IEEE P802.11  
Wireless LANs

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| --- | --- | --- | --- | --- |
| 11bn PDT-CR MAC Seamless Roaming (Part 1) | | | | |
| Date: March, 2025 | | | | |
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Abstract

This document contains Proposed Draft Text (PDT) for the Seamless Roaming feature of the proposed TGbn (UHR, Ultra High Reliability) amendment to the 802.11 standard.

This submission also proposes resolutions for the following CIDs received for TGbn CC50:

108, 736, 759, 1614, 1740, 1796, 1848, 2012, 2205, 2534, 2999, 3365, 3909, 3005, 188, 507, 2000, 2352, 2001, 2356, 2533, 3589, 3920, 3912, 2002, 2003, 2004, 2353, 2006, 2014, 493, 2007, 2009, 2715, 3457, 3892, 3921, 499, 514, 515, 2790, 516, 517, 3922, 511, 2017, 2018, 3260, 3458, 3929, 518, 519, 520, 2789

**Revision information**

The following is a summary of the important changes that occurred within each revision of this document:

|  |  |
| --- | --- |
| **Revision** | **Major changes** |
| 0 | Propose text changes needed for:   * Passing Motions since D0.1 of the draft (i.e., Motions from the TGbn meetings in Kobe and Atlanta). * Some of the CIDs from CC50 (listed in the Abstract above). |
| 1 | Major updates:   * Added AID assignment during roaming preparation. |
| 2 | Major updates:   * Minor editorial in 4.5.3.2 and other places. * Added the “General” section under 37.9.5. |
| 3 | Major updates:   * Added a condition during link preparation, the 802.1X Control Port is only blocked if the MAC-SAP is at the AP MLD (as opposed to the centralized architecture where the MAC-SAP is at the SMD level). * Clarified that when DL SN or UL SN is reset, the reset is done before any traffic is sent between the target AP MLD and the non-AP MLD.   + For the DL SN reset, clarify it’s the target AP MLD resetting the SN. For the UL SN reset, clarify it’s the non-AP MLD resetting the SN. * Keep the signaling of the timeout value between preparation and execution TBD for now. Some options to be discussed:   + The target AP MLD indicates a value to the non-AP MLD during preparation.   + A value is indicated only during the initial association between the non-AP MLD and the SMD-ME and this value applies to all the AP MLDs within the same SMD. * Removed the new reason code = ”Recommendation” in section 37.9.4 for now but will need some way to distinguish in a BTM if the non-AP MLD is asking for discovery info or roaming candidate recommendations. |

**Introduction**

Interpretation of a Motion to Adopt.

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

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

**Relevant passing motions (since draft D0.1):**

**Jan 2025 Kobe**

[Motion #279, [2]]

Move to add to the TGbn SFD the following:

* 11bn defines a Seamless Mobility Domain (SMD, exact name TBD) that covers multiple AP MLDs, where a non-AP MLD can use the UHR seamless roaming procedure to roam between the AP MLDs of the SMD
  + A logical SMD Management Entity (SMD-ME, exact name TBD) provides association, IEEE 802.1X Authenticator (except for the management of 802.1X control ports which is TBD) and RSNA Key management for non-AP MLDs across all AP MLDs of the SMD.
  + A non-AP MLD transitions between AP MLDs within the SMD while maintaining its association and security association with the SMD-ME.
  + The non-AP MLD can transition from one SMD to another SMD that are part of the same MD (Mobility Domain) using FT with improvements

[Motion #280, [2]]

Move to add to the TGbn SFD the following:

* 11bn defines that within a Seamless Mobility Domain (SMD, exact name TBD) the data path includes either one MAC-SAP for the SMD or a separate MAC-SAP per AP MLD of the SMD.
* In the case of a separate MAC-SAP per AP MLD, the DS mapping is updated when the non-AP MLD roams to another AP MLD within the SMD.
* In the case of a separate MAC-SAP per AP MLD, the component of the 802.1X Authenticator in the SMD-ME interacts with an 802.1X Authenticator component in the AP MLD that manages the 802.1X controlled port for the non-AP MLD.
* In the case of a single MAC-SAP for the SMD, the 802.1X Authenticator in the SMD-ME manages the 802.1X controlled port for the non-AP MLD.

[Motion #282, [2]]

Move to add to the TGbn SFD the following:

* When a non-AP MLD is in the process of roaming from a current AP MLD to a target AP MLD, the non-AP MLD can request to the current AP MLD what context needs to be transferred from the current AP MLD to the target AP MLD.
  + What context can be requested is TBD
  + It applies when the current AP MLD and the Target AP MLD support the context transfer

[Motion #283, [2]]

Move to add to the TGbn SFD the following:

* As part of seamless roaming procedure, a non-AP MLD can initiate a roaming preparation procedure with a target AP MLD by sending a TBD request frame to its current AP MLD.
  + The request frame indicates the set of links to be set up with the target AP MLD.
  + The request frame indicates the context to be transferred or renegotiated with the target AP MLD.
  + The current AP MLD sends a TBD response frame to the non-AP MLD to indicate the status (accept/reject) of the link setup.
    - If the link setup is accepted, the transferable context is transferred to the target AP MLD.
  + TBD on whether/how the renegotiation of context is performed in these request/response frames
  + TBD – multiple candidate target AP MLDs selection

[Motion #284, [2]]

Move to add to the TGbn SFD the following:

* As part of seamless roaming procedure, a non-AP MLD in state 4 with the SMD-ME can perform roaming transition through a target AP MLD that is a part of the SMD.
* TBD on the conditions and details for performing roaming through target AP MLD

[Motion #285, [2]]

Move to add to the TGbn SFD the following:

* For security in seamless roaming, when a non-AP MLD is in the process of roaming from the current AP MLD to a target AP MLD within the SMD, the same PMKSA, established with the SMD-ME, shall be used to protect communications with the current AP MLD and the target AP MLD.

[Motion #286, [2]]

Move to add to the TGbn SFD the following:

* For security in seamless roaming, when a non-AP MLD is in the process of roaming from the current AP MLD to a target AP MLD within the SMD, the same PTKSA, established with the SMD-ME, shall be used to protect communications with the current AP MLD and the target AP MLD.

**March 2025 Atlanta**

[Motion #333, [3]]

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

* Define a mechanism to retrieve probe response content for neighboring AP MLD(s) of the current AP MLD, through the current AP MLD
* Note. The neighboring AP MLD and the current AP MLD are in the same ESS

[Motion #335, [3]]

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

* After the roaming preparation request/response exchange, there is an indicated timeout
  + If there is no successful transmission of the roaming execution request frame from the non-AP MLD within the indicated timeout, then the target AP MLD may delete all preparation information related to the non-AP MLD
    - NOTE - This includes security context, i.e., new derived TK if new TK is derived
  + if the roaming preparation request for a target AP MLD is accepted in the roaming preparation response, and the non-AP MLD sends a following roaming execution request for the target AP MLD received within the indicated timeout, then the roaming execution request shall be accepted in the roaming execution response
  + TBD on indication of the timeout
* After the latest roaming preparation request/response exchange, the setup links with the target AP MLD is not modified until after the roaming execution request/response exchange is finished.

[Motion #336, [3]]

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

* There is only one target AP MLD indicated in the roaming preparation request frame from a non-AP MLD.

[Motion #337, [3]]

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

* The roaming preparation request frame includes Listen Interval field of the non-AP MLD for the target AP MLD
* The roaming execution request frame includes Listen Interval field of the non-AP MLD for the target AP MLD if there is no roaming preparation request/response exchange beforehand
* After the roaming execution request/response exchange with the current AP MLD, the non-AP MLD is by default in power save mode for all the setup links with the target AP MLD
* After the roaming execution request/response exchange with the current AP MLD, during the TBD period to receive DL data from the current AP MLD, the non-AP MLD is not required to listen to any Beacon frames of the APs affiliated with the target AP MLD.

[Motion #338, [3]]

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

* After the roaming execution request/response exchange with the current AP MLD, the TBD period to receive DL data from the current AP MLD ends after the indicated timeout in the roaming execution response.

