A Seminar Report

On

Ultrawideband

Presented By

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Madhur Ahuja

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Certificate

This is to certify that **Madhur Ahuja**, of class B.E. I.T., Roll No. 20, has successfully completed his seminar work on the topic

UltraWideband

under the able guidance of **Prof. Lalit Patil**, towards the partial fulfillment of the term work in the subject of

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in the academic year of 2004–2005.

Prof. Suhas Patil
(H.O.D.)

Prof. Lalit Patil
(Guide)

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Ultrawideband

Introduction

Ultrawideband is a wireless radio technology originally developed for secure military communications and radar that is now declassified. It is a high-speed, short-range wireless technology - nearly 10 times faster than 802.11b. It can be used for transferring digital content between devices in different entertainment and computing clusters in the home, such as digital video recorders, set-top boxes, televisions and PCs. UWB is designed to replace cables with short-range, wireless connections, but it offers the much higher bandwidth needed to support multimedia data streams at very low power levels. And because UWB can communicate both relative distance and position, it can be used for tracking equipment, containers or other objects.

While it has been used for a while by the military, UWB is now going through the necessary authorizations and developments for public and commercial use. Even thought the advancement of UWB has been somewhat slow, there's a possibility that UWB will become the "next best" technology for all types of wireless networks, including wireless LANs.

UWB chipsets are currently under development and testing by several companies, including Intel, Time Domain, XtremeSpectrum, Texas Instruments, Motorola, and STMicroelectronics and others. Intel is bouncing around the idea of implementing UWB technology into all of its chips.

Companies such as Sony and Panasonic hope to use UWB in their flat panel video displays, eliminating the need for wires while still broadcasting the highest quality images with full stereo sound. Other heavy hitting companies buying into UWB include Cisco and AT&T.

History of Ultrawideband

Ultra-Wideband technology has a history going back to Marconi and his original spark gap transmitters. The United States military re-invented it under a cloak of secrecy and black projects from the 1960's to the 1990's, where UWB was particularly well suited for modern RADAR and highly secure communications. One hundred years after Marconi's first demonstration of wireless technology across the Atlantic ocean we have wireless history in the making again. In 1998, the FCC recognized the significance of UWB technology and began the process of regulatory review. In May of 2000, the FCC issued a Notice of Proposed Rulemaking, accepting comments through the current period. Throughout early 2002, comments and review from the FCC, NTIA, Department of Commerce and DOD were received. The FCC adopted the formal rule changes permitting Ultra Wideband to operate on February 14, 2002.

Ultra Wideband (UWB) is only becoming commercially viable now through decreased costs and recent advancements in chip development, the evolution of the marketplace, and FCC recognition. What is driving UWB into the consumer market is the ability to render UWB circuitry into CMOS technology. Therefore as CMOS scales say from .25 to .18 to .13 micron so does the UWB circuitry. As a result some call UWB "Moore's Law Radio". Until a few years ago, the circuitry to implement UWB was power and form factor constrained. With UWB being done in CMOS this is no longer the case. As a matter of fact we will see smaller and smaller UWB devices over the next few years.

Potential commercial applications include distribution of wireless audio, video and data over local area networks for home and office. In addition UWB has the unique ability to resolve Geo-Positional location to centimeter accuracy as a by-product of sending and receiving data between multiple UWB devices. Think of wireless Internet and video capable devices such as smart phones, PDA's, laptop computers, web-pads, digital video cameras, automobiles and a wide range of consumer electronics and home appliances with extremely precise, GPS-like positioning.

Other advantageous features of UWB are penetration and signal power. In terms of penetration, for instance, an unfiltered pulse of 200 picoseconds duration, when applied through a Fourier formula, demonstrates signal energy throughout the spectrum between DC and 5 GHz. Obviously this is not a perfect square wave representation because the pulse is subject to some coloring from the antenna - and antenna technology is an extremely important facet of UWB technology - but with proper antenna implementations the distribution of energy is spread fairly evenly across the spectrum. A UWB receiver detects the presence of the energy of the pulse in time, not at specific frequencies, so absorption of specific carriers such as at 1.8GHz or 2.4GHz has little effect, provided that around 50% of the spectral energy density of the pulse penetrates whatever obstacles lie in the transmission path. Absorption at any one particular frequency does little to affect the integrity of the actual pulse.

