



Updated Radio Control I/F for Host Wire Adapter (HWA)

Abdul R. Ismail
Intel Corporation

Outline



- Rationale
- Commands & Events
- Architecture & Scope
- Division of responsibilities
- Some examples

Introduction

Why a Dedicated Interface?



- A Host Wire Adapter (HWA) contains a WiMedia UWB radio
- The Radio Control Interface (RCI) allows the host software to control and configure the radio in a HWA
- Some of the functionalities that must be implemented are common to any WiMedia device
- A Certified Wireless USB HWA implements all mandatory and a subset of optional functionalities defined by WiMedia.
- A standard interface simplifies deployment of other application protocols running on the host and sharing the radio with Certified Wireless USB

Rationale



- Low Cost, Low Complexity
 - Only the functionalities with tightest timing requirements are embedded in the HWA
- Coexistence and Scalability
 - Expose common radio functionalities, enabling extensions for other protocols. → *Common WiMedia platform*
 - Compatible with WiMedia's MAC Convergence Layer
- High Flexibility
 - Enable early development of Wire Adapters while WiMedia specifications are finalized

Radio Control Interface: Principles of Operation

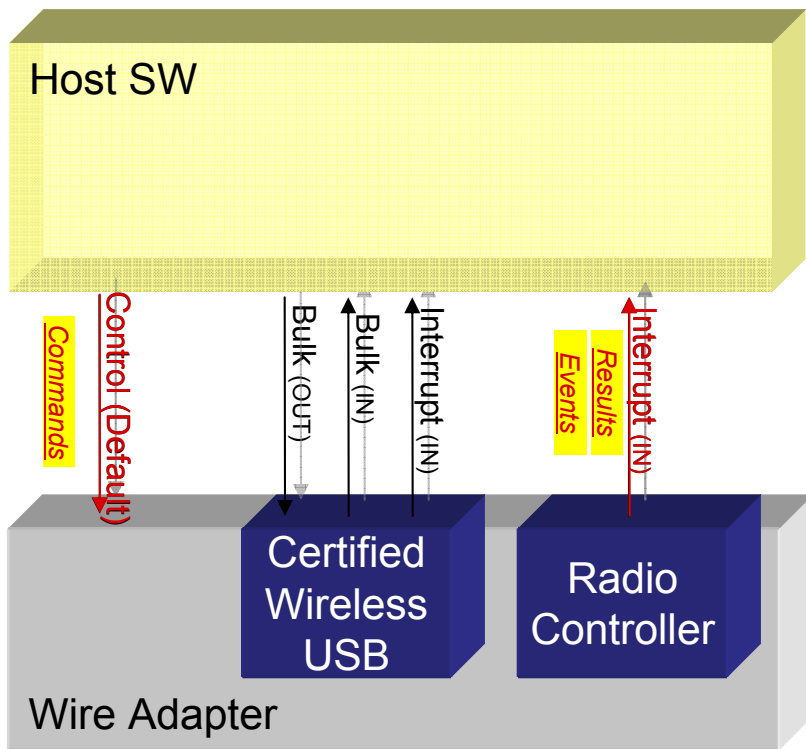


- Host → Radio

- Host sends commands to Radio Controller via the HWA's default control endpoint
- Radio Controller returns command status and results to host via its interrupt endpoint

- Radio → Host

- Radio Controller sends asynchronous notifications (events) to host through its interrupt endpoint
 - Notification filter should be set by host



Commands



<i>Value</i>	<i>Command</i>	<i>Brief Description</i>
16	Channel Change	Instruct the adapter to change operating channel after informing neighboring devices
17	Device Address	Query or set the 16-bit device address or EUI-48 address used by the adapter
18	Get IE	Retrieve Information Elements transmitted by the adapter
19	Reset	Reset the adapter's radio to the default power on state
20	Scan	Instruct the adapter to start or stop a scan operation
21	Set Beacon Filter	Enable/disable notifications of events related to neighboring devices' beacons.
22	Set DRP IE	Set the DRP IEs to be included in the adapter's beacon
23	Set IE	Set any of the host settable IEs to be included in the adapter's beacon
24	Set Notification Filter	Instruct the device to filter one or more notifications
25	Set TX Power	Set the default power for transmissions by the adapter of packets (for which power level is not set by other means)
26	Sleep	Instruct the device to enter hibernation state after informing neighboring nodes (if remote wakeup is not enabled).
27	Start Beacons	Instruct the adapter to begin beacons on the selected channel and join the specified beacon period
28	Stop Beacons	Instruct the adapter to stop beacons
29	BP Merge	Instruct the adapter to start or abort the beacon period merge operation
30	Send Command Frame	Instruct the URC to send a command frame
31	Set ASIE Notification	Instructs the URC to notify the URCD when it detects an Application Specific IE

