WIRELESS NET DesignLine techonline Community

Comprehensive UWB tests give video a green light but caution on wireless USB (Part 1 of 3)

With 22 UWB based Wireless-USB products being certified, it's time to evaluate UWB technology. While most WiMedia Alliance entries ran at less than 10% of the 480 Mbits/s PHY rate over short distances, Pulse-LINK's CWave technology was fast enough for multiple HD video streams over good distances.

By Fanny Mlinarsky and John Ziegler
December 11, 2007

With the recent media attention on UWB and the announcements of 22 UWB based Wireless-USB (W-USB) products being certified by the WiMedia Alliance, the time has come to evaluate this exciting new wireless technology and see if it has delivered on the promise of transporting hundreds of megabits per second while delivering superior QoS.

This test was organized with the cooperation of WirelessNetDesignline and EE Times and sponsored by Pulse~LINK, a vendor of UWB silicon. Our plan was to have a group of UWB companies collectively sponsor the test to promote their recently announced UWB products. UWB silicon providers and system vendors were invited to participate or to co-sponsor the test.

Based on the wave of recent WiMedia certifications, we anticipated that the latest and greatest WiMedia reference designs would be submitted for the test. However, none of the WiMedia vendors chose to participate and we had to use off-the-shelf commercially available WiMedia W-USB products. This left Pulse~LINK as the only sponsor.

The Pulse-LINK CWave implementation focuses on video distribution and embodies the complete point-to-point and point-to-multipoint communication system with TCP/IP throughput of over 500 Mbps and reaching 890 Mbps at close range. By comparison, the top throughput measured over the WiMedia links was an order of magnitude lower—around 50 Mbps at close range.

Background

The initial public awareness of Ultra Wide Band (UWB) came about in February 2002 when the FCC allocated 7.5 GHz of spectrum—3.1 to 10.6 GHz—or use by UWB devices, enabling this previously classified military technology to be commercialized, as had happened with CDMA years before.

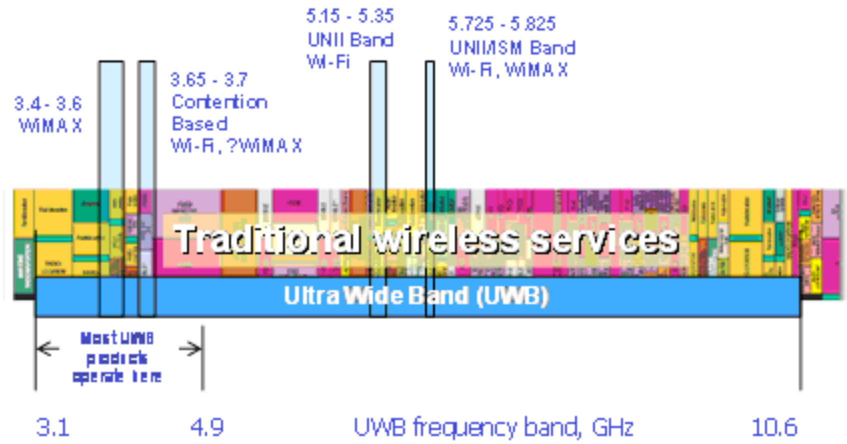

Figure 1: UWB operates in the noise floor of traditional wireless applications and is able to share the already allocated spectrum with other services while only negligibly raising their noise floor.

The unique benefit of UWB signaling— its ability to operate at the noise floor—enables UWB devices to peacefully co-exist and share spectrum with traditional wireless services (Figure 1).

The low transmit power authorized by the FCC (Table 1) curtailed the range of UWB links to about 10 meters limiting this technology to Wireless Personal Area Networking (WPAN) applications. This range is not a fundamental limitation of UWB technology itself. If transmit power limits were increased the range of UWB would increase as well.

