



Certified Wireless USB Data Transfer Model

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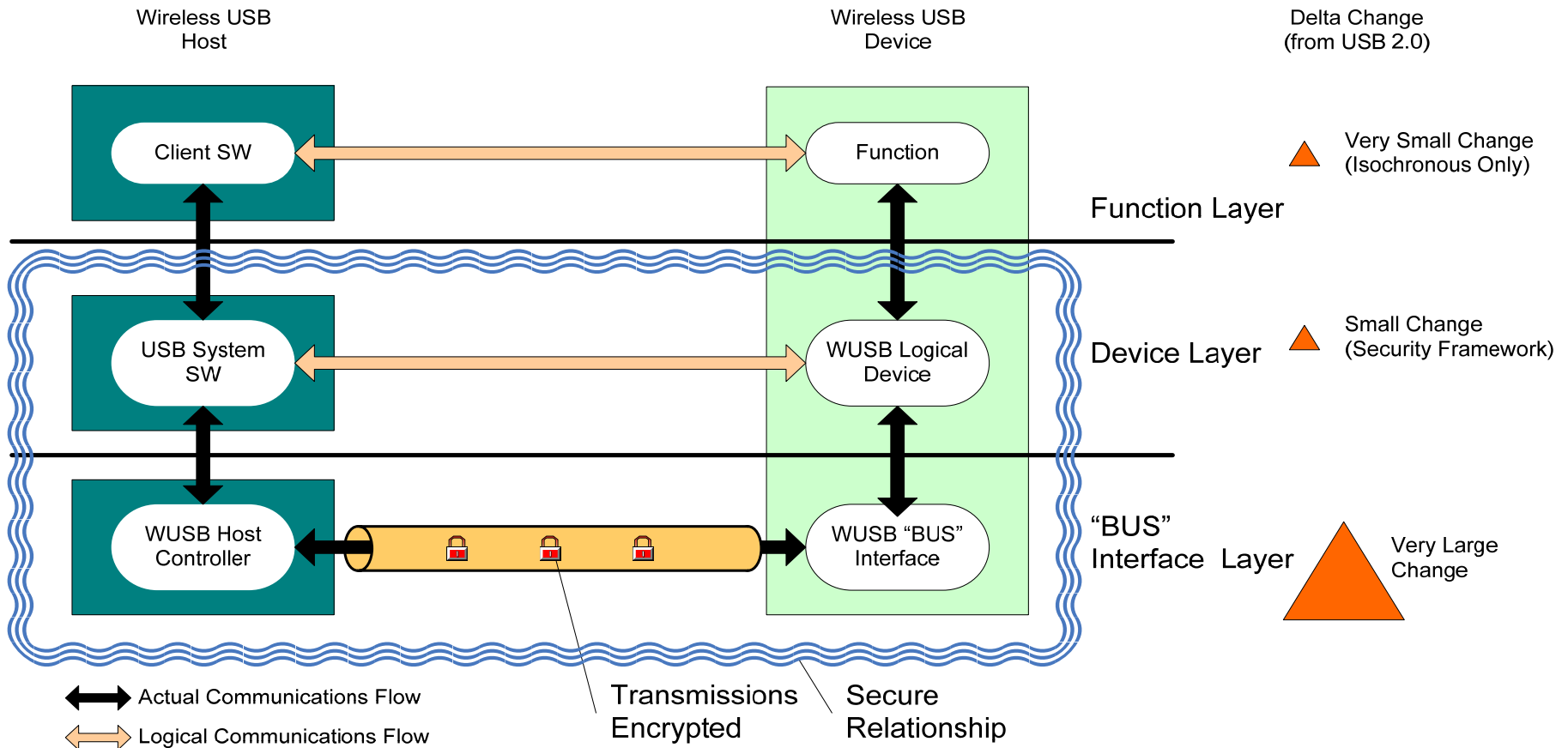
*Content also provided by:
John S. Howard, Intel Corporation*



