ULTRA WIDEBAND TECHNOLOGY CREATING A WIRELESS WORLD

Abstract:

Recent advancements in wireless technology have enabled a wide range of conveniences for the users. The need for wireless connectivity has extended well beyond the business world and has entered the consumer market, which in itself has brought new challenging demands to current Devices and technology. Soon there will be a demand for PCs, MP3 players/recorders, HDTVs, digital cameras, set-top boxes, cell phones, PDAs, and other digital equipment to have the ability to connect to each other wirelessly without losing quality of service. "However, today's wireless LAN and WPAN technologies cannot meet the needs of tomorrow's connectivity of such a host of emerging electronic devices that require high bandwidth".

Ultra-wideband (UWB) technology is Cost effective (in terms of power consumption and manufacturing costs) & brings the convenience and mobility of wireless communications to high-speed interconnects in devices throughout the digital home and office. Designed for short-range, wireless personal area networks (WPANs), UWB is the leading technology for freeing people from wires, enabling wireless connection of multiple device for transmission of video, audio and other high-bandwidth data. UWB, short-range radio technology, complements other longer range radio technologies such a Wi-Fi , Wi-MAX and cellular wide area communications.

Keywords: *PDA,HDDV,WI-FI,WPAN*

Conclusion:

Today, most computer and consumer electronic devices-everything from a digital camcorder and DVD player to a mobile PC and a high-definition TV (HDTV)-require wires to record, play or exchange data. UWB will eliminate these wires, allowing people to "unwire" their lives in new and unexpected ways. UWB, with its technical and economic advantages, should help enable mainstream adoption of WPANs. Intel envisions a world of pervasive wirelessly connectivity in the home and in the office for all- UWB can help deliver on that vision Low power, low cost, high data rates, precise positioning capability and no interference—UWB seems to have it all. Ultra wideband (UWB) has been described by some as one of the most promising technologies of our times. Recently, however, UWB technology focused on consumer electronics communications. We can fully appreciate the potential of UWB in these applications.

1. INTRODUCTION:

UWB is a Radio Frequency (RF) technology that transmits binary data, using low energy and extremely short duration impulses or bursts (in the order of picoseconds) over a wide spectrum of frequencies. It delivers data over 15 to 100 meters and does not require a dedicated radio frequency, so is also known as carrier-free, impulse or base-band radio. Once the PC manufacturers have adopted UWB as a short-range cable replacement solution, we believe that manufacturers of digital cameras, camcorders, and mobile CE devices such as MP3 players will follow suit. We anticipate cable-free and high-speed connections between the PC and such devices.

Potential markets for UWB

It is used to relay data from a host device to other devices in the immediate area (up to 10 meters, or 30 feet). UWB radio transmissions can legally operate in the range from 3.1 GHz up to 10.6 GHz, at a limited transmit power of -41dBm/MHz. Consequently, UWB provides dramatic channel capacity at short range that limits interference. Ultra Wideband was traditionally accepted as pulse radio, but the FCC and ITU-R now define UWB in terms of a transmission from an antenna for which the emitted signal bandwidth exceeds the lesser of 500 MHz or 20% of the center frequency. Thus, pulse-based systems—wherein each transmitted pulse instantaneously occupies the UWB bandwidth, or an aggregation of at least 500 MHz worth of narrow band carriers, for example in orthogonal frequency-division multiplexing (OFDM) fashion—can gain access to the UWB spectrum under the rules. Pulse repetition rates may be either low or very high. Pulse-based radars and imaging systems tend to use low repetition rates, typically in the range of 1 to 100megapulses per second. On the other hand, communications systems favour high repetition rates, typically in the range of 1 to 2 giga-pulses per second, thus enabling short-range gigabit - per - second communications systems. Each pulse in a pulse-based UWB system occupies the entire UWB bandwidth, thus reaping the benefits of relative immunity to multipath fading (but not to intersymbol interference) unlike carrier-based systems that are subject to both deep fades and intersymbol interference.

