UWB Update

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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)

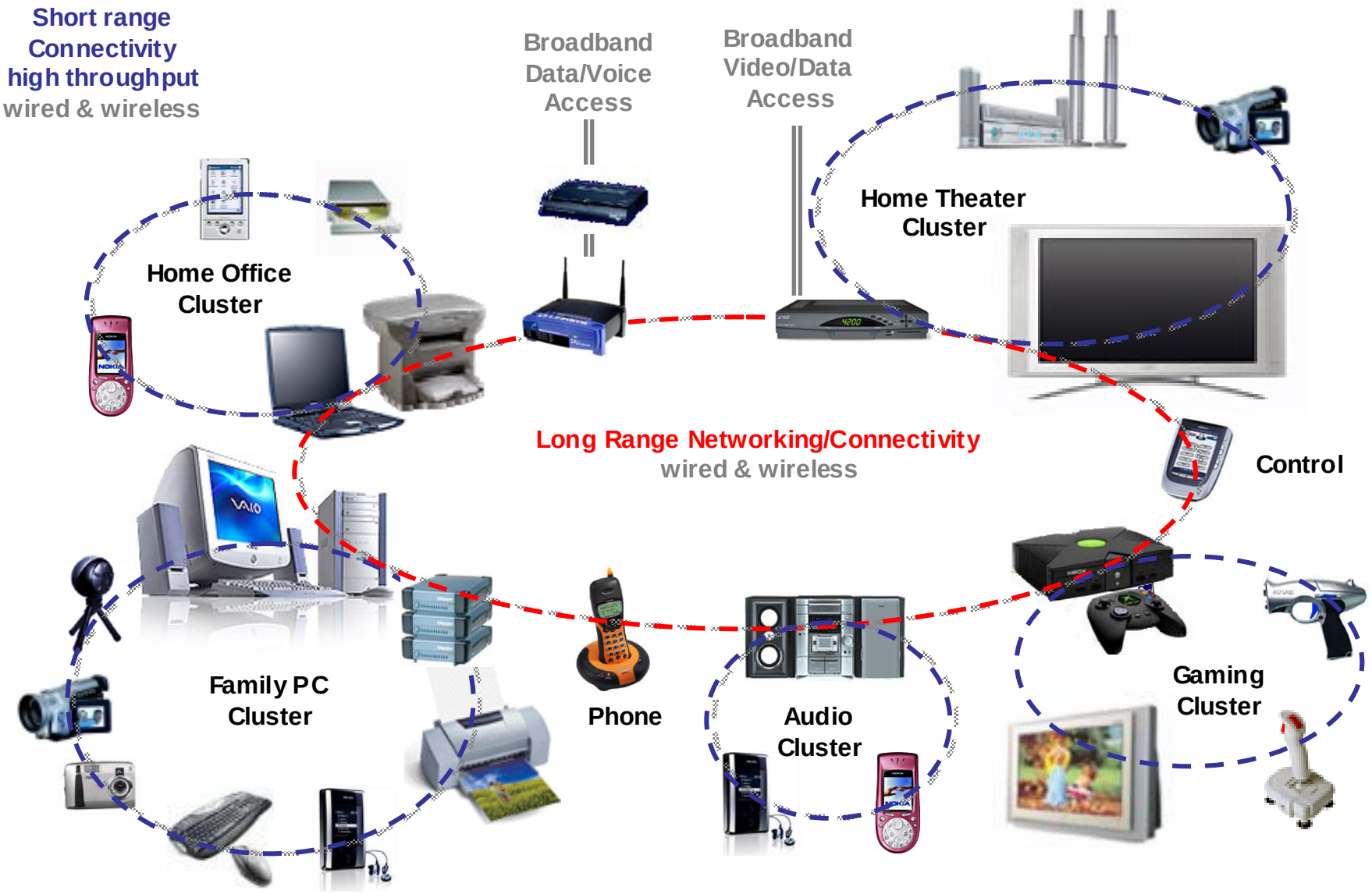
- Jan 02 – IEEE form 802.15.3a study group
- Nov 02 – IEEE form 802.15.3a task group
- Mar 03 – Presentations in response to call for proposal (33 proposals)
- May 03 – MBOA an informal organization created
- June 03 – Wireless USB efforts started
- July 03 – MB-OFDM and DS-CDMA are left after down-selection
- 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



Connectivity Application Scenarios - ENTERPRISE

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

Application Focus

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)**

Application Focus

2. Wireless Media Streaming (480 Mbps*)

"The Second Killer Application for UWB Technology"

Applications

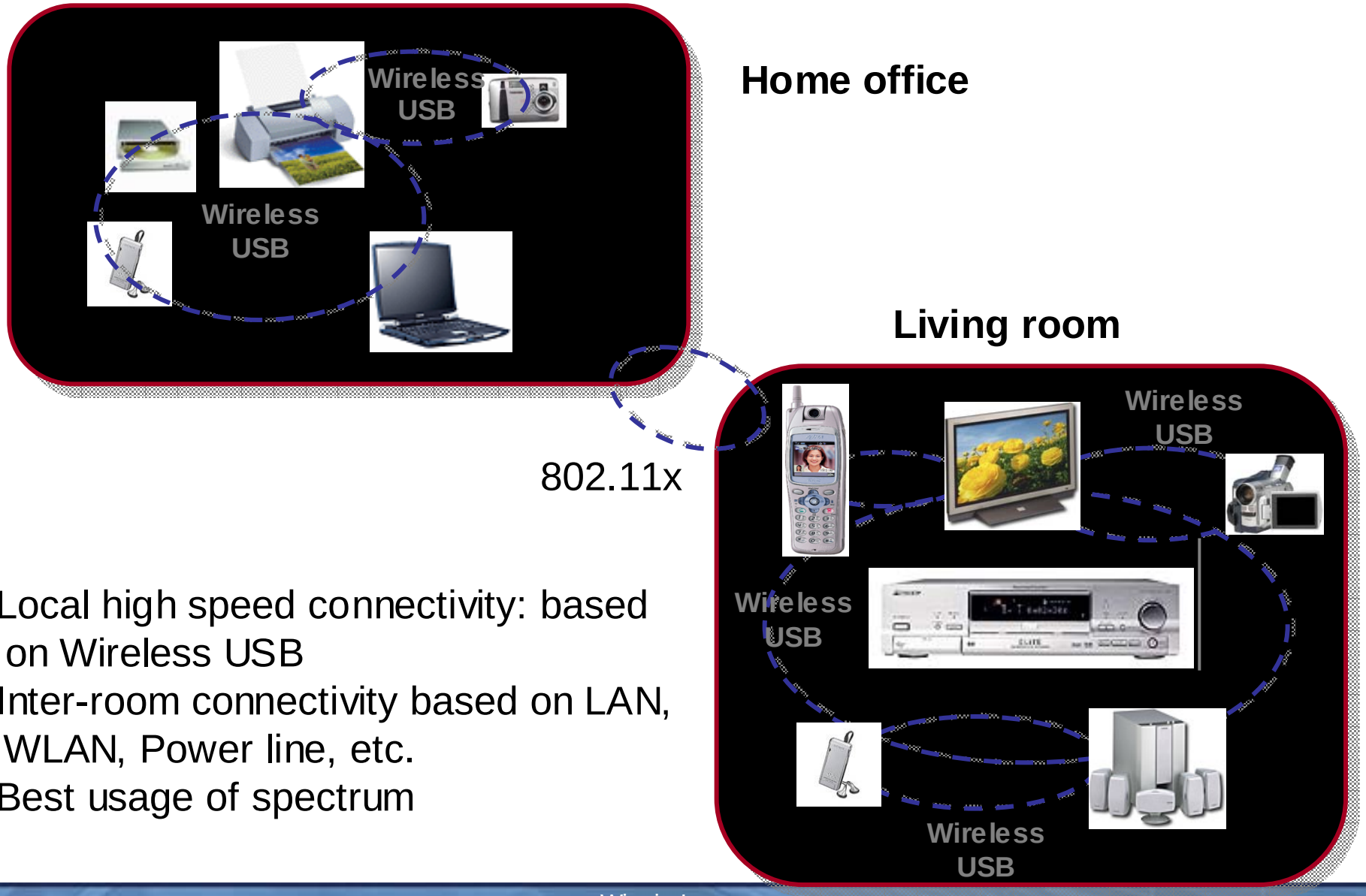
- Real-time Media Streaming w/ QoS
  - Hub to/from UI device
    - Sound, Vision, Touch
- Guaranteed latency & QoS

