



# Design Considerations for Self-Beaconing & Dual-Role Devices

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# Agenda



- Self-Beaconing Devices
  - Un-tethered from the host
- Dual-Role Devices
  - Host and device built-in
- Concurrent Connection Devices
  - Tethered to  $>1$  host!
- Questions?

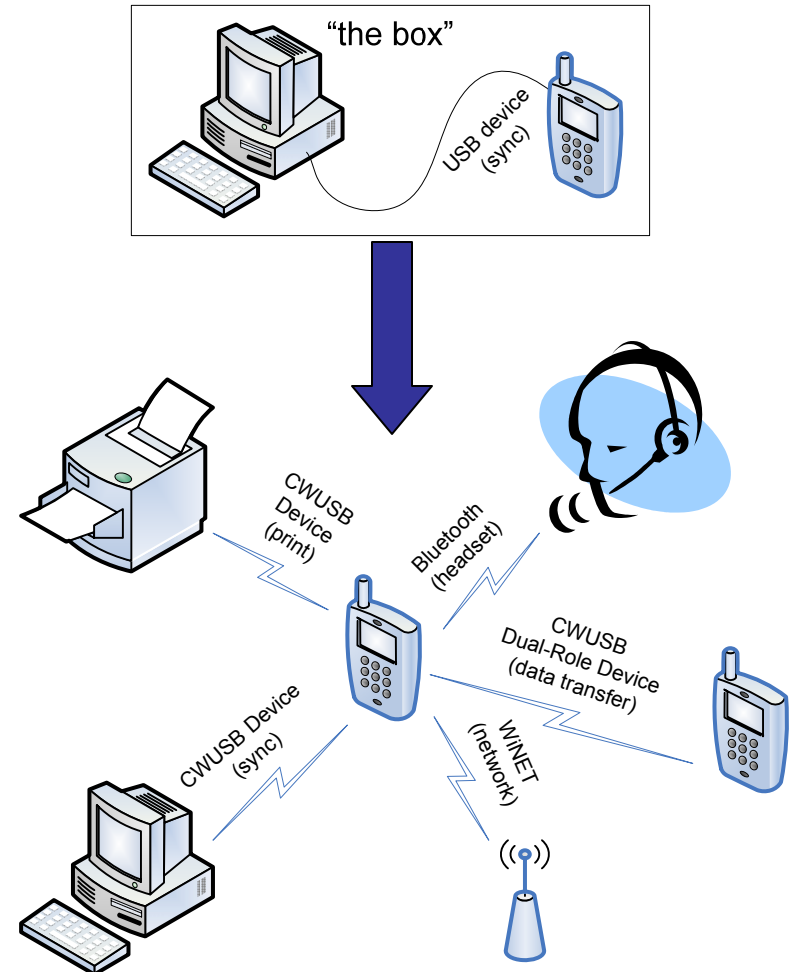


# Self-Beaconing Devices

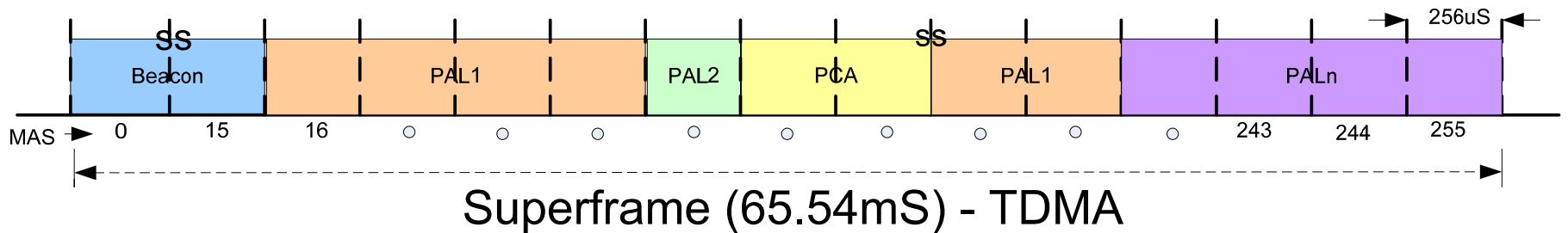
# Out in the Wild



- Wired USB devices were slaves to host
  - Provided a service or used a service on the host
  - Wire gave a clear context of connection
- Certified Wireless USB devices share the medium with other WiMedia devices
  - May lose contact with the host
  - May support other protocols using the same radio



