The Promise of VDSL in IP Services Everywhere

Abstract

The advent of the Internet has created a new paradigm in which computers must operate. The sheer volume of content requires newer and faster methods of data exchange. These requirements have resulted in the development of a number of new technologies and technology paradigms, all with the same end goal: providing high-speed Internet access to the end-user. The object of this paper is multifold:

• Educate the reader on the emergence of high-speed broadband access technologies and the markets they serve;

• Compare and contrast the major technologies with an emphasis on VDSL;

• Outline Netsy Technologies' high-speed broadband access solutions for the MxU market.

At the end of the paper, the reader should be comfortable enough with high-speed broadband access technologies to ask more detailed questions, seek further information and make a more educated buying decision.

The Technologies

The introduction of digital subscriber line (DSL) technologies has revolutionized Internet access. The ability to use existing phone lines to provide faster Internet access has put standard 56K modem access into the background, if not put it to bed. The benefits of DSL technology, coupled with the deregulation of the telecommunications industry, have caused in increase in the number of service providers (xSP) offering DSL services. Everyone from ILECs to CLECs to ISPs are offering DSL services to homes and businesses – with Asymmetric Digital Subscriber Line (ADSL) currently being the most common and cost-effective choice. However, the euphoria over the increased bandwidth and accessibility provided by ADSL has had a significant side effect in that the bandwidth is used as fast as it is made available, despite arguments to the contrary concerning technologies such as dark fiber. Research into DSL technologies has produced variants of ADSL to help resolve issues users are faced with today, as well as plan for future implementations. One of these variants is Very High Bit-Rate Digital Subscriber Line (VDSL). VDSL differs from the other DSL technologies primarily in the areas of speed and distance. Lower costs, competition with other technologies and forward thinking for future bandwidth requirements are contributing to making VDSL a viable technology for even wider implementation. With VDSL's ability to support features such as television programming, video conferencing, and high-speed data exchange, service providers are discovering that a VDSL offering is a very important weapon in their arsenal, especially in their competition with cable television companies.

The Space

The primary focus of any DSL technology is to enable broadband access to an end-user without rewiring the existing wiring infrastructure. The "end-user" in this case may be:

• An user in a commercial campus environment;

• A resident in a multi-tenant or multi-dwelling (MxU) unit;

• A student in a university campus;

• A guest at a hotel.

The difficulty in providing broadband access to users in any of these scenarios is the lack of adequate wiring to support technologies such as Ethernet. There are a staggering number of end-users that are still using traditional 56K modems because no other technology is readily available for broadband access. Listed below are some statistics on the sheer amount of potential users in the U.S. MxU/campus/hospitality environments.

• 24% of the U.S. population lives in a MDU;

• 51% of the total households has at least one home computer;

• 24.7 million small and home businesses employ 100 or fewer people.

In other parts of the world, the MxU marketplace is even greater In Japan:

• 40% of the population lives in a MDU;

• 50% of MTU tenants have had Internet access since 1998.

• Fiber to the curb (FTTC) initiative to be 100% complete by 2005. Currently at 36%;

• 5.4 million small and home businesses employ 17 million people.

The ability of DSL technologies to work over standard copper phone lines is critical since inadequate wiring infrastructure is the primary reason for the lack of broadband access availability. It can be cost-prohibitive to rewire a building using Category 5 Unshielded Twisted Pair (UTP) cable to support an Ethernet environment. DSL technologies eliminate the need for such rewiring. In commercial environments, as businesses exchange more data in both directions over the Internet, asymmetric technology solutions, such as ADSL, are no longer sufficient. Traditional access technologies, such as T1, are too slow to support newer applications and increased information exchange over the Internet. VDSL technology can support the symmetric traffic flow that businesses need, with the speed they desire – again, using the existing wiring infrastructure. Users are more sophisticated in their use of the Internet today than a few years ago. No longer satisfied with simply "surfing the Web," they want more streaming audio, streaming video and the ability to transfer more data simultaneously. Consequently more bandwidth is needed. VDSL technology enables solutions to resolve these issues.