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

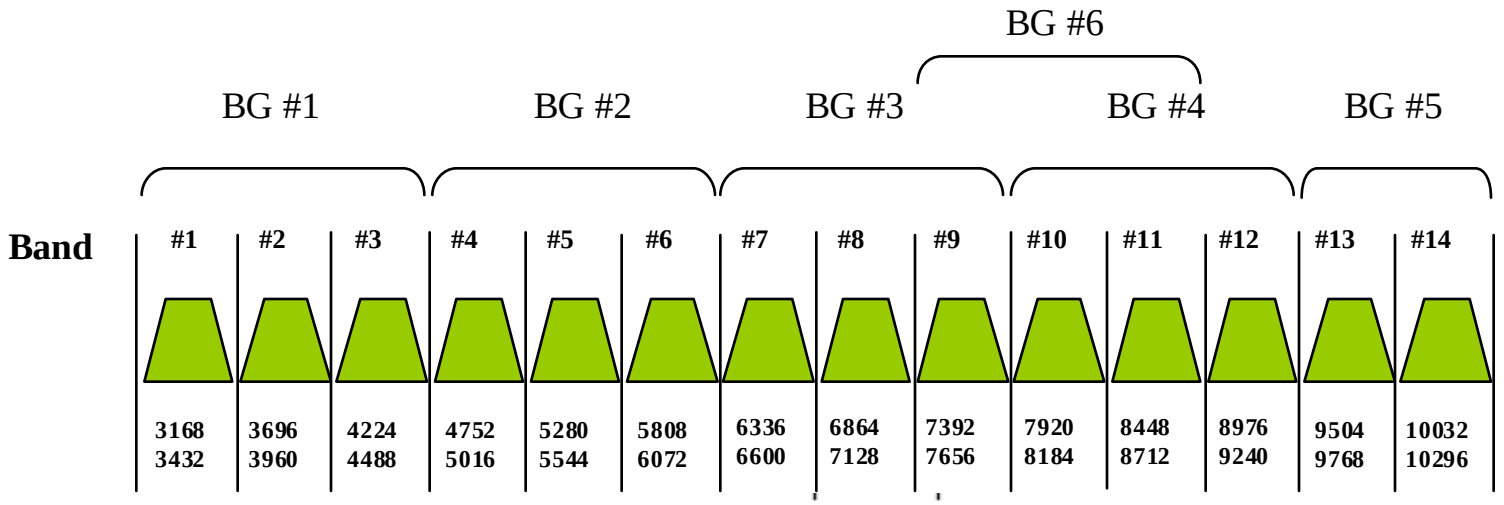
Scenario for Wireless USB in the digital home



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

Some Technical Details

WiMedia MB-OFDM Band Plan & PHY Rates



Data Rate (Mb/s)	Modulation	Coding Rate (R)	FDS	TDS	Coded Bits / 6 OFDM Symbol (N_{CBP6S})	Info Bits / 6 OFDM Symbol (N_{IBP6S})
53.3	QPSK	1/3	YES	YES	300	100
80	QPSK	1/2	YES	YES	300	150
106.7	QPSK	1/3	NO	YES	600	200
160	QPSK	1/2	NO	YES	600	300
200	QPSK	5/8	NO	YES	600	375
320	DCM	1/2	NO	NO	1200	600
400	DCM	5/8	NO	NO	1200	750
480	DCM	3/4	NO	NO	1200	900

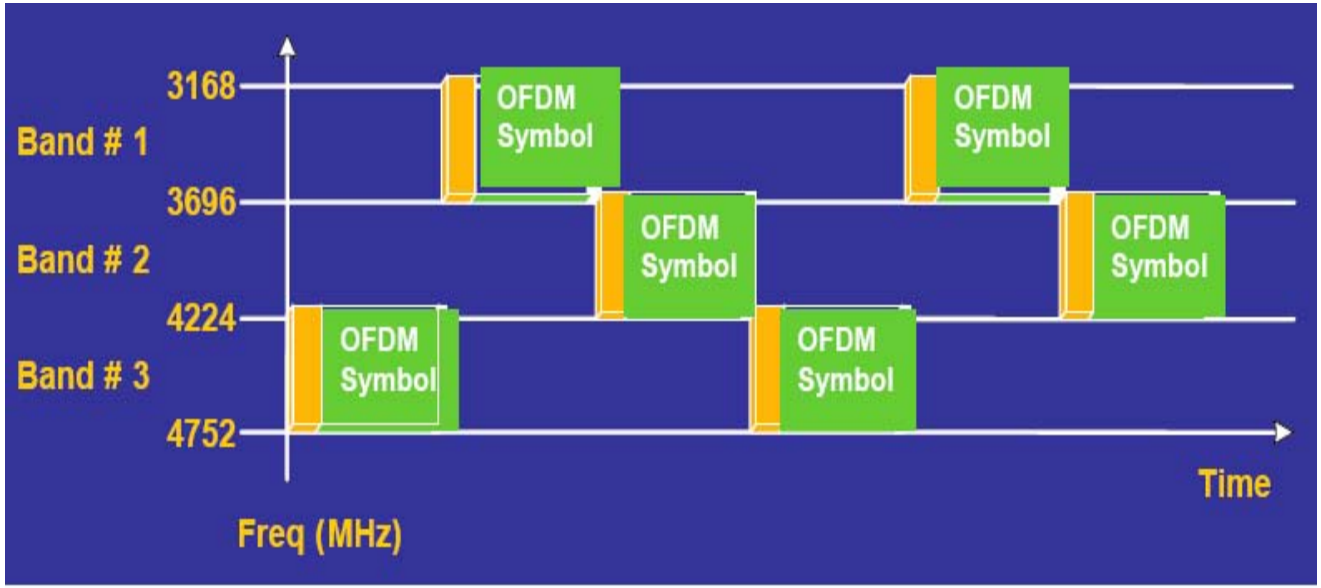
Channels

TFC Number	TFC Type	Band ID Values in Band Group 1					
1	TFI	1	2	3	1	2	3
2	TFI	1	3	2	1	3	2
3	TFI	1	1	2	2	3	3
4	TFI	1	1	3	3	2	2
5	FFI	1	1	1	1	1	1
6	FFI	2	2	2	2	2	2
7	FFI	3	3	3	3	3	3

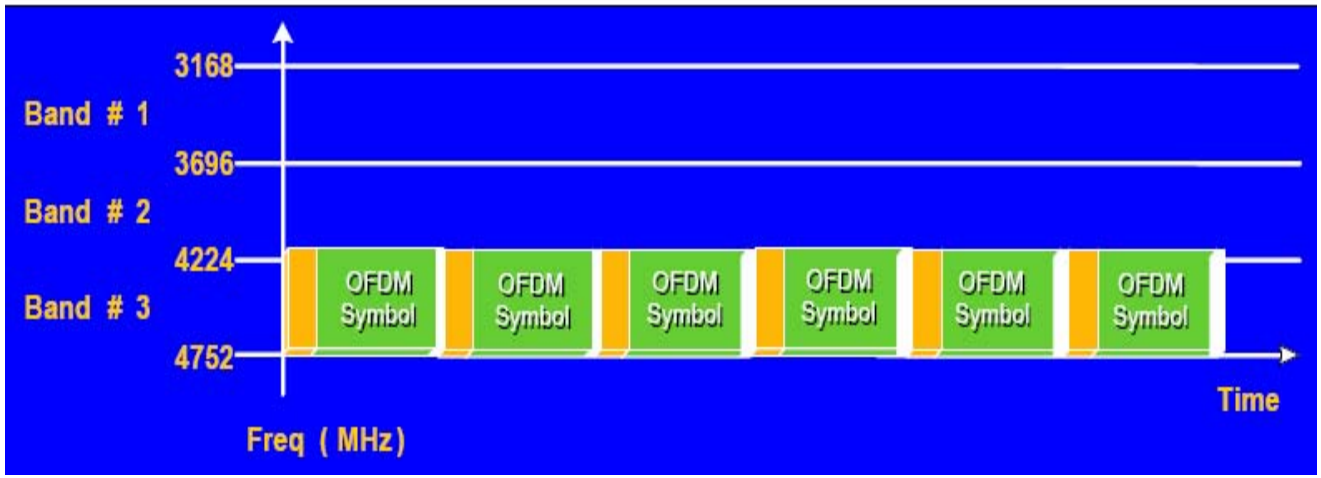
- TFC8-10 (Phy spec 1.2) hoping sequence between only 2 bands

