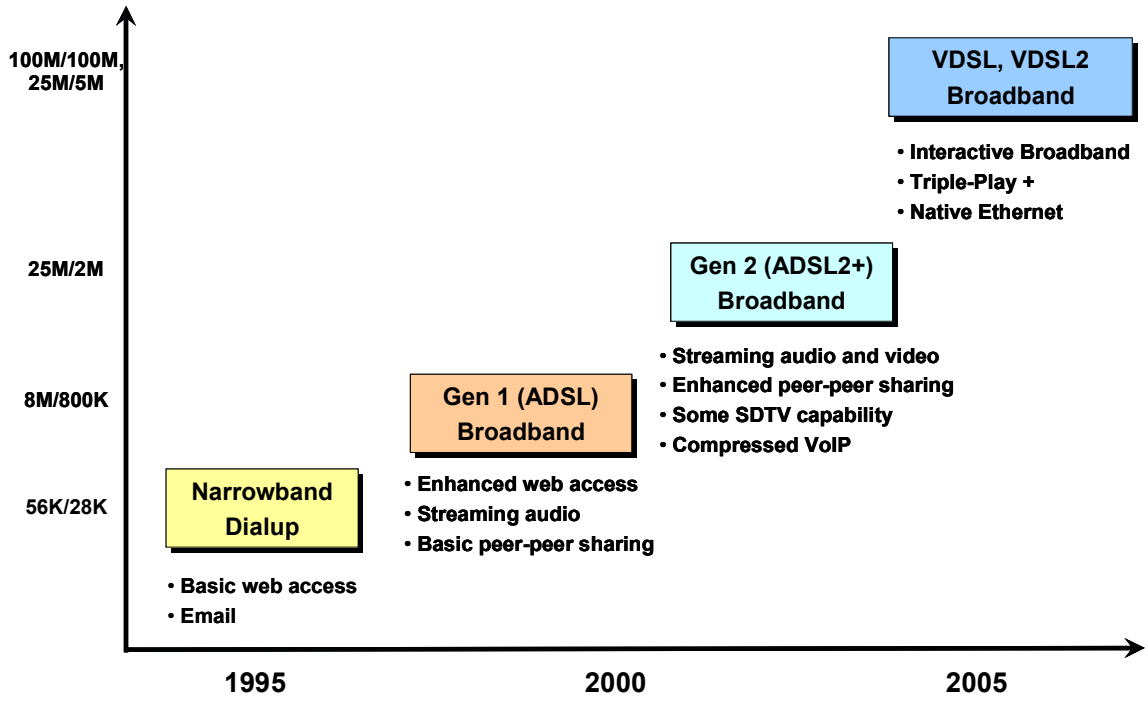

Figure 1. Advances in Broadband Technology

Despite these advances, users wanted more. The Integrated Services Digital Network (ISDN) offered great hope for the industry. But alas, the advent of digital subscriber line (DSL) technology began to erode the ISDN's marketshare. Some forms of DSL even began to supplant traditional T/E-carrier services, especially T1 and E1. Asymmetric DSL (ADSL) became the most popular rendition in the residence. But even ADSL has seen its fair share of changes—from ADSL to ADSL2 to ADSL2+—all of which required a reinvestment in infrastructure.

Of course, the Local Area Network (LAN) has witnessed a similar progression. What began with 10 Mbps Ethernet LANs, where users shared available bandwidth, soon required 10 Mbps switching. The relentless demand for bandwidth eventually witnessed the change to 100 Mbps switching, and now many organizations are migrating to 1 Gbps for server farms and in backbones. Not surprisingly, technologies such as 10 Gbps switching are presently on the drawing board.

The current access bandwidth compromise involves the upstream direction. The various versions of ADSL all deliver asymmetrical bandwidth. And just as occurred previously with 56K modems, this lack of adequate upstream throughput is now becoming obvious in the marketplace.

