IEEE P802.11  
Wireless LANs

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| Comment resolution for TWT operation | | | | |
| Date: 2016-09-10 | | | | |
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Abstract

This submission proposes resolutions for multiple comments related to TGax D0.1 with the following CIDs (69):

* 1214, 1779, 1658, 2899, 959, 416, 1735, 740, 1445, 1639, 137, 139, 2398, 2399, 1640, 1738, 2616, 1651, 1652, 1736, 1737, 742, 25, 138, 2617, 1653, 744, 957, 26, 141, 420, 142, 2618, 1741, 1874, 2400, 2845, 1649, 1650, 1740, 1739
* 695, 1641, 976, 144, 1077, 145, 146, 452, 1642, 2619, 2621, 1643, 1647, 958, 745, 586, 143, 2622, 2820, 1656, 1654, 1657, 1646 (TWT operation)
* 1318, 544, 155, 153, 151 (Misc)

Revisions:

* Rev 0: Initial version of the document.
* Rev 1: Added additional co-author and some editorial suggestions (highlighted in green)
* Rev 2: Revised on the floor based on suggestions from Guido, Matt, etc (highlighted in blue)

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 TGax Draft. This introduction is not part of the adopted material.

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

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

# PARS I (TWT general)

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| **CID** | **Commenter** | **P.L** | **Comment** | **Proposed Change** | **Resolution** |
| 1214 | Liwen Chu | 48.01 | TWT is complicated. The feature should be diveded to Implicit TWT and broadcast TWT. For Implicit TWT, two options should be announced: wakeup at the beginning of TWT without polling, polling before transmitting frames to STAss. | As in comment. | Revised –  Agree in principle with the comment. Please note that this is already the case in what has been defined so far: HE TWT operation is divided into Implicit TWT (see 10.44.3 (Implicit TWT), which as mentioned has one without polling (unannounced), and one with polling (announced. Similar considerations apply to broadcast TWT (see 10.44.4 (Broadcast TWT). Explicit TWT is not allowed as the value of the Implicit bit shall be set to 1 (see P48L61). The proposed resolution makes this clearer by stating these conditions at the beginning of the subclauses.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1214. |
| 1779 | Robert Stacey | 48.01 | New TWT functionality should be moved to 25.7 (TWT operation). | Add a TWT overview to 25.7 with statements about which parts of 10.44 apply to HE STAs. Move the sentence at P48L16 ("An AP can additionally...") here. Move 10.44.4 (Broadcast TWT operation) to 25.7. | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested changes.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1779. |
| 1658 | Matthew Fischer | 48.02 | TWT agreements contain no traffic restrictions. Consider adding them. | Add the ability to restrict traffic within TWT SPs and outside of TWT SPs by TWT participating STAs. | Revised –  Agree in principle with the comment. Proposed resolution is to specify that STAs should not transmit outside of TWT SPs and should wait for trigger frames withing trigger-enabled TWT SPs, which is a behaviour inline with recommendation in 10.45.1 (TW overview): “A TWT requesting STA that is a non-AP STA should transmit frames only within TWT SPs.”  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1658. |
| 2899 | Zhou Lan | 48.01 | No mechanism defined to terminate broadcast TWT | add a mechnism to terminate broadcast TWT | Revised –  Agree in principle with the comment. Proposed resolution is to use a TWT Command value equal to 7 (Reject TWT) to terminate the broadcast TWT that is indicated by that TWT parameter set.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 2899. |
| 959 | kaiying Lv | 48.21 | The channel access mechanism within a TWT needs to be further clarified | Comment resolution and supporting PPT will be provided | Revised –  Disagree in principle with the comment in the sense that the channel access mechanism needs no clarifications because EDCA channel access is used (please refer to 10.45.1 (TWT overview):  “There are no explicit restrictions on the class of traffic (i.e., EDCA Access Category) that can be transmitted within any specific TWT SP when multiple TWT agreements have been set up by a single TWT requesting STA.”).  Proposed resolution is to specify that STAs should not transmit outside of TWT SPs and should wait for trigger frames withing trigger-enabled TWT SPs inline with the recommendations of subclause 10.45.1.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 959. |
| 416 | Brian Hart | 48.11 | Insertion is not limited ot HE STAs; affects backwards compatibility? | Limit insertion to HE STAs | Revised –  Agree in principle with the comment. Proposed resolution is inline with suggested changes by CID 1779 that moves HE related descriptions to subclause 25.7 (TWT operation).  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 416. |
| 1735 | Osama Aboulmagd | 48.04 | It is not clear if TWT here is used for power save, or for setting a TF schedule or for other purposes. A trigger frame schedule can be advertised by the AP with no need to resort to a very heavy protocol like the one described here. As in my previous comment, I don't believe TWT serves any purpose other than attracting many comments to be resolved. | remove TWT from the amendment and all related clauses. | Rejected –  Please refer to the contributions that have discussed this topic in IEEE for details on the use of TWT in 11ax:  TargetWakeTime (for power saving benefits): <https://mentor.ieee.org/802.11/dcn/12/11-12-0823-00-00ah-targetwaketime.pptx>  Scheduled Trigger frames (for its scheduling benefits):  <https://mentor.ieee.org/802.11/dcn/15/11-15-0880-02-00ax-scheduled-trigger-frames.pptx> |