Time Frequency Codes

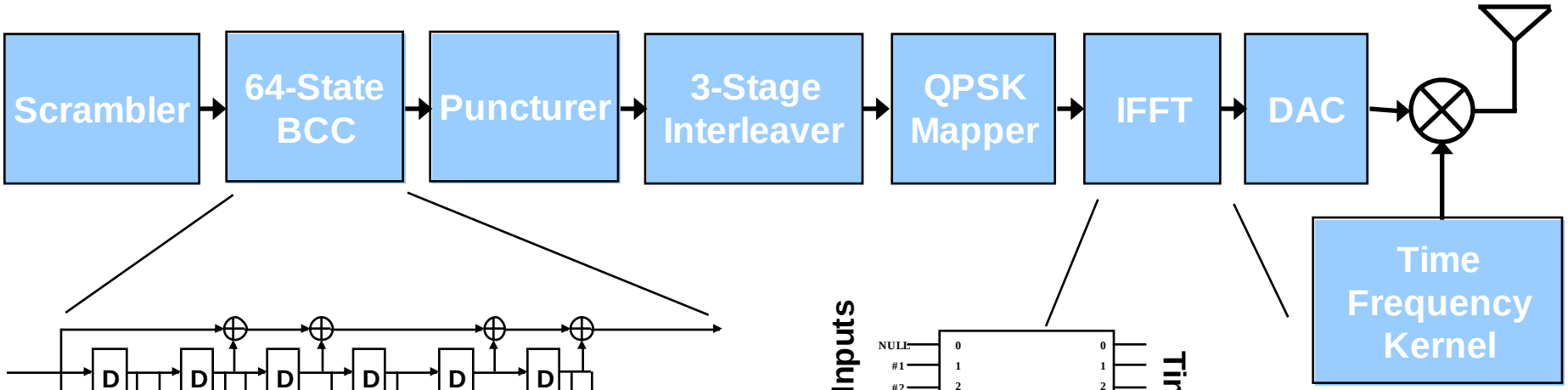
TFI – Time Frequency interleaving



FFI – Fix Frequency interleaving



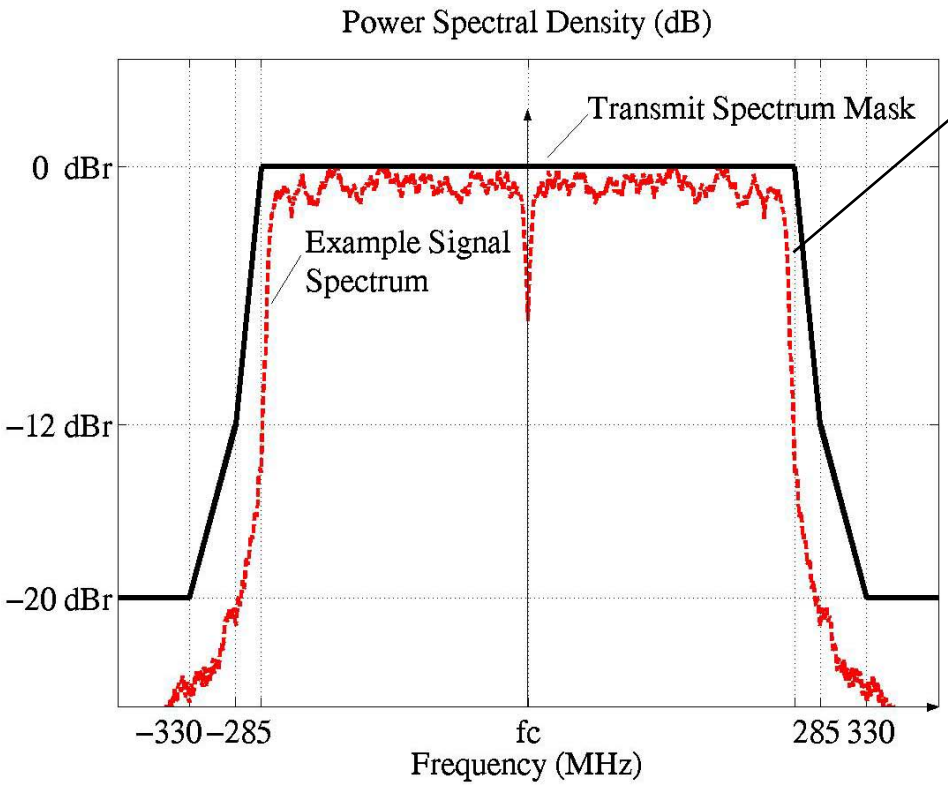
Encoder



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

Spectrum



DAC converter rate = 528 MHz

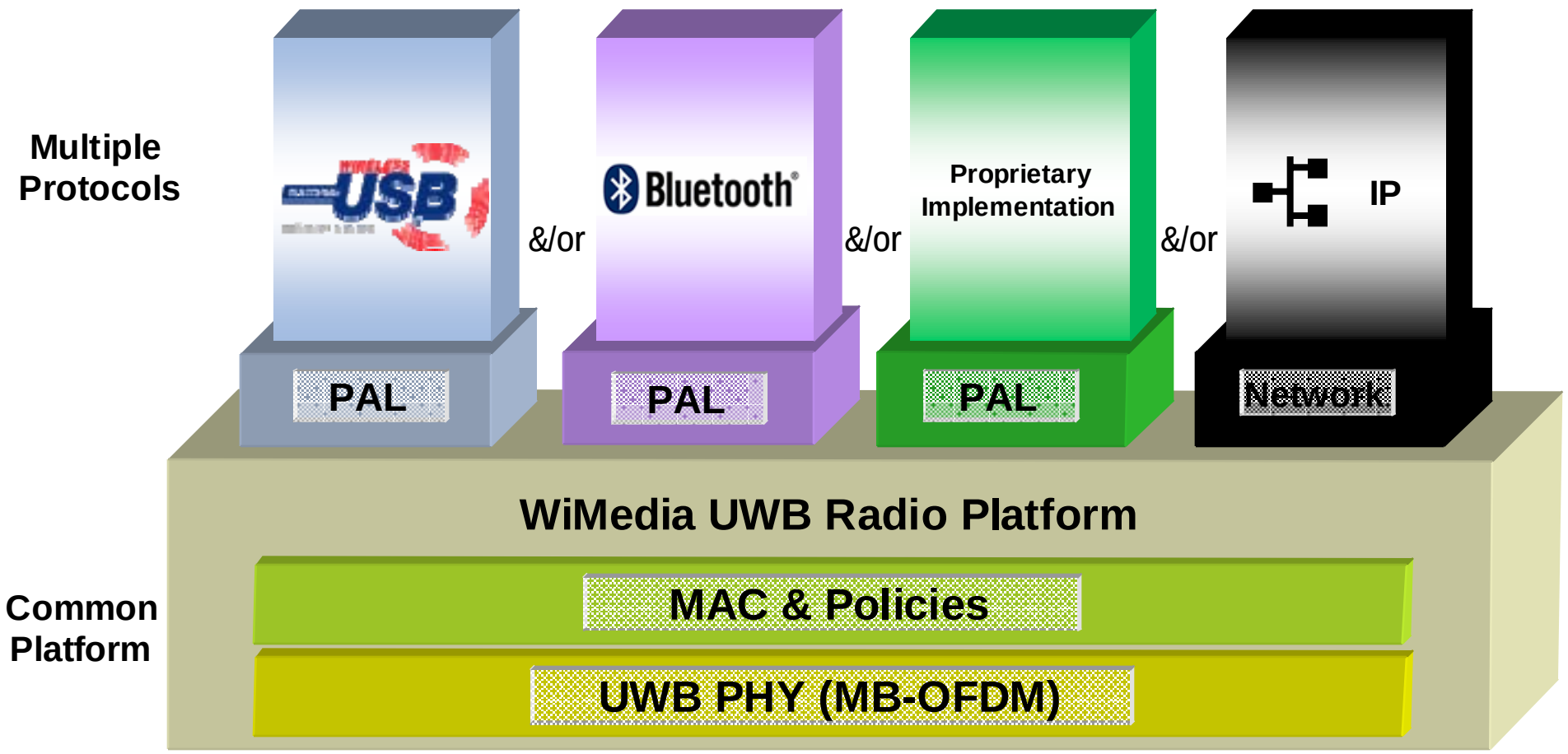
Tone width = 4.125 MHz

Instantaneous Bandwidth
≈ 123 * 4.125 MHz = 511 MHz

As characteristic of OFDM systems, signal rolloff is sharp yielding excellent adjacent channel interference characteristics

