IEEE P802.11
Wireless LANs

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| Unified SR textDSC, ATPC and inter-BSS |
| `Date: 2016 -08  |
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Abstract

This document contains the proposed text for 11ax Draft with respect to dynamic sensitivity control (DSC) and adaptive transmit power control (ATPC)

**CIDS addressed by this resolution include:**

**69, 187, 188, 208, 209, 225, 257, 463, 464, 651, 703, 704, 953, 994, 1016, 2332, 2336, 2912, 2724, 2742**

This document provides the text for DSC and Adaptive Transmit Power Control

**CID 166**

**Suggested changes for DSC to 802.11 Standard**

**BACKGROUND STUFF**

**Add to Section 3.4**

“ATPC adaptive transmit power control”

“DSC dynamic sensitivity control”

**9.4.2.27 Extended Capabilities element**

Add to Table 9-134 Extended Capabilities field

|  |  |  |
| --- | --- | --- |
| Bit | Information | Notes |
| TBD | Dynamic Sensitivity Control (DSC) | STA sets DSC field to 1 when dot11DynamicSensitivityControlImplemented is true and sets it to 0 otherwise. |

|  |  |  |
| --- | --- | --- |
| Bit | Information | Notes |
| TBD | Adaptive Transmit Power Control (ATPC) | STA sets ATPC field to 1 when dot11AdaptiveTransmitPowerControlImplemented is true and sets it to 0 otherwise. |

**Add to 9.4.2**

**9.4.2.X DSC/ATPC Parameter Set element**

The DSC/ATPC Parameter Set element provides information for operation of dynamic sensitivity control and adaptive transmit power control that is used for spatial reuse.

The format of the DSC/ATPC Parameter Set element is defined in Figure 9-xxx.

The Element ID and Length fields are defined in 9.4.2.1 (General).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Element ID 255 | Length | Element ID Extension | DSC Margin | DSC Upper Limit | ATPCCCA Max | ATPCCCA Min |

Octets 1 1 1 1 1 1 1

 **Figure 9-xxx – DSC/ATPC Parameter Set element**

For an infrastructure BSS, the DSC/ATPC Parameter Set element is used by an HE AP to establish effective CCA threshold and transmit power policy, to change policy when accepting new non-AP STAs, or to adapt to changing environmental or traffic loading conditions. Dynamic sensitivity control procedures are described in 25.9.4. Adaptive transmit power control procedures are described in 25.9.5.

The DSC Margin field is one octet in length and indicates the value of the DSC Margin, in dBs, that shall be used by HE non-AP STAs associated to an HE AP that is advertising the DSC/ATPC Parameter element.

The DSC Upper Limit field is one octet in length and indicates the value of the DSC Upper Limit in dBs below 0 dBm, that shall be used by HE non-AP STAs associated to the HE AP that is advertising the DSC/ATPC Parameter element. For example, a DSC Upper Limit field value of 40 indicates a DSC Upper Limit of -40 dBm.

Setting the values of both the DSC Margin and the DSC Upper Limit fields to zero indicates that DSC operation is prohibited for HE non-AP STAs associated to that AP.

The ATPC CCA Max field is one octet in length and indicates the maximum value of the effective CCA threshold, in dBs below 0 dBm, that shall be used by HE non-AP STAs associated to the HE AP that is advertising the DSC/ATPC Parameter Set element.

The ATPC CCA Min field is one octet in length and indicates the minimum value of the effective CCA threshold in dBs below 0 dBm, that shall be used by HE non-AP STAs associated to an HE AP that is advertising the DSC/ATPC Parameter Set element.

Setting the values of both the ATPC CCA Max and ATPC CCA Min fields to zero indicates that ATPC operation is prohibited for HE non-AP STAs associated to that AP.

**25.9.2 Color code based CCA rules**

**Make changes as shown**

If the the receiving HE STA uses a OBSS PD level that is greater than the minimum receiver(#2334) sensitivity level, it STA(#2331) should regard an inter-BSS PPDU with a valid PHY header and that has receiving power/RSSI below the OBSS PD level as not having been received at all (e.g., should not update its NAV), except that the medium condition shall indicate BUSY during the period of time that is taken by the receiving STA to validate that the PPDU is inter-BSS(#1580), but not longer than the time indicated as the length of the PPDU payload. The OBSS PD level may be set to equal to the effective CCA level, see 25.9.3.1.2.

