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Design Considerations for Self-Beaconing, Dual-Role, and Multi-PAL Devices

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Agenda

- Self-Beaconing Devices
 - Un-tethered from the host
- Dual-Role Devices
 - Host and device built-in
- Multiple Protocols
 - Adding WLP, Bluetooth, other PALs
- Questions?

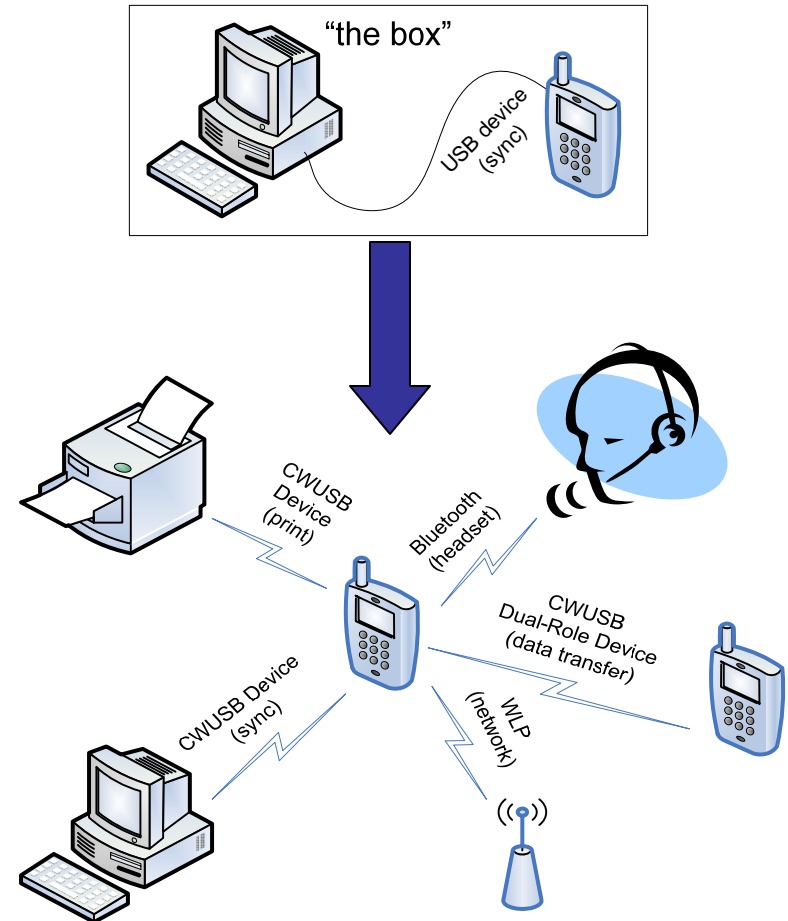


Self-Beaconing Devices

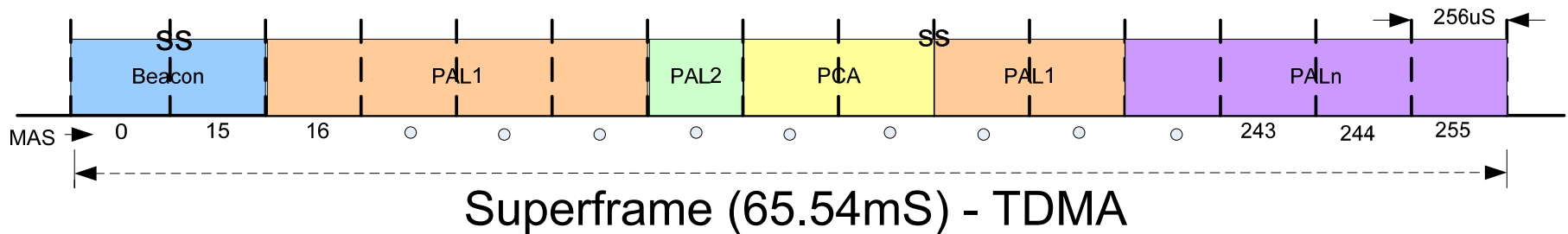
Out in the Wild



- 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

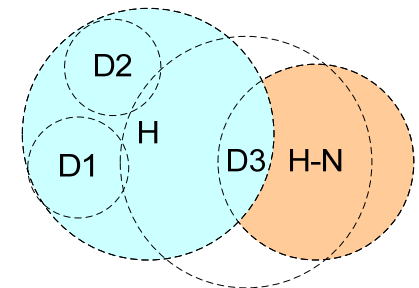


- WiMedia Devices share the medium on a superframe basis
 - Superframe (65536 us) is divided into 256 Medium Allocation Slots (MAS), each 256us
 - First 16 MAS are typically used for beacon, special frame which communicates reservation information