2. HOW UWB WORKS:

A UWB communication system

UWB broadcasts short digital pulses, which are timed very precisely (intervals of about 10 picoseconds) on a carrier signal across a very wide spectrum (number of frequency channels) at the same time. The duration of the short pulse is generally less than 1 nanosecond. Transmitter and receiver must be coordinated to send and receive pulses with an accuracy of a trillionth of a second. In a multiple access system, a user has a unique “pseudo-random” (PN) code. A receiver operating with the same PN code can decode the transmission. The UWB receiver consists of a highly accurate clock oscillator and a correlator to convert the received RF signal into a baseband digital or analog output signal. The UWB transmitter and the receiver are tightly coupled by means of an acknowledgement scheme where the transmitter waits for the receiver’s response for a specific time period (approx. 10 seconds). Specifically, UWB is defined as any radio technology having a spectrum that occupies a bandwidth greater than 20 percent of the center frequency, or a bandwidth of at least 500 MHz. Modern UWB systems use other modulation techniques, such as Orthogonal Frequency Division Multiplexing (OFDM), to occupy these extremely wide bandwidths. In addition, the use of multiple bands in combination with OFDM modulation can provide significant advantages to traditional UWB systems.The MultiBand OFDM approach allows for good coexistence with narrowband systems such as 802.11a, adaptation to different regulatory environments, future scalability and backward compatibility. This design allows the technology to comply with local regulations by dynamically turning off subbands and individual OFDM tones to comply with local rules of operation on allocated spectrum.

With the formation of the Multi-Band OFDM Alliance (MBOA) in June 2003, OFDM for each sub band was added to the initial multiband approach in order to develop the best technical solution for UWB. To date, the Multi-Band OFDM alliance has more than 60 participants (and growing) that support a single technical proposal for UWB.

In the MultiBand OFDM approach, the available spectrum of 7.5 GHz is divided into several 528-MHz bands. This allows the selective implementation of bands at certain frequency ranges while leaving other parts of the spectrum unused. The dynamic ability of the radio to operate in certain areas of the spectrum is important because it can adapt to regulatory constraints imposed by governments around the world.

The band plan for the MBOA proposal has five logical channels (see Figure). Channel 1, which contains the first three bands, is mandatory for all UWB devices and radios. Multiple groups of bands enable multiple modes of operation for MultiBand OFDM devices. In the current MultiBand OFDM Alliance's proposal, bands 1–3 are used for Mode 1 devices (mandatory mode), while the other remaining channels (2–5) are optional. There are up to four time-frequency codes per channel, thus allowing for a total of 20 piconets with the current MBOA proposal. In addition, the proposal also allows flexibility to avoid channel 2 when and if U-NII (Unlicensed-National Information Infrastructure) interference, such as from 802.11a, is present.

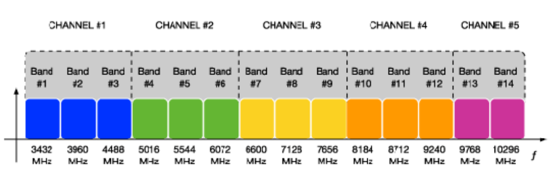


Figure 2. The MultBanc OFDM frequency band plan.

3. OFDM MODULATION:

The information transmitted on each band is modulated using OFDM. OFDM distributes the data over a large number of carriers that are spaced apart at precise frequencies. This spacing provides the orthogonality in this technique, which prevents the demodulators frequencies other than their own. The benefits of OFDM are high-spectral efficiency, resiliency to RF interference, and lower multipath distortion.

By using OFDM modulation techniques coupled with multibanding, it becomes easier to collect multipath energy using a single RF chain and allows the receiver to deal with narrowband interference without having to sacrifice subbands or data rate. These advantages relate to the ability to turn off individual tones and also easily recover damaged tones through the use of forward error-correction coding.

4. ADVANTAGES OVER TRADITIONAL SYSTEM:

The demand for high speed short-mid range data transmission has increased with the improving cell networks, video on demand applications, personal audio players, etc. In today's technology world no one wants to deal with cumbersome wires, especially with mobile devices. There is current wireless technology that can accomplish some of these demands, but not nearly as efficient as UWB. When determining whether a wireless technology fits the needs of specific applications one must take into account the spatial efficiency (i.e. effective use of spectrum), the energy required for the transceivers, and any other overhead costs associated with the physical characteristics of the technology. In comparing the spatial efficiency of current wireless technology for short range communications it is quite evident that UWB is far superior because of its inherent physical characteristics. The following example based on a 2001 Intel report on UWB will illustrate this:

1) IEEE 802.11b has a transmission range of 100 meters and a maximum data rate of 11 Mbps, and operates in the 2.4 GHz ISM band where there is enough room for three IEEE 802.11b channels of 22 MHz each. In a radius of 100 meters 3 non-interfering simultaneous transmissions could exist, which results in an aggregate throughput of 33 Mbps. Thus a spatial efficiency of roughly1,000 bits/sec/square-meter.

2) Bluetooth in low power mode has the ability to transmit 10 meters at a maximum data rate of 1 Mbps. Studies have shown that 10 simultaneous piconets can exist with minimal degradation, which yields and aggregate speed of 10 Mbps. Resulting in a special efficiency of approximately 30,000 bits/sec/square-meter.

