Netopia and the Standardization of VDSL2

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Executive Summary

As an important access technology for the delivery of voice, video, and data services, VDSL2 is poised to be broadly deployed by carriers hoping to capitalize on the triple play. While VDSL has historically been earmarked to handle the special needs of delivering high-quality video streams, it has not yet approached the level of ADSL standardization. The May 2005 issuance of the VDSL2 standard (G.993.2) by the International Telecommunications Union (ITU) is an important first step towards this type of interoperability. However, as evidenced by a similar evolution of ADSL, it is indisputable that true market-wide interoperability of VDSL2 will take years to arrive. Netopia has been successful in developing products that meet carriers' needs for years, including the years of pre-standard ADSL through to its current level of interoperability.

It has taken the same approach with VDSL2, working closely with carriers to identify their needs and delivering products based on today's dominant market technologies. As standards and the underlying silicon and related technologies move towards standardization, Netopia will continue to deliver products that meet the needs of its carrier customers, using market-leading technologies and evolving its products to adopt subsequent iterations of those technologies that adhere to published standards.

Introduction

Very high bit rate DSL 2 (VDSL2) is expected to be a key enabling technology for carriers planning to deliver triple play services by providing fiber-like bandwidth over existing copper lines that connect customer premises to fiber optic cables. As with previous versions of DSL, the process by which VDSL2 is deployed across a broad market will come about through a combination of market requirements, existing technology implementations, and standards bodies work. Many of these factors are already well advanced, and the May 2005 publication of the ITU-T Recommendation G.993.2 is an important milestone on the road to market-wide interoperability. However, mass deployment of standards-based, fully interoperable VDSL2 equipment is likely to take several years, as evidenced by the similar progression of ADSL.

This technical brief will provide a review of the background of VDSL to date, and as a frame of reference, will examine the similar evolution of ADSL from the early days of its adoption to its current state of standardized, highly interoperable products that are installed in mass carrier deployments worldwide.

The brief will then provide an evaluation of the pertinent elements of the new ITU Recommendation that have a direct impact on VDSL2 as it relates to carrier deployments of triple play services.

Finally, the brief will present Netopia's position in the evolving VDSL2 market and the company's objectives in providing highly marketable, standards-compliant VDSL2 customer premises equipment for carriers rolling out triple play services.

History of VDSL

Standardization efforts for VDSL began as early as 1995, with three separate standards organizations conducting work on VDSL: ANSI group T1E1.4, ETSI, and the ITU. Prior to this time, VDSL was known by a variety of other acronyms, including "VASDL" and "BDSL," until VDSL was agreed up by T1E1.4.

In 1997, a group of telcos banded together in an organization known as the Full Services Access Network, or FSAN, which also developed a VDSL requirements specification.

As ADSL gained market momentum in the late 1990s and early 2000s, VDSL standards efforts took a back seat across many of the standards bodies, in large part due to the fact that many of the same representatives from companies working on ADSL standards were the same needed to move VDSL forward. However, the acceptance of DMT-based ADSL over CAP-based technologies in 1999 would prove to be a catalyst for the selection of DMT for today's VDSL2 standard.

During this same time, there were many challenges associated with deploying ADSL on a massive scale, including the lack of detailed standardization and network management tools, spectrum management issues, specifications for filters, and more. The education involved in solving these issues has had a distinct impact on elements of VDSL2 standards and may allow mass deployment much earlier than happened with ADSL.

One of the most critical issues associated with VDSL has been spectrum management. The ANSI T1.424 specification issued in 2001 defined parameters for spectrum management, which helped lead the way to the TR-048 standard from the DSL Forum that specifies rate reach testing with different noise models. The more recent standard TR-067 extends those specifications even further. The organization is prepared to continue to stretch the rate reach performance of DSL technologies as a whole, driving continuous improvements in silicon design, DSP techniques, and hardware design.

