### IEEE P802.11 Wireless LANs

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| --- | --- | --- | --- | --- |
| PDT MAC Power Save | | | | |
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Introduction

Trying to make progress to meet the TGbn timeline, several contributors on the topic of power save have worked together to prepare this document detailing the proposals in text style to further clarify the proposals. The intent is to work with all TTT members of Power Save topic to prepare an official spec text proposal.

This document is based on the following SFD agreements related to Dynamic Power Save and eMLSR topic:

* TGbn defines a power save mode for a STA that is a UHR Mobile AP or a UHR non-AP STA wherein the STA may transition from a lower capability mode to a higher capability mode upon reception of an initial control frame
  + Lower capability mode (e.g., 20 MHz BW, one SS, limited data rates, PPDU format)
  + Higher capability mode (e.g., operating BW, NSS and MCSs, with at least one higher capability than that in the lower power capability mode)
  + Initial Control frame is TBD
  + Whether that applies for a non-mobile AP is TBD
* TGbn defines cross link power save signaling mechanism
* Allowing a non-AP MLD to indicate to its associated AP MLD that supports the mechanism, in a frame sent on one enabled link, the power management mode for one or more of its affiliated non-AP STAs
* Whether support for the mechanism is mandatory or optional is TBD
* An UHR STA that uses the power save mode to transition from lower capability (LC) mode to higher capability (HC) mode, advertises the amount of padding it needs in a received initial control frame
  + Padding values range between 0 and a maximum value that is TBD with a TBD resolution
* Define a new mechanism and/or enhance existing mechanism for AP power save
* If a UHR STA (UHR non-AP STA or UHR Mobile AP) operates with the power save mode where the STA transitions from a lower capability mode to a higher capability mode upon reception of an initial control frame (that we call power save mode dynamic power save (DPS)), then its associated peer UHR STA shall include an intermediate FCS, if needed by the STA, in the initial control frame that it transmits to the STA
  + Note: intermediate FCS may not be needed, for instance, if the STA requires no padding
* Scheduled periodic power save on AP side is performed in UHR using Broadcast TWT with TWT ID=0 with Responder PM=1 as described in 26.8.3.2 (Rules for TWT scheduling AP)
* If a UHR non-AP MLD operates in the eMLSR mode, then its associated UHR AP MLD, that supports transmitting intermediate FCS, shall include an intermediate FCS, if needed by the non-AP MLD, in every Initial Control Frames for eMLSR transmitted to the non-AP MLD through its affiliated APs on the eMLSR links?
  + Mandatory/optional support for transmitting intermediate FCS is TBD
  + The field that carries the Intermediate FCS shall be designed to be ignored by legacy STAs if they are scheduled in the same initial control frame
  + Note: intermediate FCS may not be needed, for instance, if the STA requires no padding.
* TGbn defines a way in 11bn to include in an initial control frame an intermediate FCS for UHR STA(s) that precedes padding and the FCS field
* If an ICF includes an intermediate FCS for UHR STA(s) that precedes padding and the FCS field, the intermediate FCS has the size of 32 bits.

***TGbn editor: Please modify the following subclause 9.2.4.6.4 HE variant***

**9.2.4.6.4 HE variant  
*Change Table 9-25 (Control ID subfield values) as follows:***

**Table 9-25—Control ID subfield values**

|  |  |  |  |
| --- | --- | --- | --- |
| **Control ID value** | **Meaning** | **Length of the Control Information subfield (bits)** | **Content of the Control Information subfield** |
| **…** |  |  |  |
| 10 | Multi-link power management (MLPM) | 20 | See 9.2.4.7.12 (MLPM Control) |
| 11–14 ~~7–14~~ | Reserved |  |  |
| 15 | Ones need expansion surely (ONES) | 26 | Set to all 1s |

***TGbn editor: Please add the following subclause 9.2.4.7.12 MLPS Control after 9.2.4.7.11 ELA Control in D2.3***

**9.2.4.7.12 MLPM Control**

The Control Information subfield in an MLPM Control subfield contains the power management mode of non-AP STA(s) affiliated with a non-AP MLD.

