IEEE P802.11
Wireless LANs

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| Resolution to CID 127 |
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Abstract

This document proposes decentralized and centralized clustering resolutions to Clustering CID: 127 wrt Draft 0.01 of TGaj.

**Revision History**

R1: Initial version.

R2: Added the CDMG centralized clustering mechanism, including 9.34a.2.2, 9.34a.3.4 and 9.34a.3.5.

R3:Changed the description on the usage of the 3 new elements to show that they can be included in the Announce frame. Inserted the 3 new rows into the Table 8-281af. Added a rule that the PCPs or APs involved in a synchronization pair can exchange their roles. Modified the definition of Cluster Switch Announcement element. Added a paragraph on how the Dynamic Bandwidth Control field is used in the clustering mechanism. Modified the channel monitoring rule that the S-PCP/S-AP should follow before performing the cluster coordination function.

R4: Fixed some typos.

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| --- | --- | --- | --- | --- | --- | --- | --- |
| 127 | Khiam Boon Png |  | 20 |  | In Section 9.40, a dynamic bandwidth control for the new 11aj channels is proposed. Within this dynamic bandwidth control structure, will clustering be supported in the new 1.08 GHz bandwidth 11aj channels? If yes, how will the clustering operate keeping in mind the requirement of backward compatibility. In particular, how does a 11aj device start a cluster started in a 1.08 GHz channel or join as a member-PCP/AP? Also, how would a 1.08 GHz cluster merge with another 1.08 GHz cluster or 2.16 GHz cluster and vice verse when they move together? | Backward compatibility on clustering mechanism in 11aj channel should be specified. | Revised.  |

***Discussion:***

CID 127 provides comments about PCP or AP clustering mechanism in IEEE 802.11aj. This proposal is intended to address and resolve the comments with adoption/revision to the suggestions.

***Proposed Resolution:***

*Insert the following subclause, 9.34a, after 9.34:*

**9.34a CDMG PCP or AP clustering**

**9.34a.1 General**

A CDMG PCP or AP may use the CDMG PCP or AP clustering mechanism to improve spatial sharing and interference mitigation with other co-channel CDMG or DMG BSSs.

A clustering enabled PCP or AP operating on a 2.16 GHz channel or a 1.08 GHz channel under the second mode of DBC mechanism (9.40) is able to start a decentralized PCP or AP cluster or a centralized PCP or AP cluster on a 2.16 GHz channel following the rules as described in 9.34.

A clustering enabled PCP or AP operating on a 1.08 GHz channel under the first mode of DBC mechanism is able to start a PCP or AP cluster on a 1.08 GHz channel, which follows the rules defined in 9.34 and in this subclause.

If a PCP or AP cluster starts on a 1.08 GHz channel, the S-PCP or S-AP shall not only transmit its DMG Beacon frame during the first Beacon SP (9.34.1) on this 1.08 GHz channel but also transmit the DMG Beacon frame during the notification period (NP) of each allocated quiet period (QP) on the corresponding 2.16 GHz common channel as described in 9.40. Moreover, according to the rules in 9.40, the S-PCP or S-AP shall set its beacon interval on 2.16 GHz common channel as an integer multiple of the beacon interval on 1.08 GHz channel in terms of TUs, and the maximum length of beacon interval on 1.08 GHz channel can be given as the same length of the beacon interval on 2.16 GHz channel.

The member PCP or AP of a cluster starting on a 1.08 GHz channel shall not allocate QP on 2.16 GHz common channel to transmit its DMG Beacon frame if there is no legacy DMG non-AP or non-PCP STA within its BSS or it does not involve in a synchronization pair with another PCP or AP operating in the adjacent 1.08 GHz channel. Otherwise, the member PCP or AP shall transmit its DMG Beacon frame during its NP of the allocated QP on 2.16 GHz common channel, similar to the S-PCP or S-AP.

**9.34a.2 Cluster formation**

**9.34a.2.1 Decentralized CDMG PCP or AP cluster formation**

A decentralized clustering enabled PCP or AP starts a decentralized PCP or AP cluster on a 1.08 GHz channel by becoming an S-PCP or S-AP, subject to the absence of existing clusters on this 1.08 GHz channel as described below and in 9.34.2.1.

The S-PCP or S-AP of a PCP or AP cluster starting on a 1.08 GHz channel should follow the rules defined in 9.34.2.1 to set the DMG Parameters field and the Clustering Control field and also set the first bit of Clustering Status subfield contained in the Dynamic Bandwidth Control element to 1.

A decentralized clustering enabled PCP or AP that receives a DMG Beacon frame from an S-PCP or S-AP on either a 2.16 GHz channel or a 1.08 GHz channel shall know the exact channel on which this S-PCP or S-AP selects to start a cluster through the Channel Splitting subfield, Clustering Status subfield and the Channel Number field contained in the Dynamic Bandwidth Control element.

If an existing cluster starts on a 2.16 GHz channel, the decentralized clustering enabled PCP or AP shall monitor the corresponding 2.16 GHz channel and then follow the procedures defined in 9.34.2.1 to become a member PCP or member AP of this cluster.