Events



Value	Command	Brief Description
0	IE Received	Reception of an IE targeted to this adapter in a beacon from a peer device
1	Beacon Received	Reception of a beacon (during scan operation or according to beacon notification filter)
2	Beacon Size Change	Change in the size of the beacon transmitted by the adapter (due to a modification of one or more of the IEs handled by the adapter).
3	BPOIE Change	Change of the BPOIE transmitted by the adapter
4	BP Slot Change	Change of the beacon slot in which the adapter is transmitting its beacon
5	BP Switch IE Received	Detection of a BP Switch IE in a peer device's beacon
6	Device Address Conflict	Detection of a device address conflict
7	DRP Availability Change	Change in own DRP availability
8	DRP	Detection of a request to create (or modify) a DRP destined to own device address or multicast address. Also detection of DRP conflict or Termination
9	BP Switch Status	Reports on the current status of the beacon period switch operation
10	Command Frame Received	Indicates that the adapter received a command frame from a peer device
11	Channel Change IE Received	Detection of a Channel Change IE in a beacon from a peer device
*	Unknown Command Received	Indicates that the adapter received a command that it could not decode

Radio Control Commands



- Sent using a Control Transfer Request via HWA's Default Control Endpoint
- Encapsulated within a Radio Control Command Block

bmRequestType	bRequest	wValue	wIndex	wLength	Data
00100001B	EXEC_RC_CMD (40)	Zero	Interface Number	Command Length	Radio Control Command Block

- CHANNEL_CHANGE 16
- DEV_ADDR 17
- GET_IE 18
- RESET 19
- SCAN 20
- SET_BEACON_FILTER 21
- SET_DRP_IE 22
- SET_IE 23
- SET_NOTIFICATION_FILTER 24
- SET_TX_POWER 25
- SLEEP 26
- START_BEACONING 27
- STOP_BEACONING 28
- BP_MERGE 29
- SEND_COMMAND_FRAME 30
- SET_ASIE_NOTIFICATION 31

bCommandType	wCommand	bCommandContext	Parameter0	...	ParameterN-1
	[16-31]	ID	1-FEH	Size and data are specific to each command	

Radio Control Events



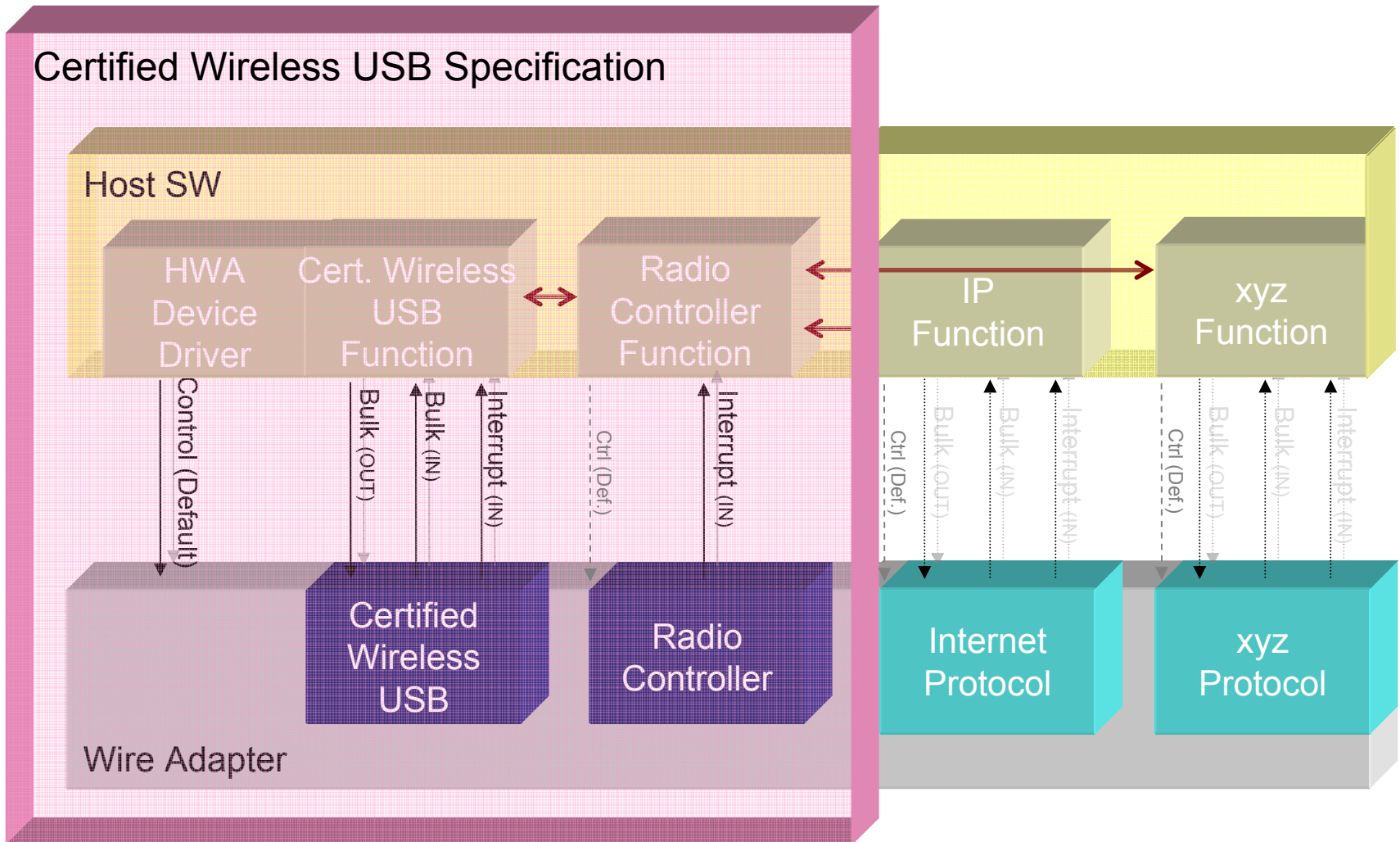
- All commands must be confirmed by the Adapter using an Event Block sent via the Interrupt endpoint
- If asynchronous notifications are enabled, these are also sent using an Event Block sent via the Interrupt endpoint