The Provider Challenge

ISP/xLECs are currently providing high-speed broadband access using predominantly ADSL and SDSL technologies. Deployments of these technologies have a number of benefits for providers: leverage existing equipment and wiring infrastructure. ISPs work with xLECs to use the phone lines in order to provide their services to end-users. However, increasing bandwidth demand has shown these technologies to be marginal solutions for many customers. Providers are now looking to other technologies such as VDSL to provide increased bandwidth to meet the needs of their customers. Deploying VDSL-based solutions, however, presents other challenges. To provide high-speed broadband access without cost-prohibitive rewiring, service providers are rapidly upgrading access to the buildings, primarily by installing/lighting new optical fiber from the central office (CO) to the building. This allows data from the xSP to travel over optical fiber links to the building, where VDSL equipment sends it over existing copper phone lines to users. This deployment is currently in progress within the United States, Europe and parts of Asia. The fiber outlay will not only provide access to the MxU market but also enable future technologies, such as Gigabit Ethernet and 10 Gigabit Ethernet, that cannot run long haul distances over copper wires. VDSL technology is one of the biggest beneficiaries of this effort, making the time right to deploy VDSL-based access solutions into the MxU environment.

VDSL vs.ADSL

More recently, emphasis has been placed on ADSL for a variety of reasons. Newer variants, such as VDSL, SDSL, HDSL, etc., are just now coming into prominence. Because of the potential impact of VDSL in the marketplace, it is important to explain the difference between VDSL and ADSL.Table 1 outlines the basic speed and distance differences between ADSL and VDSL technologies.

	VDSL	ADSL
Mode	Symmetric & Asymmetric	Asymmetric
Max. Theoretical Speed (Total)	52Mbps (total)	6.1Mbps
Down Speed/ Distance Min.	52Mbps/300m (proj.)	1.5-2.0Mbps/5.5km
Down Speed/ Distance Max.	13Mbps/1500m (proj.)	6.1Mbps/2.7km
Max. Distance	1000m/1500m	5500m

Table 1 – VDSL vs. ADSL

ADSL Basics

Developed with the high-speed broadband access to the consumer marketplace in mind, ADSL has enjoyed widespread deployment. The combination of speeds and distances are favorable for a home and small office environment. ADSL technology is generally premised on, though not restricted to, the existence of ATM as the Link Layer protocol. This is done for a couple of reasons: leverage the existing ATM infrastructure in the local loop and maximize Quality of Service (QoS) potential. Historically, carriers installed and used a significant amount of ATM equipment to access the local loop, based on the idea that ATM would be the ubiquitous technology in the WAN. One of the goals of ATM was to provide a Link Layer protocol that could support the transport of multiple traffic types (voice, data, video, etc.), with a supporting Adaptation Layer to classify traffic streams and a strong QoS. An ADSL implementation consists of two basic components: an access point for the user (customer premise equipment - CPE), and an aggregation point where all of the access points merge.

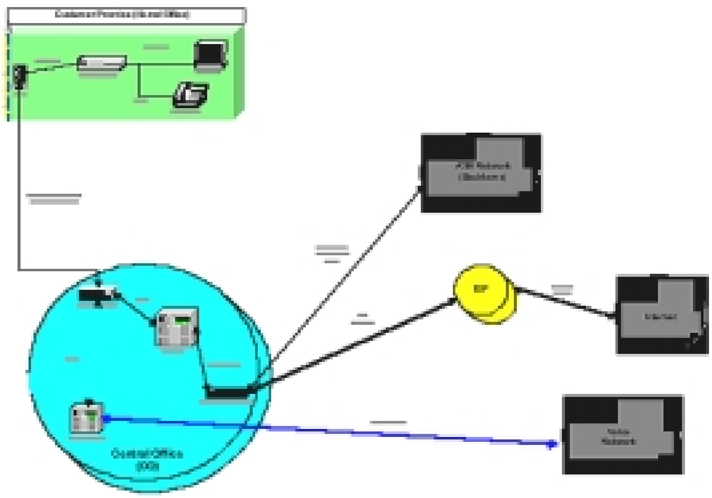

Figure 1
Typical Broadband Access Deployment using ADSL Technology

The access point is generally an ADSL router. The access point takes the user data and converts it to ATM cells to be transported using ADSL framing over the copper wiring infrastructure. The aggregation point is a DSLAM usually located at the CO, but can also be located in the basement of a building. The DSLAM accepts the ADSL framed data from the customer, which may contain both voice and data traffic. A POTS splitter, integrated into the DSLAM or external, splits the voice traffic from the data and routes it to a voice switch and subsequently to the voice network. The remaining data traffic is ATM cells and is sent to an ATM switch within the CO premises and then out to the carrier's ATM network. A typical ADSL implementation is shown in Figure 1 above.

