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References and credits

- IEEE - 802.15.3a proceedings
- Philips
- WiMedia
- Wisair
About Wisair

• Fabless semiconductor company
• UWB and Wireless USB chipset solutions for personal computing, consumer electronics and mobile devices
• Founded May 2001
  • Offices: Israel (HQ), Japan, Taiwan, USA
  • Sales representatives: Korea, Singapore, Germany, China
• 110 employees
• Investors
About WiMedia

• A global non-profit organization
• Standards Development
• Defines and Certifies UWB PAN radio platforms shared with partner SIGs
• Worldwide regulatory engagement
• Best practices recommendations
About WiMedia

Why WiMedia?
• Create a radio standard to meet market requirements, including
  • Multi-vendor interoperability
  • Peaceful co-existence in the spectrum we are all sharing and to avoid interference with dissimilar radios in close proximity
• Avoid need for multiple radios to insure connectivity
• Maximize economies of scale

Membership
• Current Membership: ~350 companies
• Complete ecosystem: chipsets, software, test, OEMs/ODMs
UWB History (Regulatory)

- UWB technology has been used since the 60’s for military applications (radar, secure communication)
- Original UWB applications were based on transmission of high power short pulses and later by using spread spectrum methods (chirp, direct sequence)
- August 1998 – FCC issued a Notice On Inquiry (NOI) into ultra wide band
- February 2002 – FCC issued first UWB Report and Order (R&O)
UWB History (Standardization)

- Jan 02 – IEEE form 802.15.3a study group
- Nov 02 – IEEE form 802.15.3a task group
- Mar 03 – Presentations in response to call for proposal (33 proposals)
- May 03 – MBOA an informal organization created
- June 03 – Wireless USB efforts started
- July 03 – MB-OFDM and DS-CDMA are left after down-selection
- Feb 04 – MBOA MAC activity started
- Sep 04 – Formal MBOA SIG created
- Dec 04 – MBOA MAC spec 0.9 released
- Dec 04 – Wireless USB spec 0.9 released
- Jan 05 – WiMedia PHY spec 1.0 released
- Dec 05 – ECMA releases UWB standard based on WiMedia (Ecma-368 and 369)
- Mar 06 – ISO formally adapts Ecma-368/369 as ISO standard
UWB - Key Attributes

- Power: -41dBm/MHz
- Range: in-room / W-PAN
- Rate: 480Mbps PHY
  - 250-350Mbps Application
- Spectrum: 3.1 – 10.6GHz with 500MHz min BW
  - Coexistence
  - Underlay technology
Considerations for the Next Gen Networking Solutions
Connectivity Application Scenarios - HOME

Short range Connectivity
high throughput
wired & wireless

Long Range Networking/Connectivity
wired & wireless

Home Office Cluster

Family PC Cluster

Phone

Audio Cluster

Gaming Cluster

Control

Broadband Data/Voice Access

Broadband Video/Data Access

Home Theater Cluster

Wisair, Inc.
Connectivity Application Scenarios - ENTERPRISE

- **Office Desktop Connectivity**
  - Wired / Wireless

- **Conference Room Connectivity (Ad Hoc)**
  - Wired / Wireless

- **LAN Connectivity**
  - Wired/Wireless
  - IEEE 802.11a/g & n
  - IEEE 802.3 Ethernet

- **Intra-Campus Connectivity (Ad Hoc)**
  - Wired/Wireless

- **Broadband Access**
UWB - Key Applications

• Data transfer
  • Up/downloading
  • Data/file sharing
  • Sync
  • Kiosk

• Multimedia streaming
  • Mobile (PMP) to TV
  • PC to TV
What consumer wants

- Move data
  - Connectivity to desktop peripherals – Wire replacement
  - Easy sync&go
  - Connect fixed networks

- Share data
  - Mobile peer-to-peer applications

- Play content
  - From mobile phones
  - Portable media players
  - Gaming
1. Wireless USB (480 Mbps*)

“The First Killer Application for UWB Technology”

* 480 Mbps is the total capacity available through the air, and does not include any overheads

Applications

- High speed file/content transfer
- Device-to-device
- Device-to-file/content hub
- E.g. DVD (4.7 GB) to HDD ~ <2 min.
- Not QoS critical
  - Content is access off-line
- Media streaming