# WiMedia – MAS and Beacon

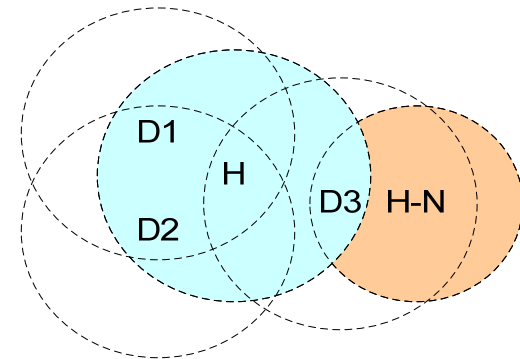


- WiMedia Devices make reservation in each superframe (65.54mS)
- A Super frame is divided in to 256 Medium Allocation Slots (MAS) of each 256uS.
  - The first 16 MAS are typically used for Beacon
  - Beacon time is used for WiMedia devices to communicate to each other about reservation and other information
  - WiMedia uses Distributed Reservation Protocol (DRP)
  - Unreserved MAS slots can be arbitrated through Prioritized Contention Access protocol (PCA)
  - CWUSB Hosts always make reservation, the CWUSB devices don't make reservation
  - CWUSB doesn't use PCA

# Beaconing - Three Types of Certified Wireless USB Devices



- Host uses the capabilities of the beaconing devices to get information about it's hidden neighbors
- Three types of Devices
  - No Beaconing
    - The device must always be very close to the host, the device and host see the same neighbor
  - Directed Beaconing
    - Not aware of WiMedia Protocols
  - Self Beaconing
    - WiMedia aware device



H – Host  
D\* - Devices  
H-N – Hidden Neighbor

# Survival Tools

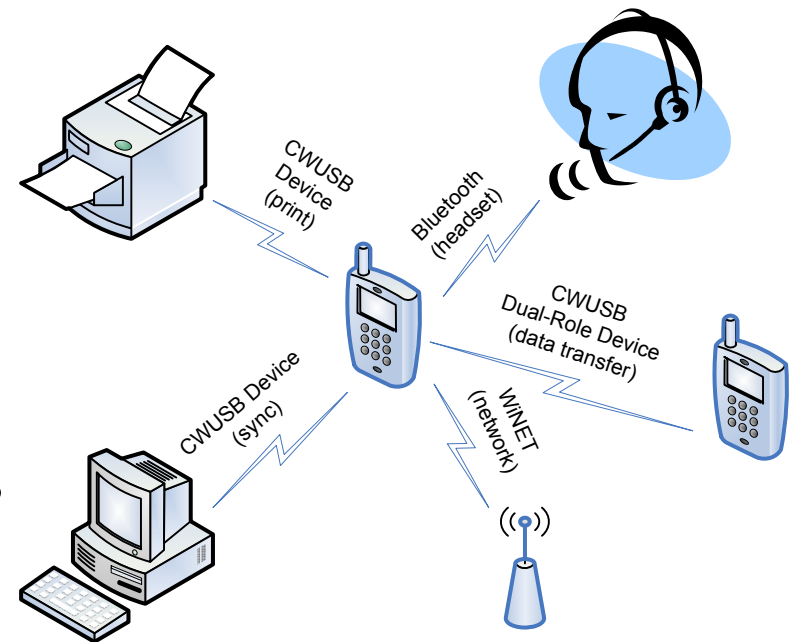


- In order to cooperate with other WiMedia devices, Certified Wireless USB devices must beacon
- Directed-Beaconing Device (DBD) is told how to beacon by its host
  - Loses the ability to communicate when host is out of range or turned off
  - Sufficient for most USB-replacement devices
- Self-Beaconing Device (SBD) must take care of itself

# Self-Beaconing Devices



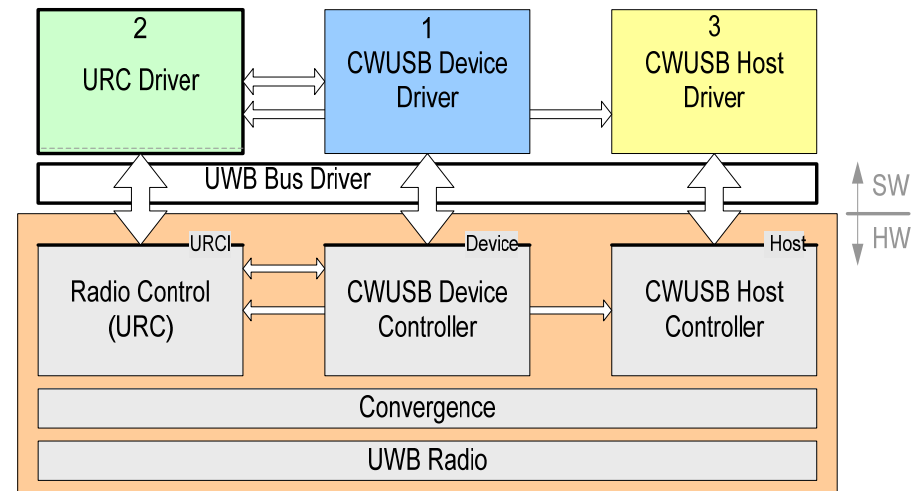
- May roam away from host and still provide a useful function
- SBD Capability enables more types of products
  - Dual-Role Device
  - Concurrent Host Connections
  - Multiple PALs in one device