If a DMG Beacon frame containing the Cluster Control field is received from an S-PCP or S-AP on a 1.08 GHz channel, the decentralized clustering enabled PCP or AP shall monitor the corresponding 1.08 GHz channel during each Beacon SP to listen whether the Beacon SP is occupied by other member PCP or AP. If an empty Beacon SP is discovered, the PCP or AP shall follow the same procedures defined in 9.34.2.1 to become a member PCP or member AP of this cluster.

A decentralized clustering enabled PCP or AP shall not become a member of a cluster starting on a 1.08 GHz channel if no Beacon SP is determined to be empty during aMinChannelTime, in which case, subject to the requirements described in 9.34.2.1, then the PCP or AP may become the S-PCP or S-AP of a new cluster, or may cease its activity on this 1.08 GHz channel, or may request to operate on the unoccupied adjacent 1.08 GHz channel within the 2.16 GHz common channel (9.40.2.3), and, if desired, attempt operation on a different 2.16 GHz or 1.08 GHz channel.

The PCP or AP of a decentralized PCP or AP cluster should not transmit or schedule transmissions during a Beacon SP that is not its own Beacon SP and a QP duration that is not its own QP.

Figure 9-47a illustrates an example of a decentralized PCP or AP cluster starting on the 1.08 GHz Channel 5 while the adjacent 1.08 GHz Channel 6 is unoccupied. The S-PCP or S-AP and member PCP or AP 3 with a BSS in which there is at least one DMG STA transmit DMG Beacon frames during the NPs of the allocated QPs on the 2.16 GHz channel 2 and their own Beacon SPs on channel 5, respectively. Other member PCPs or member APs transmit DMG Beacon frames only during their own Beacon SPs on channel 5.



Figure 9-47a Example of a decentralized PCP OR AP cluster on a 1.08 GHz channel

Figure 9-47b illustrates an example of two decentralized PCP or AP clusters starting on two adjacent 1.08 GHz Channel 5 and Channel 6, respectively. Two S-PCPs or S-APs form a synchronization pair under the first mode of DBC mechanism (9.40) and transmit DMG Beacon frames during their own NPs of the allocated QPs on the 2.16 GHz channel 2 and the Beacon SPs on the 1.08 GHz channel 5 and channel 6, respectively. Other member PCPs or member APs transmit DMG Beacon frames only during their own Beacon SPs on the corresponding 1.08 GHz channels.



Figure 9-47b Example of decentralized clusters for two PCPs/APs of a synchronization pair

The member PCP or member AP operating on a 1.08GHz channel shall select a beacon interval length on the 1.08 GHz channel that is equal to the beacon interval length of its S-PCP or S-AP on the same channel.

If a member PCP or member AP does not involve in a synchronization pair with another PCP or AP (9.40.2.3), it shall set the beacon interval length on 2.16 GHz channel as an integer multiple of its beacon interval length on 1.08 GHz channel. Otherwise, if the member PCP or member AP has involved in a synchronization pair with another PCP or AP operating in the adjacent 1.08 GHz channel, it shall adjust its beacon interval length on 2.16 GHz channel as an integer multiple of its beacon interval length on 1.08 GHz channels and also notify the neighbouring PCP or AP that is involved in the synchronization pair to adjust the beacon interval on 2.16 GHz channel as the same value through a DMG BSS Parameter Change element within the DMG Beacon frame transmitted in its NP of the allocated QP on the 2.16 GHz common channel following the rules in 10.30.3. In this case, subject to the requirement described in 9.40, the neighbouring PCP or AP may further adjust its beacon interval on 1.08 GHz channel as an integer factor of the new interval length on 2.16 GHz channel in terms of TUs. The procedures of adjusting BI and SBBI for PCP or AP 1 and PCP or AP 2 that has involved in a synchronization pair should be as follows:

a) If PCP or AP 1 detected an empty Beacon SP on 1.08 GHz channel, PCP or AP 1 should change the current beacon interval length BI 1 to BI 2 on 2.16GHz channel, to align the beginning of the first BTI on 1.08GHz channel after BI 2 duration with the beginning of the empty Beacon SP.

b) If the ratio of BI2 divided by SBBI of the S-PCP or S-AP is an integer, PCP or AP 1 should adjust SBBI 1 to equal to SBBI of the S-PCP or S-AP; otherwise, PCP or AP 1 shall change its beacon interval length BI 2 to BI 3 on 2.16GHz channel during its next NP 1 and set its SBBI 1 to the SBBI of S-PCP or S-AP during BTI, to make the ratio of BI 3 divided by SBBI of the S-PCP or S-AP is an integer. PCP or AP 2 should also adjust its SBBI 2, to make the ratio of BI 3 divided by SBBI 2 is an integer.

c) PCP or AP 1 transmits the DMG Beacon frame including the Clustering Control field during the empty Beacon SP on the 1.08GHz channel, to join the intended 1.08GHz cluster as a member PCP or AP.

An example of adjusting BI and SBBI for step a) and b) is illustrated in Figure 9-47c.



Figure 9-47c Example of joining the CDMG PCP or AP cluster for a CDMG PCP or AP involved in a synchronization pair with another PCP or AP

If a PCP or AP involved in a synchronization pair is a synchronized PCP or AP and intends to join to a co-channel PCP or AP cluster, it shall set the PCP/AP Role subfield within the Dynamic Bandwidth Control element to 0, in order to exchange the role with the synchronizing PCP or AP before joining the co-channel cluster. In case when the PCP/AP Role subfield value is changed, the synchronized PCP or AP shall include the Cluster Switch Announcement element in the DMG Beacon frame to indicate the time that the PCP/AP role exchange occurs.

