Very high speed digital subscriber line 2 (VDSL2) was standardized as ITU-T G.993.2 in February 2006 as an enhancement to G.993.1 (VDSL) by the International Telecommunication Union (ITU), enabling the transmission of asymmetric and symmetric aggregate data rates up to 200 Mbit/s downstream and upstream on twisted pairs using bandwidth up to 30 MHz.

Based on discrete multitone (DMT) line code, the VDSL2 standard specifies eight (8) bandplans or profiles, optimized for different deployment scenarios. VDSL2 allows for operation in spectrum ranging from a minimum of 8MHz up to 30MHz, allowing for better performance under various loop length and noise/crosstalk scenarios. Its achievements include longer reach than VDSL (up to 2.4 kilometers from the DSLAM), and speeds of up to 100 Mbps symmetric on short loops. A significant feature is that VDSL2 uses Ethernet as a multiplexing technology, eliminating the use of asynchronous transfer mode (ATM).

As triple play services, including IPTV and enhanced video services, over multiple screens and formats (3D, HD) in a home and over-the-top (OTT) content is becoming a norm rather than an exception, average homes need in excess of 50 Mbps service to satisfy today’s communication and entertainment lifestyle. VDSL2 makes that a reality for the service providers and users in a cost-effective manner due to its ability to reuse existing copper network and provide high-bandwidth connectivity.

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>YEAR RATIFIED</th>
<th>DOWNSTREAM MAX</th>
<th>UPSTREAM MAX</th>
<th>BANDWIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADSL</td>
<td>1996</td>
<td>8 Mbps</td>
<td>1.0 Mbps</td>
<td>1.1 MHz</td>
</tr>
<tr>
<td>ADSL2</td>
<td>2002</td>
<td>12 Mbps</td>
<td>3.5 Mbps</td>
<td>1.1 MHz</td>
</tr>
<tr>
<td>ADSL2+</td>
<td>2003</td>
<td>24 Mbps</td>
<td>3.3 Mbps</td>
<td>2.2 MHz</td>
</tr>
<tr>
<td>VDSL</td>
<td>2004</td>
<td>52 Mbps</td>
<td>16.0 Mbps</td>
<td>12 MHz</td>
</tr>
<tr>
<td>VDSL2 17a</td>
<td>2006</td>
<td>100 Mbps</td>
<td>50 Mbps</td>
<td>17 MHz</td>
</tr>
<tr>
<td>VDSL2 30a</td>
<td>2006</td>
<td>100 Mbps</td>
<td>100 Mbps</td>
<td>30 MHz</td>
</tr>
</tbody>
</table>

“Zhone has become a worldwide leader in the FTTH space in the past year thanks to the strong success of its MXK Terabit Access Concentrator platform – which supports not only GPON and Active Ethernet but also ultra-high-speed copper connectivity – and Zhone is well-positioned to generate additional customer and market traction on the strength of its new FiberHome solution set,” said Erik M. Keith, Principal Analyst for Fixed Access Infrastructure at Current Analysis. “Zhone’s FiberHome solution provides operators with cost-effective technologies that enable incremental revenue generation from their network investments – whether a fiber overlay or enhanced utilization of existing copper. Finally, the FiberHome portfolio delivers the much-needed extended network/serving area reach that is critical for advanced triple-play applications – most notably, high bandwidth video services – and early reviews of the FiberHome portfolio indicate that Zhone’s customers will find success in doing so.”
xDSL evolution over the years has been driven by the goal of providing increased bandwidth while leveraging existing copper. VDSL2 functions over copper wires in much the same way as ADSL2+, with some key distinctions. In simplistic terms, while ADSL2+ utilizes 12 MHz of bandwidth and is limited to speeds of approximately 24 Mbps downstream and 3.3 Mbps upstream, VDSL2 utilizes up to 30 MHz of bandwidth to provide speeds of 100 Mbps both downstream and upstream within 1,000 ft. Data rates in excess of 25 Mbps are available for distances up to 4,000 ft. Leveraging existing copper, VDSL2 can deliver up to 15% improvement over ADSL2+ by avoiding ATM cell overhead.