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| **CID** | **Commenter** | **P.L** | **Comment** | **Proposed Change** | **Resolution** |
| 740 | Jarkko Kneckt | 48.51 | In Triggered TWT there seems to be a contradiction of the minimum operation needed in the Trigger frame transmission. The clause in p50l45 says that a Trigger frame shall be transmitted, but it needs not to be addressed to a STA in TWT. The text here requires that the Trigger frame is addressed to the STA. | Please use the wording in p50l45, only a trigger frame trnasmission is mandatory, it may not be addressed to a STA in TWT. | Rejected –  The normative behaviors are correct. Spec text in P50L45 is related to broadcast TWT, wherein it is not necessary to specify to which STA the trigger frame is transmitted since it can be transmitted to any of the STAs that may be awake or even containing random access RUs. The text here, in P48L51 refers to an individually set up TWT as such the AP knows the STA will be awake as such the Trigger frame needs to be addressed to it, otherwise the STA would be awake for no reason if the AP sends the Trigger frame but not to it. |
| 1445 | Mark RISON | 48.32 | "set the TWT Requester Support subfield to 1 in all S1G Capabilities or HE Capabilities elements" -- no such field in HE caps. Also "TWT Responder Support subfield" a few lines down | Refer to a subfield that exists | Rejected –  The TWT Requester Support and TWT Responder suport are already present in the HE Capabilities element. Please refer to P31L9, and P321L21-31. |
| 1639 | Matthew Fischer | 48.31 | Unsolicited TWT needs to be defined to allow minimal exchange of TWT information and maximum control of non-AP STA contention and scheduling of trigger frame transmissions for power savings. | Allow for the AP to send an unsolicited TWT response to any associated STA as a mechanism for scheduling. E.g. the unsolicited TWT response would indicate wake times for the receiving STA that correspond to times when the AP will transmit trigger frames that might contain the STAID of the recipient STA. | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested change, though the response can only be sent to those STAs that declare support of being a TWT responder STA, not all associated STAs.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1639. |
| 137 | Alfred Asterjadhi | 66.56 | The Cascade Indication (by the way make this field's name consistent with the one found in the Trigger frame) also indicates the termination of a Trigger-enabled TWT SP. Add this clarification and perhaps for clarity add a note that says something like: "NOTE--The TWT responding STA can indicate that a service period has ended by setting either the EOSP subfield of a QoS Data or QoS Null frame to 1 (see 10.2.2.5 (Power Management with APSD), or by setting the Cascaded subfield of a Trigger frame to 0" | As in comment | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested changes. Regarding the note it is more appropriate to have the behaviour explicitly indicated from the recipient side. In addition, removing the condition based on the Cascade Inidicaton for individual TWTs as in these cases an explicit indication of EOSP or MD settings in received frames suffices (inline with baseline PS modes).  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 137. |
| 139 | Alfred Asterjadhi | 67.28 | Need to clarify what an HE STA indicates/negotiates with the TWT Channel field. The obvious choice being the primary channel and operation channel width within TWT SP (applicable to MU op as well). | As in comment. | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested change though limited to the primary channel and a 20MHz width which are operations that are defined in the SFD.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 139. |
| 2398 | Yongho Kim | 49.13 | In HE STA, since UL MU is adopted, PS poll frames in TWT SP can also be sent in UL MU. | Insert the sentence in the paragraph after ' from the TWT requesting STA':  "For HE TWT requesting STA, PS poll frames may be sent in UL MU during TWT SP." | Revised –  Agree in principle with the comment. Proposed resolution is to specify that the response can be a PS-Poll or an APSD trigger frame when the STA is a PS STA that intends to solicit buffered BUs at the TWT responding STA and the TWT is an announced TWT.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 2398. |
| 2399 | Yongho Kim | 49.28 | The use of TWT channel field for HE PPDU is still undecided | Change the sentence 'An HE STA indicates TBD' as below: "An HE TWT requesting or responding STA indicates the temporary channel used in TWT SP using the TWT Channel subfield. After the indication, HE TWT requesting STA monitors the channel indicated in TWT channel subfield during the TWT SP(s)." | Revised –  The concept of the temporary primary channel does not exist in 11ax. Moreover, its existence would potentially cause issues with legacy devices operating in the primary channel. Proposed resolution is to specify that the TWT Channel field is used to negotiate the use of the primary channel (i.e., channel width of 20 Mhz) during the TWT SP similar to the resolution provided by CID 139 as these are operations that are allowed in the SFD.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 2399. |
| 1640 | Matthew Fischer | 48.31 | Draft needs to indicate the optional/mandatory status of the TWT mechanism at the AP. | Add a requirement for TWT to be implemented by an HE AP and add a bit to the HE operation IE that indicates if association requires TWT support by the associating non-AP STA. Add a behavioral line that indicates that the bit can be set by an HE AP. | Revised –  Agree in principle with the comment, however, this is not a discussion on the optionality/mandatory status of the TWT mechanism at the AP but rather on the enablement of TWT by STAs that support it. Proposed resolution accounts for the suggested changes incorporating the requirement, as suggested, for STAs supporting TWT.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1640. |
| 1738 | Osama Aboulmagd | 49.01 | A TWT requesting STA transmits a frame during a trigger-enabled TWT SP in response to a Trigger frame...Really. Just one STA. Why even the need to trigger a single STA. | Clarify | Revised –  The normative behaviour of multiple STAs responding to a Trigger frame is defined in 25.5.2 (UL MU operation). The intention of this declarative statement is to provide the reader the appropriate subclause where such a normative behaviour is defined and not to indicate that the trigger frame is sent to only one STA. In order to make this part clearer the proposed resolution provides some extra details to the declarative statement and adds one note to clarify this part.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1738. |
| 2616 | Young Hoon Kwon | 49.11 | If TWT is used for triggering UL MU transmission ffor HE STAs, it does not make sense to set the Flow Type to 0 because the first frame in a TWT SP should be sent from the TWT responding STA (AP). Therefore, the exception mentioned in this sentence does not happen, and instead it's better to clarify that Flow Type shall be set to 1 for Trigger operation. | Delete "frame, except for a Trigger frame within a trigger-enabled TWT SP,", and add the following sentence at the end of the paragraph: "The Flow Type field in a TWT response shall be set to 1 if the Trigger subfield in the TWT response is set to 1." | Revised –  Disagree in principle with the comment. The difference between the two fields is that when the Flow Type field is set to 0 this is an announced TWT (as such the STA that is in PS mode needs to send a PS-Poll or APSD trigger to retrieve its BUs, if it is an unannounced TWT then it needs not send these polling frames). Proposed resolution is to clarify these aspects.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 2616. |
| 1651 | Matthew Fischer | 48.32 | wrong conjuction | change "or HE Capabilities" to "and HE Capabilities" in two places in this paragraph, but not in the next paragraph. | Revised –  Agree in principle with the comment. Due to the re-organization of the subclause as suggested by CID 1799 this paragraph is removed and its technical contents are moved to 25.7 (TWT operation). The new description resolves this issue as well.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1651. |
| 1652 | Matthew Fischer | 49.28 | Channel selection mechanism for individual TWT is not specified. | Provide a description of the channel selection and advertisement mechanism for an HE STA employing individual TWT. | Revised –  Agree in principle with the comment. Proposed resolution is the same as for CIDs 139, and 2399, wherein the selection mechanism enables a device to operate in 20 MHz only during the TWT SPs (inline with the SFD).  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1652. |
| 1736 | Osama Aboulmagd | 48.50 | What is a trigger-enables TWT? | define | Revised –  Agree in principle. Proposed resolution specifies that a TWT or TWT SP that is setup under a TWT agreement with a Trigger field equal to 1 is a trigger-enabled TWT, or TWT SP respectively.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1736. |
| 1737 | Osama Aboulmagd | 48.54 | TWT SP is defined in 11ah as a period of time during which a TWT station (STA) is awake or transmit and/or receive frames. Is the same definition applicable for the so called trigger-enabled TWT SP? It seems to me that the TF is all about triggering some MU transmission, where as the TWT SP is for a single STA. Perhaps it is useful to describe what is happening during a trigger-enable TWT SP. | As in Comment | Revised –  TWT SPs are not exclusively assigned to one STA, though from the perspective of the TWT requesting STA it does not matter how the TWT responding STA has allocated these TWTs. In fact 10.45.1 has a statement for this: “STAs need not be made aware of the TWT values of other STAs.” Since it appears that this may still be confusing the proposed resolution is to add a clarification in 25.7 as well, highlighting the fact that frame exchanges between multiple STAs can occur.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1737. |

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| **CID** | **Commenter** | **P.L** | **Comment** | **Proposed Change** | **Resolution** |
| 742 | Jarkko Kneckt | 49.00 | The TWT SP termination when a trigger frame is addressed to a STA should be described. The termination should be possible to do with transmission of acknowledged data or null frame or just through an acknowledgement / BA frame. The same mechanism needs to be applicable also for U-APSD to avoid mutliple mechanisms implementation and to support high efficiency with the power save mechanisms. | Add a simple and low overhead mechanism to terminate TWT SP and U-APSD SP. The termination may be done with acknowledgemetn/BA or acknowledged data frame tarnsmission with specific indication of the service period termination. | Revised –  Agree in principle with the comment. The proposed resolution is the same as for CID 137 which indicates the use of the EOSP subfield of the received frame to early terminate the service period. Note that this is already allowed in the TWT operation (and U-APSD as well), and here we are explicitly adding this case for the trigger-enabled TWT as wells.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 742. |
| 25 | Ahmadreza Hedayat | 49.38 | This text is ambiguous: "A TWT requesting STA awake for a trigger-enabled TWT SP may transition to the doze state if it receives a Trigger frame from the TWT responding STA with a Cascade Indicaion field equal to 0 that is not intended to it." | Suggestion: "A TWT requesting STA awake for a trigger-enabled TWT SP may transition to the doze state if it receives from the TWT responding STA a Trigger frame with a Cascade Indicaion field equal to 0 that is not intended to it." | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested change however only for the case of broadcast TWT operation since for the individual TWT SP terminations the EOSP and MD settings are used for ending the SPS..  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 25. |
| 138 | Alfred Asterjadhi | 67.40 | TWT operation specifies that (P301L43@TGah D6.0): "A TWT requesting STA that is a non-AP STA should transmit frames only within TWT SPs". However it is not specified what the TWT requesting `STA should do outside of the TWT SPs or within Trigger-enabled TWT SPs. Since the TWT is acting as a scheduler we need to specify that the TWT requesting sta should not transmit outside of TWT SPs or within trigger-enabled TWT SPs unless it is as a response to a Trigger frame intended for them. Same consideration for TWT scheduled STAs. Also if different EDCA priorities (for MU vs SU) are defined then they should apply to TWT as well. | As in comment. | Revised –  Agree in principle with the commenter. Proposed resolution clarifies this aspect as proposed by comment resolutions for CID 1658 and 959. Regarding different EDCA parameters for MU they are not defined as of now in the spec so no changes accounted for in this document.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 138. |
| 2617 | Young Hoon Kwon | 49.38 | Cascade Indication field equal to 0 simply implies that there will not be no following Trigger frame within the TWT SP. As the Trigger frame is used only for UL MU transmission, it has no information about pending DL frame transmission. Therefore, it is not appropriate for a STA to switch to the doze state only checking UL transmission status. | Modify the text to "... if it receives a Trigger frame from the TWT responding STA with a Cascade Indicaion field equal to 0 that is not intended to it and More Data (MD) subfield of the most recently received downlink frame intended to it is set to 0.". | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested changes (though the subfield that dictates this switch is either the EOSP subfield or the MD field). The text has been converted to an itemized list to explicitly indicate all of the conditions. And removed the Cascade Indication condition in the individual TWT case.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 2617. |
| 1653 | Matthew Fischer | 49.39 | Incomplete wording. | Change "that is not intended to it" to "that does not include the STAID of the receiving STA in any per STA Info field. A TWT requesting STA awake for a trigger-enabled TWT SP may transition to the doze state if it receives a Trigger frame from the TWT responding STA with a Cascade Indication field equal to 0 that includes the STAID of the receiving STA in a per STA Info field and the receiving STA has either not transmitted in response to the Trigger or has completed its response transmission and has either received an expected acknowledgement or waited for the acknowledgement timeout if an acknowledgement was expected but not received, or immediately after transmitting if no acknowledgement is expected." | Revised –  Agree in principle with the comment. The text has been converted to an itemized list to explicitly indicate all of the conditions of the early termination of TWT SPs for both individual and broadcast TWTs.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1653. |