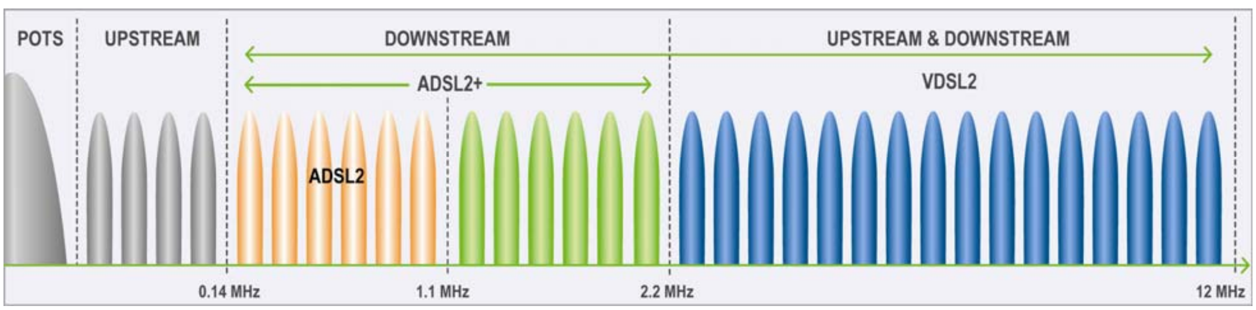

Figure 1: Spectrum Allocation

In 2003, eleven major DSL silicon suppliers collectively announced support for DMT line coding for standards-based VDSL, with a major motivator being the goal of greater interoperability and compatibility with existing ADSL installations. Carriers additionally had gained spectrum management experience with DMT-based ADSL that would apply to VDSL deployments. The competitive QAM modulation remains more widely deployed in Korea and Japan than other parts of the world.

Learning from ADSL Standardization

Although ADSL's lineage reaches back much farther than VDSL, it is useful to review how it evolved – both for the lessons that have been learned by vendors and carriers, as well as for how its maturity may serve to smooth VDSL2's standardization.

Bell Labs first developed a digital technology using standard copper lines in 1985, and in 1990 telephone companies began using HDSL to deliver T1 services. By 1995, innovative companies began to see ADSL as an ideal solution for high-speed Internet access over existing phone lines.

The first ADSL standard was issued by the ANSI working group T1E1.4 in 1995 (ANSI T1.413 Issue I), followed by the ETSI standard ETR 328 released in 1996 to address European DSL requirements. ANSI T1.413 Issue II was approved in 1998, closely followed by ETSI TS 101 388 for Europe. Concurrently, work towards an Issue III was submitted to the ITU-T, to develop the international standards for ADSL. The ITU-T issued the G.lite (G.992.2) and G.dmt (G.992.1) standards in June of 1999, which hastened the demise of CAP-based ADSL.

Also in 1999, the ITU issued the G.994.1 standard, also known as G.handshake, which specifies a common handshake interface between ADSL CPE and DSLAMs. G.994.1 is still the standard interface specification used today for ADSL, as well as for VDSL2.

At the same time that significant progress was being made on standards development, a group of silicon and equipment vendors, service providers, and others formed what was then known as the ADSL Forum in December 1994. The Forum's name was subsequently changed to the DSL Forum to represent a broader selection of DSL technologies. The DSL Forum was instrumental in driving vendor interoperability through "plug fests" and interoperability testing performed at third-party testing facilities such as the University of New Hampshire.

As the G.lite and G.dmt standards were issued, Microsoft and Intel stepped behind G.lite, forming the Universal ADSL Working Group (UAWG) in conjunction with Compaq. The goal of the UAWG was to promote ADSL as a retail-level product that could be installed by consumers. However, in order for this approach to succeed, carriers would have had to deploy G.lite DSLAMs across their networks. G.dmt was the preferred solution for carriers, preventing G.lite from reaching mass market acceptance, and cementing G.dmt as the broadly accepted standard.

The ITU standards G.992.3 (G.dmt.bis) and G.992.4 (G.lite.bis) were issued in 2002 defining ADSL2, and specifying features and functionality designed to improve performance, interoperability, reach, diagnostics, many of which features were geared towards carrier requirements for mass deployment.

The ADSL2+ standard G.992.5 was issued in 2003, which increased shorter distance bandwidth to 24 Mbps over line lengths of 3,000 feet or less.

From the initial issuance of the first ANSI T1E1 standard in 1995, it took at least seven years to reach full broad market interoperability. However, subsequent standards, such as ADSL2 and ADSL2+ have reached interoperability much faster due to the underlying standards upon which they are based.

The graphic below shows a comparison of data rates in varying loop lengths for ADSL2, ADSL2+, VDSL1, and VDSL2.