If a PCP or AP that is involved in a synchronization pair intends to join a discovered cluster or intends to start a cluster on the 2.16 GHz common channel, it should send a Cluster Switch Announcement element included in the DMG Beacon frame during its NP, to notify the peer PCP or AP involved in the synchronization pair to join the cluster on 2.16 GHz channel. After the Cluster Switch Announcement element is transmitted, the PCP or AP should cease transmission during its NP.

In case when a decentralized clustering enabled PCP or AP operating on 1.08 GHz channel receives a DMG Beacon frame that contains the clustering control information fields in the Cluster Switch Announcement element from its neighbouring PCP or AP of a synchronization pair to indicate the presence of a cluster on the 2.16 GHz common channel, it may monitor this 2.16 GHz channel to become a member PCP or member AP following the procedures described in 9.34.2.1.

In case when a decentralized clustering enabled PCP or AP operating on a 1.08 GHz channel still experiences poor channel conditions after performing all the actions in an attempt to mitigate any interference, it may broadcast one or more Cluster Probe elements using the DMG Beacon frame or Probe Request frame to detect the presence of a cluster actively on the 2.16 GHz common channel during its NPs, SPs or CBAPs.

The S-PCP or S-AP that is operating on the 2.16 GHz common channel and receives a Cluster Probe element shall respond with a Probe Response frame including an Extended Cluster Report element to indicate its presence. After receiving a Probe Response frame from an S-PCP or S-AP, the decentralized clustering enabled PCP or AP may switch to the 2.16 GHz common channel and discover an empty Beacon SP to become a member PCP or member AP of this cluster following the procedures described in 9.34.2.1.

If the decentralized clustering enabled PCP or AP does not receive a Probe Response frame from an S-PCP or S-AP, it may try again in the following NPs, SPs or CBAPs.

**9.34a.2.2 Centralized CDMG PCP or AP cluster formation**

In order to become an S-AP, a centralized clustering enabled CDMG STA that is operating on a 2.16GHz channel or a 1.08GHz channel and is stationary with respect to its local environment shall successfully perform both the configuration step and verification step in order and take the actions following the rules as described in 9.34.2.2.

If at least one DMG Beacon frame that has the ECPAC Policy Enforced field set to 1 and was sent by an S-AP or member PCP or member AP from another ECPAC is received during the monitoring period, the centralized clustering enabled CDMG STA shall follow the rules as described in 9.34.2.2.

The remaining available channels for a centralized CDMG PCP or AP cluster are channel 3, 7 and 8. Channel 2, 5 and 6 are the channels upon which the S-AP is excluded from operating. The channels 3, 7, 8 that interfere with each other form a channel set. The channel set available for a centralized CDMG PCP or AP cluster is channel {3, 7, 8}.

The functions of a CDMG CCSR shall cover the channel set. The CDMG CCSR shall provide coordination services for all the S-APs operating on the channels of the channel set {3, 7, 8} within the CCSS to minimize interference. The CDMG CCSR should provide an S-AP with the cluster information of other S-APs. Thus, each S-AP operating on a channel within the channel set can obtain the same cluster information from the CDMG CCSR.

After receiving a DMG Beacon frame including cluster information transmitted by an S-AP, a centralized cluster enabled PCP or AP that intends to become a member PCP or AP shall successfully perform the following steps in order:

* 1. The PCP or AP shall monitor the channel for DMG Beacon frames during each Beacon SP over an interval of length at least aMinChannelTime to find an empty Beacon SP and measure the signal quality of the received DMG Beacon frames.
	2. The second non-PCP/non-AP STA shall attempt to associate with the S-AP and thereby receive an Announce frame from the S-AP. The contents of the Announce frame are passed to the PCP or AP. All the centralized cluster information of the S-APs operating on the channels in the same channel set except the current S-AP shall be included in the Announce frame. The cluster information of the other S-APs can be conveyed in Extended Cluster Report elements.
	3. The CDMG PCP or AP should determine whether to join the current cluster based on the signal quality of the S-AP or the member PCPs/APs of the current cluster. If the PCP or AP elects to join the current cluster, proceed to step d); otherwise, the PCP or AP monitors the channels for DMG Beacon frames during each Beacon SP of all the centralized clusters over an interval of length at least aMinChannelTime using the cluster information from the current S-AP. The CDMG PCP or AP may determine an intended cluster based on the signal quality of the DMG Beacon frames of the other clusters. The second non-PCP/non-AP STA shall disassociate with the current S-AP and associate with the S-AP of the intended cluster, receive the Announce frame from the S-AP and pass the contents of the Announce frame to the PCP or AP.
	4. Upon receiving an Announce frame that includes the ECPAC Policy element, the PCP or AP shall select a Cluster Time Offset index from the intersection of 1) the Cluster Time Offset indices of the empty Beacon SPs with 2) the indices indicated by the Available Cluster Offset Bitmap field in the ECPAC Policy element. If the intersection is empty, the PCP or AP shall select a Cluster Time Offset index of an empty Beacon SP. The selected Cluster Time Offset index is passed to the second non-PCP/non-AP STA.
	5. The second non-PCP/non-AP STA shall respond to the Announce frame with an Information Response frame that includes the Cluster Time Offset element containing the Cluster Time Offset Index set to the selected index.
	6. The PCP or AP shall operate its BSS at the selected Cluster Time Offset on the channel of the S-AP and include the PCP or AP clustering control field in transmitted DMG Beacon frames.