[Motion #344, [3]]

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

* TGbn does not define a requirement for a UHR AP to report non-collocated APs in the Reduced Neighbor Report element that is carried in its Beacon and FILS Discovery frames

[Motion #345, [3]]

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

* The Link Reconfiguration Request/Response frames (with necessary extensions) shall be used as the roaming preparation Request/Response frames
  + The Per-STA Profile subelement of the Multi-Link shall be present and each corresponds to the requested/accepted links
  + TBD signaling to indicate that the request is to initiate roaming preparation
  + Other extension (if needed) TBD

[Motion #346, [3]]

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

* The Link Reconfiguration Request/Response frames (with necessary extensions) shall be used as the roaming execution Request/Response frames?
  + The Per-STA Profile subelement of Multi-Link element is not required to be present.
  + TBD signaling to indicate that the request is to initiate roaming execution transition
  + Other extension (if needed) TBD

[Motion #348, [3]]

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

* TGbn allows a second mode for security in roaming (in addition to the first mode with single TK used across all AP MLDs of the SMD) where a non-AP MLD can derive a new TK under the same PTKSA with the target AP MLD
  + The new TK is derived as part of the single PTKSA
  + The PN is maintained per PTKSA: The new TK negotiated with the target AP MLD shares the same PN space with the TK of the current AP MLD (PN is monotonically increasing)

[Motion #349, [3]]

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

* During the TBD time for retrieving DL from the Current AP MLD, the non-AP MLD may provide an indication to the Target AP MLD that the TBD time for DL retrieval is early-terminated before the TBD time
* TBD signaling of the indication

[Motion #350, [3]]

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

* During a roaming transition, the current AP MLD shall be capable of signaling termination of downlink data transmission to the non-AP MLD before the TBD time period to receive buffered downlink data from current AP MLD ends
  + Signaling TBD

NOTE: AP sends the indication when there is no more pending DL data (all TIDs). TBD other conditions.

[Motion #351, [3]]

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

* In the seamless roaming procedure, non-AP MLD can request not to transfer from the current AP MLD to the target AP MLD any of the following as part of the context transfer
  + The next SN for existing DL BA agreements of all TIDs
  + The latest SN that has been passed up for existing UL BA agreements of all TIDs

[Motion #352, [3]]

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

* 11bn defines an SMD element that provides identification for the SMD and SMD level capabilities for a seamless mobility domain
  + The SMD element is advertised in Probe Response frames
  + The SMD element is included in Authentication frame when performing authentication with an SMD
  + The SMD element is included in (Re)Association Request & Response frames when performing initial association with the SMD-ME

[Motion #353, [3]]

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

* 11bn enhances Neighbor Report element to provide SMD related information
  + Add a ‘Same SMD’ indication in the BSSID Information in the NR element, to signal whether the reported neighboring AP is part of the same SMD as the reporting AP
  + Allow including the SMD element as a subelement in the Optional Subelements of the Neighbor Report element, when reported neighboring AP is not part of the same SMD

[Motion #354, [3]]

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

* Enable the following contexts to be transferred to target AP MLD to preserve the data exchange context for the non-AP MLD
* Block Ack Parameters and Block Ack Timeout Value indicated by the non-AP MLD for existing BA agreement of a TID
* Next SN to be assigned for DL individually addressed data frame of each TID
* Latest duplicate receiver cache for TID without BA agreement
* latest SN that has been pass up for TID with UL BA agreement
* Starting PN to be assigned for DL individually addressed frame by the target AP MLD
* Initial value to be used by each replay counter of the target AP MLD for UL individually addressed frame
* WinStartO of an existing DL BA agreement
  + So that the target AP MLD does not exceed reordering buffer window of the non-AP MLD
* TBD for other contexts

[Motion #356, [3]]

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

* TBD request frame initiating roaming preparation carries the Diffie-Hellman Parameter element of the non-AP MLD when new PTK is derived
* TBD response frame during roaming preparation carries Diffie-Hellman Parameter element generated by the target AP MLD when new PTK is derived
* Non-AP MLD and the target AP MLD derive the PTK based on the shared PMK and DHss in TBD request and TBD response frames

Note: Details of the algorithm used to derive the DHss are TBD

[Motion #364, [3]]

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

* A serving AP MLD can use the BTM procedure with update(s) (if required) to recommend one or more candidate target AP MLDs within the UHR seamless roaming mobility domain to a non-AP MLD for roaming.
  + Note – An AP can transmit the BTM Request frame unsolicited or as a response to BTM Query from a non-AP MLD.
* TBD – detailed information to be carried

[Motion #368, [3]]

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

* For seamless roaming, a non-AP MLD is allowed to request preparing more than one candidate target AP MLDs in an SMD during the roaming preparation phase
  + Preparation with multiple AP MLDs is performed using a separate roaming preparation request for each AP MLD
  + If successful roaming preparation was performed with multiple candidate target AP MLDs, then the non-AP MLD shall attempt roaming execution with only one of those target AP MLDs at a time.
    - Retries with other target AP MLDs are permitted for roaming execution
  + TBD on policy indication from the AP on multiple target AP MLDs preparation

[Motion #369, [3]]

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

* For a Seamless Mobility Domain (SMD), the SMD and the 802.1X Authenticator component in the corresponding SMD-ME are uniquely identified by an SMD identifier
  + The SMD identifier is in the format of a 48-bit MAC address
  + The SMD identifier is used in establishing single PMKSA and PTKSA for a non-AP MLD that associates with the SMD-ME

[Motion #378, [3]]

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

* If the SMD is part of an FT mobility domain the following applies
  + The single PMKSA to be used in the SMD is the PMK-R1 SA and is bound to the SMD-ME, when the non-AP MLD initially associates with the SMD ME using FT initial MD association.

CIDs included in this document:

|  |  |  |
| --- | --- | --- |
| Topics | Relevant Motion | CIDs |
| **Editorial** |  |  |
| Seamless roaming should be a subclause or 37 |  | 108, 736, 759, 1614, 1740, 1796, 1848, 2012, 2205, 2534, 2999, 3365, 3909 |
| Misc. |  | 3005 |
|  |  |  |
| **Roaming Discovery** |  |  |
| Add discovery, target selection sections |  | 188, 507, 2000, 2352 |
| SDM discovery | M#352, M#353 | 2001, 2356, 2533, 3589, 3920 |
|  |  |  |
| **Initial Assoc** |  |  |
| Create a new section | M#352 | 3912 |
|  |  |  |
| **Target selection recommendation** |  |  |
| Use BTM | M#364 | 2002, 2003, 2004, 2353 |
|  |  |  |
| **Roaming Preparation** |  |  |
| Some introduction text |  | 2006 |
| STA can perform prep with any target (already the current assumption) |  | 2014 |
| Use Link Reconfiguration Req/Resp to prepare target | M#345 | 493, 2007, 2009, 2715, 3457, 3892, 3921 |
| STA indicates some context not to be transferred | M#351 | 499 |
| Target links in power save | M#337 | 514 |
| Timeout and prep state cleanup | M#335 | 515, 2790 |
| Indicate target AP MLD MAC addr during prep | M#336 | 516 |
| Include the Listen Interval during link prep | M#337 | 517 |
| Preparing one or more targets | M#368 | 3922 |
|  |  |  |
| **Roaming Execution** |  |  |
| Use the Link Reconfiguration Req/Resp for execution | M#346 | 511, 2017, 2018, 3260, 3458, 3929 |
| Indicate target AP MLD MAC addr during execution | M#337 | 518 |
| Include the Listen Interval during link execution | M#337 | 519 |
| DL data retrieval | M#337, M#338 | 520 |
|  |  |  |
| **Per-AP MLD TK** |  |  |
| Allow a Per-AP MLD TK | M#348 | 2789 |
|  |  |  |