bEventType	wEvent	bEventContext	Parameter0	...	ParameterN-1
GENERAL 0 VENDOR SP. F0-FFH	NOTIFICATIONS [0-11] RESULTS [16-31]	EVENT 0 RESULT 1-FEH	Size and data are specific to each command		

AS_PROBE_IE_RECEIVED	0
BEACON_RECEIVED	1
BEACON_SIZE_CHANGE	2
BPOIE_CHANGE	3
BP_SLOT_CHANGE	4
BP_SWITCH_IE_RECEIVED	5
DEV_ADDR_CONFLICT	6
DRP_AVAILABILITY_CHANGE	7
DRP	8
BP_SWITCH_STATUS	9
COMMAND_FRAME_RECEIVED	10
CHANNEL_CHANGE_IE_RECEIVED	11

CHANNEL_CHANGE	16
DEV_ADDR	17
GET_IE	18
RESET	19
SCAN	20
SET_BEACON_FILTER	21
SET_DRP_IE	22
SET_IE	23
SET_NOTIFICATION_FILTER	24
SET_TX_POWER	25
SLEEP	26
START_BEACONING	27
STOP_BEACONING	28
BP_MERGE	29
SEND_COMMAND_FRAME	30
SET_ASIE_NOTIFICATION	31

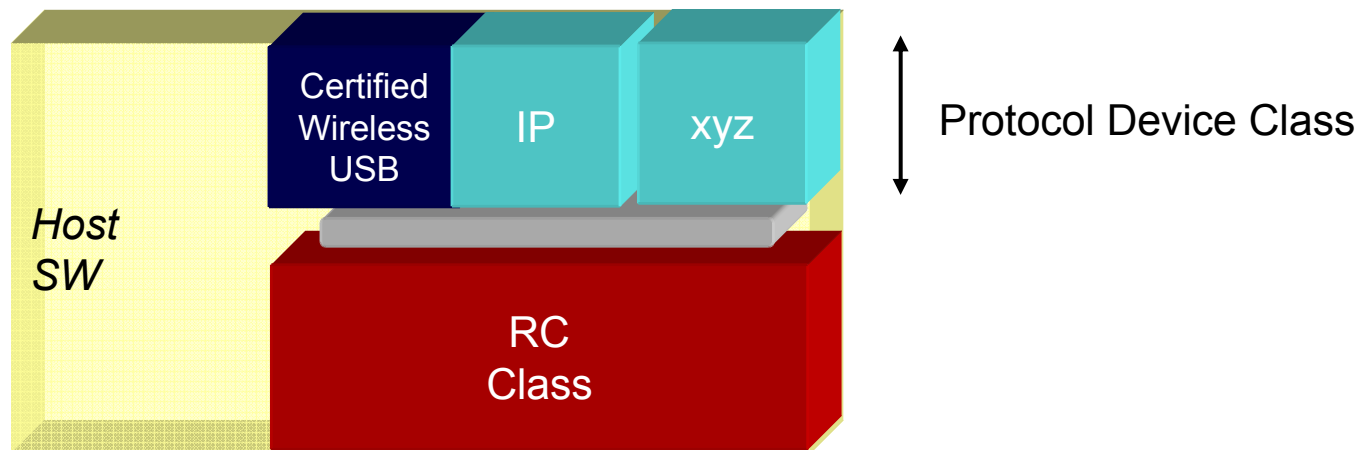
Architecture & Scope



Radio Controller & Protocol Function Drivers



- Different Protocol Function Drivers interact with the Radio Controller Function Driver in the Host
- The Radio Controller Function Driver manages all individual requests to the Radio
- Each Protocol Function Driver is responsible for properly configuring and operating its associated block in the HWA