Advantages

- Reduced installation costs
- Modularity
- Portability
- Simplicity of use
- Multiple easy connections between several sources and several displays
- No “non-standard” interface problems
- Low power (power efficient)
2. Wireless Media Streaming (480 Mbps*)
“The Second Killer Application for UWB Technology”

Applications
• Real-time Media Streaming w/ QoS
  • Hub to/from UI device
  • Sound, Vision, Touch
  • Guaranteed latency & QoS

Advantages
• Reduced installation costs
• Modularity
• Portability
• Simplicity of use
• Multiple easy connections between several sources and several displays
• No “non-standard” interface problems

*480 Mbps is the total capacity available through the air, and does not include any overheads
Scenario for Wireless USB in the digital home

- Local high speed connectivity: based on Wireless USB
- Inter-room connectivity based on LAN, WLAN, Power line, etc.
- Best usage of spectrum

802.11x

Home office

Living room
Some Technical Details
## WiMedia MB-OFDM Band Plan & PHY Rates

### Bands

<table>
<thead>
<tr>
<th>Band</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
<th>#5</th>
<th>#6</th>
<th>#7</th>
<th>#8</th>
<th>#9</th>
<th>#10</th>
<th>#11</th>
<th>#12</th>
<th>#13</th>
<th>#14</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG #1</td>
<td>3168-3432</td>
<td>3696-3960</td>
<td>4224-4488</td>
<td>4752-5016</td>
<td>5280-5544</td>
<td>5808-6072</td>
<td>6336-6600</td>
<td>6864-7128</td>
<td>7392-7656</td>
<td>7920-8184</td>
<td>8448-8712</td>
<td>8976-9240</td>
<td>9504-9768</td>
<td>10032-10296</td>
</tr>
<tr>
<td>BG #2</td>
<td></td>
<td></td>
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<tr>
<td>BG #3</td>
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<tr>
<td>BG #4</td>
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<tr>
<td>BG #5</td>
<td></td>
<td></td>
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<tr>
<td>BG #6</td>
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</tr>
</tbody>
</table>

### Data Rate (Mb/s) | Modulation | Coding Rate (R) | FDS | TDS | Coded Bits / 6 OFDM Symbol ($N_{CBPSS}$) | Info Bits / 6 OFDM Symbol ($N_{IBPSS}$)
<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>53.3</td>
<td>QPSK</td>
<td>1/3</td>
<td>YES</td>
<td>YES</td>
<td>300</td>
<td>100</td>
</tr>
<tr>
<td>80</td>
<td>QPSK</td>
<td>1/2</td>
<td>YES</td>
<td>YES</td>
<td>300</td>
<td>150</td>
</tr>
<tr>
<td>106.7</td>
<td>QPSK</td>
<td>1/3</td>
<td>NO</td>
<td>YES</td>
<td>600</td>
<td>200</td>
</tr>
<tr>
<td>160</td>
<td>QPSK</td>
<td>1/2</td>
<td>NO</td>
<td>YES</td>
<td>600</td>
<td>300</td>
</tr>
<tr>
<td>200</td>
<td>QPSK</td>
<td>5/8</td>
<td>NO</td>
<td>YES</td>
<td>600</td>
<td>375</td>
</tr>
<tr>
<td>320</td>
<td>DCM</td>
<td>1/2</td>
<td>NO</td>
<td>NO</td>
<td>1200</td>
<td>600</td>
</tr>
<tr>
<td>400</td>
<td>DCM</td>
<td>5/8</td>
<td>NO</td>
<td>NO</td>
<td>1200</td>
<td>750</td>
</tr>
<tr>
<td>480</td>
<td>DCM</td>
<td>3/4</td>
<td>NO</td>
<td>NO</td>
<td>1200</td>
<td>900</td>
</tr>
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</table>
### Channels

<table>
<thead>
<tr>
<th>TFC Number</th>
<th>TFC Type</th>
<th>Band ID Values in Band Group 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TFI</td>
<td>1 2 3 1 2 3</td>
</tr>
<tr>
<td>2</td>
<td>TFI</td>
<td>1 3 2 1 3 2</td>
</tr>
<tr>
<td>3</td>
<td>TFI</td>
<td>1 1 2 2 3 3</td>
</tr>
<tr>
<td>4</td>
<td>TFI</td>
<td>1 1 3 3 2 2</td>
</tr>
<tr>
<td>5</td>
<td>FFI</td>
<td>1 1 1 1 1 1</td>
</tr>
<tr>
<td>6</td>
<td>FFI</td>
<td>2 2 2 2 2 2</td>
</tr>
<tr>
<td>7</td>
<td>FFI</td>
<td>3 3 3 3 3 3</td>
</tr>
</tbody>
</table>