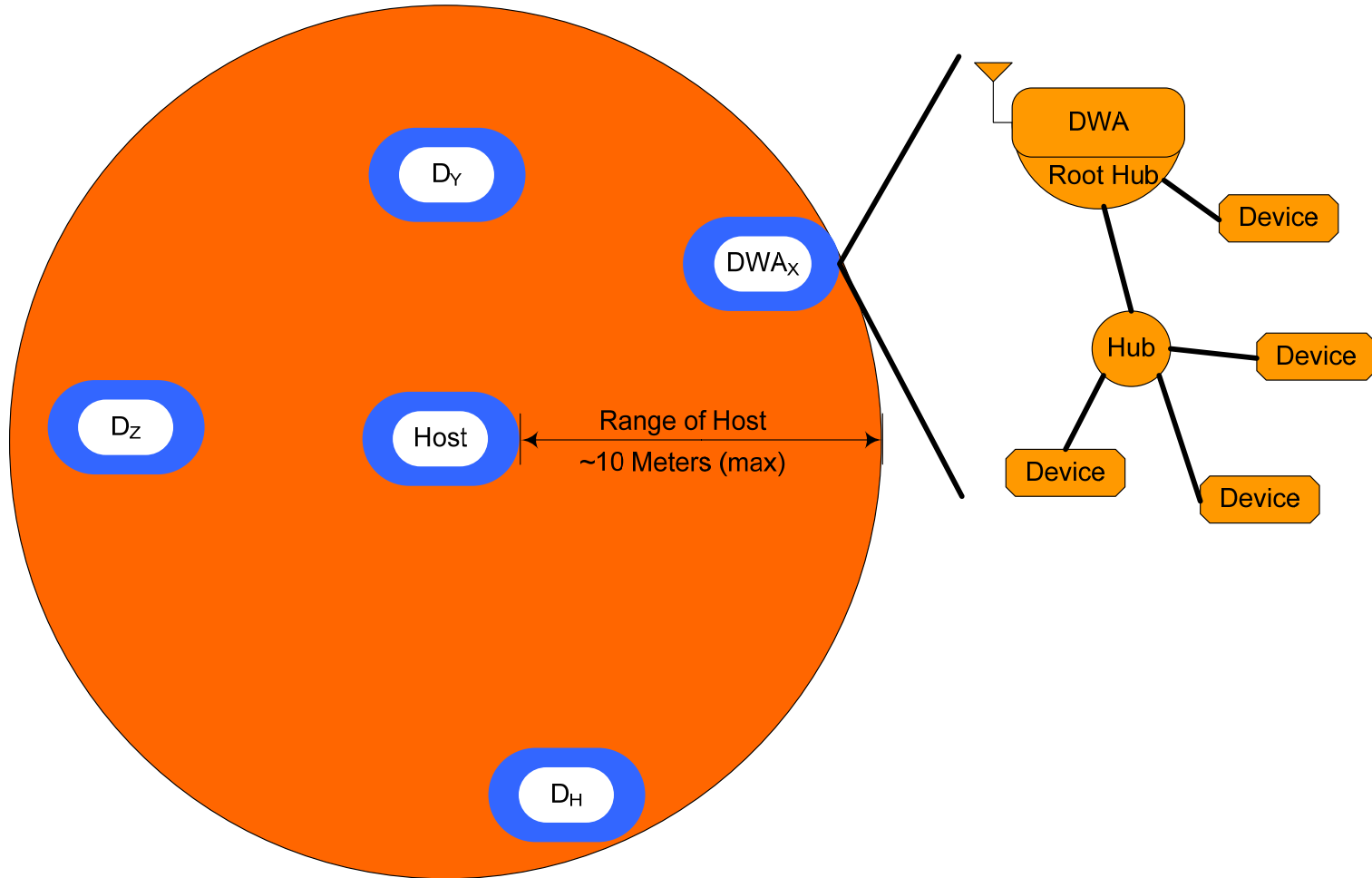
Agenda

- Topology
- Certified Wireless USB Channel
- Hosts
- Devices
- Data Communications
- Examples