# Block Diagram



- Module 1:
  - No-Beaconing or Direct Beaconing Device
- Module 1 + 2:
  - Self Beaconing Device
- Module 1 + 2 + 3
  - Dual Role Device

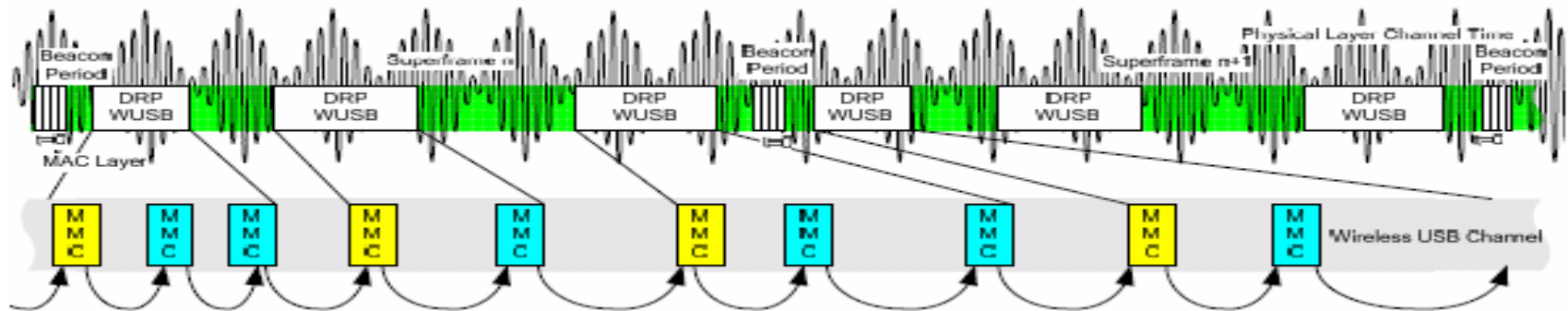




# What is an SBD?

- A Certified Wireless USB device that operates in a WiMedia channel with minimal direction from host
  - Manages beacon transmission/reception
  - BP length adjustment
  - Beacon collision detection
  - BP contraction
- Host involvement
  - Private reservation setup for WUSB Channel
  - Reservation movement after a BP Merge

# Private WUSB Reservation



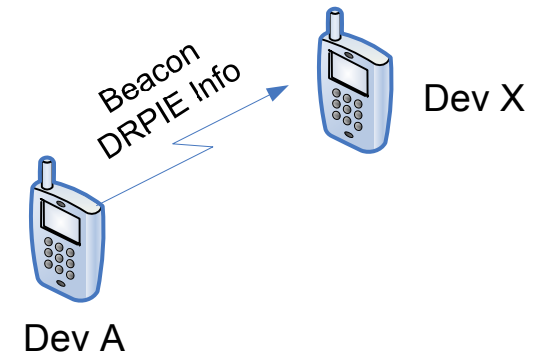
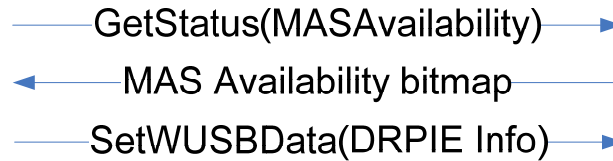
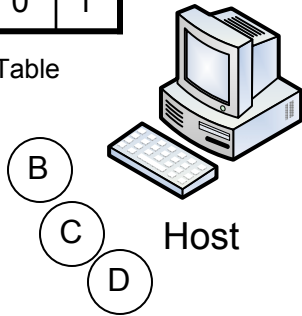
- WUSB Channel uses a Private Reservation
  - Provides exclusive access to the medium for the reservation owner (host) and target (devices)
  - Addresses from 0 to 255 allowed
- Host creates this reservation
  - Communicates the reservation to SBD's via the "backdoor"
  - An SBD reflects this reservation to other WiMedia devices in its beacon