Business subscribers were the first to recognize ADSL's limitations. This is why many such subscribers continue to utilize traditional T1/E1 services, and why many carriers offer mostly symmetric forms of DSL to their business subscribers. The reason businesses need bandwidth symmetry is fairly straightforward: content. Organizations consume and generate a significant amount of content, requiring adequate bandwidth in both the downstream and upstream directions, respectively. Where fiber optic cabling is

available to the premises, businesses often turn to DS-3 or Fractional DS-3 services. And where only copper is available, carriers have found it necessary to multiplex T/E1 or DSL services to meet the bandwidth demand.

The very same situation is now occurring with residential subscribers. Although a vast amount of consumer-oriented content continues to reside outside the home on the World Wide Web, the balance is changing. Homes now house and even generate a growing and significant amount of content. Witness the popularity of 100+ Gigabyte disc drives, digital still and video cameras, special video publishing software, personal sheet-fed scanners, home wireless networks, MP3 players and more. In the future, home will not only be where the heart is, it will increasingly be where the content is.

Here is sampling of some emerging residential applications that will all demand greater bandwidth in the upstream direction:

Home Networks

Gone are the days of the single-PC family. Indeed, the home network is starting to resemble that of a small business, with multiple client PCs and a shared server. Multiple household members, all accessing the Internet during "Computer Time" will require higher bandwidth, both downstream and upstream, to ensure that the Internet experience remains acceptable. Additionally, to access these resources effectively while away from home—at work, at school, on vacation or just while visiting friends—requires adequate upstream bandwidth. And after all, what is the use of all the content residing on the home network if it cannot be accessed remotely?

Telecommuting

The social trend for an enhanced work/life balance, along with the need for substantial cost-savings by businesses, have caused a dramatic increase in the number of people telecommuting full- or part-time. And creating an "office-like" work environment for these workers requires adequate symmetrical bandwidth, as the SOHO telecommuter is a lot like a business – not just downloading files, but uploading content such as presentations, spreadsheets, etc., all of which require significant upstream bandwidth.

Peer-to-Peer (P2P) Applications

P2P is becoming increasingly popular—and powerful. In effect, the PC is both client and server. Asymmetric bandwidth is simply insufficient for many of these needs. A University of Washington study, shown in the figure below, that P2P bandwidth dominates Internet bandwidth, and contributes to its "peaky" traffic patterns.

According to the study, 24 percent of Internet users use P2P, and consume over 90 percent of the bandwidth. In addition, the upstream bandwidth is a lot higher than downstream bandwidth, because users typically share audio and video files, which are much larger in size than data files. Figures 3 and 43 show the comparison of traffic types in this study.