After joining the centralized PCP or AP cluster, the CDMG member PCP or AP shall transmit its DMG Beacon frames and include the ECPAC Policy element in (Re)Association Response, Announce, and Information Response frames following the rules as described in 9.34.2.2.

**9.34a.3 Cluster maintenance**

**9.34a.3.1 General cluster maintenance**

Regardless of whether a cluster starts on a 2.16 GHz channel or a 1.08 GHz channel, the member PCP or member AP is able to maintain synchronization with the S-PCP or S-AP and other member PCPs or member APs through receiving DMG Beacon frames from the S-PCP or S-AP on this channel.

If a PCP or AP cluster starts on a 1.08 GHz channel and the PCP or AP of this cluster involves in a synchronization pair with another PCP or AP operating in the adjacent 1.08 GHz channel at the same time, this pair of PCPs or APs shall also maintain synchronization according to the rules described in 9.40 unless one of them ceases its BSS.

**9.34a.3.2 Decentralized CDMG PCP or AP cluster maintenance**

In the case when the S-PCP or S-AP of a decentralized PCP or AP cluster on 1.08 GHz channel is lost, or appears to a member PCP or member AP to have been lost, the S-PCP or S-AP handover procedures shall follow the rules in 9.34.3.2. In addition, the new S-PCP or S-AP shall also transmit DMG Beacon frame during its NP of the allocated QP on the 2.16 GHz common channel as described in 9.40.5, even if there is no legacy DMG non-AP or non-PCP STA within its BSS or it does not involve in a synchronization pair with another PCP or AP operating in the adjacent 1.08 GHz channel.

The S-PCP or S-AP of a decentralized PCP or AP cluster detects the presence of the S-PCP or S-AP of another decentralized PCP or AP cluster through receiving a DMG Beacon frame on either a 2.16 GHz channel or a 1.08 GHz channel or receiving a Probe Response frame including the Extended Cluster Report element on a 2.16 GHz channel with the DBC Present field equal to 1 and the Channel Splitting subfield equal to 1, it should become a member PCP or AP of the other cluster on the corresponding channel according to the procedures described in 9.34a.2 if the value of its Adjacent Channel Occupancy subfield, Clustering Status subfield and the Synchronizing PCP/ AP MAC Address subfield in Dynamic Bandwidth Control element is higher than that of the other S-PCP or S-AP.

The S-PCP or S-AP of a decentralized PCP or AP cluster detects the presence of the S-PCP or S-AP of another decentralized PCP or AP cluster through receiving a DMG Beacon frame on either a 2.16 GHz channel or a 1.08 GHz channel or receiving a Probe Response frame including the Extended Cluster Report element on a 2.16 GHz channel with the DBC Present field equal to 1 and the Channel Splitting subfield equal to 0, it should become a member PCP or AP of the other cluster on the corresponding channel according to the procedures described in 9.34a.2 if the value of its Channel Splitting subfield is equal to 1 or the value of its Channel Splitting subfield is equal to 0, but the MAC Address is higher than that of the other S-PCP or S-AP.

The S-PCP or S-AP of a decentralized PCP or AP cluster detects the presence of the DMG S-PCP or S-AP of another decentralized PCP or AP cluster through receiving a DMG Beacon frame on a 2.16 GHz channel with the DBC Present field set to 0, it should become a member PCP or AP of the other cluster on this 2.16 GHz channel according to the procedures described in 9.34.2 if its MAC address is higher than that of the other DMG S-PCP or S-AP.

If the S-PCP or S-AP operating on a 1.08 GHz channel detects the presence of the S-PCP or S-AP of another decentralized PCP or AP cluster starting on the 2.16 GHz common channel and intends to become a member PCP or member AP of the other cluster, it may transmit DMG Beacon frame containing the Cluster Switch Announcement element to its member APs or member PCPs before it switches to the 2.16 GHz common channel. After that, the S-PCP or S-AP may continue transmitting DMG Beacon frames on the 1.08GHz channel within a time period of (aMinBTIPeriod × BI + aMinChannelTime) to maintain the time reference for the cluster, where BI equals to Reported BI Duration field in the Cluster Switch Announcement element. And then it shall monitor the 1.08GHz channel for DMG Beacon frames within the next time interval of (aMinChannelTime + SBBI) , where SBBI is its beacon interval on the 1.08GHz channel.

If no DMG Beacon frames are received over the monitoring period, the S-PCP or S-AP shall cease operation on the 1.08GHz channel. Otherwise, it may use the cluster coordination mechanism described in 9.34a.3.3 to mitigate interference between the cluster operating on the 1.08GHz channel and the cluster operating on the 2.16GHz common channel.

