

UWB COMMUNICATIONS – A STANDARDS WAR

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Abstract- Ultra Wideband radio communications is an emerging technology for very high speed wireless communications, especially suited for data connections between consumer devices such as computer peripherals, laptops, PDAs, home theater equipment, digital cameras and portable audio devices. Key advantages of UWB include unprecedentedly high wireless data transfer speeds (ranging from 100 Mb/s to 500 Mb/s or more), low power consumption, very high spatial capacity of wireless data transmission, and sophisticated usage of radio frequencies that allows UWB to coexist with other simultaneously operating RF systems. At present, two competing proposals are being presented as candidates for a UWB communication standard under IEEE standardizing process. The IEEE 801.15.3a Task Group has been trying to reach a decision upon a standard for a UWB Physical Layer (PHY) specification, but the opposing parties, Motorola and the MBOA Alliance (consisting of more than 90 companies as of April 2004), have been unable to agree. It is unclear if the IEEE process will ever reach its goal as both parties may eventually start launching products hoping their products will eventually emerge as de facto standards.

Keywords- UWB, ultra wideband communications, MBOA Alliance, Motorola, IEEE 802.15.3, a standards war.

1. INTRODUCTION

“As opposed to traditional narrowband radios, Ultra-Wideband (UWB) is a wireless digital communication system exchanging data using short duration pulses. The complexity of the analog front-end in UWB is drastically reduced due to its intrinsic baseband transmission. Based on this simplification and the high spreading gain it possesses, UWB promises low-cost implementation with fine time resolution and high throughput at short distances without interfering with other existing wireless communication systems.” (Stanley Wang, Berkeley University UWB Group) As the above quote suggests, impulse radio UWB is fundamentally different from what is usually thought of RF communications. Instead of using a carrier frequency, as traditional systems like FM radio or GSM networks do, the UWB impulse radio technology is based on sending and receiving carrier less radio impulses using extremely accurate timing (Win and Scholtz, 1998). The radio impulses are transmitted in sub-nanosecond intervals which inherently lead to spectrally wide signals and a very accurate spatial resolution, which can be taken

advantage of in positioning applications. Very fast impulse rates enable high connection speeds, up to 500 Mb/s or even 1 Gb/s over short distances. Because UWB signals occupy a very broad radio frequency spectrum, low transmission power must be used in order not to interfere with existing RF systems, such as GPS. The practical approach is to set UWB power levels so low that the signals cannot be distinguished from external noise by traditional RF systems operating simultaneously in the overlapping frequencies. UWB is not a new idea: it actually dates back to the 1980's (Foerster et al, 2001). However, it has been used mainly in radar-based applications since the timing and synchronization requirements of UWB communications have been too challenging for producing reasonable cost consumer products. However, recent developments in semiconductor technology have made consumer applications possible, and the regulatory steps taken in the US, namely by the Federal Communications Commission in 2002, have speeded up industry efforts aiming at product launches. During the last 12 months the efforts of the industry have been aimed at designing the best possible UWB solution for consumer devices. Everything started out as impulse radio but after FCC published the regulations for commercial UWB devices, the field has split in two: an impulse radio UWB approach backed by Motorola, and a multi-band OFDM solution backed by a 90-company industry alliance, MBOA (Multi-Band OFDM Alliance). The two opposing standard proposals have been presented (IEEE, 2004), and now both parties continue to develop their own products, as well as participate in the formal standardizing process. Full-fledged standard proposals can be expected from either party during the next couple of months. From a communications point of view UWB is not a technology for cellular networks, instead it can be seen as a complementing technology for WLANs. However, the most prominent application field for UWB is WPAN, wireless personal area networks, or to put it in more practical terms: cable replacement. This application field in particular lets UWB excel in what it is best: very high bandwidth, short- to medium-range wireless connectivity at very low cost and very low power consumption. These features are, in the end the day, the key features of both UWB PHY proposals, even though they differ quite significantly from each other technically. In the above table UWB is compared to WLAN and Bluetooth, its closest parallels in wireless communication. Probably the biggest advantages of UWB compared to Bluetooth

or 802.11x are the capability reach 500 Mb/s data transfer speeds and a superior mW/Mbps ratio. In practice the UWB devices would consume about the same amount of power as Bluetooth devices but with a hundredfold data transfer speed. Wired solutions in the application field of UWB include USB (Universal Serial Bus), USB 2.0, and Fire wire (IEEE 1394). Not coincidentally, one of the higher data speeds specified for MBOA's UWB is 480 Mb/s, the exact speed of USB is 2.0.