3) IEEE 802.11a operating in the 5 GHz U-NII band can transmit data up to 50 meters at a peak rate of 54 Mbps. According to the specification 12 systems can concurrently operate, which results in an aggregate throughput of 648 Mbps. Therefore, the spatial efficiency is approximately 83,000 bits/sec/square-meter.

4) UWB systems at this point boast data rates over 50 Mbps with a range of 10 meters, and it was projected that six such systems could concurrently operate without significant signal degradation. Following the same procedure, the spatial efficiency would be over 1,000,000 bits/sec/square-meter.

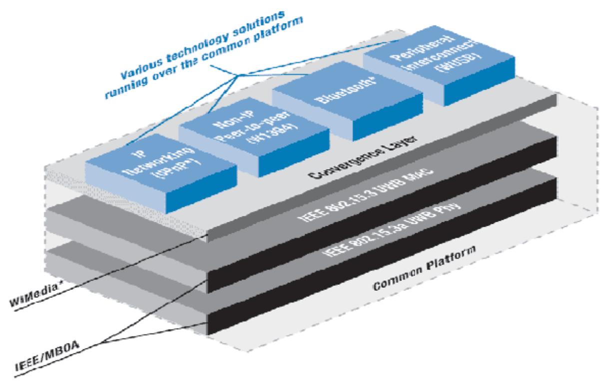
5.Wi-Fi Vs. UWB:

Wifi has a significant problem: the lack of what's known in the industry as Quality of Service or QoS. Instead , Wi-Fi uses a contention – based access scheme which is exactly what it sounds like , everybody that's trying to use the network musty fight for it. That works okay for data but it's death for video. Since most wireless routers aren't smart enough to prioritize data streams the more devices that are connected the slower the connection speed for all those devices. With video , the issue is particularly vexing since any data loss during transmission of these large files leads to image stuttering or worse.

Where does Ultra Wide Band come down on this? The WiMedia standard allows for bandwidth reservations for applications like video , ensuring the delivery of a high- Quality viewing experience

6.Wider Applications of UWB

The concept of a UWB radio spans many different applications and industries and has been coined the "common UWB radio platform." The UWB radio, along with the convergence layer, becomes the underlying transport mechanism for different applications, some of which are currently only wired. Some of the more notable applications that would operate on top of the common UWB platform would be wireless universal serial bus (WUSB), IEEE 1394, the next generation of Bluetooth, and Universal Plug and Play (UPnP). You can see a diagram of this vision in **Figure** .



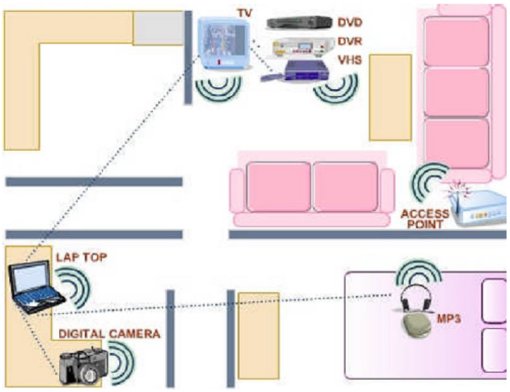
This concept has many potential applications since it creates the first high-speed wireless interconnects. UWB technology offers a combination of performance and ease of use unparalleled by other interconnect options available today.

APPLICATION AREAS FOR UWB:

Some of the potential areas considered for UWB application are:

1.Wireless Home Networks :

Typically, a wireless home network should provide connection among various electronic consumer devices such as PC, MP3 player, digital camera, printer, scanner, High-Definition TV (HDTV) and video game console. Some esoteric requirements such as home control appliances are also finding interest and adoption. However, the current popular usage of home networking is sharing data from PC to PC and from PCs to peripherals. With increased customer demand for home control, multiplayer gaming, and video distributions, significant efforts are being invested in building solutions around UWB enabled home networks.



Today's wireless home networks are directly connected to a broadband via cable or xDSL modem, and cover the entire domestic area from one point of access. This is usually referred to as the residential gateway. This is a mono-cluster approach, which may be cost effective but is ineffective for "whole house coverage". With the right wireless networking solution, home connectivity applications will continue to grow. For instance, an entire home theater environment could be constructed without cables, and it would completely replicate the wired experience. Additionally, home theater source content, such as the DVD player, could be broadcasted to another TV in a separate room in the house. With the right wireless solution, technology will have the opportunity to "follow" users throughout their home so that they can access content from any room. Broadband content from cable, satellite and ADSL service provider is difficult to route within the home without installing cables. With a wireless network, a single set-top box or gateway could distribute all the broadband content. Additionally, the set-top box could route Internet access traffic from multiple users within the home to the single broadband connection.