Upon receiving a DMG Beacon frame including Cluster Switch Announcement element on a 1.08GHz channel, a member PCP or AP should switch to the corresponding 2.16GHz common channel to become a member PCP or AP of the cluster operating on this 2.16GHz channel following the procedure described in 9.34.2.1. If the PCP or AP can not detects the presence of the S-PCP or S-AP of another decentralized PCP or AP cluster operating on the 2.16GHz channel or can not discover an empty Beacon SP, it should switch back to the former 1.08GHz channel. After that, the decentralized clustering enabled PCP or AP may monitor this 1.08GHz channel and follow the same procedures defined in 9.34.2.1 to become a member PCP or AP of the cluster corresponding to the former S-PCP or S-AP or start an S-PCP or S-AP handover process according to 9.34.3.2.

**9.34a.3.3 Cluster coordination**

Cluster coordination mechanism allows a CDMG S-PCP or S-AP of a decentralized cluster operating on the 1.08 GHz channel to be a member PCP (or member AP) or S-PCP (or S-AP) of a decentralized cluster operating on the 2.16 GHz channel simultaneously by transmitting and receiving DMG Beacon frames within both clusters. By this means, cluster synchronization and control information can be exchanged to mitigate interference and improve spatial sharing.

In the case when a decentralized clustering enabled CDMG PCP or AP using cluster coordination mechanism, it shall maintain schedule information for both clusters (i.e., beacon intervals, Beacon SPs or SPs) to switch alternatively between the 1.08GHz channel and 2.16GHz channel. For example, it should switch to the 2.16GHz channel prior to a Beacon SP allocated on the 2.16GHz channel and transmit or receive DMG Beacon frames.

The decentralized clustering enabled CDMG PCP or AP using cluster coordination mechanism should schedule at least one SP within the cluster operating on the 2.16GHz channel that has source and destination DMG AIDs set to 255 and allocation type set to 2 indicating Beacon SP1 of the cluster operating on the 1.08GHz channel. In addition, it may schedule more SPs indicating other nonempty Beacon SPs of the cluster operating on the 1.08GHz channel.

As being an S-PCP or S-AP of the cluster operating on the 1.08GHz channel, the PCP or AP using coordination mechanism shall adjust its TBTT, thus avoid overlapping to any Beacon SP of the cluster operating on the 2.16GHz channel. In addition, it should schedule multiple SPs within the cluster operating on the 1.08GHz channel that has source and destination DMG AIDs set to 255 and allocation type set to 0 indicating the schedule information of a nonempty Beacon SPn of the cluster operating on the 2.16GHz channel.

If a member PCP or AP of a cluster operating on the 1.08 GHz channel receives an Extended Schedule element from an S-PCP or S-AP with the same Cluster ID, which includes at least one Allocation field with the allocation type subfield set to 0 and the source and destination AID subfields set to 255, it may switch to the 2.16 GHz channel according to the schedule information in an attempt to receive a DMG Beacon frame.

**9.34a.3.4 Centralized CDMG PCP or AP cluster maintenance**

In the case when the S-PCP or S-AP of a centralized PCP or AP cluster on 1.08 GHz channel is lost, or appears to a member PCP or member AP to have been lost, the S-AP handover procedures shall follow the rules in 9.34.3.3. In addition, the new S-PCP or S-AP shall also transmit DMG Beacon frame during its NP of the allocated QP on the 2.16 GHz common channel as described in 9.40.5, even if there is no legacy DMG non-AP or non-PCP STA within its BSS or it does not involve in a synchronization pair with another PCP or AP operating on the adjacent 1.08 GHz channel.

If a CDMG CCSR detects that a new S-AP that is joining the CCSS is a DMG AP or a CDMG AP operating on the 2.16GHz channel and there is at least one S-AP operating on a 1.08GHz channel in its CCSS, the CDMG CCSR shall announce the cluster information including the cluster ID, cluster synchronization and control information, channel number of the new S-AP operating the 2.16GHz common channel to each S-AP operating on 1.08GHz channel, in order to facilitate the detection of the presence of the new S-AP for the S-APs operating on 1.08GHz channel.

If a CDMG S-AP operating on a 1.08GHz channel receives the cluster information of the new S-AP operating on 2.16 GHz channel from the CCSR, it should measure the state and the signal quality of each Beacon SP and determine whether to join the centralized cluster of the new S-AP based on the state or signal quality of each Beacon SP.

The S-AP shall broadcast the cluster information of the new S-AP to all the member PCPs or APs in its centralized cluster using the Extended Cluster Report element. The member PCPs or APs on the 1.08GHz channels should determine whether to join the centralized cluster of the new S-AP based on the cluster information and the monitoring results of the new S-AP operating on the 2.16GHz channel.

If an S-AP or a member PCP or AP operating on 1.08GHz channel decides to join the centralized cluster of the new S-AP operating on 2.16GHz channel, the S-AP or member PCP or AP shall transmit a Cluster Switch Announcement element to all its cluster members, to broadcast the cluster information and its cluster switching determination to all the member PCPs or APs in the centralized cluster. The remaining member PCPs or APs can update Available Cluster Offset Bitmap by using the Cluster Switch Announcement element transmitted by a member PCP or AP.

**9.34a.3.5 Centralized CDMG PCP/AP cluster MAC requirements**

Centralized CDMG PCP/AP cluster MAC requirements shall follow the rules described in 9.34.3.4.

**9.34a.4 Cluster report and re-scheduling**

Regardless of whether a PCP or AP cluster starts on a 2.16 GHz channel or a 1.08 GHz channel, the cluster report and re-scheduling follow the rules defined in 9.34.4.