# Backdoor DRP Negotiation Example



A	1	1	1	0	0
B	0	1	1	1	1
C	1	1	1	0	0
D	1	1	1	0	1

MAS Availability Table



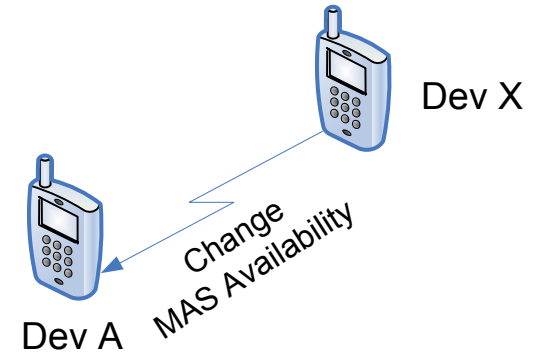
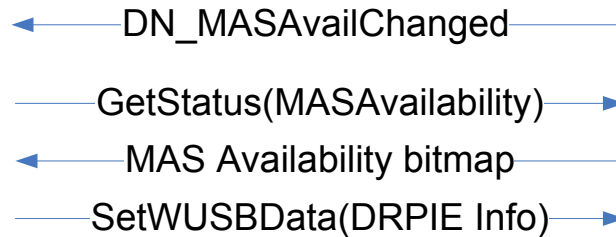
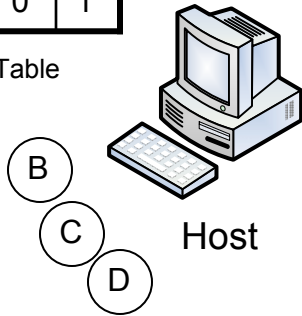
- SBD's A, B, C, and D are connected to the host
- Host cannot see WiMedia Device X
- Device A's Availability takes into account X's reservations
- Host decides which MAS can be reserved
- Host directly sets the DRP IE used in A's beacon

# Backdoor DRP Negotiation Example



A	1	1	0	0	0
B	0	1	1	1	1
C	1	1	1	0	0
D	1	1	1	0	1

MAS Availability Table



- Dev A notices change in Dev X's reservations
- Host obtains new Availability and sets new DRP IE

# Private Reservation Maintenance



- To free up Private Reservation, Host will send a WRELEASE\_CHANNEL\_IE *and* UDA
  - SBD should listen to IE, not UDA
  - The UDA/UDR is for the benefit of other WiMedia devices to use the remainder of the reservation
- Relinquish Request IE
  - If Host made an unsafe reservation, SBD may be the target of Relinquish Request IE
  - SBD transmits RRIE in its Beacon with Host as its target (forwarding the request)

# Beacon Period Merging, Power Management



- SBD is responsible for taking part in BP Merge process
  - Either host or device could detect an Alien Beacon, and includes BP Switch IE
  - Other WiMedia devices see BP Switch IE
- After merge
  - SBD may send DN\_MASAvailChanged to host
  - Host will deliver new DRP IE to SBD to assert existing reservations in new BP
- Power Management
  - SBD should synchronize WiMedia (Hibernation IE) with WUSB Sleep

# Channel Changing



- SBD with multiple PALs communicating on same channel
- If host wants to change channel, SBD may:
  - Put Channel Change IE in beacon and move with host, or
  - Ignore channel change
    - Disconnect from host and stay with other devices
- If WiMedia device wants to change channel, SBD may:
  - Put Channel Change IE in beacon and move with the device and maybe the host, or
  - Ignore channel change
    - Disconnect from devices and stay with host
- Devices with display can ask user which connection to keep
- Devices with multiple PHYs or channel hopping can stay on both channels



Dual-Role Devices (DRD)

