Seminar

ON

WIRELESS USB

BY

CH.VENKATESH

H.T.No. 07281A0568

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

KAMALA INSTITUTE OF TECHNOLOGY & SCIENCE
SINGAPUR, KARIMNAGAR- 505468
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ABSTRACT

Wireless USB is a logical bus that supports data exchange between a host device (typically a PC) and a wide range of simultaneously accessible peripherals. The attached peripherals share bandwidth through a host-scheduled, TDMA-based protocol. The bus allows peripherals to be attached, configured, used, and detached while the host and other peripherals are in operation. Security definitions are provided to assure secure associations between hosts and devices, and to assure private communication.

Wireless USB is a wireless technology which enables the high speed computer peripheral interface, USB, wireless. It is a wire replacement of existing USB technology using a Multi Band Orthogonal Frequency Division Multiplexing radio technique.

1. INTRODUCTION

Wireless USB is a wireless technology which enables the high speed computer peripheral interface, USB, wireless. It is a wire replacement of existing USB technology using a Multi Band Orthogonal Frequency Division Multiplexing radio technique.

Wireless USB interest group was formed in 2004. It is the first high speed personal interconnect. The physical layer is standardized under IEEE 802.15.3 PHY. Today it is in the developing stage. The major WUSB promoters are HP, Intel, Microsoft, NEC Philips, & Samsung

A USB system consists of a host and some number of devices all operating together on the same time base and the same logical interconnect. A USB system can be described by three definitional areas:

- USB interconnect
- USB devices
- USB host

The USB interconnect

The USB interconnect is the manner in which USB devices are connected to and communicate with the host. USB devices

Wireless USB devices are one of the following:

Functions, which provide capabilities to the system, such as a printer, a digital camera, or speakers

Device Wire Adapter, which provides a connection point for wired USB devices.

USB Host

There is only one host in any USB system. The USB interface to the host computer system is referred to as the Host Controller. Host controllers are typically connected to PCs through an internal bus such as PCI. The Host Controller may be implemented in a combination of hardware, firmware, or software.

Wireless USB has an advanced power management system which consumes very low power. The power management system is based on Tx/Rx system. It also supports an advanced encryption system in order to ensure the secure connection between the host and device.

2. NEED FOR ANOTHER WIRELESS TECHNIQUE

USB is a fast growing technology and now above 80% of all devices supports USB connectivity to a PC. It will be a great reduce of number of wires and cost for paying the cables, if the existing USB technique goes wireless.

Today, an office PC is disturbed with rat's nest of cables. By adopting the current wireless technology such as Bluetooth, WiFi, ZigBee, IR, etc doesn't reduces the number of wires since they have not enough bandwidth to support bigger data transfer rate.

A survey reveals the requirements of bandwidth for different devices, which is shown in the table below.

Peripheral	*Desired BW*	*Comments*
Video conf & digital still cameras	75-150Mbps	MPEG-2 quality w/o compression; roll download in seconds not minutes.
Scanners	50-100Mbps+	Faster, high resolution scan
Printers	50-100Mbps+	Higher resolutions, more colors, or elimination of line/page buffers allows lower cost
External storage	Up to 240Mbps	SCSI/IDE performance levels. CD/ RW, DVD-RAM, HDD, flash memory
Broadband	10-1000Mbps	Cable, DSL, Ethernet, HPNA, ...
High resolution monitors, projectors	63Mbps+	Upper limit (to ~4Gbps) a function of tolerable compression

Wireless USB support a high bandwidth of 480Mbps and it's scalable architecture extends the bandwidth up to lGbps.Moreover it is much less costly than Bluetooth and consumes much less power than any other wireless device.

Wireless USB supports both PC as well as personal Consumer Electronics devices such as audio/video players.

Wireless USB supports a mixture of both high speed and low speed devices and can be operated in multiple data transfer rates.

3. **ARCHITECTURAL OVERVIEW**

Wireless USB is a logical bus that supports data exchange between a host device (typically a PC) and a wide range of simultaneously accessible peripherals. The attached peripherals share bandwidth through a host-scheduled, TDMA-based

protocol. The bus allows peripherals to be attached, configured, used, and detached while the host and other peripherals are in operation. Security definitions are provided to assure secure associations between hosts and devices, and to assure private communication.

3.1 USB System Description

A USB system consists of a host and some number of devices all operating together on the same time base and the same logical interconnect. A USB system can be described by three definitional areas:

- USB interconnect
- USB devices
- USB host

3.1.1 USB interconnect

The USB interconnect is the manner in which USB devices are connected to and communicate with the host. This includes the following:

- Topology
- Data Flow Models
- USB Schedule

3.1.1.1 Topology

Wireless USB connects USB devices with the USB host using a 'hub and spoke' model. The Wireless USB host is the 'hub' at the center, and each device

sits at the end of a 'spoke'. Each 'spoke' is a point-to-point connection between the host and device Wireless USB hosts can support up to 127 devices and because Wireless USB does not have physical ports there is no need, nor any definition provided, for hub devices to provide port expansion. The figure illustrates the topology system

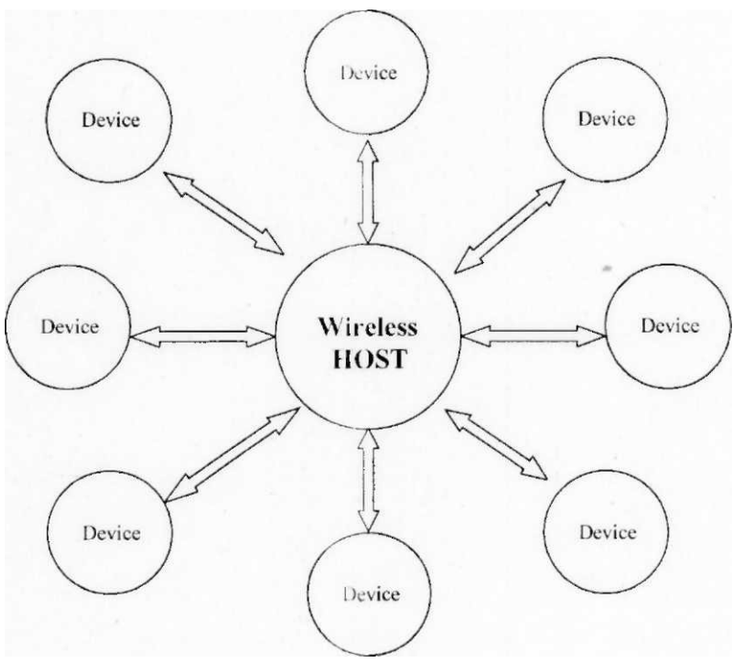


Fig 3.1.1 Hub and Spoke topology

3.1.1.2:Data Flow Models

The manner in which data moves in the system over the USB between producers and consumers.