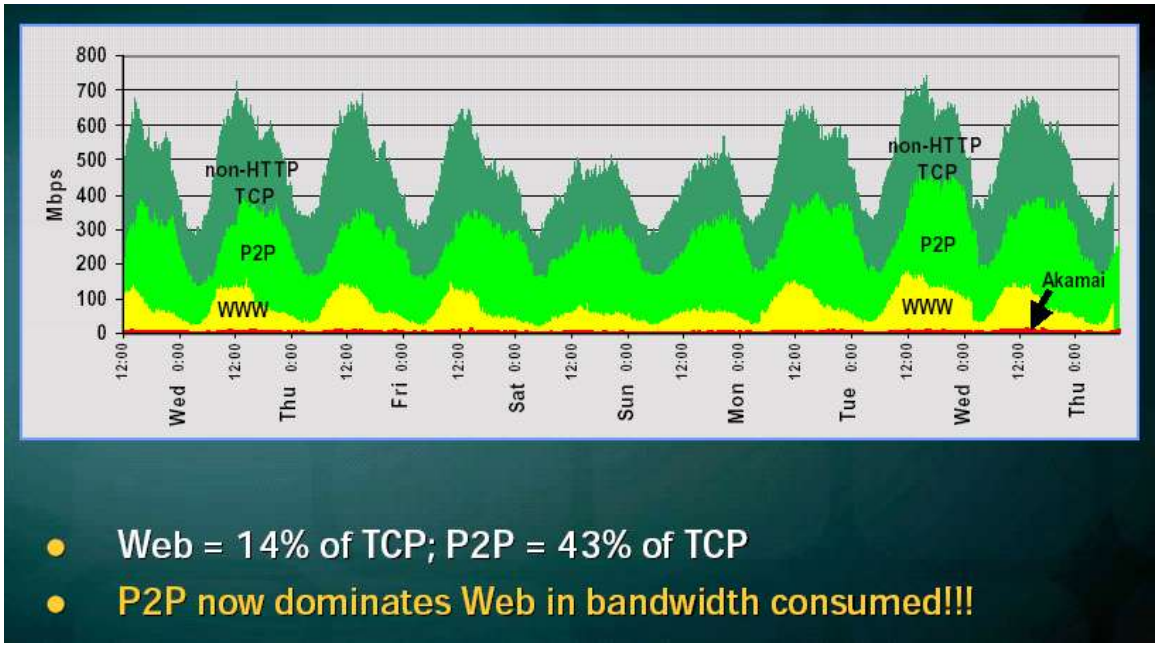

Figure 2: P2P Bandwidth Dominates Internet TCP Traffic.
Source: University of Washington

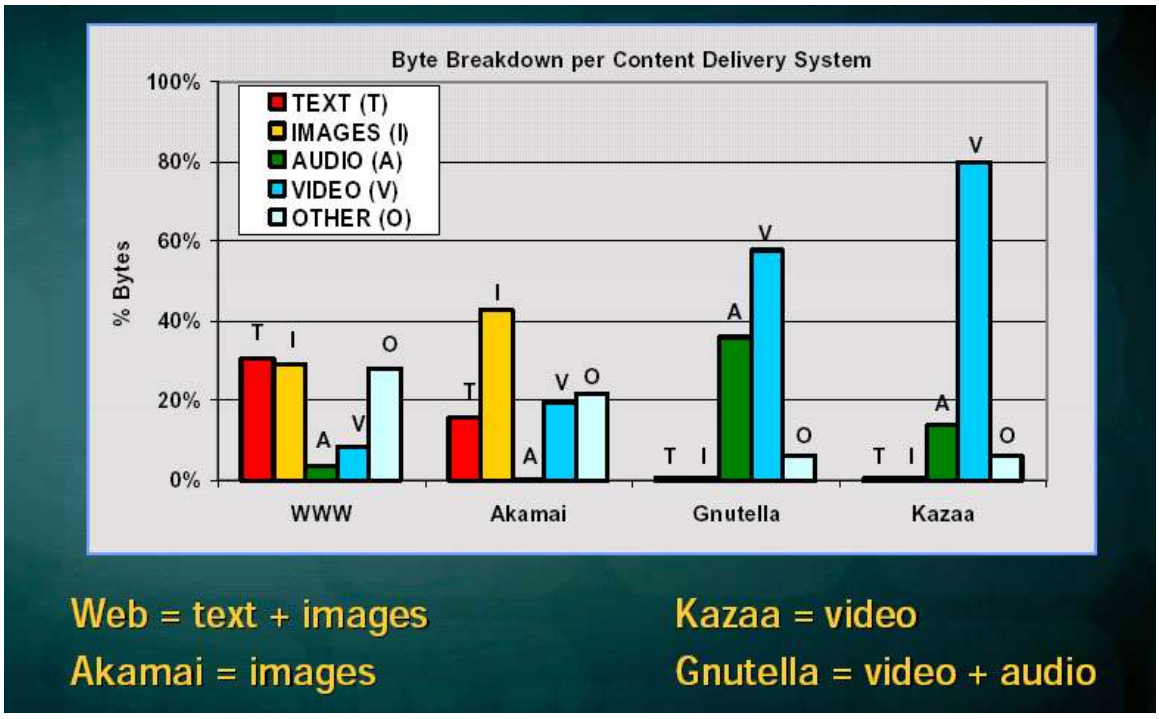

Figure 3: Types of Traffic in P2P
Source: University of Washington Study

As traffic patterns go, P2P is driving consumer bandwidth usage worldwide, and is also causing bottlenecks. This can be a revenue-generating opportunity for carriers.

One significant point: The carriers can only offer services to address P2P if they deploy higher upstream bandwidth, of the type offered by VDSL technology.