- Wireless USB Host reserves a set of MAS for the WUSB Channel
 - But this channel of communication must be clear to all Wireless USB Devices



Beaconing - Two Types of Wireless USB Devices

- Host needs to learn about hidden neighbors
- Two types of Wireless USB Devices
 - Non Beaconing Device (NBD)
 - The device must always be very close to the host, the device and host see the same neighbors
 - Provides no information about hidden neighbors
 - Self Beaconing Device (SBD)
 - WiMedia aware device, beacons on its own
 - Reflects hidden neighbor reservations

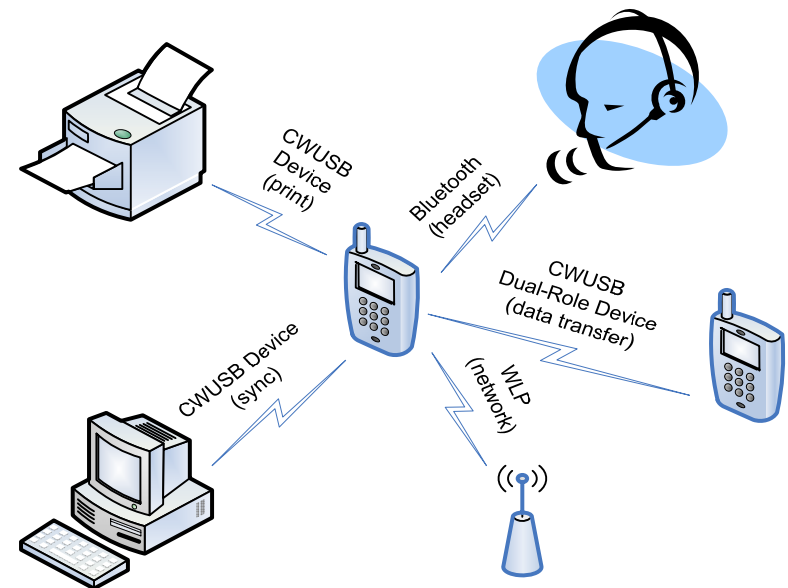


H – Host
D1, D2 – NBDs, D3 – SBD
H-N – Hidden Neighbor

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
 - Other PALs in one device

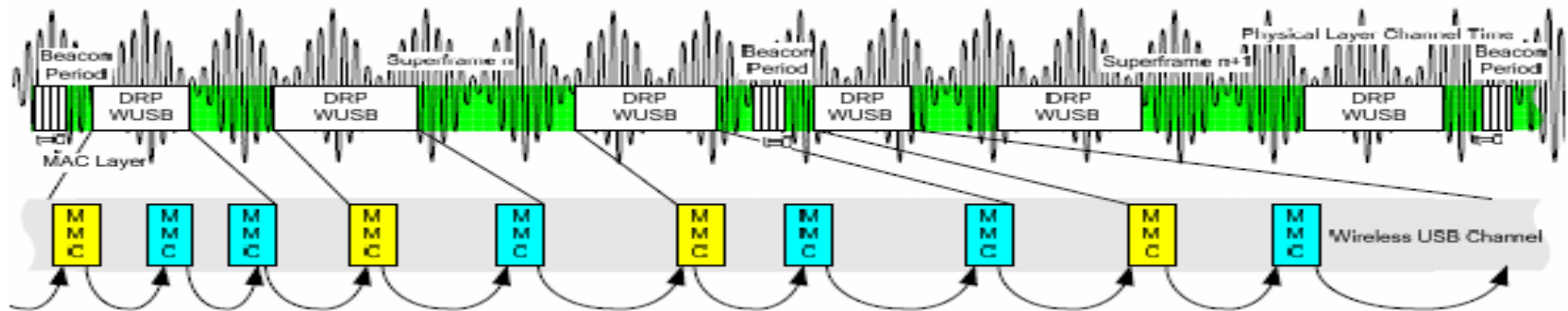




What is an SBD?