3.1.1.3:USB Schedule

The USB provides a shared interconnect. Access to the interconnect is scheduled in order to support isochronous data transfers and to eliminate arbitration overhead.

3.1.2:USB Devices

Wireless USB devices are one of the following:

Functions, which provide capabilities to the system, such as a printer, a digital camera, or speakers

- Device Wire Adapter, which provides a connection point for wired USB devices. Wireless USB devices present a standard USB interface in terms of the following:
- Their comprehension of the Wireless USB protocol
- Their response to standard USB operations, such as configuration and reset

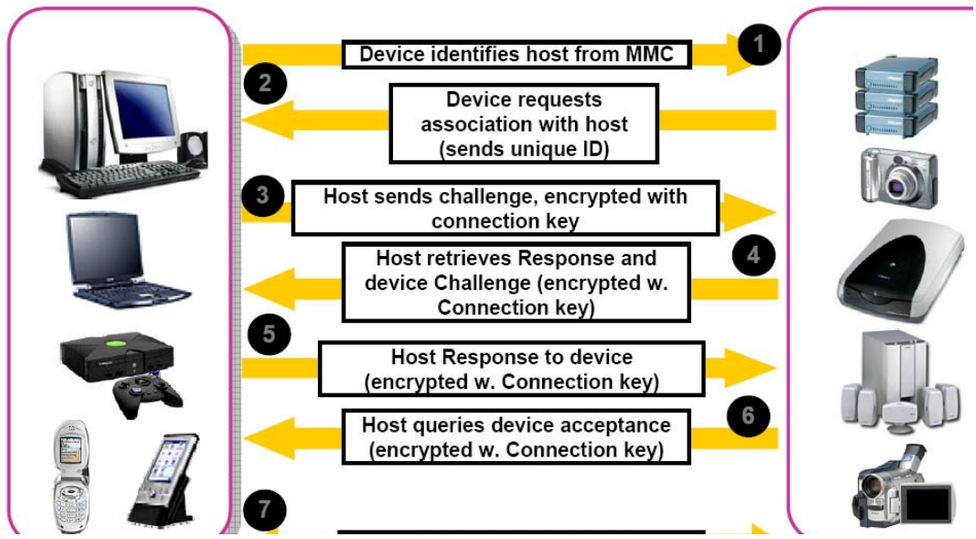


***Fig*:Sample device connect**

3.1.3:USB Hosts

There is only one host in any USB system. The USB interface to the host computer system is referred to as the Host Controller. Host controllers are typically connected to PCs through an internal bus such as PCI. The Host Controller may be implemented in a combination of hardware, firmware, or software. This specification defines another way that a host controller may be 'connected' to a PC. Chapter 8 describes a Wire Adapter device class that allows USB host functionality to be connected to a PC through a USB connection (either wired or wireless). Wire Adapters that directly connect to the PC using wired USB are known as Host Wire Adapters. Host Wire Adapters add Wireless USB capability to a PC. Wire Adapters that are Wireless USB devices and hence connect to the PC wirelessly are known as Device Wire Adapters. Device Wire Adapters typically have USB 'A' connectors (i.e. they look like wired hubs) and allow wired USB devices to be connected wirelessly to a host PC. Note that each Wire Adapter creates a new 'USB system', in that there is one host (the wire adapter) talking to one or more devices using the same time base and

interconnect. Wire Adapters are important enabling devices for Wireless USB. Host Wire Adapters enable existing PCs to support Wireless USB. Device Wire Adapters allow existing wired USB devices to have a wireless connection to the host PC.

3.2:Physical Interface

Physical layer of Wireless USB is described in the Multi band OFDM Alliance (MBOA) UWB PHY specification, see reference [4]. The PHY supports information data rates of 53.3, 80, 106.7, 200, 320, 400 and 480 Mb/s and multiple channels. The PHY also provides appropriate error detection and correction schemes to provide as robust a communication channel as possible. For Wireless USB devices, the support of transmitting and receiving data at rates of 53.3, 106.7, and 200 Mb/s is mandatory. The support for the remaining data rates of 80, 160, 320, 400 and 480 Mb/s is optional. Wireless USB Hosts are required to support all data rates for both transmission and reception. All Wireless USB

3.3:Power Management

A Wireless USB host may have a power management system that is independent of the USB. The USB System Software interacts with the host's power management system to handle system power events such as suspend or resume. Additionally, USB devices typically implement additional power management features that allow them to be power managed by system software. This specification defines mechanisms and protocols that allow hosts and devices to be as power efficient as possible.

3.4:Bus Protocol

Logically, Wireless USB is a polled, TDMA based protocol, similar to wired USB. The Host Controller initiates all data transfers. Like wired USB, each transfer logically consists of three 'packets': token, data, and handshake. However, to increase the usage efficiency of the physical layer by eliminating costly transitions between sending and receiving, hosts combine multiple token information into a single packet. In that packet, the host indicates the specific time when the appropriate devices should either listen for an OUT data packet, or transmit an IN data packet or handshake (see Figure 3-2).

3.5 Robustness

There are several attributes of wireless USB that contribute to its robustness:

The physical layer, defined by [4], is designed for reliable communication and robust error detection and correction.

- Detection of attach and detach and system-level configuration of resources
- Self-recovery in protocol, using timeouts for lost or corrupted packets

Flow control, buffering and retries ensure isochrony and hardware buffer management

3.5.1:Error Handling

The protocol allows for error handling in hardware or software. Hardware error handling includes reporting and retry of failed transfers. A Wireless USB Host will try a transmission that encounters errors up to a limited number of times before informing the client software of the failure. The client software can recover in an implementation-specific way.

3.6:Security

All hosts and all devices must support Wireless USB security. The security mechanisms ensure that both hosts and devices are able to authenticate their communication partner (avoiding man-in-the-middle attacks), and that communications between host and device are private. The security mechanisms are based on AES 128/CCM encryption, providing integrity checking as well as encryption. Communications between host and device are encrypted using 'keys' that only the authenticated host and authenticated device possess.