Videoconferencing

The debut of videoconferencing dates back to the 1969 World's Fair. But this promising capability has not been ready for "prime time" owing to its poor quality. People have become accustomed to digital quality, and now expect the same of one-on-one or group videoconferences. The only remaining hurdle to achieving HDTV-quality videoconferencing is adequate bi-directional bandwidth—on the order of several megabits per second.

Multimedia Messaging

MMS and other forms of instant messaging are already standard applications in PCs and handheld wireless devices. The future of MMS calls for more robust support of video. Inexpensive built-in or add-on cameras could allow users to send video-mail and video messages, or conduct a video chat session quite easily—if there were only enough bandwidth.

Video Monitoring and Surveillance

Although this one might seem a bit Orwellian, people really do want to "check up" on things at home while away. Web-enabled cameras are now so affordable that it is feasible to see when the kids get home, or when the gardener arrives, or how the nanny is doing, or why the alarm went off. The activity can be monitored via the Internet, and it provides security and peace of mind to a large segment of consumers. However, in order to get decent video quality, the upstream data rate must be capable of being dynamically partitioned and also must be sufficient to support good video quality (3-4 Mbps for cheap, MPEG-2 USB webcams).

Content Creation and Publishing

The Web has leveled the intellectual playing field. Anyone who doubts the public's desire to publish need look no further than the popularity of weblogs, or blogs. Can the Video Blog be far behind? Not really – in fact, Google and Yahoo! both offer video blogging services. The general trend toward "rich media" and full multimedia (audio/video) productions—whether for personal consumption or profit—will demand an ever-increasing amount of upstream bandwidth.

Interactive Gaming

Too much work and not enough play… Perhaps the old saying is a bit trite, but the fact remains: Home PCs owe much of their popularity to games and "edutainment" applications. And many of today's popular games are becoming too sophisticated for yesterday's bandwidth.

Remote Desktop Control

Many applications benefit from the ability to control one PC from another; for example, the controlling the work PC from home or vice versa. The complexity of PCs also now

makes it beneficial for the Help Desk to have such access. Without bi-directional broadband bandwidth, this capability can be painfully slow.

Not listed above are the many other possible uses or applications that are certain to emerge in the future. For example, what potential does virtual reality hold to change the way people work or play? Will grid computing technology evolve and grow to the point it becomes pervasive? Will there be other technologies that revolutionize work/life balance or the educational system? If past is prologue, there are certain to be many now-unforeseen and very powerful capabilities in our future.

The many new and emerging bandwidth-intensive applications, along with competitive pressures from cable and satellite providers, are forcing incumbent and competitive carriers to rethink their strategies. Newer technologies, especially Hybrid Fiber/Coax (HFC) and broadband wireless, threaten to undermine the inherent strategic advantage of a carrier's copper/fiber infrastructure. What carriers need is a robust bi-directional broadband solution that can be provisioned profitably for business and residential subscribers alike, and will—this time—stand the test of time.

Bi-directional Broadband with VDSL and VDSL2

Most carriers have already begun to lay fiber optic cabling deeper into their networks because they realize that offering new or enhanced revenue-generating services, such as those just discussed, requires copious amounts of bandwidth. And fiber optic technology enjoys virtually unlimited bandwidth potential. As such, it is a rock-solid investment that will surely endure the test of time. But laying fiber all the way to every single subscriber is difficult if not impossible to justify financially—even in the face of increasing competition. Additionally, laying fiber all the way to the consumer's home involves trenching driveways, drilling holes in walls, and setting up 2-hour windows for appointments and then keeping them – all of which are an inconvenience to the consumer.

One DSL technology was designed to enable carriers to take full advantage of this fiber build-out: Very-high-bit-rate Digital Subscriber Line (VDSL). VDSL technology delivers fiber-like bi-directional bandwidth over ordinary unshielded twisted pair wiring. Of all the DSL technologies available, VDSL is simply the fastest, delivering up to 100 Mbps in both the downstream and upstream directions.