- A 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



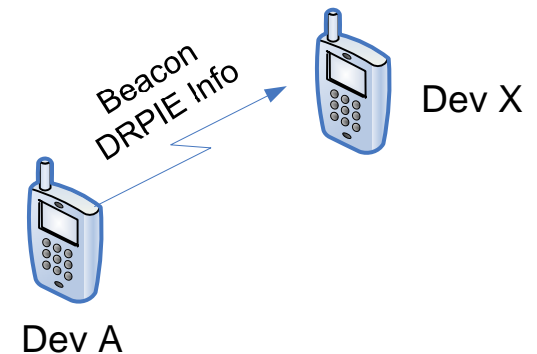
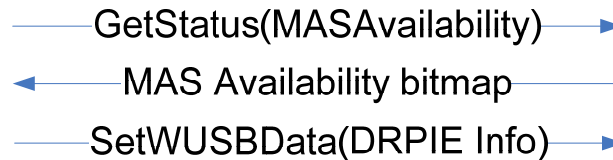
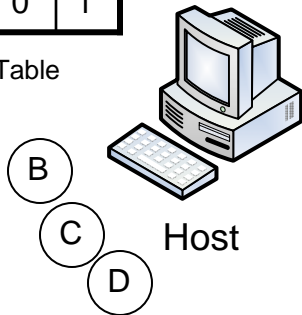
- WUSB Channel uses a Private Reservation
 - Provides exclusive access to the medium for the reservation owner (host) and target (devices)
 - Addresses from 0 to 255 allowed
- Host creates this reservation
 - Communicates the reservation to SBD's via the "backdoor"
 - An SBD reflects this reservation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



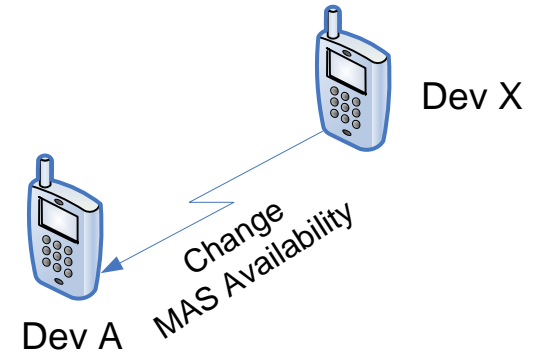
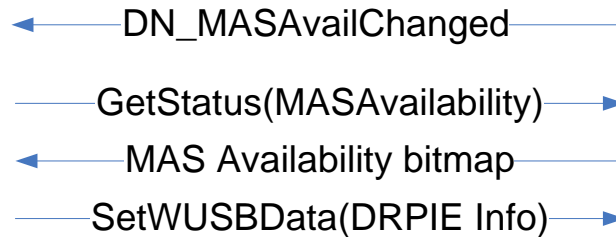
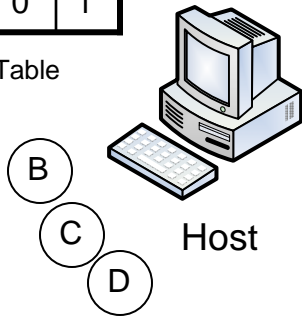
- SBD's A, B, C, and D are connected to the host
- Host cannot see WiMedia Device X
- Device A's Availability takes into account X's reservations
- Host decides which MAS can be reserved
- Host directly sets the DRP IE used in A's beacon