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| **CID** | **Commenter** | **P.L** | **Comment** | **Proposed Change** | **Resolution** |
| 744 | Jarkko Kneckt | 50.16 | The figure 10-ax10 shows a possibilty for STAs to return Doze after receiving the M-BA frame. This operation would be good to write in the normative text as well. | Check if there is normative text to put the STAs to Doze with M-BA frame. Write the normative text if it is missing. | Revised –  The figure shows a TWT scheduled STA that returns to Doze state at the end of the TWT SP, which duration is specified in the TWT element included in the beacon frame. The STA cannot go to Doze state unless it receives explicit permission by the AP to do so (e.g., receiving an individually addressed frame (including an M-BA if it is individually addressed) with EOSP equal to 1 or MD equal to 0.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 744. |
| 957 | kaiying Lv | 50.02 | There is no separate subclause for "Rules for TWT scheduled STA". Modify the sentence or add a corresponding subclause | Please clarify it | Revised –  Agree in principle with the comment. Proposed resolution clarifies that inconsistency, harmonizing the resolution with those of other CIDs in the same context.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 957. |
| 26 | Ahmadreza Hedayat | 49.60 | Regarding "TBD: Declares support of being a TWT scheduled STA". It is not clear whether this declaration is via HE capability or somethings else. | Specify the method to this declaration | Revised –  Agree in principle with the comment. Proposed resolution is inline with the proposed change of CID 1649 that suggests adding a capability bit for it.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 26. |
| 141 | Alfred Asterjadhi | 67.60 | THe TBD below needs to be clariified "1) TBD: Declares support of being an TWT scheduled STA". | As in comment. | Revised –  Agree in principle with the comment. Proposed resolution is inline with the proposed change of CID 1649 that suggests adding a capability bit for it.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 141. |
| 420 | Brian Hart | 50.04 | "can negotiate the TBTT ... it intends to receive" is confusing. A STA doesn't negotiate TBTT, the AP defines it. Yes this is modified by "it intends to receive" but the language is misleading | Define "Broadcast TWT listening schedule" (BTLS) or similar. Then the STA can negotiate the BTLS. Ditto replace heading of 10.44.4.3. And "between consecutive TBTTs" should be "in units of Beacon Interval" | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested changes and harmonizes part of the resolution with that of CID 1654 which suggests clarifying the first ambiguity by prepending “wake” to TBTT. Also please note that the unit of the value of the listen interval in this element is expressed in the same units derived from the TWT Wake Interval Exponent and TWT wake interval, i.e., not in units of Beacon Interval.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 420. |
| 142 | Alfred Asterjadhi | 68.01 | Reference to non-existing subclause. Either add a new subclause (where that reference points to) or describe the behavior of TWT scheduled STAs in this subclause (behavior should be similar to that of TWT requesting STAs). Reference to non-existing subclause. Either add a new subclause (where that reference points to) or describe the behavior of TWT scheduled STAs in this subclause (behavior should be similar to that of TWT requesting STAs). Especially we need to specify how a PS STA that is a TWT scheduled STA transitions between doze to awake state outside and within broadcast TWT SPs. | As in comment. | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested changes, harmonizing with those of other CIDs in the same subclause.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 142. |
| 2618 | Young Hoon Kwon | 49.55 | Broadcast TWT operation can be used for unassociated STAs, which may receive management frames before association. Therefore, there's no reason not to include TWT element in those management frames (such as Probe Response, Authentication, Association Response frames) to indicate TWT schedule. | Modify the text to "that includes a TWT element in the management frames including the Beacon frame, and follows". | Revised –  The TWT element is already allowed as part of the (Re-) Association Request/Response frames as part of the individual TWT agreement process. Broadcast TWT can only be included in a broadcast MGMT frame not individually addressed ones.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 2618. |
| 1741 | Osama Aboulmagd | 50.59 | Is the intention to specify the specify the time at which the first TWT is scheduled? Or the time at which the first TF is scheduled? I am not sure what is the behavior at this point | Clarify the behavior | Revised –  The first question contains the correct answer as well and reflects the intention, as stated in the quoted statement, i.e., “the timer at which the first TWT is scheduled”. And the behaviour related to the transmission of the Trigger frames is already specified in P68L44-50. In order to make this part clearer the proposed resolution is to specify of the first TWT of this TWT parameter set.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1741. |
| 1874 | Shusaku Shimada | 49.55 | The description of Broadcast TWT operation is not sufficient enough, especially for the reliable reachability of trigger frame. | As in comment, rewrite entirely. | Revised –  Agree in principle with the comment that the description of the broadcast TWT is not sufficient enough as there are several TBDs and missing rules. However it is not clear the correlation of the broadcast TWT and the reliable reachability of a Trigger frame.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1874. |
| 2400 | Yongho Kim | 50.02 | Rules for TWT scheduled STA needs to be defined | "Insert the followings after 10.44.4.3(Negotiation of TBTT and listen interval):  "10.44.4.4 Rules for TWT scheduled STA  A TWT scheduled STA receives TWT element in a Beacont frame at TBTT. In TWT element in Beacon frame, one or more TWT parameter set can be indicated.  The TWT scheduled STA shall be in awake state for at least the AdjustedMinimumTWTWakeDuration time(Nominal Minimum TWT Wake Duration minus the elapsed time from the scheduled start of the TWT SP to the actual start of the SP) for each TWT SP indicated by TWT parameter set(s) in TWT element in a Beacon frame.  The TWT schedule STA should only send frames that satisfy the TWT flow identifier recommendations listed in Table 8.248n1 (TWT Flow Identifier field for a broadcast TWT element) during the TWT SP(s).  The TWT scheduling STA awake for trigger-enabled TWT SP may transition to the doze state if it receives a Trigger frame from the TWT responding STA with a Cascade Indicaion field equal to 0 that is not intended to it and no other condition requires the STA to remain awake." | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested changes and harmonizes the resolution across different resolutions of other CIDs in the same context.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 2400. |
| 2845 | Yusuke Tanaka | 50.15 | During trigger-enabled TWT SP, it is unclear whether the received trigger is for PS-Poll or UL data for STAs which were in Doze state | Add "PS-Poll" into reserved Trigger Type field table(p.21 Table 9-ax2) Common Info field and Per User field of this variant is TBD | Revised –  It is not necessary to define a new trigger type for this functionality as a PS STA that transitions from doze to awake stat should transmit a PS-Poll or QoS Null frame to solicit DL BUs from the AP. The proposed resolution is to clarify this behaviour, especially for the announced TWT case.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 2845. |
| 1649 | Matthew Fischer | 49.60 | How does an HE STA declare support for TWT scheduled STA operation? | Add a capability bit in the HE Capabilities IE that indicates support for TWT scheduled STA operation. | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested change.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1649. |
| 1650 | Matthew Fischer | 49.64 | Why can an HE STA not operate both as a TWT scheduled STA and using an individual TWT agreement? | Allow an HE STA to use both broadcast TWT and individual TWT simultaneously. | Revised –  A STA that has negotiated individual TWTs need not wake for beacon frames to receive its buffered BUs as it is receives such BUs at the scheduled TWTs. Since it does not wake to receive beacon frames then it does not operate as TWT scheduled STA. Proposed resolution clarifies this aspect by adding a statement to what from the baseline PS modes apply to a STA that sets up individual TWT agreements.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1650. |
| 1740 | Osama Aboulmagd | 50.49 | Is this "TWT SP" or "triggered enabled TWT SP"? | Clarify | Rejected –  The text is already clear since the qualifier of the “same” TWT SP that precedes this qualifier already states that it is a trigger-enabled TWT. Quoting:  “The TWT scheduling STA that intends to transmit additional Trigger frames during a trigger-enabled TWT SP shall set the Cascade Indication field of the Trigger frame to 1 to indicate that it will transmit another Trigger frame within the same TWT SP” |
| 1739 | Osama Aboulmagd | 50.15 | Figure 10-ax10 needs further explanation. For example what is unannounced TWT SP? Is the trigger frame used to trigger PS-Poll frames? Can it trigger other frame types? More than one STA are transmitting in the trigger-enabled TWT SP, which contradict the definition of the TWT SP. Additionally I am not sure why TWT is needed. As I mentioned before the TF schedule can be announced by the AP without the need for this heavy protocol. | include more discussion of Figure 10-ax10. Alternatively delete TWT and all related clauses. | Rejected –  The figure provides a brief exemple how broadcast TWT can be set up and how basic exchanges during TWT SPs can be envisioned. For more details on the behaviour please refer to the detailed normative behaviour described in the respective TWT subclauses. For benefits of the TWT operation please refer to the available literature on this topic:  TargetWakeTime: <https://mentor.ieee.org/802.11/dcn/12/11-12-0823-00-00ah-targetwaketime.pptx>  Scheduled Trigger frames (for its scheduling benefits):  <https://mentor.ieee.org/802.11/dcn/15/11-15-0880-02-00ax-scheduled-trigger-frames.pptx> |