In terms of signal power, the simplest conceptual demonstration would be to think of Morse code. Imagine hooking up a microphone to a one-watt transmitter and speaking into it. Your voice is being used to generate a complex modulation onto an analog carrier. That same complex modulation must be received and de-modulated at the receiver. In order to recover your voice at the receiver, the integrity of both the modulation and the carrier must be maintained. Although the carrier is capable of going great distances, the modulation is much more fragile and degrades quickly over distance. Therefore, you might be able to recover the voice modulated signal a mile or more away. Now, remove the microphone from the one-watt transmitter and attach a Morse code oscillator to the same one-watt transmitter. All you need to recover are the dots and dashes, (in essence, is the signal present or not?). These simple pulses can be detected at increased distances by a factor of over ten relative to a modulated carrier. In Ultra Wideband, we might radiate a 200 picoseconds (.2 billionths of a second) pulse of one-watt energy. At any given frequency between DC and 5 GHz the demonstrated energy of the pulse is beneath the noise floor, hence peaceful co-existence with carrier technologies.

Carrier based technologies must modulate and demodulate a complex analog carrier waveform, and incorporate the componentry required to do so. UWB, on the other hand, offers a truly binary form of communication that can essentially be boiled down to four components. The first is the UWB transmit / receive chip, the second is an UWB antenna. Third is a digital baseband processor that handles events like packetizing data, forward error correction, etc. Fourth is the embedded firmware and protocols that drive the digital baseband processor.

Why Ultrawideband

UWB presents a compelling solution to many of the challenges facing today's wireless industry.

- By many accounts, an impeding crunch in RF spectrum availability will bottleneck the evolution of wireless technologies. UWB does not use an RF Carrier, which opens up vast new "real estate".
- Variations in RF spectrum assignments from one country to the next essentially prohibits the possibility of global interoperability for RF based devices. Without such RF limitations, UWB offers the promise of global interoperability.
- RF spectrum is so extensively allocated that there is no RF bandwidth available to match UWB bandwidth potential.
- Devices using RF Spectrum are more complex, cost more, and consume more power than UWB.
- UWB, which operates in the "noise floor", offers greater security.
- UWB offers inexpensive Geographic Positioning.

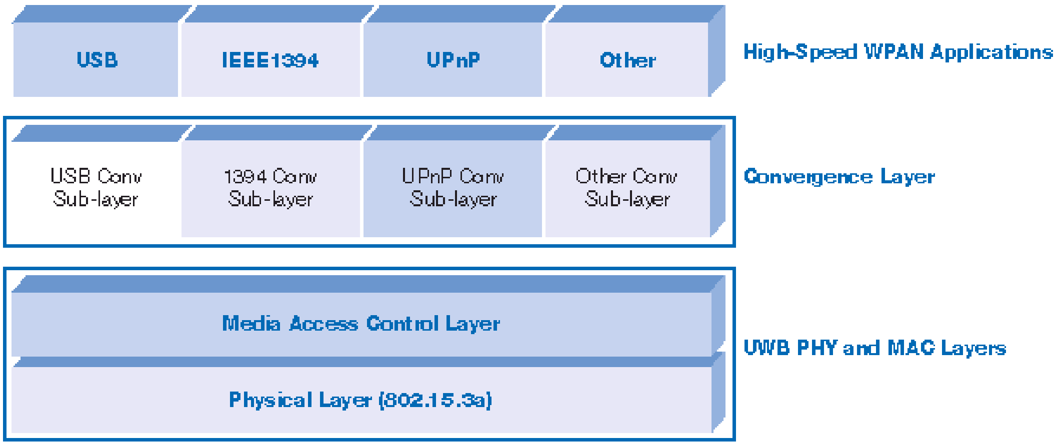
Ultrawideband Technology

UWB differs substantially from conventional narrowband radio frequency (RF) and spread spectrum technologies (SS), such as Bluetooth Technology and 802.11a/g. UWB uses an extremely wide band of RF spectrum to transmit data. In so doing, UWB is able to transmit more data in a given period of time than the more traditional technologies.

The potential data rate over a given RF link is proportional to the bandwidth of the channel and the logarithm of the signal-to-noise ratio (Shannon's Law). RF design engineers typically have little control over the bandwidth parameter, because this is dictated by FCC regulations that stipulate the allowable bandwidth of the signal for a given radio type and application. Bluetooth Technology, 802.11a/g Wi-Fi, cordless phones, and numerous other devices are relegated to the unlicensed frequency bands that are provided at 900 MHz, 2.4 GHz, and 5.1 GHz. Each radio channel is constrained to occupy only a narrow band of frequencies, relative to what is allowed for UWB.