In case when the PCP or AP operating on a 1.08 GHz channel still experiences poor channel conditions after performing all the actions in an attempt to mitigate any interference, it may send a Information Request frame to one of non-AP or non-PCP STAs within its BSS to monitor the corresponding 2.16 GHz common channel for a Cluster Monitoring Period defined in 9.34.3.2. The non-PCP or non-AP STA that receives a DMG Beacon frame on the 2.16 GHz common channel shall report the monitoring results through sending a Cluster Report element contained in an Announce or Information Response frame to the PCP or AP if the received DMG Beacon frame meets the conditions given in 9.34.4.

Upon receiving a Cluster Report element from the non-PCP or non-AP STA with the Cluster Report field set to 1 and the Cluster Channel Number field set to 0, a decentralized cluster enabled PCP or AP may re-schedule SPs and CBAPs in its beacon interval, move the BTI if the clustering enabled PCP or AP is an S-PCP or S-AP in a decentralized PCP or AP cluster, or change the Cluster Time Offset if the clustering enabled PCP or AP is a member PCP or AP, or perform other actions, in an attempt to mitigate any interference with the transmissions indicated in the received Cluster Report element. The PCP or AP may also create SPs in its beacon interval with the source and destination AID set to 255 to prevent transmissions during specific periods in the beacon interval. In addition, the PCP/AP can reserve one or more SPs in DTI based on the clustering synchronization and control information included in the Cluster Report element, to identify whether there is an empty Beacon SP of the decentralized cluster operating on the channel indicated by the Cluster Channel Number field.

Upon receiving a Cluster Report element from a non-PCP or non-AP STA with the Cluster Report field set to 1 and the Cluster Channel Number field set to 0, a clustering enabled PCP or AP that is either a S-PCP or S-AP or a member PCP or member AP may switch to the corresponding 2.16 GHz common channel and discover an empty Beacon SP to become a member PCP or member AP of this cluster following the procedures described in 9.34a.3.2. The PCP or AP should also broadcast a DMG Beacon frame containing the Cluster Switch Announcement element to other PCPs or APs of the same cluster before it switches to the 2.16 GHz common channel.

**9.34a.5 Decentralized PCP or AP cluster request**

Regardless of whether a BSS starts on a 2.16 GHz channel or a 1.08 GHz channel, the cluster request follows the rules defined in 9.34.4.

To request PCP or AP clustering to be enabled in the BSS, the STA shall transmit a Cluster Report element with the Cluster request subfield set to 1 to its PCP or AP. Upon receiving a Cluster Report element with the Cluster request subfield set to 1, the PCP or AP should form and maintain decentralized PCP or AP clustering in the BSS according to the procedures described in 9.34.2, 9.34.3, 9.34a.2 and 9.34a.3.

*Insert the following subclauses, 8.4.2.160，8.4.2.161 and 8.4.2.161, after 8.4.2.159:*

**8.4.2.160 Cluster Probe element**

The Cluster Probe element is used to probe the presence of a CDMG PCP or AP cluster operating on the common 2.16GHz channel by the CDMG PCP or AP operating on a 1.08GHz channel. The Cluster Probe element contains timing information for the CDMG S-PCP/S-AP to transmit Probe Response frame for the Cluster Probe element. This element defines a sequence of SPs that are scheduled by both the cluster probe requester PCP or AP and responder PCP or AP for receiving and transmitting the response frames. This element can be included in the DMG Beacon frame, Announce frame and the Probe Request frame. The Cluster Probe element is shown in Figure 8-401bp.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Element ID  | Length  | Request Token  | SP Offset  |  SP Space  |  SP Duration  | Repetition Count  |
| Octets  | 1 | 1 | 2 | 2 | 4 | 2 | 1 |

Figure 8-401bp—Cluster Probe element format

The Element ID field is equal to the value for the Cluster Probe, specified in Table 8-54.

The Length field is set to 11.

The Request Token field is set to a nonzero value chosen by the requester PCP or AP.

The SP Offset field is set to the offset of the start of the first SP from the frame that contains this element, expressed in TUs. The reference time is the start of the preamble of the PPDU that contains this element.

The SP interval field is set to the spacing between the start of two consecutive SP intervals, expressed in TUs.

The SP Duration field is set to duration of a single SP, expressed in TUs.

The Repetition Count field is set to the number of requested SPs.

**8.4.2.161 Extended Cluster Report element**

The Extended Cluster Report element is used to report the cluster synchronization and control information to the cluster probe requester CDMG PCP or AP by the S-PCP/S-AP of a CDMG PCP or AP cluster. The Extended Cluster Report element is also used by an S-AP to report the cluster information of the S-APs within the same CCSS for a PCP or AP that intends to join the centralized cluster. This element can be included in the DMG Beacon frame, Announce frame and the Probe Response frame. The Extended Cluster Report element is shown in Figure 8-401bq.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Element ID | Length | Extended Cluster Report Control | Request Token | Next BTI Offset | Reported Clustering Control | Reported BI Duration | Cluster Channel Number | Available Cluster Offset Bitmap |
| Octets  | 1 | 1 | 1 | 0 or 2 | 4 | 8 | 0 or 2 | 0 or 1 | 0 or 4 |

Figure 8-401bq—Extended Cluster Report element format

The Element ID field is equal to the value for the Extended Cluster Report, specified in Table 8-54.