3.7:System Configuration

Like wired USB, Wireless USB supports devices attaching to and detaching from the host at any time. Consequently, system software must accommodate dynamic changes in the physical bus topology.

3.7.1 Attachment of Wireless USB Devices

Unlike wired USB, Wireless USB devices 'attach' to a host by sending the host a message at **a** well defined time. The host and device then authenticate each other using their unique IDs and the appropriate security keys. After the host and device have been authenticated and authorized, the host assigns a unique USB address to the device and notifies host software about the attached device.

3.7.2 Removal of Wireless USB Devices

Devices can be detached explicitly by either the host or device using protocol mechanisms. Device detach also happens when a host is not able to communicate with a device for an extended period of time.

3.7.3 Bus Enumeration

Bus enumeration is the activity that identifies and assigns unique addresses to devices attached to a logical bus. Because Wireless USB allows devices to attach to or detach from the logical bus at any time, bus enumeration is an on-going activity for the USB System Software. Additionally, bus enumeration for Wireless USB also includes the detection and processing of removals.

4. DATA FLOW MODEL

4.1Implementer Viewpoints

Wireless USB is very similar to USB 2.0 in that it provides communication services between a Wireless USB Host and attached Wireless USB Devices. The Wireless USB communication model view preserves the USB 2.0 layered architecture and basic components of the communication flow (i.e. point-to-point, same transfer types, etc

4.2Communications Topology

The general communications topology of Wireless USB is identical to that used in USB 2.0 (see Figure 4-1). The obvious advantage of this is that many existing USB 2.0 functional components (in hosts and devices) continue to work without modification when the physical layer components supporting USB 2.0 are replaced with those supporting Wireless USB. The delta change from USB 2.0 to Wireless USB is illustrated to the right- hand side of Figure 4-1. The Function Layer is (almost) completely the same. The only difference is the isochronous transfer model has some enhancements to allow functions to react to the increased unreliability of the "Bus Layer". The Device Layer includes a small number of framework extensions to support security

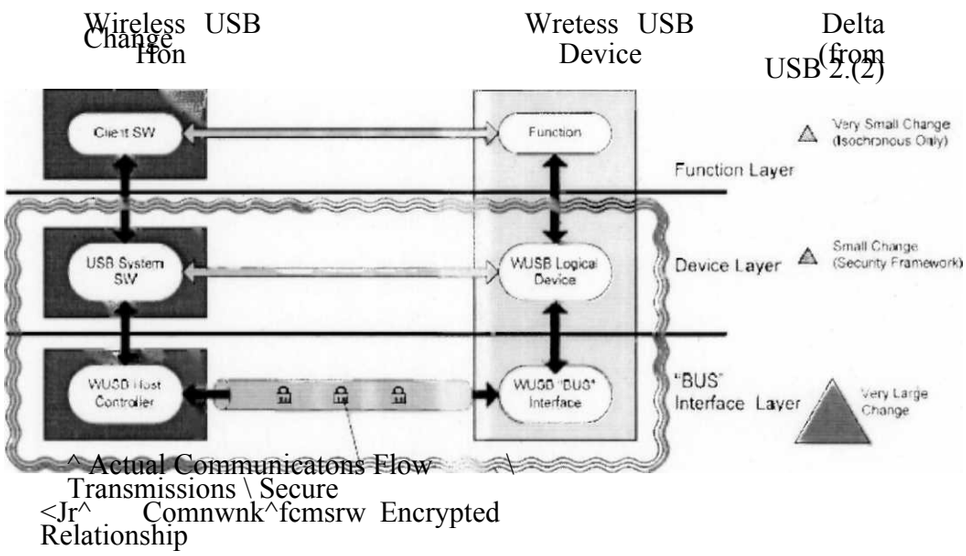


Fig: 4.1 Wireless USB data communication topology

and management commands required to manage devices on the wireless media. Finally, the Bus Layer includes significant changes to provide an efficient, secure communication service over a wireless media. The copper wire in USB 2.0 provides significant value with regards to security of data communications. The User knows which host the device is associated with because the device has to be physically plugged into a receptacle and the wire provides a specific path for data communications flow between a host and devices that cannot be casually observed by devices not purposely connected. Replacing the physical layer copper with a radio results in ambiguity about the actual association between devices and hosts, and also exposes data communication flows to all devices within listening range. In other words, the loss of the wire results in a significant loss of security which must be replaced by other mechanisms in order for Wireless USB to be a viable and usable technology. Wireless USB defines processes which allow a device and host to exchange the information required to establish a Secure Relationship (see Section 6.2.8). Alter a secure relationship has been established, the host and device have the necessary information required to support data encryption for "over the air" communications. Figure 4-1 illustrates how the standard USB data communications flow topology is extended for Wireless USB

to include the concept of a secure relationship between a host and device and also illustrates that over-the-air data communications are encrypted. Notice that these new features extend only up to the device layer of the topology, allowing existing applications and device functions to exist and work without modification.

4.3 Physical Topology

Wireless USB Devices are not physically attached to a Wireless USB Host. Devices within radio range of a host establish a secure relationship with the host before application data communications are allowed. A host and its associated devices are referred to as a Wireless USB Cluster. A Wireless USB Cluster is comprised of a Wireless USB Host and all the Wireless USB Devices that it directly manages. Figure 4-2 illustrates an example physical topology enabled by Wireless USB. The host has a radio range of about 10 meters. Devices within the host's range can establish a secure relationship with the host and become part of the host's Wireless USB Cluster. All communication flows between the host and devices are point-to- point which means the physical topology of Wireless USB is a 1:1 match with the defined logical communications topology familiar to USB architecture. Likewise the client software-to-function relationship remains