- TFC8-10 (Phy spec 1.2) hoping sequence between only 2 bands
Time Frequency Codes

TFI – Time Frequency interleaving

FFI – Fix Frequency interleaving
Encoder

Scrambler → 64-State BCC → Puncturer → 3-Stage Interleaver → QPSK Mapper → IFFT → DAC

Error Control Coding
- Standard 64-State Binary Convolutional Code
- Punctured to achieve various data rates

IFFT
- 128 points
- 100 data, 12 pilot, 10 guard, 6 null

Time Frequency Kernel

Frequency-Domain Inputs

Time-Domain Outputs
As characteristic of OFDM systems, signal rolloff is sharp yielding excellent adjacent channel interference characteristics.

**DAC converter rate** = 528 MHz

**Tone width** = 4.125 MHz

**Instantaneous Bandwidth**

\[ \approx 123 \times 4.125 \text{ MHz} = 511 \text{ MHz} \]
MAC, PAL / Protocol Layers
WiMedia Common Radio Platform

- Multiple Protocols
- WiMedia UWB Radio Platform
- PAL: Protocol Adaptation Layer
- MAC & Policies
- UWB PHY (MB-OFDM)
- Proprietary Implementation
- IP
- Network

PAL: Protocol Adaptation Layer
WiMedia MAC Principles

- No Central Coordinator
  - Facilitate spatial reuse
  - Higher robustness to interference and mobility / topology changes
- Every device transmits a beacon with:
  - DRP reservations + negotiations + (availability)
  - Beacon Period Occupancy (neighbors, hooks to “shrink” BP)
  - Hibernation (for self and neighbors – anchor)
  - Network Management info
    - BP Switch IE
    - Channel change IE, etc.
  - Link Feedback for peers (requested TX power and data rate)
  - PCA traffic related IEs: TIM (Traffic Information Map), PCA availability
  - Capability IE (for peer discovery)
- Media Access Methods:
  - DRP - Distributed Reservation Protocol – Reservation-based
  - PCA - CSMA/CA, Contention-based, with tools for handling hidden node problems.
- Fixed length super-frame: (256 MAS Slots) x 256 us = 65 ms;
- Each MAS slot is of type: DRP / PCA / Beacon
- Move data from DRP to PCA whenever there is a link reliability problem due to mobility / interference, etc.
Superframe Structure

Figure 2 — MBOA MAC superframe structure

MAS – Media Access Slot
The BP is dynamic in length and consists of a dynamic number of beacon slots, up to 16 contiguous MAS slots. Each MAS slot contains 3 beacon slots.

BP is dynamically expanded and contracted, according to needs.

All devices track the slowest device for beacons (and Superframe) synchronization.

In case of merging networks with un-aligned BPs, BPs must be merged within up to ~8 sec (earlier if instructed by upper layer)
**MAS Allocation policy**

- 16 MAS Allocation Zones, 16 MAS slots each
- Tradeoff between low-latency, low buffering and throughput and power efficiency
Prioritized Contention Access (PCA)

- CSMA/CA access method. Mainly for transfer of asynchronous data and commands.
- Based on 802.11e Enhanced Distributed Channel Access (EDCA).
- Map user priorities to MAC access priorities, defined by channel access parameters (Listening Window and Contention Window);
- Use RTS / CTS control frames for minimizing collisions due to “hidden nodes”.
- Use “Duration” field in frames transmitted during PCA to protect the frames exchange (Network Allocation Vector - NAV).
- Can be used for DRP traffic in case of problems in DRP transfer due to networks merger, interference, peaks in VBR traffic, etc.
Wireless USB
Wireless USB Philosophy

• Preserve USB asymmetry between host and devices
  • Host is complex and more expensive, devices are simple and less expensive
  • Wireless USB communication model is based on the wired USB model
    • One host, many devices
    • Host-poled communications
      – Device don’t send or receive USB data unless explicitly scheduled by the host

• Keep the original USB types of transfer: Control, Bulk, Interrupt, Isochronous

• Allow “easy porting” of wired USB devices to Wireless USB
  • Utilize the existing USB software infrastructure
  • Minimize cost and complexity of device implementation