Details of the CIDs and proposed resolution:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **CID** | **Commenter** | **Clause** | **Pg/Ln** | **Comment** | **Proposed Change** | **Resolution** |
| 108 | Haorui Yang | 37.8.2.5 | 0.00 | The clause for seamless roaming should be a subclause of Clause 37, instead of being 37.8.2.5 | Move the whole subclause 37.8.2.5 to subclause 37.X. | Revised.  The section has already been moved to 37.9 in D0.2. No more actions are needed for the editor. |
| 736 | JinHo Choi | 37.8.2.5 | 75.36 | The section number seems to be wrong. Seamless Roaming should be placed as an independent subcluase of Clause 37. | Change 37.8.2.5 and its subcluases to 37.9. (The subsequent subclauses would be pushed back.) | Revised.  The section has already been moved to 37.9 in D0.2. No more actions are needed for the editor. |
| 759 | Junbin Chen | 37.8.2.5 | 0.00 | 37.8.2.5 seamless roaming should not be within section 37.8 Multi-AP coordination framework and ought to be a separate chapter instead.This is because even through seamless roaming has a connection with the Multi-AP coordination framework,the overall procedure is independent of Multi-AP coordination framework | please list seamless roaming as a separate chaper | Revised.  The section has already been moved to 37.9 in D0.2. No more actions are needed for the editor. |
| 1614 | Jian Yu | 37.8.2.5 | 75.36 | Make 37.8.2.5 Seamless Roaming a second level subclause | as in comment | Revised.  The section has already been moved to 37.9 in D0.2. No more actions are needed for the editor. |
| 1740 | Kosuke Aio | 37.8.2.5 | 75.35 | The definition of "Multi-AP Coordination" does not include Seamless Roaming. | Please make Seamless Roaming a separate chapter from Multi-AP Coordination. | Revised.  The section has already been moved to 37.9 in D0.2. No more actions are needed for the editor. |
| 1796 | Ryuichi Hirata | 37.8.2.5 | 75.36 | Seamless Roaming is not part of Multi-AP Coordination. | Separate Seamless Roaming subclause from 37.8 Multi-AP coordination framework. | Revised.  The section has already been moved to 37.9 in D0.2. No more actions are needed for the editor. |
| 1848 | Yusuke Tanaka | 37.8.2.5 | 75.36 | Seamless Roaming should be in an independent subclause. | As commented. | Revised.  The section has already been moved to 37.9 in D0.2. No more actions are needed for the editor. |
| 2012 | Yelin Yoon | 37.8.2.5 | 9.36 | It seems unclear to put Seamless Roaming under the Multi-AP coordination framework subclause. | Put the Seamless Roaming subclause under the UHR MAC Specification subclause. | Revised.  The section has already been moved to 37.9 in D0.2. No more actions are needed for the editor. |
| 2205 | Brian Hart | 37.8.2.5 | 75.36 | Seamless roaming is completely different than MAPC (is same administrative domain only; and the AP2AP piece is out-of-band only). Seamless roaming was a separate section in the skeleton D0,1 spec (24/1993) | Move 37.8.2.5 Seamless Roaming to 37.xx Seamless Roaming | Revised.  The section has already been moved to 37.9 in D0.2. No more actions are needed for the editor. |
| 2534 | Jarkko Kneckt | 37.8.2.5 | 75.36 | The seamless roaming is incorrectly placed under multi-AP operations. There is no need to support multi-AP operations if AP MLD supports seamless roaming. | Please move seamless roaming clauses to a separate clause that is independent of multi-AP operations. | Revised.  The section has already been moved to 37.9 in D0.2. No more actions are needed for the editor. |
| 2999 | Mark RISON | 37.8.2.5 | 75.35 | I don't think Seamless Roaming is a form of MAPC (it's not mentioned in the definition of MAPC) | Move to be 37.8.2b | Revised.  The section has already been moved to 37.9 in D0.2. No more actions are needed for the editor. |
| 3365 | Giovanni Chisci | 37.8.2.5 | 75.36 | The subclause number for Seamless Roaming (currently 37.8.2.5) should not be under 37.8 (Multi-AP coordination framework), rather, it should be on the same level. | As in comment | Revised.  The section has already been moved to 37.9 in D0.2. No more actions are needed for the editor. |
| 3909 | Binita Gupta | 37.8.2.5 | 75.36 | Seamless roaming is a completely different feature than the MAPC. It is done in the same management domain and the AP2AP exchanges are over-the-DS. Hence, seamless roaming needs to be in a separate 37.xx clause of its own, and not under MAPC clause. | Move 'Seamless roaming' to a new 37.xx higher level clause. | Revised.  The section has already been moved to 37.9 in D0.2. No more actions are needed for the editor. |
| 3005 | Mark RISON | 37.8.2.5.2 | 76.05 | "DL Data frames" -- no such frames | Delete "DL " | Accepted. |
| 188 | Yonggang Fang | 37.8.2.5.2 | 75.52 | The roaming preparation procedure should include the neighbor AP discovery and target AP selection. Please add it. | Please add the neighbor AP discovery and the target AP selection in the roaming preparation. | Revised.  Agreed in principle. Create the “Roaming discovery procedure” subclause and the “Target AP MLD selection recommendation” subclause as shown in the “Text to be adopted” part of this submission. |
| 507 | Peshal Nayak | 37.8.2.5.1 | 75.41 | How does the non-AP MLD discover the target AP MLD? With baseline procedures, the non-AP MLD may need to perform off-channel probing which can be very time consuming and can create a lot of disruption to the non-AP MLD's data traffic. | A procedure to enable the non-AP MLD to discover the target AP MLD through the current AP MLD is needed. | Revised  Agreed in principle. Create the “Roaming discovery procedure” subclause as shown in the “Text to be adopted” part of this submission. |
| 2000 | Yelin Yoon | 37.8.2.5.1 | 75.45 | New subcluses for Discovery and Recommendation may be needed | As in comment | Revised.  Agreed in principle. Create the “Roaming discovery procedure” subclause and the “Target AP MLD selection recommendation” subclause as shown in the “Text to be adopted” part of this submission. |
| 2352 | Ahmadreza Hedayat | 37.8.2.5 | 75.36 | 11bn Seamless Roaming feature lacks a mechanism where a non-AP STA can discover its neighborhood with least OTA scan. Without a proper discovery mechanism, seamless roaming feature may underperform due to a less qualified/desired target AP(s) being selected for roaming. | Enhance existing mechanism to introduce negibordhood discovery mechanism, via the serving AP, to UHR seamless roaming feature. | Revised.  Agreed in principle. Create the “Roaming discovery procedure” subclause as shown in the “Text to be adopted” part of this submission. |
| 2001 | Yelin Yoon | 37.8.2.5.1 | 75.45 | In Discovery phase, the non-AP MLD needs to be able to know whether a discovered AP MLD is within the same SMD as the current AP MLD | "Distinguishing the SMD can come in two ways. A new field can be defined in the RNR IE of the beacon frame indicating that the discovered AP MLD is in the same SMD by setting a bit 1. Otherwise, bit 0. | Revised.  Agreed in principle. Covered by the same changes for Motion #352 and #353 as shown in the “Text to be adopted” part of this submission. |
| 2356 | Ahmadreza Hedayat | 37.8.2.5 | 75.36 | During roaming, a non-AP STA may end up roaming to a target AP that many belong to a different SMD, e.g. when a STA goes outside of the covergae of current SMD. Current discovery mechanisms lack the capability to discover APs in other networks through the associated AP. | Enhance existing discovery mechanisms where a non-AP STA can discover APs that belong to the same SMD (as the associated AP) or not. | Revised.  Agreed in principle. Covered by the same changes for Motion #352 and #353 as shown in the “Text to be adopted” part of this submission. |
| 2533 | Jarkko Kneckt | 37.8.2.5 | 75.36 | A non-AP MLD should detect through discovery information whether seamless roaming is possible to a candidate AP MLD. | Please add a process and identifiers to select the seamless roaming candidate AP. | Revised.  Agreed in principle. Covered by the same changes for Motion #352 and #353 as shown in the “Text to be adopted” part of this submission. |
| 3589 | Tuncer Baykas | add | 0.00 | There should be a mechanism for STAs to know about candidate target APs that STA can roam seamlessly. | Include information of how STA can determine if it is possible to roam seamlessly from serving AP to a target AP. | Revised.  Agreed in principle. Covered by the same changes for Motion #352 and #353 as shown in the “Text to be adopted” part of this submission. |
| 3920 | Binita Gupta | 37.8.2.5 | 75.36 | With the SMD architecture, the Neighbor Report element should be enhanced to provide SMD related info such as 'Same SMD' indication, SMD MAC Address/SMD Identifier and SMD capabilities. | Enhance Neighbor Report element to provide SMD information and allow including an SMD element for neighboring reported APs that are part of different SMD than the reporting AP. | Revised.  Agreed in principle. Covered by the same changes for Motion #352 and #353 as shown in the “Text to be adopted” part of this submission. |
| 3912 | Binita Gupta | 37.8.2.5 | 75.36 | For SMD level association, a non-AP MLD needs to discover SMD and its capabilities as part of pre-association discovery during active/passive scan. | "Add a clause on SMD Discovery that describes including SMD level information (SMD Identifier, SMD capabilities etc.) as part of Beacon and Probe Response by including an SMD element. | Revised.  Agreed in principle. Covered by the same changes for Motion #352 and #353 as shown in the “Text to be adopted” part of this submission. |
| 2002 | Yelin Yoon | 37.8.2.5.1 | 75.45 | We need a frame for recommending the AP MLDs. For efficiency when sending information on the recommended AP MLDs, the frame should be able to be sent to multiple non-AP MLDs | BSS Transition Management frame or Link Reconfiguration Notify frame is reused for recommending the candidate AP MLDs to the non-AP MLD | Revised.  Agreed in principle about the first part of the comment. Regarding the second part, since the recommendation in general is non-AP MLD specific, sending the same recommendation to multiple non-AP MLDs may not be helpful.  Covered by the same changes for Motion #364 as shown in the “Text to be adopted” part of this submission. |
| 2003 | Yelin Yoon | 37.8.2.5.1 | 75.45 | The non-AP MLD should be able to request for the recommended AP MLDs. To do so, we need a frame that requests the current AP MLD to send the information of the recommended AP MLDs | We can define a frame that solicits the Link Reconfiguration Notify frame. For example, Link Reconfiguration Notify Request frame | Revised.  Agreed in principle. Covered by the same changes for Motion #364 as shown in the “Text to be adopted” part of this submission. |
| 2004 | Yelin Yoon | 37.8.2.5.1 | 75.45 | We need to define what is included in the recommendation frame. | The recommendation frame includes:  - Recommended list of AP MLDs  - Reason Code  - Priority  The recommendation frame includes multiple AP MLDs that are the candidate AP MLDs for roaming.  It may provide a Reason Code that indicates why the non-AP MLD needs to roam. This helps the non-AP MLD to decide which AP MLD to roam and the current AP MLD to choose the candidate AP MLDs within the same SMD. | Revised.  Agreed in principle. Covered by the same changes for Motion #364 as shown in the “Text to be adopted” part of this submission. |
| 2353 | Ahmadreza Hedayat | 37.8.2.5 | 75.36 | Baseline BSS Transition Management feature offers limited or no options to a non-AP STA to discover nearby APs that are suitable for roaming. | Enhance baseline BSS Transition Management to enable a non-AP STA to find the best APs for roaming. | Revised.  Agreed in principle. Covered by the same changes for Motion #364 as shown in the “Text to be adopted” part of this submission. |
| 2006 | Yelin Yoon | 37.8.2.5.2 | 75.47 | There needs to be a general explanation of the Roaming Preparation phase. | To minimize the time during which connectivity between the non-AP MLD and DS is lost, we may need a preparation phase that includes setting up links and transfer of static context before the Roaming Execution phase. | Revised.  Agreed in principle. Covered by the changes tagged as (#2006) in the “Text to be adopted” part of this submission. |