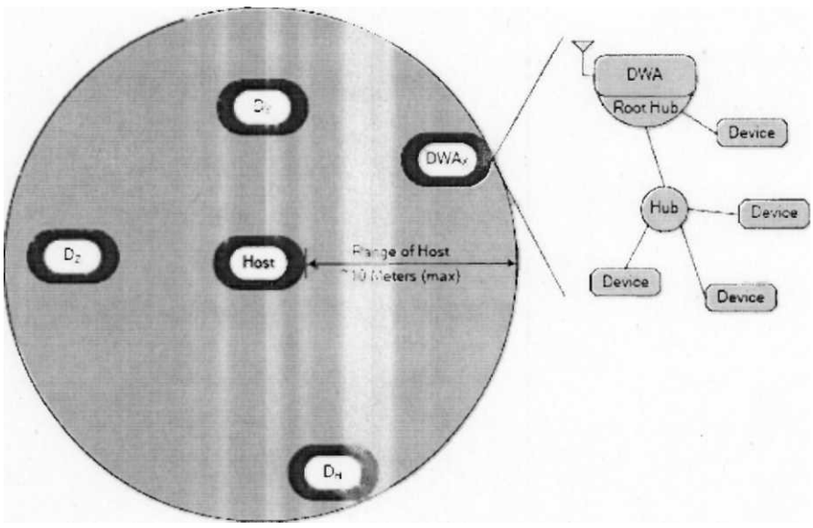


Fig 4.2 Physical Wireless USB connection topology

unchanged. Wireless USB also defines a specific class of device called the Wire Adapter that bridges between a Wireless USB bus and a USB 2.0 bus. The effect on the communications topology is essentially a cascading of USB busses.

5. POWER MANAGEMENT

Wireless USB provides mechanisms that allow hosts and devices to opportunistically and explicitly control their power consumption. Because Wireless USB protocol is TDMA-based, hosts and devices know exactly when their radios do not need to be transmitting or receiving and can take steps to conserve power during these times. Other mechanisms allow hosts and devices to turn off their radios for longer periods of time. The sections below cover power management mechanisms available for devices and for hosts and define the interactions between the two.

5.1 Device Power Management

Devices have three general ways to manage their Wireless USB power consumption. The first is to manage power during normal operation by taking advantage of the TDMA nature of Wireless USB protocol and opportunistically turning their radio off during periods when it isn't needed. Devices can do this at any time with the host being unaware of the efforts. The second way to manage power is to have the device go to 'sleep' for extended periods of time but still stay 'connected'. In this case the device will not be responsive to any communications from the host. Devices must notify the host before sleeping.

5.1.1Device Sleep

During periods of inactivity, a device may want to conserve power by turning off its radio and being unresponsive for an extended period of time. A device is

required to notify the host before going to sleep and the host will acknowledge the notification.

5.1.2 Device Wakeup

After entering the Sleep state, devices may want to occasionally check with the host to find out if there is any work pending or the device may want to go back to the Awake state because the device now has data to deliver to the host (maybe for an Interrupt IN endpoint).

5.2 Host Power Management

A host has two general ways to manage Wireless USB power. The first can be done during normal operation by taking advantage of the TDMA nature of WUSB protocol and turning the radio off during periods when it is not needed. During times of low activity, the host can manage the Wireless USB channel to have long periods between MMCs(Micro-Sheduled Management Commands) and thereby have more time when the radio can be off. Devices are unaware of this power management, and since the Wireless USB channel is maintained, they just follow from one MMC to the next. The second general way for a host to manage power is to interrupt the Wireless USB channel, meaning that the continuous string of linked MMCs is stopped. Some typical reasons for the host to do this include:

The platform going to a low power state (Standby, Hibernate, ...)

The platform being shut down.

The user disabling the radio • Aggressive host power management For this case, devices are made aware of the hosts actions through an explicit, communication from the host.

6. PROTOCOL LAYER

6.1 Packet Formats

This chapter presents a bottom-up view of the Wireless USB protocol starting at packet format definitions inherited from the MAC Layer standard and the application-defined extension required for Wireless USB.

Wireless USB uses the packet (Frame) formats defined in the MAC Layer standard. The general structure of a packet is that it contains a PHY Preamble, PHY Header and MAC Header followed by a data payload (MAC frame body) which can be transmitted at a signaling rate different than that of the PHY and MAC Header (see top of Figure 6-1). The PHY layer provides standard support for error correction for all bits in the logical packet (PHY/MAC Header plus frame body). The PHY also CRC checks the PHY and MAC Header. The Frame Check Sequence field, which is the CRC value for the frame body payload is managed by the MAC layer. See the MAC Layer standard for implementation requirements. Note that when the Security bit component of the Frame Control field is set to zero (0), the security-related fields are not present in the packet. These fields are TKID, Rsrvd, Encryption Offset, SFN, and MIC. These fields are present if the Security bit is set to one (1).

