This document presents a functional specification for the IxWLAN SED configured with multiple radios. The original release of the SED featured a single radio; this will be increased to three radios to permit simultaneous operation on multiple channels or across 802.11 bands, synchronization with multiple APs (SUTs), more flexible roaming operation and more elaborate testing capabilities in general.

The term "wport" used in this document refers to a specific radio or WLAN interface device. The SED-MR+ uses a CM9 mini-PCI card based on the Atheros AR5213A chipset for each WLAN interface. The SED platform has a total of 4 mini-PCI slots available, one slot is occupied by a Cavium encryption processor card and the 3 other slots contain Wistron CM9 radios. Each radio can operate on a single channel and synchronize (join) with a single AP at a time.

The SED-MR+ will support both Transmit Power Control (TPC) and Dynamic Frequency Selection (DFS). TPC/DFS is being done under a separate task.

1.1 Marketing and Customer Requirements Summary

A summary of marketing requirements for multiple radio support:

- Provide the capability for more elaborate testing roaming operation.
- Allow simultaneous testing against multiple access points and/or multiple 802.11 channels from a single platform.

1.2 Engineering Requirements

The Engineering requirements are as follows:

- Implement support for multiple, independent 802.11 WLAN interfaces (i.e., wports).
- The WLAN interface is implemented on an Atheros AR5213A chipset-based mini-PCI card.
- The multiple wports may operate simultaneously on the same or different channels in the same or different 802.11 bands.
- The IxWLAN SED-MR+ unit taken as a whole should transmit a single ACK frame, when appropriate, in response to any 802.11 frame directed to a 'virtual station' (vSTA) in the unit.

1.3 General Characteristics

The following items describe the functional characteristics of the system in general with respect to this feature.

- The number of wports present in the unit will be determined at startup time. Wports will be referred to externally as wport1, wport2 and wport3.
- The factory default wireless mode for wport1 will be 802.11g if permitted by the current country code, else 802.11b. The factory default for wport2 (if present) will be 802.11b. The factory default for wport3 (if present) will be 802.11a if permitted, else 802.11g if permitted, else 802.11b.

- At startup time each wport will passively scan its configured wireless mode, in accordance with the system-wide bootscan setting.
- Each wport will have its own WLAN base MAC address and WLAN address mask.
- Each wport will be assigned a single BSSID against which it will operate at any given time. Multiple wports may be assigned the same BSSID. Following a Join, the wport will operate on the 802.11 channel on which its assigned BSSID, if present, is operating.
- Each wport will host a population of vSTAs (**v**irtual **STA**tions). A vSTA is assigned a wport and therefore its SUT BSSID. All vSTAs hosted by a given wport will interact with the AP identified by the BSSID assigned to that wport.
- The user may select one of two multi-radio operating modes: static and dynamic. The default will be static mode.
    - In the static mode: vSTAs are static to a given wport. Each wport must have a MAC address that is unique from other wports to the extent of each's WLAN mask. This may require a runtime override of the factory MAC assigned each wport at interface card manufacture time. Each vSTA should be configured with a MAC address that is consistent with that of its wport (the user is responsible for this).
    - In the dynamic mode: migration of vSTAs between wports is permitted, including roaming among the BSSIDs assigned to the wports or manual reassignment of vSTAs to wports by the user. Each vSTA should be configured with a MAC address that is consistent with that of the system (the user is responsible for this).
    - The multi-radio mode cannot be changed if any vSTAs are active (in state AUTH or higher).
- The CLI user will be allowed to specify the "current" wport. Subsequent wport-specific commands will apply to this wport as appropriate. Wport-specific commands are discussed below. At startup time the current wport will default to be wport1. The GUI will not require this approach; settings may be changed for any wport at any time in the GUI.
- Each wport will maintain its own list of BSSs it discovers in a scan. These will be merged into a single list for presentation to the user when in the dynamic multi-radio mode. In the static mode, only the BSS list for the current wport will be presented.
- Every CLI session has its own independent notion of the current wport. The current wport for a given CLI session will be indicated in its prompt.
- All persistent system settings (ie, those stored in the configuration file and restored upon reboot) which are now per-wport will be stored and restored on a per-wport basis.
- vSTAs will have an attribute: wport. This indicates the wport to which the vSTA is assigned. The vSTA will operate on that wport and against the BSSID which is assigned to the wport.