VDSL2 has provided a major impetus to extend the life of copper networks and enable cost-effective high-bandwidth connectivity. VDSL2 theoretically doubles (2x) the downstream data rates delivered by VDSL and quadruples (4x) those delivered by ADSL2+ networks depending upon loop length and some other constraints. VDSL2 is particularly effective in the Fiber-to-the-Node (FTTN), Fiber-to-the-Building (FTTB) and Fiber-to-the-Curb (FTTC) topology as the service provider reuses existing copper deployed and enables high-speed connectivity to subscriber homes and businesses utilizing VDSL2 in the last-mile, with fiber being extended to the node, building or curb.

Whereas VDSL supported DMT (Discrete Multi-Tone Modulation) in the main body and QAM (Quadrature Amplitude Modulation) in a normative annex, VDSL2 was only specified to support DMT modulation. Since the underlying DMT modulation code is the same as ADSL and ADSL2+, VDSL2 is fully compatible with existing services and enables backward-interoperability with ADSL.

<table>
<thead>
<tr>
<th>VDSL2 Profiles</th>
<th>8a</th>
<th>8b</th>
<th>8c</th>
<th>8d</th>
<th>12a</th>
<th>12b</th>
<th>17a</th>
<th>30a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth MHz</td>
<td>8.5</td>
<td>4.312</td>
<td>4.312</td>
<td>4.312</td>
<td>12</td>
<td>4.312</td>
<td>17.7</td>
<td>30</td>
</tr>
<tr>
<td>Bandwidth KHz</td>
<td>4.312</td>
<td>4.312</td>
<td>4.312</td>
<td>4.312</td>
<td>2770</td>
<td>4.312</td>
<td>8.625</td>
<td></td>
</tr>
<tr>
<td>Tones D/S</td>
<td>1971</td>
<td>2770</td>
<td>4095</td>
<td>2098</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TX Power D/S dBm</td>
<td>+17.5</td>
<td>+20.5</td>
<td>+11.5</td>
<td>+14.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Throughput (Mbps, downstream)</td>
<td>50</td>
<td>68</td>
<td>100</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As telephone companies replace many of their main feeds with fiber (FTTC/N for example), this presents an opportunity for an additional application of VDSL2. By placing a VDSL2 transceiver in the home and a VDSL2 DSLAM in a cabinet, the distance constraints that VDSL2 faces past 1000 ft can be overcome by leveraging fiber. The VDSL2 DSLAM addresses the analog to digital to analog conversion problem that disables ADSL over fiber, and will convert the data received transmitting it over the fiber back to the CO where it is routed to its final destination. In effect, VDSL2 is a great fit for service providers deploying fiber across their networks given its ease to connect to these new, fiber networks.

Lower frequency VDSL2 profiles have better performance metrics over longer loops than higher frequencies but at the cost of slower speeds per user. Today the preference is towards VDSL2 17a and 30a profiles as some service providers are extending fiber closer to the subscriber and providing VDSL2 for the end-points.

Confined by limited loop length, VDSL2 30a is ideally suited for FTTB or FTTH deployments, offering data rate speeds of 100 Mbps, while VDSL2 17a is ideal for FTTT deployments. As a lower cost option, VDSL2 17a is an attractive alternative when the higher upstream rates of VDSL2 30a are not required.
MX-160 and MX-162 From Zhone Technologies

**Zhone’s MX 160** is a 1U Single Line Multi-Service (SLMS™) based IP-DSLAM providing 24-port VDSL2 30a high-speed Copper to the Premise (CTTP) connectivity with ADSL2+ fallback and 4x FE/GE uplink ports

Zhone’s MX 162 is a 1U Single Line Multi-Service (SLMS™) based IP-DSLAM providing 24-port VDSL2 30a high-speed Copper to the Premise (CTTP) connectivity with ADSL2+ fallback, 4x FE/GE uplink ports and 900 Ohm POTS splitters

As part of the Zhone FiberHome™ portfolio, Zhone is providing Fiber-to-the-Node (FTTN), Fiber-to-the-Curb (FTTC) and Fiber-to-the-Building (FTTB) solutions to extend operators’ last-mile reach with high-speed Copper to the Premise (CTTP), wire-speed Ethernet to the Premise (ETTP) and Fiber to the Premise (FTTP) connectivity to enable advanced broadband and multi-play services.