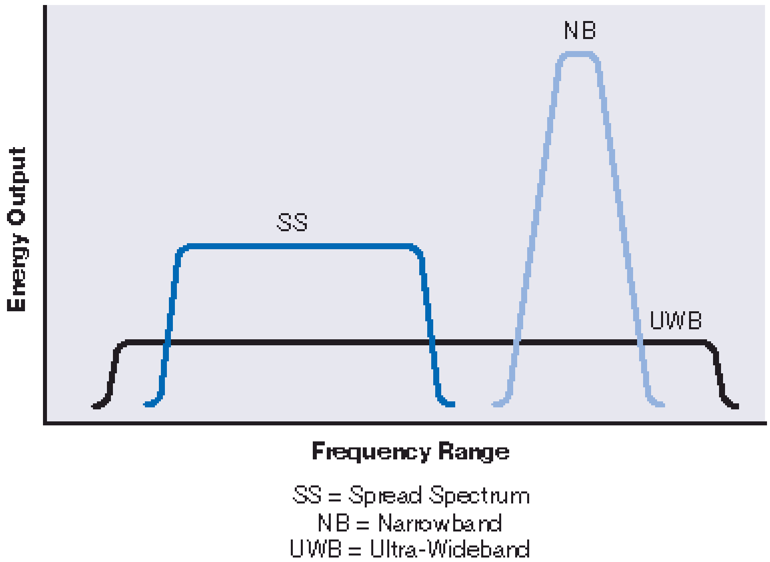
UWB is a unique and new usage of a recently legalized frequency spectrum. UWB radios can use frequencies from 3.1 GHz to 10.6 GHz—a band more than 7 GHz wide. Each radio channel can have a bandwidth of more than 500 MHz, depending on its center frequency. To allow for such a large signal bandwidth, the FCC put in place severe broadcast power restrictions. By doing so, UWB devices can make use of an extremely wide frequency band while not emitting enough energy to be noticed by narrower band devices nearby, such as 802.11a/g radios. This sharing of spectrum allows devices to obtain very high data throughput, but they must be within close proximity.

Strict power limits mean the radios themselves must be lowpower consumers. Because of the low power requirements, it is feasible to develop cost-effective CMOS implementations of UWB radios. With the characteristics of low power, low cost, and very high data rates at limited range, UWB is positioned to address the market for a high-speed WPAN.



Application and protocol layers for UWB

UWB technology also allows spectrum reuse. A cluster of devices in proximity (for example, an entertainment system in a living area) can communicate on the same channel as another cluster of devices in another room (for example, a gaming system in a bedroom). UWB-based WPANs have such a short range that nearby clusters can use the same channel without causing interference. An 802.11g WLAN solution, however, would quickly use up the available data bandwidth in a single device cluster, and that radio channel would be unavailable for reuse anywhere else in the home. Because of UWB technology's limited range, 802.11 WLAN solutions are an excellent complement to a WPAN, serving as a backbone for data transmission between home clusters.



Comparison of narrowband (NB), spread spectrum (SS), and ultra-wideband (UWB) signal concepts

Advantages of Ultrawideband

UWB offers many advantages over narrowband technology where certain applications are involved. Improved channel capacity is one major advantage of UWB. The channel is the RF spectrum within which information is transferred. Shannon's capacity limit equation shows capacity increasing as a function of BW (bandwidth) faster than as a function of SNR (signal to noise ratio).

$$C = BW * \log 2\ (1+SNR)$$

C = Channel Capacity (bits/sec)
BW = Channel Bandwidth (Hz)
SNR = Signal to noise ratio

SNR = P/BW *No
P = Received Signal Power

No = Noise Power Spectral Density (watts/Hz)
Shannon's equation shows that increasing channel capacity requires linear increases in Bandwidth while similar channel capacity increases would require exponential increases in power. This is why UWB technology is capable of transmitting very high data rates using very low power.

UWB does not use the traditional radio frequency carriers employed by cellular, satellite, television, cable or other communications technologies. Frequency based technologies must operate in specific slices of an increasingly crowded radio spectrum, otherwise they would interfere with one another. Because UWB signals will not interfere with each other or with conventional RF carriers, the technology has opened up vast new communications possibilities by creating a new communications medium that peacefully co-exists with existing technologies.

UWB is not line-of-sight. The fundamental physics of Ultra Wideband lends UWB technology to better propagation characteristics through walls and other obstacles. That is why UWB technology is also used for things like "through-the-wall" imaging devices and ground penetration radar.