In many cases, the POTS splitter, the DSLAM and the ATM switch can be integrated into a single device, accomplishing all three functions.

ADSL Advantages

ADSL has some significant advantages, which are summarized below.

• Long reach (5500 m.);

• Cost-effective solution for home and small office environment;

• Leverage ATM infrastructure of carriers and service providers;

• ATM QoS for voice, video, multimedia, etc.;

• Value add features (bandwidth provisioning, etc.) in ADSL equipment to maximize revenue for xSP.

The advantages listed here are the primary reasons why ADS enjoys its current level of acceptance. However, the next section will discuss why some of these advantages of ADSL will become disadvantages in the near future.

ADSL Disadvantages

In spite of its popularity, ADSL has a number of disadvantages –many of which have come to light because of recent advances in other technologies.

• Theoretical 6.1Mbps downstream but 1-2Mbps are normal and typical;

• Lower typical speeds limit transmission of high-grade streaming multimedia applications, digital TV, HDTV, video-conferencing and high-speed data exchange;

• Asymmetric nature less suited for today's business/commercial environments;

• ATM QoS not being used because ADSL primarily used for data;

• ADSL rollouts have been problematic;

• ADSL/ATM equipment is still expensive because ATM is still expensive;

• ATM infrastructure at carrier level is going more to the core network.

Because of the increased sophistication of Internet and application usage by users, the practical speeds and asymmetric nature of ADSL have become a limiting factor when once they were more than sufficient. Office environments are finding it more difficult to use ADSL because businesses often send and receive large amounts of data, making the disparity between the upstream and downstream speeds unacceptable. Consequently, businesses are switching to SDSL, which provides symmetric T1 speeds (1.544Mbps), or VDSL. Over the past few years, ADSL rollouts have been less than stellar for most service providers – not necessarily due to the provider themselves. Complaints include:

- Slow implementations;
- Inadequate service;
- Service level agreements (SLAs) not meeting established use level.

Some complaints are due to the ILEC/CLEC not providing appropriate bandwidth to the xSP; some have to do with complexity of the equipment and the associated provisioning. Additionally, the ATM QoS benefits have largely gone unused. Even at the writing of this paper, Voice over DSL (VoDSL) implementations were only just beginning rollout and in low volumes. Though ATM provides a level of QoS that can be used to ensure proper traffic delivery, its use is not widespread because ADSL is still used primarily for data delivery. ADSL does not take advantage of the QoS metrics available because they are not critical in non-real time data delivery. Where QoS is availableonly the default metrics are being provided – best-effort.

ADSL Future

The popularity of ADSL as an Internet access technology will keep it alive for a umber of years to come. Service providers have invested too much money into equipment supporting this technology to allow it to fade quickly. ADSL has played in a major role in increasing the popularity of the Internet because of the access potential it provides but if issues with ADSL deployment and service do not improve, ADSL may well be the "dial-up" technology of the 21st century. Additionally, the increasing demands of users and emergence of DSL variants as well as other technologies are gradually reducing the fascination with ADSL. These demands are forcing the research into newer technologies to replace ADSL with something better. VDSL is one such technology.

VDSL Steps In

The simplicity of VDSL remedies a number of the problems currently faced by ADSL. VDSL is not necessarily supplanting ADSL as an access technology, but rather complementing it by reaching many more users and providing more capabilities.

- VDSL runs in symmetric or asymmetric mode;
- Symmetric operation is well suited for today's business and enterprise environments;
- Equipment is not ATM-centric, so is cheaper than ADSL;
- Bandwidth enables future technologies, such as streaming multimedia, HDTV, digital TV, etc, that ADSL cannot support;
- Simplicity of the equipment lessens problematic rollouts and cost for the xSP.