MAC, PAL / Protocol Layers

WiMedia Common Radio Platform



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

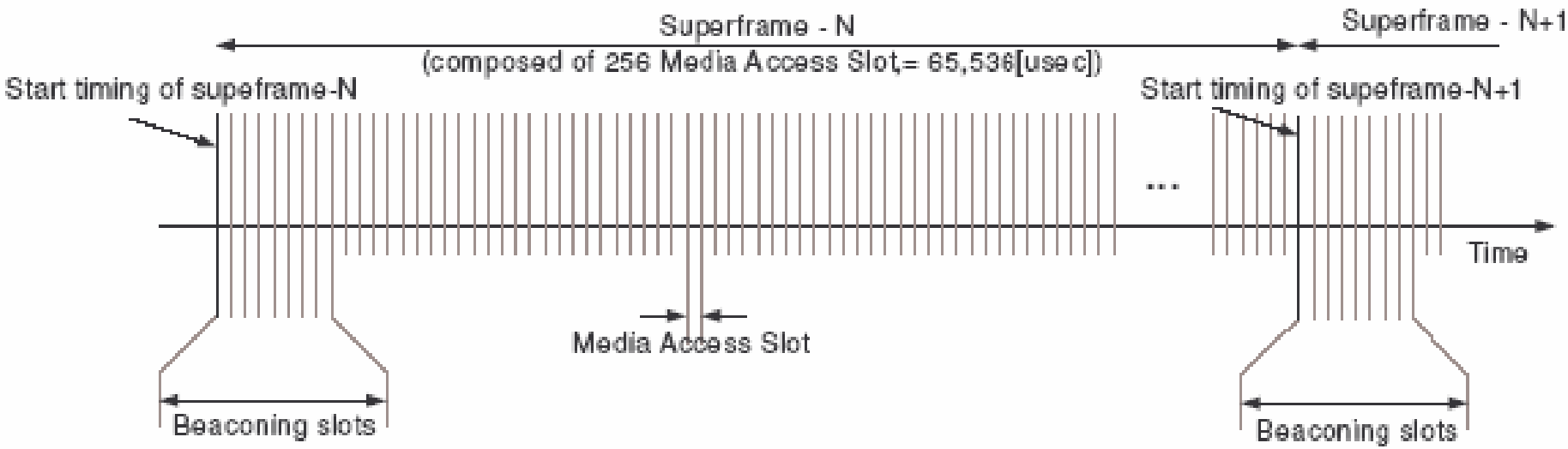
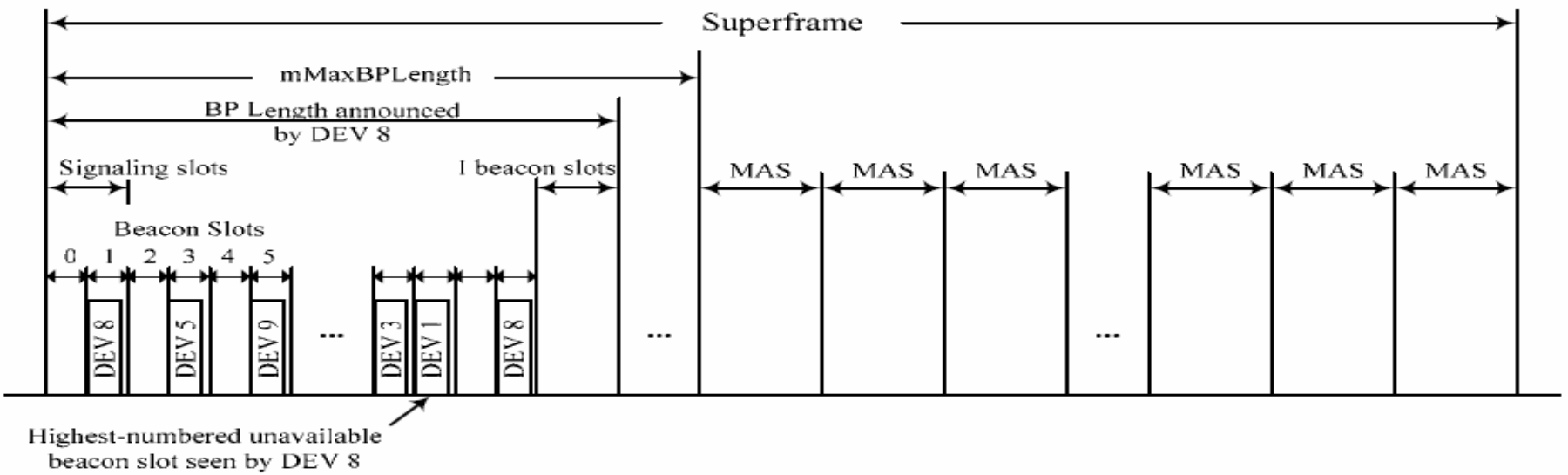


Figure 2 — MBOA MAC superframe structu

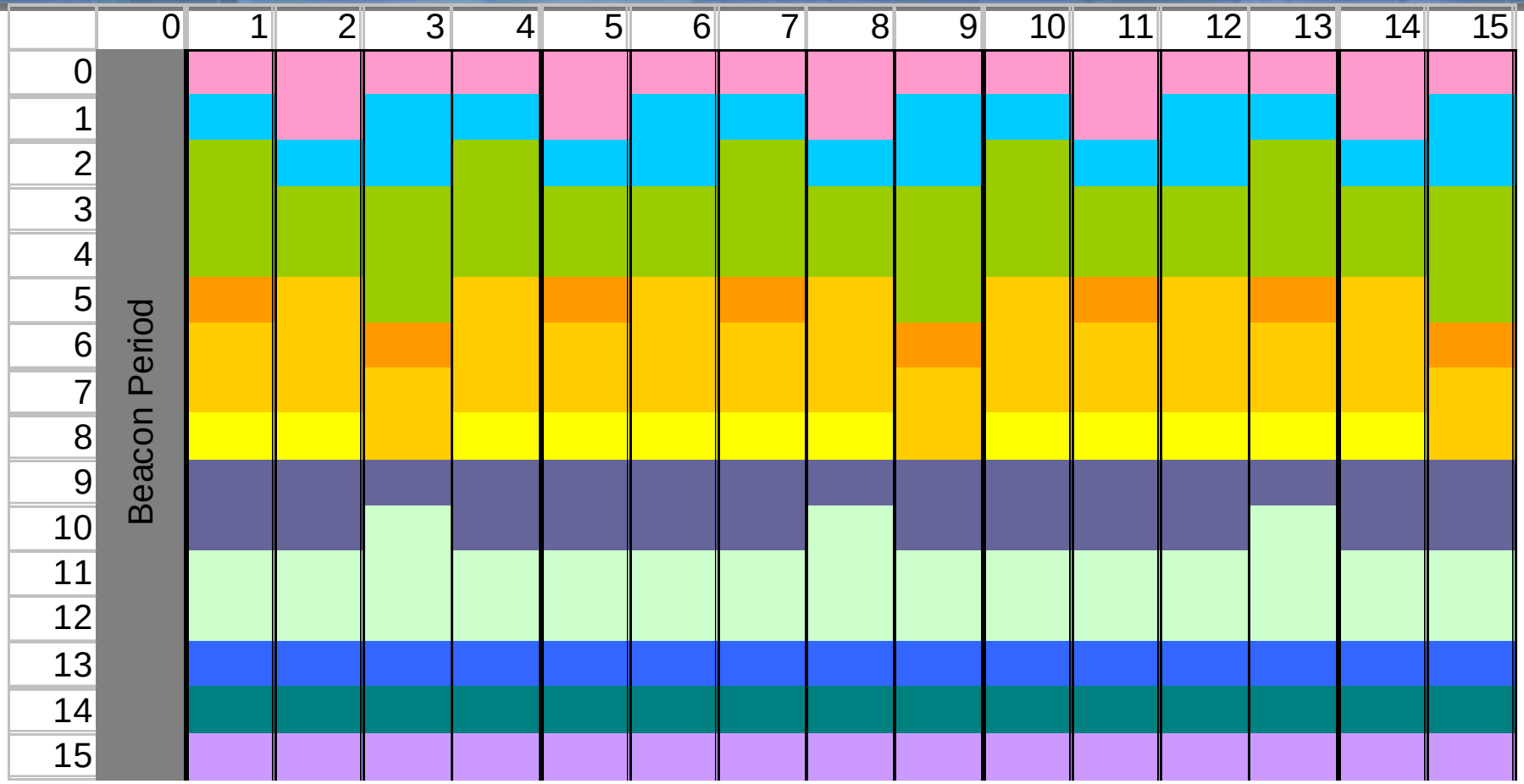
MAS – Media Access Slot

Beacon Period



- 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)

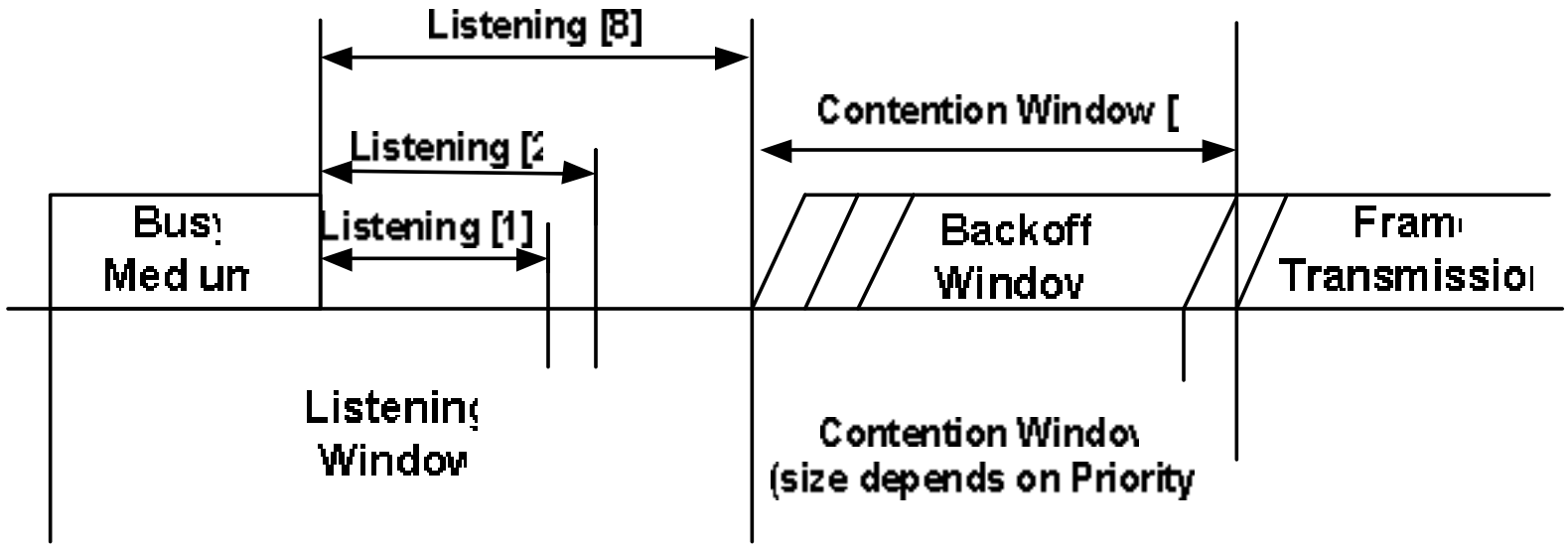
MAS Allocation policy



- 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-polled 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