Not only does it outperform traditional RF signals in cluttered environments, it can also use multi-path effects for error correction. Although a range of several miles is possible, the FCC limitations on broadcast power restrict range to wireless PAN and LAN applications – generally less than 100 meters.

Reduced Cost vs. Current Wireless Technology: Several areas for reduced cost exist due to the nature of UWB. UWB technology is made possible on a silicon germanium micro-chipset that will cost approximately $20 to $30 per device. UWB operates on microwatts, less than 1/1000 the power required by conventional cellular phones. The digital nature of the UWB transmission itself removes the need for significant componentry found in today's frequency based wireless devices that must modulate and demodulate a complex analog carrier RF waveform (the frequency carrier).

How UWB Works

Ultra-Wideband (UWB) technology is loosely defined as any wireless transmission scheme that occupies a bandwidth of more than 25% of a center frequency, or more than 1.5GHz. The Federal Communications Commission (FCC) is currently working on setting emissions limits that would allow UWB communication systems to be deployed on an unlicensed basis for radiated emissions of intentional radiators, the same rules governing the radiated emissions from home computers, for example. This rule change would allow UWB-enabled devices to overlay existing narrowband systems, which is currently not allowed, and result in a much more efficient use of the available spectrum. Devices could, in essence, fill in the unused portions of the frequency spectrum in any particular location.

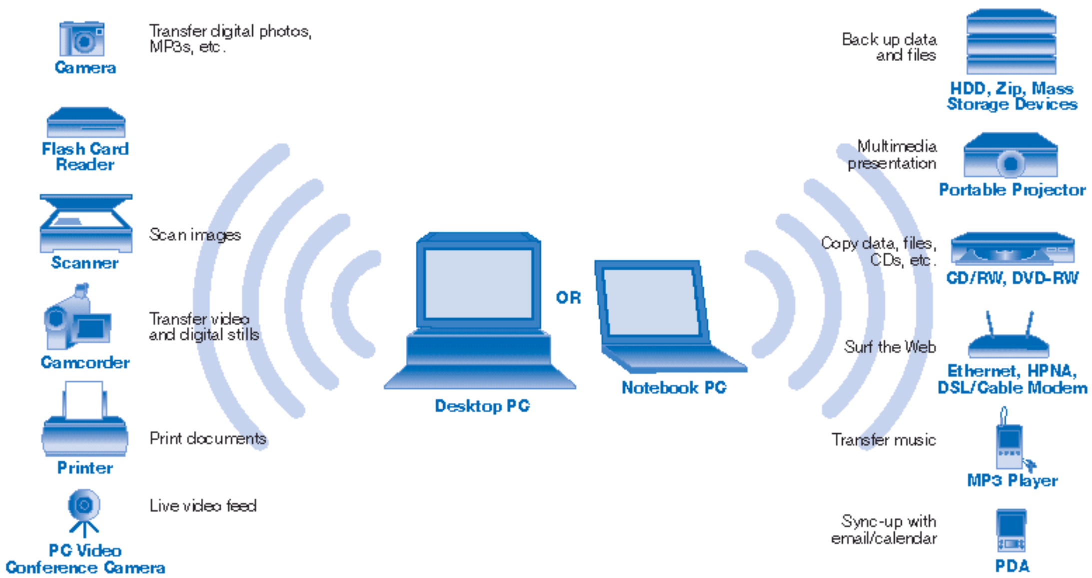
A traditional UWB transmitter works by sending billions of pulses across a very wide spectrum of frequencies several GHz in bandwidth. The corresponding receiver then translates the pulses into data by listening for a familiar pulse sequence sent by the transmitter. Specifically, UWB is defined as any 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.

UWB's combination of broader spectrum and lower power improves speed and reduces interference with other wireless spectra. In the United States, the Federal Communications Commission (FCC) has mandated that 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.

Wireless PC peripheral connectivity

For wireless PC peripheral connectivity, UWB technology can take the performance and ease-of-use found in USB to the next level. Presently, wired USB has significant market segment share as the cable interconnect of choice for the PC platform. But the cable can get in the way. Bluetooth Technology has resolved this issue to some degree, but it has enjoyed little success so far due to performance limitations and interoperability problems. A UWB-enabled WUSB solution provides the performance users have come to expect from wired USB without the cable. Enabling un-tethered USB connectivity, UWB has the possibility of gaining significant volume in the PC peripheral interconnect market segment. The recently announced Wireless USB Working Group objective is to define a specification that delivers on this promise by providing speeds up to 480 Mbps— equivalent to wired USB 2.0—within a 10-meter range. With WUSB, a user can bring a mobile device, such as a portable media player (PMP), in proximity to a content source, like a PC, laptop, or external hard disk drive, and, once authentication and authorization are complete, video files can be streamed onto the PMP for later viewing.