• Security
  • Provide highly secured connection: “comparable to wired USB”
Wireless USB Philosophy

- Power management (battery preservation)
  - Enable Low-power optimization
- Ease of use
  - Easy installation and set up
  - Backward compatible to wired USB
- Minimize Cost/Complexity of device implementation
  - Enable Low-power, Low-memory optimization
Wireless USB Topology

- Connection model is wire replacement
  - Point-to-point communication between host and devices
  - Intercommunication between devices or other host-device clusters is not supported
- Asymmetric model
  - Host is smart and “powerful”, devices are cheap and “dumb”
  - The host pushes or pulls application traffic, devices cannot initiate traffic
- WUSB cluster
  - WUSB host with one or more peripheral (up to 127, 48)
- WUSB clusters should co-exist
WiMedia – WUSB relationship

- WiMedia common radio platform provides tools for W-USB operation:
  - Private DRP for W-USB operation reservation;
  - W-USB treats other WiMedia devices as a “good neighbor”:
    - Should respects their DRP reservations;
    - Lets them know of Private DRP reservation used by W-USB, to avoid collisions;
    - Exchanges information with other devices through beacons.
Wireless USB Configurations

- Native Host
- Native Device
- Host Wire Adaptor
- Device Wire Adaptor
- DRD
Wire Adapter (HWA and DWA)

• **Purpose:**
  - Uses existing host and device’s wired USB connections
  - To be an enabler of WUSB technology inheriting the popularity of the most successful interface in the world
  - To utilize the existing USB infrastructure
    - Richest set of supported device classes
    - Excellent protocol for keeping device cost low
  - To provide a USB to WUSB bridge
Wire Adapters

• **Advantages**
  • Will work with any USB host and devices - All existing drivers are valid
  • Supports the legacy installed base - Immediate use
  • No device side driver development and WUSB integration

• **Disadvantages**
  • Lower (than native mode) throughput performance
  • Dongle and hub configuration (could be built in, too, in some cases)
Two Types of Wire Adapter

Host Wire Adapter & Device Wire Adapter

Host Wire Adaptor: HWA

Device Wire Adaptor: DWA

USB2.0
Native Host & Native Device solutions

- **Advantages**
  - Highest performance
  - Targets embedded solutions
  - Long term
  - Lower cost
  - Lower power

- **Disadvantages**
  - System level design considerations, may not a simple add-on
    - F/F, antenna, power, etc.
  - Native WUSB driver development (especially for the Device side)
Native WUSB Solution examples

- **PC (Host)**
  - PCIe Mini or Half Mini Card (a la Notebook WiFi cards)
  - Requires (on PC) WHCI driver

- **Device**
  - Printer, DSC, camcorder, PMP using SDIO with built in WUSB drivers
  - Other local bus based built-in solutions with various RTOS and drivers
Native WUSB

Inherent “Hub” over the air without the costly hardware
Dual-Role Device

- For P2P only (à la USB OTG)
- Acts as a Host, in part of superframe and Device in other part of superframe (time mux)
- Host part of a DRD, is a simple host with limited, enabled with pre-determined capabilities
- A static dual role device may be defined by the OEM:
  - Host at select times and device on others
  - Could be user or auto-select
  - Example:
    - a DSC can act as WUSB device for reading picture files by a PC.
    - At a later time it can act as a WUSB host for printing pictures to a WUSB printer
Wireless USB Association Models
Connection Context (CC)

- The CC bears all the information needed in order to set up a secure communication between host and device
- Includes a secret key (128 bits)
- It is unique for each host-device connection
- The CC is generated by the host
- Needs to be downloaded to the device

Association gets the CC from the host to the device
Cable Association Method

1. User connect host and device with USB cable.
2. Host sends Connection Context

WUSB Host

WUSB Devices
Numeric Association Method

1. The host and the device must have a display and button.
Other Potential Association Methods

- NFC
- Long PIN
  - “Proprietary” mode that is being requested by some PC OEMs in order to have a single pairing method for all wireless technologies
    - WiFi, WUSB, etc.
WUSB, Bluetooth, 802.11n
## WUSB vs. 802.11n