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| **CID** | **Commenter** | **P.L** | **Comment** | **Proposed Change** | **Resolution** |
| 695 | Jae Seung Lee | 50.65 | TBD IFS | Remove the TBD. | Accepted –  Though please note that that particular TBD has nothing to do with the IFS. |
| 1641 | Matthew Fischer | 50.52 | The table reference is incorrect. Table 8.248n1 is incorrect. | Fix the table reference for Table 8.248n1 (TWT Flow Identifier field for a broadcast TWT element) - probably should be 8.248L1 | Revised –  Agree with the comment. Proposed resolution fixes the reference inconsistency.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1641. |
| 976 | kaiying Lv | 50.36 | The current Broadcast TWT element doesn't support carrying one or more TWT parameter sets in one TWT element. | Please clarify it by modifying the TWT element format. | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested change.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 976. |
| 144 | Alfred Asterjadhi | 68.58 | Need to fix these two TBDs. If the TWT field is 8 bytes then remvove these TBDs. If it is appropriate to reduce broadcast TWT element duraiton then reduce this fields length to 2 Bytes and specify the respective value in terms of LSBs of the TSF. i.e., fill in the TBDs. | As in comment. | Revised –  Agree in principle with the comment. Proposed resolution is to specify that the field is 2 Bytes in a broadcast TWT and contains partial TSF (since the Beacon contains the absolute TSF timer, as such the 6 MS octets are not needed).  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 144. |
| 1077 | Kiseon Ryu | 50.65 | Delete TBD | Delete TBD | Accepted |
| 145 | Alfred Asterjadhi | 68.63 | While obvious the value of the TWT Wake Interval is missing for aperiodic TWT. Specify that it is set to 0. | As in comment. | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested change.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 145. |
| 146 | Alfred Asterjadhi | 68.65 | Add the setting for any of the remaining fields of the TWT parameter set (the ones that are needed) and remove this TBD item. | As in comment | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested changes and defines all the remaining fields o fthe TWT parameter set.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 146. |
| 452 | Chittabrata Ghosh | 38.17 | There is a statement as follows: "The TWT scheduling STA that intends to transmit additional Trigger frames during a trigger-enabled TWT SP shall set the Cascade Indicaion field of the Trigger frame to 1 to indicate that it will transmit another Trigger frame within the same TWT SP. Otherwise, it shall set the Cascade Indicaion field to 0." We need to explicitly mention about the case of the last Trigger frame within trigger-enabled TWT SP.  Also, please replace the word "Indicaion" in the quoted text above with "Indication" | I would suggest to include the following text: "The TWT scheduling STA shall set the Cascade Indication field of the Trigger frame to 0 to indicate that this is the last Trigger frame within the trigger-enabled TWT SP for the TWT scheduled STAs. The TWT scheduling STA shall not set the Cascade Indication field of the Trigger frame to 1 outside the tirgger-enabled TWT SP for the TWT scheduled STAs." | Revised –  The “otherwise, shall set …” statement already covers those two cases. Though agree that an explicit statement provides more insights. Proposed resolution accounts for the suggested change.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 452. |
| 1642 | Matthew Fischer | 49.05 | Specify a mechanism to allow a broadcast TWT to be disabled or deleted. | Specify that the value of 0 in the wake interval is the means to disable a broadcast TWT. Note that the AP should transmit this notification more than once to ensure that all STAs see the notification. At some point, the AP can stop sending the notification, so there should be an additional non-AP STA behavior that says that if the STA does not see the broadcast TWT in the beacon for N beacons, then it is no longer active. | Revised – Agree in principle with the comment. Proposed resolution is to provide a mechanism to disable and/or delete broadcast TWT, though since wake interval value 0 indicates aperiodic TWT the proposal is to use the value Reject TWT of the TWT Setup Command.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1642. |
| 2619 | Young Hoon Kwon | 50.33 | Broadcast TWT operation can be used for unassociated STAs, which may receive management frames before association. Therefore, there's no reason not to include TWT element in those management frames (such as Probe Response, Authentication, Association Response frames) to indicate TWT schedule. | Modify the text to "A TWT scheduling STA may include a TWT element in a Beacon frame scheduled at a TBTT, Probe Response frame, and (Re)Association Response frame.". | Revised –  The TWT element is already allowed as part of the (Re-) Association Request/Response frames as part of the individual TWT agreement process. Broadcast TWT can only be included in a broadcast MGMT frame not individually addressed ones (i.e., proposed resolution is the same as for CID 2618).  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 2619. |
| 2621 | Young Hoon Kwon | 50.62 | Periodic TWT is valid only within a beacon period. | Modify the text to "The TWT parameters are valid for each successive TWT of the periodic TWT until the next TBTT". | Revised –  Having the periodic TWTs only valid for one beacon interval reduces the likelihood of PS STAs be able to determine the schedule due to loss of the beacon and also would require STAs to always wake every beacon to determine the schedule which in turns affects power consumption. Proposed resolution is to have the validity over a long period of time, similar to other system updates in the spec.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 2621. |
| 1643 | Matthew Fischer | 49.05 | Specify a mechanism to allow a broadcast TWT to be modified | Include a mechanism to allow the parameters of a broadcast TWT to be modified. | Revised –  The parameters of the broadcast TWT can already be modified. What is missing is a mechanism that indicates that a change has occurred. Proposed resolution is to specify that a change has occurred by using the TWT Setup Command of Alternate TWT.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1643. |
| 1647 | Matthew Fischer | 50.65 | Allow the AP to specify some subset of STAs that particpate in any given unsolicited broadcast TWT. | Include a mechanism that allows the AP to specify some subset of STAs that particpate in unsolicited broadcast TWTs. | Rejected –  The TWT element provides broadcast TWT information to the STAs. A subset selection can be obtained by sending a Trigger frame to that subset of STAs or even by relying on the bit setting of the TIM element included in the same beacon. |