PC clusters interconnected through USB

Wireless multimedia connectivity for AV CE devices

Closely related to PC peripheral connectivity is wireless multimedia connectivity for audio and video consumer electronics (AV CE) devices. The benefits are similar to those of PC's and peripherals; wireless ease of use and data transfer performance are key advantages.

The variety of devices within the entertainment cluster is wide: digital video disc players (DVDs), HDTVs, STBs, personal video recorders (PVRs), MP3 players and stereos, digital camcorders and digital cameras, and other CE devices found throughout the home. For example, UWB could connect a wall-mounted plasma display or HDTV to an STB or DVD player, without annoying and unaesthetic cables. UWB can also enable multiple streams to multiple devices, simultaneously. This would allow picture-in-picture functionality or the ability to view the same or different content on multiple devices throughout the home. UWB can also connect devices between the PC and entertainment clusters, such as a digital camcorder to a media PC for digital video editing or to a large LCD for viewing. Connect a digital camera to a mobile notebook PC for editing, compiling, and sending pictures via e-mail to a family member while sitting at a public hotspot. UWB offers key benefits for these kinds of uses (Table 1, on the next page). With UWB-enabled WPANs, once the devices are within proximity, they recognize each other, and streaming occurs when the user presses the Play button.

Feature	Benefit
High-speed throughput	Fast, high-quality transfers
Low power consumption	Long battery life of portable devices
Silicon-based, standards-based radios	Low cost
Wired connectivity options	Convenience and flexibility

Wireless USB

Universal serial bus (USB) technology has been a popular connection type for PCs and it's migrating into consumer electronic (CE) and mobile devices. Now this high-speed and effective connection interface is unwiring to provide the functionality of wired USB without the burden of cables. This next iteration of USB technology is the focus of the new Wireless USB Promoter Group, which will define the specifications that will eventually provide standards for the technology.

Wireless USB will be the first high speed wireless personal interconnect technology to take advantages of UWB. Building on the success of wired USB, it will bring USB technology into the wireless world.

To maintain the same usage and architecture as wired USB, the Wireless USB Promoter Group is defining the wireless USB specification as a high speed host to device connection. This will enable an easy migration path for today’s wired USB solutions. Targeted bandwidth is 480 Mbps – plenty fast for multimedia streaming and high bandwidth data transfers. With one billion units in the installed base, USB is already the de facto interconnect for PC and many CE and mobile devices. With Wireless USB, all the benefits of USB will be realized but without the wire.

There are several architectural considerations in developing WUSB. In addition to providing wireless connectivity, WUSB must be backwards compatible with wired USB and provide a bridge to wired USB devices. Also, the host and solutions will need to enable the exchange of data between clusters or devices not related to the same host.

Low-cost implementation of WUSB will also be important to the successful integration of the technology. Implementation will follow the wired USB connectivity models as closely as possible to reduce development time and to preserve the low-cost, easy-to-use model, which has become pervasive in the PC industry.

Performance

WUSB performance at launch will provide adequate bandwidth to meet the requirements of a typical user experience with wired connections. The 480 Mbps initial target bandwidth of WUSB is comparable to the current wired USB 2.0 standard. With 480 Mbps being the initial target, WUSB specifications will allow for generation steps of data throughput as the ultra wideband radio evolves and with future process technologies, exceeding limits of 1 Gbps.

The specification is intended for WUSB to operate as a wire replacement with targeted usage models for cluster connectivity to the host and device-to-device connectivity at less than 10 meters. The interface will support quality delivery of rich digital multimedia formats, including audio and video, and will be capable of high rate streaming (isochronous transfers).

Usage Applications

With the growing use of digital media in the PC, consumer electronic (CE) and mobile communication environments, a common standard interconnect is needed to support the on-going convergence of these environments. The trend toward convenient wireless distribution of digital information provides an opportunity to introduce a single, standard wireless interconnect capable of supporting usage models across all three environments.

The CE environment will have high-performance wireless interface expectations. Consumer usage models will center on streaming media distribution that typically uses compression algorithms. The performance objective is to ensure a high quality of service is maintained to meet typical consumer entertainment expectations.

