**IEEE P802.11  
Wireless LANs**

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| 11bn PDT MAC Dynamic Bandwidth Expansion (DBE) | | | | |
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**Abstract**

This document contains Proposed Draft Text (PDT) for the Dynamic Bandwidth Expansion (DBE) feature of the proposed 11bn/UHR amendment to the 802.11 standard.

This document resolves following CIDs:

* 3942, 3943, 2212, 2213, 3575

Revisions:

* Rev 0: Initial version of the document.
* Rev 1: Revisions based on comments from Mark.
* Rev 2: Changes based on feedback from Laurent.
* Rev 3: Incorporating changes based on comments received from multiple members offline and during the TGbn MAC call.
* Rev 4: Incorporated changes based on further offline feedback and CIDs resolution.
* Rev 5: Added definitions, acronym and additional text in 37.x to specify content of DBE announcement and PPDU BW selection when DBE is enabled.
* Rev 6: Some editorial text revisions based on offline feedback.
* Rev 7: Added Note to clarify that the switch time for when DBE enablement, DBE BW change or disablement takes effect is indicated as part of the advance notification mechanism for UHR critical updates. Some editorial updates.
* Rev 8: Edits based on offline feedback
* Rev 9: Editorial changes

**Introduction**

Interpretation of a Motion to Adopt.

A motion to approve this submission means that the editing instructions and any changed or added material are actioned in the TGbe Draft. The abstract, revision information, introduction, explanation of the proposed changes and references sections are not part of the adopted material.

***Editing instructions formatted like this are intended to be copied into the TGbe Draft (i.e. they are instructions to the 802.11 editor on how to merge the text with the baseline documents).***

***TGbn Editor: Editing instructions preceded by “TGbn Editor” are instructions to the TGbn editor to modify existing material in the TGbn draft. As a result of adopting the changes, the TGbn editor will execute the instructions rather than copy them to the TGbn Draft.***

**Relevant passing motions:**

[Motion #334, [1]]

**Move to add to the TGbn SFD the following:**

* 11bn defines a mechanism for dynamic bandwidth expansion (DBE) that enables a UHR AP to modify (expand/reset) its Dynamic UHR operating BSS bandwidth for UHR STAs that support the DBE operation
  + The dynamic bandwidth change is signaled using management frames and is announced for multiple beacon intervals in advance, and the AP shall stay on the expanded bandwidth until a subsequent dynamic bandwidth change occurs
  + The primary channel does not change as part of the dynamic BW expansion.
  + TBD on DBE signaling details