WiMedia Beaconsing Overview



- WiMedia Beacon Protocol
 - Beacon Period
 - Beacon Slots
 - Beacon Protection/BPOIE
 - Synchronization/BPST
 - Contraction/Expansion
 - Alien BP

WiMedia Reservations Overview



- WiMedia Distributed Reservation Protocol
 - Implicit DRP
 - Explicit DRP
 - DRP Information Element
 - DRP Availability Map

Radio Controller Responsibilities: Beaconing



- Radio Controller is responsible for transmitting its beacon according to WiMedia rules
 - Super-frame synchronization
 - Beacon period Start Time (BPST)
 - Slowest clock in the Beaconing Group
 - Beacon Slot selection
 - Beacon Period contraction/expansion
 - Beacon transmission
 - Beacon reception
 - Processing of primary IEs
 - (see next slide)

Radio Controller Responsibilities: Primary IEs Processing



- Time critical Information Elements
 - DRP IE processing
 - BPOIE processing
 - Keep own BPOIE up-to-date
 - Keep own availability map up-to-date
 - Detection of conflicts
 - DRP-IE
 - Beacon Slot
 - Device Address

Radio Controller Function Driver Responsibilities: Configuration & Secondary IEs



- Radio Controller Function Driver (RCFD) is responsible for the initial configuration of the adapter's radio
 - Device address
 - Address generation and conflict resolution
 - Channel scan and selection
 - Beacon Period(s) discovery
 - Channel change
- It is RCFD's responsibility to instruct the adapter's radio to start and stop beaconing
- Information Elements
 - Generation and Management of other IE's (i.e., non beacon protocol) included in HWA's beacon
 - (see next slide)
 - Configuration of notification filters as appropriate
 - Processing of IE's received by the HWA
 - Response generation

Radio Control Function Driver Responsibilities: DRP & Power Mgt



- RCFD is entirely responsible for the management of all DRPs owned by the HWA
 - Coordinate requests of all serviced PALs
 - Medium Access Slots (MAS) allocation and redistribution amongst PALs
 - Reservation Protocol (implicit and/or explicit)
 - Initiate a DRP request
 - Respond to a DRP request
 - Resolve DRP-IE conflicts
- Power Management
 - Hibernation and Wakeup
 - Setting Default Transmit (TX) Power

WiMedia Information Elements Summary



Adapter

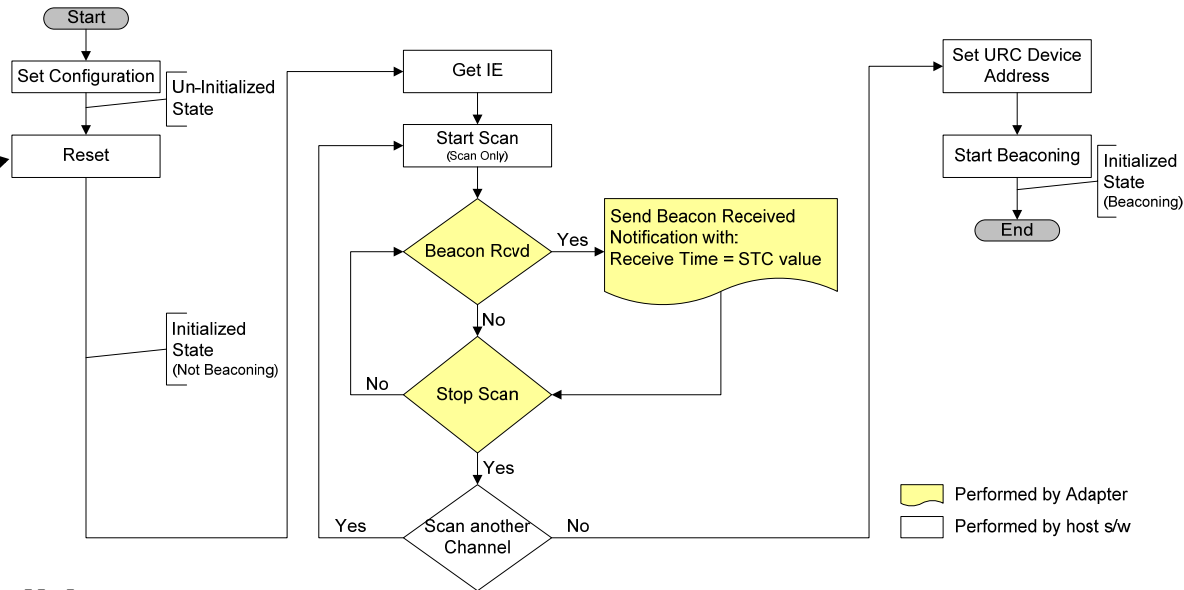
- DRP Availability
- Beacon Period Occupancy IE
- DRP-IE (reception)
- Channel Change IE
- BP Switch IE
- Hibernation IE

Host

- DRP-IE (generation)
- MAC and PHY Capabilities IE
- Identification IE
- PCA Availability IE
- Application-specific Probe IE
- Master Key Identifier (MKID) IE
- Application Specific IE (ASIE)