Typical video delivery with standard SDTV/DVD will consume between 3 and 7 Mbps while HDTV will use between 19 and 24 Mbps. A point distribution technology like wireless USB with an effective bandwidth of 480 Mbps could manage multiple HDTV streams. Host buffering could enable a network backbone to effectively distribute content to all distribution hosts, enhancing the quality experience for all users.

Business applications for WUSB include a variety of different usage possibilities. Common devices such as printers, scanners, hard drives, and projectors could all be used in wireless scenarios. These devices would function the same way as if they were using wired USB, but without all the cables. Office services on the corporate network could migrate to WUSB and benefit from faster performance than shared network devices offer.

Security and Device Association

WUSB security will ensure the same level of security as wired USB. Connection-level security between devices will ensure that the appropriate device is associated and authenticated before operation of the device is permitted. Higher levels of security involving encryption should be implemented at the application level. Processing overhead supporting security should not impose noticeable performance impacts or add device costs.

One of the primary objectives when implementing a wireless interconnect is that it is easy to install and use. Wired connections provide the user with implied expectations, that is that the device is connected as specified by the user when they install the wire. When the wire is installed, the user has basic expectations and when these expectations do not take place (plug does not fit), there is a known recourse.

Wireless connections, on the other hand, due to environmental characteristics, may establish connection paths that are not obvious. In fact, it may not be obvious when a device is connected.

So WUSB devices installed for the first time should automatically install drivers, security features, and so on and associate with systems that they can interact with. The concepts of 'turn on and use it' with an easy setup procedure will be employed.

WUSB in the Future

The first Wireless USB implementations will likely be in the form of discrete silicon that will be introduced in a number of form factors. These may include add-in cards and dongles along with embedded solutions to support the technology's introduction and subsequent rapid ramp up.

But the wireless future will arrive once WUSB, along with the common ultra wideband platform, becomes a standard part of every processor and chipset and is integrated in CMOS silicon.

As the latest iteration of USB technology, wireless USB (WUSB) will offer the same functionality as standard wired USB devices but without the cabling. As the new Wireless USB Promoter Group prepares to develop the specifications that will help standardize the technology, the industry is planning products that can take advantage of the convenience and mobility that this new device interconnect will offer.

Applications of Ultrawideband

There are three overlapping target segments that could benefit from short-range wireless connections enabled by UWB: PC and peripheral devices, mobile devices, and consumer electronics. Many devices in each of these three segments frequently communicate significant amounts of data over very short distances with other complementary devices, usually by means of an interconnect cable. For example, a digital still camera, with a large storage capacity, typically requires a high-speed serial connection to the PC to transfer images. At the time of transfer, the distance between the PC and the camera is typically a few meters at most. UWB allows us to create a wireless link by enabling the necessary data rates in a radio suitable for cost-sensitive, battery-powered mobile devices, like a camera or PDA. Similar examples are smart phones, home entertainment centers, printers, handheld computers, camcorders, video projectors and MP3 players. By eliminating the need for a physical cable connection, a new level of user convenience and mobility is provided.

UWB technology can enable a wide variety of WPAN applications.
Examples include:

- Replacing IEEE1394 cables between portable multimedia CE devices, such as camcorders, digital cameras, and portable MP3 players, with wireless connectivity
- Enabling high-speed wireless universal serial bus (WUSB) connectivity for PCs and PC peripherals, including printers, scanners, and external storage devices

Wi-Fi replacement or competitor?

There are mixed opinions on this subject. Many feel that the two will complement each other rather than compete -- after all, at one time, many thought Bluetooth and 802.11 would fight it out and they now live in harmony. Likewise, 802.11 will most likely remain the preferred home data networking technology, with UWB covering the home multimedia networking arena.

802.11 should also remain as the most effective technology for public access and enterprise markets, where power consumption issues are less important and data is still more important than multimedia. Many people feel this could change if the FCC loosens the reigns on UWB, but nobody can really be sure.

Because of the projected growth of 802.11 systems by the time that higher-powered UWB may be available, 802.ll will represent a relatively large installed wireless LAN base. As a result, many homeowners and companies will likely continue to support 802.11. The possible introduction of UWB as a new physical layer within the 802.11 suite of standards, however, would provide another option for new wireless LAN deployments and a possible migration path from existing 802.11b/g and 802.11a systems.