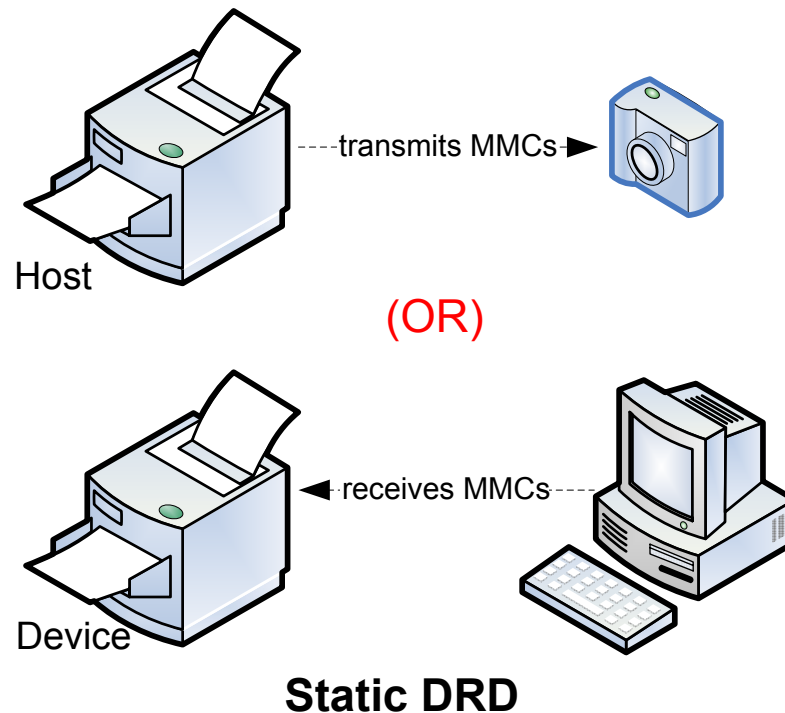
# Dual-Role Device



- Two Types of Dual Role Devices
  - Static DRD Device
  - Dynamic DRD Device

# Static Dual-Role Device

- Static DRD acts as a host or a device at a given time
- Less complex implementation
- User chooses host or device mode



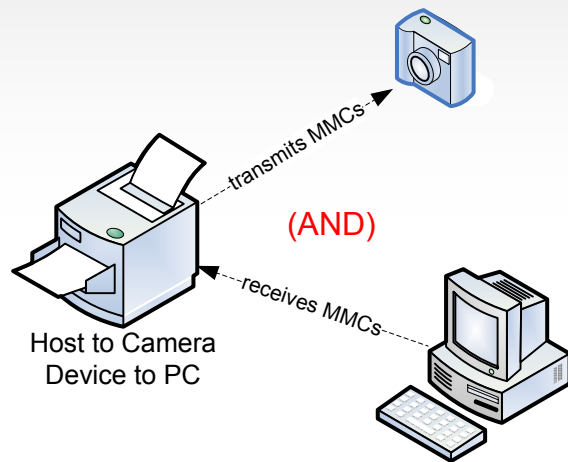
# Dynamic Dual-Role Devices



- DRD acts as both a host and device simultaneously
- Transmits and receives MMC's on the same channel

## Combination DRD

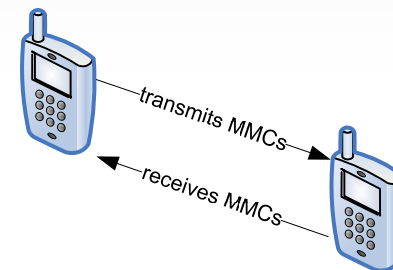
- Printer connected to PC and digital camera



Dynamic DRD

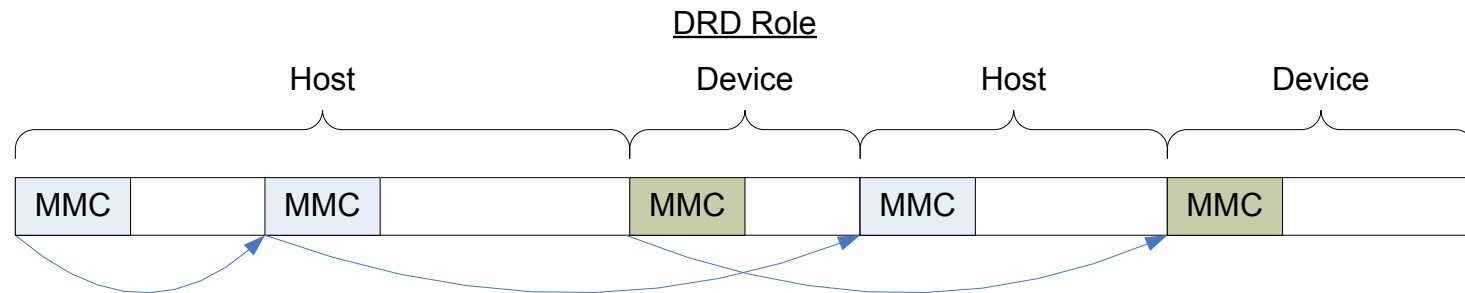
## Point-to-Point DRD

- Two cellphones/MP3 players connected to each other
- Could be limited function – Allows communication only between same vendors cellphones



# The DRD Trick

- Act like a device
  - Follow the thread of MMC's from a host
- Act like a host
  - Transmit a thread of MMC's
  - Host functionality can be limited (ala Targeted Peripheral List)