2. Radar in Automotive Industry:

A compelling application for UWB is radar in the automotive industry. It is ideally suited for collision avoidance, detecting the movement and location of objects near a vehicle, improving airbag activation and suspension settings . Studies prove conclusively that UWB will not interfere with GPS,
Especially as the first cars to have collision avoidance will be the same premium models that also host GPS-based Telematics systems. This will be important in North America, as safety is a key driver in the automobile industry , with airbags, GPS and E-911 emergency calling legislation.

3. Security applications:

Applications such as ground penetrating radar (GPR), through-wall surveillance, appear attractive given today's focus on detection, but are best handled by established systems companies.

4. Tracking applications:

Applications involving the tracking of children, personnel, equipment and inventory, to an accuracy of less than one inch, are attractive, especially as UWB can work indoors (factories, shopping malls),unlike GPS.

7. CHARACTERISTICS / ADVANTAGES OF UWB:

UWB technology has the following significant characteristics:

i. High Data Rates:

UWB technology can do things that the existing wireless networking systems cannot. Most importantly, UWB can handle more bandwidth-intensive applications like streaming video than Bluetooth because it can send data at much faster rates. UWB technology has a data rate of roughly 100 megabits per second, with speeds up to 500 megabits per second, This compares with maximum speeds of 11 megabits per second for 802.11b (often referred to as Wi-Fi) which is the technology currently used in most wireless LANs; and 54 megabits per second for 802.11a, which is Wi-Fi at 5MHz. Bluetooth has a data rate of about 1 megabit per second.

ii. Low Power Consumption:

When transmitting data, UWB devices consume less than several tens of microwatts. That is a huge saving and the reason is that UWB transmits short impulses constantly instead of transmitting modulated waves continuously like most narrowband systems do. UWB chipsets do not require Radio Frequency (RF) to Intermediate Frequency (IF) conversion, local oscillators, mixers, and other filters. The low power consumption makes UWB ideal for use in battery-powered devices like cameras and cell phones.

iii. Interference Immunity:

Due to low power and high frequency transmission, UWB's aggregate interference is "undetected" by narrowband receivers. Its power spectral density is at or below narrowband thermal noise floor. The low power level thus causes no irritating interferences to existing home wireless systems. According to its First Report and Order, the FCC requires that indoor UWB devices transmit only when operating with a receiver. A device connected to AC power is not constrained to reduce or conserve power by ceasing transmission, so this restriction will eliminate unnecessary emissions.

Additional tests conducted by the FCC have also demonstrated conclusively that UWB devices may be permitted to operate under a proper set of standards without causing harmful interference to other radio operations.

iv. High Security:

UWB's white-noise-like transmissions enhance security since receivers without the specific code cannot decode it. Different coding schemes, algorithms, and modulation techniques can be assigned to different users for data transmissions. Security can also be realized at the Media Access Control (MAC) level by allowing two devices to communicate with each other.

v. Reasonable Range :

IEEE 802.15.3a Study Group defined 10 meters as the minimum range at speed 100Mbps However, UWB can go further. The Philips Company has used its Digital Light Processor (DLP) technology in UWB device so it can operate beyond 45 feet at 50 Mbps for four DVD screens.

vi. Low Complexity, Low Cost:

The most attractive of UWB's advantages are of low system complexity and cost. Traditional carrier based technologies modulate and demodulate complex analog carrier waveforms. In contrast, UWB systems are made of "all-digital" with minimal RF or microwave

electronics. The inherent RF simplicity in UWB designs make the systems highly frequency adaptive and enable the to be positioned anywhere within the RF spectrum. Also home UWB wireless devices do not need transmitting power amplifier. This is a great advantage over narrowband architectures that require amplifiers with significant power back-off to support high-order modulation waveforms for high data
rates. The cost of placing UWB technology inside a consumer electronics device - is $20, compared with $40 for 802.11b and $65 for 802.11a.

One of the most significant advantages to ultra wideband is its ability to operate both wirelessly and over wires.

Characteristics such as high data throughput, low power consumption, interference immunity, high security, reasonable range, and low cost, make UWB highly suitable for home networks.

CHALLENGES:

- UWB devices will have to support a wide range of automotive operating temperature and failure rate
- Design cycle for automotive projects is quite long; measured in number of years, dealing with the tier one vendor, carmaker, design standards (QS9000), car trials (winter/summer tests) and production ramp-up. This all could be resource intensive and exhaustive
- The UWB device may require greater transmitting power owing to the amount of noise in an industrial setting
- Wide temperature range operation may be required for some environments