CIDs and proposed resolution:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **CID** | **Commenter** | **Clause** | **Pg/Ln** | **Comment** | **Proposed Change** | **Resolution** |
| 3942 | Binita Gupta | 37 | 67.04 | For enterprise deployments, the RRM favors stability and determinism and hence a higher frequency reuse is employed with neighboring APs using different P20 channels and non-overlapping BWs. Typical BW deployment in 5GH is 20/40 MHz and in 6GHz 40 or 80 MHz Due to high freq reuse, higher BWs of 160 and 320 are rarely deployed in enterprise deployments. Due to legacy devices issues observed in deployments (e.g. 2xroam away, non-reconnect etc.), RRM prefers to change channel or BW using CSA/ECSA very infrequently e.g. once a day. Thus currently enterprise deployments don't have an easy way to make use of wider 160 and 320 MHz BW and realize high throughput gains as a result. In enterprise use cases when certain APs are experiencing temporal high load and other neighboring APs are experiencing lower load, the AP with the higher load can expand its BW to better serve its traffic.  11bn should define a mechanism for UHR APs to dynamically expand their operating BW (aka Dynamic Bandwidth Expansion) for UHR supporting STAs to serve temporal high load, w/o impacting legacy STAs. | Define a Dynamic Bandwidth Expansion (DBE) mechanism in 11bn to enable wider BW usage in enterprise deployments. The DBE mechanism should define new signaling such that any impact on legacy devices is avoided.  Note that using CSA/ECSA/OMI mechanisms are not designed to be used for frequent/dynamic BW changes based on load, say every 5 mins. Sending dynamic BW changes using these mechanisms in Beacon results in BW changes being visible to legacy devices as well, and these mechanisms are not tested in the field to be used every few mins for BW changes, hence there could be potential field inter-op issues if CSA/ECSA/OMI options are used. To avoid legacy impact and potential field inter-op issues, it is desired to define new signaling for DBE.  DBE signaling should advertise dynamic BW switch in advance for few beacon intervals before the BW change happens, and allow AP and STAs to indicate BW switch time for seamless BW switch. Commentor will bring in a contribution. | Revised.  Agree in principle. Added text for the DBE feature.  TGbn editor, please make changes tagged with #3942. |
| 3943 | Binita Gupta | 37 | 67.04 | There are several discussions on supporting DSO (Dynamic Subchannel Operation) in 11bn where DSO gains are achieved for 160/320 MHz BSSes. However, for enterprise deployments favoring WLAN stability and legacy compatibility, there is no mechanism defined for such deployments to make use of DSO benefits. | Define the DBE mechanism for UHR AP to seamlessly expand its operating BW for UHR supporting devices. DBE enables enterprise deployments to benefit from wider bandwidth features such as DSO and NPCA. | Revised.  Agree in principle. Same resolution as for CID #3942. |
| 2212 | Brian Hart | 37.1 | 78.23 | NPCA assumes a 80/160 MHz BSS at minimum but provides no way for enterprise networks, with their emphasis on determinism and legacy compatibility, to get there. | Introduce a seamless way for UHR devices in BSSs to widen and narrow their BW over say a "5" min time scale, without perturbing legacy devices (aka Dynamic Bandwidth Expanion). Include a countdown warning and signal (and account for) AP and non-AP STA unavailability durations at each UHR bandwidth change. | Revised.  Agree in principle. Same resolution as for CID #3942. |
| 2213 | Brian Hart | 37 | 67.04 | Despite not yet being in D0.1, there have been many discussions on DSO, with value only for 160/320 MHz BSSs at minimum; but DSO provides no way for enterprise networks, with their emphasis on determinism and legacy compatibility, to get there. | Assuming ultimate success for DSP, introduce a seamless way for UHR devices in BSSs to widen and narrow their BW over say a "5" min time scale, without perturbing legacy devices (aka Dynamic Bandwidth Expanion). Include a countdown warning and signal (and account for) AP and non-AP STA unavailability durations at each UHR bandwidth change. | Revised.  Agree in principle. Same resolution as for CID #3942. |
| 3575 | Malcolm Smith | 37 | 67.05 | We expect DSO to be added to 11bn to explot higher BW BSS (e.g. 160MHz). However, contributions on this topic inicate many 802.11 networks won't be able to explot this BW unless an explictly tested companion method is introduced to safely enable these high BW BSS without affecting legacy STA | A new method to expand and contract the BW for UHR STA in a UHR BSS in a timeframe similar to the existing CSA/ECSA method (e.g. minutes) that is transaprent to legacy STA such as Dynamic BW Expasnion (DBE) is proposed. This should account for UHR STA capability (e.g. switching time) and ability (e.g. availability to operate at that PPDU BW) . | Revised.  Agree in principle. Same resolution as for CID #3942. |

Technical discussion:

Based on offline discussion among members, following aspects are proposed for DBE and reflected in this PDT:

* AP or STA indicates its support for DBE feature in UHR Capabilities
* An AP indicates its maximum supported DBE bandwidth
* If DBE feature is supported by the AP, then an AP can announce an upcoming enablement of DBE mode, or a change to the DBE bandwidth for already enabled DBE mode or a disablement of DBE mode, using the UHR critical update advance notification mechanism.
* When DBE mode is enabled, DBE bandwidth is higher than the BSS bandwidth and smaller or equal to AP’s maximum supported DBE bandwidth.
* TBD rules that regulate frequency of DBE BW changes

Note1: When DBE mode is enabled, the expanded BW is referred to as DBE bandwidth.  
Note2: Disablement of DBE mode refers to when AP is no longer operating with expanded DBE bandwidth.

**Text to be adopted begins here.**

**3.1 Definitions**

***TGbn editor: Insert the following definition (maintaining alphabetical order) in subclause 3.1 (Definitions):***

dynamic bandwidth expansion: [DBE] A mode of operation that allows an access point (AP) to dynamically expand its bandwidth that is greater than the basic service set (BSS) bandwidth and up to the AP’s maximum supported bandwidth for DBE, for ultra-high reliability (UHR) non-AP STAs that support DBE mode.

dynamic bandwidth expansion (DBE) bandwidth: [DBE bandwidth] The operating bandwidth of the access point (AP) for DBE when the DBE mode is enabled by the AP. The DBE bandwidth is greater than the AP’s basic service set (BSS) bandwidth and smaller or equal to the AP’s maximum supported bandwidth for DBE.