The format of this subfield is TBD.

**9.3.1.22 Trigger frame format**

***TGbn editor: Please add a new subclause as follows***

**9.3.1.22.X Intermediate FCS**

The Intermediate FCS field contains a CRC that is calculated following the rules in 9.2.4.9 (FCS field) except that the *calculation fields* only include all of the fields of the MAC header and the Frame Body field up to and excluding the Intermediate FCS field.

The size of the Intermediate FCS field is 32 bits. The Intermediate FCS is located before the padding and FCS field, with specific location TBD.

The Intermediate FCS field is present in a Trigger frame that is used as an initial Control frame subject to the requirements defined in 37.x.x (Padding for an Initial Control Frame).

**9.3.3.6 Association Response frame format**

***TGbn editor: Please insert two new rows as follows:***

**Table 9-63—Association Response frame body**

|  |  |  |
| --- | --- | --- |
| **Order** | **Information** | **Notes** |
| … |  |  |
| <Last assigned + 1> | UHR Capabilities | The UHR Capabilities element is present if dot11UHROptionImple mented is true; otherwise, it is not present. |
| <Last assigned + 2> | UHR Operation | The UHR Operation element is present if dot11UHROptionImple mented is true; otherwise, it is not present. |

**9.3.3.8 Reassociation Response frame format**

***TGbn editor: Please insert two new rows as follows:***

**Table 9-65—Reassociation Response frame body**

|  |  |  |
| --- | --- | --- |
| **Order** | **Information** | **Notes** |
| … |  |  |
| <Last assigned + 1> | UHR Capabilities | The UHR Capabilities element is present if dot11UHROptionImple mented is true; otherwise, it is not present. |
| <Last assigned + 2> | UHR Operation | The UHR Operation element is present if dot11UHROptionImple mented is true; otherwise, it is not present. |

**9.3.3.10 Probe Response frame format**

***TGbn editor: Please insert a new row as follows:***

**Table 9-67—Probe Response frame body**

|  |  |  |
| --- | --- | --- |
| **Order** | **Information** | **Notes** |
| … |  |  |
| <Last assigned + 1> | UHR Capabilities | The UHR Capabilities element is present if dot11UHROptionImple mented is true; otherwise, it is not present. |
| <Last assigned + 2> | UHR Operation | The UHR Operation element is present if dot11UHROptionImplemented is true; otherwise, it is not present. |

**9.4.1 Fields that are not elements**

***TGbn editor: Please add the following subclause in 9.4.1:***

**9.4.1.xx DPS Operation Parameters field**

The DPS Parameter field is defined in Figure 9-xx (DPS Operation Parameters field format).

B0 B7 B8 B15

|  |  |
| --- | --- |
| DPS Padding Delay | DPS Transition Delay |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Bits: | 8 |  | 8 |  |

Figure 9-xx DPS Operation Parameters field format

The DPS Padding Delay subfield indicates the MAC padding duration of the initial Control frame needed by a DPS STA from the lower capability mode to the higher capability mode and is calculated as defined in 37.x.x (Padding for an Initial Control frame). The DPS Padding Delay subfield contains a number between 0 and TBD. The unit of DPS Padding Delay is TBD.

[TBD] The DPS Transition Delay subfield indicates the transition delay time needed by a DPS STA from the higher capability mode to the lower capability mode. The DPS Transition Delay subfield contains a number between 0 and TBD. The unit of DPS Transition Delay is TBD.

***TGbn editor: Please add the following subclause 9.4.1.xx UHR Control field***

**9.4.1.xx UHR Control field**

The UHR Control field is defined in [Figure 9-xxx (UHR Control field format)](#_bookmark127).