**Change 25.9.3 to read as below**

**25.9.3 Adaptive CCA and Transmit Power Control**

**25.9.3.1 Dynamic Sensitivity Control**

An HE STA may use DSC procedures.

An HE STA indicates its support of Dynamic Sensitivity Control (DSC) procedures by setting dot11DynamicSensitivityControlImplemented to true and setting the Dynamic Sensitivity Control bit in the Extended Capabilities field to 1. An HE STA that is using DSC procedures is a DSC STA.

In an infrastructure network, a DSC AP may include the DSC/ATPC Parameter element, as defined in 9.4.2.X, in beacons and probe responses. A DSC AP may advertise the values for DSC Margin and DSC Upper Limit in the DSC/ATPC Parameter Set element. In this case, an associated DSC non-AP STA shall set its values of dot11DSCMargin and dot11DSCUpperLimit equal to the respective advertised values in the DSC Parameter element.

A DSP AP may set an effective CS/CCA threshold for itself so as to be compatible with the DSC Margin and DSC Upper Limit values advertised in its DSC Parameter element. Recommended procedures for DSC AP settings of DSC Margin, DSC Upper Limit and CCA threshold values are given in Annex (TBA).

A DSC non-AP STA that is associated to a DSC AP shall set its effective CS/CCA threshold, CCAeff, as per equation 25-1:

 CCAeff = MIN (Upper Limit, RSSI beacon ) – Margin 25-1

Where,

Upper Limit is the value of dotDSCUpper Limit,

Margin is the value of dot11DSCMargin, and

RSSIbeacon is the received signal strength of the beacon transmitted by the DSC AP

NOTE: It is recommended that the value of RSSIbeacon is a value averaged over several beacons as described in Annex TBA.

The effective CCA threshold is valid for any 20 MHz channel and is increased by 3 dB for 40 MHz channels, 6 dB for 80 MHz channels and 9 dB for 160 MHz channels.

A DSC AP may indicate that DSC procedures are prohibited by setting both the DSC Margin and DSC Upper Limit fields in the DSC Parameter element to 0. In this case a DSC non-AP STA associated to that AP shall not use DSC procedures.

If a DSC non-AP STA is associated to an AP that does not include the DSC Parameters element in its beacons, then the DSC STA may still use DSC procedures with the DSC Margin value set to a minimum of 20 dB, and the DSC Upper Limit set to a maximum of -40 dBm in the 2.4GHz band and -30dBm in the 5GHz band.

**25.9.3.1.1 DSC Procedures for a non-AP STA**

In an infrastructure network, a DSC non-AP STA monitors the beacons transmitted by the AP to which it is associated and measures the received signal strength of the beacons. The received signal strength of beacon frames may be time averaged over recent history by a vendor-specific smoothing function. The value of dot11DSCMargin is then subtracted from the time averaged received signal strength of the beacons to provide an interim effective CS/CCA threshold value, using the formula shown in equation 25-1.

The effective CS/CCA threshold based upon the time averaged received signal strength of the beacons, dot11DSCMargin and dot11DSCUpperLimit is valid for any 20 MHz channel. The effective CS/CCA threshold is increased by 3 dB for 40 MHz channels, 6 dB for 80 MHz channels and 9 dB for 160 MHz channels.

Annex TBA describes recommended practice for DSC procedures.

**25.9.3.1.2 DSC, and inter-BSS OBSS PD**

The effective CS/CCA threshold, as derived using the DSC procedures may be used to only apply to inter-BSS frames as defined in 25.9.2 and not to intra-BSS frames. In this case, the OBSS PD level is set to be equal to the effective CS/CCA threshold value. The fixed CS/CCA thresholds shall apply to the intra-BSS frames.