| 2014 | Yelin Yoon | 37.8.2.5.1 | 75.45 | We need to define whether the non-AP MLD can only set the links with the recommended AP MLDs or it is open to setting up links with unrecommended AP MLDs | As in comment | Revised.  Agreed in principle. Current there is so such restriction, so the client is free to perform link prep with any target AP MLD as it pleases. The PDT is aligned with this already. |
| 493 | Peshal Nayak | 37.8.2.5.2 | 75.58 | How does the current AP MLD/Target AP MLD know which link(s) the non-AP MLD intends to setup at the target AP MLD? | The non-AP MLD should be allowed to indicate in the request frame for the preparation procedure which link(s) it wants to setup at the target AP MLD. | Revised.  Agreed in principle. Covered by the same changes for Motion #345 as shown in the “Text to be adopted” part of this submission. |
| 2007 | Yelin Yoon | 37.8.2.5.2 | 75.58 | How the link is set up needs to be defined. | Link Reconfiguration Request and Response frames are used for signaling the link setup. | Revised.  Agreed in principle. Covered by the same changes for Motion #345 as shown in the “Text to be adopted” part of this submission. |
| 2009 | Yelin Yoon | 37.8.2.5.2 | 75.58 | We need to be able to distinguish whether the Link Reconfiguration frame used during the Roaming Preparation phase is for Seamless roaming or for 11be AP MLDs. Otherwise, the AP MLD cannot know if the received Link Reconfiguration frame is for the reconfiguration of links within its AP MLD or if it is for roaming which requires the reconfiguration of links of other AP MLDs. | The Serving AP MLD can distinguish that the Multi-Link Reconfiguration IE is for Seamless roaming by finding a target AP MLD's MAC address in the Multi-Link Reconfiguration IE | Revised  Agreed in principle and added a “type” to distinguish different types of Link Reconfig Request as shown in the “Text to be adopted” part of this submission. |
| 2715 | Chittabrata Ghosh | 37.8.2.5.2 | 75.52 | It is not clear if the roaming preparation frame exchange is performed between non-AP MLD and current AP MLD. Please provide details of request and responses frames and transmitting or responding STAs of these frames | As in the comment | Revised.  Agreed in principle. See the changes tagged as (#2715) in the “Text to be adopted” part of this submission. |
| 3457 | Pooya Monajemi | 37.8.2.5.2 | 75.49 | Frame exchange and procedures for roaming preparation need to be defined | Define what frames are used in roaming preparation phase and how the roam procedure can be configured | Revised.  Agreed in principle. Covered by the same changes for Motion #345 as shown in the “Text to be adopted” part of this submission. |
| 3892 | Abhishek Patil | 37.8.2.5.2 | 75.62 | Provide the signaling details to enable roam preparation. The ML Reconfiguration framework defined by 11be seems to fit the bill to meet the signaling needs for preparation phase. Reuse existing techniques such as Link Reconfiguration Request / Response frames for this purpose. | As in comment | Revised.  Agreed in principle. Covered by the same changes for Motion #345 as shown in the “Text to be adopted” part of this submission. |
| 3921 | Binita Gupta | 37.8.2.5.2 | 75.47 | 11be Link Reconfiguration Request/Response framework can be used with some enhancements for roaming preparation procedure. Some of the enhancements include indicating the target AP MLD MAC and to provide a 'Roaming Execution Time' in the response that indicates the allowed time duration within which the roaming execution will be accepted. | Define use of Link Reconfiguration Request/Response frames for roaming preparation with needed enhancements as per the comment. | Revised.  Agreed in principle. Covered by the same changes for Motion #345 as shown in the “Text to be adopted” part of this submission. |
| 499 | Peshal Nayak | 37.8.2.5.3 | 76.14 | What happens if the non-AP MLD does not want to transfer some context during execution phase? E.g., reset SN at the target AP MLD instead of transferring? The line says 'shall transfer'. | Not transferring the context based on an indication from the non-AP MLD should be allowed. | Revised.  Agreed in principle. Covered by the same changes for Motion #351 as shown in the “Text to be adopted” part of this submission. |
| 514 | Peshal Nayak | 37.8.2.5.2 | 75.58 | When links are setup at the target AP MLD, what is the default state of the links? Are then in inactive/power save mode or can they be used for communications after they are added? | A behavior is needed for the links setup at the target AP MLD w.r.t. their default state and when data transmission can start on those links. | Revised.  Agreed in principle. Covered by the same changes for Motion #337 as shown in the “Text to be adopted” part of this submission. |
| 515 | Po-Kai Huang | 37.8.2.5.2 | 75.49 | The roaming execution and roaming preparation needs to have a clear relation. Take the experience from existing design, there is a reassociation deadline time for transition to happen and UHR roaming is doing similar things with enhanced context transfer through current AP MLD. The critical detail is that there is a unified deadline time across all MD. This is also critical for UHR because then non-AP MLD has ideas how much preparation time beforehand is needed before the roaming execution request. Suggest to add the texts in the proposed change column. | "There is only one target AP MLD indicated in the roaming preparation request frame from a non-AP MLD. After the roaming preparation request/response exchange, there is a timeout to send roaming execution request frame to roam to the target AP MLD indicated in theY roaming preparation request frame.  -If there is no transmission of the roaming execution request frame from the non-AP MLD within the timeout, then the target AP MLD deletes all preparation information related to the non-AP MLD.  -The timeout value is indicated in the timeout interval element from an AP MLD of a SMD during the initial connection to the SMD and is the same across the SMD.  After the roaming preparation request/response exchange, the setup links with the target AP MLD is not modified before the start of the TBD period to receive DL data from the current AP MLD after the roaming execution request/response exchange. | Revised.  Agreed in principle. Covered by the same changes for Motion #335 as shown in the “Text to be adopted” part of this submission. |
| 2790 | Chittabrata Ghosh | 37.8.2.5.2 | 75.60 | "A timer should be introduced in roaming preparation procedure to define an upper limit to  initiating roaming execution procedure | As in the comment | Revised.  Agreed in principle. Covered by the same changes for Motion #335 as shown in the “Text to be adopted” part of this submission. |
| 516 | Po-Kai Huang | 37.8.2.5.2 | 75.49 | Roaming preparation request frame needs to indicate the MAC address of the target AP MLD. | The roaming preparation request frame indicates the MAC address of the target AP MLD. | Revised.  Agreed in principle. Covered by the same changes for Motion #336 as shown in the “Text to be adopted” part of this submission. |
| 517 | Po-Kai Huang | 37.8.2.5.2 | 75.49 | Roaming preparation request frame fundamentally need to provide all the information that is there in reassociation request frame. Since we can not reuse reassociation request frame for preparation, then it is required to indicate listen interval. Suggest to add the texts in the proposed change column. | The roaming preparation request frame includes Listen Interval field of the non-AP MLD for the target AP MLD, | Revised.  Agreed in principle. Covered by the same changes for Motion #337 as shown in the “Text to be adopted” part of this submission. |
| 3922 | Binita Gupta | 37.8.2.5.2 | 75.47 | There are use cases such as IIoT (AGVs/AMRs), Automotive etc. where a client can benefit from preparing a small # of target APs (say 2/3 APs) and then roam to one of those APs based on client's actual mobility. 11bn Seamless roaming must enable these use cases and allow a client to prepare multiple target AP MLDs if desired. | Define roaming preparation procedure to allow preparing multiple target AP MLDs. Allow clients to specify set of target AP MLDs in a preference order and serving AP MLD can prepare a subset of target AP MLDs based on its policy and resource constraint. | Revised.  Agreed in principle. Covered by the same changes for Motion #368 as shown in the “Text to be adopted” part of this submission. |
| 511 | Peshal Nayak | 37.8.2.5.3 | 76.04 | The request and response should be handled via a modified ML reconfiguration framework | A multi-link reconfiguration based approach should be defined to perform roam execution | Revised.  Agreed in principle. Covered by the same changes for Motion #345 as shown in the “Text to be adopted” part of this submission. |
| 2017 | Yelin Yoon | 37.8.2.5.3 | 76.05 | TBD needs to be resolved | Replace TBD Request frame to Link Reconfiguration Request frame. | Accepted. |
| 2018 | Yelin Yoon | 37.8.2.5.3 | 76.07 | TBD needs to be resolved | Replace TBD Response frame to Link Reconfiguration Response frame. | Accepted. |
| 3260 | GEORGE CHERIAN | 37.8.2.5.3 | 0.00 | Define the frames used for this purpose, and remove TBDs | As in the comment | Revised.  Agreed in principle. Covered by the same changes for Motion #345 as shown in the “Text to be adopted” part of this submission. |
| 3458 | Pooya Monajemi | 37.8.2.5.3 | 76.03 | Frame exchange for roaming execution needs to be defined | Define what frames are used in roaming execution phase | Revised.  Agreed in principle. Covered by the same changes for Motion #345 as shown in the “Text to be adopted” part of this submission. |
| 3929 | Binita Gupta | 37.8.2.5.3 | 76.05 | 11be Link Reconfiguration Request/Response framework can be used with some enhancements for roaming execution procedure. Some of the enhancements include providing AID information in the response frame + providing time duration related to buffered DL data delivery. | Define use of Link Reconfiguration Request/Response frames for roaming execution with needed enhancements as per the comment. | Revised.  Agreed in principle. Covered by the same changes for Motion #345 as shown in the “Text to be adopted” part of this submission. |
| 518 | Po-Kai Huang | 37.8.2.5.3 | 76.01 | Roaming execution request frame needs to indicate the MAC address of the target AP MLD. | The roaming execution request frame includes the target AP MLD MAC address. | Revised.  Agreed in principle. Covered by the same changes for Motion #337 as shown in the “Text to be adopted” part of this submission. |
| 519 | Po-Kai Huang | 37.8.2.5.3 | 76.01 | Roaming execution request frame fundamentally needs to provide all the information that is there in reassociation request frame. Since we may not reuse reassociation request frame for roaming execution to define new behaviors of roaming, then it is required to indicate listen interval. Suggest to add the texts in the proposed change column. | The roaming execution request frame includes Listen Interval field of the non-AP MLD for the target AP MLD if there is no roaming preparation request/response exchange beforehand. | Revised.  Agreed in principle. Covered by the same changes for Motion #337 as shown in the “Text to be adopted” part of this submission. |
| 520 | Po-Kai Huang | 37.8.2.5.5 | 76.36 | "Based on the approved motion in SFD, we have ""\* after the request/response exchange that initiates notification of the DS mapping change from the current AP MLD to the target AP MLD, | Add "after the roaming execution request/response exchange that initiates notification of the DS mapping change from the current AP MLD to the target AP MLD, the current AP MLD may deliver buffered DL data frames for a TBD period of time" | Revised.  Agreed in principle. Covered by the same changes for Motion #337 as shown in the “Text to be adopted” part of this submission. |
| 2789 | Chittabrata Ghosh | 37.8.2.5.2 | 75.55 | A new PTK derivation mechanism should be allowed between non-AP MLD and target AP MLD for secured seamless roaming; please add details about process of derving the new PTK during the roaming preparation procedure | As in the comment | Revised.  Agreed in principle. Covered by the same changes for Motion #348 as shown in the “Text to be adopted” part of this submission. |