B0 B1 B2 B7

Bits: 1 1 6

|  |  |  |
| --- | --- | --- |
| **DUO Mode** | **DPS mode** | **Reserved** |

**Figure 9-xxx—UHR Control field format**

**Table xxx—DPS Mode subfield**

|  |  |
| --- | --- |
| **Subfield** | **Description** |
| DPS Mode | For a non-AP STA:  Set to 0 to indicate that the DPS mode is disabled for the non-AP STA.  Set to 1 to indicate that the DPS mode is enabled for the non-AP STA.  See 37.X.1 (Dynamic Power Save (DPS) operation)  For an AP:  Reserved |

**9.4.2 Elements**

**9.4.2.1 General**

***TGbn editor: Please insert a new row as follows:***

**Table 9-128—Element IDs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Element** | **Element ID** | **Element ID Extension** | **Extensible** | **Fragmentable** |
| … |  |  |  |  |
| UHR Capabilities (see [9.4.2.x (UHR](#_bookmark180)  [Capabilities element)](#_bookmark180)) | 255 | <ANA> | Yes | No |
| UHR Operation (see [9.4.2.x (UHR](#_bookmark180)  [Operation element)](#_bookmark180)) | 255 | <ANA> | Yes | No |

***TGbn editor: Please insert a new subclause as follows:***

**9.4.2.xx UHR Capabilities**

**9.4.2.xx.1 General**

A STA declares that it is an UHR STA by transmitting the UHR Capabilities element.

The UHR Capabilities element contains a number of fields that are used to advertise the UHR capabilities of an UHR STA. The UHR Capabilities element is defined in Figure 9-xxxx (UHR Capabilities element for[mat)](#bookmark249).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Element ID | Length | Element ID Extension | UHR MAC  Capabilities Information | UHR PHY  Capabilities Information | Supported UHR-MCS  And NSS Set |

Octets: 1 1 1 2 9 variable

**Figure 9-xxx—UHR Capabilities element format**

**9.4.2.xx.2** **UHR MAC Capabilities Information field**

The format of the UHR MAC Capabilities Information field is defined in [Figure 9-xxxx (UHR MAC](#bookmark2) [Capabilities Information field format)](#bookmark3). [TBD]

B0 B1 B2 B7

|  |  |  |
| --- | --- | --- |
| DPS Support | DPS Assisting Support | Reserved |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Bits: | 1 | 1 | 6 |  |  |

[Figure 9-xxxx UHR MAC](#bookmark2) [Capabilities Information field format](#bookmark3)

The subfields of the UHR MAC Capabilities Information field are defined in [Table 9-xxxx (Subfields of the](#bookmark4) [UHR MAC Capabilities Information field)](#bookmark5).

**Table 9-xxxx Subfields of the UHR MAC Capabilities Information field**

|  |  |  |
| --- | --- | --- |
| **Subfield** | **Definition** | **Encoding** |
| DPS Support | Indicates whether or not DPS is supported | Set to 1 if dot11DynamicPowerSaveSupport is true (see 37.X.1 (Dynamic Power Save (DPS) operation).  Set to 0 otherwise. |
| DPS assisting support | Indicates whether or not the transmission of ICF for DPS is supported. | Set to 1 if dot11DynamicPowerSaveAssistingSupport is true (see 37.X.1 (Dynamic Power Save (DPS) operation).  Set to 0 otherwise. |

***TGbn editor: Please insert a new subclause as follows:***

**9.4.2.x UHR Operation element**

The operation of UHR STAs in an UHR BSS is controlled by the following:

* The HT Operation element, HE Operation element, EHT Operation, and UHR Operation element if operating in the 2.4 GHz band
* The HT Operation element, VHT Operation element (if present), HE Operation element, EHT Operation element, and UHR Operation element if operating in the 5 GHz band
* The HE Operation element, EHT Operation element and UHR Operation element if operating in the 6 GHz band

The format of the UHR Operation element is shown in [Figure 9-X (UHR Operation element format)](#bookmark181).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Element ID | Length | Element ID Extension | UHR Operation Parameters | Basic UHR-MCS And Nss Set | DPS Operation Parameters |

Octets: 1 1 1 TBD TBD 0 or TBD

**Figure 9-X—UHR Operation element format**

The Element ID, Length, and Element ID Extension fields are defined in [9.4.2.1 (General)](#bookmark6).