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| **CID** | **Commenter** | **P.L** | **Comment** | **Proposed Change** | **Resolution** |
| 958 | kaiying Lv | 69.30 | There is no separate subclause for "Rules for TWT scheduled STA". Modify the sentence or add a corresponding subclause | Please clarify it | Revised –  Agree in principle with the comment. Proposed resolution clarifies the ambiguity by adding the corresponding subclause (resolution that is inline with proposed change by CID 1657, 2400, 957, etc.).  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 958. |
| 745 | Jarkko Kneckt | 51.03 | The spec shall provide the beacon listening rules for a power saving STA when it has not yet transmitted a TWT request. For instance now it is unclear does the STA need to wakeup to receive all beacons or could it learn the Beacons that it will receive through other means. | Write a beacon reception rule for a STA that has not yet established a TWT request frame to AP. There should be a mechanism to allow the STA to go to Doze also in this mode and operate with Trigger frames and MU transmissions. | Revised –  Agree in principle with the comment. The beacon reception rule that is followed by PS STAs that have not negotiated TBTT and listen interval is the same as the one of the baseline (shall wake to receive a beacon every listen interval). The proposed resolution is to provide the rules that are followed by these PS STAs to indicate to the AP that they are in the awake state when broadcast TWT is used, e.g., using every opportunity they have to transmit in UL (being the access to a random allocation in a Trigger frame, sending the PS-Poll in SU mode, etc.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 745. |
| 586 | EVGENY KHOROV | 51.25 | The STA shall wake up well before TBTT taking into account possible clock drifting | modify according to the comment | Rejected –  There is no requirement for a STA to wake up well before the TBTT as long as the STA ensures to be awake at the TBTT (i.e., the STA may wake up 1 us earlier or never go to doze state to ensure its being awake when required by the AP (i.e., at the TBTT, since the Beacon frame is sent not earlier than that). |
| 143 | Alfred Asterjadhi | 68.37 | Need to specify when the AP can change the values for periodic TWT. To increase the likelyhood that PS STAs notice the change the AP may report it in a DTIM Beacon frame. | As in comment. | Revised –  Agree in principle with the comment. Proposed resolution is inline with the suggested change.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 2622. |
| 2622 | Young Hoon Kwon | 51.13 | There's no indication that TWT request is for individual TWT or Broadcast TWT, and it may not be enough for an AP to figure out only based on the requested TWT value and TWT wake interval. | Specify in the TWT element that current TWT request/response is for individual or broadcast. | Revised –  Agreee in principle with the comment. The proposed resolution accounts for the suggested changes and uses the one bit in the TWT element (as suggested by CID 682) to differentiate between the two cases.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 2622. |
| 2820 | Yunbo Li | 51.16 | " is equal to the STA's listen interval "is ambiguous,"the STA"should refer to "sheduled STA" | change"the STA's"to"its" | Revised –  Agree in principle with the comment. That portion of the sentence was removed as part of the comment resolution for CID 1656. Hence, the resolution for this comment is the same as for CID 1656.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 2820. |
| 1656 | Matthew Fischer | 51.15 | Why is there a condition that couples the listen interval to the wake interval? | Provide a rationale for why the two parameters must have the same value, or delete the requirement that this condition must be met. | Revised –  Agree in principle with the comment. Proposed resolution is to use a bit in the TWT element that specifies this particular negotiation (as suggested by CID 682).  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1656. |
| 1654 | Matthew Fischer | 51.01 | Heading is misleading - not really negotiating a TBTT, but a TBTT at which the non-AP STA will wake. | Change the heading - change "Negotiation of TBTT and listen interval" to "Negotiation of Wake TBTT and listen interval" | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested change.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1654. |
| 1657 | Matthew Fischer | 51.29 | An entire subclause is missing. "Rules for TWT scheduled STA" - there is a reference to this subclause, but no such subclause. | Provide the missing subclause that describes the rules of behavior for a TWT scheduled STA. | Revised –  Agree in principle with the comment. The proposed resolution adds the missing subclause and describes the behaviour of a TWT scheduled STA.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1657. |
| 1646 | Matthew Fischer |  | Need some normative behavior regarding the use of various access mechanisms that are allowed per STA in order for the AP to control access to the medium. | Add normative language that allows the AP to place limits on the behavior of STAs when they are attempting to access the medium. For example, if a STA is part of a TWT agreement, then the STA might be restricted from operating outside of its TWT SPs. | Revised –  Agree in principle with the comment. Proposed resolution is to specify that STAs should not transmit outside of TWT SPs and should wait for trigger frames withing trigger-enabled TWT SPs.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1646. |

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| **CID** | **Commenter** | **P.L** | **Comment** | **Proposed Change** | **Resolution** |
| 1318 | Mark RISON |  | Sometimes "broadcast TWT" is followed by SP, sometimes not. However at e.g. 26.53 consistency would suggest that it should be | Add "SP" wherever missing after "broadcast TWT" | Revised –  Both terminologies are used interchangeably. Proposed resolution is to state this clearly at the beginning of the subclause for trigger-enabled TWT and implicit TWT in the individual TWT subclause, which then are inherited in the case of broadcast TWT.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 1318. |
| 544 | EVGENY KHOROV | 3.10 | TWT scheduling STA and TWT scheduled STA are not defined | Define the terms | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested changes.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 544. |
| 155 | Alfred Asterjadhi | 67.31 | From the twt setup description it is not clear whether the AP can send TWT responses directly to TWT requesting capable STAs which helps to schedule stas when the networks becomes congested. Clarify that the AP can send a TWT response to the TWT responding STA to schedule implicit TWTs. | As in comment. | Revised –  Agree in principle with the comment. Proposed resolution accounts for the suggested changes.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 155. |
| 153 | Alfred Asterjadhi | 1584.35 | The PS STA needs to send one PS-Poll for retrieving a single MPDU, and repeat this multiple times. This is not very efficient for a high efficiency PS STA. However, the HE PS STA may have RX time (similar to Rx BW and Rx NSS, see ROMI) limitations for DL BUs frame reception. Enable an HE PS STA to send an enhanced PS-Poll/U-APSD trigger frame that contains the duration of the service period (or some time reference to the end of it) during which it is available to receive DL BUs by the AP. During this time allow the AP to send as much DL BUs as possible to the STA | As in comment. | Revised –  Agree in principle with the comment. Proposed resolution is to specify that baseline PS mode is followed by STAs that negotiate announced TWTs while enhanced mode is followed by STAs that negotiate unannounced TWTs which is conceptually inline with the functionality of TWT in the baseline.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 153. |
| 151 | Alfred Asterjadhi | 1584.32 | A PS STA can be triggered by the AP after the TIM Beacon with a trigger frame, where the trigger frame may come at any time after the beacon. If the PS STA is not fully awake to receive and respond to the trigger (can be sent at high BWs) after the beacon (lowest MCS/BWs) then it may lose the opportunity to send its ps-polls/apsd triggers as a response. Ensure that the AP sends the trigger frame after enough time has passed from the last beacon/multicast frame). | As in comment. | Revised –  Agree in principle with the comment. Proposed resolution is to allow the STA chose which broadcast TWT to wake up and start exchanging frames with the TWT scheduled STA.  TGax editor to make the changes shown in 11-16/1189r2 under all headings that include CID 151. |