Logical Communication Topology



Physical Communication Topology

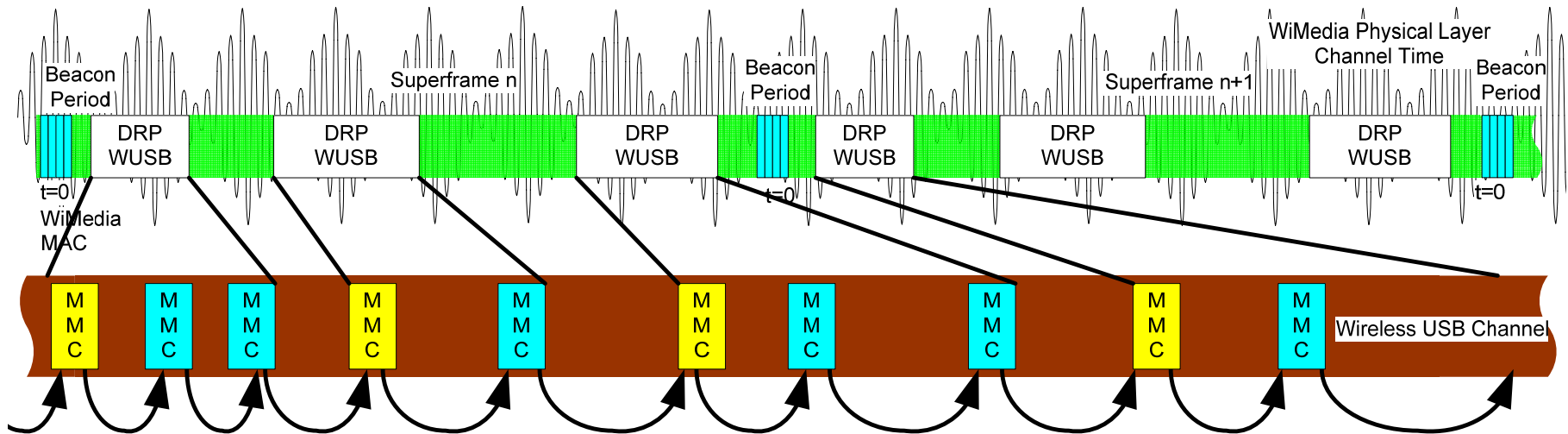


Agenda



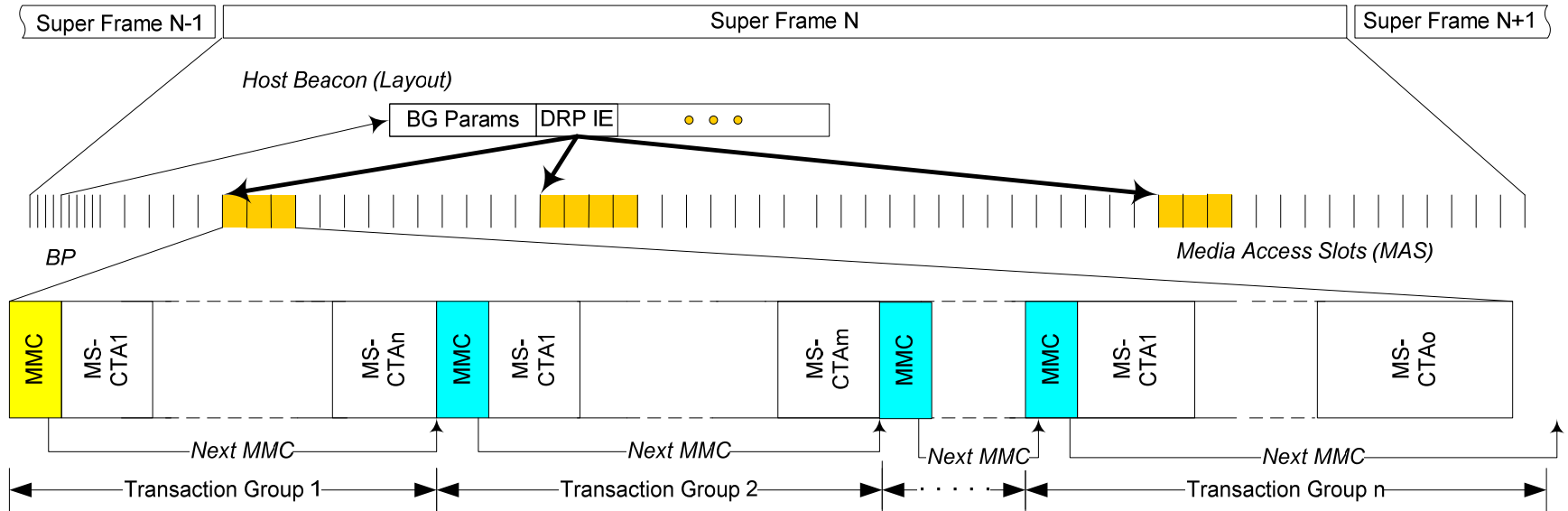
- Topology
- Certified Wireless USB Channel
 - Certified Wireless USB Channel (Definition)
 - USB Time
 - Certified Wireless USB Cluster
- Hosts
- Devices
- Data Communications
- Transfer Types / Constraints

Certified Wireless USB Channel



- The Certified Wireless USB Channel is encapsulated by the WiMedia 'channel'
- Uses WiMedia PHY/MAC compliant components
 - WiMedia PHY signaling and frames
 - WiMedia MAC Headers, Security Encapsulation, etc.
- Certified Wireless USB channel is continuous sequence of linked control packets transmitted by the Host during reserved WiMedia channel time
 - CWUSB time is reserved from WiMedia channel time (DRPs)
 - Called MMCs – Micro-schedule Management Commands
- All Certified Wireless USB Data communications are over the CWUSB Channel

Certified Wireless USB Channel Control



- Continuous linked series of MMCs transmitted by Host
- Contain:
 - Certified Wireless USB Channel Time Stamp
 - Time to next MMC
 - General Channel Management Info (Host ID, etc.)
 - Certified Wireless USB channel time allocation declarations

USB Time



- Wired USB hosts maintain USB channel time
 - In wired USB, HW has 11-bit SOF frame counter providing millisecond resolution or 1/8th millisecond resolution
 - Exported to client drivers through USBDI as 32-bit value
 - In wired USB, time values are primarily used for isochronous traffic
 - SOFs (Start Of Frame packets) pass time information to devices
- Certified Wireless USB hosts also maintain USB channel time
 - 17-bit 1/8th millisecond counter and 7 bit microsecond counter
 - Still exported to client drivers as 32-bit millisecond value
 - Timer used for isochronous and directed beaconing
 - MMCs used to pass time information