- Security Keys
  - Combo-DRD = 2 GTK's & 1+N PTK's
  - P2P-DRD = 1 GTK & 1 PTK

# DRD Considerations



- Channel Change
  - DRD's host may change channels
  - Combo DRD relays WCHANNEL\_CHANGE\_IE to its devices
  - P2P DRD just moves with the initiator of the channel change
  - With multiples PALs, same issues as SBD
- Disconnect/Sleep
  - DRD's host may disconnect or stop channel
  - Combo DRD keeps connections to devices alive
    - Digital camera can print even though the PC is off!
  - P2P DRD can disconnect/sleep since there is only 1 link

# Power Management For DRD



- As a Device - Need to Follow WUSB Sleep
- As a Host – Need to Poll for Remote Wakeup
- As a WiMedia Device - Need to Follow Hibernation
- DRD Need to Synchronize all the Three Events



# Concurrent Devices

# Multi-Host Definitions

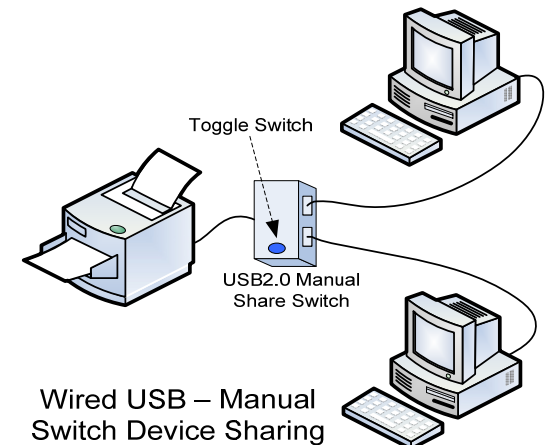
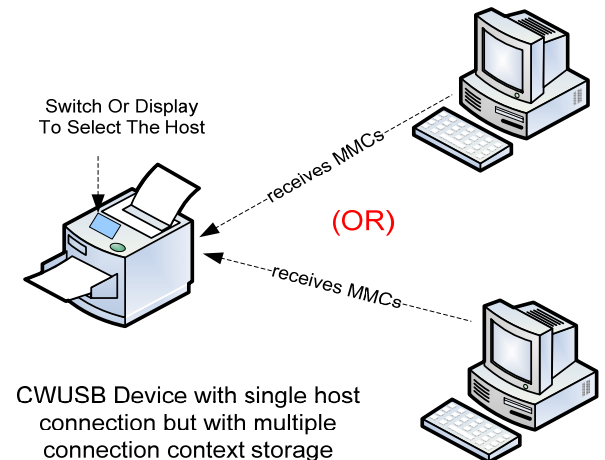


- Because it is wireless, the user expects to share the device between multiple hosts
- Two Types of Multiple connection Devices
  1. Multiple Connection Contexts Device
  2. Concurrent Device

# Multi-Host Definitions



- Device with Multiple Connection Contexts
  - Connected to 1 host at a time, but can switch without going through the association process
  - Need to store multiple connection context and provide user interface to select one of them
  - Application: A printer shared by two PCs, user selects the PC to connect
  - Conceptually similar to a wired USB manual share switch
  - Unlike wired USB no additional external component; switch function is built in to the device
  - Switch function is easier to build; no Device-class specific SW/HW component

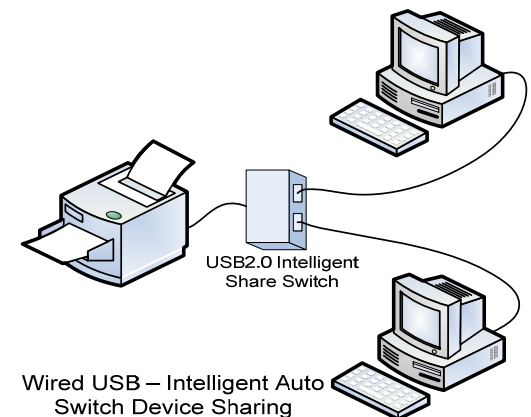
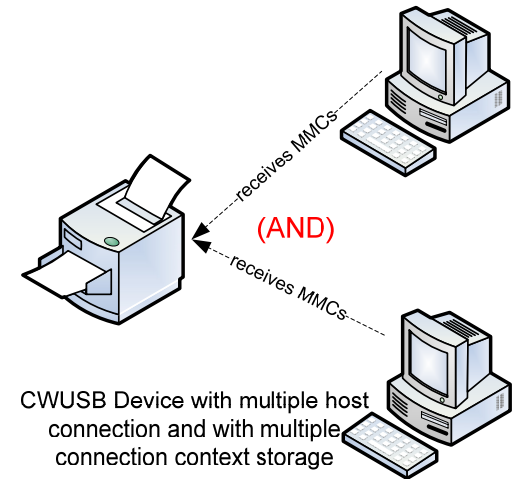