Table 1: Wireless PAN and Wireless LAN Communication technologies in comparison

	Bluetooth	802.11b	802.11a	UWB
Frequency band	2.4 GHz	2.4 GHz	5 GHz	3 - 10 GHz
Typical carrier rate	1 Mb/s	5.5 Mb/s (max. 11 Mb/s)	36 Mb/s (max. 54 Mb/s)	100 - 500 Mb/s
Outdoor range	10-100 m	105 m (11 Mb/s) → 325 m (1 Mb/s)	30 m (54 Mb/s) → 305 m (6 Mb/s)	Appr. 10 m → 50 m
Indoor range (m)	10	30 m (11 Mb/s) → 60 m (1 Mb/s)	12 m (54 Mb/s) → 91 m (6 Mb/s)	Appr. 10 m
Availability	Now	Now	Now	2005?
Spatial capacity in kbps/m²	30	1	83	1000

2. BEFORE THE WAR

The UWB communications technology development started gaining speed in the end of 1990's as companies such as Discrete Time Communications and Xtreme Spectrum were founded (1996 and 1998, respectively). Each of the early developers were experimenting with the technology and presenting new results and product demos from time to time, but a real boost to the UWB R&D was given by FCC in February 2002 when FCC published new regulations under which it became possible to design UWB products for the commercial market. As things proceeded, several organizations and

working groups became associated with UWB-related issues. For example WiMedia Alliance (www.wimedia.org) was founded to take care of WPAN technology branding by bringing industry players together and providing e.g. compliance testing, hence assuring customers of a reliable and a well-known standard, pretty much in the same way as Wi-Fi works in the 802.11 field. The difference here is that WiMedia was founded way before UWB product launches whereas Wi-Fi came into being years after initial IEEE work on 802.11 standards. However, from a technical point of view, WiMedia works on a middle layer, for example, between the UWB physical layer (PHY) and a higher level standard such as Wireless USB and the physical layer is where the battle really goes on.

3. WARS ON STANDARDS

When two rival mutually incompatible technologies struggle to become a de facto or industry standard, the situation can be called a standards war (Shapiro and Varian, 1999). According to Shapiro and Varian these wars can end in a truce (possibly a compromised, common standard), a duopoly (two significant but incompatible solutions prevail in the market), or a battle with an ultimate winner and a loser. In the case of UWB communications technology the battle has been a very heated one for already a year with two counterparts, Motorola and the MBOA Alliance. According to the taxonomy by Shapiro and Varian (1999), standards wars can be classified as presented in the table below. Both the Motorola proposal and the Multi-Band OFDM proposal by define a technology that is by far incompatible with any existing communications devices, hence this is clearly a battle between rival revolutions.

Table 2: Types of Standards Wars

Your Technology	Rival Technology	
	Compatible	Incompatible
Compatible	Rival evolutions	Evolution versus revolution
Incompatible	Revolution versus evolution	Rival revolutions

(Shapiro and Varian, 1999)

Further, Shapiro and Varian (1999) name seven key assets that are usually decisive in waging a standards war. These are:

- 1) Control over an installed base of customers
- 2) Intellectual property rights
- 3) Ability to innovate
- 4) First-mover advantages
- 5) Manufacturing abilities
- 6) Strength in complements

7) Reputation and brand name

Because we are looking at a case of rival revolutions, the asset number 1 does not really apply. Also the IPR issue seems of secondary significance as both parties own the key rights for their respective technical solutions. However, in the ability to innovate the competing parties differ. Both Motorola and the leading companies in the MBOA Alliance have a very strong reputation in designing and producing new high-quality products, but the MBOA Alliance has an advantage because of its sheer magnitude: with over 90 companies in the alliance today MBOA can be quite confident about its First-mover advantages bring another slight difference. Motorola's hands are on the technology developed by Xtreme Spectrum, an UWB pioneer now acquired by Motorola, and according to publicly available information the technology itself is mature, practically ready for commercial product launches any day now. The technology promoted by MBOA Alliance has developed rapidly during the last year, and the former time gap compared to Motorola has narrowed. However, as a 90-company alliance today, MBOA is not likely to be as agile in its moves, giving Motorola a possibility to try and launch consumer products before MBOA. The last three assets, however, seem to be strongly in favor of the MBOA Alliance: Manufacturing abilities, Strength in complements, and Reputation and brand name. With the huge industry backing MBOA can produce a vast variety of UWB-enabled products compared to Motorola, and especially in the strength in complements the alliance seems invincible. Having companies like Intel (motherboards, processors), Nokia (mobile equipment), Samsung, Panasonic, Philips, Texas Instruments, Fujitsu, NEC, Toshiba, and Hewlett-Packard (consumer electronics, computers, peripherals) onboard, the MBOA Alliance companies clearly have the power to introduce a dominant design. Capability to bring about successful new products in all application fields of UWB technology.

