CAPWAP Extension for 802.11n and Power/channel Reconfiguration
draft-ietf-opsawg-capwap-extension-01

Abstract

CAPWAP binding for 802.11 is specified by RFC5416 and it was based on
IEEE 802-11.2007 standard. After RFC5416 was published in 2009,
there was several new amendment of 802.11 has been published.
802.11n is one of those amendment and it has been widely used in real
deployment. This document extends the CAPWAP binding for 802.11 to
support 802.11n and also defines a power and channel auto
configuration extension.

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1. Introduction

IEEE 802.11n standard was published in 2009 and it is an amendment to the IEEE 802.11-2007 standard to improve network throughput. The maximum data rate increases to 600Mbit/s physical throughput rate. In the physical layer, 802.11n use OFDM and MIMO to achieve the high throughput. 802.11n use multiple antennas to form antenna array which can be dynamically adjusted to improve the signal strength and extend the coverage.

There are couple of capabilities of 802.11n need to be supported by CAPWAP control message such as radio capability, radio configuration and station information.

2. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL","SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

3. CAPWAP 802.11n support
The IEEE-802.11-2009 standard was published in 2009 and it is an amendment of the IEEE 802.11-2007 standard to improve throughput. The maximum data rate increases to 600Mbit/s physical throughput rate. In the physical layer, 802.11n use OFDM and MIMO to achieve the high throughput. 802.11n use multiple antennas to form antenna array which can be dynamically adjusted to improve the signal strength and extend the coverage.

802.11n support three modes of channel usage: 20MHz mode, 40MHz mode and mixed mode. 802.11n has a new feature called channel binding. It can bind two adjacent 20MHz channel to one 40MHz channel to improve the throughput. If using 40MHz channel configuration there will be only one non-overlapping channel in 2.4GHz. In the large scale deployment scenario, operator need to use 20MHz channel configuration in 2.4GHz to allow more non-overlapping channels.

In MAC layer, a new feature of 802.11n is Short Guard Interval (GI). 802.11a/g use 800ns guard interval between the adjacent information symbols. In 802.11n, the GI can be configured to 400ns under good wireless condition.

Another feature in 802.11 MAC layer is Block ACK. 802.11n can use one ACK frame to acknowledge several MPDU receiving event.

CAPWAP need to be extended to support the above new 802.11n features. For example, CAPWAP should allow the access controller to know the supported 802.11n features and the access controller should be able to configure the different channel binding modes. This document defines extension of the CAPWAP 802.11 binding to support 802.11n features.

4. CAPWAP extension for 802.11n support

There are three 802.11n features need to be supported by CAPWAP 802.11 binding: 802.11n radio capability, 802.11n radio configuration and station information. This section defines the extension of current CAPWAP 802.11 binding to support 802.11n features.

4.1. 802.11n Radio Capability Message Element

[RFC5416] defines IEEE 802.11 binding for CAPWAP protocol. It defines IEEE 802.11 Information Element which is used to communicate any IE defined in IEEE 802.11 protocol. This document defines 802.11n radio capability information element which is composed of the IEEE 802.11 Information Element header that defined in section 6.6 of [RFC5416] and the IEEE 802.11 HT information element that defined in section 8.4.2.58 of [IEEE-802.11.2012]. The HT IE is carried by the IEEE 802.11 information element that defined in section 6.6 of
[RFC5416] to form the 802.11n radio capability message element. 802.11n Radio Capability message element may be included in the CAPWAP Configuration Status Request/Response messages.