Wired USB Equivalent

# Multi-Host Definitions



- Concurrent Device
  - Connected to >1 host at a time, arbitration between hosts handled by the device
  - Usage model: Shared printer between two PCs
  - Conceptually similar to a wired USB intelligent share switch
  - Similar to wired USB auto share switches, implementation is specific to a Device-class
  - Additional complexity specific to CWUSB

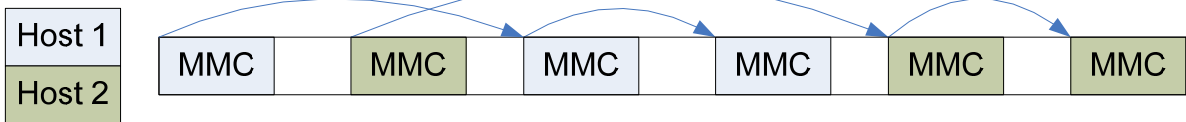
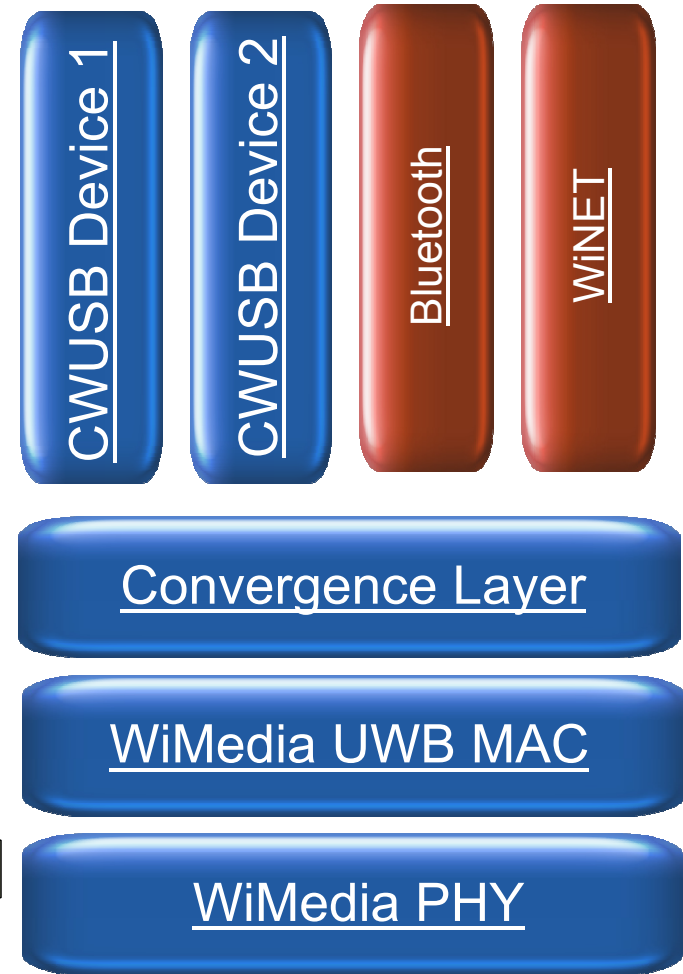


Wired USB Equivalent

# Concurrent Device



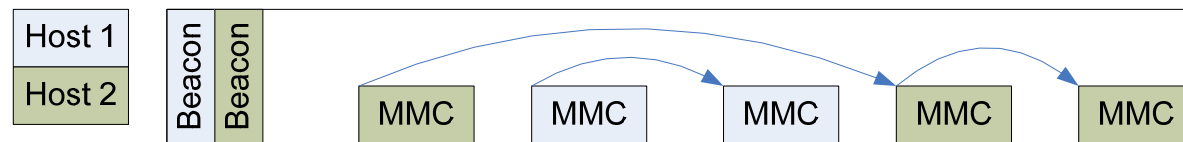
- Device follows 2 or more threads of MMC's
- Similar to having 2 Certified Wireless USB device PALs
  - Not the same as a compound device