**Discussion:** *None.*

**10.45 Target wake time (TWT)**

**10.45.1 TWT overview**

**TGax Editor: *Change the paragraphs below of this subclause as follows (#CID 1779, 416):***

A TWT requesting STA communicates wake scheduling information to its TWT responding STA and the TWT responding STA devises a schedule and delivers TWT values to the TWT requesting STA when a TWT agreement has been established between them. When explicit TWT is employed, a TWT requesting STA wakes and performs a frame exchange and receives the next TWT information in a response from the TWT responding STA as described in 10.45.2.2 (Explicit TWT operation). When implicit TWT is used, the TWT requesting STA calculates the Next TWT by adding a fixed value to the current TWT value as described in 10.45.3 (Implicit TWT operation). *(#1779, 416)*

**TGax Editor: *Delete the rest of the subclauses of clause 10.44 from .11ax D0.1 (#CID 1779)***

25.7 TWT operation*(#1779, 416)*

**TGax Editor: *Insert the following subclauses in 25.7(TWT operation) of .11ax D0.1 (#CID 1779):***

**[Note to the TGax Editor: *A clean version of this subclause can be obtained by switching off the track changes.*]**

**25.7.1 General***(#1779)*

Target wake times (TWTs) allow STAs to manage activity in the BSS by scheduling STAs to operate at different times in order to minimize contention between STAs and to reduce the required amount of time that a STA in PS mode needs to be awake.

An HE STA can negotiate individual TWT values, as defined in 10.45 (Target wake time (TWT)), subject to the additional rules and restrictions that are defined in 25.7.2 (Individual TWT agreements). broadcast ,2573*(#1779)*

STAs need not be made aware of the TWT values of other STAs or that a TWT service period (SP) can be used to exchange frames with multiple STAs. Frames transmitted during a TWT SP can be carried in any PPDU format supported by the STAs, including DL MU PPDU, trigger-based PPDU, etc.*(#1737)*

An HE STA with dot11TWTOptionActivated equal to true shall set:

* The TWT Requester Support subfield to 1 in the HE Capabilities element that it transmits if it supports operating in the role of a TWT requester STA; otherwise set to 0.
* The TWT Responder Support subfield to 1 in the HE Capabilities elements that it transmits if it supports operating in the role of a TWT responding STA; otherwise set to 0.
* The Broadcast TWT Support subfield to 1 in the HE Capabilities element that it transmits if it supports operating in the role of a TWT scheduled STA or in the role of a TWT scheduling STA; otherwise set to 0.*(#1651, 1649, 141, 26)*

An AP may set the TWT Required subfield to 1 in the HE Operation element it transmits to request TWT participation by all STAs that are associated to it and that have declared support for TWT. A STA that supports TWT and is associated with an AP from which it receives an HE Operation element whose TWT Required subfield is 1 shall either negotiate individual TWT agreements, as defined in 25.7.2 (Individual TWT agreements), or participate in broadcast TWT operation, as defined in 25.7.3 (Broadcast TWT operation).*(#1640)*

**25.7.2 Individual TWT agreements***(#1214)*

An HE STA may negotiate individual TWT agreements with another HE STA as defined in 10.45.1 (TWT overview), except that the STA:

* May set the Responder PM Mode subfield to 1 if it is a TWT responding STA that intends to go to doze state outside of TWT SPs.
  + If the TWT responding STA is an AP then it may set the Responder PM Mode subfield to 1 only if all non-AP STAs, which are associated to it, indicate support of TWT in the role of a TWT requester; otherwise it shall set it to 0.
  + An AP that sets the Responder PM Mode subfield to 1 follows the rules defined in 10.45.7 (TWT Sleep Setup).*(#156)*
* Shall set the Implicit subfield to 1 and the NDP Paging Indicator subfield to 0 in the TWT element it transmits during the TWT setup
* May set the Trigger subfield to 1 in the TWT element it transmits during the TWT setup to negotiate a trigger-enabled TWT
  + A successful TWT agreement whose Trigger subfield in the TWT response sent by the AP is 1 is a trigger-enabled TWT; otherwise it is an implicit TWT*(#1214)*
  + A successful TWT agreement whose Flow Type subfield is 1 is an unannounced TWT; otherwise it is an announced TWT *(#2616, 1214)*
* May set the TWT Channel subfield in the TWT element it transmits to a value that corresponds to the primary channel of the BSS to indicate a 20 MHz operation; otherwise it shall set it to 0.*(#139, 2399, 1652)*
* May set the TWT Protection field to 1 to indicate that TXOPs within the TWT SPs shall be initiated with a NAV protection mechanism, such as (MU) RTS/CTS, or CTS-to-self frame; otherwise it shall set it to 0.*(#2391)*

An HE STA that successfully sets up a TWT agreement with another HE STA shall follow the rules defined in 10.45.1 (TWT overview) and 10.45.4 (Implicit TWT operation), except that the additional rules defined in this subclause supercede the respective rules defined in 10.45.1 (TWT overview) and 10.45.4 (Implicit TWT operation). A TWT or TWT SP that is setup under an implicit TWT agreement is an implicit TWT or implicit TWT SP, respectively (see 10.45.1 (TWT overview). A TWT or TWT SP that is setup under a trigger-enabled TWT agreement is a trigger-enabled TWT or trigger-enabled TWT SP, respectively. *(#1736, 1214, 1318)*

An HE STA that successfully sets up an individual TWT agreement and operates in PS mode shall not be required to listen to Beacon frames, as defined in 11.2.2.1 (General).*(#1650)*

An HE AP may send an unsolicited TWT response frame with the Trigger subfield equal to 1 to an HE non-AP STA that has set the TWT Requester Support subfield to 1 in the HE Capabilities elements that it transmits to the AP.*(#1639, 155)*

transmit

A TWT requesting STA should not initiate transmission of frames to the TWT responding STA outside of negotiated TWT SPs (for both implicit TWT and trigger-enabled TWT) for that TWT agreement and should not initiate transmission of frames to the TWT responding STA within trigger-enabled TWT SPs for that TWT agreement.*(#1658, 1646, 959, 138)*

NOTE—The STA decides what frames to transmit within or outside TWT SPs.

*(#1651)(#1651)(#1736)*

The TWT responding STA of a trigger-enabled TWT agreement shall schedule for transmission a Trigger frame for the TWT requesting STA, as described in 25.5.2 (UL MU operation), within each TWT SP for that TWT agreement. The TWT responding STA that intends to transmit additional Trigger frames during a trigger-enabled TWT SP shall set the Cascade Indication field of the Trigger frame to 1 to indicate that it will transmit another Trigger frame within the same TWT SP. The TWT responding STA shall set the Cascade Indication field to 0 when the Trigger frame is the last Trigger frame of the TWT SP or when the Trigger frame is sent outside of a TWT SP.*(#137, 452)*

NOTE 1—The TWT responding STA is not required to schedule for transmission a Trigger frame for the TWT requesting STA when the TWT agreement is not a trigger-enabled TWT agreement or when the TWT requesting STA has sent an OMI A-Control field that has the UL MU disable bit equal to 1 (see 25.8 (Receive operating mode).

NOTE 2— The Trigger frame can also be an UL MU Response Scheduling A-Control field contained in an MPDU carried in a DL MU PPDU.

*(#1779)*A TWT requesting STA transmits a trigger-based PPDU as a response to a Trigger frame that is intended for it and is sent during a trigger-enabled TWT SP (see 25.5.2 (UL MU operation))*(#1738)*. A TWT requesting STA that is in PS mode and is awake shall include a PS-Poll frame or an APSD trigger frame in the trigger-based PPDU if the TWT is an announced TWT unless the STA has already transmitted the PS-Poll or APSD trigger frame within that TWT SP. The STA may include other frames in the trigger-based PPDU.*(#2398)*

NOTE–A Trigger frame is intended for a TWT requesting STA if it is sent by the AP to which the STA is associated and the frame contains the STA’s AID in any of its Per User Info fields. The Trigger frame can have multiple recipients, each of which is identified by the presence of the recipient’s AID in any of its Per User Info fields (see 25.5.2 (UL MU operation)).*(#1738)*

A TWT responding STA that receives a PS-Poll frame or an APSD trigger frame from a TWT requesting STA during an announced TWT SP shall follow the rules defined in 11.2.2.2.6 (AP operation during the CP) to deliver buffered BUs to the STA. A TWT responding STA may deliver multiple buffered BUs to the TWT requesting STAs during:

* An announced TWT SP, without following the rules in 11.2.2.2.6 (AP operation during the CP) as long as the BU delivery does not exceed the duration of the TWT SP and the PS STA sending the QoS Null frame does not follow APSD.*(#2845, 153)*
* An unannounced TWT SP, without following the rules in 11.2.2.2.6 (AP operation during the CP) as long as the BU delivery does not exceed the duration of the TWT SP.*(#2845, 153)*

NOTE —The TWT responding STA can deliver the buffered BUs in an A-MPDU under a blockack agreement if the TWT is an announced TWT and the PS mode of the STA allows it, or if the TWT is an unannounced TWT.