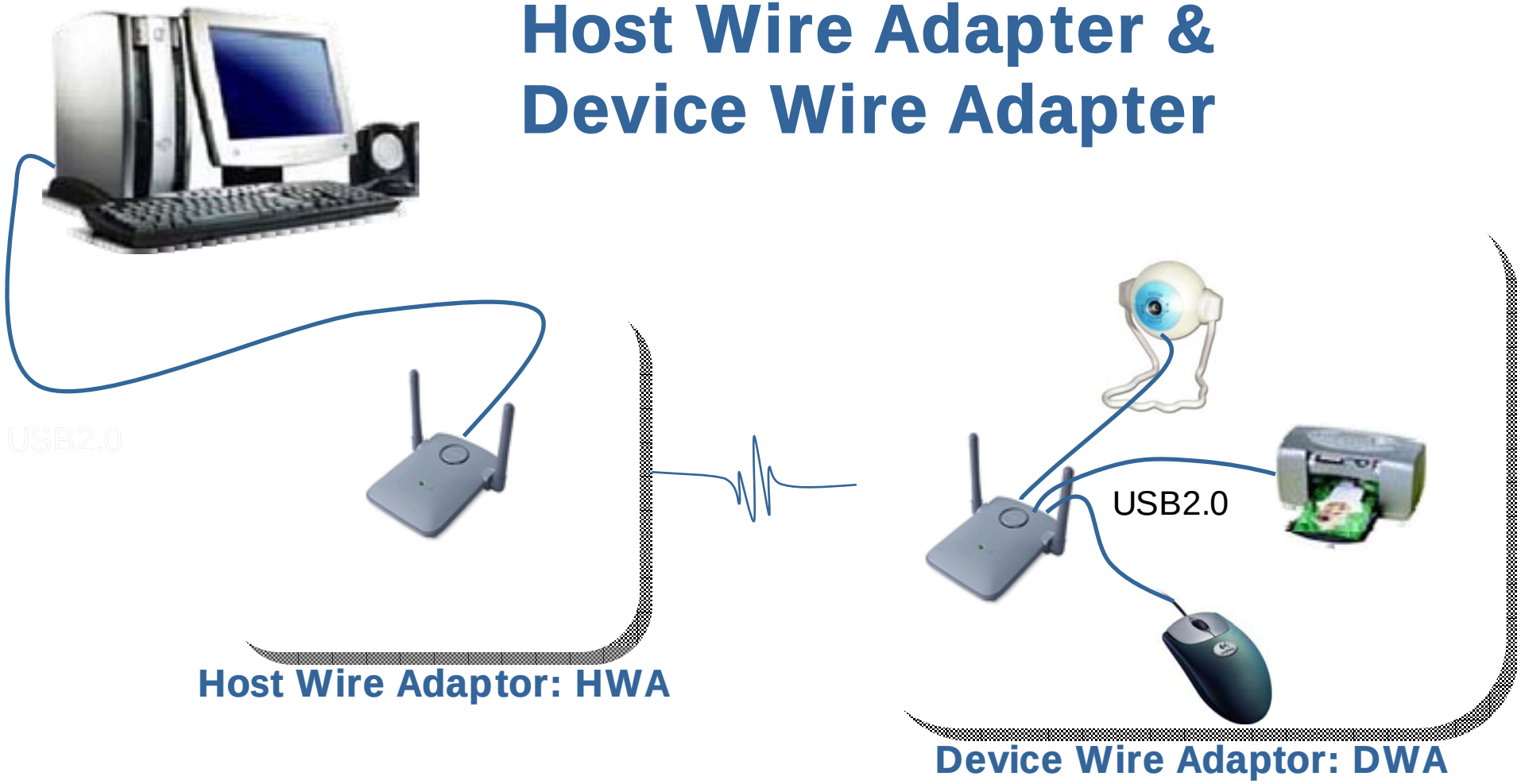
Wire Adapter (HWA and DWA)

- 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



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 (a 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

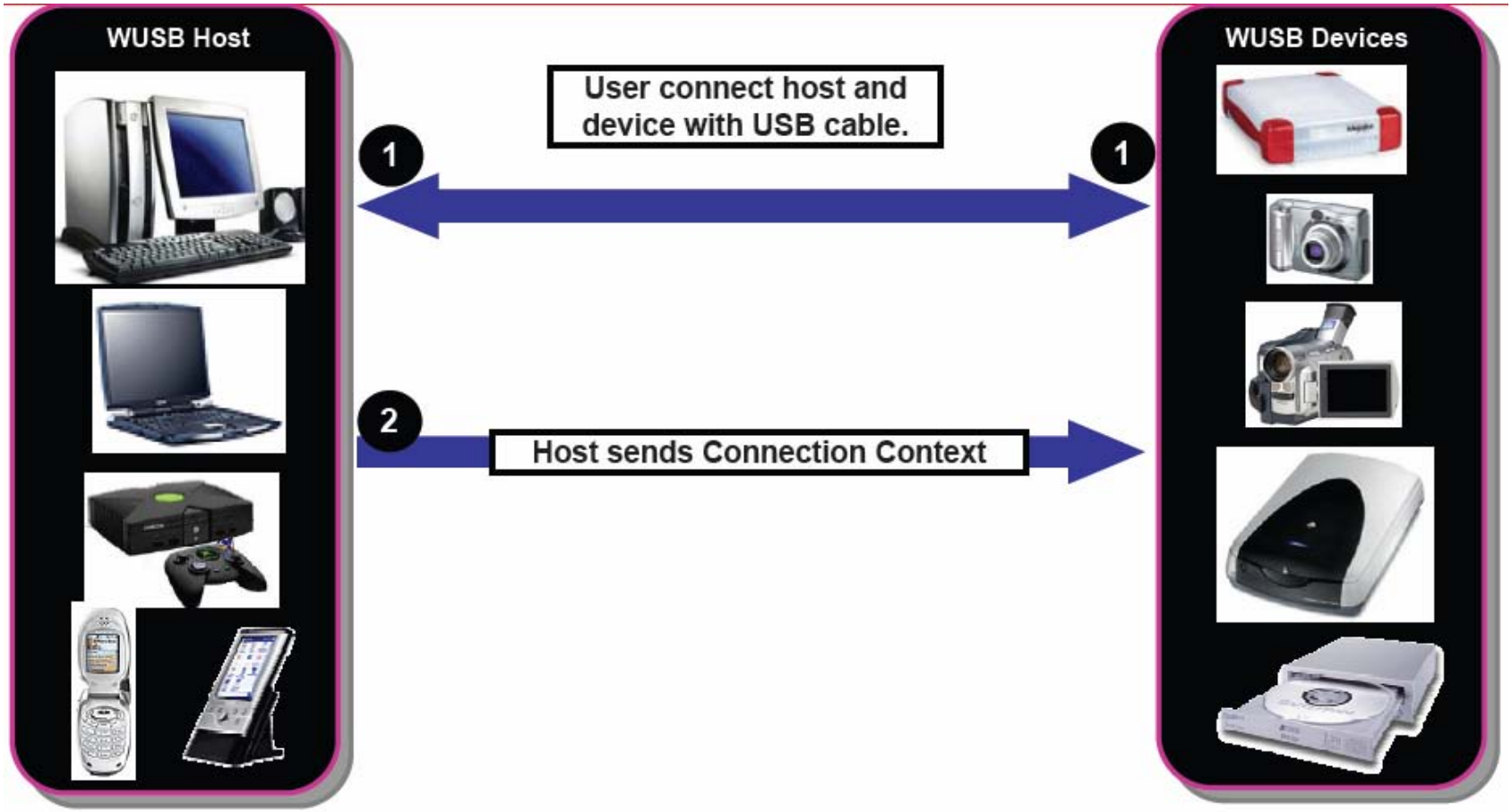
Wireless USB Association Models

Connection Context (CC)