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

2 Problems with Backdoor DRP Negotiation



- Long turn-around time to resolve a DRP Conflict
 - 1 Device Notification, 1 Control Read, and 1 Control Write to resolve
 - If this takes longer than 1 superframe, violates the MAC spec
- DRP Conflict during WUSB reservation
 - Another WiMedia device may claim some MAS from the WUSB reservation as its own
 - If enough MAS are in conflict, SBD cannot send a DN to tell the host about the conflict
 - The only common channel is Beacon Period
- SBD should detect the conflict on its own and report it in its Beacon as well to guarantee Host sees the conflict

Private Reservation Maintenance



- To free up Private Reservation, Host sends a WRELEASE_CHANNEL_IE *and* UDA (Unused DRP Announce) frame
 - However, some hosts may not include SBD's in the WRELEASE_CHANNEL_IE device list
 - SBD should listen to UDA, not the IE
 - 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
- SBD should have 2 addresses: a Generated Address (16 bit) and a Private Address (8 bit)
 - SBD must use its Generated Address in its beacon to be compatible with future versions of the MAC spec



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)

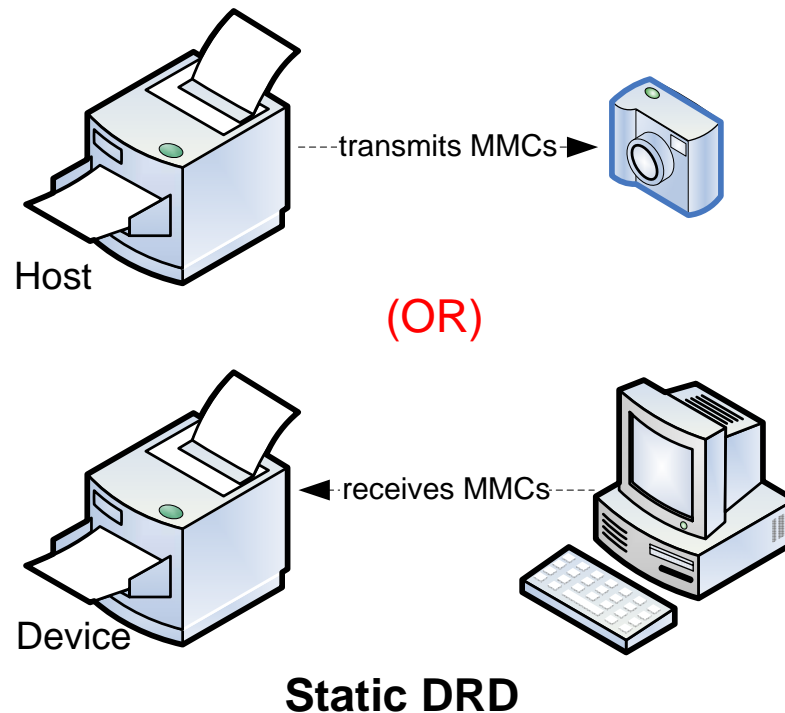
Dual-Role Device



- 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



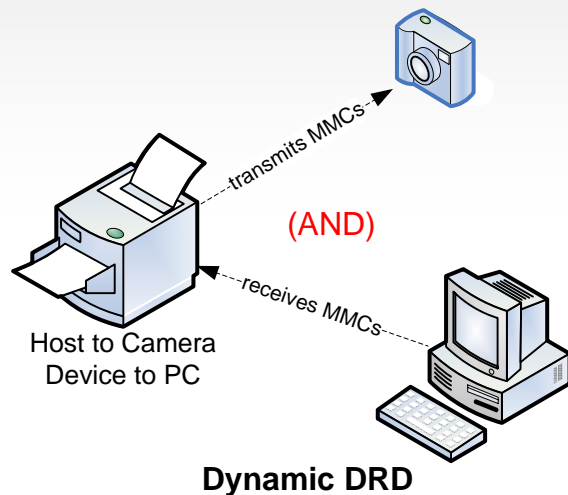
Dynamic Dual-Role Devices



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

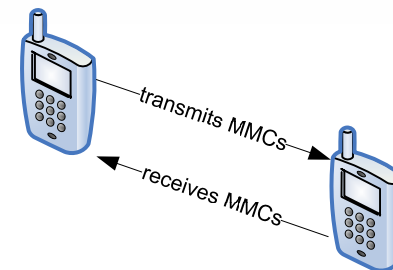
Combination DRD