Certified Wireless USB Time vs. WiMedia Time



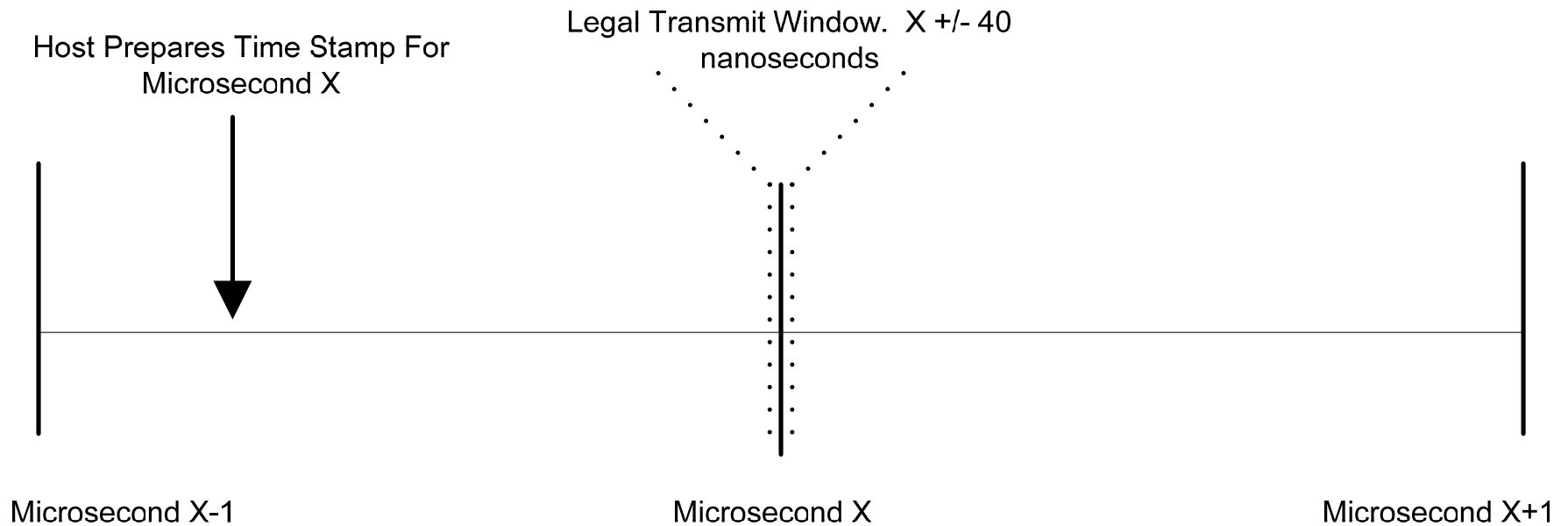
- Certified Wireless USB time is NOT slaved to WiMedia time
- WiMedia superframes will be some number of CWUSB microseconds
 - Host by itself means it will be exactly 64K microseconds
 - If there is a slow beaconing WiMedia device, superframe may be a few more CWUSB usecs than 64K

Device Synchronization



- Devices use MMC timestamps to synchronize their internal usec clocks
 - Only done on devices that need clocks
 - Ex. Isochronous capable and directed beaconing
 - Device clocks must adjust to host rate

MMC Transmission Accuracy



Hosts transmit MMCs on Micro-second boundaries

USB Time Across Hierarchy

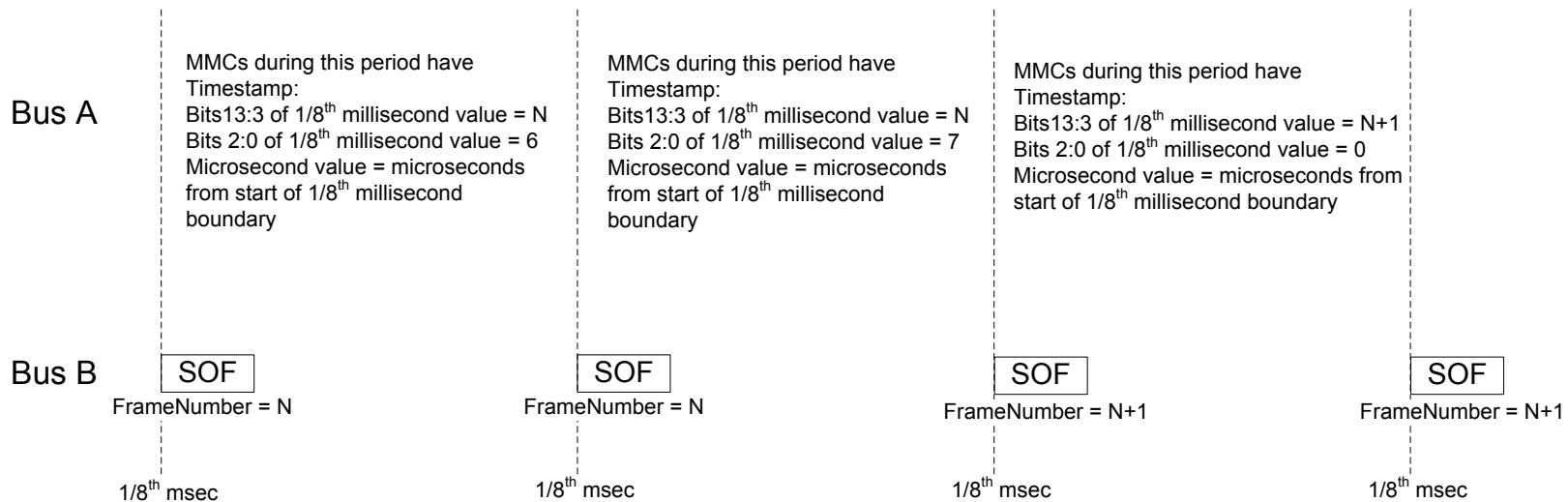


Example Topology



Actual times in MMC and SOFs are the same

Bus Timings



- Device Wire Adapters synch to upstream USB time and propagate to downstream USB time

Certified Wireless USB Cluster



- Term used to refer to all devices connected to and communicating via the same Certified Wireless USB Channel
- One Certified Wireless USB Host
- One (or more) Certified Wireless USB Devices