﻿**3.4 Abbreviations and acronyms**

***TGbn editor: Insert the following abbreviation (maintaining alphabetical order) in subclause 3.4 (Abbreviations and acronyms):***

DBE dynamic bandwidth expansion

* UHR Operation Element

***TGbn editor: Please update UHR MAC Capabilities to add DBE Enabled field as below (CID #3942)***

The format of the UHR Operation element is shown in Figure9-aa1 (UHR Operation element format).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | B0 | B1 | B2 | B3 | B4 B5 | B6 Bx |
|  | DPS Enabled | NPCA Operation Information Present | DBE Enabled | Reserved | Reserved | Reserved |
| Bits: | 1 | 1 | 1 | 1 | 3 | Y |
| * **UHR Operation Parameters field format** | | | | | | |

The DBE Enabled field indicates whether the UHR AP is operating with an expanded DBE bandwidth that is greater than the BSS bandwidth. The DBE Enabled field is set to 1 if the UHR AP is operating with an expanded DBE bandwidth greater than the BSS bandwidth and is set to 0 otherwise.

* UHR Capabilities element
* General
* UHR MAC Capabilities Information field

***TGbn editor: Please update UHR MAC Capabilities to add DBE Support field as below (CID #3942)***

The format of the UHR MAC Capabilities Information field is defined in ﻿Figure 9-aa5 (UHR MAC Capabilities Information field format).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0 | B1 | B2 | B4 | B5 | B6 | B7 Bx |
|  | DPS Support | DPS Assisting Support | Multi-Link Power Management | NPCA Supported | BSR Enhancement Support | DBE Support | Reserved |
| Bits: | 1 | 1 | 1 | 1 | 1 | 1 | x |

﻿Figure 9-aa5 —UHR MAC Capabilities Information field format

|  |  |  |
| --- | --- | --- |
| * Subfields of the UHR MAC Capabilities Information field (continued) | | |
| Subfield | Definition | Encoding |
| … | … | … |
| DBE Support | Indicates whether or not DBE operation is supported. | Set to 1 if dot11DBEOptionActivated is true (see 37.x (Dynamic bandwidth expansion (DBE))).  Set to 0 otherwise. |

***TGbn editor: Please add the following new subclause 37.x Dynamic Bandwidth Expansion (DBE) to the 802.11bn draft (CID #3942)***

37. Ultra-high reliability (UHR) MAC specification

**37.x Dynamic bandwidth expansion (DBE)**

Dynamic bandwidth expansion (DBE) is a mode of operation that allows a UHR AP to dynamically enable operation with an expanded bandwidth that is greater than its BSS bandwidth and up to the AP’s maximum supported bandwidth for DBE, for UHR non-AP STAs that support DBE mode. When an AP is operating with an expanded operating bandwidth, the expanded bandwidth is referred to as the DBE bandwidth and the DBE mode is enabled on the AP. When an AP is no longer operating with expanded bandwidth greater than the BSS bandwidth, DBE mode becomes disabled on the AP.

When DBE mode is enabled, the DBE bandwidth can be changed to another DBE bandwidth value that is greater than the BSS bandwidth. The BSS primary channel does not change when the DBE mode is enabled, the DBE bandwidth is changed or the DBE mode is disabled. When an AP has the DBE mode enabled,, non-AP STAs that do not support DBE mode continue to operate with the BSS bandwidth.

﻿A STA that supports DBE operation has dot11DBEOptionActivated equal to true, is called a DBE STA and shall set the DBE Support field of the UHR MAC Capabilities Information field of the UHR Capabilities element to 1. A UHR AP that supports DBE operation is called a DBE AP. A UHR non-AP STA that supports DBE operation is called a DBE non-AP STA.

A DBE AP shall announce an upcoming enablement of DBE mode, changes to the DBE bandwidth or disablement of DBE mode in Beacon, Probe Response and (Re)Association Response frames, using the advance notification mechanism for UHR critical updates. The DBE mode enablement, the DBE bandwidth change, or the DBE mode disablement shall be announced for multiple beacon intervals before the corresponding update takes effect. After the DBE mode is enabled and/or the DBE bandwidth is changed, the DBE AP shall continue operating with its DBE bandwidth until a subsequent change to its DBE bandwidth takes effect, or DBE mode disablement becomes effective.