<table>
<thead>
<tr>
<th>Purpose/application</th>
<th>802.11n</th>
<th>Wireless USB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Networking technology</td>
<td>Wire replacement, personal area network (PAN)</td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td>30-40 meters</td>
<td>10 meters</td>
</tr>
<tr>
<td>Throughput</td>
<td>60-120 Mbps @ 3-30 meters</td>
<td>40-200 Mbps @ 3 meters</td>
</tr>
<tr>
<td>Power consumption (average)</td>
<td>~2W • assumes 2-3 antennas</td>
<td>250 mW • assumes 400 Mbps PHY, active ½ the time • Host/device can sleep in synchronized way during transmission</td>
</tr>
<tr>
<td>Issues</td>
<td>• High throughput requires multiple transmit receive (3x3, 3x2) antennas • Higher cost</td>
<td>• High throughput with single antenna • Low cost • Ease of use</td>
</tr>
<tr>
<td>Conclusion</td>
<td>Best for wall-powered, full home applications (networking)</td>
<td>Best for mobile, battery-powered applications (PAN)</td>
</tr>
</tbody>
</table>
# WUSB vs. Bluetooth

<table>
<thead>
<tr>
<th></th>
<th>Bluetooth</th>
<th>Wireless USB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose/application</strong></td>
<td>Wire replacement, personal area network</td>
<td>Wire replacement, personal area network</td>
</tr>
<tr>
<td><strong>Distance</strong></td>
<td>10 meters</td>
<td>10 meters</td>
</tr>
<tr>
<td><strong>Throughput</strong></td>
<td>1-2 Mbps</td>
<td>40-200 Mbps</td>
</tr>
<tr>
<td><strong>Power consumption (average)</strong></td>
<td>60 mW (active mode)</td>
<td>250 mW&lt;br&gt;- assumes 400 Mbps PHY, active $\frac{1}{2}$ the time&lt;br&gt;- Host/device can sleep in synchronized way during transmission</td>
</tr>
<tr>
<td><strong>Conclusion</strong></td>
<td>Suitable for low-data rate applications (headsets)</td>
<td>Best for applications with high data rate, multimedia</td>
</tr>
</tbody>
</table>
## Comparison Table

<table>
<thead>
<tr>
<th></th>
<th>Bluetooth</th>
<th>802.11</th>
<th>UWB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average data transfer rate</strong></td>
<td>1 Mbps</td>
<td>20 Mbps</td>
<td>100 Mbps</td>
</tr>
<tr>
<td><strong>Average power consumption (active mode)</strong></td>
<td>60 mW</td>
<td>500 mW</td>
<td>250 mW (assumes 400 Mbps PHY rate, active half the time)</td>
</tr>
<tr>
<td><strong>Time (4GB transfer)</strong></td>
<td>32,768 seconds (4096/0.125)</td>
<td>1638 seconds (4096/2.5)</td>
<td>328 seconds (4096/12.5)</td>
</tr>
<tr>
<td><strong>Power consumed</strong></td>
<td>546 mWh</td>
<td>228 mWh</td>
<td>22.7 mWh</td>
</tr>
<tr>
<td><strong>% of a 3Wh battery</strong></td>
<td>18%</td>
<td>7.6 %</td>
<td>0.75%</td>
</tr>
</tbody>
</table>
Time/Power for 4GB Transfer

- **Time (minutes):**
  - Bluetooth: 546
  - 802.11: 27.3
  - UWB: 5.5

- **Power Consumption (%):**
  - Bluetooth: 18%
  - Wi-Fi: 7.6%
  - UWB: 0.75%
Summary

• UWB provides the most cost and power-efficient solution for short range connectivity amongst wireless technologies

• This is enabled by
  • The significantly higher throughput (compensating for higher power consumption than BT)
  • Superframe structure. Enables host & device to sleep in synchronized way during data transmission – reducing power

• Worldwide standards (via WiMedia, Ecma and ISO/IEC) enables multi-vendor interoperable products

• Established, ongoing certification process

• Worldwide regulatory acceptance
Wireless USB and Market
Wireless USB Value Proposition

- Wire replacement technology
- Speed and security of wired technology with the ease-of-use of wireless technology
- New usage models, not possible in wired world (peer-to-peer connectivity, device sharing)
- The optimal short-range, high data rate, power-efficient wireless solution
Emerging Applications – Wire Replacement

Wiring Rats’ Nests

Scanners
Printers
External Hard Drives

DVD
DVR
STB
Game Console
Docking Version 1:
Touch the display, projector, etc.
and it is associated.