Addressing in a Certified Wireless USB Cluster



Address Tag

UnAssociated_Device_Address

UnAuthenticated_Device_Address_Range

USB_Device_Address_Range

Range

255 (00FFH)

128-254 (0080H-00FEH)

0-127 (0000H-007FH)

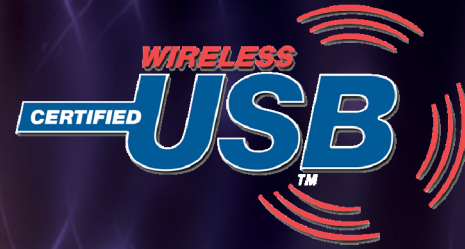
- Assigned Address Range (0-254)
 - For devices
- Cluster/Channel Broadcast Address
 - Destination Address for MMCs (assigned by Host from 128-254 range)
- Stream Index Value
 - Assigned by Host



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Host Responsibilities



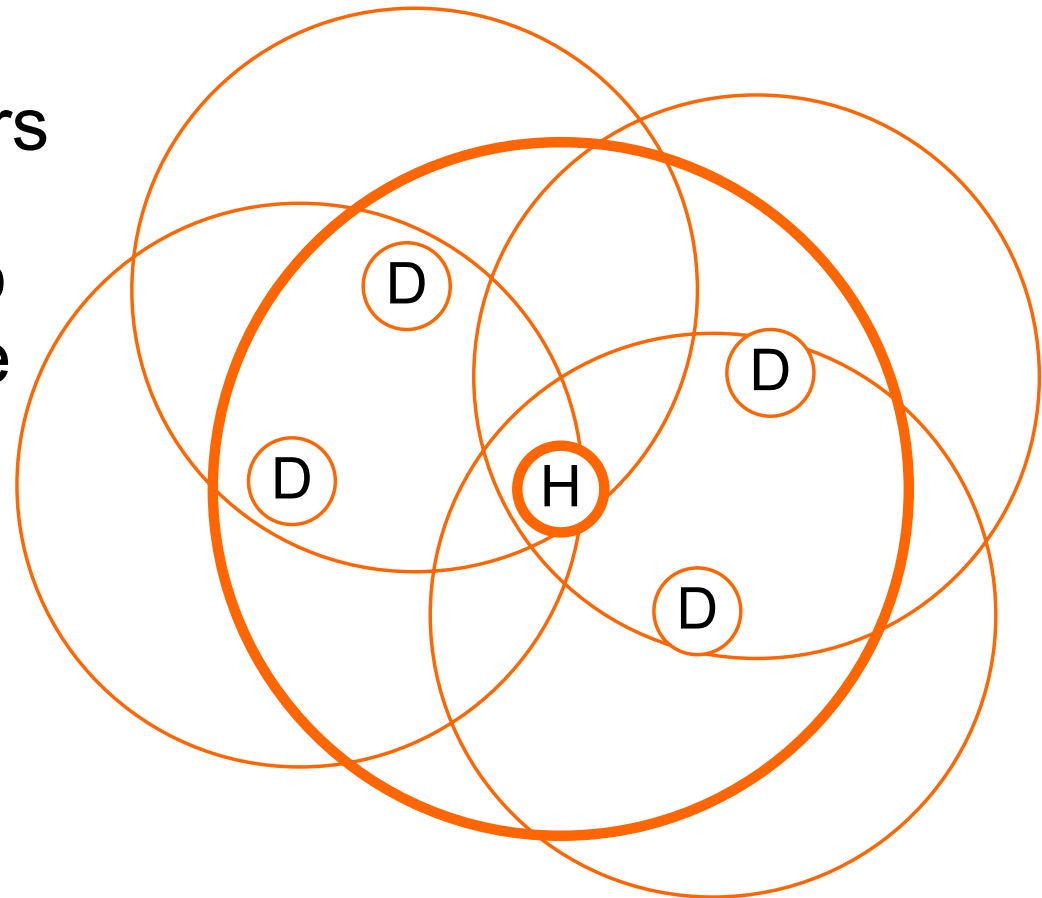
- WiMedia MAC compliant
- Manage / Maintain the Certified Wireless USB Channel
 - Maintain WiMedia Reservation (for CWUSB Channel(s))
 - USB Time
 - CWUSB Periodic Bandwidth
 - CWUSB Data Communications
 - Device Management (addressing, security, enumeration)
 - Endpoint Data Streams (Transfer Pipes)
 - CWUSB Power Management

Hosts

Managing 2-hop Topology



- Case 1: Host has no hidden neighbors
- Only Host needs to beacon to preserve reservation
- Host uses cluster members to detect this condition

