Bluetooth Seattle broadens the user experience through a transparent mix of technologies

As this special EWT section unfolds, improvements in ultrawideband (UWB) wireless and ultralow-power Bluetooth, it sheds light on the integration of UWB technology into Bluetooth specifications. It also describes solutions that bring the benefits of this integration to consumer and mobile communications products.

By Mark E. Hazen

Bluetooth Seattle is the code name for merging Bluetooth technology with WiMedia Ultrawideband (UWB) technology. Through the efforts of the Bluetooth Special Interest Group (BT-SIG), these technologies will merge elegantly under the Bluetooth umbrella to offer the 'next-level' user experience—ultrahigh-speed connectivity for portable devices.

Table 1 provides a comparison of the existing and developing Bluetooth technologies. The leap from 3 Mbps to 480 Mbps that this merger delivers will enable lightning-fast sync-up, sharing and streaming.

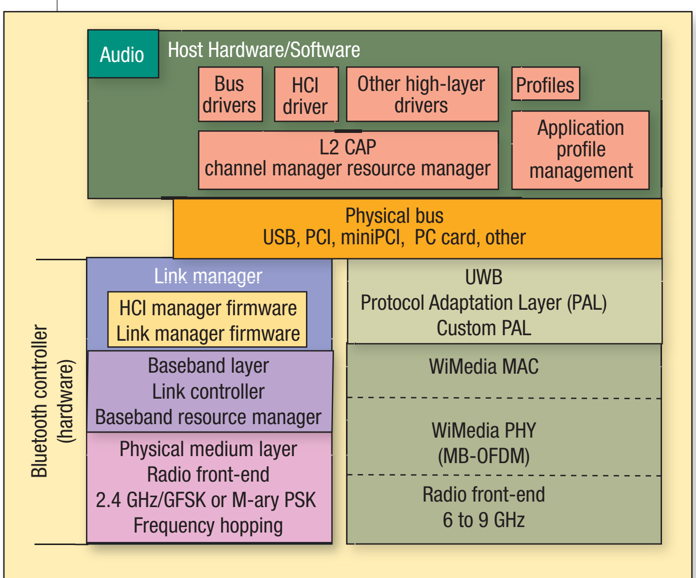

Figure 1. Bluetooth Seattle hybrid architecture.

Moving toward Bluetooth Seattle

The BT v2.1+EDR specification was ratified and released in August 2007 and will rapidly deploy throughout the globe in 2008. Meanwhile, the BT-SIG is hammering out the Bluetooth Seattle specification with product deployment in the 2008/2009 time frame.

Currently, Bluetooth-enabled devices use BT technology to stream low-bandwidth audio—music and voice.

"Bluetooth core technology has become even more user friendly and capable with the addition of secure simple pairing along with new low-power modes that extend battery life," said Gillian Ewers, vice president, UWB marketing at CSR. "The Bluetooth SIG is in the process of expanding the scope of Bluetooth by merging WiMedia UWB technology that will add a new dimension to the user experience—fast high-volume content transfer. This added functionality is seamless and will require nothing more of the user."

Cell phones, PDAs and personal media players (PMPs) must be loaded with music content using a transfer technology before the music can be enjoyed 'on the go.' How music content gets into the device requires a multistep process of connecting a sync cable to a host PC or manually loading a memory card in a PC-connected reader/writer bay. What the Bluetooth camp wants to do is make this process quick and convenient for the user—enter UWB.

Using the high-speed capability of UWB, embedded in the user device and content source, a library of music can be quickly transferred from source to portable device. UWB offers the speed of USB v2.0 and the convenience of not having to connect a cable or run software.

Using the data transfer case previously described, the user experience is enhanced and enabled in rapid device-to-device content sharing, video projector/display/TV connectivity for streaming video and presentations, kiosk connectivity for advertising and information and more.

The BT-SIG is working to achieve full Bluetooth backward compatibility while adding UWB in a hybrid radio design. In a typical use case, Bluetooth functionality is working in a discovery mode that determines application need. If the need is voice or music connectivity, the device remains in a basic rate (BR) mode (1 Mbps) or moves to an enhanced data rate (EDR) mode (3 Mbps). If it is established that high volumes of data are to be transferred (music library, video(s), photo(s)), the UWB radios in the source and receiver are engaged for the task followed by an immediate return to a low-power BT mode. This scenario is transparent to the user.