**Text to be adopted begins here.**

**3.1 Definition**

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

**Seamless mobility domain:** [SMD] a mobility domain that consists of multiple AP MLDs where a non-AP MLD can perform seamless roaming between the AP MLDs while maintaining association with the SMD-ME.

**Seamless mobility domain management entity:** [SMD-ME] an entity that manages the association, authentication, and security association of a non-AP MLD within an SMD.

**4. General description**

**4.5.3.2 Mobility types**

***TGbn editor: Please Change the first paragraph of 4.5.3.2 as follows:***

The [M#279]three transition types that are supported within this standard that describe the mobility of non-GLK STAs or MLDs within a network are as follows:

* + - * 1. ***No-transition:*** In this type, two subclasses that are usually indistinguishable are identified:

Static—no motion.

Local movement—movement within the PHY range of the communicating STAs, i.e., movement within a basic service area (BSA).

* + - * 1. ***BSS-transition:*** This type is defined for a STA or an MLD as follows:

(non-MLO to non-MLO): aA STA movement from one BSS in one ESS to another BSS within the same ESS.

* + - * 1. ***[M#279]Seamless roaming:*** This type is defined for an MLD as follows:

A non-AP MLD movement from one AP MLD in one SMD, where each non-AP STA affiliated with the non-AP MLD is within one BSS and different non-AP STAs affiliated with the non-AP MLD are within different BSSs, to another AP MLD within the same SMD, where each non-AP STA affiliated with the non-AP MLD is within another BSS and different non-AP STAs affiliated with the non-AP MLD are within different BSSs.

A fourth type of transition is STA movement from a BSS in one ESS to a BSS in a different ESS or a non-AP MLD movement from an AP MLD in one ESS to another AP MLD in a different ESS. Maintenance of upper layer connections during transition between ESSs cannot be guaranteed by IEEE Std 802.11; disruption of service is likely to occur.

**9.4.2.1 General**

***TGbn editor: Please add the following new element in 9.4.2.1 (General) Table 9-130 of the 802.11bn draft D0.1:*****Table 9-130—Element IDs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Element** | **Element ID** | **Element ID Extension** | **Extensible** | **Fragmentable** |
| … |  |  |  |  |
| TWT Information Extension (see [9.4.2.329 (TWT Information Extension](file:///C:\\Users\\dho\\AppData\\Local\\Temp\\6865032b-8857-437c-a796-9cd2d0252258_Draft%20P802.11be_D6.0%20-%20Word%20(4).zip.258\\Draft%20P802.11be_D6.0%20-%20Word\\TGbe_Cl_09.docx" \l "_bookmark287)  [element)](file:///C:\\Users\\dho\\AppData\\Local\\Temp\\6865032b-8857-437c-a796-9cd2d0252258_Draft%20P802.11be_D6.0%20-%20Word%20(4).zip.258\\Draft%20P802.11be_D6.0%20-%20Word\\TGbe_Cl_09.docx" \l "_bookmark287)) | 255 | 141 | Yes | No |
| SMD (see 9.4.2.xxx) [M#352, #369](#3920) | 255 | <ANA> | Yes | No |

[Editorial note: should we consider adding “Info” or “Parameters” in the name of this SMD element so it is different from the SMD concept?]