Not used by
Certified Wireless USB

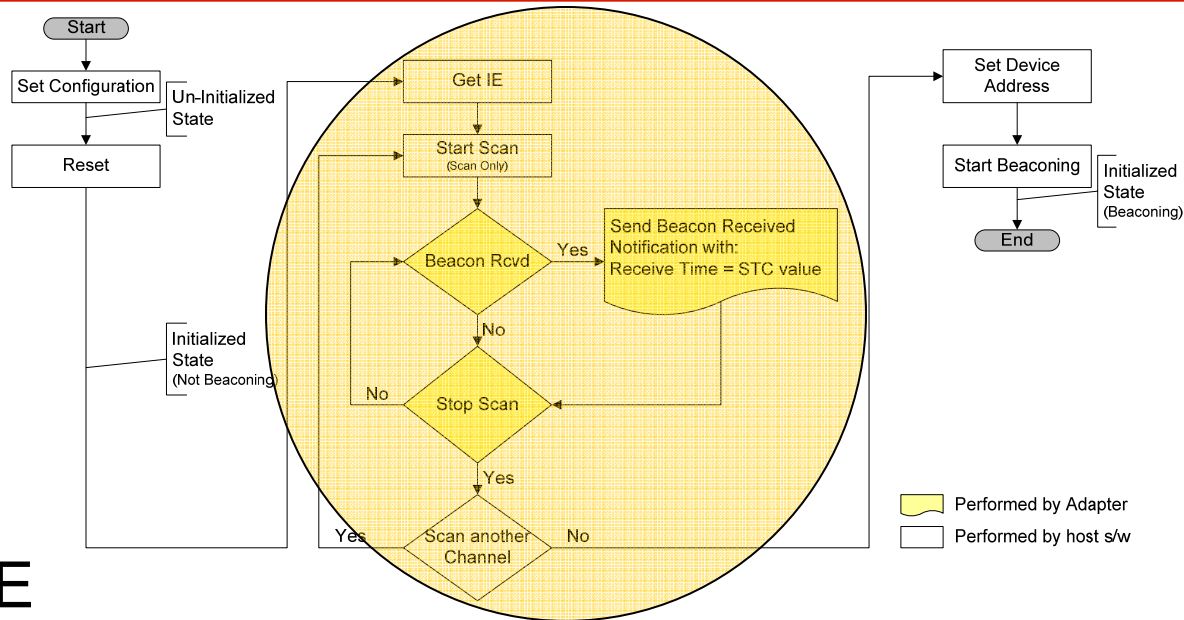
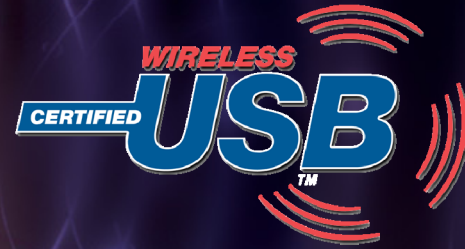
Radio Controller Initialization



Reset conditions

- Highest transmission power level
- Free-running Superframe Time Counter (STC)
- Scan disabled
- Beacon Notification filters off
- Notification filters all off
- Buffers empty

Radio Controller Initialization



- **Get IE**

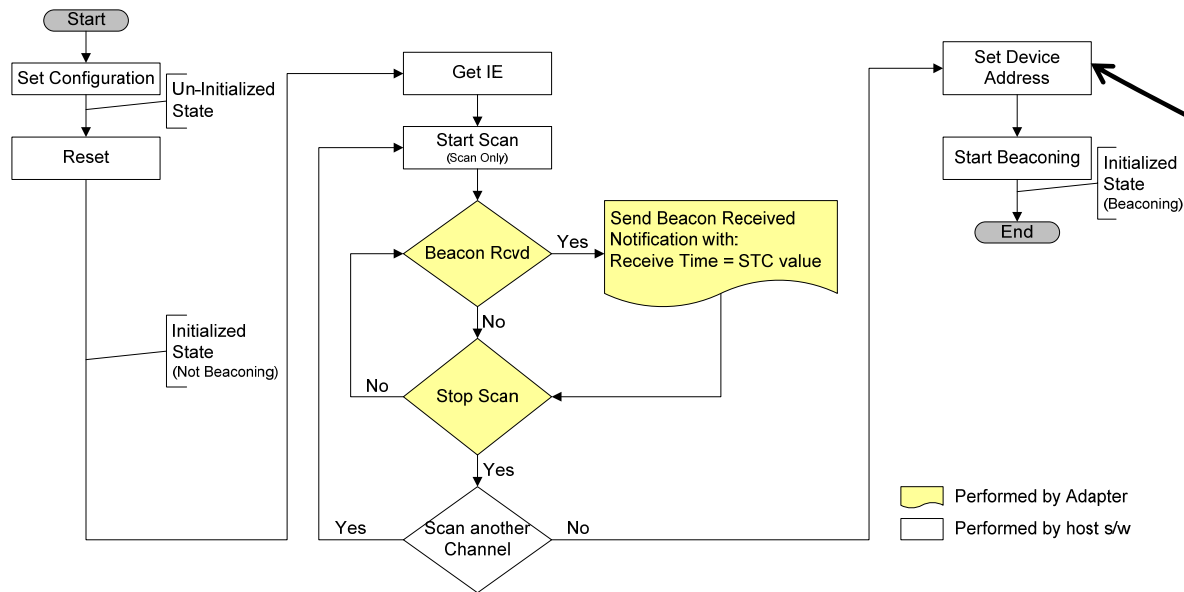
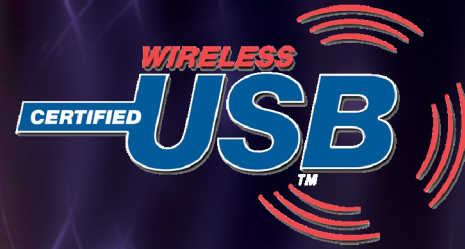
- Used to derive the UWB channels supported