1.4 Support DFS and TPC & 802.11h

1.4.1 Spectrum Management Capability

There are two MIB objects that determine whether the STA will comply with the spectrum management (DFS and TPC) requirements of 802.11h: dot11SpectrumManagementImplemented and dot11SpectrumManagementRequired. The value of the former is a matter of the vSTA's capabilities as built; the value of the latter will be TRUE when the Spectrum Management bit is set in the Capability Information field in Beacons and Probe Responses received from the AP. If the AP requires Spectrum Management and the vSTA does not support it, the AP may fail Association Requests from the vSTA. IxWLAN will include the same parameters corresponding to information elements included in Beacon and Probe response frames in (re)association frames sent to the AP.

1.4.2 Transmit Power Control and Adaptation

1.4.2.1 Association with the AP

If an AP sets the Spectrum Management bit in the Capability Information field in Beacons and Probe Responses as indicated above, IxWLAN's vSTAs will provide the AP with its minimum and maximum transmit power capability for the current channel when associating or reassociating, using a Power Capability element in Association Request frames or Reassociation Request frames. Additionally, vSTA will also include Supported Channels Element in Association/Reassociation Request Frames.

1.4.2.2 Tx Power adaptation

IxWLAN will support dynamic adaptation of transmit power described below.

An AP supporting 802.11h will advertise the regulatory maximum transmit power for the current channel in Beacon frames and Probe Response frames using a Country element, as well as the local maximum transmit power for the current channel in Beacon frames and Probe Response frames using the combination of a Country element and a Power Constraint element.

With dynamic TPC implementation, IxWLAN will adjust the transmit power per radio based on the information contained in the Country and Power Constraint elements included in Beacon and Probe response frames. IxWLAN will dynamically adjust its output power to match corresponding information carried in beacons or probe response frames.

Additionally, to ensure all regulatory requirements are met, regardless of the power settiongs advertised by the AP, IxWLAN 11a channel tables have been scaled down by 3dB to meet all regulatory requirements for transmit power control. Dynamic power adaptation described above has only been put in place to "follow" the AP advertised maximum power. IxWLAN will take the lesser value of the two (local 3dB channel table adjusted value vs the AP advertised value).

1.4.3 Dynamic Frequency Selection

1.4.3.1 Association with the AP

If AP sets the Spectrum Management bit in the Capability Information field in Beacons and Probe Responses as indicated above, IxWLAN vSTAs will provide the AP with the list of channels in which they can operate in Supported Channels element included in Association and Reassociation request frames.

1.4.3.2 Channel Switch Scheduling and Execution

Once an AP detects presence of radar on a current operational channel, it will inform associated vSTAs that the AP is moving to a new channel and maintain the association by advertising the switch using Channel Switch Announcement elements in Beacon frames, Probe Response frames, and Channel Switch Announcement frames until the intended channel switch time.

IxWLAN vSTAs associated with the AP doing the channel switch will stop all transmissions until the channel switch takes place if the AP sets the Channel Switch Mode field in the Channel Switch Announcement element. Irrespective of the Mode field being set or not, transmission from all vSTAs will stop within the limit identified in ETSI and FCC DFS specifications. This value is known as the Channel Closing Transmission time and is set at 260ms for ETSI and same for FCC. Each IxWLAN vSta shall execute the above action within the above indicated timeframe, irrespective of other stations.

The actual move to a new channel indicated by the AP will take place once 1 or more vSTA(s) have received the above indication. Since the time limit is identified at 10s (both ETSI and FCC), there should be plenty of time for several if not all vSTAs to receive several beacons with the above indication. However since the AP does not require any form of protocol acknowledgement to CSA Action frames, channel switch execution shall be orchestrated as soon as the first vSTA receives such indication from the AP either via action frames, beacons or probe responses. In other words, there is no need for more than one vSTA to obtain such notification in order for channel switch execution to take place.

According to 802.11h specification, the above protocol between the AP and the client should create the necessary conditions for the channel switch to take place without the need for the AP to drop existing client associations. There is no "mandatory" language to this effect in the spec, hence behavior by each vendor's equipment may vary. Correspondingly, it will not be necessary for vSTAs to initiate a (re)association lifecycle upon channel switch execution. From the standpoint of 802.11h or FCC compliance, there is no requirement for any upper layer traffic flow to continue uninterrupted upon successful channel switch execution.