4.2. 802.11n Radio Configuration Message Element

The 802.11n Radio Configuration Information Element message element is used by the AC to configure a Radio on the WTP, and by the WTP to deliver its radio configuration to the AC. The 802.11n Radio Configuration Information Element is defined in figure 1. 802.11n Radio Configuration message element may be included in the CAPWAP Configuration Update Request message.

```
+---------------------------------+-----------------+-----------------+-----------------+-----------------+
<p>|  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 | 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 | 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 |
|---------------------------------------------|-----------------|-----------------|-----------------|
| | Radio ID |S|P|N|G|B|     |    MaxSup MCS | Max MandMCS   |
|---------------------------------------------|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th></th>
<th>TxAntenna</th>
<th>RxAntenna</th>
<th>Reserved</th>
</tr>
</thead>
</table>

Figure 1: 802.11n Radio Configuration Message Element

Type: TBD for 802.11n Radio Configuration Message Element.

Length: 16.

S bit: A-MSDU Cfg: Set to 0 if disabled. Set to 1 if enabled.

P bit: A-MPDU Cfg: Set to 0 if disabled. Set to 1 if enabled.

N bit: 11N Only Cfg: Whether allow only 11n user access. Set to 0 if allow non-802.11n user access. Set to 1 if do not allow non-802.11n user access.

G bit: Short GI Cfg: Set to 0 if disabled. Set to 1 if enabled.

B bit: Bandwidth Cfg: Bandwidth binding mode. Set to 0 if 40MHz binding mode. Set to 1 if 20MHz binding mode.

Max Support MCS: Maximal MCS.

Max Mandatory MCS: Maximal mandatory MCS.

TxAntenna: Transmitting antenna configuration. Each TxAntenna bit represent one antenna, set to 1 if enabled, set to 0 if disabled.
RxAntenna: Receiving antenna configuration. Each RxAntenna bit represent one antenna, set to 1 if enabled, set to 0 if disabled.

### 4.3. 802.11n Station Information

The 802.11n Station Information message element is used to deliver IEEE 802.11n station policy from the AC to the WTP. The definition of the 802.11n Station Information message element is in figure 2. 802.11n Station Information may be included in the CAPWAP Station Configuration Request message.

<table>
<thead>
<tr>
<th>MAC Address</th>
<th>S</th>
<th>P</th>
<th>T</th>
<th>F</th>
<th>H</th>
<th>M</th>
<th>Max RxFactor</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAC Address</td>
<td>S</td>
<td>P</td>
<td>T</td>
<td>F</td>
<td>H</td>
<td>M</td>
<td>Max RxFactor</td>
</tr>
<tr>
<td>Min StaSpacing</td>
<td>HiSuppDataRate</td>
<td>AMPDUBufSize</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AMPDUBufSize</td>
<td>HtcSupp</td>
<td>MCS Set</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCS Set</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: 802.11n Station Information

Type: TBD for 802.11 Station Information.

Length: 29.

- **S bit**: SupChanl width: Supporting bandwidth mode. 0x00: 20MHz bandwidth mode. 0x01: 40MHz bandwidth binding mode.
- **P flag**: Power Save: 0x00: Static power saving mode. 0x01: Dynamic power saving mode. 0x03: Do not support power saving mode.
- **T bit**: ShortGi20: Whether support short GI in 20MHz bandwidth mode. 0x00: Do not support short GI. 0x01: Support short GI.
- **F bit**: ShortGi40: Whether support short GI in 40MHz bandwidth mode. 0x00: Do not support short GI. 0x01: Support short GI.
H bit: HtDelyBlkack: Whether block Ack support delay mode. 0x00: Do not support delay mode. 0x01: Support delay mode.

M bit: Max Amsdu: The maximal AMSDU length. 0x00: 3839 bytes. 0x01: 7935 bytes.

Max RxFactor: The maximal receiving AMPDU factor.

Min StaSpacing: Minimum MPDU Start Spacing.

HiSuppDataRate: Maximal transmission speed.

AMPDUBufSize: AMPDU buffer size.

HtcSupp: Whether the packet have HT header.

MCS Set: The MCS bitmap that the station supports.

5. Power and Channel auto reconfiguration

Power and channel auto reconfiguration could avoid potential radio interference and improve the WLAN performance. In general, the auto-configuration of radio power and channel could occur at two stages: when the WTP power on or during the WTP running time.

When the WTP is power-on, it is of necessity to configure a proper channel to the WTP in order to achieve best status of radio links. IEEE 802.11 Direct Sequence Control elements or IEEE 802.11 OFDM Control element defined in RFC5416 should be carried to offer WTP a channel at this stage. Those element should be carried in the Configure Status Response message. If those information element is zero, the WTP will determine its channel by itself, otherwise the WTP should be configured according to the provided information element.

When the WTP determines its own channel configuration, it should first scan the channel information, then determine which channel it will work on and form a channel quality scan report. The channel quality report will be sent to the AC using WTP Event Request message by the WTP. The AC can use IEEE 802.11 Direct Sequence Control or IEEE 802.11 OFDM Control information element carried by the configure Update Request message to configure a new channel for the WTP.

IEEE 802.11 Tx Power information element is used by the AC to control the transmission power of the WTP. The 802.11 Tx Power information element is carried in the Configure Status Response message during the power on phase or in the Configure Update Request message during the running phase.
Channel Scan Procedure.

The Channel Scan Procedure is illustrated by the figure 3.

![Diagram of Channel Scan Procedure]

5.1. Scan Parameter Message Element

The definition of the Scan Para Message Element is as follows:

```
+-------------------------------+-------------------------------+
| Radio ID                     | Report Time                   |
| PrimeChlsrvTime              | On Channel ScanTime           |
| Off Channel ScanTime         |                               |
```

Figure 4: Scan Parameter Message Element

Type: TBD for Scan Parameter Message Element.

Length: 18.

Radio ID: An 8-bit value representing the radio, whose value is between one (1) and 31.
M bit: AP oper mode: the work mode of the WTP. 0x01: normal mode. 0x02: monitor only mode.

S bit: Scan Type: 0x01: active scan; 0x02: passive scan.


Report Time: Channel quality report time.

PrimeChlSrvTime: Service time on the working scan channel. This segment is invalid (set to 0) when WTP oper mode is set to 2. The maximum value of this segment is 10000, the minimum value of this segment is 5000, the default value is 5000.

On Channel ScanTime: The scan time of the working channel. When the WTP oper mode is set to 2, this segment is invalid (set to 0). The maximum value of this segment is 120, the minimum value of this segment is 60, the default value is 60.

5.2. Channel Bind Message Element

The definition of the Channel Bind Message EElement is as follows:

```
0                   1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Radio ID    |   Max Cycles  |Channel Count  |ScanChannelSet.|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: Channel Bind Message Element

Type: TBD for Channel Bind Message Element.