- **RCFD starts Scanning**

- The RC returns Beacon Received notifications generated for every received beacon

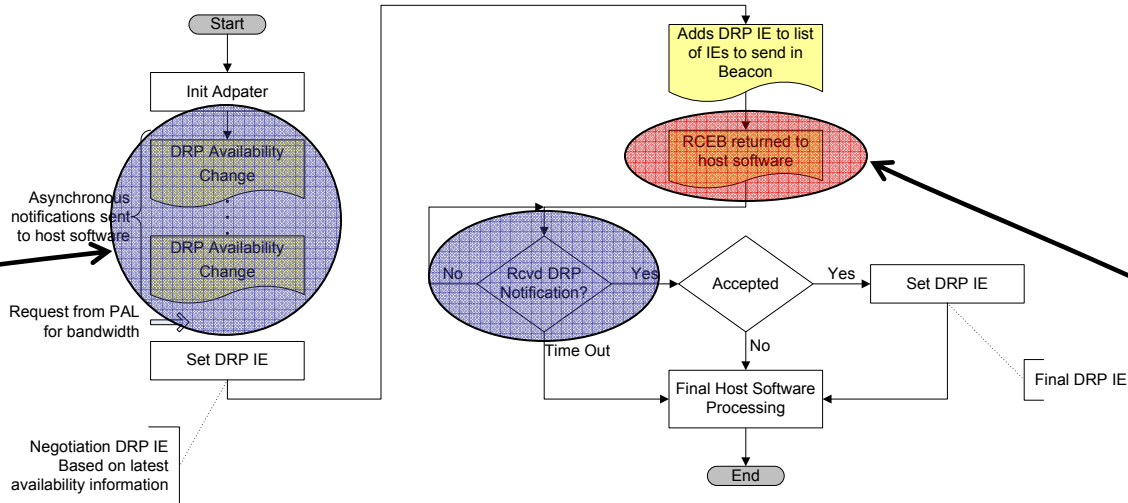
- **RCFD determines the channel to be used**

Radio Controller Initialization



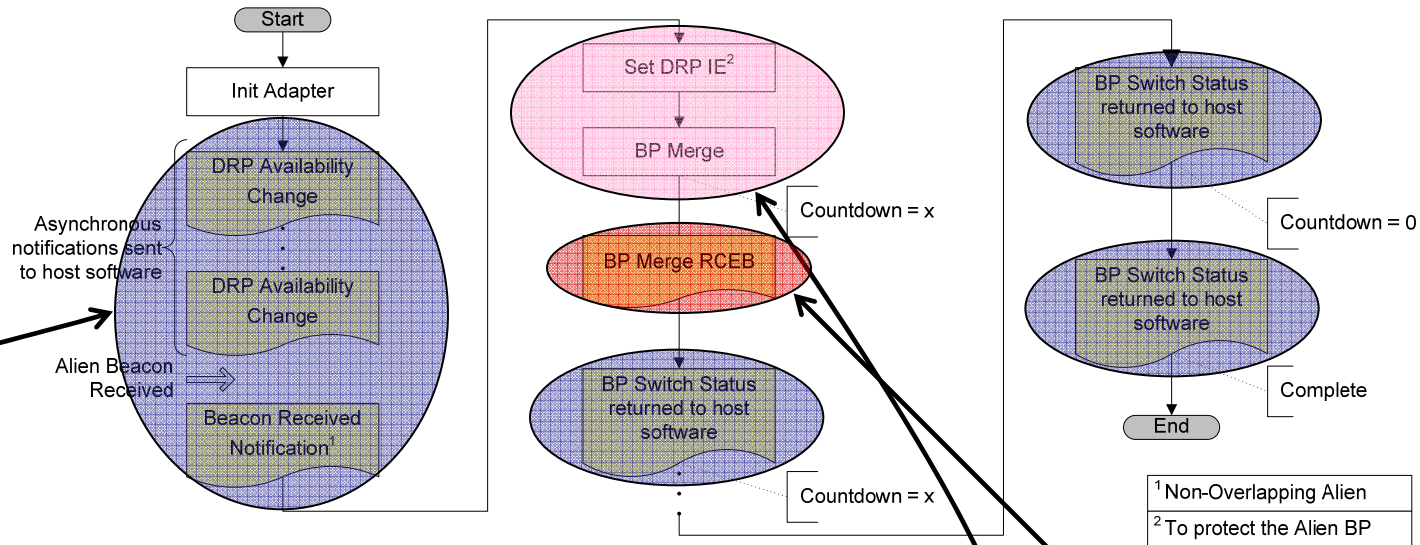
- IEEE defined 48-bit extended unique identifier (EUI-48)
 - This can be either statically configured or assigned by the host
- 16-bit device address (DevAddr)
 - It is host's responsibility to assign one to the adapter and modify it as needed