***TGbn editor: Please add the following new subclause 9.4.2.xxx (SMD element) to the 802.11bn draft D0.1:***

**9.4.2.xxx SMD element [M#352][M#369](#3920)**

The SMD element contains the SMD Identifier field and SMD Capabilities field for a seamless mobility domain. The format of the SMD element is shown in Figure 9-xx1 (SMD element format).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Element ID | Length | Element ID Extension | SMD Identifier | SMD Capabilities |

Octets: 1 1 1 6 1

**Figure 9-xx1—SMD element format**

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

The SMD Identifier field indicates a unique identifier for the SMD and is in the format of a 48-bit MAC address.

The format of the SMD Capabilities field is defined in Figure 9-xx2 (SMD Capabilities field format).

B0 B1 B7

|  |  |
| --- | --- |
| DL Data Forwarding | Reserved |

Bits: 1 7

**Figure 9-xx2—SMD Capabilities field format**

The DL Data Forwarding field is set to 1 if forwarding of buffered DL data of a non-AP MLD from the current AP MLD to a target AP MLD is supported by the SMD and is set to 0 otherwise.

[TBD other fields for other SMD level capabilities]

**9.4.2.35 Neighbor Report element [M#353](#2001)(#2356)(#2533)(#3589)(#3920)**

***TGbn editor: Please modify subclause 9.4.2.35 Neigbor Report element as shown below:***

***Change [Figure 9-417 (BSSID Information field format)](file:///C:\\Users\\dho\\AppData\\Local\\Temp\\fc595bd6-eb99-4c5d-adad-c745ce80e494_Draft%20P802.11be_D6.0%20-%20Word%20(3).zip.494\\Draft%20P802.11be_D6.0%20-%20Word\\TGbe_Cl_09.docx" \l "_bookmark153) as follows:***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| B0 B1 | B2 | B3 | B4 B9 | B10 | B11 | B12 | B13 | B14 |
| AP  Reachability | Security | Key Scope | Capabilities | Mobility Domain | High Throughput | Very High Throughput | FTM | High Efficiency |
| 2  B15 | 1  B16 | 1  B17 | 6  B18 | 1  B19 | 1  B20 | 1  B21 | 1  B22 | 1  B23 B30 |

Bits:

B15 B16 B17 B18 B19 B20 B21 B22 <ANA> <ANA>

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ER BSS | Colocated AP | Unsolicited Probe Responses Active | Members Of ESS With  2.4/5 GHz  Colocated AP | OCT Supported With Reporting AP | Colocated With 6 GHz AP | Extremely High Throughput | DMG  Positioning | Same SMD | Reserved |

Bits: 1 1 1 1 1 1 1 1 1 8

**Figure 9-417—BSSID Information field format**

***Insert the following paragraphs after the 21st paragraph (“The DMG Positioning field indicates…”):***

The Same SMD field is set to 1 to indicate that the AP represented by this BSSID (reported AP) belongs to the same SMD as the reporting AP. Otherwise, the Same SMD field is set to 0.

***Change*** [***Table 9-212 (Optional subelement IDs for Neighbor Report)***](file:///C:\Users\dho\AppData\Local\Temp\fc595bd6-eb99-4c5d-adad-c745ce80e494_Draft%20P802.11be_D6.0%20-%20Word%20(3).zip.494\Draft%20P802.11be_D6.0%20-%20Word\TGbe_Cl_09.docx#_bookmark154) ***(not all lines shown) as follows:***

**Table 9-212—Optional subelement IDs for Neighbor Report [M#353]**

|  |  |  |
| --- | --- | --- |
| **Subelement ID** | **Name** | **Extensible** |
| … |  |  |
| 199 | EHT Capabilities | Yes |
| 200 | EHT Operation | Yes |
| 201 | Basic Multi-Link | Yes |
| <ANA> | SMD | Yes |
| … |  |  |

***Insert the following paragraph after the 65th paragraph (“The Data field of the Basic Multi-Link subelement ...”):***

The Data field of the SMD subelement has the same format as the Information field of the SMD element defined in [9.4.2.xxx (SMD element)](file:///C:\Users\dho\AppData\Local\Temp\fc595bd6-eb99-4c5d-adad-c745ce80e494_Draft%20P802.11be_D6.0%20-%20Word%20(3).zip.494\Draft%20P802.11be_D6.0%20-%20Word\TGbe_Cl_09.docx#_bookmark205). The SMD subelement is not present if the Same SMD field in the BSSID Information field is equal to 1 or the reported AP is not covered by an SMD. Otherwise, the SMD subelement is included.

***TGbn editor: Please modify subclause 37.9 Seamless Roaming in the 802.11bn draft D0.2 as follows:***

## Seamless Roaming

### General

Seamless roaming is a mechanism for a non-AP MLD to transition from its current AP MLD to a target AP MLD (#3891)without requiring reassociation. Seamless roaming minimizes the time during which connectivity between the non-AP MLD and the DS is lost. The non-AP MLD remains in State 4 of association with a seamless mobility domain management entity (SMD-ME) during the seamless roaming transition while preserving the context for data transmission for a seamless experience.[M#279] To support seamless roaming, an SMD is introduced in the IEEE 802.11 architecture. The SMD consists of multiple AP MLDs, where a non-AP MLD can use the seamless roaming procedure to transition between the AP MLDs within the SMD. An SMD-ME provides SMD level authentication and association (see 11.3 (STA authentication and association)), IEEE 802.1X Authenticator functions (except for the management of 802.1X Controlled Ports which is TBD) and RSNA key management functions for non-AP MLDs across all AP MLDs within the SMD.

[#369] The SMD and the 802.1X Authenticator component in the corresponding SMD-ME are uniquely identified by an SMD Identifier (see 9.4.2.xxx (SMD element)). The SMD Identifier is used in establishing single PMKSA and PTKSA for a non-AP MLD that associates with the SMD-ME.

[M#378] If the SMD is part of an FT mobility domain, the single PMKSA to be used in the SMD is a PMK-R1 security association that is bound to the SMD-ME (through the SMD Identifier (see 9.4.2.xxx (SMD element))), when the non-AP MLD initially associates with the SMD-ME using FT initial MD association.

[M#279] A non-AP MLD performs initial association with the SMD-ME through an AP MLD within the SMD that establishes an SMD level security association across all AP MLDs in the SMD. The non-AP MLD transitions between AP MLDs within the SMD while maintaining its association and security association with the SMD-ME. This new mobility type is called TBD name [Editorial note: this new name will replace the term “seamless roaming” in all the sections in this document].

[M#279] A non-AP MLD can transition from one SMD to another SMD that is part of the same mobility domain using fast BSS transition with improvements.[M#284, M#285] When a non-AP MLD is in the process of transitioning from its current AP MLD to a target AP MLD within the SMD, the same PMKSA and PTKSA created as part of RSNA security association established with the SMD-ME, shall be used to protect the communications with its current AP MLD and the target AP MLD. [M#348](#2789)If a per-AP MLD TK is used, the per-AP MLD TK will be used for cryptographic encapsulation for the non-AP MLD.

[TBD the condition of when a per-AP MLD TK can be used]

Seamless roaming includes the following procedures:

* Roaming discovery procedure (see 37.9.2)
* Initial association to the SMD-ME (see 37.9.3)
* Target AP MLD selection recommendation (see 37.9.4)
* Roaming preparation (see 37.9.5)
* Roaming execution procedure
  + Through current AP MLD (see 37.9.6)
  + Through a target AP MLD (see 37.9.7)

### Roaming discovery procedure (#188)(#507)(#2000)(#2352)

[Editorial note: this section captures how a UHR non-AP MLD discovers whether an AP MLD supports seamless roaming, the corresponding sub-capabilities of seamless roaming, and the SMD/SMD-ME that manages this AP MLD.]

A non-AP MLD can use mechanisms such as active scanning (see 11.1.4.3.2 (Active scanning procedure for a non-DMG STA) and 35.3.4.2 (Use of multi-link probe request and response)), the BTM framework (see 11.21.7 (BSS transition management) and 35.3.23 (BSS transition management for MLDs)) or the neighbor report framework (see 11.10.10 (Usage of the neighbor report)) for discovery of the neighboring AP MLDs and seamless roaming support by those AP MLDs.