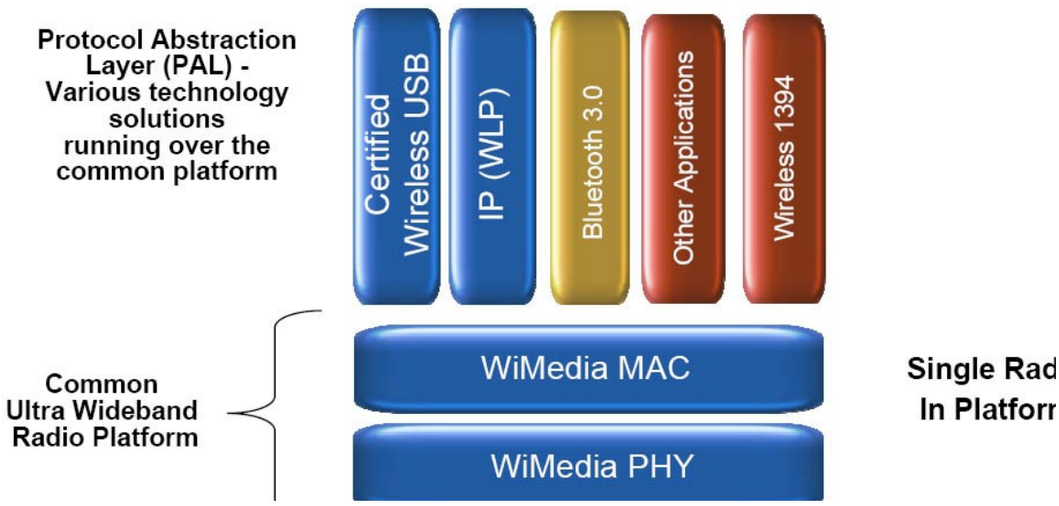


Fig 2.1 Position of UWB in protocol stacks

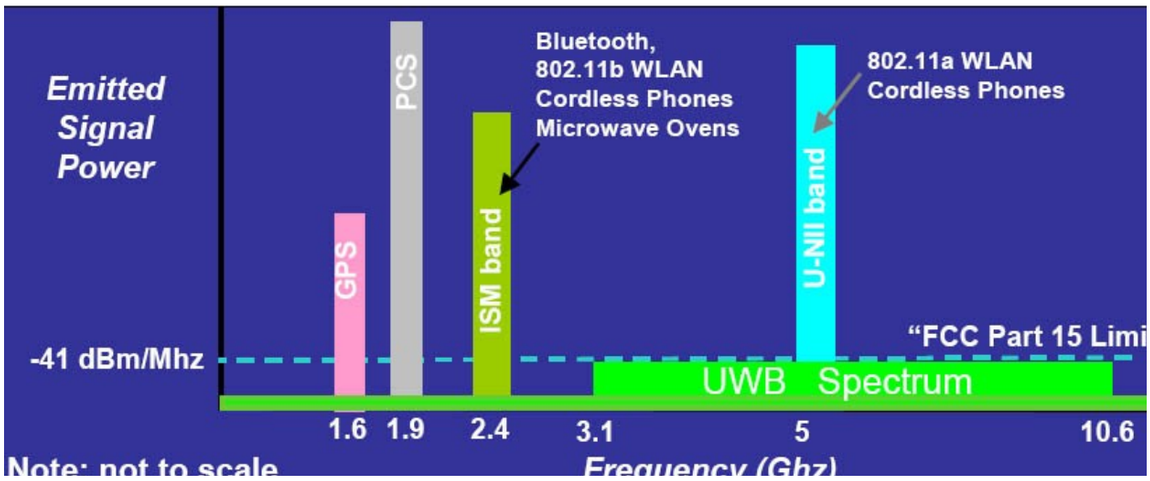
Ultra-Wideband (UWB) may be used to refer to any radio technology having bandwidth exceeding the lesser of 500 MHz or 20% of the arithmetic center frequency, according to Federal Communications Commission (FCC). A February 14,2002 Report and Order by the FCC [1] authorizes the unlicensed use of UWB in 3.1–10.6 GHz. The FCC power spectral density emission limit for UWB emitters operating in the UWB band is -41.3 dBm/MHz. This is the same limit that applies to unintentional emitters in the UWB band, the so called Part 15 limit. However, the emission limit for UWB emitters can be significantly lower (as low as -75 dBm/MHz) in other segments of the spectrum.

Deliberations in the International Telecommunication Union Radio communication Sector (ITU-R) have resulted in a Report and Recommendation on

UWB in November 2005. National jurisdictions around the globe are expected to act on national regulations for UWB very soon. The UK regulator Ofcom announced a similar decision [2] on 9 August 2007. Other national regulatory

bodies apparently are somewhat reluctant to allow common unlicensed use

The below figure illustrates the position of UWB spectrum in the whole band used for common radio communications.



7. SECURITY

This chapter provides Wireless USB security-related information. It describes the security inherent in wired USB (USB 2.0). This inherent security establishes a baseline that a wireless version must meet to be successful. When considering security solutions, one must keep in mind that no solution is currently or can be proven to be Impervious. Security systems are designed not to explicitly stop the attacker, but rather to make the cost of a successful attack far higher than any gain the attacker might realize from the attack. For the sake of brevity, when we say that a particular solution prevents attacks, we mean that the solution meets the objective listed above. The solution is not impervious, but the cost of compromising the solution outweighs the gain to be realized.

7.1 Encryption Methods

The standard method of encryption for the first generation of Wireless USB is AES-128 Counter with CBC- Mac (CCM). This is a symmetric encryption algorithm that uses the AES block cipher to create a robust stream cipher that can be used to provide integrity, encryption, or both. It is capable of real-time operation when Implemented in hardware. This is the only method currently defined for general session encryption.

Wireless USB also supports public key encryption, but only for authentication. Devices may choose to start a first-time authentication with public key encryption. In this case, PK encryption is used to authenticate the device and to protect the distribution of the initial CCM key. When PK is used, it will be used in a manner that will allow for software implementations of the algorithms.

The CCM encryption suite provides 128 bits of security for run-time operation. The PK cryptography suite must provide the same level of strength or else the strength of the entire suite is compromised. For this reason, Wireless USB will use RSA with 3072 bit keys for encryption and SHA-256 for hashing. The Security Architecture also recognizes a wired connection as an encryption method. This allows the SME to recognize a wired connection as a secure connection, without resorting to additional cryptography. This allows for wired/wireless devices, Where the wired connection can be used for initial CCM Connection Key distribution.

7.2 Message Format

Encryption will generally cause the message length to grow. In addition to the original message, the encrypted message must now contain additional keying material, freshness values, and an integrity value. The exact nature of these

additional message components is dependent on the type of encryption used. In general, any new additional material added to the message, other than the integrity v|lue, will be added as a header. This header will immediately precede the encrypted message. The integrity value will immediately follow the message.

8. CONCLUSION

Wireless USB offers more band width than any other current wireless technology. Its power management and security features will enable it to wipe out all the current wireless personal interconnect. And tomorrow an office or a home computer will be cable free and inexpensive. Ease of installation and usage will makes Wireless USB the most accepted Wireless technology by the consumers.

9. FUTURE SCOPE

In future, every mobile phones, PDA's, Keyboard, Mice, Monitors, Projectors, External Storage, etc will become wireless. Today wireless USB is in the developing stage. In the middle of 2007 wireless USB will dominate the market.

Moreover, the scalable architecture of WUSB enable the technology to upgrade the data transfer rate more than 1 Gbps.

Many companies are now joining the WUSB special interest group and soon every product with a USB 2.0 connectivity will enable Wireless USB.

Connection:

In order to make secure relationships consistent across multiple connections, some amount of context must be maintained by both device and host. In the case of wireless USB. This connection context consists of three pieces of information., a unique host ID (CHID), a unique device ID (CDID) and a symmetric key (CK) that is shared by both parties. The symmetric key is referred to in this document as

the connection key. This key is used to reestablish the connection at a later time. This key is always unique. The host never gives the same connection key to multiple devices.

Fig 3.4 Connection context

A connection context must contain non zero CHID and CDID values to be useable by the device. A host can use a CC with a value of zero in either field to revoke an existing context. When loading a context for conection purposes, if a device discovers a CC that contain CHID or CCID values of zero , it shall treat that CC as if it were entirely blank. The device shall make no use of the other fields.

Devices may find ways to add value by supporting multiple CCs . Each CC supported by the device must contain a unique CHID. In the case a device supports multiple CCs only the CC used to connect the host shall be made accessible to the host.