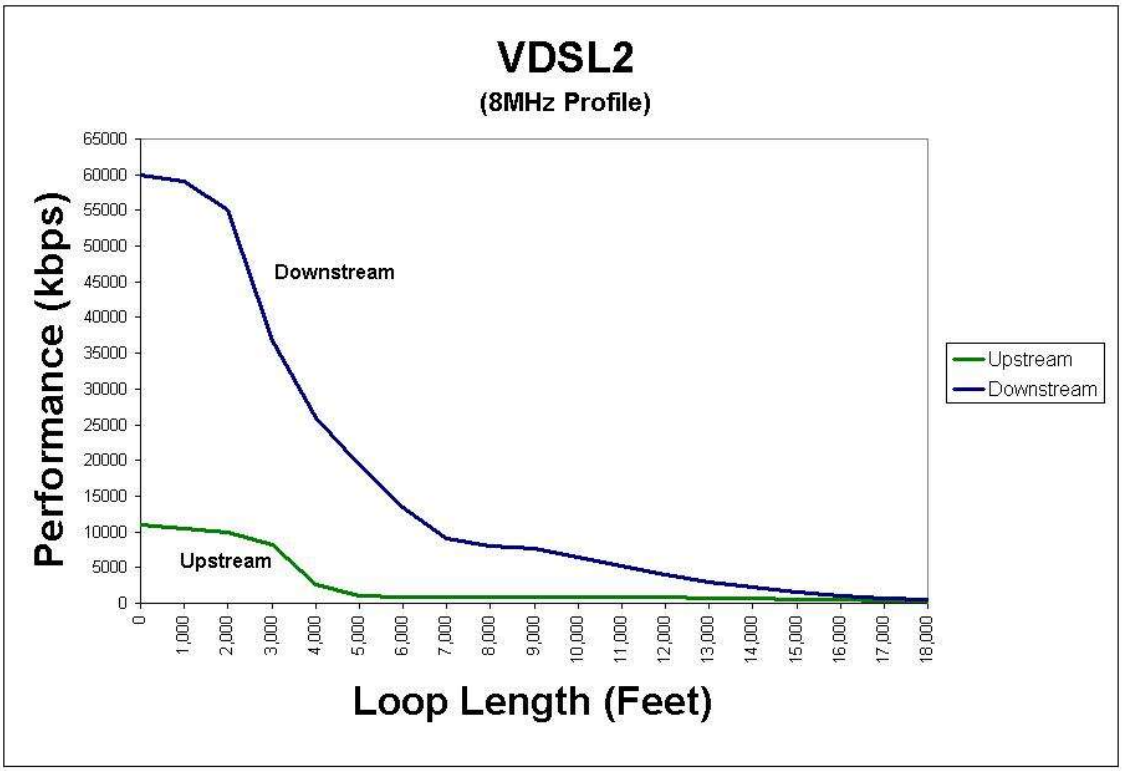

Figure 5. As a next-generation technology, VDSL delivers greater bandwidth than ADSL everywhere in the Customer Serving Area. The difference is most profound where fiber reaches out ever closer to potential subscribers.

This data rate (100 Mbps) is significant. Switched 100 Mbps is the predominant choice today for desktop connectivity in the LAN. The power of delivering the same 100 Mbps service in the access network represents a major breakthrough: the first time ever that local access bandwidth has caught up with the LAN in a mass-market way. For this reason, VDSL promises longevity that carriers have yet to experience with any previous technology. Putting it another way: it will be a long time until VDSL's potential is exhausted.

VDSL can deliver ADSL2+-like connectivity to all subscribers throughout the Customer Serving Area (CSA), and affords its highest level of performance to those subscribers closer to the carrier's Central Office (CO) or Remote Terminal (RT). With this robust rate/reach profile, carriers have greater flexibility to offer full broadband interactive services to offices/homes closer the CO/RT and basic Internet connectivity to consumers at longer distances. VDSL solutions are available in full-featured DSL access multiplexers (DSLAMs) or as remote gateways/concentrators that can be deployed either in the CO or RT. The customer premise equipment (CPE) is typically a single-port gateway or "modem" incorporating a DSL transceiver.