1.4.4 Support of Spectrum Management Action Frames

Aside from execution of DFS procedures based on a number of information elements communicated by an AP in beacons and probe responses, 802.11h specification also supports a notion of management action frames. IxWLAN will support the Channel Switch Announcement frame which uses the Action frame body format and is transmitted by an AP in a BSS to advertise a channel switch. Channel switch and execution is done per section 1.4.3.2 - Channel Switch Scheduling and Execution.

1.5 Active Scan Suppression

FCC, ETSI and TELEC specifications for DFS compliance mandate that a client device which is not capable of radar detection not initiate active scanning for frequency bands where DFS is required. IxWLAN will not initiatate active scanning on those 11a DFS restricted channels where no AP beacons with dot11spectrum management enabled bit set are seen.

IxWLAN will update the regulatory domain tables for indicating the channels that require passive scanning. This means that even is the user selects "active" scan mode, the channels which fall in regulatory domains will not be actively scanned.

1.6 Support of new U-NII band channels

IxWLAN shall support operation in the new U-NII bands in 5.47-5.725 GHz frequency range. This range includes the following channels: 5500, 5520, 5540, 5560, 5580, 5600, 5620, 5640, 5660, 5680, 5700.

Note that IxWLAN shall only enable use of the above channels in regulatory domains where they are allowed. Currently those bands are open for operation in the US, Canada and Europe.

1.7 Performance and Related Metrics

IxWLAN will support a number of metrics for DFS performance related to channel switching and stopping traffic. Statistics counters are maintained on per vSTA and per WPORT level. On a per-vSTA basis, the number of transmit dropped frames is maintained during Channel Switch events. The cumulative dropped frame count is added up in vSTA master stats. WPORT stats

will also show dropped frame count for itself, channel move and transmission closing time for the last CSA event, as well as maintain the total count of all channel switches since last power-on or reboot.

Note that CSA counters both per WPORT and per VSTA will only be displayed when there has been at least one Channel Switch Announcement event since last reboot.

The system will maintain the following DFS-related metrics:

- Channel Move time – total time to move to a new channel upon receiving an indication from the AP. One value is recorded per each radio/WLAN module.
- Transmission Closing Time – Time to stop all transmissions on the vstas associated with the AP which sent the channel move indication. The system will log the following events with records in the event log.
- Frames dropped – number of frames dropped during either channel move. Data frames received on the wired interface for a VSTA in external mode, or generated for a vSTA in internal mode, during channel move will be dropped and this counter will be incremented. Maintained per vsta and cumulatively.

1.8 Radio Specifications

Frequency Range :	**USA:** 2.400 – 2.483GHz, 5.15 ~ 5.35Ghz, 5.725 ~ 5.825Ghz **Europe:** 2.400 – 2.483GHz, 5.15~ 5.35 Ghz, 5.47 ~ 5.725Ghz **Japan:** 2.400 – 2.483GHz, 4.90 – 5.091GHz, 5.15 – 5.25GHz **China:** 2.400 – 2.483GHz, 5.725 ~ 5.85 Ghz
Modulation Technique:	**802.11a** OFDM (BPSK,QPSK, 16-QAM, 64-QAM) **802.11b/g** DSSS (DBPSK, DQPSK, CCK) OFDM (BPSK, QPSK, 16-QAM, 64-QAM)
Channels Supported:	**802.11a** US/Canada: 12 non-overlapping channels (5.15 ~ 5.35GHz, 5.725 ~ 5.825GHz) Europe: 19 non-overlapping channel (5.15 ~ 5.35GHz, 5.47 ~ 5.725GHz) Japan: 4 non-overlapping channels (5.15 ~ 5.25GHz) China: 5 non-overlapping channels (5.725 ~ 5.85GHz) **802.11b/g** US/Canada: 11 (1 ~ 11) Major European country: 13 (1 ~ 13) France: 4 (10 ~ 13) Japan: 11b: 14 (1~13 or 14th), 11g: 13 (1 ~ 13) China: 13 (1 ~ 13)
Security :	64-bit,128-bit, 152-bit WEP Encryption 802.1x Authentication AES-CCM & TKIP Encryption
FCC ID:	Modular Radio FCC ID: NKRCM9

Note: The radio will operate in 802.11a or 802.11b/g mode, but not both at the same time