In the announcement to enable the DBE mode or to change the DBE bandwidth for already enabled DBE mode, the DBE AP shall include the following:

* DBE bandwidth
* CCFS0 and CCFS1 for the DBE bandwidth (see ﻿9.4.2.321 EHT Operation element)
* Disabled subchannel bitmap (if any) for the DBE bandwidth (﻿see 9.4.2.321 EHT Operation element)

In the announcement to disable the DBE mode, the DBE AP shall indicate that the DBE bandwidth is being reset to the BSS bandwidth.

NOTE 1—The switch time when the DBE mode enablement, the DBE bandwidth change, or the DBE mode disablement takes effect is indicated as part of the advance notification mechanism for UHR critical updates.

NOTE 2—As described above, the enablement of DBE mode, change to DBE bandwidth or disablement of DBE mode are announced in advance for multiple beacon intervals and these operations are not performed at the TxOP timescale.

When a DBE mode becomes enabled (i.e. the AP starts operating with an expanded DBE bandwidth), then the AP shall set the DBE Enabled field in the UHR Operation element to 1. When a UHR AP changes its DBE bandwidth to another bandwidth value greater than the BSS bandwidth, the DBE Enabled field in the UHR Operation element remains set to 1.

When a DBE mode becomes disabled (i.e. the AP stops operating with an expanded bandwidth for DBE), then the AP shall set the DBE Enabled field in the UHR Operation element to 0.

When a DBE AP is operating with the DBE mode enabled, the following applies:

* The maximum PPDU bandwidth used by the AP in DL and trigger-based UL for a DBE non-AP STA shall not be more than the minimum of AP’s DBE bandwidth and non-AP STA’s bandwidth for DBE.
* The maximum PPDU bandwidth in UL EDCA used by a DBE non-AP STA shall not be more than the minimum of AP’s DBE bandwidth and non-AP STA’s bandwidth for DBE.
* The AP shall support receiving UL PPDUs from a DBE non-AP STA for up to the bandwidth that is minimum of AP’s DBE bandwidth and non-AP STA’s bandwidth for DBE.
* A DBE non-AP STA shall support receiving DL PPDUs up to the bandwidth that is minimum of AP’s DBE bandwidth and non-AP STA’s bandwidth for DBE.

﻿**Annex C**

**C.3 MIB Detail**

***TGbn editor: Please add the following new MIB variable for DBE***

Dot11UHRStationConfigEntry ::=

SEQUENCE {

dot11CoRTWTOptionImplemented TruthValue,

dot11NPCAOptionImplemented TruthValue,

dot11DUOOptionImplemented TruthValue,

dot11UHRBSROptionImplemented TruthValue,

dot11DBEOptionActivated TruthValue

}

dot11DBEOptionActivated OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This is a control variable.

﻿It is written by an external management entity or the SME. Changes take

effect as soon as practical in the implementation.

This attribute, when true, indicates that the station supports DBE operation. If this attribute is false, it indicates that the station does not support DBE operation.”

::= { dot11UHRStationConfigEntry <ana> }

**Text to be adopted ends here.**

**References:**

1. [11-25-0014r13](https://mentor.ieee.org/802.11/dcn/25/11-25-0014-13-00bn-tgbn-motions-list-part-2.pptx): 11-25-0014-13-00bn-tgbn-motions-list-part-2, Alfred Asterjadhi (Qualcomm Inc.)
2. [11-24/0209](https://mentor.ieee.org/802.11/dcn/24/11-24-0209-14-00bn-specification-framework-for-tgbn.docx) “Specification Framework for TGbn”, Ross Jian Yu (Huawei)
3. [11-24-0815r1](https://mentor.ieee.org/802.11/dcn/24/11-24-0815-01-00bn-dynamic-bandwidth-selection-signaling-details.pptx): “Dynamic Bandwidth Selection Signaling Details”, Binita Gupta *et al* (Cisco Systems)
4. [11-24-0088r1](https://mentor.ieee.org/802.11/dcn/24/11-24-0088-01-00bn-maximizing-channel-bandwidth-in-dense-ap-deployments.pptx): “Maximizing channel bandwidth in dense AP deployments”,Malcolm Smith *et al* (Cisco Systems)