*(#2616)(#139, 2399, 1652)*A TWT requesting STA in PS mode that is awake for a TWT SP may transition to the doze state after AdjustedMinimumTWTWakeDuration time has elapsed from the TWT SP start time as identified by the TWT requesting STA if there is no frame exchange with the STA during the AdjustedMinimumTWTWakeDuration or after an early TWT SP termination event if there is at least one frame exchange with the STA during AdjustedMinimumTWTWakeDuration. The TWT requesting STA may classify any of the following events as an early TWT SP termination event:

1. The reception of a Trigger frame with the Cascade Indication field equal to 0 that is not intended to the STA and does not allocate any random RU during an unannounced TWT,
2. The transmission of an acknowledgement in response to a soliciting frame sent by the TWT responding STA that had either the EOSP subfield equal to 1 or the More Data field equal to 0 when the frame does not contain an EOSP subfield,*(#2617, 137, 742, 744)*
3. The reception of a frame sent by the TWT responding STA that had either the EOSP subfield equal to 1 or the More Data field equal to0 when the frame does not contain an EOSP subfield.*(#2617, 137, 742, 744)*

*(#2617, 137, 25, 1653)*

**25.7.3 Broadcast TWT operation***(#1779, 1874, 1214)*

**25.7.3.1 General**

A TWT scheduling STA is an HE AP with dot11TWTOptionActivated equal to true that includes a broadcast TWT element in the Beacon frame, and follows the rules described in 25.7.3.2 (Rules for TWT scheduling STA). The TWT scheduling STA may also include the broadcast TWT element in broadcast Probe Response frames.*(#2618, 2619)*

A TWT scheduled STA is an HE non-AP STA that:

* Sets the Broadcast TWT Support field of the HE Capabilities element it transmits to 1*(#1649, 141, 26)*
* Receives a broadcast TWT element transmitted by an HE AP that is a TWT scheduling STA and,
* Has not negotiated any implicit TWT agreement with the HE AP as described in 25.7.2 (Individual TWT agreements).

A TWT scheduled STA follows the schedule provided by the TWT scheduling STA as described in 25.7.3.2 (Rules for TWT scheduled STA)*(#1657, 958, 2400, 142, 957)*. A TWT scheduled STA can negotiate the wake*(#1654, 420)* TBTT and listen interval for Beacon frames it intends to receive as described in 25.7.3.3 (Negotiation of TBTT and listen interval).

An example of broadcast TWT operation is shown in Figure 25‑4 (Example of broadcast TWT operation), where the AP is the TWT scheduling STA and STA 1 and STA 2 are the TWT scheduled STAs.



**Figure 25‑4 - Example of broadcast TWT operation**

**25.7.3.2 Rules for TWT scheduling STA**

* A TWT scheduling STA may include a broadcast TWT element in a Beacon frame that is scheduled at a TBTT (see 11.1.3.2 (Beacon generation in non-DMG infrastructure networks)). The TWT scheduling STA shall include one or more TWT parameter sets in the TWT element, and each TWT parameter set may indicate a periodic occurrence of TWTs. The TWT scheduling STA shall set the NDP Paging Indicator subfield to 0, the Broadcast subfield to 1, the Implicit subfield to 1, and the Responder PM Mode subfield to 0 in the TWT element (see 10.45.7 (TWT Sleep Setup)). Each TWT parameter set specifies the TWT parameters of a broadcast TWT that are valid within a broadcast TWT SP.

The TWT scheduling STA sets the TWT parameters of each TWT parameter set as described below:

* The TWT scheduling STA shall set the TWT Request subfield to 0 and the TWT Setup Command subfield to Accept TWT, except that it may set the TWT Setup Command subfield to:
  + Reject TWT when the periodic TWT is being terminated or,
  + Alternate TWT when the periodic TWT is being modified *(#1642, 2621, 1643, 143, 2899)*
* The TWT scheduling STA shall set the Trigger field to 1 to indicate a trigger-enabled TWT. Otherwise, it shall set the Trigger field to 0 to indicate an implicit TWT*(#1214)*.

The TWT scheduling STA shall schedule for transmission a Trigger frame intended to one or more TWT scheduled STAs during a trigger-enabled TWT SP. The TWT scheduling STA that intends to transmit additional Trigger frames during a trigger-enabled TWT SP shall set the Cascade Indication field of the Trigger frame to 1 to indicate that it will transmit another Trigger frame within the same TWT SP. The TWT scheduling STA shall set the Cascade Indication field to 0 when the Trigger frame is the last Trigger frame of the TWT SP or when the Trigger frame is sent outside of a TWT SP.*(#137, 452)*NOTE 1—The TWT scheduling STA is not required to schedule for transmission a Trigger frame for the TWT scheduled STA when the broadcast TWT is not a trigger-enabled TWT or when the TWT scheduled STA has sent an OMI A-Control field that has the UL MU disable bit equal to 1 (see 25.8 (Receive operating mode).

NOTE 2— The Trigger frame can also be an UL MU Response Scheduling A-Control field contained in an MPDU carried in a DL MU PPDU.

* The TWT scheduling STA shall set the Flow Type field to 1 to indicate an unannounced TWT. Otherwise, it shall set the Flow Type field to 0 to indicate an announced TWT*(#1214, 2616)*.
  + The TWT scheduling STA should schedule delivery of DL BUs during unannounced TWT SPs.
* The TWT scheduling STA shall set the TWT Flow Identifier field according to Table 9.248l1 (TWT Flow Identifier field for a broadcast TWT element)*(#1641)*.
  + The TWT scheduling STA should only send frames that satisfy the TWT flow identifier recommendations listed in Table 9.248l1 (TWT Flow Identifier field for a broadcast TWT element)*(#1641)* during the TWT SP(s).
* The TWT scheduling STA shall set the TWT field to the TSF timer [4: 19]*(#144)* at which the first TWT is scheduled for this TWT parameter set*(#1741)*.
* The TWT scheduling STA shall include a nonzero value for the TWT wake interval in the TWT Wake Interval Exponent and TWT Wake Interval Mantissa fields for a periodic TWT and a zero value for an aperiodic TWT*(#145)*.
  + The TWT parameters are valid for each successive TWT of the periodic TWT or for the only TWT of the aperiodic TWT*(#145)*.
* The TWT scheduling STA may set the TWT Protection field to 1 to indicate that TXOPs within the TWT SP shall be initiated with a NAV protection mechanism defined in 10.3.2.4 (Setting and resetting the NAV), 10.3.2.8a (MU RTS/CTS procedure), or CTS-to-self as described in 10.3.2.13(NAV distribution); otherwise it shall set it to 0. *(#2391)*
* *(#1077, 695, 139, 2399, 1652, 146)*

A TWT scheduling STA that receives a PS-Poll or an APSD trigger frame from a TWT scheduled STA during an announced TWT SP shall follow the rules defined in 11.2.2.2.6 (AP operation during the CP) to deliver buffered BUs to the STA. A TWT scheduling STA may deliver multiple buffered BUs to the TWT scheduled STA during:

* An announced TWT SP, without following the rules in 11.2.2.2.6 (AP operation during the CP) as long as the BU delivery does not exceed the duration of the TWT SP and the PS STA sending the QoS Null frame does not follow APSD.*(#2845, 153)*
* An unannounced TWT SP, without following the rules in 11.2.2.2..6 (AP operation during the CP) as long as the BU delivery does not exceed the duration of the TWT SP and the STA has switched to AM.*(#2845)*

NOTE—The TWT scheduling STA can deliver the buffered BUs in an A-MPDU under a BlockAck agreement.