**25.9.3.2 Adaptive Transmit Power Control**

An HE STA may use ATPC procedures together with DSC procedures and inter-BSS procedures. An ATPC STA is also a DSC STA.

An HE STA indicates its support of Adaptive Transmit Power Control (ATPC) procedures by setting dot11AdaptiveTransmitPowerControlImplemented to true and setting the Adaptive Transmit Power Control bit in the Extended Capabilities field to 1. An HE STA that is using ATPC procedures is an ATPC STA.

In an infrastructure network, an ATPC AP may include the DSC/ATPC Parameter element, as defined in 9.4.2.X, in beacons and probe responses. An ATPC AP may advertise non-zero values for ATPC CCA Max and ATPC CCA Min in the DSC/ATPC Parameter Set element. In this case, the AP must also advertise non-zero values for DSC Margin and DSC Upper Limit. An associated ATPC non-AP STA shall set its values of dot11ATPCCCAMax and dot11ATPCCCAMin equal to the respective advertised values in the DSC/ATPC Parameter element.

An ATPC AP may set dot11ATPCCCAMax and dot11ATPCCCAMin for itself to be the same as the ATPC CCA Max and ATPC CCA Min values advertised in its DSC/ATPC Parameter element, or may choose other values.

An ATPC STA adjusts its transmit power adaptively with its effective CS/CCA threshold based so as to satisfy the adjustment rules as shown in equation 25-2.

$CCAeff=max\left\{\begin{matrix}CCA\_{min}\\min\left\{\begin{matrix}CCA\_{max}\\CCA\_{min}+(TX\\_PWR\_{ref}-TX\\_PWR)\end{matrix}\right.\end{matrix}\right.$ 25-2

Where,

TX\_PWRref is set to 21 dBm for non-AP STAs or AP STAs with 1 and 2 spatial streams

TX\_PWRref is set to 25 dBm for AP STAs of 3 spatial streams or more.

CCAmax is the value of dot11ATPCCCAMax

CCAmin is the value of dot11ATPCCCAMin

If the transmit bandwidth differs from 20MHz, both CCAmax and CCAmin shall be adjusted based on the following formulas:

$CCA\_{max}= CCA\_{max} (20MHz)+10∙log\left(\frac{Bandwidth}{20MHz}\right)$ 25-3

$CCA\_{min}= CCA\_{min} (20MHz)+10∙log\left(\frac{Bandwidth}{20MHz}\right)$ 25-4

If an ATPC non-AP STA is associated to an AP that does not include the DSC/ATPC Parameters element in its beacons or probe responses, then the ATPC STA may use DSC and ATPC procedures with the CCAmax (20 MHz) value set to -82dBm and the CCAmin (20 MHz) value set to -62dBm.

**In C.3 MIB Detail**

**ADD to “dot11StationConfig TABLE”**

Dot11StationConfigEntry : : = SEQUENCE

 Dot11DynamicSensitivityControlImplemented TruthValue

 Dot11 AdaptiveTransmitPowerControlImplemented TruthValue

**ADD to SA Query Procedure MIBs**

dot11DynamicSensitivityControlImplemented OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This attribute, when true, indicates that the STA implementation is capable

of supporting Dynamic Sensitivity Control."

DEFVAL { false }

::= { dot11StationConfigEntry TBA }

dot11DSCMargin OBJECT-TYPE

SYNTAX Unsigned32 (1..100)

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"This attribute indicates the value, in dBs, of the DSC Margin that a DSC STA adds to the received signal strength of Beacon frames received on the channel. The received signal strength of Beacon frames may be time averaged over recent history by a vendor-specific smoothing function.”

DEFVAL { 20 }

::= { dot11StationConfigEntry TBA }

dot11DSCUpperLimitLimit OBJECT-TYPE

SYNTAX Unsigned32 (1.. 100)

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"This attribute indicates the value, in dBs below 0dBm, of the DSC Upper Limit for a DSC STA. For example, a value of 40 indicates a DSC Upper Limit of -40dBm.”