The format of the UHR Operation Parameters field is defined in [Figure 9-Y (UHR Operation Parameters field format(11bn))](#bookmark182).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | B0 | | B1 | B2 | B3 | B4 B5 | B6 BX |
|  | | DPS Enabled | | Reserved | Reserved | Reserved | Reserved | Reserved |
| Bits: | | 1 | | 1 | 1 | 1 | 2 | Y |
|  | |

**Figure 9-Y—UHR Operation Parameters field format**

The DPS Enabled subfield is set to 1 if the AP sending a frame containing with field is a Mobile AP and dynamic power save (DPS) is enabled at the AP side and set to 0 otherwise.

The Basic UHR-MCS And NSS Set field indicates the UHR-MCSs for each number of special streams in UHR PPDUs that are supported by all UHR STAs in the BSS (including IBSS and MBSS) for transmission and reception.

[field location TBD] The DPS Operation Parameters field contains parameters for dynamic power save operation as defined in 9.4.1.xx (DPS Operation Parameters). The DPS Operation Parameters field is present if the DPS Enabled field is 1. The DPS Operation Parameters field is not present if the DPS Enabled field is 0.

***TGbn editor: please add the following subclause 9.6.39 UHR Action frame details***

**9.6.39 Protected UHR Action frame details**

**9.6.39.1 Protected UHR Action field [TBD]**

A Protected UHR Action field, in the octet immediately after the Category field, differentiates the Protected UHR Action frame formats. The Protected UHR Action field values associated with each frame format within the UHR category are defined in [Table 9-xxx (Protected UHR Action field values)](#_bookmark328).

**Table 9-xxx—Protected UHR Action field values**

|  |  |  |
| --- | --- | --- |
| **Value** | **Meaning** | **Time priority** |
| 0 | UHR Operating Mode Notification | No |
| 3–255 |  |  |

* + - 1. **UHR Operating Mode Notification frame details [TBD]**

The UHR Operating Mode Notification frame is used to indicate that a non-AP STA is changing its UHR operation (see 37.x (In-device coexistence mechanisms)) and is used by its associated STA as a response to the received ICF Operating Mode Notification frame from the soliciting STA.

The Action field of the UHR Operating Mode Notification frame contains the information shown in [Table 9-](#_bookmark335)xxx [(Protected UHR Operating Mode Notification frame Action field format)](#_bookmark335).

**Table 9-xxx—Protected ICF Operating Mode Notification frame Action field format**

|  |  |
| --- | --- |
| **Order** | **Information** |
| 1 | Category |
| 2 | Protected UHR Action |
| 3 | Dialog Token |
| 4 | UHR Control (see [9.4.1.xx (UHR Control field)](#_bookmark126)) |
| 5 | DPS Operation Parameters (see 9.4.1.xx (DPS Operation Parameters field) ) |

The Category field is defined in [9.4.1.11 (Action field)](#_bookmark114).

The Protected UHR Action field is defined in [9.6.40.1 (Protected UHR Action field)](#_bookmark327).

The Dialog Token field is set by a non-AP STA to a nonzero value chosen by the STA for sending a request and is set by an AP to the value copied from the corresponding received UHR Operating Mode Notification frame for sending a response.

The UHR Control field is defined in [9.4.1.xx (UHR Control field)](#_bookmark126).

The DPS Operation Parameters field is described in 9.4.1.xx (DPS Operation Parameters field).

**37. Ultra High Reliability (UHR) MAC specification**

***TGbn editor: Please insert a new subclause as follows***

**37.X Power Management**

**37.X.1 Dynamic Power Save (DPS) operation**

[DPS Assisting STA definition]A UHR non-AP STA that has dot11UHRDPSAssistingSupported equal to 1 is called a DPS Assisting non-AP STA and shall set the DPS Assisting Support subfield to 1 in the UHR Capabilities element in management frames that it transmits. A UHR AP that has dot11UHRDPSAssistingSupported equal to 1 is called a DPS Assisting AP and shall set the DPS Assisting subfield to 1 in the UHR Capabilities element in management frames that it transmits.

[Enablement/Disablement on non-AP STA]A UHR non-AP STA that has dot11UHRDPSSupported equal to 1 and that has enabled its DPS mode and is called a DPS non-AP STA.