Enabling products

It is useful to note in a discussion regarding Wireless USB is that the end goal of the solution is to provide a cable replacement for a pure USB connection. Many Wireless USB adapters exist today, but these adapters do not perform the function required of a true Wireless USB solution.

A USB adapter, devices such as USB-to-Serial, USB-to-Ethernet, USB-to-802.11 and USB modems (USB-to-Telco or USB-to-Cable TV), provides an external connection and protocol conversion that just happens to connect to the

PC via USB. The USB device itself is the dongle or adapter unit directly connected to the host. The remote side is not a USB device, and the connection is not USB.

The goal of a true Wirelesses solution is to enable connectivity of any USB device, and provide the same convenience of a simple wired USB connection.

Device Wire Adapters

Device wire adapter looks like a simple USB hub. It consists of traditional USB A type ports in it and USB devices can connet to it with the wired USB technology. The

DWA connects wirelessly to the HWA or the wireless host integrated into the host Certified Wireless USB

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machine as PCI or PCI(e). Single chip implementations of DWA can be directly integrated into devices which makes no need for the hub. A sample fugure of a device

wire adapter is shown below

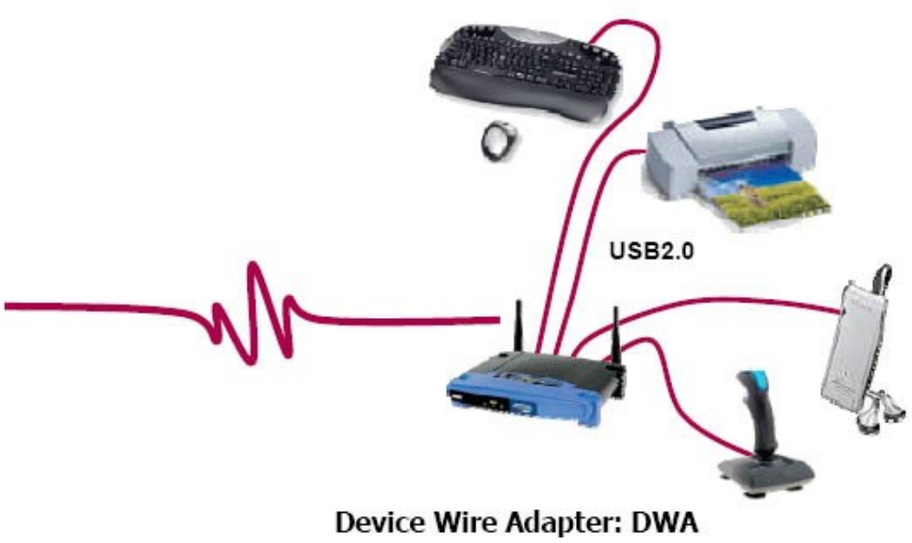

Fig 3.5 Device wire adapter

Host Wire Adapters

Host wire adapters lies on the WUSB host they are small adapters that look like a dongle which can be connected to the USB ports of the host computer. This host wire

adapters make use of the wired USB connection to connect to the host PC and the wireless USB technology to connect to the Device wire adapters to which the wireless

USB devices are connected.

The whole connection makes a mixture of wired and wireless conection which leads to decrease in throughput. It is always recommended to use the wireless host integrated into the host system as PCI or PCI(e) device.

10. BIBLIOGRAPHY

1. www.usb.org

2. www.wikipedia.org

3. www.intel.com

4 .www.techonline.com

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.

USB JOINS THE WIRELESS REVOLUTION

Since its debut in 1996, the universal serial bus (USB) has conquered the PC and PC peripheral markets and captured a significant share of the consumer electronics market. Now USB is going wireless—a move that will add the convenience of mobility to its unrivalled low-cost performance and ease of use.

The Wireless USB Promoter Group is crafting a specification for a Wireless USB standard that will provide high-speed connectivity over a distance of 10 meters. The target data rate is 480 Mbps—comparable to the speed of wired USB 2.0 and much higher than the speed of other short-range wireless interconnects such as Bluetooth. That means Wireless USB will be the first wireless technology capable of high-bandwidth multimedia streaming and data transfers. Additionally, Wireless USB will maintain the host-to-device architecture, usage models, and simplicity of wired USB to enable easy migration from wired to wireless USB solutions.

UWB: THE UNDERLYING TECHNOLOGY

The basic transport mechanism for Wireless USB is the ultra-wide band (UWB) radio platform, which has been the focus of recent efforts by the Multiband OFDM Alliance (MBOA) and the WiMedia Alliance. The platform consists of two core layers: the UWB radio layer and the convergence layer (Figure 1).

UWB RADIO LAYER

UWB technology is fundamentally different from conventional narrow-band radio frequency (RF) and spread-spectrum technologies (SS) such as Bluetooth and 802.11a/g. Conventional radios transmit a single continuous carrier wave over a specified frequency. In contrast, UWB transmits short, fast, low-power wavelets of energy over a very wide band of frequencies.

In 2002, the Federal Communications Commission (FCC) legalized commercial use of UWB communications in the 3.10 to 10.6 GHz slice of the radio spectrum. At the same time, the FCC imposed stringent limitations on UWB power emissions to enable the co-existence of UWB and other services that operate in this spectrum. This combination of a very broad band and restricted power provides the high speed and limited range of UWB-based applications. It also enables spectrum reuse: unlike narrow-band RF wireless technologies, a wireless USB cluster can communicate on the same channel as another cluster in proximity. An additional advantage of UWB technology is that the radio circuitry can be implemented in cost-effective CMOS.

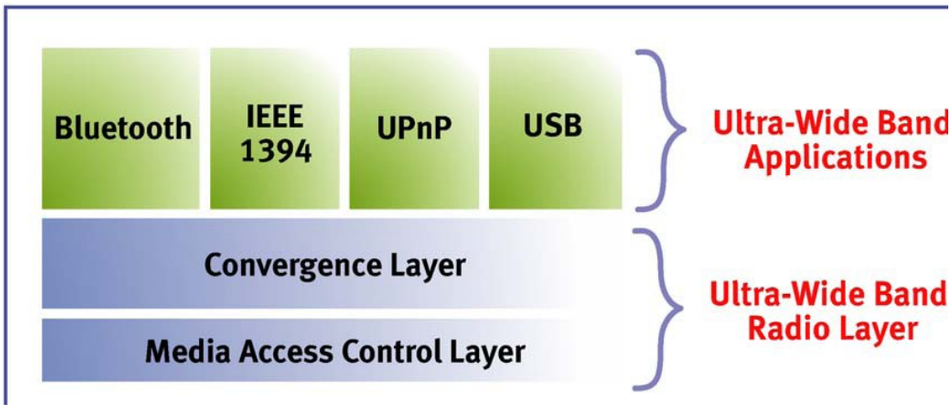

Figure 1. UWB radio platform and emerging UWB applications

THE CONVERGENCE LAYER

The convergence layer serves as an interface between the UWB radio layer and UWB-based applications. It allows multiple applications to share a single radio. Wireless USB is the first of several wireless applications that will run on the UWB platform.