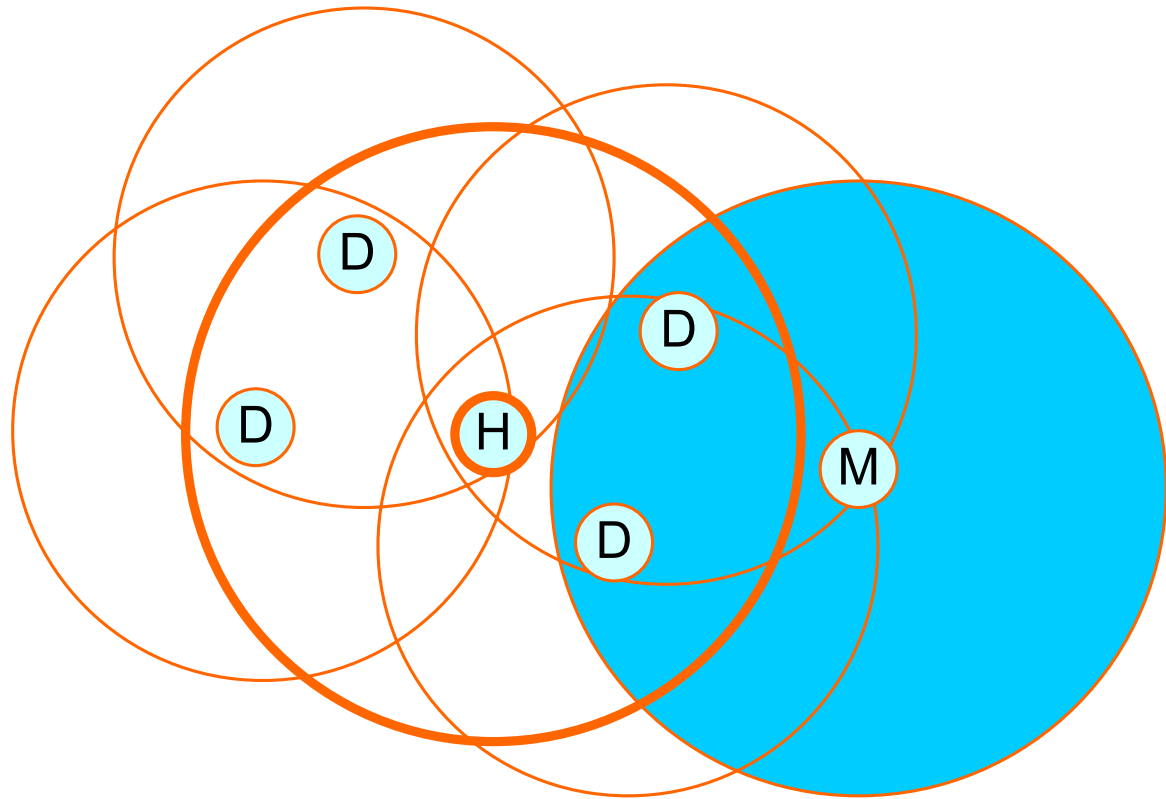


Hosts

Managing 2-hop Topology (cont).



- Case 2:
Hidden Neighbor
- Host uses cluster members to detect this condition and propagate its reservations to hidden neighbor





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- **Devices**
- Data Communications
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Certified Wireless USB Device Types



- Self Beaconsing Devices
 - Devices are full WiMedia MAC aware
 - Attend “Design Considerations for SBDs/DRDs” for details
- Directed Beaconsing Devices
 - Devices are not full WiMedia MAC aware
 - Depend on host to make them ‘good citizens’
 - Attend “Certified Wireless USB Framework” for details
- Non Beaconsing Devices
 - Limited transmit and receive range
 - Fully encompassed by hosts range
 - Not enough detail to be built (yet)

Agenda



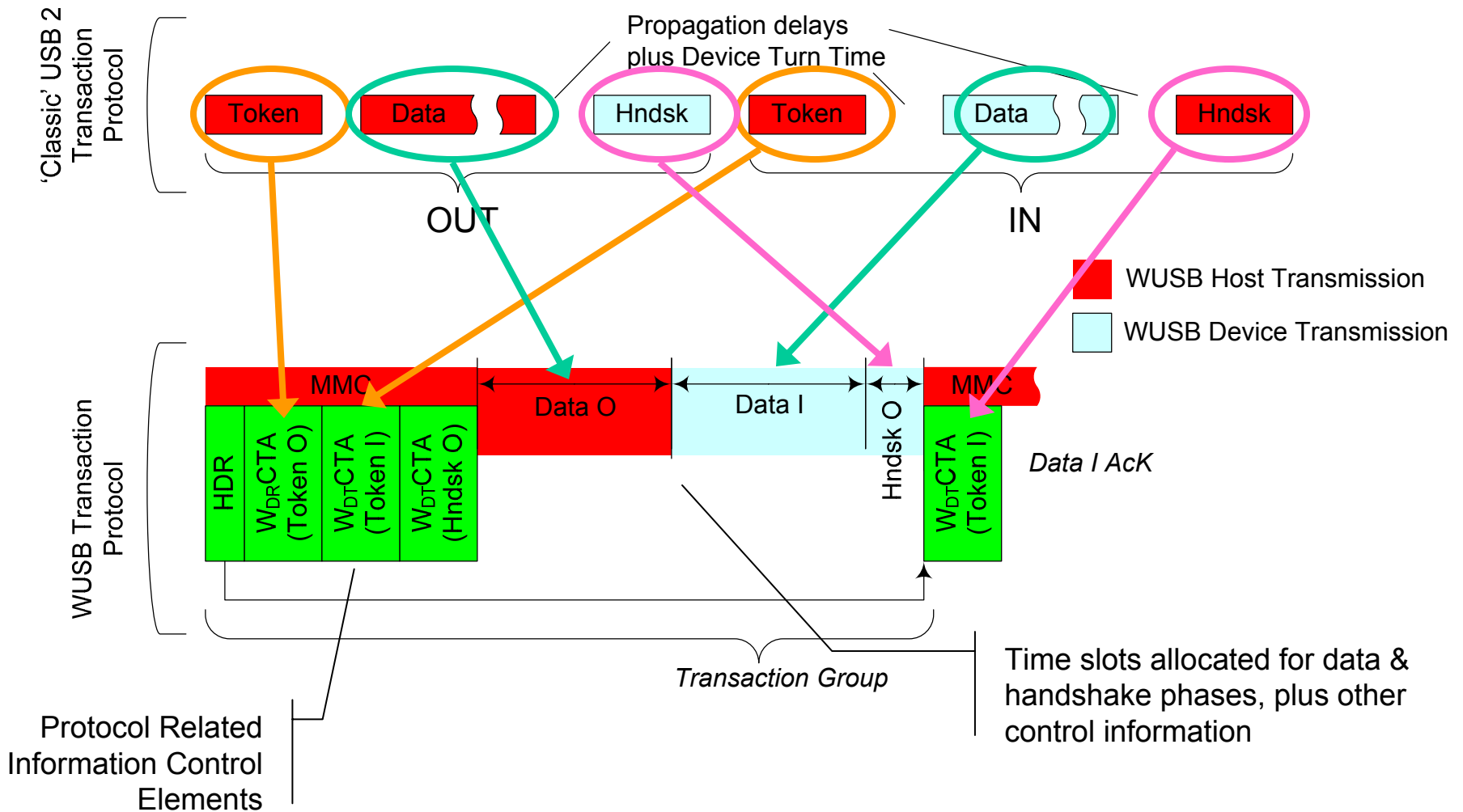
- Topology
- Certified Wireless USB Channel
- Hosts
- Devices
- Data Communications
 - MMCs – Micro-scheduled Management Command
 - Transactions
 - Device Notifications
 - Certified Wireless USB Connection
- Transfer Types / Constraints