VDSL has the ability to run in either asymmetric or symmetric mode. The symmetric mode of VDSL provides speeds up to 13Mbps (currently) in each direction, making it a desirable solution for a business environment. This bandwidth far exceeds the other xDSL variants. Because VDSL is not ATM-based, the expensive ATM-based DSLAM at the CO or in the basement can be replaced by a more cost-effective access concentrator in the basement of the building it is servicing. VDSL leverages existing equipment to minimize cost, rollout time and effort. The access concentrator can take Ethernet data traffic, merge the voice traffic from the Public Switched Telephone Network (PSTN) coming into the building, and send the mixed data over the phone lines into the residences or offices. The access point in the residence or office is simple; it splits the voice and data traffic so a user can use the phone and access the Internet at the same time. Note that VDSL exists only between the access concentrator in the building basement and the access point to which it is connected. It does not extend beyond the access concentrator toward the service provider. Advances in the area of television programming, particularly digital TV and HDTV, will prohibit the long-term use of ADSL very quickly. With the prediction by Cahners In-Stat Group that by 2005, more than 23 million homes will be watching television over existing phone lines, VDSL technology will gain wider acceptance to help meet this demand.

Service providers will be able to provision the VDSL bandwidth in order to provide a customer the specific bandwidth requested. If users require more or less bandwidth, a simple telephone call is all that is necessary to make the change. The applications that can run on top of the VDSL channels can provide a greater level of value-add, in the form of revenue generating potential, to the service provider. Because ADSL is a commodity service, the difference in price is not significant between xSPs because only a single service is being offered –pure bandwidth. With VDSL, the service provider can provision a VDSL device to not only offer the appropriate bandwidth for features like HDTV or video conferencing, but can provision the appropriate QoS metrics to ensure that the feature operates properly and to the satisfaction of the customer. This level of provisioning can provide the xSP a higher level of value-add service, allowing it to differentiate itself from other xSPs.

The Provider Challenge for VDSL Implementations

The benefits provided by VDSL begs the question "why should one use ADSL if VDSL is available?" As alluded to earlier, VDSL is a technology that is not readily available to consumers - yet. This leads to other issues regarding VDSL, many similar to those faced by ADSL in the past and currently:

- VDSL Availability: VDSL is just now being deployed in niche environments (hospitality, campus);

- Practical speeds available: Many implementations have been able to achieve 13Mbps symmetrical rates (26 Mbps total). While less than the 52Mbps total theoretical rate, more than sufficient to support high-grade multimedia applications;
- QoS potential: Most of the VDSL implementations revolve around Ethernet and currently use the 802.1Q and p based QoS. Advanced QoS techniques are being developed for IP to ensure QoS to the edge of the VDSL environment;
- Cost: VDSL may initially be more costly than ADSL. If VDSL is touted to be the replacement for ADSL, then its cost must be comparable. If VDSL is deemed to be a complimentary technology, the cost/value assessment can be made by the xSP;
- Rollout: The rollouts should be easier than ADSL because there is less equipment to install;
- Standards: VDSL standards are well defined but not yet finalized. This leaves the possibility of interoperability issues between access concentrators and access points of multiple vendors.

VDSL provides many benefits and has solutions to resolve issues faced by ADSL. However, because it is still early in its implementation, it will likely be 2002 before mass rollouts in MxU, campus and hospitality markets will be commonly seen. Some service providers will roll out VDSL as a premium service for large-bandwidth customers who can generate significant revenue. An xSP may provide an option to the user, ADSL or VDSL service based on the user's personal or business requirements. The customer will then be charged accordingly. VDSL can be used as the premium service, thus garnering a larger revenue stream from customers while ADSL may still be used as an Internet access service.

Cable Modem

In the midst of the DSL talk exists cable modem technology. This is a broadband access method offered by companies that offer cable television service to end-users.