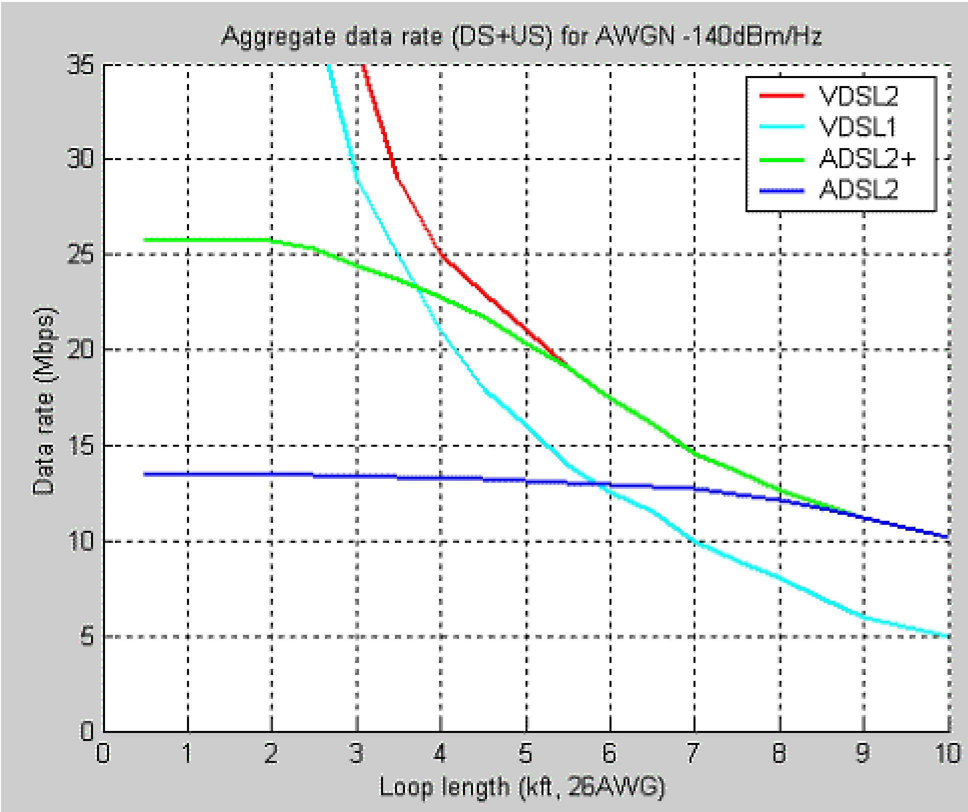

Figure 2: Data Rate Comparison

Standardization of VDSL2

ITU Standard

The ITU VDSL2 Recommendation announced in May 2005 – ITU-T G.993.2 – defines a number of elements key to the delivery of triple play services, particularly the highly quality-sensitive needs of video delivery, including delivery of multiple high-definition TV (HDTV) streams. Some of the more important areas defined are DSL Forum TR-069 management, filter specifications, spectrum management, and coexistence within bundles of other transmission cables.

G.993.2 permits the transmission of asymmetric and symmetric aggregate data rates up to 200 Mbps on twisted pairs – up to 100 Mbps both up and downstream. The ideal deployment scenario is the ability to deliver a guaranteed 10 Mbps over 7,000-foot loops – and as IP-based access networks become more prevalent, these loops will operate similar to Ethernet LANs.

Based on the ITU Recommendations G.993.1-2004 for VDSL and G.992.3 for ADSL2, G.993.2 specifies only DMT modulation. It also includes worldwide frequency plans that allow asymmetric and symmetric services in the same group of wire pairs, by designating frequency bands for the transmission of upstream and downstream signals.

Transceiver and power specifications have been defined that address many types of ingress and egress interference that are likely to occur in the types of environments most likely to house VDSL2 equipment, such as central offices, wiring cabinets in neighborhoods or office parks, or within buildings.