Frequency range (GHz)	Average EIRP* (dBm/MHz)	Mode
3.1-10.6	-41.3	Intentional
1.99-3.1	-51.3	Unintentional
1.61-1.99	-53.3	Unintentional
0.96-1.61	-76.3	Unintentional
<0.96	See Part 15.209	Unintentional

* *Effective Isotropic Radiated Power*

Table 1: Indoor UWB emission limits in the US.

The FCC approved the UWB spectrum allocation and transmit power limit but did not specify an air interface, modulation or Media Access Controller (MAC) " specifications that were undertaken by the IEEE 802.15 committee in December of 2002 and abandoned in January of 2006. For more information, see the sidebar article IEEE 802.15 Standardization of UWB .

Today, UWB implementations are not constrained to any particular MAC or PHY and have the flexibility of using any MAC and PHY layers as long as they comply with the FCC spectrum mask limits.

Many of the companies originally working on the IEEE 802.15 standard joined the WiMedia Alliance creating their own specification of UWB based on OFDM PHY and a distributed USB-like MAC.

IEEE 802.15 standardization of UWB

While negotiating the FCC approval for UWB, the IEEE 802.15 member companies initiated a Study Group to adapt the emerging IEEE 802.15.3 specification to support the UWB physical (PHY) layer.

At the same time, led by Motorola, members of

This WiMedia specification was published as the European Computer Manufacturers Association ECMA-368 standard. Pulse-LINK developed and enhanced their original impulse-based UWB signaling and implemented their solution based on the IEEE 802.15.3b MAC.

UWB Applications

While the original goal of 802.15.3 was wireless video distribution with QoS, the WiMedia Alliance has chosen to focus primarily on the PC-centric W-USB application.

Pulse-LINK, an early pioneer of UWB technology, focused on the original Consumer Electronics (CE) application of UWB—HD video distribution. Pulse-Link's approach has an interesting twist in that they have developed their CWave architecture to work on both wireless and wired media such as coax, power-line and phone-line.

An innovative aspect of the CWave architecture is that any device using the Pulse-Link chipset is capable of supporting wireless, coaxial and power-line transmissions under a single 802.15.3b MAC, enabling HD video transport throughout the entire house on whatever media are available. The isochronous 802.15.3b MAC, with QoS built-in from the ground up, is designed to support whole-home networking of streaming video, multi-channel audio and high data rate networking.

Comparing PC-centric WiMedia products with CE-centric Pulse-LINK products may at first seem inappropriate, but with the rapid convergence of PC and CE devices the mission of both solutions is to move bits fast and with QoS that supports high quality video, audio and data. It is the speed and quality of UWB transport that we set out to test.

UWB video distribution

While Pulse-LINK persisted with the initial goal of 802.15.3—streaming and distribution of HD content and multi-channel audio—the WiMedia group has at least initially strayed from this goal. Only two WiMedia vendors, Tzero and Sigma Designs, announced HD video distribution architectures. And while both companies have announced availability of UWB silicon as far back as CES 2005, neither of them have commercially available products in the market and chose not to submit their reference designs for our test.

Our understanding is that WiMedia may embrace the video applications in the near future, but today most of the commercial WiMedia products are implementations of W-USB. One exception is the Toshiba port replicator that supports USB, Gigabit Ethernet and a video/audio link over a single UWB link, WiDV TM, which is based on the WiMedia

802.15.3 group formed the WiMedia Alliance to act as the trade group for standards that would emerge from 802.15.3.

The idea was for WiMedia to serve the same purpose for 802.15 based technology as the Wi-Fi Alliance did supporting uniform interoperability, certification, and promotion of the 802.11 technology.

The stage was now set for what was to emerge as the most contentious IEEE standards battle to date.

The IEEE 802.15.3a task group worked on the selection of an ALT PHY (ALTernate PHYsical layer) over the course of 3 years, until January 2006. During that time over 20 proposals were evaluated for selection as the ALT PHY.

Through the IEEE's down selection process, the proposals under consideration were finally reduced to two: MB-OFDM (Multi-Band OFDM) and DS-UWB (Direct-Sequence UWB).