Multiband OFDM Alliance (MBOA)	MBOA, an organization representing over 170 companies, is defining standards for the UWB radio layer and creating specifications for the UWB PHY and MAC.

WiMedia Alliance	WiMedia Alliance is developing a convergence layer and IP stack that will run on the UWB radio layer specification produced by MBOA and IEEE. The alliance also plans to administer certification for UWB-based products to ensure multivendor interoperability.
Wireless USB Promoter Group	The Wireless USB Promoter Group is developing a Wireless USB specification based on UWB technology. The group, which consists of Intel, NEC, Agere Systems, HP, Microsoft Corporation, Philips Semiconductors and Samsung Electronics, is expected to have a standard by the end of 2004.

WUSB CLUSTER TOPOLOGY

Wireless USB clusters use a simple hub and spoke topology, with point-to-point connections between the host and the devices connected to it. The host —which can logically connect to as many as 127 devices—initiates and schedules data transfers to the devices in the cluster, allotting time slots and bandwidth to each connected device. Clusters will be able to physically overlap with minimal interference.

FEATURES

Wireless USB will build on the success of Wired USB. An important goal of the WUSB Promoter Group is to ensure that wireless USB offers users the

experience they have come to expect from wired USB. Toward that end, the Wireless USB standard is being designed to support the following features.

- Backward compatibility Wireless USB will be fully backward compatible with the one billion wired USB connections already in operation. Moreover, Wireless USB will be compatible with current USB drivers and firmware and provide bridging from wired USB devices and hosts.
- High performance At launch, Wireless USB will provide speeds up to 480 Mbps, a performance comparable to the wired USB 2.0 standard and high enough to provide wireless transfer of rich digital multimedia formats. As UWB technology and process technologies evolve, bandwidth may exceed 1 Gbps.
- Simple, low-cost implementation Implementation will follow the wired USB connectivity models as closely as possible to reduce development time and preserve the low-cost, ease-of-use model that has made wired USB the interconnect of choice.
- An easy migration path To enable an easy migration path from wired USB, Wireless USB will maintain the same usage models and architecture as wired USB.
- Security Wireless USB will provide the same level of security as wired USB. All certified Wireless USB devices will incorporate standard, non-removable security features. Connection-level security will be designed to ensure that devices are associated and that both hosts and devices are authenticated before operation. Higher levels of security involving encryption will be implemented at the application level. At the same time, an important goal of the specification is to ensure that security requirements do not impact the performance or cost of Wireless USB applications.
- Host-to-device architecture Wireless USB will use a point-to-point connection topology similar to the host-to-device architecture used for

wired USB. For ease of use, Wireless USB will employ an asymmetric host-centric model that confines complexity to the host.

WUSB APPLICATIONS

Wireless USB will benefit both from the success of wired USB in the PC market and from the growing demand for wireless technologies in the booming consumer electronics market. The shift to wireless will revitalize existing markets and contribute to the creation of new markets, particularly for multimedia devices that can take advantage of the high data rate. For example, Wireless USB will make possible next-generation notebook PCs with fewer I/O connectors and a more compact design, as well as digital AV equipment that can wirelessly transmit high-definition video.

HOME USAGE MODELS

In the home environment, Wireless USB will eliminate the tangle of cables connecting PCs and peripherals such as printers, scanners, monitors, and digital cameras. In addition, it will wirelessly connect myriad home products, including PCs, stereos, HDTVs, STBs, DVD players, video recorders, digital AV equipment, and the growing class of devices with rich functionality and multimedia capabilities. The home of the not-too-distant wireless future will support individual high-speed wireless personal area networks (WPANs) for entertainment, home office equipment, gaming, and audio devices. Wireless USB will introduce a standard wireless interconnect that supports multiple devices and usage models.