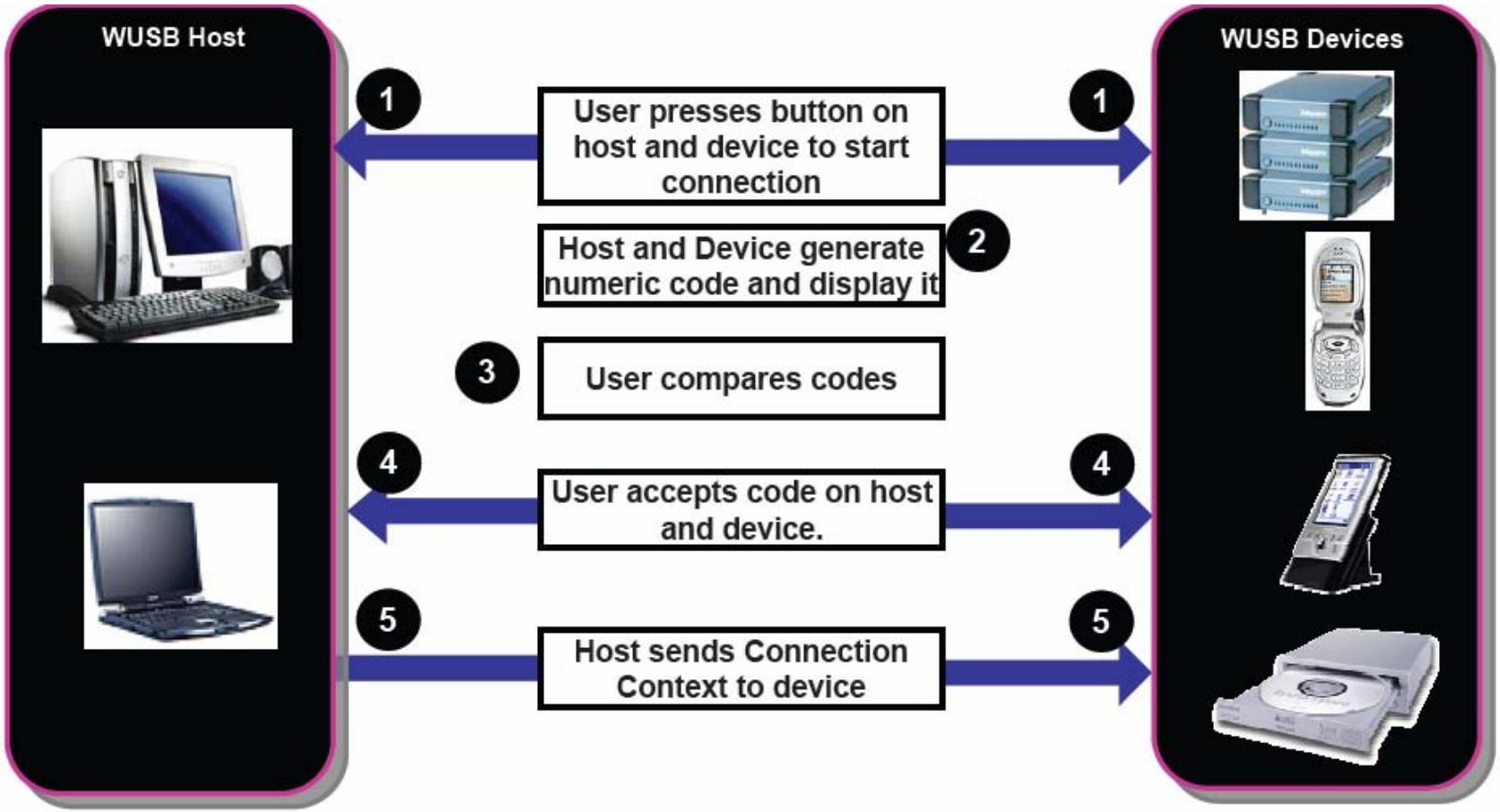
- The CC bears all the information needed in order to set up a secure communication between host and device
- Includes a secret key (128 bits)
- It is unique for each host-device connection
- The CC is generated by the host
- Needs to be downloaded to the device

Association gets the CC from the host to the device

Cable Association Method



Numeric Association Method



- 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

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

WUSB vs. Bluetooth

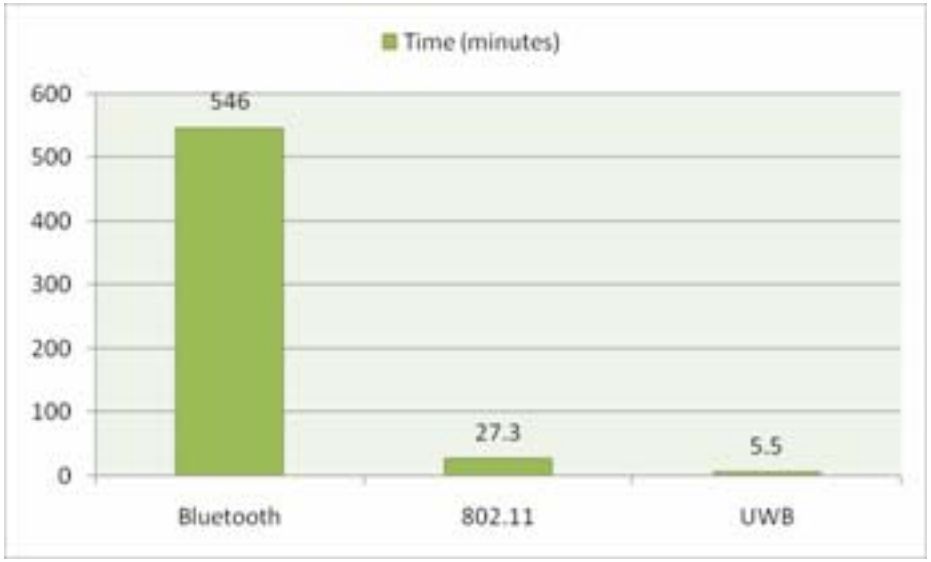
	Bluetooth	Wireless USB
Purpose/application	Wire replacement, personal area network	Wire replacement, personal area network
Distance	10 meters	10 meters
Throughput	1-2 Mbps	40-200 Mbps
Power consumption (average)	60 mW (active mode)	250 mW •assumes 400 Mbps PHY, active ½ the time •Host/device can sleep in synchronized way during transmission
Conclusion	Suitable for low-data rate applications (headsets)	Best for applications with high data rate, multimedia

Comparison Table

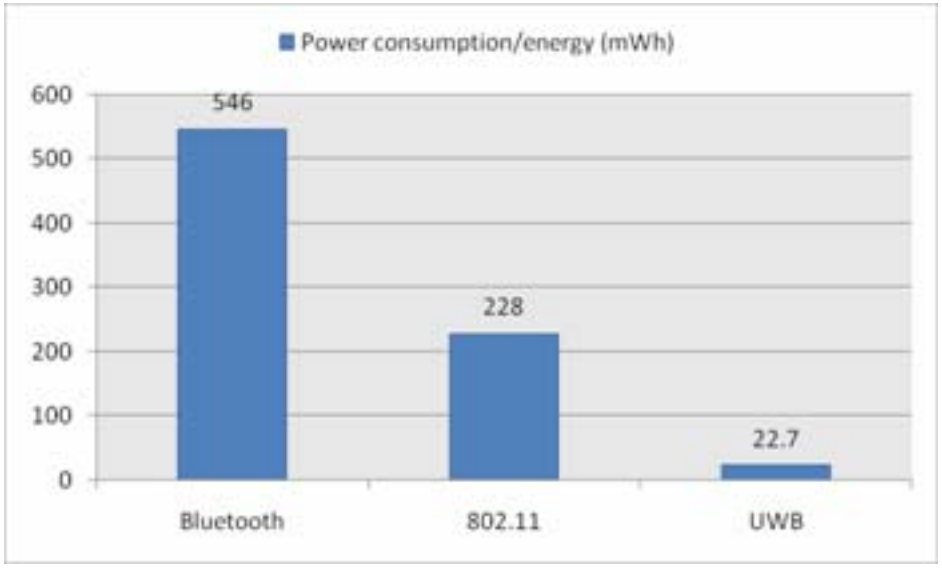
	Bluetooth	802.11	UWB
Average data transfer rate	1 Mbps	20 Mbps	100 Mbps
Average power consumption (active mode)	60 mW	500 mW	250 mW (assumes 400 Mbps PHY rate, active half the time)
Time (4GB transfer)	32,768 seconds (4096/0.125)	1638 seconds (4096/2.5)	328 seconds (4096/12.5)
Power consumed	546 mWh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