DEFVAL { 40 }

::= { dot11StationConfigEntry TBA }

dot11AdaptiveTransmitPowerControlImplemented OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This attribute, when true, indicates that the STA implementation is capable

of supporting Adaptive Transmit Power Control."

DEFVAL { false }

::= { dot11StationConfigEntry TBA }

dot11TPCCCAMax OBJECT-TYPE

SYNTAX Unsigned32 (1..100)

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"This attribute indicates the value, in dBs below 0dBm, of ATPC CCA Max for an ATPC STA. For example, a value of 62 indicates a CCA Max of -62dBm.”

DEFVAL { 62 }

::= { dot11StationConfigEntry TBA }

dot11ATPCCCAMin OBJECT-TYPE

SYNTAX Unsigned32 (1.. 100)

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"This attribute indicates the value, in dBs below 0dBm, of ATPC CCA Min for an ATPC STA. For example, a value of -82 indicates a DSC Upper Limit of -82dBm.”

DEFVAL { 82 }

::= { dot11StationConfigEntry TBA }

**ADD NEW ANNEX**

**ANNEX TBA**

(informative)

**Spatial Reuse Procedures**

**TBA.1 Dynamic Sensitivity Control**

When dot11DynamicReceiveSensitivityImplemented is true, the STA is a DSC STA. A DSC STA sets the DSC Supported bit to 1 in the Extended Capabilities field.

Dynamic Sensitivity Control (DSC) procedures may be used to control the effective carrier sense/clear channel assessment (CS/CCA) mechanism threshold or the receive sensitivity of a DSC STA in order to improve the efficiency of an infrastructure network. A DSC non-AP STA may use DSC procedures unless the DSC Margin and DSC Upper Limit fields in the DSC Parameter set element are both set to 0 by the AP to which the non-AP DSC STA is associated, in which case the STA sets dot11DynamicReceiveSensitivityImplemented to false.

**TBA.1.1 DSC Operation for non-AP DSC STA**

**TBA.1.1.1 Basic Operation**

There are two settings used in DSC: DSC Upper Limit and DSC Margin. In general the non-AP DSC STA measures the average signal strength of the received beacon and then subtracts the DSC Margin to arrive at the effective value for the CCA threshold. For example, if the averaged signal strength of the beacon is -45 dBm and the DSC Margin is set to 20 dB, the effective CCA threshold is set to -45 -20 = -65 dBm. If the STA is very close to its AP, say a few feet, then the received beacon signal strength could be relatively high and the effective CCA threshold would be set to a level representing a limited range with the result that other stations in the same network could be ‘hidden’ and the network efficiency would suffer. The DSC Upper Limit sets the maximum value for the received signal strength of the beacon and this effectively sets the maximum CCA threshold at a value given by DSC Upper Limit minus DSC Margin. For example, if the DSC Upper Limit is -30 dBm and the DSC Margin is 20 dB, then the maximum value for the CCA threshold is -50 dBm. Hence, by setting the DSC Upper Limit and DSC Margin it is possible to set an effective network coverage area such that all stations in the network will contend.

If the AP to which the STA is associated is transmitting the DSC Parameter element, the STA uses the values for Upper Limit and Margin that are included in the DSC Parameter element. In the case that the AP is not a DSC AP or does not transmit a DSC Parameter element, then the DSC non-AP STA may set values for the DSC Upper Limit and DSC Margin within the limitations given in 25.9.3.1.

As the beacon is transmitting in a 20 MHz channel, the effective CCA threshold calculated using the DSC Margin and DSC Upper Limit is also valid for a 20 MHz channel. The effective CCA threshold would be 3 dB, 6 dB and 9 dB higher for channel bandwidths of 40 MHz, 80, MHz and 160 MHz respectively.

**TBA.1.2 Determining Beacon Signal Strength value**

It is recommended that the received signal strength of the beacon frames be averaged over time. The received signal strength may be calculated using a variety of averaging methods but a recommended method is to use a moving average so that the average signal strength value is more influenced by the latest reading than previous ones. It is further suggested that the time to update the average received signal strength value is in the order of one second so as to account for sudden variations due to obstructions or movement.