As far as the release dates for UWB products go, there is some uncertainty. Many systems are already in the testing and demonstration phase, but actual consumer release dates are still sketchy. Predictions range from the fourth quarter of 2003 to two years out. Whenever the products hit the shelves, it will definitely be interesting to watch things develop, though. Only time will tell whether UWB will totally dominate the wireless world or just play its near-term, WPAN role.

Comparison of performance of UWB with others

By comparison, today's Bluetooth works at about 1 megabit-per-second. And at 11 to 50 megabits-per-second, even today's Wi-Fi pales in comparison.

UWB has higher data rates, greater range, lower cost and lower power needs than many other technologies:

Technology	Data Rate	Range	Cost	Power	Spectrum	Summary
UWB	50-100Mb/s (theoretically up to 500Mb/s)	500 ft	Low	Low	Ultra-wideband	Only high data rate WLAN in 300-500 ft. range
802.11a	54 Mb/s	90-100 ft	High	High	5.0 GHz	Power, cost issues
HyperLAN	25 Mb/s	100 ft	High	High	2.4 GHz	European standard, same as 802.11b issues
802.11b	11 Mb/s	250-300 ft	Med	Med	2.4 GHz	Speed issues
Home RF	11 Mb/s	150 ft	Med	Med	2.4 GHz	Lost Intel support; speed issues
Bluetooth	1 Mb/s	30 ft	Low	Low	2.4 GHz	Speed issues

Impact of UWB on the industry

UWB has the potential to eventually dominate every wireless "area network," from wireless personal area networks (WPANs) to wireless wide area networks (WWANs). In its current restricted state, UWB will most likely be the preferred technology for wireless personal area networks, replacing Bluetooth's 1-2Mbps bandwidth with 400-500Mbps data rates.

As far as WLANs are concerned, UWB is not in an immediate position to take over. This has to so with the power limitations imposed by the FCC, but even if the limitations are lightened some say that it could take at least five years before UWB will become a dominant player in the wireless LAN market.

There has been discussion of using UWB to provide cheap, fast, last mile wireless access systems, which would solve the interference issues that plague current spread spectrum-based Metropolitan Area Networks (MANs). These UWB systems could be set up in rural areas, bringing never seen before high-speed connectivity to those users.

Right now the best killer application for UWB is home multimedia networking systems, where high bandwidth is crucial. UWB can support multiple channel multimedia streaming of broadcast quality video, making it the preferred technology to use when setting up a wireless home multimedia network.

UWB could connect virtually every multimedia device in your home without using any wires. Digital cameras and camcorders could wirelessly stream images and video to your TV or PC, DVD players and TV's could stream videos throughout your home, and flat screen monitors could wirelessly connected to computers, DVD players, or any other source you desire. UWB will very likely revolutionize the home multimedia scene and eliminate the mounds of tangled wires found behind home entertainment centers.

Other uses of Ultrawideband

It is believed that many uses will be discovered but much depends on what the U.S. Federal Communications Commission (FCC) will allow. If the FCC relaxes its rules in the future, a wide range of wireless data communications devices could become available, such as wireless networks with far greater bandwidth than existing technologies like Bluetooth, 802.11a and 802.11b. The FCC's current rules allow only the following:

- Automotive collision-detection systems and suspension systems that respond to road conditions.
- Medical imaging, similar to X-ray and CAT scans.
- Through-wall imaging for detecting people or objects in law-enforcement or rescue applications.
- Construction applications, including through-wall imaging systems and ground-penetrating radar.
- Communications devices, such as high-speed home or office networking, provided that the devices are designed for indoor use; outdoor use is restricted to handheld devices engaged only in peer-to-peer operation.

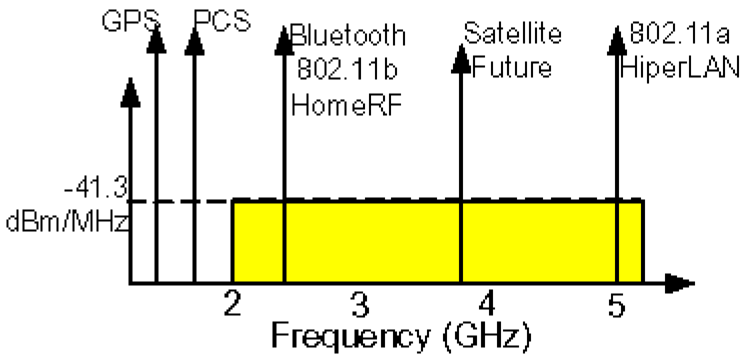
Regulatory and Standards Issues

The Federal Communications Commission (FCC) is in the process of determining the legality of Ultra-Wideband (UWB) transmissions. Due to the wideband nature of UWB emissions, it could potentially interfere with other licensed bands in the frequency domain if left unregulated. It's a fine line that the FCC must walk in order to satisfy the need for more efficient methods of utilizing the available spectrum, as represented by UWB, while not causing undo interference to those currently occupying the spectrum, as represented by those users owning licenses to certain frequency bands. In general, the FCC is interested in making the most of the available spectrum as well as trying to foster competition among different technologies.