The Length field for this element indicates the length of the Information field.

If the Extended Cluster Report Control field is set to 0, this element is used in decentralized clustering mechanism, and the Reported BI duration, Cluster Channel Number and Available Cluster Offset Bitmap fields are not present in this element. Otherwise, this element is used in centralized clustering mechanism, and the Request Token field is not present in this element.

The Request Token field value is copied from the corresponding received Cluster Probe element.

The Next BTI field contains the low-order 4 octets of the TSF for the earliest time at which the next BTI in a subsequent beacon interval starts.

The Reported Clustering Control field is defined in 8.3.4.1 and contains the Clustering Control field in the last transmitted DMG Beacon frame of the S-PCP or S-AP or the reported S-AP.

The Reported BI Duration field is set to the BI value of the reported S-AP, expressed in TUs.

The Cluster Channel Number field is set to the operating channel number of the reported S-AP.

The Available Cluster Time Offset Bitmap field is set to the Available Cluster Time Offset Bitmap field of the ECPAC Policy element.

The Extended Cluster Report element can be included in the Probe Response, DMG Beacon frames.

**8.4.2.162 Cluster Switch Announcement element**

A CDMG PCP or AP should transmit the Cluster Switch Announcement element to its original cluster before switching from a cluster to another. One of the synchronization pair PCPs or APs should also transmit the Cluster Switch Announcement element to its peer CDMG PCP or AP before joining a cluster. The Cluster Switch Announcement element can be included in the DMG Beacon frame or the Announce frame, thus can be received by other member PCPs or APs. The format of the Cluster Switch Announcement element is shown in Figure 8-401br.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Element ID | Length | New Channel Number | Reference Timestamp | Reported Clustering Control | Reported BI Duration | Cluster Switch Count |
| Octets  | 1 | 1 | 1 | 4 | 8 | 2 | 1 |

Figure 8-401br—Cluster Switch Announcement element format

The Element ID field is equal to the value for the Cluster Switch Announcement, specified in Table 8-54.

The Length field is set to 16.

The New Channel Number is set to the operating channel number of the target cluster after cluster switching.

The Reference Timestamp field contains the lower 4 octets of the TSF timer value sampled at the instant that the STA’s MAC received the DMG Beacon frame of the S-PCP or S-AP of the target cluster.

The Reported Cluster Control field contains the Cluster Control field included in the received DMG Beacon frame of the S-PCP or S-AP.

The Reported BI Duration field is set to the BI value of the reported S-PCP or S-AP, expressed in TUs.

The Cluster Switch Count field either is set to the number of TBTTs until the PCP/AP sending the Cluster Switch Announcement element switches to the new cluster or is set to 0. A value of 1 indicates that the switch occurs immediately before the next TBTT. A value of 0 indicates that the switch occurs at any time after the frame containing the element is transmitted.

**8.4.2.149 Cluster Report element**

*Change the Figure 8-401ay as following:*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0 | B1 | B2 | B3 | B4 | B5 | B6 B7 |
|  | Cluster Request | Cluster Report | Schedule Present | TSCONSTPresent | ECPAC Policy Enforced | ECPAC Policy Present | Cluster Channel Number |
| Bits | 1 | 1 | 1 | 1 | 1 | 1 | 2 |

Figure 8-401ay—Cluster Control field format

*Insert the following paragraph after the sixth paragraph below Figure 8-401ay:*

The Cluster Channel Number field is set to 0 to indicate the operating channel of the reported cluster is the common 2.16GHz channel; It is set to 1 to indicate the operating channel of the reported PCP or AP cluster is the low frequency 1.08GHz channel 5 or 7; It is set to 2 to indicate the operating channel of the reported PCP or AP cluster is the high frequency 1.08GHz channel 6 or 8; the value 3 is reserved.

*Insert the 3 new rows into the Table 8-33a before the Last–n row:*

Table 8-33a – DMG Beacon frame body

|  |  |  |
| --- | --- | --- |
| **Order** | **Information** | **Notes** |
| … | … | … |
| 13 | Multi-band | The Multi-band element is optionally present if dot11MultibandImplemented is true. |
| ANA | Cluster Probe | The Cluster Probe element is optionally present if dot11ClusteringActivated is true. |
| ANA | Extended Cluster Report | The Extended Cluster Report element is optionally present if dot11ClusteringActivated is true. |
| ANA | Cluster Switch Announcement  | The Cluster Switch Announcement element is optionally present if dot11ClusteringActivated is true. |
| Last - *n* | One or more elements can appear in this frame. These elements follow all other elements that are not vendor-specific elements and precede all other elements that are vendor-specific elements that are part of the Last field in the frame. Except for the Multi-band element, an element can be included only once in the frame. | Optional |
| last | Vendor Specific | One or more vendor-specific elements are optionally present. These elements follow all other elements. |

*Insert the 3 new rows into the Table* 8-281af *before the Last–n row:*

Table 8-281af—Announce frame Action field format

|  |  |
| --- | --- |
| **Order**  | **Information** |
| 1 | Category |
| … | … |
| 12 | Multi-band (optional) |
| ANA | Cluster Probe (optional) |
| ANA | Extended Cluster Report (optional) |
| ANA | Cluster Switch Announcement (optional) |
| Last - n | Multiple elements can appear in this frame. These elements follow all other elements that are not vendor-specific elements and precede all other elements that are vendor-specific elements. |
| Last | Vendor Specific (optional) |