NOTE 1 – a neighboring AP MLD might or might not be part of the same SMD.

[M#344] NOTE 2 – An AP is not required to report non-collocated APs in the Reduced Neighbor Report element that is carried in its Beacon and FILS Discovery frames.

[M#352](#3912) An SMD element provides an SMD Identifier and SMD capabilities for an SMD. The SMD element is advertised in the Probe Response frames. The SMD element is provided as part of the Neighbor Report element in the BTM Request and Neighbor Report Response frames for a reported AP that is part of a different SMD than the reporting AP.

[M#333] A mechanism is defined to retrieve probe response content for neighboring AP MLD(s) of the current AP MLD, through the current AP MLD.

NOTE - The neighboring AP MLD and the current AP MLD are in the same ESS.

### Initial association to the SMD-ME [M#352][M#369]

[M#352](#3912) To perform SMD level association, a non-AP MLD shall initiate association and authentication with the SMD-ME. The SMD element shall be included in the Authentication frame when authenticating with an SMD-ME. The SMD element shall be included in the (Re)Association Request & Response frames when performing initial association with the SMD-ME.

[M#369] As part of performing authentication of a non-AP MLD with the SMD-ME, a single PMKSA shall be established between the non-AP MLD and the SMD-ME using the SMD Identifier. The PMKSA includes an SMD level PMK. [TBD PMK computation details]

[M#378] If the SMD is part of an FT mobility domain, and if the non-AP MLD initially associates with the SMD-ME using FT initial MD association, then the single PMKSA to be used in the SMD shall be a PMK-R1 security association that is bound to the SMD-ME. [TBD PMK-R1 computation details]

[M#369] As part of initial association of a non-AP MLD with the SMD-ME, an SMD level PTK is derived between the non-AP MLD and the SMD-ME using the SMD Identifier. [TBD PTK computation details]

### Target AP MLD selection recommendation [M#364] (#188) (#2000)(#2002)(#2003)(#2004)(#2353)

The current AP MLD may use the BSS transition management procedure (see 11.21.7 (BSS transition management) and 35.3.23 (BSS transition management for MLDs)) [+TBD updates if required] to recommend one or more candidate target AP MLDs within the same SMD (or a different neighboring SMD) to the non-AP MLD, as shown in Figure 37-x2. (TBD – detailed information to be carried in the BTM frames).

A non-AP MLD may send a BTM Query frame (see 11.21.7.2 (BSS transition management query)) to its current AP MLD to request recommendation for candidate target AP MLDs. The current AP MLD shall respond with a BTM Request frame. In addition, the current AP MLD may send an unsolicited BTM Request frame (see 11.21.7.4 (BSS transition management response)) to the non-AP MLD to indicate its recommendation for candidate target AP MLDs for seamless roaming. TBD – detailed information to be carried.



**Figure 37-x2— Candidate selection for target AP MLDs**

### Roaming preparation procedure

#### General

When a non-AP MLD uses seamless roaming to transition from its current AP MLD to a target AP MLD within an SMD, a roaming preparation procedure as shown in Figure 37-x3 may be performed before performing the roaming execution procedure that is described in 37.9.6 (Roaming execution procedure via the current AP MLD) and 37.9.7 (Roaming execution procedure via the target AP MLD). The roaming preparation procedure consists of (#2006)the following to minimize the time during which connectivity between the non-AP MLD and the DS is lost:

* Transfer of the context (see 37.9.7 (Context)) related to the non-AP MLD from its current AP MLD to the target AP MLD or the renegotiation of the context with the target AP MLD. The context that can be transferred or renegotiated in this procedure is defined in 37.9.7 (Context).
* Setting up the link(s) with the target AP MLD as described in 37.9.5.1.



**Figure 37-x3— Seamless roaming preparation and execution procedures**

[M#368](#3922) A non-AP MLD may prepare one or more candidate target AP MLDs within an SMD by sending a separate Link Reconfiguration Request frame (with type set to “Preparation”) for each candidate target AP MLD. If a roaming preparation was successful with one or more candidate target AP MLDs, then the non-AP MLD shall attempt roaming execution with only one of those target AP MLDs at a time. If the attempted roaming execution fails, the non-AP MLD may attempt roaming execution with another prepared AP MLD. (TBD on policy indication from the AP on multiple target AP MLDs preparation).

[Editorial note: TBD “(with type set to…)” will need to be globally replaced later once the actual means to indicate is defined in the actual frame.]

#### Target links preparation

[M#283](#2715) When a non-AP MLD performs the roaming preparation procedure to prepare a target AP MLD, the non-AP MLD shall send a Link Reconfiguration Request frame (with type set to “Preparation”) [M#345](#493)(#2007)(#2009)(#2715)(#3457)(#3892)(#3921)to its current AP MLD. The Link Reconfiguration Request frame shall include the following:

* [M#336](#516) The AP MLD MAC address of a single target AP MLD
* [M#345](#493) The per-STA profile of the links to be set up with the target AP MLD in the Reconfiguration Multi-link element (see 35.3.6.4 (Link reconfiguration to the setup links)).

[M#351](#499) The non-AP MLD shall indicate it in the Link Reconfiguration Request frame if the non-AP MLD requests part of the context not to be transferred as described in 37.9.8 (TBD actual signaling).

[M#337](#517)The non-AP MLD shall include the Listen Interval in the Link Reconfiguration Request frame.

[M#356] The non-AP MLD shall include the Diffie-Hellman Parameter element (see 9.4.2.312 (Diffie-Hellman Parameter element)) in the Link Reconfiguration Request frame if a per-AP MLD TK is used.

After receiving the Link Reconfiguration Request frame (with type set to “Preparation”):

* If the target AP MLD accepts one or more links requested by the non-AP MLD in the Link Reconfiguration Request frame:
  + The target AP MLD shall assign an AID to the non-AP MLD.
  + The target AP MLD shall set up the accepted links at the target AP MLD according to procedures defined in 35.3.6.4 (Link reconfiguration to the setup links) for adding the accepted links [Editorial note: need to capture any exceptions or differences or additional rules with respect to 35.3.6.4].
  + The target AP MLD shall keep the IEEE 802.1X Controlled Port blocked so that general data traffic cannot pass directly between the non-AP MLD and the target AP MLD if the MAC-SAP is at the AP MLD (as opposed to be at the SMD).
  + [M#348] If a per-AP MLD TK is used, the target AP MLD shall derive a new TK with the non-AP MLD as described in 37.9.5.2.
  + The transferable context (see 37.9.8 (Context)) is transferred from the current AP MLD to the target AP MLD.
  + [M#335](#515)(#2790) The non-AP MLD and the target AP MLD shall not modify the setup links unless another preparation is performed.
* The current AP MLD shall send a Link Reconfiguration Response frame [M#345] (#493)(#2007)(#2009)(#2715) (#3457)(#3892)(#3921)to the non-AP MLD and the frame shall include the following:
  + The status (accept/reject) of the requested links for setup at the target AP MLD.
  + The AID assigned to the non-AP MLD by the target AP MLD.
  + [M#356] A Diffie-Hellman Parameter element (see 9.4.2.312 (Diffie-Hellman Parameter element)), if a per-AP MLD TK is used.
* [M#335] (#515) If a Link Reconfiguration Request frame (with type set to “Execution”) from the non-AP MLD requesting seamless roaming to a target AP MLD is not received by the current AP MLD or the target AP MLD within a timeout(#515) value (TBD how to indicate this timeout value to the non-AP MLD), the roaming preparation at the target AP MLD, including setup links, transferred context and newly derived TK if a per-AP MLD TK is used, shall be deleted.

TBD on whether/how the renegotiation of context is performed in these request/response frames.

After receiving a Link Reconfiguration Response frame from the current AP MLD that indicates that the roaming preparation was successfully completed at the target AP MLD:

* [M#348] If a per-AP MLD TK is used, the non-AP MLD shall derive a new TK with the target AP MLD as described in 37.9.5.2.
* [M#337](#514)The non-AP MLD shall be in power-save mode for all the setup links with the target AP MLD as specified in 35.3.6.4 (Link reconfiguration to the setup links).
* [M#335] (#515) The non-AP MLD may initiate roaming execution procedure by sending a Link Reconfiguration Request frame (with type set to “Execution”) requesting the same target AP MLD within the timeout value described above in this subclause.