MMC Information Elements



- Transaction protocol control elements
- Host Channel Identification/Information
- Controls for Analogs to Wired signaling events
 - Connect, disconnect, suspend & resume, device reset
- Certified Wireless USB Channel maintenance
 - Communicates to cluster the channel time allocation

Certified Wireless USB Transactions

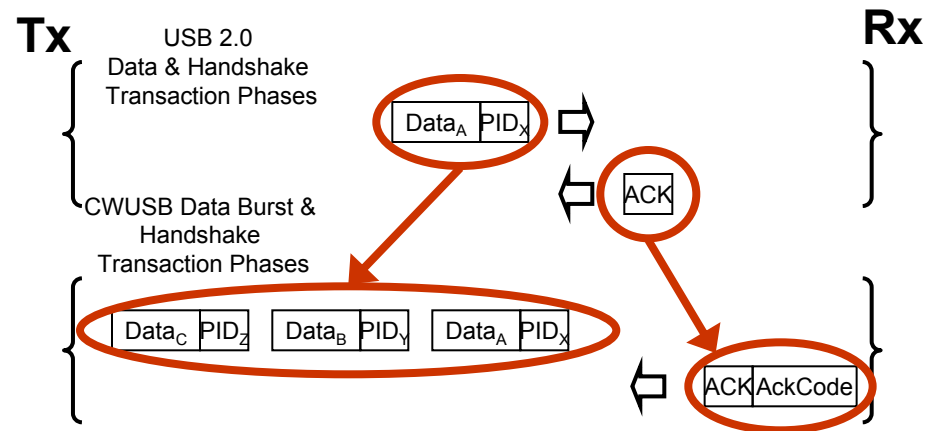


Certified Wireless USB Transactions

Data Bursting



- Transaction data phases may have more than one data packet
- Data Payloads are *aMaxPacketSize*
 - wMaxPacketSize or
 - Smaller
 - Host decision

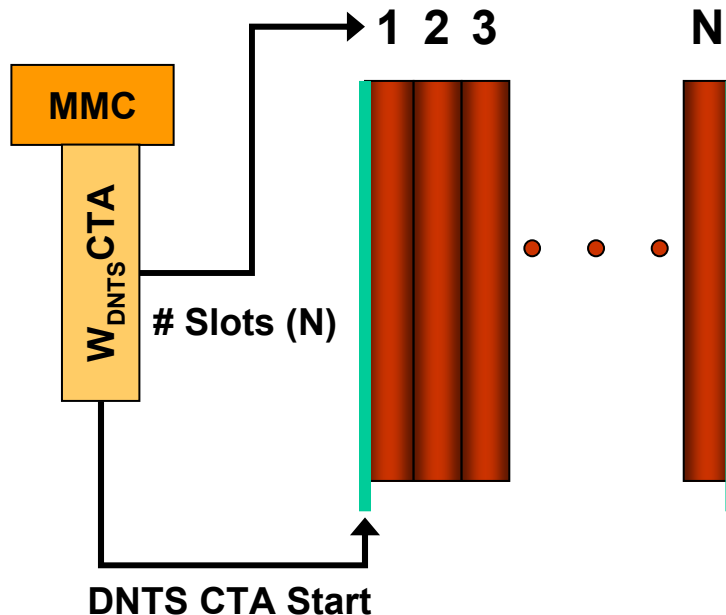


Lots more detail in Data Bursting Session

Device Notifications



- Used for small, infrequent, asynchronous messages from a Device to the Host
 - Analogs for Wired USB signaling events, etc.