*Insert the new row into the table before the Last–l row:*

**Table 8-26 – Probe Request frame body**

|  |  |  |
| --- | --- | --- |
| **Order** | **Information** | **Notes** |
| … | … | … |
| 2 | Supported Rates | This field is not present if dot11DMGOptionImplemented is true.  |
| 3 | Request information | The Request element is optionally present if dot11MultiDomainCapabilityActivated is true. |
| 4 | Extended Supported Rates | The Extended Supported Rates element is present if there are more than eight supported rates, and is optionally present otherwise. This element is not present if dot11DMGOptionImplemented is true. |
| … | … | … |
| 14 | Multi-band | The Multi-band element is optionally present if dot11MultibandImplemented is true. |
| 15 | DMG Capabilities | The DMG Capabilities element is present if dot11DMGOptionImplemented is true.  |
| 16 | Multiple MAC Sublayers | The Multiple MAC Sublayers element is present if dot11MultipleMACActivated is true. |
| ANA | Cluster Probe | The Cluster Probe element is optionally present if dot11ClusteringActivated is true. |

*Insert the new rows into Table 8-27 before the Last–l row:*

**Table 8-27 – Probe Response frame body**

|  |  |  |
| --- | --- | --- |
| **Order** | **Information** | **Notes** |
| … | … | … |
| 5 | Supported Rates | This field is not present if dot11DMGOptionImplemented is true.  |
| … | … | … |
| 19 | Extended Supported Rates | The Extended Supported Rates element is present if there are more than eight supported rates, and it is optionally present otherwise. This element is not present if dot11DMGOptionImplemented is true. |
| … | … | … |
| 55 | Multi-band | The Multi-band element is optionally present if dot11MultibandImplemented is true. |
| 56 | DMG Capabilities | The DMG Capabilities element is present if dot11DMGOptionImplemented is true.  |
| 57 | DMG Operation | The DMG Operation element is present if dot11DMGOptionImplemented is true.  |
| 58 | Multiple MAC Sublayers | The Multiple MAC Sublayers element is present if dot11MultipleMACActivated is true. |
| 59 | Antenna Sector ID Pattern | The Antenna Sector ID Pattern element is optionally present if dot11DMGOptionImplemented is true. |
| ANA | Extended Cluster Report | The Extended Cluster Report element is optionally present if dot11ClusteringActivated is true. |

*Insert the new rows into Table 8-54 in numeric order:*

**Table 8-54 – Element IDs**

|  |  |  |  |
| --- | --- | --- | --- |
| **Element** | **Element ID** | **Length (in octets)** | **Extensible** |
| … | … | … | … |
| TSPEC (see 8.4.2.32) | 13 | 57 (non-DMG) or 59 (DMG) | Non-DMG: no DMG: yes |
| … | … | … | … |
| Non-transmitted BSSID Capability (see 8.4.2.74) | 83 | 4 (non-DMG) or 24 (DMG)  |  |
| … | … | … | … |
| Wakeup Schedule | 143 | 10 | Yes |
| Extended Schedule | 144 | 17 to 257 |  |
| STA Availability | 145 | 4 to 257 |  |
| DMG TSPEC | 146 | 16 to 253 |  |
| Next DMG ATI | 147 | 8  | Yes |
| DMG Capabilities | 148 | 19 | Yes |
| … | … | … | … |
| DMG Operation | 151 | 12 | Yes |
| DMG BSS Parameter Change | 152 | 9 | Yes |
| DMG Beam Refinement | 153 | 7 | Yes |
| Channel Measurement Feedback | 154 | 6 to 257 |  |
| … | … | … | … |
| Awake Window | 157 | 4 | Yes |
| Multi-band | 158 | 24 to 257 | Yes  |
| ADDBA Extension | 159 | 3 | Yes |
| NextPCP List | 160 | 4 to 257 |  |
| PCP Handover | 161 | 15 | Yes |
| DMG Link Margin | 162 | 10 | Yes |
| Switching Stream | 163 | 6 to 257 |  |
| Session Transition | 164 | 13 | Yes |
| Dynamic Tone Pairing Report | 165 | 34 | Yes |
| Cluster Report | 166 | 3 to 257 |  |
| Relay Capabilities | 167 | 4 | Yes |
| Relay Transfer Parameter Set | 168 | 10 | Yes |
| BeamLink Maintenance | 169 | 3 | Yes |
| Multiple MAC Sublayers | 170 | 8 to 254 | Yes |
| U-PID | 171 | 11 | Yes |
| DMG Link Adaptation Acknowledgement | 172 | 7 | Yes |
| … | … | … | … |
| Quiet Period Request | 175 | 19 | Yes |
| … | … | … | … |
| Quiet Period Response | 177 | 12 | Yes |
| … | … | … | … |
| ECPAC Policy  | 182 | 13 or 17 | Yes |
| Cluster Time Offset | 183 | 3 | Yes |
| Antenna Sector ID Pattern | 190 | 6 | Yes |
| Cluster Probe | ANA | 11 | Yes |
| Extended Cluster Report | ANA | 15 or 20 | Yes |
| Cluster Switch Announcement | ANA | 16 | Yes |
| Reserved  | ANA–220 |  |  |