The FCC first initiated a Notice of Inquiry (NOI) in September of 1998, which solicited feedback from the industry regarding the possibility of allowing UWB emissions on an unlicensed basis following power restrictions described in the FCC Part 15 rules. The FCC part 15 rules place emission limits on intentional and unintentional radiators in unlicensed bands. These emission limits are defined in terms of microvolts per meter (uV/m), which represent the electric field strength of the radiator. In order to express this in terms of radiated power (terms that are better understood by communications engineers), the following formula can be used. The emitted power from a radiator is given by the following:

$$P = E_0^2 4\pi R^2 / \eta$$

where 0 *E* represents the electric field strength in terms of V/m, *R* is the radius of the sphere at which the field strength is measured, and . is the characteristic impedance of a vacuum where . = 377 ohms. For example, the FCC Part 15.209 rules limit the emissions for intentional radiators to 500uV/m measured at a distance of 3 meters in a 1MHz bandwidth for frequencies greater than 960MHz. This corresponds to an emitted power spectral density of -41.3dBm/MHz. In May of 2000, the FCC issued a Notice of Proposed Rule Making (NPRM), which solicited feedback from the industry on specific rule changes that could allow UWB emitters under the Part 15 rules. More than 500 comments have been filed since the first NOI, which shows significant industry interest in this rule-making process. Figure below shows how the current NPRM rules would limit UWB transmitted power spectral density for frequencies greater than 2GHz.



Restrictions on Ultrawideband

Because UWB uses a wide swatch of frequency, there are concerns that it will interfere with existing communications.

Initially, the main concern about UWB was whether or not they would interfere with existing RF systems that provide essential military, aviation, fire, police, and rescue services. Because of this, the FCC spent two years evaluating the proposed UWB specifications and concluded that there will be no major interference. The Department of Defense reviewed the tests and issued statements that it was satisfied with the current restrictions being placed on UWB as well.

Concerns still remain, however, about the interference of higher-power UWB systems. The FCC says they will reevaluate UWB in the near future, and they will take a closer look at the issue of higher-power systems. Until then, you're limited to UWB products with somewhat short range propagation.

Conclusion

UWB and the associated networking protocol efforts are in the early stages of development, and several key deployment scenarios are being defined and evaluated. UWB complements currently deployed wireless networks in the WLAN environment, plus it extends high bit-rate, multimedia connectivity to WPANs supporting PC and CE devices. This combination will enable true convergence of computers and consumer electronics. A common radio platform that connects seamlessly with the existing networking protocols and cost effectively enables connectivity solutions among CE peripherals will shift the home entertainment environment. It will enable multiple usage models from cable replacement to the streaming of video, audio, and other entertainment media. Many UWB components and systems are already in the testing and demonstration phases, with actual release dates for final consumer products expected in early 2005.

Abbreviations

UWB – Ultrawideband

WLAN – Wireless Local Area Network

WPAN - Wireless Personal Area Network

WWAN – Wireless Wide Area Network

WUSB – Wireless Universal Serial Bus

AVCE – Audio Video Consumer Electronics

FCC - Federal Communications Commission

HDTV – High Definition Tele Vision

PDA – Personal Digital Assistant

LCD – Liquid Crystal Display

DVD – Digital Versatile Disk

PMP – Personal Media Player

PVR – Personal Video Recorder

OFDM – Orthogonal Frequency Division Multiplexing

RF – Radio Frequency

SS – Spread Spectrum

Appendix

FCC - The FCC regulates all use of radio-emitting devices within the United States. It has the authority to prohibit operation of any device that emits an electro-magnetic signal if it interferes with the operation of any device that the FCC has approved

Bluetooth - is the codename of wireless personal area network specification that is being developed by the Bluetooth SIG(Special Interest Group). Bluetooth will enable electronic devices to spontaneously set up wireless networks within small areas.

IEEE 802.11 – This working group is defining standards for wireless networks. It is working on the standardization of mediums such as spread spectrum radio, narrowband radio, infrared, and transmission over power lines.

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