- Printer connected to PC and digital camera



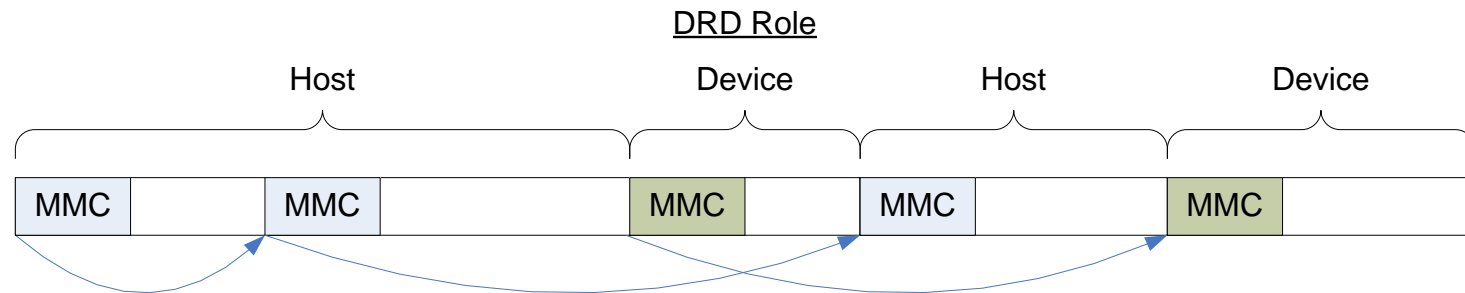
Point-to-Point DRD

- 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

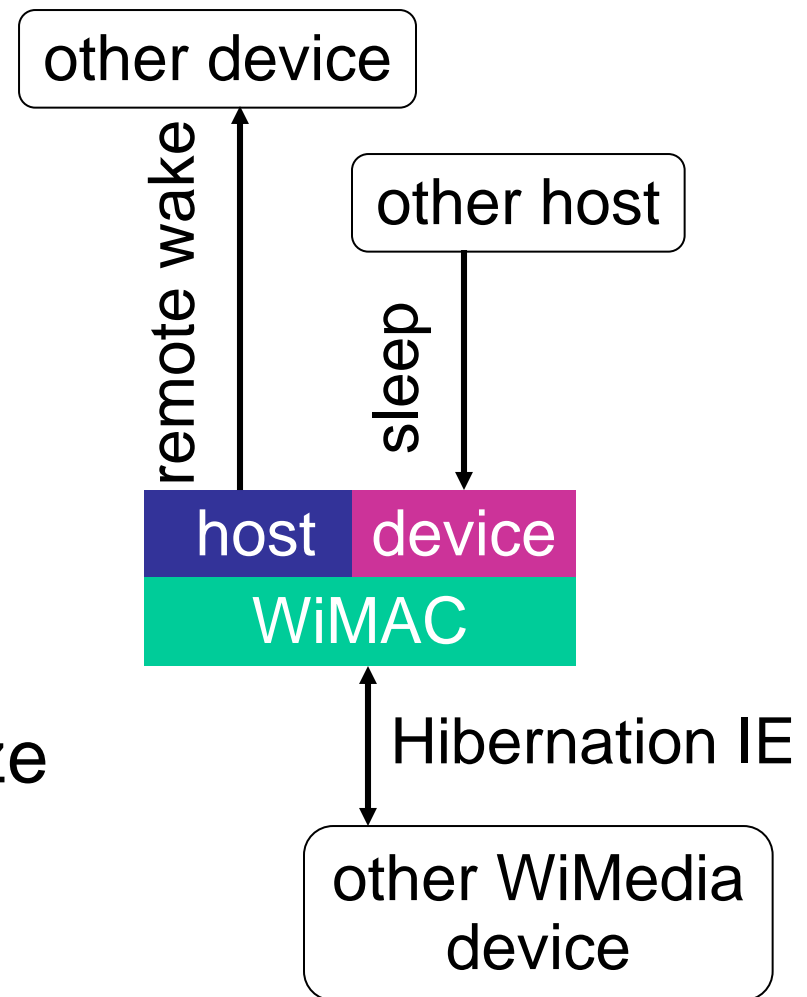


- Channel Change
 - DRD's host may change channels
 - Combo DRD relays WCHANNEL_CHANGE_IE to its devices
 - P2P DRD just moves with the initiator of the channel change
 - With multiples PALs, same issues as SBD
- Disconnect/Sleep
 - DRD's host may disconnect or stop channel
 - Combo DRD keeps connections 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



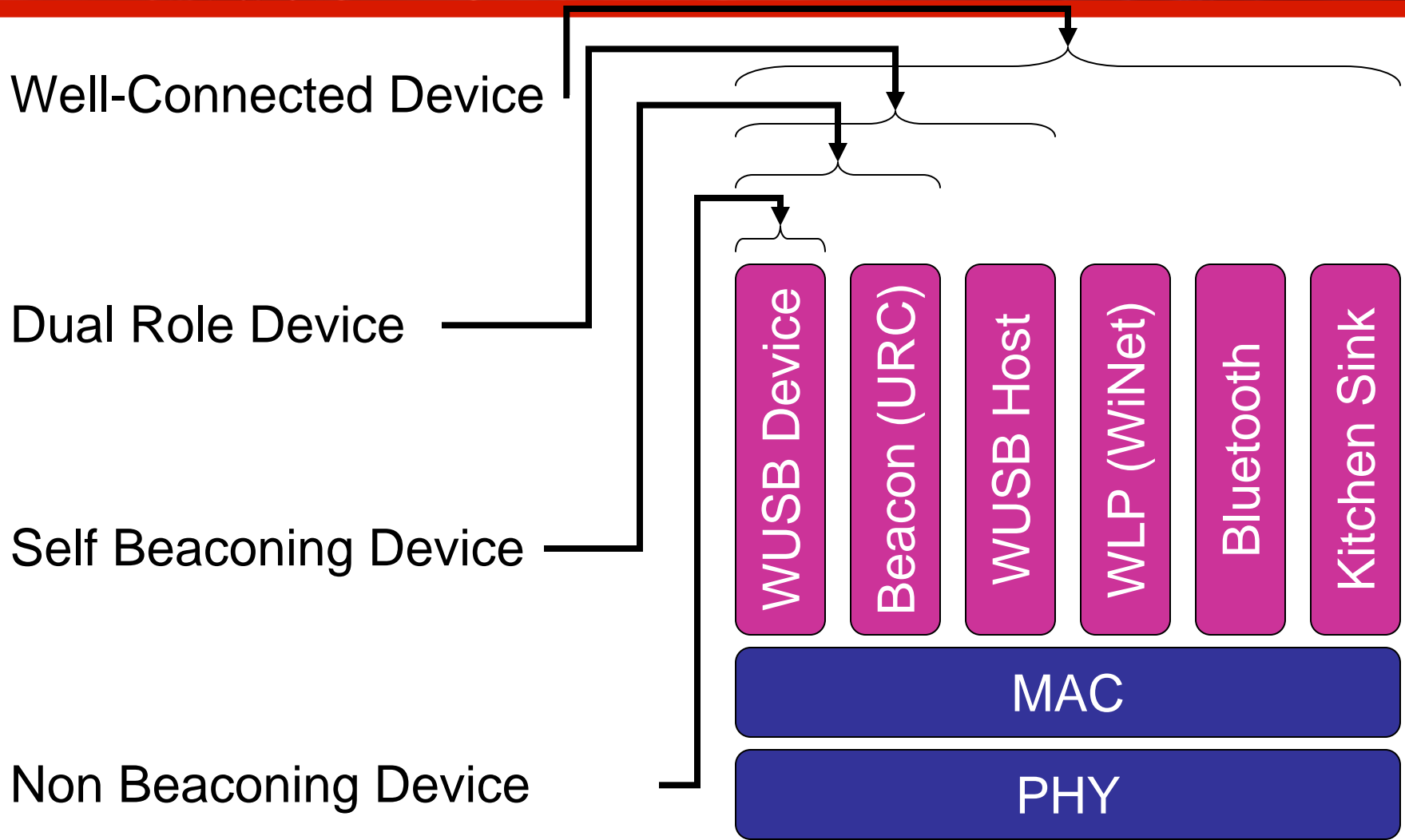
- As a Device
 - Follow WUSB Sleep
- As a Host
 - Poll for Remote Wakeup
- As a WiMedia Device
 - Follow Hibernation IE
- DRD needs to synchronize all three events