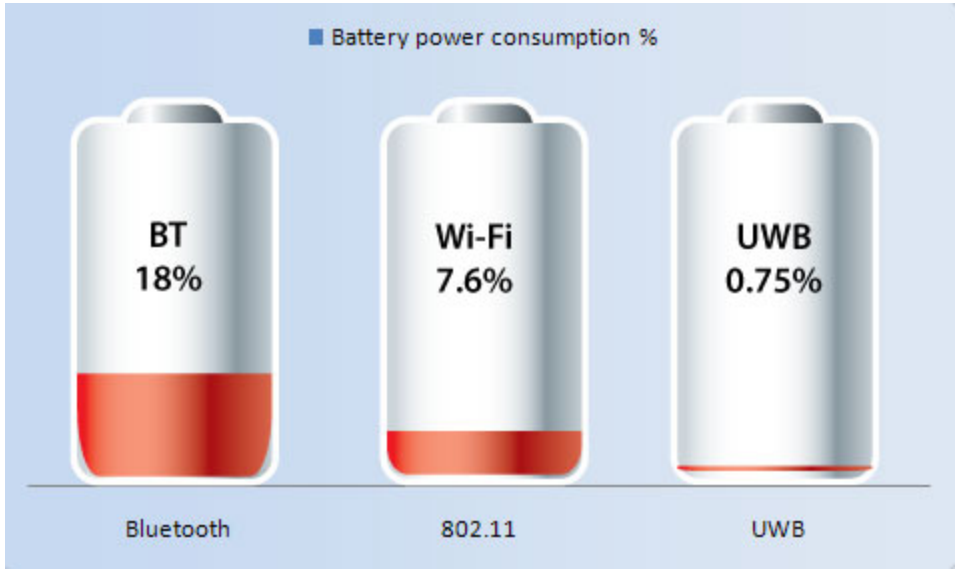
Time/Power for 4GB Transfer

Time



Power Consumption





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

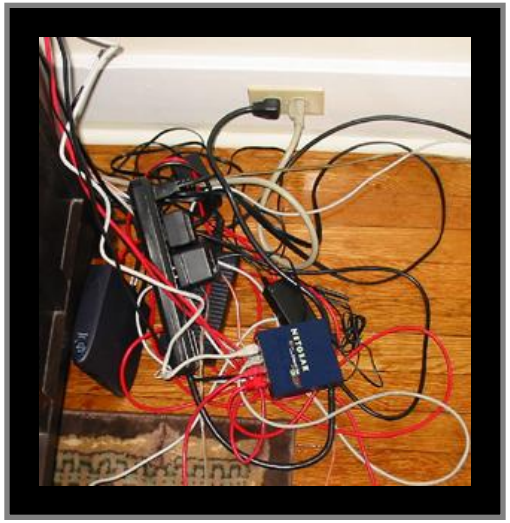
Emerging Applications – Wire Replacement

Scanners

Printers

External
Hard Drives

Wiring
Rats' Nests



DVD

DVR

STB

Game
Console

Emerging Applications – Wireless Docking

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.

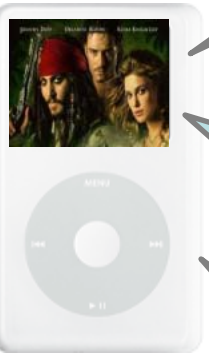
Ideal for Internet cafes
Can be used to amplify automobile capabilities.

Internet Café' Workstation

Emerging Applications/Services

Video On The Go

Automobile
Plane



PVP
Mobile Phone
Mobile Internet Device

Kiosk
Network

PVR

Internet

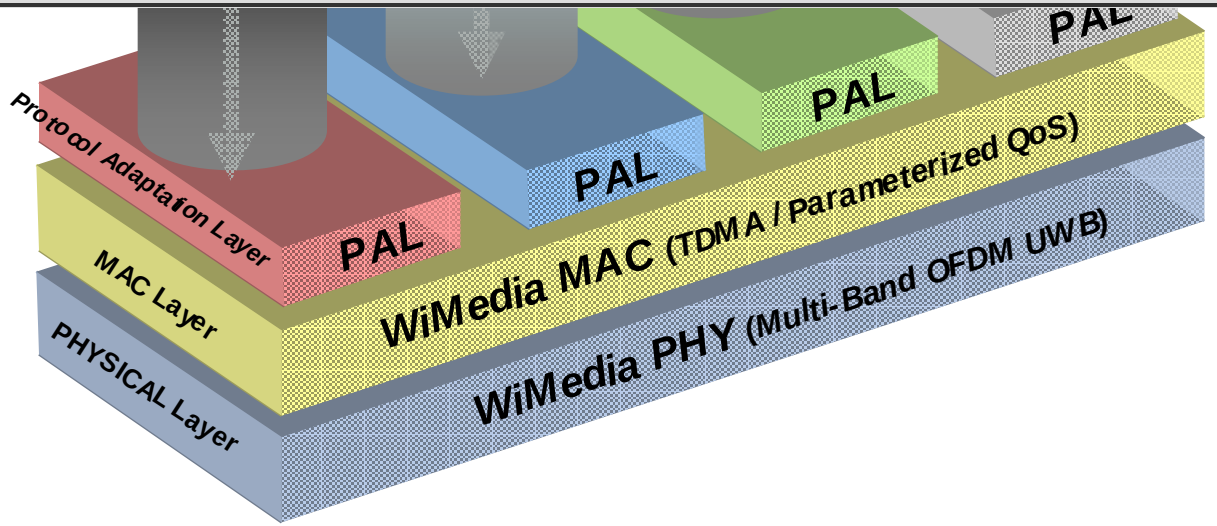
Status

Radio Chips (PHY):

- ✓ 19 chipsets

Platform Products (PHY + MAC):

- ✓ 21 PHY + MAC implementations

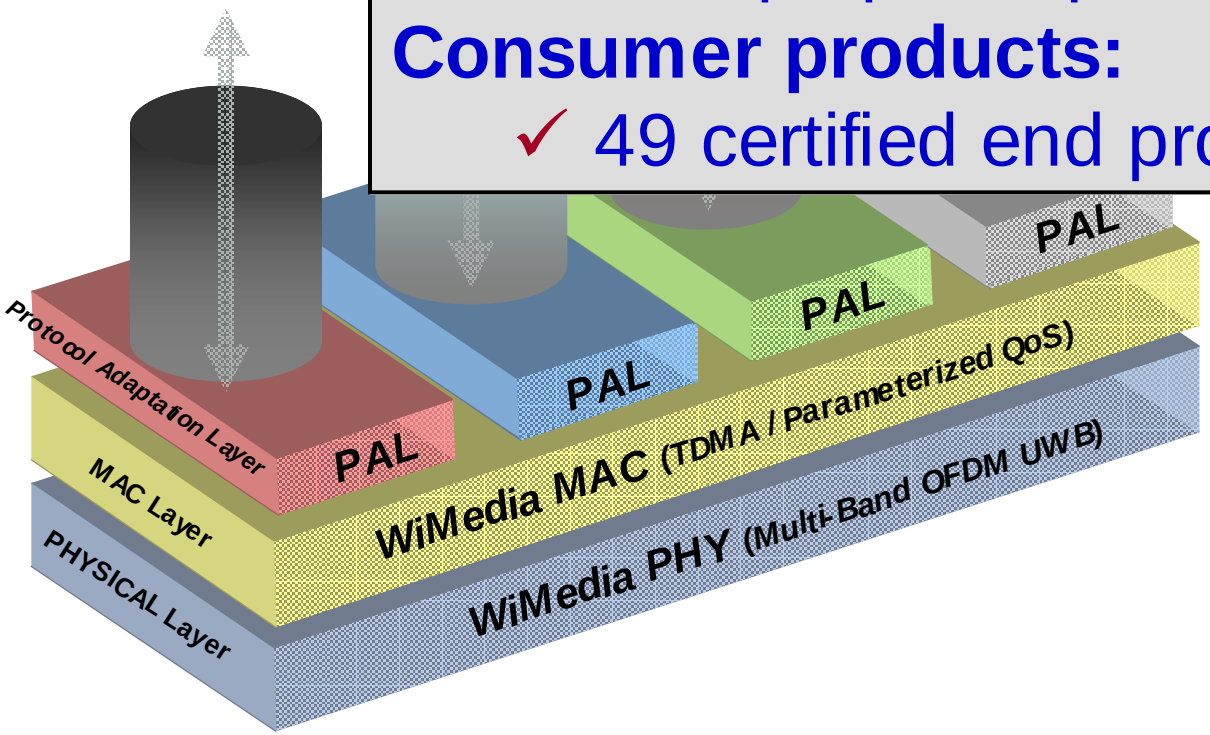


Computer products:

✓ 12 laptop computers

Consumer products:

✓ 49 certified end products



WiMedia **UWB Radio Platform**

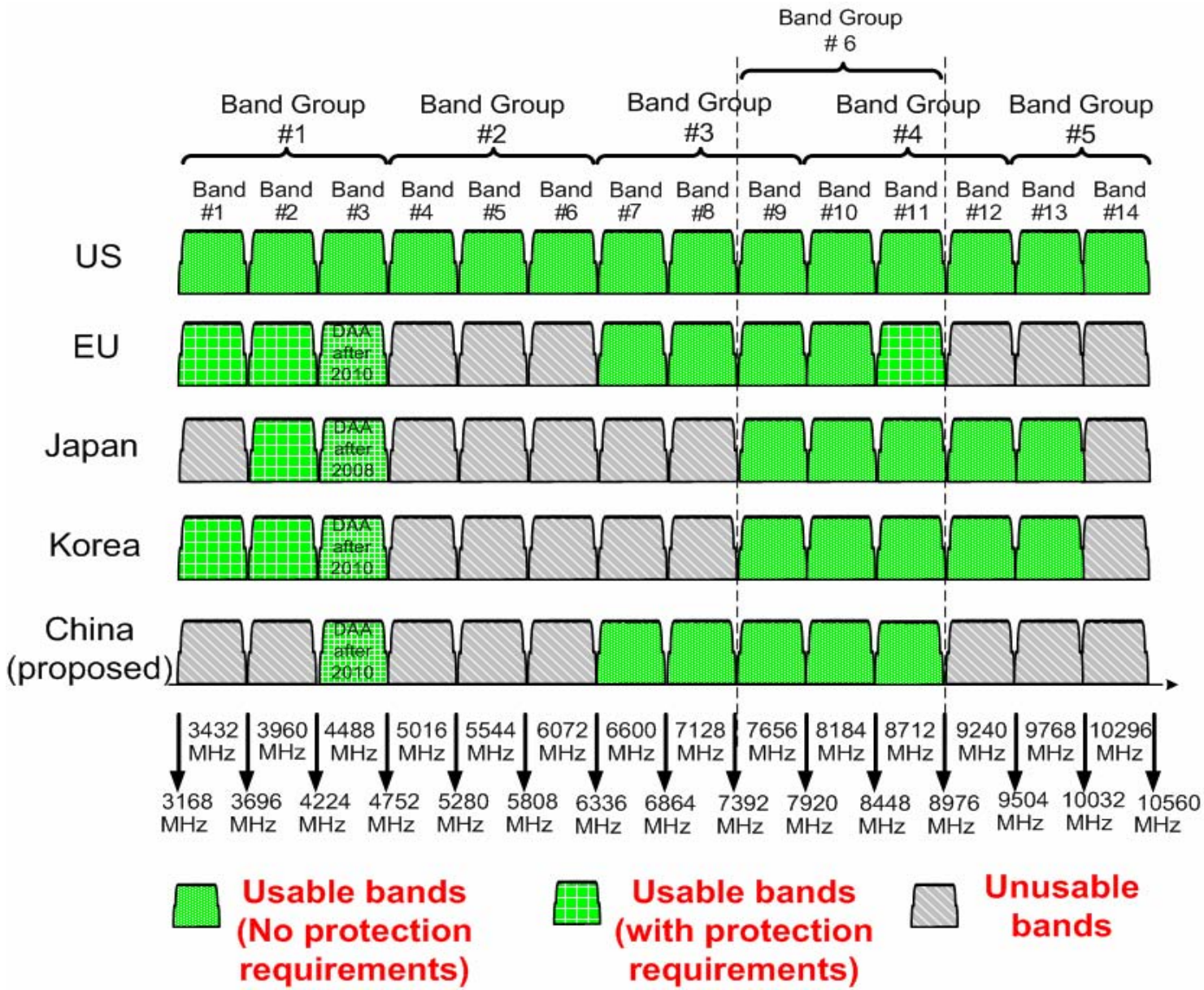
Regulatory Status

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

Offering Description

- 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

	Throughput	Devices
Device Wire Adapter (DWA)	Up to 40 Mbps	Any USB device (printer, hub…)
Native WUSB device with UltraSpeed™	Up to 70 Mbps (HWA) Over 200Mbps (Native host)	AIO/MFP, External HDD or other mass storage devices

WSR601 Certification Status

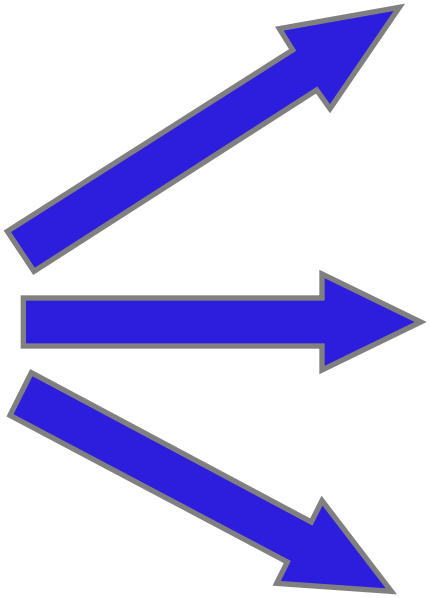
Regulations		
Region	Status	Description
US	✓ Done	FCC authorization granted Dec-07.
Japan	✓ Done	TELEC authorization granted Sept.-07.
Europe	✓Done	1. ETSI Class 1 UWB device approved in Feb-08 2. Taking part of the WALTER EC-FP7 project with ETSI and At4Wireless lab (also ST and others) to define the test cases and procedures
S. Korea	✓Done	Waiting on the formal approval letter
Standards		
Standard	Status	Description
WiMedia PHY	✓ Done	Registered PHY
WiMedia MAC	✓ Done	Platform certified
USB-IF	✓ Done	WSR601is USB-IF certified

Next steps

Next Steps in UWB Development

Today:

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



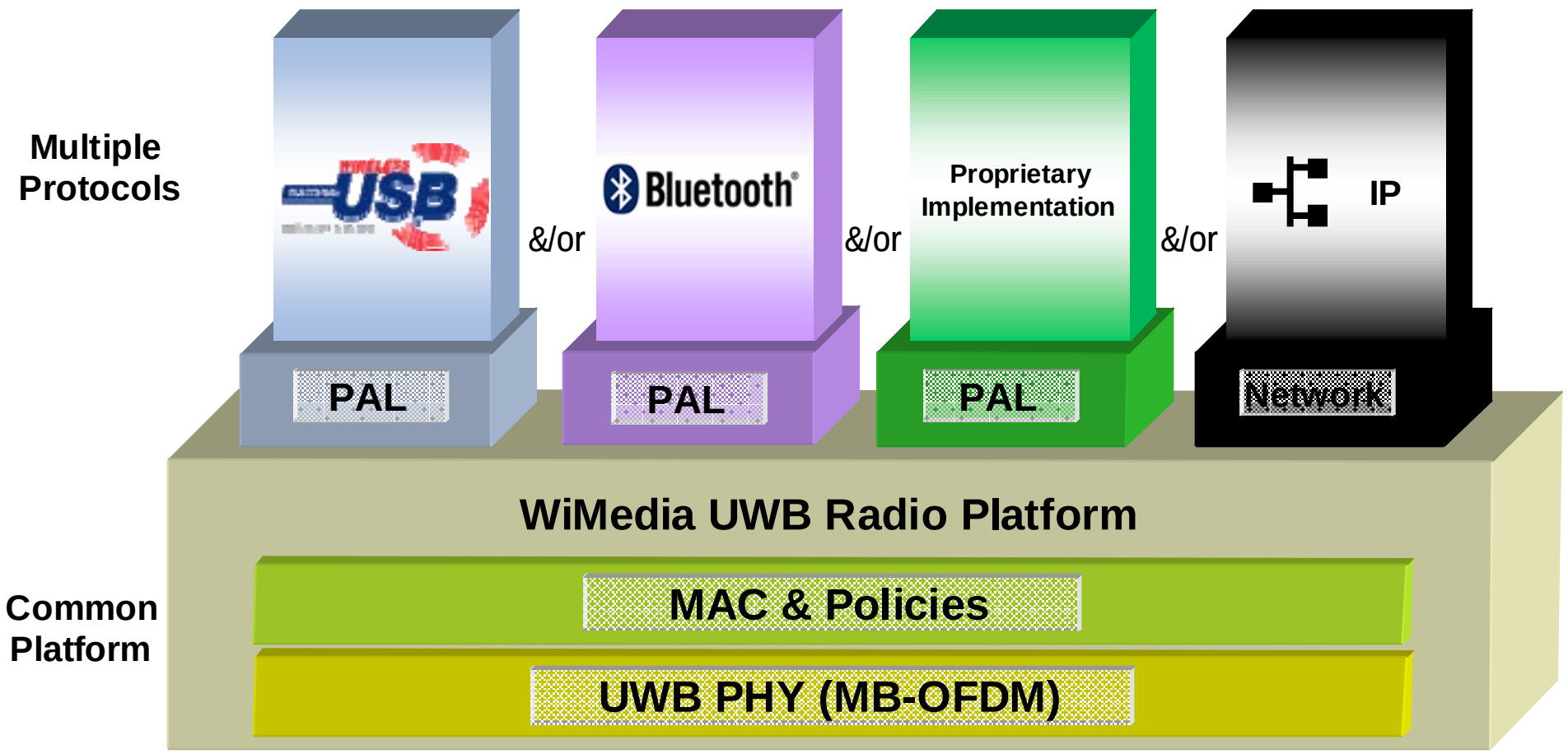
By 2010:

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



PAL: Protocol Adaptation Layer

WUSB Demo
Q&A

Thank you

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