Bluetooth strengths carry over

To preserve the Bluetooth legacy, low-power operation is essential and battery life must be preserved. This is accomplished by using a low-power standby mode or a low-power BR or EDR mode and using UWB for short burst periods only, just long enough for data transfer to take place.

The WiMedia UWB radio has an extremely low-power output, on the order of 0.11 mW, and has the highest Mbps/ma ratio of all radio technologies. That means WiMedia UWB is fast and power efficient. The power consumed by the UWB radio is greater than an active BT radio, but the duration of use is short and infrequent.

Bluetooth devices use well-defined application profiles. These profiles ensure that a Bluetooth device will interoperate with any other device designed for that, or those, profiled applications regardless of who or where the device was manufactured. The same will be true for Bluetooth Seattle because the profiles will continue to be used and possibly expanded to add new ones in the future.

The Bluetooth Seattle architecture

Figure 1 proposes how the WiMedia UWB radio may be merged with the Bluetooth system core under a common host. In this hybrid architecture, UWB layers (green) are available for use under the control of the Bluetooth higher layers in the host. The UWB protocol adaptation layer (PAL) serves as a translator between the application profile management entity plus logical link control and adaptation layer protocol (L2CAP) and the WiMedia MAC.

Other radios could also be used. UWB is just one of the Bluetooth Seattle alternative MAC/PHYs (AMP), another one being the 802.11 radio. It is the intention of the Bluetooth SIG to expand the specification in such a way that other radios can be added in the future with a PAL for each.

The blue blocks of Figure 1 define the hardware and embedded firmware of the Bluetooth controller. The Bluetooth controller is a standard building block that contains three layers in hardware and firmware. At the lowest layer is the 2.4 GHz radio front-end—the next is the baseband

Specification version	V1.2	V2.0 + EDR	V2.0 + EDR	Ultrawideband Bluetooth Seattle
Adoption date	November 2003	November 2004	August 2007	Late in 2008 (Bluetooth/WiMedia Cooperation Agreement March 2006)
Applications	Cell phone, headsets, notebooks, car kits, printers, GPS, cameras, MP3 players,	Stereo headphones, sunglasses, radios, picture frames, PMPs	All previous applications	Short-burst high-volume content transfer between kindred devices and PCs. Streaming compressed video.
Freq. band	2.4 to 2.4835 GHz – 79 channels			Unlicensed above 6 GHz
Tx power (max.)	1 mW Class 3, 2.5 mW Class 2, 100 mW Class 1			-41.2 dBm/MHz (0.11 mW)
Range	Class 3: 1 m (consumer and medical) Class 2: 10 m (consumer apps.) Class 1: 100 m (industrial)			Up to 10 m
Speed	1 Mbps	1 Mbps basic rate		480 Mbps (PHY)
Air interface	Adaptive frequency hopping (AFH) across 79 channels – 1600 hops per second			WiMedia MB-OFDM (Multiband - orthogonal frequency division multiplexing)
Modulation	GFSK	Adaptive frequency hopping (AFH) across 79 channels – 1600 hops per second		QPSK/DCM
Multiple access	Time division multiple access (TDMA)			
Pairing	Many manual steps differing from device to device, including manual security setting		Nearly automatic discovery and encryption	
Battery life	1x	1x	Up to 5x improvement	Little impact because UWB mode is used in short burst only as needed.

Table 1. Bluetooth specifications and roadmap.

layer—then the link manager layer.

■ The physical medium layer consists of the radio front-end, which converts frame bits to analog symbols that are carried at some radio frequency or frequencies. For Bluetooth, the symbols are created using Gaussian frequency shift keying (GFSK) or M-ary PSK carried by RF energy in an adaptive, or dynamic, frequency-hopping scheme composed from a selection of 79 channels. The adaptive nature of the frequency hopping provides a means of avoiding interference.