Other key enhancements from the earlier VDSL and ADSL2 specifications include:

- The definition of different profiles to support a wide range of deployment scenarios, such as those identified above
- Improvements to initialization, including a channel discovery phase, that provides better interoperability
- Support for an optional extension of the US0 band to 276 kHz and performance improvements to US0 that takes into consideration the needs of carriers worldwide who have varying spectrum requirements to deliver different services such as POTS and ISDN
- Of particular importance to ensuring clear, reliable video feeds are support for optional cyclic extension up to 1/4 (16/64), improved framing based on ADSL2 with improved overhead channel, and support of Impulse Noise Protection (INP) up to 16 symbols. INP is vital to protect against interference from fans, engines, and the like.
- Support for ATM, STM, and PTM based on IEEE 802.3ah 64/65 octet encapsulation, to address the existing implementations of ATM worldwide, STM largely in Korea and Japan, and PTM for packet-based networks that will become more common as carriers move from a CAPEX to an OPEX emphasis
- Definition of a loop diagnostics mode similar to that currently being implemented in ADSL2+, along with support for a wide range of test parameters, adopted from ADSL2

While VDSL has always been intended for the delivery of video services, G.993.2 defines key specifications that will support mass deployment and takes into consideration the requirements of carriers around the world. Many of the elements addressed by G.993.2 are, in fact, the fruition of many of the concepts and ideals promulgated by FSAN organization nearly 10 years ago – with the added benefit of lessons learned from large-scale ADSL deployments.

Other Standardization Enablers

As evidenced by the past evolution of ADSL and other similar technologies, true standardization of VDSL2 will be reached through a coming together of specifications developed by standards bodies, revisions to silicon and equipment already in deployment developed in response to carrier requirements, “plug fests”, vendor alliances, and other interoperability efforts. The ITU standard is a significant step in the right direction.

Silicon availability. Today, a small but growing core of silicon vendors leads the DMT-based VDSL2 market, with very limited carrier deployments in Europe and North America. Korea and Japan have embraced QAM-based VDSL and are further along in mass deployments.

VDSL2 equipment based on existing silicon offerings comprises the market majority of VDSL2 implementations today. It can be anticipated that this equipment will meet the needs of carriers who wish to be early to market offering triple play services, and with equal certainty it can be expected that these same silicon vendors and others will evolve their offerings to adhere to the new standard.

Interoperability testing. As was the case with ADSL, the DSL Forum can be expected to drive independent interoperability testing, or “plug fests.” These activities will serve to help identify interoperability issues and, along with specifications identified in the ITU standard, will provide silicon vendors and equipment manufacturers with the information necessary to produce fully interoperable products. This is an evolutionary process that can be expected to take some years to complete.

Netopia and VDSL2

It is inevitable that VDSL2 will be widely deployed as a key enabler for triple play services. Recognizing the importance of the May 2005 issuance of the ITU-T G.993.2 standard, and the continuing work of the DSL Forum in identifying ever greater rate reach specifications and hosting interoperability testing, Netopia is committed to the support of the standardization of this vital technology.

As the progression of ADSL has demonstrated, it will be a number of years before widespread standards-based interoperability will be achieved for VDSL2. But because market needs are moving faster than standards-based interoperability, Netopia has already developed VDSL-based products that meet the needs of service providers deploying triple play services today. As silicon offerings evolve in order to meet all aspects of the ITU standard and attain true interoperability, Netopia will likewise evolve its product line to incorporate newer silicon.

While existing market requirements drive products that differ in some respects, the market will ultimately demand broadly interoperable, standardized products. To fulfill the requirements of forward-thinking carriers as well as support mass deployments of triple play services based on VDSL2, Netopia will continue to provide VDSL and VDSL2 products that meet its customers’ needs today, as well as support standards-based products for mass market acceptance moving forward.

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As Netopia’s vice president of hardware engineering, Philip Simmons has over 20 years of industry experience in the field of data and voice communications, specializing in architecture and design of DSL, Ethernet, wireless, and telephony technologies. Philip has been active in the development of international standards with participation at the IEEE, ATM Forum, and DSL Forum, including serving as editor of the DSL Forum VoDSL working group. Prior to Netopia, Philip served as Director of Advanced Architecture for StarNet Technologies, producing the industry’s first Integrated Access Device. Prior to StarNet, Philip was a Member of the Technical Staff for Advanced Micro Devices working on the architecture and design of Ethernet devices. Before AMD, Philip worked at Retix and at GPT as a Hardware Design Engineer for various bridges, routers, and packet switch exchanges. Philip gained a Bachelor’s Degree in Electrical and Electronic Engineering from the University of Portsmouth, his work has been published on many occasions, and he holds nine patents relating to Ethernet, QoS, and PCI.