Zhone FiberHome portfolio was introduced in early 2011 to address FTTN, FTTB, FTTC and overall FTTx market opportunities. The MX 16x platforms are part of the Zhone FiberHome portfolio providing high-speed CTPP VDSL2 30a connectivity. Zhone’s high-speed CTPP solutions enables up to 100Mbps symmetrical connectivity in areas where fiber directly to the subscriber becomes cost prohibitive. In these cases, as an end-to-end solution, Zhone offers VDSL2 CPE and Central Office (CO) products to provide high-speed, long reach and cost-effective solutions for MDUs, remote terminals and CO deployments.

In a short span of time, the Zhone’s MX 16x platforms have been widely deployed globally and are installed in more than 10 countries today including the United States (US), Canada, Japan, United Arab Emirates (UAE), Germany, Norway, Finland, Poland and New Zealand. A key differentiator for the MX 16x platforms is its ability to offer **seamless ADSL2+ fallback**. ADSL2+ fallback is imperative due to the loop length limitation of VDSL2. As the performance diminishes below 100 Mbps symmetrical throughput due to distance limitations, the MX 16x platforms provides a threshold with seamless fallback to ADSL2+ connectivity.

“At Uniserve Communications, the MX-162 has enabled us to extend the reach of our network in the Greater Vancouver area,” noted Tom Samplonius, **vice president of network operations and technology, Uniserve Communications**. “Our customers are primarily residents in MDUs and business users in commercial and shopping centers. Using VDSL2, we have upgraded our network to provide a high-bandwidth service offering that improves the quality and reliability of the end-user experience. Zhone has helped us deliver a solution that will provide our customers with high-speed connectivity while cost-effectively addressing our network migration challenges to support critical bandwidth needs today and in the future.”

**Key Differentiators**

- VDSL2 30a 100 Mbps symmetrical connectivity
- ADSL2+ fallback
- 4x FE/GE Uplink Ports
- Optional POTS Splitters
- Dual Power Inputs
- Up to 4 Alarm Inputs
- Port Status LEDs
- Removable Fan Trays
- Link Aggregation, RSTP and EAPS Support
Since its introduction in Q1 2011, the MX-16x platforms have been deployed in over 10 countries while enabling advanced broadband connectivity and multi-service solutions for residential and business users. Some examples of commercial and business deployments of the MX-16x platforms include educational institutions and hospitality entities which have embraced the MX-16x for, both, new network build and network upgrades.

University Network
The first diagram depicts a university deployment in central United States where the university is managing its own new broadband network utilizing the MX-16x platform as the foundation for its access network. The MX-16x is deployed at a central site to provide VDSL2 high-speed connectivity to the dormitories, other student housing and various construction trailers located on-campus. Additionally, the same infrastructure is used for security and surveillance services on the entire campus. Multi-service capability and delivery of high-speed data access makes the MX-16x platform the cornerstone of the university’s new broadband network.

Managed Service Network
A significant deployment for Zhone’s MX-16x is with a leading ISP in southern United States. The ISP is responsible for a managed services network for a leading university with the ISP primarily responsible for providing high-speed VDSL2 connectivity and voice service to on-campus student and other housing facilities. Leveraging a carrier-class next-generation access platform from Zhone, the ISP is enabling cost-effective high-bandwidth downstream and upstream connectivity and multi-service capability to thousands of students at the university.

Hospitality Network
A highly popular deployment scenario for Zhone’s MX-16x platform is in a hospitality environment. Utilizing Zhone’s IADs and CPEs with WiFi capability, the MX-16x platform can be located in the main distribution center of the hotel and provide high-speed VDSL2 connectivity in every part of the hotel including lobby, rooms and all other indoor and outdoor facilities at the hotel. Triple play services, including voice, data and video, can be enabled utilizing the same network to provide cost-effective converged services for the hotel guests and patrons.

The xDSL technology has undergone tremendous advancements over the years and extended the life of the copper network that has been around for decades. With enhancements like Vectoring and Bonding, VDSL2 provides the bandwidth needed to become either a preferred or complementary option in the next-generation build-out as service providers weigh performance with cost metrics to make their technology choice for the future. 100 Mbps will quickly become the minimum benchmark for bandwidth requirement per home as communication and entertainment habits continue to evolve with the proliferation of OTT video, 3DTV, HDTV and, soon to be coming, ultra-HDTV.

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