[TBD] A UHR non-AP STA may enable the DPS mode only if its associated AP is a DPS Assisting AP. When a UHR non-AP STA intends to enable the DPS mode with its associated AP, then:

* the non-AP STA shall transmit an UHR Operating Mode Notification frame with the DPS Mode subfield of the UHR Control field of the frame set to 1 to the AP, and include a DPS Operation Parameters field in the UHR Operating Mode Notification frame with the DPS Transition Delay and DPS Padding delay.
* The AP shall transmit an UHR Operating Mode Notification frame, after the AP is ready to serve the non-AP STA in the DPS operation, as a response to the received UHR Operating Mode Notification frame, to the non-AP STA.

[TBD] When a DPS non-AP STA intends to disable the DPS mode, then:

* the non-AP STA shall transmit an UHR Operating Mode Notification frame with the DPS Mode subfield of the UHR Control field of the frame set to 0 to its associated AP.
* the associated AP shall transmit an UHR Operating Mode Notification frame, after the AP is no longer serving the non-AP STA in the DPS operation, as a response to the received UHR Operating Mode Notification frame, to the non-AP STA.

[Enablement/Disablement on Mobile AP]A UHR Mobile AP that has dot11UHRDPSOSupported equal to 1 and that has enabled its DPS mode and is called a DPS mobile AP.

A mobile AP may enable its DPS mode only under TBD conditions. A DPS Mobile AP shall have value 1 in its transmitted DPS Enabled subfield and 0 otherwise. The mechanism for enablement/disablement of DPS by a Mobile-AP is TBD.

A DPS STA is either a DPS non-AP STA or a DPS mobile AP. It is TBD whether an AP that is not a Mobile AP may be a DPS AP or not.

[DPS operation]The DPS operation allows a DPS STA to operate in lower capability (LC) mode and to transition to higher capability (HC) mode upon reception of an initial Control frame [TBD] transmitted by its associated DPS Supporting STA and that is addressed to the STA. The DPS STA remains in HC mode no longer than the TxOP duration and transitions back to the LC mode following conditions defined in this subclause.

A DPS STA that is in LC mode shall be capable of receiving TBD PPDUs (e.g., with non-HT (duplicate) PPDU format using a rate of 6 Mbps, 12 Mbps, 24Mbps?). A DPS STA that is in HC mode (e.g., operating BW, NSS and MCSs) shall be capable of receiving all supported PPDU formats corresponding to the HC mode.

If a DPS assisting STA intends to solicit a transition of its peer DPS STA to HC mode, then the DPS assisting STA shall initiate frame exchanges with the DPS STA with an initial control frame (ICF) transmitted in non-HT (duplicate) PPDU format using a rate of 6 Mb/s, 12 Mb/s, or 24 Mb/s [TBD]. The ICF addressed to the DPS STA shall include an intermediate FCS field if the DPS STA has a DPS Padding delay that is non-zero and shall include padding to ensure the padding requirement(s) of the DPS STA(s) as defined in 37.5.2.2.3 (Padding for a UHR initial Control frame). It is TBD whether a DPS assisting STA shall initiate any frame exchange with a DPS STA by sending an ICF or only some frame exchanges.

**37.x.2 AP power save**

An AP can use a new mechanism and/or enhance existing mechanism for AP power save.

An AP may announce the Broadcast TWT schedule with TWT ID field equal to 0 and Responder PM field equal to 1 as described in 26.8.3.2 (Rules for TWT scheduling AP) to implement the scheduled periodic power.

**37.x.3 Multi-Link power management signaling**

A non-AP MLD that has dot11UHRMLMPImplemented set to 1 supports Multi-Link power management signaling, is called an MLPM non-AP MLD and shall set to 1 the Multi-Link Power Management field in the UHR MAC Capabilities element in management frames that it transmits.

An AP MLD that has dot11UHRMLMPImplemented set to 1 supports Multi-Link power management signaling, is called an MLPM AP MLD and shall set to 1 the Multi-Link Power Management field in the UHR MAC Capabilities element in management frames that it transmits.