It is relatively common to miss a certain number of Beacons especially if the STA is in Power Save mode where the STA may deliberately sleep through a number of beacons. The averaging and the update time for determining the received signal strength value may need to be adjusted to account for this.

**TBA.1.2.1 DSC operational algorithm**

A sample DSC operational algorithm is shown in Figure TBA – 1. In this example the following parameter settings might be used:

* BeaconCountLimit: the limit of consecutive missed beacons. When exceeded the averaged signal strength of the beacon, AverageRSSI, is decremented by a value of RSSI\_Decrement. An example default value is 3.
* UpdatePeriod: the period over which the received beacon signals are averaged. An example default value is 1 second.
* RSSI\_Decrement: the value, in dBs, that the existing averaged beacon signal strength, Average RSSI, is decreased by if the BeaconCountLimit is reached. An example default value is 6 dB.
* Min\_RX\_Sensitivity: the minimum value for receiver sensitivity threshold, set to a value that corresponds to RX sensitivity for the STA if it was not using DSC. An example default value is -92 dBm.



**Figure TBA – 1 – Sample DSC Operational Algorithm**

**TBA.1.3 DSC Operation for DSC AP**

A DSC AP may transmit the DSC Parameter element in beacons and probe responses in order to set the values for DSC Margin and DSC Upper Limit in all associated DSC STA within the limitations given in 25.9.3.1. A variety of methods could be used for the AP to determine these values, either by pre-setting them based upon the location and environment of the network, or by a learning process. For example, if the AP is located in an apartment or house then with advanced knowledge of the dimensions or ranges required, suitable values for DSC Upper Limit and DSC Margin could be derived and used. Similarly, in the cases of an enterprise or managed network, the values for the DSC Margin and DSC Upper Limit may be determined so as to set a desired network coverage area. Alternatively an AP could discover the channel, overlapping situation and signal conditions by monitoring beacons and traffic from its own and overlapping networks. Based upon this monitoring, the AP could then determine the DSC Upper Limit and DSC Margin values that would suit the environment and afford an improvement in network efficiency.

The AP may set a CCA Threshold for itself that is compatible with its network and the values for DSC Upper Limit and DSC Margin that it has set. In most practical situations an effective CCA threshold setting that is equal to the DSC Upper Limit minus the DSC Margin is suggested. An alternative is to set the effective CCA threshold to be 10 dB less than the expected or actual received signal strength from a non-AP STA that is located at the edge of the network.

**TBA.2 Adaptive Transmit Power Control, ATPC**

Adaptive Transmit Power Control (ATPC) adjusts the STA transmit power according to the effective CS/CCA threshold, CCAeff, according to equation 25-3. An ATPC AP can set the values of ATPC Max and ATPC Min in the DSC/ATPC Parameters element as well as the DSC parameters of DSC Upper Limit and DSC Margin.

The two set parameters used for transmit power control, ATPC CCA Max and ATPC CCA Min, bound the value of CCAeff as used in equation 25-3, as follows:

 ATPC CCA Min ≤ CCAeff ≤ ATPC CCA Max

It is recommended that ATPC CCA Min is set to -82dBm for a 20 MHz bandwidth, -79 dBm for 40 MHz, bandwidth, -76dBm for 80 MHz bandwidth and -73dBm for 160 MHz bandwidth.

It is recommended that ATPC CCA Max is set to a value equal to (DSC Upper Limit – DSC Margin) which is the maximum effective CCA that is set by the DSC procedure.

Using these values, the transmit power of an ATPC non-AP STA will be at a minimum when it is close to the AP and will in increase its transmit power by 1 dB for every 1dB decrease in the effective CCA threshold up to its maximum transmit power.

**TBA3 Inter-BSS, DSC and ATPC**

The effective CS/CCA threshold, as derived using the DSC procedures may be used to only apply to an inter-BSS frame as defined in 25.9.2 and not to intra-BSS frames. OBSS PD is set to be equal in value to CCAeff. In this case, the fixed CS/CCA thresholds shall apply to the intra-BSS frames. ATPC procedures may still be followed for the settings of the STA transmit power.