In the UWB radio (green), orthogonal frequency-division multiplexing (OFDM) is used. It is a scheme in which a large number of evenly spaced carriers are orthogonally modulated using some multiple of quadrature phase shift keying (QPSK) or dual-carrier modulation (DCM).

■ The Bluetooth baseband layer includes the link controller and baseband resource manager along with a device manager (not shown). The link controller encodes and decodes packets based upon the data and parameters related to the physical channel, logical transport and logical link. The baseband resource manager has two functions: 1) schedule and grant time on the physical channel for all sources that have requested access and 2) negotiate access contracts with the sources, which establishes the quality of service (QoS) for each source. The device manager controls the behavior of the Bluetooth device and plays a key role in the discovery of other devices.

■ The link manager layer uses link manager protocol (LMP) to establish, modify and release logical links between Bluetooth devices. The link manager works to establish link status. It contains host-to-controller interface (HCI) firmware. The HCI firmware is used to form a bridge to the host via the HCI driver in the host. The HCI is used to ensure that the Bluetooth controller remains generic, as a standard part, and can be associated and controlled by any host. The Bluetooth protocol defines host controller interfaces, which enable the stack to be divided between the host processor and the Bluetooth controller chip(s). The Bluetooth v2.1+EDR HCIs are UART, SDIO and USB. These will be expanded in the new specification to ensure there are HCIs that can handle the high data rates of UWB.

Host

■ Crossing the physical bus to the host is the logical link control and adaptation layer protocol (L2CAP) running on the host processor. In many products, the radio chip(s) are under the direction of a host processor, where the majority of the software for the system is run. In this case, the Bluetooth controller is assumed to have limited data-buffering capabilities in comparison with the host. Therefore, the L2CAP layer is expected to carry out simple resource management when submitting packets to the controller for transport to a peer device. This includes segmentation into manageable sizes suitable for the controller buffers and organization into start and continuation packets, plus management of the use of the controller buffers to ensure availability for channels with QoS commitments.

■ The application profile management block manages services, which covers items like service discovery, connection and association along with profiles. The Bluetooth profiles define the possible applications. Bluetooth profiles are general behaviors through which Bluetooth-enabled devices communicate with other devices. A range of profiles describe different types of use cases. At a minimum, each profile specification contains information about its dependency on other profiles. Additional profiles are being developed for Bluetooth Seattle.

UWB radio

■ Linked to the host via the UWB protocol adaptation layer, is the WiMedia medium access controller (MAC). The MAC and managers provide synchronization and error control (ACK, REQ) to make communications possible between devices. After discovery and synchronization, the MAC and managers of communicating devices must exchange control messages to configure and manage the baseband MAC/PHY.

■ The Physical (PHY) layer of the UWB radio is part of the baseband processor. It is here that forward error correction is added and modulation takes place to form QPSK or DCM symbols on a large number of individual carriers (OFDM).

■ The radio front-end is used to mix the OFDM spectrum to move it from baseband to a range between 6 and 9 GHz.

Bringing it all together

The Bluetooth controller, L2CAP and profiles are used for device discovery, service discovery, error recovery and physical layer discovery to establish a UWB connection. In addition, the Bluetooth system is used to re-establish the UWB link if it is broken. By using a UWB PAL, the WiMedia MAC/PHY radio can be mated with and controlled by the Bluetooth system, making use of the Bluetooth profiles available.The Bluetooth system will handle all traffic unless it is discovered that a high data rate is needed. The service is passed seamlessly to UWB only as long as it is needed.

Bluetooth Seattle will retain all of the advantages of previous generations with the guarantee of backward compatibility while enabling the UWB functionality that leads to new high-speed applications. Low-power consumption will be preserved because the low-power Bluetooth BR/EDR side of the solution will be in control and will offer the high-speed capability when it is needed.

ABOUT THE AUTHOR

Mark E. Hazen is an electronics engineer and professional technical writer. He has written several college-level engineering textbooks, a paperback on alternative energy and innumerable articles covering analog circuits and communications. He is the editor for Emerging Wireless Technology, a bimonthly e-newsletter of RF Design.

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