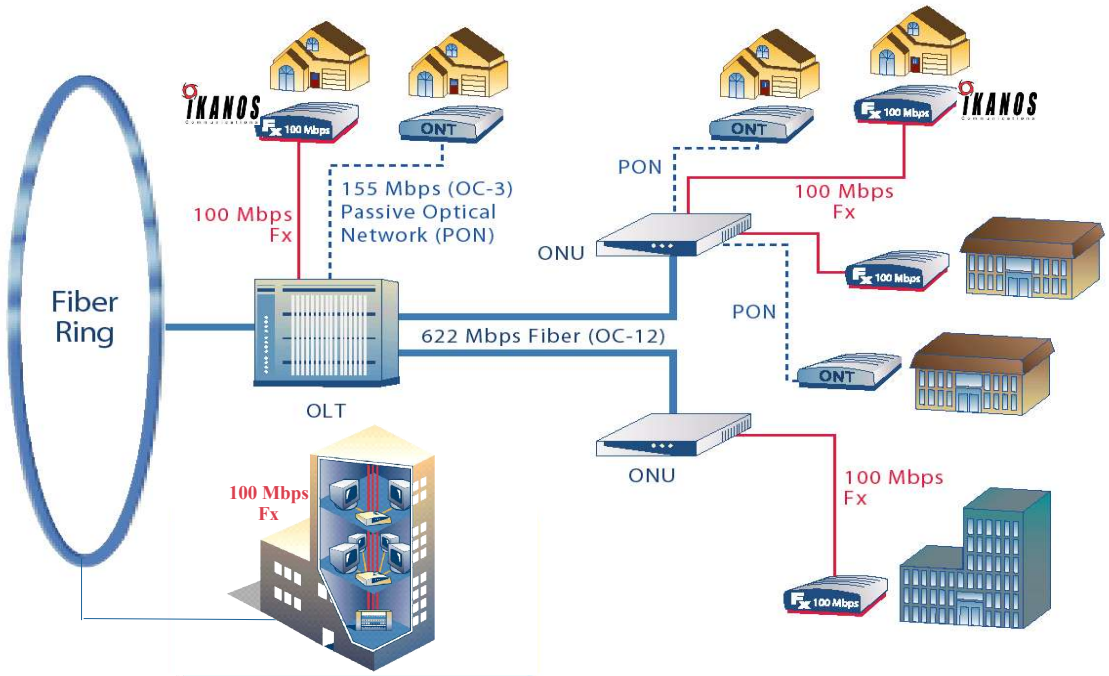

Figure 6: Typical VDSL/2 Network. Very-high-bit-rate DSL technology enables carriers to deliver premium broadband services that compete effectively with any available alternative.

Very-high-bit-rate digital subscriber line services are available in two technologies: VDSL and VDSL2. Both are international standards embraced by the International Telecommunications Union (ITU), the American National Standards Institute (ANSI) and the European Telecommunications Standards Institute (ETSI). The VDSL standard was ratified in mid 2003; the VDSL2 standard was consented in May 2005. VDSL chipsets have long been in production, and have recently been joined by VDSL2 chipsets. And both are now being integrated into existing platforms by most equipment vendors.

VDSL and VDSL2 share several other characteristics. Both employ Discrete Multi-Tone (DMT) modulation based on its superior proven performance characteristics and spectral compatibility with other services, including analog POTS (Plain Old Telephone Service), ISDN and other types of DSL services. Both are available in implementations that are interoperable with ADSL, ADSL2 and ADSL2+. Both accommodate an analog POTS line that can be made available on a separate port through a passive splitter. And both support ATM (cell) and Ethernet (packet) encoding, which gives carriers tremendous versatility in their service offerings.

There are a couple of noteworthy differences between the two, however. VDSL allocates up to 12 MHz of spectrum, whereas VDSL2 permits use of up to 30 MHz. The latter results in much higher potential bandwidth for the consumer. VDSL does permit optional use of spectrum beyond 12 MHz, and many implementations take advantage of this option. Secondly, VDSL2 adds enhancements to line diagnostics similar to those available with ADSL2+. Third, VDSL2 specifically defines profiles, which enable carriers to buy a product that is optimized for their deployment scenario, whether it be

FTTB, FTTN, RT, or CO. It also enables chipset vendors to optimize products for these specific application requirements.