A non-AP STA affiliated with an MLPM non-AP MLD may transmit a frame that carries an MLPM Control subfield to change the power management mode of the other non-AP STA(s) affiliated with the same non-AP MLD and operating on an enabled link. (Signaling TBD)

A non-AP STA affiliated with the MLPM non-AP MLD, for which a power management mode change has been indicated through the MLPM signaling, follows the rules defined in 11.2.3.2 (non-AP STA power management modes) for that changed power management mode and whether there are additional or alternative rules is TBD.

If an MLPM AP MLD receives, via an affiliated AP, a power management mode change for a non-AP STA affiliated with an associated MLPM non-AP MLD and operating on an enabled link, then the AP affiliated with the MLPM AP MLD and operating on the corresponding enabled link follows the rules defined in 11.2.3.6 (AP operation) and 35.3.12 (ML power management) for the changed power management mode of the non-AP STA, as if it had received, on the link, a frame, from the non-AP STA, that indicates the same power management change. Whether additional AP behavior and rules are needed, compared to baseline, upon reception of the MLPM Control subfield is TBD.

***TGbn editor: Please insert a new subclause as follows***

**37.x.x Enhanced multi-link single-radio (EMLSR) operation for a UHR non-AP MLD**

A UHR AP MLD with dot11EHTEMLSROptionActivated equal to true shall follow the rules defined in 35.3.17 (Enhanced multi-link single-radio (EMLSR) operation) and in this subclause.

In EMLSR mode, a UHR non-AP MLD shall follow the rules defined in 35.3.17 (Enhanced multi-link single-radio (EMLSR) operation) and in this subclause.

If a UHR non-AP MLD operates in the eMLSR mode and is associated to a UHR AP MLD, then:

* the UHR AP MLD shall include an intermediate FCS field in the initial control frame that is the first frame of frame exchanges to the non-AP MLD on an eMLSR link, if needed by the non-AP MLD. It is TBD how the need from the non-AP MLD for the presence of intermediate FCS field in the initial control frame is determined.
* The AP affiliated with the AP MLD shall set the length of the Padding field of the initial Control frame based on the rules defined in 37.5.2.2.3 (Padding for a Trigger frame when the intermediate FCS field is present), except that no non-AP MLD with which the STA addressed by the initial control frame is affiliated announces the need of the presence of intermediate FCS field in the initial control frame.

***TGbn editor: Please insert a new subclause as follows***

**37.x.x.x Padding for an Initial Control Frame**

[TBD] If a Trigger frame contains an Intermediate FCS field, and padding is required, then

A UHR STA affiliated with an MLD shall set the length of the Padding field of a Trigger frame based on the rules defined in 35.5.2.2.3 (Padding for a Trigger frame), except that:

* If the TXOP responder is a DPS non-AP STA and the value in the DPS Transition Delay subfield received from the DPS non-AP STA is more than MinTrigProcTime, the MinTrigProcTimeis replaced by the value in the DPS Transition Delay subfield.
* If the TXOP responder is a DPS mobile AP, the MinTrigProcTimeis replaced by the value in the DPS Transition Delay subfield received from the DPS mobile AP.
* The UHR STA may be a non-AP STA if the trigger frame is a BSRP Trigger frame soliciting a responding frame non-HT PPDU format
* if an Intermediate FCS field is included in the Trigger frame, then the STA shall ensure that the number of bits in the PSDU following the last bit of the Intermediate FCS field is at least *LPAD, MAC* defined in Equation (35-1) or Equation (35-2), whichever applies, together with the padding requirement defined in 26.5.2.2.3 (Padding for a triggering frame)
* if an Intermediate FCS field is not included in the Trigger frame and if the Trigger frame is protected, then the STA shall ensure that the number of bits in the PSDU following the last bit of the MIC field is at least *LPAD, MAC* defined in Equation (35-1) or Equation (35-2), whichever applies, together with the padding requirement defined in 26.5.2.2.3 (Padding for a triggering frame)

# Annex C

(normative)

## ASN.1 encoding of the MAC and PHY MIB

### C.3 MIB Detail

WORK IN PROGRESS.