Example: DRP Negotiation



- RCFD chooses which notifications it wants to receive
- By default all notifications are enabled
- Asynchronous notifications
- Notification that is the result of a previous Command

Example: BP Merge



- Asynchronous notifications
- Commands
- Notification that is the result of a previous Command



Back-up Foils

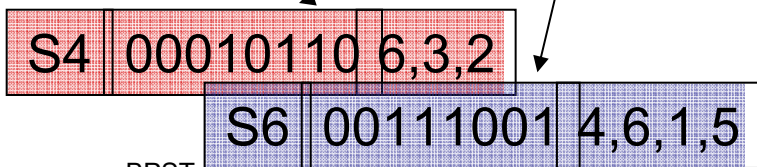
Example: Discovering a Beacon Period



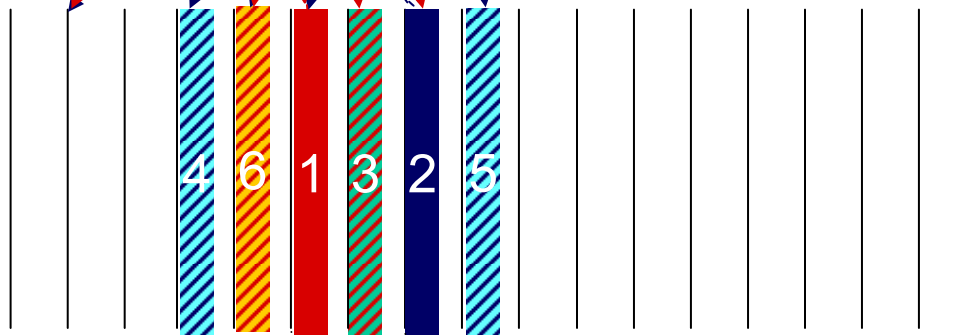
1 Superframe = 256 MAS



BPOIE / beacon structures simplified for illustrative purpose

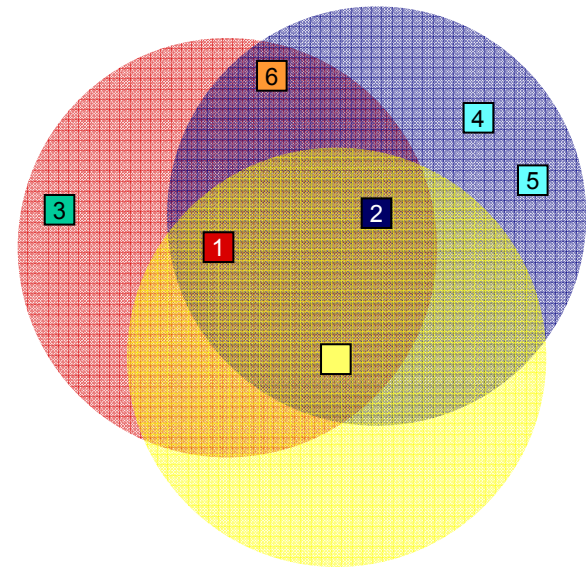


BPST

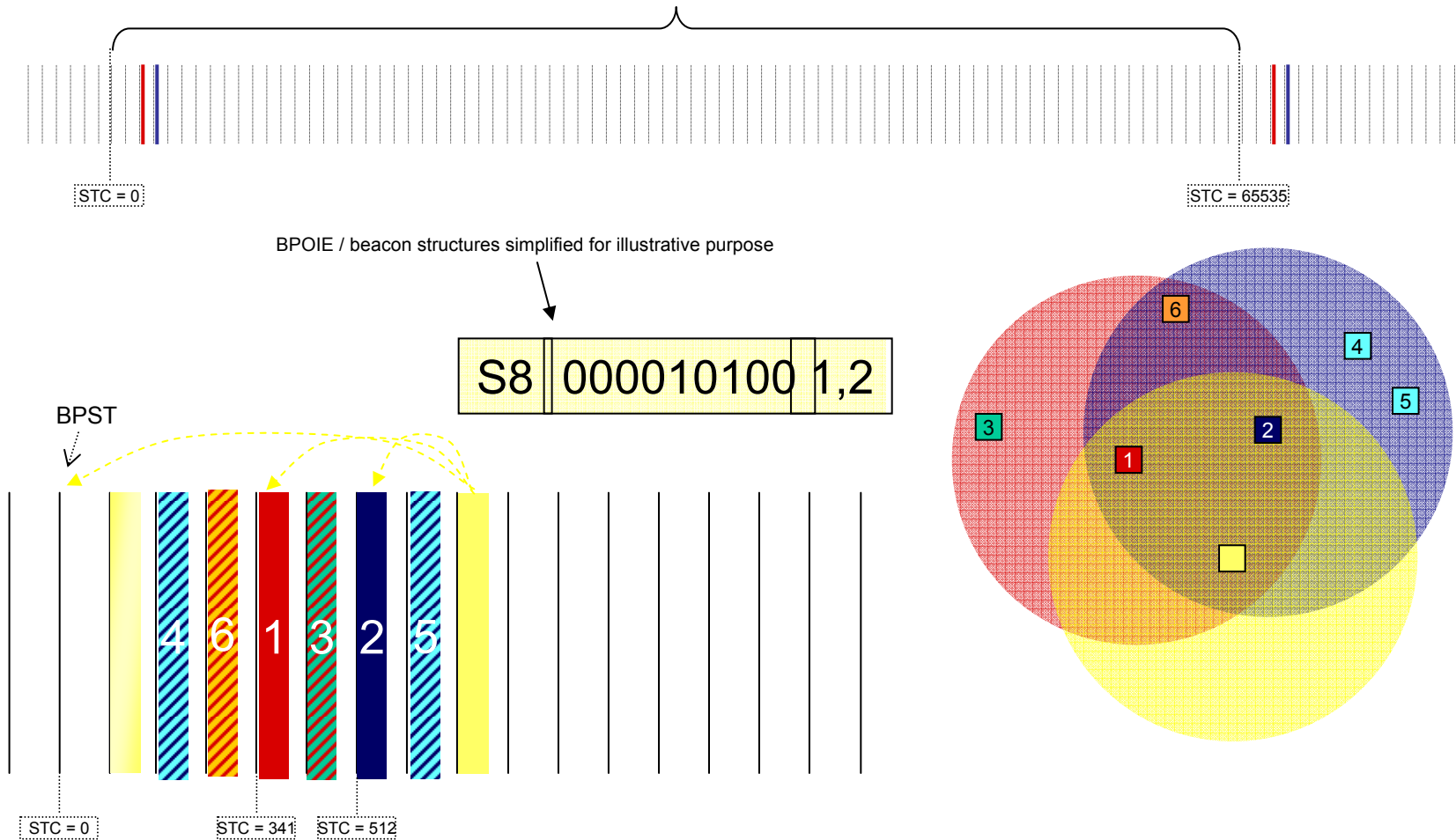


STC = 2098 STC = 2269

1 MAS



Example: Joining a Beacon Period



Descriptors



Offset	Field	Size	Value	Description
0	<i>bLength</i>	1	9	Size of this descriptor in bytes, including this field.
1	<i>bDescriptorType</i>	1	4	INTERFACE Descriptor Type
2	<i>bInterfaceNumber</i>	1	Number	Number of this interface
3	<i>bAlternateSetting</i>	1	0	Value used to select this alternate setting for the interface identified in the prior field
4	<i>bNumEndpoints</i>	1	1	Number of endpoints used by this interface.