VDSL Today… and Tomorrow

Because VDSL technology has been around a few years, carriers around the world have deployed the service in production applications. Here are just three examples that demonstrate the technology's market potential.

In Japan, NTT began deploying VDSL-DMT in 2002 with an initial asymmetric offering of 50 Mbps downstream and 11 Mbps upstream. In the following year, NTT rolled out two enhanced services: 50/30 Mbps and 70/30 Mbps upstream/downstream. In 2004, NTT added a 100/50 Mbps service. Although these data rates seem to imply "fixed" service levels, the technology employed allows NTT to offer bandwidth-on-demand in both the upstream and downstream directions. This empowers the carrier to devise premium service enhancements based on its existing investment.

In the United States, SBC is planning an aggressive roll-out of its U-verse service based on VDSL technology in the last mile. U-verse is part of the carrier's Project Lightspeed, a $4 billion initiative to expand fiber optics deeper into residential neighborhoods to deliver IP-based TV, voice and data broadband services. SBC has partnered with Microsoft to provide next-generation IPTV services with advanced features like video-on-demand (VoD), picture-in-picture (PIP), user-selectable viewing angles, Internet integration, remote digital video recording (RDVR) and more. SBC is also forming partnerships with other infrastructure and content providers.

In Europe, Belgacom supports VDSL "*For people who want to move ahead faster.*" Recognizing the growth in home networks, the carrier's VDSL Boost offering allows for connection of up to four home PCs and up to eight mailboxes. Belgacom is also in the pilot stage of an interactive digital TV (IDTV) that will deliver digital picture and sound quality, more channels than cable competitors, VoD movies, an on-line program guide, "recorderless" recording of favorite programs (the NDVR), and of course, a fully interactive experience that promises, according to Belgacom, "a new approach to watching TV that will completely change the way you interact with this medium."

This is just a small sampling. Many other carriers are now deploying VDSL, including Bell Canada, Hanaro (Korea), KDDI (Japan), K-Opticom (Japan), Korea Telecom, PT-Lux (Luxembourg), Telenor and USEN (Japan). And many others are currently evaluating VDSL/VDSL2 in anticipation of imminent roll-outs, including Bellsouth, Deutsche Telecom, France Telecom and Swisscom.

The growing popularity of VDSL and VDSL2 has not gone unnoticed by industry analysts. InStat/MDR expects VDSL to experience a compound annual growth rate (CAGR) of 58 percent through 2008. The Yankee Group is even more bullish on VDSL with its forecast of a CAGR of 102 percent through 2008. In that year, the Yankee group expects roughly one in every five DSL subscribers will be utilizing VDSL or VDSL2.

Conclusion

The lack of adequate upstream bandwidth has begun to place limitations on the types of services carriers can offer their business and residential subscribers. Fortunately, carriers still enjoy an inherent advantage over the competition: a basic infrastructure capable of delivering broadband bi-directionally and cost-effectively.

With VDSL and VDSL2 technology, carriers have a more versatile and universal way to offer a wide assortment of new or enhanced—and quite lucrative—services. Jeff Weber of SBC expressed the advantage in the residential market this way: "Because we don't have to take fiber all the way to the house… rather than spending $40 billion, we can spend four, five or six billion dollars." And all of those savings go directly to the bottom line as the revenue continues to roll in.

A variety of VDSL/VDSL2 DSLAMs, concentrators and gateways are available today for deployment in pilots or roll-out in full production networks. Or talk with your preferred equipment provider about their plans to support VDSL. And if your vendor has no definitive plans yet for VDSL yet, have them talk with Ikanos about leveraging available chipsets designed to integrate with existing platforms. After all, Ikanos is the market leader in VDSL chipsets with over 5 million ports shipped to-date worldwide.

The day will eventually come when even 100 Mbps upstream and downstream is insufficient for many applications. But until then, carriers have a long and lucrative opportunity with VDSL and VDSL2.

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