4. CASE MBOA

The MBOA Alliance (Multi-Band OFDM Alliance) was formed in June 2003 but the story of the alliance dates back to October 2002 when several UWB developer firms started to discuss multi-band approaches to the UWB development. However, the bandwagon started originally rolling already in February 2002 when FCC released its first report and order on UWB regulations (FCC, 2002). The regulations were read and understood by several UWB developers and this time from a slightly different viewpoint. Keeping the goal in producing an efficient solution to the actual problem: very high speed wireless connectivity with low cost and low power consumption (enabling cable replacement), these companies put aside the traditional impulse

radio approach to UWB communications, and instead came up with a multi-band approach. In this approach, parts of the 7.5 GHz wide free spectrum appointed by FCC were divided into more than 500 MHz wide slices. This allowed two advantages. First, separate 500 MHz wide bands were much simpler to implement with current CMOS compared to several GHz wide impulse radio signals, and second, these 500 MHz bands could be dynamically turned on and off which made possible adjusting the UWB traffic according to local radio conditions. With these intentions, six UWB developer companies formed the Multi-Band Coalition (MBC) in January 2003.

However, already in March 2003 Texas Instruments presented a radically enhanced radio implementation, the Multi-Band OFDM, which integrated UWB with the proven Orthogonal Frequency Division Multiplexing, also used in ADSL, DVB, 802.11a, VDSL, and many other current radio communication technologies. (At the same time, March 2003, Motorola teamed with Xtreme Spectrum in backing the opposing physical layer proposal for UWB which uses Direct Sequence Code Division Multiple Access, or DS-CDMA.) The battle for a standard in IEEE continued for the rest of the year 2003. Many companies joined the MBOA, but Motorola still managed to restrain the alliance from gaining the necessary 75 % of all votes in the IEEE process, despite voting in numerous meetings. This leads the alliance into forming a new special interest group (SIG) in January 2004, in which MBOA tries to put its proposal forward without a formal decision from IEEE.

5. UWB BATTLE FIELD TODAY

Motorola, after buying all assets of Xtreme Spectrum, continues to support its own proposal for an UWB PHY, whereas MBOA consists today of over 90 member companies such as Intel, Microsoft, Nokia, Samsung, Philips, Panasonic, Hewlett Packard, Toshiba, NEC, Fujitsu, Sharp, Mitsubishi, Olympus, Realtek, TDK, Texas Instruments, VIA and so on.

As the latest actions, Motorola has announced a very liberal IPR policy if its proposal becomes selected, to which all MBOA members have responded by agreeing to the IEEE policy and providing any IP adopted as part of the 802.15.3a standard specification under Reasonable and Non-Discriminatory (RAND) terms.

In February 2004 Intel unveiled its plans to support MBOA proposal as a building block for Wireless USB or WUSB, delivering same speeds as USB 2.0—480 Mb/s—over distances up to 10 meters. (Ultrawidebandplanet.com, 2004). Soon after this Motorola came out with a compromise proposal for the IEEE standardizing process, according to which both MBOA and Motorola versions of UWB physical layer could coexist in the same standard.

6. CONCLUSIONS

Since late 1990's and early 2000's when impulse radio UWB was a very hot topic—hyped with the most laudatory technical superlatives, a lot has changed. The FCC ruling on UWB in February 2002 seems to have been a great divider after which the technology development gained a lot of speed and got entirely new directions. Although the FCC ruling was made in the spirit of impulse radio UWB—having special emphasize on several impulse radio applications such as ground penetrating radar and super accurate positioning—it has turned out that instead of giving rise to impulse radio UWB products, the FCC regulations just opened up an unprecedentedly wide free spectrum slot (of more than 7 GHz, ranging from approximately 3 GHz to 10 GHz) which now is likely to become used for multi-band OFDM Wireless PAN networking. Despite this partly unintentional and very complex evolution path, UWB communications technology is likely to have a very bright future. The trend of “unwiring” is very strong in all sectors of consumer electronics, and as the amount of personal data keeps growing (due to the introduction of digital cameras, camera phones and camcorders as well as the digitalization of TV content), the demand for very high speed wireless data transmission is growing. Besides PC-to-Media Device connections and cable replacement in ICT installations, UWB will also be needed in for example home theaters where high bandwidth signals must be transmitted from source devices to the video projector and multiple speakers, all in situated in different corners of the room. The standards war itself seems almost over. When it comes to PC-related cable replacement solutions and things like Wireless USB or Wireless Fire wire, the multi-band OFDM solution seems the inevitable choice. The MBOA Alliance has the market power and the technical expertise to pull it off, which makes it merely a matter of time. According to their press releases, consumer products can be expected during the year 2005, regardless of the progress in IEEE. However, this does not mean that Motorola's UWB proposal will die out. Latest version of the DS-UWB by Free scale Semiconductor (former Motorola's Semiconductor Products Sector, now spun off) claims to provide 1.3 Gb/s with two meter range and a lot higher efficiency than the MBOA's proposal (Meade, 2004). It may well be that after all the market will get two different UWB versions that both become successful. This would require that the application field, product branding, and usefulness/usability issues eventually produce two very different technologies for different purposes, although at one point they competed for the same standard.

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