Typical Home Applications

- PCs and peripherals
- PDAs
- External storage devices (HDDs)
- HDTVs and STBs

• Game consoles

• Digital cameras

• Digital camcorders

• DVD players

• MP3 players

• CD players

• Wireless speakers

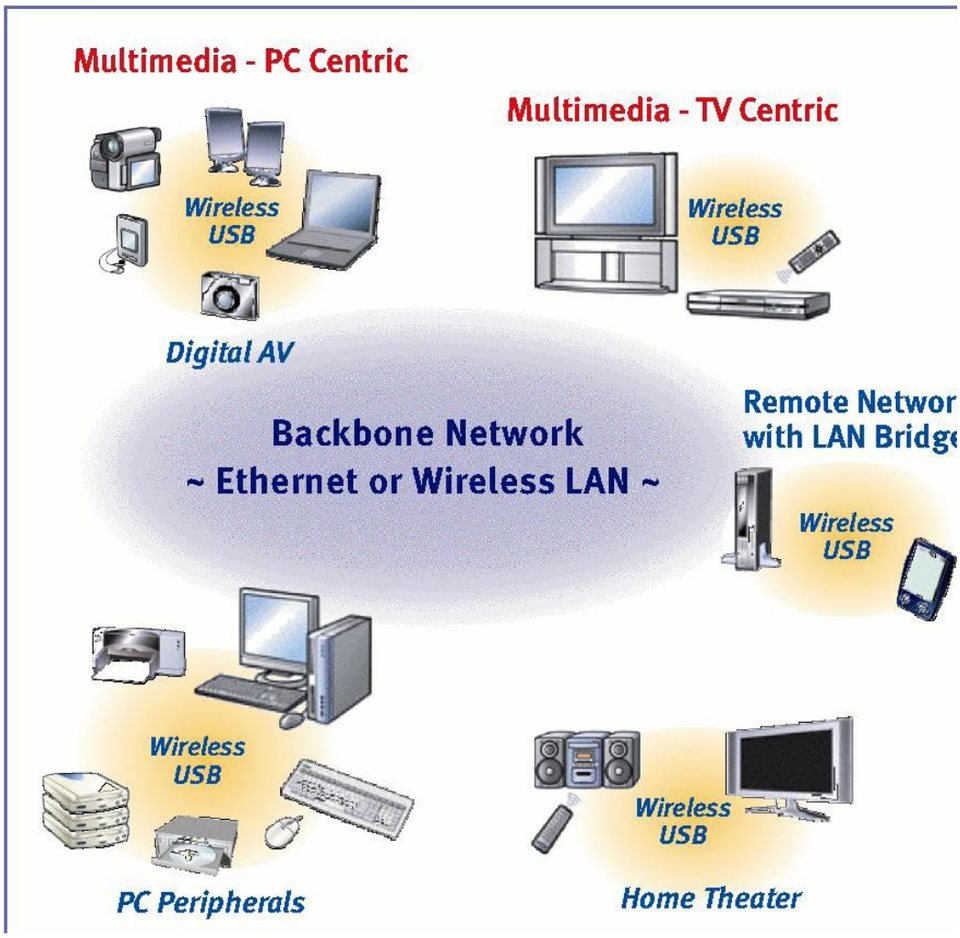

Figure 2. Wireless USB home usage model

OFFICE USAGE MODELS

In the office environment, Wireless USB will offer a broad range of time-saving and productivity-enhancing applications. Users of portable devices such as notebook PCs, PDAs, and cell phones will be able to connect to printers and scanners quickly and easily. Employees will be able to share

printers, scanners and storage devices, back up files quickly, exchange large files without sending them through e-mail, and synchronize their PDAs to a network—all without a single wire.

Typical Office Applications

• Laptop and notebooks computers

• Printers

• Scanners

• Projectors

• Mass storages devices (HDDs)

• PDAs

• Cell phones

NEC ELECTRONICS' COMMITMENT TO WIRELESS USB TECHNOLOGY :

NEC Electronics America is committed to the evolution of USB technology. The company was a driving force in the development of the USB 2.0 standard, working closely with industry-leading companies to make high-speed USB the most successful interface in PC history. Today, NEC Electronics holds fifty percent of the worldwide USB market share and, as an active member of the Wireless USB Promoter Group, MBOA and IEEE, continues to work closely with Intel and other industry leaders to develop a standard Wireless USB specification this year.

WIRELESS USB DEMOS

NEC Electronics America was a lead contributor to the first demonstration of Wireless USB technology at the Intel Developer Forum in Spring 2004. The demo showed two types of wireless transfer: a live video stream and a data file transfer from a USB hard drive.

At the Intel Developer Forum Systems Conference in September 2004, NEC Electronics America exhibited an upgraded Wireless USB prototype demo that featured NEC Electronics' Wireless USB host controller board and new single-board device wire adapter.

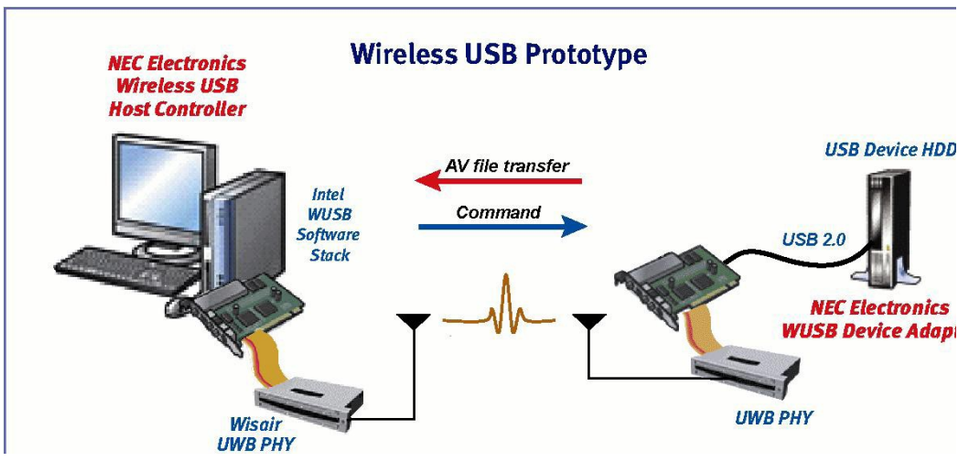

Figure 3. NEC Electronics Wireless USB host controller and device wire adapter

PRODUCT ROADMAP

NEC Electronics' experience with USB will enable the company to develop industry-leading products based on the new Wireless USB standard at a very affordable price. Product development efforts are well underway with plans to begin mass production in 2005. The first generation of Wireless USB products will consist of discrete host controllers that connect to the host via a PCI interface and device adapters for existing USB devices. The company will then bring to market single-chip Wireless USB solutions with an integrated controller and PHY.

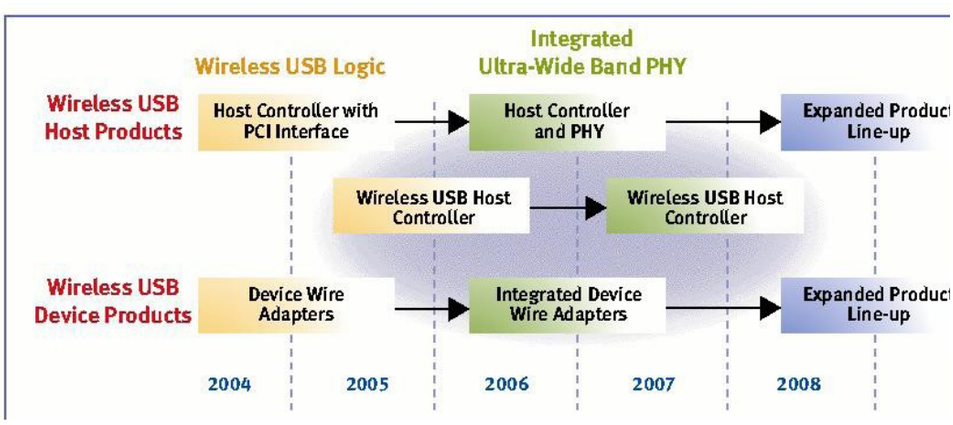

Figure 4. NEC Electronics Wireless USB product roadmap

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