The possibilities with this offering should be obvious: wherever cable television is available, cable modem access can be made available. In fact, broadband access using cable modem technology is more common than any other access technology, except for traditional analog modems. Cable modem technology does not require any rewiring of the premise. When a cable modem is installed, it uses a coaxial cable from the local head end into the end-user's premise, in a manner similar to the cable television wire. The device the cable connects into is called a cable modem (a CPE device). It generally has the coaxial cable in one end and an Ethernet port on the other end, as the connection point to the home computer. The technology is fairly simple: it is a modem that has its signals running over a coaxial cable. The modulation techniques are modified to allow a significant increase in the bandwidth provided, but generally speaking, this is a modem. The speeds attained by cable modem technology are impressive: up to 27Mbps downstream from the head end to the end-user and up to 10Mbps upstream from the end-user to the head end.

The service model of the ISP, generally the cable company, is also quite simple: a flat fee for a single IP Address assignment. There is little, if any, bandwidth provisioning, so no "levels" of service available for purchase, as there are in DSL technology based Services. Cable companies are quietly and consistently increasing the number of broadband access deployments throughout the United States. As the ISP, cable companies provide a single point of presence for both cable television service and high-speed Internet access. With all of this information in hand, it would seem that cable companies are well suited to provide access solutions to the MxU markets. But in fact there are limitations to cable modem technology that will prevent it from expanding beyond a certain point.

• Broadband access using cable modems is generally considered to be a U.S.-based technology and not nearly as prevalent or even in existence in other parts of the world;

- Access using cable modem technology is on a shared media. A typical local hub may connect anywhere from 500 to 1000 end-users meaning that the total downstream bandwidth of up to 27Mbps is shared among up to 1000 users. There is no guaranteed bandwidth per end-user, so performance can be severely impacted based on the number of users "logged on" at any point in time. This type of performance would not be acceptable to any business environment, and can severely affect the quality of streaming multimedia;
- Traffic is asymmetric in nature and has no symmetric capabilities. This will prevent the technology from extending into an office environment;
- From an xSP perspective, the lack of provisioning capabilities within the cable modem technology removes a significant level of value-add revenue;
- Because it is typical to have a single cable company in a specific geographic area, it is very difficult to "break" into the cable industry.

In spite of these drawbacks to cable modem technology, it will continue to remain a popular choice among end users for the simple reason that it currently offers a cheap, fast, and easy way to get high-speed broadband access to the end user. Though cable providers have the ability to provide voice services, it is not common and limitations exist in the capabilities of the set-top box that resides in the customer premise to support those services and still provide a competitive cost point. Additionally, cable providers are not seen by the public as the entity to provide a mix of services, they are seen only as the cable and Internet access provider. Cable companies and partners are attempting to address these shortcomings, among others, in order to allow the expansion of cable modem technology into more of the MxU environments. Until such point, cable modem will remain a popular choice for high-speed Internet access.

Conclusion： The idea of providing high-speed broadband access to the masses is undergoing changes as we speak because of the constant and increased desire for more bandwidth to support bandwidth- hungry applications. Deployments using ADSL technology have garnered much of the focus over the past three years, but the demand for bandwidth has easily outgrown the benefits provided by ADSL technology. Because of that, providers are looking at other technologies to continue to extend the Internet access to the end-user. VDSL is an exciting new technology that has the potential to open up improved Internet access to huge amounts of new users by leveraging technology that exists already – Ethernet, copper wire, the voice network and standard phone lines. The ability to support newer applications such as streaming multimedia, digital TV, collaborative gaming, VoIP and HDTV are promoting widespread anticipation of broadband access deployments using VDSL technology. Not since ADSL has such promise been shown by a technology. Because of its close relationship to ADSL, VDSL has addressed and staved off many of the pitfalls thatbefell ADSL. Broadband access deployments using VDSL technology are now taking place in niche environments such as the hospitality, MxU, education and business campus markets. Widespread implementations will occur once the standard is ratified and costs are competitive. VDSL can co-exist with ADSL, and will have to for some time because of ADSL's prominence in the marketplace. Because of the benefits, simplicity and the direction of the Internet towards "IP services everywhere," VDSL is well positioned to become the dominant high-speed broadband access enabling technology in the near future.