#### Per-AP MLD TK derivation [M#356]

[Editorial note: this subclause captures how the per-AP MLD TK is derived for the case when a per-AP MLD TK is used.]

[TBD all the key derivation details]

### Roaming execution procedure via the current AP MLD

When a non-AP MLD uses seamless roaming to transition from its current AP MLD to a target AP MLD within an SMD through its current AP MLD, the non-AP MLD shall send a [M#346](#511)(#2017)(#3260)(#3458)(#3929)Link Reconfiguration Request frame (with type set to “Execution” (a new type to be defined in 11bn)) to its current AP MLD (#3893) and shall stop sending UL data frames to its current AP MLD. [M#337](#519)(#518) The Link Reconfiguration Request frame shall include the target AP MLD MAC address. The Link Reconfiguration Request frame shall include the Listen Interval(#517) if it was not included during roaming preparation. [M#346] The Per-STA Profile subelement in the Reconfiguration Multi-Link element may not be present in the Link Reconfiguration Request frame if it was included during roaming preparation.

[M#335](#515) If the current AP MLD receives a Link Reconfiguration Request frame (with type set to “Execution”) within the timeout value(#515) described in 37.9.5.1 (Target links preparation) and the target AP MLD has been prepared for seamless roaming for the non-AP MLD, then:

* The current AP MLD shall transfer any context that is required per37.9.8 (Context) and has not already been transferred to the target AP MLD.
* The target AP MLD may initiate the DS mapping update, if necessary, for the non-AP MLD. The target AP MLD shall unblock the IEEE 802.1X Controlled Port for general data traffic to pass between the non-AP MLD and the target AP MLD.
* [M#351] If the non-AP MLD had requested its current AP MLD not to transfer the next SN for existing DL BA agreement of all TIDs (see 37.9.8 (Context)), the target AP MLD shall reset the SN to 0 for all the DL TIDs before DL traffic delivery from the target AP MLD to the non-AP MLD.
* [M#351] If the non-AP MLD had requested its current AP MLD not to transfer the latest SN that has been passed up for existing UL BA agreement of all TIDs (see 37.9.8 (Context)), the non-AP MLD shall reset the SN to 0 for all the UL TIDs before UL traffic delivery from non-AP MLD to the target AP MLD.
* Once the DLDrainTime has expired or terminated as described in 37.9.9 (DL data transmission)), the target AP MLD shall consider the seamless roaming execution procedure complete (i.e., the non-AP MLD has fully transitioned to the target AP MLD).
* The current AP MLD shall send a [M#346](#511)(#2017)(#3260)(#3458)(#3929)Link Reconfiguration Response frame to the non-AP MLD after the transfer or renegotiation of the context is completed. The current AP MLD shall include the following in the Link Reconfiguration Response frame:
  + [M#338] The value of the DLDrainTime.
  + If it is necessary to initiate the DS mapping update for the non-AP MLD and the target AP MLD has not initiated it, the target AP MLD shall initiate the DS mapping update for the non-AP MLD.
* [#348] If a per-AP MLD TK is used, the target AP MLD shall not reset the PNs for both UL and DL. The PNs keep increasing monotonically when the non-AP MLD roams to the target AP MLD even though the target AP MLD is using a new TK.
* The target AP MLD shall consider the seamless roaming execution procedure has completed if the period of DLDrainTime has passed since the Link Reconfigure Response frame or the non-AP MLD has indicated that the period of DLDrainTime is to be terminated early (i.e., the non-AP MLD has fully transitioned to the target AP MLD).

[M#44] The non-AP MLD shall not transmit Class 3 frames to the target AP MLD until it has received the Link Reconfiguration Response frame from the current AP MLD.

### Roaming execution procedure via the target AP MLD [M#284]

When a non-AP MLD uses seamless roaming to transition from its current AP MLD to a target AP MLD within an SMD through the target AP MLD, the non-AP MLD shall send a Link Reconfiguration Request frame (with type set to “Execution” (a new type to be defined in 11bn)) to the target AP MLD (#3893) and shall stop sending UL data frames to its current AP MLD.

[M#335](#515) If the target AP MLD receives a Link Reconfiguration Request frame (with type set to “Execution”) within the timeout value(#515) directly from the non-AP MLD described in 37.9.5.1 (Target links preparation) and the target AP MLD has been prepared for seamless roaming for that non-AP MLD, then:

* The target AP MLD shall transfer any context from the current AP MLD that is required per 37.9.8 (Context) and has not already been transferred to the target AP MLD.
* The target AP MLD may initiate the DS mapping update, if necessary, for the non-AP MLD. The target AP MLD shall unblock the IEEE 802.1X Controlled Port for general data traffic to pass between the non-AP MLD and the target AP MLD.
* [M#351] If the non-AP MLD had requested its current AP MLD not to transfer the next SN for existing DL BA agreement of all TIDs (see 37.9.8 (Context)), the target AP MLD shall reset the SN to 0 for all the DL TIDs before DL traffic delivery from the target AP MLD to the non-AP MLD.
* [M#351] If the non-AP MLD had requested its current AP MLD not to transfer the latest SN that has been passed up for existing UL BA agreement of all TIDs (see 37.9.8 (Context)), the non-AP MLD shall reset the SN to 0 for all the TIDs before UL traffic delivery from non-AP MLD to the target AP MLD.
* The target AP MLD shall send a Link Reconfiguration Response frame to the non-AP MLD after the transfer or renegotiation of the context is completed. The target AP MLD shall include the following in the Link Reconfiguration Response frame:
  + [M#338] The value of the DLDrainTime (set to 0).
  + If it is necessary to initiate the DS mapping update for the non-AP MLD and the target AP MLD has not initiated it, the target AP MLD shall initiate the DS mapping update for the non-AP MLD.
* [#348] If a per-AP MLD TK is used, the target AP MLD shall not reset the PNs for both UL and DL. The PNs keep increasing monotonically when the non-AP MLD roams to the target AP MLD even though the target AP MLD is using a new TK.
* The target AP MLD shall consider the seamless roaming execution procedure complete (i.e., the non-AP MLD has fully transitioned to the target AP MLD).

The non-AP MLD shall not transmit Class 3 frames (other than the Link Reconfiguration Request frame (with type set to “Execution”)) to the target AP MLD until it has received the Link Reconfiguration Response frame from the target AP MLD.

### Context [M#282]M#354]

The following context can be transferred to the target AP MLD:

* The block ack parameters and block ack timeout value for any block ack agreement on each TID.
* The next SN to be assigned for DL individually addressed data frame of each TID.
* The latest duplicate receiver cache for each TID without block ack agreement.
* The latest SN that has been passed up for each TID with UL block ack agreement.
* The starting PN to be assigned for DL individually addressed frame by the target AP MLD.
* The initial value to be used by each replay counter of the target AP MLD for UL individually addressed frame.
* WinStartO of each existing DL block ack agreement.

NOTE 1 – The WinStartO of each existing DL block ack agreement ensures the target AP MLD does not exceed reordering buffer window of the non-AP MLD.

NOTE 2 – TBD on the agreed buffer size with the target AP MLD.

[M#351] A non-AP MLD may request the following part of the context not to be transferred from its current AP MLD to the target AP MLD and the current AP MLD shall accept such a request:

* The next SN for existing DL block ack agreements.
* The latest SN that has been passed up for existing UL block ack agreements.

### DL data transmission(#3459)

When the non-AP MLD receives a Link Reconfiguration Response frame in response to a Link Reconfiguration Request frame (with type set to “Execution”) sent by the non-AP MLD, if the non-AP MLD receives the individually addressed buffered downlink Data frames from its current AP MLD, [M#338](#520)it may do so for a period of DLDrainTime if the DLDrainTime is greater than 0. During the period of (non-zero) DLDrainTime, the following applies:

* [M#337] The non-AP MLD is not required to listen to any Beacon frames of the APs affiliated with the target AP MLD.
* [M#350] The current AP MLD shall support signaling termination of downlink data transmission to the non-AP MLD before the DLDrainTime ends (actual signaling TBD).

NOTE – AP sends the indication when there is no more pending DL data on any TID. TBD other conditions.

* [M#349] The non-AP MLD may provide an indication to the target AP MLD to indicate that the period of DLDrainTime is to be terminated before the DLDrainTime ends.

### DL data forwarding

As part of seamless roaming, the current AP MLD may forward DL data to the target AP MLD (when and how to initiate the forwarding of DL data is TBD).

**Text to be adopted ends here.**

**References:**

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