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BLUWB?

In last month's Hot Topic, we discussed the evolution of the WiFi PHY and MAC including support for mesh networking. We suggested that this would bring WiFi into more direct competition with Bluetooth based personal area networks (PANS) and Device Access/Device Area Networks (DANS) including possible future integration with UWB based PAN/DAN solutions.

In this month's Hot Topic, we look specifically at how Bluetooth and UWB are evolving and how WiFi, Bluetooth and UWB might co-exist and complement each other in future applications including home networking and wideband wearable wireless.

The Bluetooth PHY

Bluetooth now has a new PHY extension known as EDR (enhanced data rate). This is based on using Pi4DQPSK rather than the GFSK used for the standard PHY ie three bits per symbol rather than one bit per symbol ie 2.1 megabits per second rather than the 721 kbps for v1.2 standard rate. The significance of EDR is not so much the higher headline data rate so much as the ability to support multiple simultaneous data streams - voice and image combined with wireless mouse and or wireless keyboard support for example. (The benefits of a flexible phy). This opens up new wearable wireless applications including MP3 transfer with simultaneous voice or multiple body worn device to device communication. It also moves Bluetooth more directly into competition with WiFi HiFi in the home entertainment space. An example would be using Bluetooth EDR to support Dolby 5.1 surround sound stereo (at data rates of typically 1 Mbps).

The UWB PHY

Home networking and personal area networking are however also target applications for UWB. Ultra wideband systems are generally considered as systems that occupy a bandwidth of at least 25% of the centre frequency of the system. The generic origin of wideband systems in military applications is that, in principle, the shorter the pulse, the wider the bandwidth and the wider the bandwidth, the greater the system gain. This system gain is analogous to the capture effect realisable from wideband FM and can deliver link margin benefits of 40 dB or more. The additional link margin can be used either to support very low transmit powers and/or high data rates over short distances and/or low data rates over long distances. From a hardware perspective, as CMOS geometries have reduced, it has become practical to build low cost pulse train generators and detectors with the bandwidth effectively dictated by the rise time of the IC process. In parallel, the FCC released (in February 1992) a spectral mask specification for UWB with a low band mask from 3.1 to 4.9 GHz and a high band from 6.2 to 9.7 GHz. The idea is to keep ultra wide band emissions well clear of GPS at 1.5 GHz and to notch out any potential interference with the 5 GHz U-NIII band (used for example by 802.11 a). The snag at the moment is that there are two competing PHY proposals - the DS-UWB PHY (www.uwbforum.org) and the Multiband OFDM PHY (www.multibandofdm.org)

The DS-UWB PHY

The DS-UWB Phy is based on a system developed by Xtreme spectrum, now owned by Freescale (formerly Motorola Semiconductor). DS designates that the PHY uses direct sequence spread spectrum variable length codes BPSK modulated on to the UWB pulse train. The data rate is scaleable from 28 Mbps to 1320 Mbps. The 28 Mbps data rate has a code length of 24, the 1320 Mbps rate has a code rate of 1 (ie no spreading gain). The range at 28 Mbps is typically 35 m down to 3.3 m at 1320 Mbps. There is a choice of FEC convolutional encoding ranging from ½ to ¾ to 1/1 . In other words, the 1320 Mbps is effectively an uncoded channel with no spreading gain. The channel can be uncoded due to the inherently low fading characteristics of the DS-UWB waveform. Given a good local path, UWB is therefore well suited to maximising throughput at minimum power ie the PHY can be optimised to support home networking (high data rates and plenty of power available) and/or personal area networking (lower data rates and very little power available).

There are six baseline chip rates defined at 1300, 1313, 1326, 1339, 1352 and 1365 MHz. The six chip rates can be used to differentiate up to 6 local piconets in low band or up to 12 piconets in combined low band /high band applications. The chip rates all have a 13 MHz offset and are divisible by 13 so all frequencies can be derived from the 13 MHz clock used in GSM and UMTS (typically using a low cost 26 MHz reference crystal). A lower gate count than OFDM should also deliver some cost and performance advantage.

The UWB Forum are promoting a common signalling mode (CSM) which would allow either of the PHYS to be used by a UWB device and support 'co-coordinated contention' between competing devices.

The Multiband UWB PHY

Originally promoted by TI and Intel, the multiband PHY proposals now have a wide body of industry support and for this reason should be considered as a plausible alternative even though the group is slightly behind DS-UWB in terms of practical implementation. In the multiband proposal, there is a 528 MHz lower band and 528 MHz upper band either side of the 5 GHz ISM/U-NIII band with each band split into multiple OFDM sub carriers. In this respect, it is similar to 802.11 g and 802.11 b and to DAB, DMB and DVB-H and could potentially benefit (both in terms of performance and power budget) from processor commonalities with these devices.

802.15 PHY/MAC Integration

Which points to a clear need to find some way of allowing WiFi, Bluetooth and UWB devices to work together. In principle this is what 802.15 is supposed to be doing. 802.15-2 addresses the co-existence of wireless personal area networks and wireless local area networks. 802.15-3 is setting out to establish an agreed standard for high rate (20 Mbit/s or greater) PANS and DANS or in other words UWB and/or WiFi based PAN/DAN topologies. 802.15-4 addresses low rate low power applications which could potentially be Bluetooth and/or WiFi and/or UWB. Power saving comes partly from lower data rates, partly from carefully managed power down and sleep mode and partly from reduced protocol and header overheads.

Distance and positioning support
In addition, UWB is being promoted for it's potentially super accurate location and position capabilities. The higher chip rates achievable in these broader band systems make it possible to get accurate triangulation information from multiple proximate devices and to get information from the delay paths of transmitted pulse trains. A 3D accuracy of =< 15cm is reasonably easily achievable and sub centimetre positioning is possible. This could be used to help devices interact with one another, to help people interact with devices and/or to help people interact with other people.

Integration with Near Field Communication (Nokia example)

There could also be some neat integration with the Near Field Communication initiative supported by Nokia, Philips and Sony.(www.nfc.com). NFC is intended to work at 13.56 MHz over a distance of a few inches at data rates of 106 k/bit/s and 212 k/bits/s and would be used to help initialise Bluetooth, WiFi and UWB protocols. A radio subsystem designed to sort out other radio sub systems. The intention also is also to make NFC compatible with contactless smart card infrastructure products like Philip's MIFARE technology and Sony's Felica card which would open up new application opportunities in wireless driven access control.

Integration with IrDA
And last but not least, the integration could extend to include the ETSI/ARIBN IrDA Area Infra Red (AIR) multi point infra red specification. This extends infra red to support 1200 beamwidths and a 4 M/bit 4 metre or 260 k/bit 8 metre data rate/distance capability with the option of adding 3600 optics (with some reduction in sensitivity). See www.irda.org for additional background.

Summary
WiFi (802.11 a, b and g), Bluetooth (1.2 and EDR) and UWB (DS UWB and Multiband OFDM UWB) are all evolving both in terms of PHY and MAC functionality. New capabilities open up new application opportunities both in home networking (the moving of audio and video between multiple devices) and in personal area networking (wideband wearable wireless).
As often happens, we are spoilt for choice in terms of radio layer and MAC layer options any of which are capable of fulfilling the application requirement. It comes down to cost versus capability and on this metric, UWB offers interesting potential advantage providing present intellectual property and licensing issues are resolved. Much of the relevant MAC layer and higher layer protocol work has however already been done within the Bluetooth SIG (special interest groups) hence the appeal of integrating Bluetooth, UWB and WiFi in to a common BluWB family tree.

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