Length >= 12.

Flag: bitmap, reserved.

Max Cycles: Scan repeat times. 255 means continuous scan.

Channel Count: The number of channel will be scanned.

Scan Channel Set: The channel information. The format is as follows:
Figure 6: Channel Information Format

Channel ID: the channel ID of the channel which will be scanned.

Flag: Bitmap, reserved for future use.

The channel scan procedure:

The WTP has two work mode: the first one is normal mode. In this mode, the WTP can provide service for the STA access and scan the channel at the same time. Whether the WTP will scan the channel is determined by the Max Cycles segment in the Channel Bind TLV. When this segment is set to 0, the WTP will not scan the channel. If this segment is set to 255, the WTP will continuous scan the channel. The type of the scan is determined by the Scan Type segment. In the passive scan type, the WTP monitor the air interface, based on the received beacon frame to determine the nearby WTPs. In the active scan type, the WTP will send probe message and receive the probe response message. In the normal scan mode, the WTP will use 3 parameters: PrimeChlSrvTime, OnChannelScanTIme, OffChannelScnTIme. The WTP will provide access service for the STAs for PrimeChlSrvTime duration and then start to scan the channel for On Channel ScnTime duration. Back to the working channel, provide STA access service for PrimeChlSrvTime, then leave the working channel, start to scan the next channel for Off Channel ScanTime duration. This process will be repeated until all the channel is scanned.

When the WTP work in the scan only mode, there is no difference between the working channel and scan channel. Every channel’s scan duration will be OffChannelScnTIme and the PrimeChlSrvTime and OnChannelScanTime is set to 0.

Scan Report. The WTP send the scan report to the AC through WTP Event Request message. The information element that used to carry the scan report is Channel Scan Report Message Element and Neighbor WTP Report Message Element.

5.3. Channel Scan Report
The definition of the Channel Scan Report Message Element is in figure 7.

0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Radio ID     | Report Count    |    Channel Scan Report       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

Figure 7: Channel Scan Report Message Element

Type: TBD for Channel Scan Report Message Element.

Length: >=29.

Report Count: The channel number will be reported.

Channel Scan Report: The definition of the Channel Scan Report is in figure 8. It complies with the IEEE 802.11 Beacon report that defined in section 8.4.2.24.7 of [IEEE-802.11.2012].

0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Operating Class|Channel Number |Actual Measurement Start Time..|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|...Actual Measurement Start Time       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|..Actual Measurement Start Time| Measurement Duration |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Reported Frame | RCPI | BSSID... |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|...BSSID |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Antena ID | Parent TSF... |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|...Parent TSF | Optional Subelements(variable) |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
Operating Class: Indicates the channel set for which the measurement request applies. Country. The definition of this field complies with the definition in section 8.4.2.24.7 of [IEEE-802.11.2012].

Channel Number: Indicates the channel number for which the measurement report applies. The definition of this field complies with the definition in section 8.4.2.24.7 of [IEEE-802.11.2012].

Actual Measurement Start Time: Is set to the value of the measuring STA’s TSF timer at the time the measurement started.

Measurement Duration: Is set to the duration over which the Beacon Report was measured. The definition of this field complies with the definition in section 8.4.2.24.7 of [IEEE-802.11.2012].

Reported Frame Information: This field contains two subfields as defined in [IEEE-802.11.2012].

RCPI: Indicates the received channel power of the Beacon, Measurement Pilot, or Probe Response frame.

RSNI: Indicates the received signal to noise indication for the Beacon, Measurement Pilot, or Probe Response frame.

BSSID: This field contains the BSSID from the Beacon, Measurement Pilot, or Probe Response frame being reported.

Antenna ID: This field contains the identifying number for the antennas used for this measurement.

Parent TSF: This field contains the lower 4 octets of the measuring STA’s TSF timer value at the start of reception of the first octet of the timestamp field of the reported Beacon, Measurement Pilot, or Probe Response frame at the time the Beacon frame being reported was received.

Optional Subelements: This field contains zero or more subelements.

5.4. Neighbor WTP Report

The neighbor WTP report message element is composed of the IEEE 802.11 Information Element that defined in section 6.6 of [RFC5416] and IEEE 802.11 Neighbor Report Element that defined in section 8.4.2.39 of [IEEE-802.11.2012]. The Neighbor Report Element is carried by the IEEE 802.11 Information Element to form the neighbor WTP report message element.
6. Security Considerations

This document is based on RFC5415/RFC5416 and it doesn’t increase any security risk. The security considerations of this document aligns with RFC5415/5416.

7. IANA Considerations

The extension defined in this document need to extend CAPWAP IEEE 802.11 binding message element which is defined in section 6 of [RFC5416]. The following IEEE 802.11 specific message element type need to be defined by IANA.

802.11n Radio Configuration Message Element type value described in section 4.2.

802.11n Station Message Element type value described in section 4.3.
Scan Parameter Message Element type value described in section 5.1.
Channel Bind Message Element type value described in section 5.2.
Channel Scan Report Message Element type value described in section 5.3.

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