5	<i>bInterfaceClass</i>	1	E0H	Wireless Controller
6	<i>bInterfaceSubclass</i>	1	01H	RF Controller
7	<i>bInterfaceProtocol</i>	1	02H	UWB Radio Control Interface
8	<i>iInterface</i>	1	Index	Index of String Descriptor describing this interface

← Interface

Offset	Field	Size	Value	Description
0	<i>bLength</i>	1	4	Size of this descriptor in bytes, including this field.
1	<i>bDescriptorType</i>	1	23H	Radio Control Descriptor Type
2	<i>bcdRCVersion</i>	2	0100H	Radio Control Interface Version number in Binary-Coded Decimal.

← Class

Offset	Field	Size	Value	Description
0	<i>bLength</i>	1	7	Size of this descriptor in bytes, including this field.
1	<i>bDescriptorType</i>	1	5	ENDPOINT Descriptor Type
2	<i>bEndpointAddress</i>	1	Number	The address of this endpoint
3	<i>bmAttributes</i>	1	Bitmap	Interrupt endpoint of 00000011b.
4	<i>wMaxPacketSize</i>	2	200H	Maximum packet size this endpoint
6	<i>bInterval</i>	1	1	Interval for polling endpoint for data transfers. Expressed in frames or microframes depending on the device operating speed (i.e., either 1 millisecond or 125 μs units).

← Endpoint