A TWT scheduling STA should indicate Alternate TWT or Reject TWT in the TWT Command Setup field of the broadcast TWT element for as many DTIM periods as needed to exceed the longest interval any STA is expected to not receive Beacon frames either when:

* The TWT parameters of a periodic TWT have changed, or
* The periodic TWT spedified by that TWT parameter set is terminated.

A change in the TWT parameter set occurs in a subsequent DTIM Beacon frame. *(#1642, 2621, 1643, 143, 2899)*

**25.7.3.3 Rules for TWT scheduled STA***(#1657, 958, 2400, 142, 957)*

A TWT scheduled STA that receives a broadcast TWT element in a Beacon frame shall follow the rules defined in this subclause to interact with the TWT scheduling STA.

A TWT scheduled STA should not initiate transmission of frames to the TWT scheduling STA outside of broadcast TWT SPs and within trigger-enabled TWT SPs.*(#1658, 1646, 959, 138)*

A TWT scheduled STA that is in PS mode may go to doze state after receiving the Beacon frame and shall be in the awake state at a broadcast TWT start time during which the STA intends to exchange frames with the TWT scheduling STA. The TWT scheduled STA shall be in the awake state for AdjustedMinimumTWTWakeDuration time that corresponds to that TWT parameter set, except that the STA may go to doze state when a TWT SP termination event occurs.*(#151)* The TWT SP termination event occurs when the AdjustedMinimumWakeDuration time has elapsed from the TWT SP start time as identified by the TWT scheduled STA if there is no frame exchange with the STA during the AdjustedMinimumTWTWakeDuration or after an early TWT SP termination event if there is at least one frame exchange with the STA during AdjustedMinimumTWTWakeDuration. The early TWT SP termination events are as defined below:

1. The reception from the TWT scheduling STA of a Trigger frame with a Cascade Indication field equal to 0 that is not intended to the STA and does not allocate any random RU.*(#25)*
2. The transmission of an acknowledgement in response to a soliciting frame sent by the TWT responding STA that has either the EOSP subfield equal to 1 or the More Data field equal to 0 when the frame does not contain an EOSP subfield.*(#2617, 137, 742, 744)*

The reception of a frame sent by the TWT responding STA that has either the EOSP subfield equal to 1 or the More Data field equal to 0 when the frame does not contain an EOSP subfield.*(#2617, 137, 742, 744)*NOTE–A Trigger frame, sent by the TWT scheduling STA, is defined as intended for the TWT scheduled STA when the Trigger frame contains the AID of the STA in one of its Per User Info fields (see 25.5.2 (UL MU operation)). Otherwise, the Trigger frame is not intended for the STA. If the Trigger frame contains one or more random RU(s) for which the STA can gain access according to 25.5.2.6 (UL OFDMA-based random access) then the STA can follow the rules defined in 25.42 (Power save with UL OFDMA-based random access) to determine an early TWT SP termination event. *(#1653)*

A TWT scheduled STA transmits a trigger-based PPDU as a response to a Trigger frame that is intended for it and is sent during a trigger-enabled TWT SP (see 25.5.2 (UL MU operation)). The TWT scheduled STA that is in PS mode and is awake shall include a PS-Poll frame or an APSD trigger frame in the trigger-based PPDU if it intends to solicit buffered BUs from the TWT scheduling STA (see 11.2.2.8 (Receive operation for STAs in PS mode during the CP)) unless the STA has already transmitted the PS-Poll or APSD trigger frame within that TWT SP. The STA may include other frames in the trigger-based PPDU. *(#2845, 745, 2398)*

NOTE–A TWT scheduling STA sets the bit in the TIM element of the Beacon frame that corresponds to the AID of the TWT scheduled STA to 1 to indicate that it expects the TWT scheduled STA to solicit available buffered BUs (see 11.2.2.8 (Receive operation for STAs in PS mode during the CP)).

A TWT scheduled STA should only send frames that satisfy the TWT flow identifier recommendations defined in Table 9.248l1 (TWT Flow Identifier field for a broadcast TWT element) during the corresponding TWT SP(s). Frames sent as a response to a Trigger frame are subject to further restrictions as defined in 25.5.2 (UL MU operation).

**25.7.3.3 Negotiation of wake(#1654, 420) TBTT and listen interval**

A TWT scheduled STA that intends to operate in power save mode (see 11.2.2.2 (STA Power Management modes)) may transmit a TWT request frame to the TWT scheduling STA that identifies the wake*(#420)* TBTT of the first Beacon frame and the wake*(#420)* interval between subsequent Beacon frames it intends to receive. The TWT request frame shall contain:

* The value of the Wake TBTT Negotiation subfield equal to 1 and the TWT Command field to Suggest TWT or Demand TWT, and *(#1656, 2622, 682)*
* The value of the requested listen interval between consecutive TBTTs in the TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields.
* All other fields in the TWT element are reserved.

A TWT scheduling STA that receives a TWT request frame from a STA whose value of the Wake TBTT Negotiation subfield is 1*(#1656, 2820)* shall respond with a TWT response frame that contains either Accept TWT or Reject TWT in the TWT Command field and, in the case of an Accept TWT, it shall also contain:

* The value of the Wake TBTT Negotiation subfield equal to 1, and*(#1656, 2622, 682)*
* The value of the allocated first wake TBTT*(#1654, 420)* in the Target Wake Time field, and
* The value of the listen interval between consecutive TBTTs in the TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields.
* All other fields in the TWT element are reserved.

After successfully completing the negotiation, the TWT scheduled STA may go to doze state until its TSF matches the next negotiated wake TBTT*(#1654, 420)* provided that the STA is in power save mode, and no other condition requires the STA to remain awake. The TWT scheduled STA shall be in the awake state to listen to Beacon frames transmitted at negotiated wake TBTTs and shall operate as described in in 25.7.3.2(Rules for TWT scheduled STA)*(#1657)*.

Either STA can tear down an established negotiation following the tear down procedure described in 10.44.8 (TWT Teardown).

**9.4.2.213 HE Capabilities element**

**TGax Editor: *Insert a “Broadcast TWT Support” bit in Figure 9-554b (HE Capabilities element)(#CID 1649, 141, 26)***

**TGax Editor: *Insert a new paragraph at the end of this subclause as follows (#CID 1649, 141, 26):***

The Broadcast TWT Support subfield indicates support by an HE non-AP STA for the role of TWT scheduled STA and by an AP for the role of TWT scheduling STA as described in 25.7.3 (Broadcast TWT operation). The Broadcast TWT Support subfield is set to 1 when the STA supports broadcast TWT functionality; otherwise it is set to 0.*(#1649, 141, 26)*

**9.4.2.213 HE Operation element**

**TGax Editor: *Insert a “TWT Required” bit in Figure 9-554c (HE Operation element)(#CID 1640)***

**TGax Editor: *Insert a new paragraph at the end of this subclause as follows (#CID 1640):***

The TWT Required subfield indicates that the AP requires the HE non-AP STAs to operate in the role of either TWT requesting STA, as described 25.7.2 (Individual TWT agreements), or TWT scheduled STA, as described in 25.7.3 (Broadcast TWT operation). The TWT Required subfield is set to 1 when the AP requires such functionality; otherwise it is set to 0.*(#1640)*

3.2 Definitions specific to IEEE 802.11

***TGax Editor: Insert the following definitions (#CID 544):***

**target wake time (TWT) scheduling STA:** A STA that schedules broadcast TWTs and provides these schedules in a broadcast TWT element.

**target wake time (TWT) scheduled STA:** A STA that follows the schedules provided in a broadcast TWT element. *(#544)*