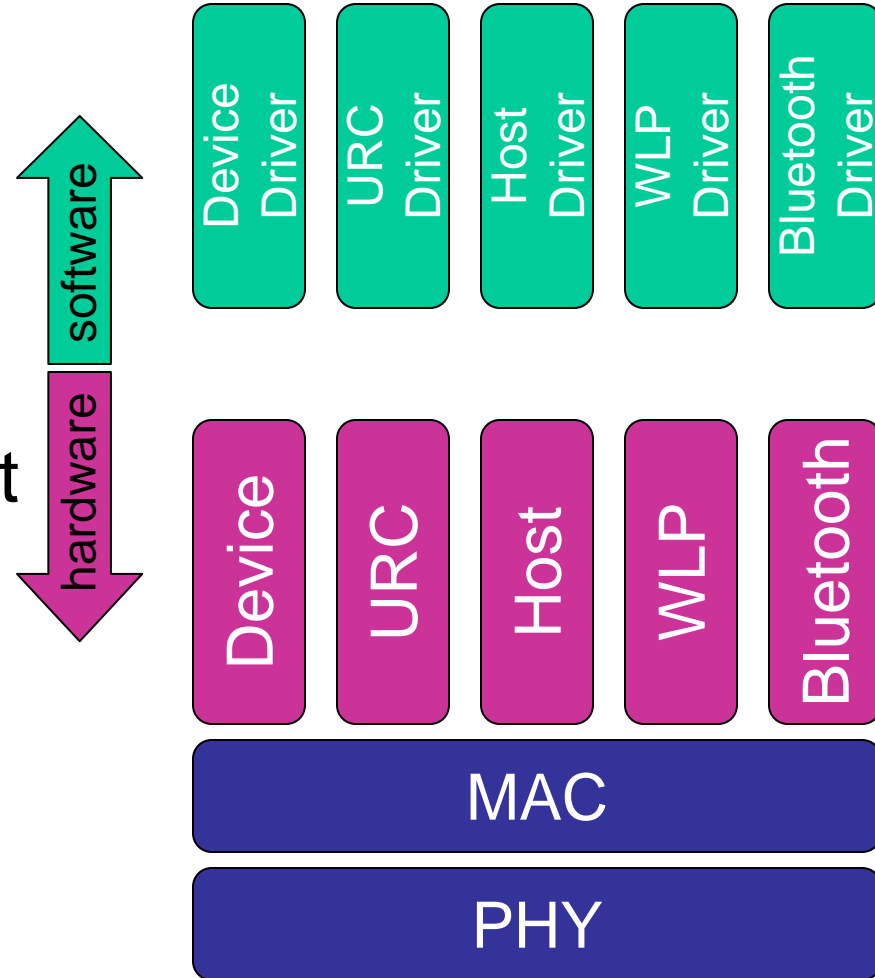
Support for Multiple Protocols
PAL = Protocol Adaptation Layer

Protocol Overload!