DS-UWB was proposed by XtremeSpectrum / Motorola / Freescale. MB-OFDM was proposed by Texas Instruments and supported by the MBOA (Multi-Band OFDM Alliance), which was initially an association of proposers that contributed to the merged MB-OFDM proposal.

As the task group worked to reduce these two proposals to a single ALT PHY specification, the task group became deadlocked, alternating between selection of the two remaining proposals for over 2 years.

Originally, WiMedia had an open membership policy, welcoming any company interested in making products utilizing the IEEE 802.15.3 high rate PAN (Personal Area Network) standards.

In 2004, several MBOA member companies joined WiMedia as promoters, giving MBOA interests a majority on the WiMedia board. Eventually, WiMedia's board, either from frustration or as an exclusionary measure, decided that the IEEE process would never suit the needs of their membership, and sanctioned creation of not only a specification for the MB-OFDM PHY, but also creation of a completely new MAC.

Concurrent with this action, the MBOA controlled compatible air interface.

WiMedia board amended WiMedia's charter to exclusively promote the MBOA proposed MB-OFDM solution being considered for standardization by the membership of IEEE 802.15. WiMedia's MBOA membership saw this as a major symbolic win for the MB-OFDM technology that could not gain consensus as the IEEE 802.15.3a technical selection.

Today, there is no ultra-wideband based IEEE PHY standard, only the IEEE 802.15.3b MAC standard that is capable of supporting operation with almost any high performance PHY. WiMedia submitted its technical specifications to ECMA (European Computer Manufacturer's Association) and subsequently published two documents, ECMA-368 and ECMA-369, which describe the current WiMedia MAC and PHY.

Video distribution: Throughput and network architecture considerations

Video content is transported and stored in a compressed format. Most broadcast and cable TV transmissions and conventional DVDs use MPEG-2 compression. H.264/MPEG-4 and JPEG 2000 are the emerging video compression formats that roughly double the efficiency of video transport and storage afforded by MPEG-2.

Format		Average throughput required for high quality video	
		480i60	1080p30
Broadcast Cable TV	MPEG-2	8 Mbps	20 Mbps
Windows Media Video DivX XviD QuickTime	MPEG-4 Part 10/H.264	5 Mbps	12 Mbps

Table 2. Throughput requirements for common video formats and resolutions.

The video transport media in a typical home include coaxial, twisted pair, powerline and wireless. Wired video transmission technologies, such as HomePlug and HomePNA perate within a spectral mask below 30 MHz in order to meet the FCC emissions limit. Pulse-LINK pioneered the use of UWB over these wired media. The wide frequency band of UWB enables CWave to outperform HomePlug and HomePNA on their native media.

Further advantage of the multi-interface CWave architecture is that a single device can simultaneously support multiple media, including powerline now supported by HomePlug and coax and twisted pair now supported by HomePNA. CWave's TDMA MAC can effectively bridge these disparate media by time-slicing the traffic over multiple network interfaces.

Editor's note: A list of resource links is available at www.wirelessnetdesignline.com/showArticle.jhtml?articleID=204800791.

The next installment of this series can be found at Comprehensive UWB product testing: Part 2: Architectural features of WiMedia and CWave..

About the authors

Fanny Mlinarsky *is the President of octoScope, a consulting firm focusing on architecture and performance of wireless* *data communications systems. She can be reached at fm@octoscope.com. **John Ziegler** is a data communications software development consultant with experience in communications protocols including 802.11, SIP, and a variety of voice and video technologies. He can be reached at john.ziegler@octoscope.com.*

Acknowledgements:

We would like to thank Agilent, ETS-Lindgren and Ixia for providing the equipment for our test. Agilent has provided the E4440A PSA Series Spectrum Analyzer and ETS Lindgren has provided Model 3117 Double-Ridged Waveguide Horn antenna for UWB spectrum measurements. Both the analyzer and the antenna cover the entire UWB frequency band from 3.1 to 10.6 GHz. Ixia has provided IxChariot for IP layer throughput measurements.