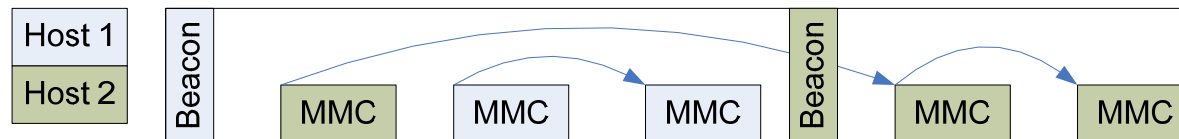
# Host Locations



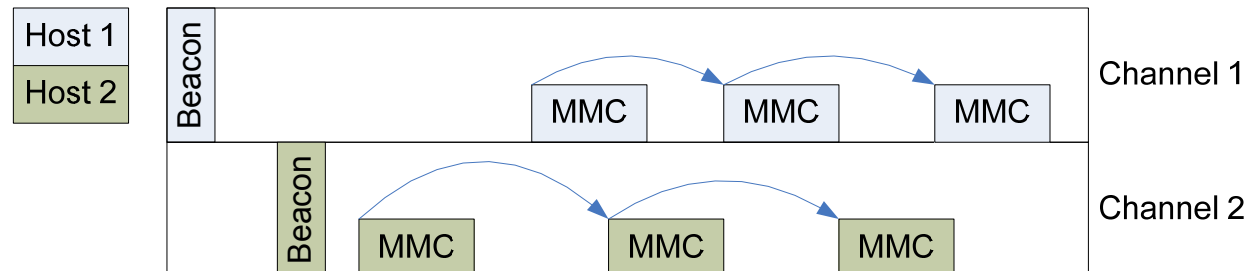
- Device behavior depends on host locations
  - Hosts on same channel and coordinated



- Hosts on same channel but uncoordinated



- Hosts on different channels



# Host Locations (Cont.)



- Coordinated hosts
  - Expect SBD to beacon multiple DRP IE's
- Uncoordinated hosts
  - Expect SBD to beacon in both beacon periods
  - Should eventually result in BP Merge
- Hosts on different channels
  - Expect SBD to beacon in both channels
  - Tricky if device has only one PHY (e.g. BP's may overlap)
- Concurrent devices may support one or all three configurations

# Concurrent Connection Device Considerations



- Device accessed from multiple hosts
  - Behavior depends on class of device
  - Printer can stall one host while it finishes the job from the other
  - Mass storage may be able to interleave multi-host accesses
- One host asks the device to go to sleep or change PHY channels
  - Device may require all hosts to be on the same channel
- Many challenges to overcome
  - Do what it takes to make each host to think it has an exclusive connection to device
  - The size of Hardware/Software will depend upon how many hosts you want support simultaneously

# Products and Capabilities



Products	Capabilities				
	Host	Device	MAC (Self Beaconsing)	Directed Beaconsing	Concurrent Device
Host	✓		✓		
Self-Beaconsing Device		✓	✓		✓
Directed-Beaconsing Device		✓		✓	
Dual-Role Device	✓	✓	✓		✓
Non-Beaconsing Device		✓			
Other PAL Functions (Example: WiNet)	N/A	N/A	✓	N/A	N/A

# Conclusion



- A Self-Beaconing Device has 2 personalities
  - As a WiMedia device, obey the MAC spec
  - As a Certified Wireless USB device, need to obey the host
- A Dual-Role Device has 3 personalities
  - WiMedia device, Certified Wireless USB host, and Certified Wireless USB device
- Concurrent Device can be connected to multiple hosts at the same time
  - Device needs to follow multiple threads of MMC's
  - Biggest challenges are driver-related and obeying more than 1 host

# Recommendation



- Since many flavors of the devices can be developed, when you are developing a Certified Wireless USB solution:
    - Choose a scalable architecture
    - Preferably a blend of HW and firmware approach where the firmware provides the customization.
- Challenges:
- Making it easier to integrate in any of your future SoC and application
  - Comparable in power, area, and performance to a HW only approach



# Developers Conference 2006

Taipei, Taiwan



Backup Slides

# Addressing



	48-bit MAC Addr	8-bit CWUSB Cluster Addr	8-bit CWUSB Device Addr	16-bit Generated DevAddr
Self-Beaconing Device	1	1	1	1
Combo-DRD	1	2	1	1
P2P-DRD	1	1	1	1
Concurrent Device	1	2+	2+	1
Directed Beaconing Device	0	1	1	0
Non-Beaconing Device	0	1	1	0

# Security Keys



	CWUSB PTK's	CWUSB GTK's
Self-Beaconing Device		
Directed-Beaconing Device	1	1
Non-Beaconing Device		
Combo-DRD	$1 + N_{\text{devs}}$	2
P2P-DRD	1	1
Concurrent Device	$N_{\text{hosts}}$	$N_{\text{hosts}}$
Host	$N_{\text{devs}}$	1



# Class Driver Support

- Printer class driver supports knowledge of beginning/end of job
- A shared printer can block another host if a job is in progress
- What's the difference compared to a network printer?