- Opportunities to transmit Device Notifications are also scheduled by the Certified Wireless USB Host
 - Other CTAs types have single transmitter (Host or Device)
 - Any device may transmit during DNTS CTAs
 - Access type for DNTS is contention based (has contention avoidance mechanism)

Slot Select = uniform(1, N)

Certified Wireless USB Connection



- A host and device exchange data using a secure connection
- A process is defined for making the connection secure
 - Establishing Trust
 - Limited 'non-secure' data communications allowed to establish secure connection
- All data communications in a secure connection are either encrypted or authenticated
 - MMC are authenticated by devices belonging to the cluster
 - Transmitted with secure packet, but payload is in clear text (not encrypted)
 - Other data protocol and Device notifications are encrypted
 - Transmitted with secure packets, with payload encrypted

Certified Wireless USB Connection (cont.)



- Session Keys:
 - Certified Wireless USB Cluster has a single Group Key
 - Used by devices to Authenticate MMCs
 - Each device in Cluster has a unique symmetric session key
 - Encrypt/decrypt of data, protocol and notification packets
- Keys only valid while Connection is Secure
 - *TrustTimeout* requires re-authentication (re-establishment of keys)

Certified Wireless USB Connection Connection Lifetime



- A secure connection has a Lifetime
 - Maintenance of the secure connection requires exchange of secure information so that the connection can be kept 'fresh'
 - No data received by host or device for TrustTimeout (4 seconds) results in requirement to re-authenticate
- Re-authentication can be initiated by either the host or device
 - Loss of trust is asymmetric
- Device informs host of Loss of Trust by sending a Reconnect request
- Host re-establishes trust by performing 4-way handshake with the Device



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Transfer Type Constraints

- Same Transfer types as USB 2.0
 - Bulk
 - Control
 - Interrupt
 - Isochronous
- Different/new constraints to make more efficient for Wireless Media

Transfer Type Constraints

Bulk



- Retains many/most constraints and behavior of Wired USB
 - Reliable Delivery
 - “Good Effort” service
 - Host may restrict number of data packets (burst size) to provide some level of service in available channel time
 - Short-packet Semantics preserved
- Maximum Packet Size, one of
 - 512, 1024, 1536, 2048, 2560, 3072 and 3584 (only)
- Maximum burst size of 1 to 16
- Use any bit transfer rate supported by device
 - Host choice
- On Flow control event, taken from active list
 - Device must notify host when ‘ready’

Transfer Type Constraints

Control



- Retains many/most constraints and behavior of Wired USB
 - “Best Effort” service
 - Reliable data delivery
- Maximum Packet Size of 512 (only)
- Maximum burst size of 1 data packet per data phase
- Host must use PHY Base rate with Default Control Pipe (Standard Commands)
- On Flow control event, taken from active list
 - Device must notify host when ready

Transfer Type Constraints

Interrupt



- Not more than 80% of Certified Wireless USB Channel (combined all periodic)
- Similar purpose and characteristics of Wired USB
 - Reliable data delivery (protocol)
- Periodic (allocated) Bandwidth service
 - Interval = $(2^{\text{Interval}-1}) * 128 \mu\text{s}$; range : (6 to 16) [$\sim 4\text{ms}$ to $\sim 4\text{s}$]
 - (host will provide polling @ rate or faster)
 - Retries during service interval to reduce PER
 - Host may adjust payload packet size (& number of transactions per interval) to reduce PER
- Use any bit transfer rate supported by device
 - Host choice
- On Flow control event, skip to next service interval

Transfer Type Constraints

Interrupt (cont.)



- Two 'Power Flavors' of Interrupt Endpoint
- Normal power
 - Traditional behavior – including retry/halt policy
 - Maximum packet size (1 – 1024) Max burst size : 1
 - Retries per service interval : 5 (to achieve PER)
- Low Power
 - Intended for low-latency but very low bandwidth
 - Device to Host ONLY
 - Endpoint responds only when it has data *
 - Relaxed retry/halt policy
 - Maximum Packet Size of 64 (only) Max burst size : 1
 - Retries per service interval : 2 (max)

***must NAK to avoid
TrustTimeout**

Transfer Type Constraints

Isochronous



- Not more than 80% of Certified Wireless USB Channel (combined all periodic)
- Similar purpose and characteristics of Wired USB
- Periodic (allocated) Bandwidth service
 - Interval = $(2^{\text{Interval}-1}) * 128 \mu\text{s}$; range : (6 to 16) [$\sim 4\text{ms}$ to $\sim 4\text{s}$]
 - (host will provide polling @ rate or faster)
 - Retries during service interval to reduce PER
 - Host cannot adjust payload packet size
- Maximum Packet Size of 0-3584 Max burst size : 1-16
 - At least one retry per service interval
- Use any bit transfer rate supported by device
 - Host choice
- On Flow control event, next service interval

Allocation includes additional 30% of average throughput (for retries)



Questions



Developers Conference 2006

Taipei, Taiwan