Docking Version 2:
Mobile computers dock with monitor + Keyboard
amplify the small user interface.

Ideal for Internet cafes
Can be used to amplify automobile
capabilities.

Internet Café’
Workstation
Emerging Applications/Services

Video On The Go

Automobile
Plane

PVP
Mobile Phone
Mobile Internet Device

Kiosk
Network

PVR

Internet
Status
Radio Chips (PHY):
- 19 chipsets

Platform Products (PHY + MAC):
- 21 PHY + MAC implementations
Computer products:
✓ 12 laptop computers

Consumer products:
✓ 49 certified end products
Regulatory Status

Summary

- Spectrum allocation already approved for most major geographic regions
- Additional regions in process and expect full approval shortly
- 14 bands available in the US
- At least 5 bands available in each region
- At least 3 bands common in every region

*Detailed info by region on following slides*
Regulatory Status Summary
Pending Approval

• China
• Canada
Wisair Offerings
Wisair WSR601 Offering

- Host & Device solutions based on CMOS single chip
- Offering the best combination for Wireless USB of:

**Enhanced Performance + Power Efficiency + Low Cost**

Overview

- Single Chip
- Embedded Solutions
- Dongle Set
- PCB Antenna
• **External adapters**
  - Device dongle:
    - Native Device over USB
    - Auto-detect-combo (DWA & Native Device)
  - Host dongle
    - HWA

• **Embedded Solutions**
  - Embedded PCB module reference design (wired/wireless support)
  - Small form factor module (10x10mm) under development by module vendor (prototype is now in production)

• **PC Drivers**
  - HWA & DWA for Vista & XP
  - Native Device over USB does not require a driver
**WSR601 Optimized Throughput Per Device Type**

- Unified DWA & Native Device over USB (auto sensing feature)
- USB device type is automatically identified → the appropriate WUSB protocol (DWA/Native) is employed

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Throughput</th>
<th>Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Wire Adapter (DWA)</td>
<td>Up to 40 Mbps</td>
<td>Any USB device (printer, hub…)</td>
</tr>
<tr>
<td>Native WUSB device with UltraSpeed™</td>
<td>Up to 70 Mbps (HWA)</td>
<td>AIO/MFP, External HDD or other mass storage devices</td>
</tr>
<tr>
<td></td>
<td>Over 200Mbps (Native host)</td>
<td></td>
</tr>
</tbody>
</table>
# WSR601 Certification Status

## Regulations

<table>
<thead>
<tr>
<th>Region</th>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>✔️ Done</td>
<td>FCC authorization granted Dec-07.</td>
</tr>
<tr>
<td>Japan</td>
<td>✔️ Done</td>
<td>TELEC authorization granted Sept.-07.</td>
</tr>
</tbody>
</table>
| Europe   | ✔️ Done| 1. ETSI Class 1 UWB device approved in Feb-08  
2. Taking part of the WALTER EC-FP7 project with ETSI and At4Wireless lab (also ST and others) to define the test cases and procedures |
| S. Korea | ✔️ Done| Waiting on the formal approval letter                                        |

## Standards

<table>
<thead>
<tr>
<th>Standard</th>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WiMedia PHY</td>
<td>✔️ Done</td>
<td>Registered PHY</td>
</tr>
<tr>
<td>WiMedia MAC</td>
<td>✔️ Done</td>
<td>Platform certified</td>
</tr>
<tr>
<td>USB-IF</td>
<td>✔️ Done</td>
<td>WSR601is USB-IF certified</td>
</tr>
</tbody>
</table>
Next steps
Next Steps in UWB Development

Today:

• High performance
  • 480Mb/s
• Lowest Power
  • 1.5-2 mW/Mbps
• Regulatory compliance
  • Major markets

By 2010:

Higher Throughput
For Video & Synch & Go Applications

Spectrum Enhancements
For Worldwide Regulatory Compliance

Ultra Low Power
Consumption for additional Mobile Applications
WiMedia Common Radio Platform

Multiple Protocols
- USB
- Bluetooth

&/or

Proprietary Implementation

Common Platform

WiMedia UWB Radio Platform

MAC & Policies

UWB PHY (MB-OFDM)

PAL: Protocol Adaptation Layer
WUSB Demo
Q&A
Thank you

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serdar@wisair.com