WiMedia Convergence

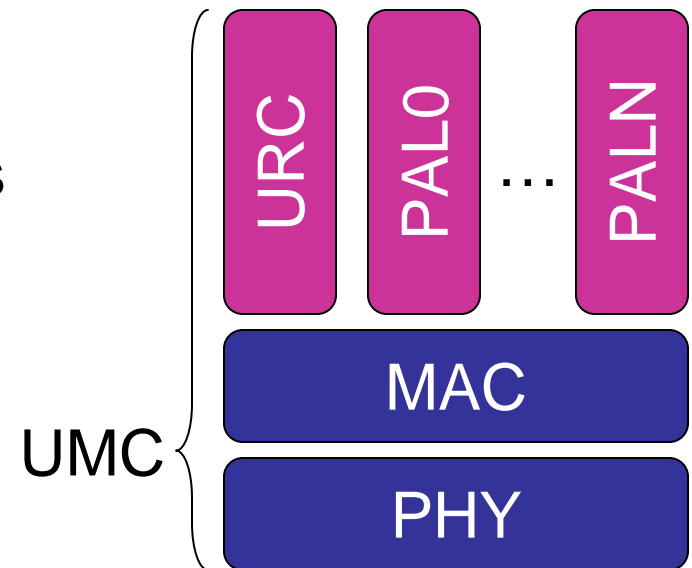
- This is the goal of WiMedia protocol convergence
- Each PAL has a hardware and driver part
- What does this look like at the driver level?



UWB Multi-Interface Controller (UMC)



- UMC is described in the WHCI specification
 - Register definitions for exposing multiple PALs
 - Enables multiple protocols to share the radio
- Each PAL has a hardware and driver part
 - UWB Radio Controller (URC) is required, responsible for beaconing
 - PAL is responsible for data transfer
- Programming model specifications
 - URC: Specified in WHCI
 - Host: Specified in WHCI
 - Device: Vendor-specific
 - WLP: WiNet HCI
 - Bluetooth: Bluetooth HCI



Exposing PALs in UMC



UWBBASE



UWBCAPINFO (URC)	
UWBCAPDATA (Host)	
UWBCAPDATA (Device)	
UWBCAPDATA (WLP)	
UWBCAPDATA (Bluetooth)	

URCCMD
URCSTS
URCINTR
URCCMDADDR
URCEVTADDR

WNHCVER
WNHCPARAM
WNHCCTL
...

WHCIVERSION
WHCSPARAMS
WUSBCMD
...

DVERSION
DSPARAMS
DCMD
...

BTVER?
BTPARAM?
BTCMD?
...

N_CAPS [Number of PALs supported] = 4
 maximum value = 8

URCSTS register



- Reflects interrupts from URC and other PALs
 - Bit positions are relative to the UWBCAPDATA order

31:8	7	6	5	4	3	2	1	0
URC					Bluetooth	WLP	WUSB Device	WUSB Host

PAL Programming Model



- Different PAL programming models
 - Descriptor based: Set up linked list of data structures, like scatter-gather DMA
 - Command/event based: Issue requests to the hardware, get notifications back

<i>Protocol</i>	<i>Descriptor Based</i>	<i>Command/Event Based</i>
URC		✓
Wireless USB Host	✓	
Wireless USB Device	✓	
WLP	✓	
Bluetooth		✓

Products and Capabilities



Products	Capabilities			
	Host	Device	Self Beaconsing (URC)	Other PALs
Host	✓		✓	
Self-Beaconsing Device		✓	✓	
Dual-Role Device	✓	✓	✓	
Non-Beaconsing Device		✓		
Multi-PAL			✓	✓

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
- Multiple PALs can be integrated together using the recommended programming model

Recommendation



- Many flavors of devices can be developed, so when you are developing a Certified Wireless USB solution:
 - Choose an architecture that is scalable
 - Should be basic hardware plus firmware which provides the customization
- Challenges:
 - Make it easier to integrate in any of your future SoC and application
 - Comparable in power, area, and performance to a HW only approach



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Backup Slides

Addressing



	48-bit MAC Addr	8-bit WUSB Cluster Addr	8-bit WUSB 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



	WUSB PTK's	WUSB 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_{hosts}	N_{hosts}
Host	N_{devs}	1

URCCMD register



- Indicates a command is ready to fetch

31	30	...	15	...	12:0
UWB Reset	URC Run/Stop		Command Active		Command Size



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