**IEEE P802.15**

**Wireless Personal Area Networks**

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| Re: |  |
| Abstract | Text proposals for 802.15.7r1 D0 |
| Purpose | This contribution provides text proposals for 802.15.7r1 D0 |
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# General description

## Network topologies

The IEEE 802.15.7r1 specification supports three topologies: peer-to-peer, star, and coordinated, as show in Figure 1‑1.



 Figure 1‑1 Supported MAC topologies

In the peer to peer topology, two devices can establish a connection through the optical wireless link and communicate to each other directly within its coverage area. One of the peers acts as a coordinator, usually the one being the first device to communicate on the channel.

In the star topology, a VPAN comprises a coordinator and one or multiple devices. The coordinator can provide optical wireless access to the devices.

In the coordinated topology, multiple coordinators are connected to each other and to a global controller through the backhaul link. The backhaul link can be either a wired connection (Power line link, Ethernet link, etc.) or a wireless connection (LTE link, WiMAX link, etc.), which is out of the scope of this specification. Multiple VPANs are coordinated by the global controller. The global controller is in charge of various kinds of coordination among the multiple VPANs, e.g. handover, interference management, VPAN status monitoring, etc.

Each VPAN shall have a unique VPAN ID, which is chosen by the coordinator when it established the VPAN. Each device and the coordinator have a unique 64 bits extended address and a [8] bits short address. The 64 bits extended address is assigned by the manufactures of the devices. The [8] bit short address is assigned by the coordinator once the device has successfully associated with the VPAN. The short address of the coordinator is chosen by itself when the coordinator established the VPAN.

## Heterogeneous network of VLC and RF

The IEEE 802.15.7r1 specification supports heterogeneous network of VLC and RF. The topology is shown in Figure 1‑2. Each coordinator is connected to the Global controller and other coordinators through backhaul link. The Global controller is co-located with a RF AP. Each coordinator provides optical wireless access to devices while the RF AP co-located with global controller provides RF access to one or multiple devices



Figure 1‑2 heterogeneous network comprised of RF links and VLC links

As shown in Table 1‑1, three types of devices according to the capabilities in supporting VLC and RF are considered for IEEE 802.15.7r1. Type 1 devices support VLC only operations. Type 2 devices support VLC downlink operations as well as RF downlink and uplink operations. Type 3 devices support VLC uplink and downlink operations as well as RF uplink and downlink operations.

Type 2 and type 3 devices can operate via VLC and RF simultaneously. In the downlink, joint transmission through both VLC link and RF link and handover between VLC link and RF link can be used. For type 2 devices, uplink traffic shall be transmitted through RF link. Command frames or ACK frames with destination address set to the coordinator shall be first transmitted to the Global controller through RF link and then forwarded to the coordinator through the backhaul link.

Table 1‑1 Device classification according to supported RF capabilities

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Device type  | RF down link | RF uplink | VLC downlink | VLC uplink |
| Type 1 |  |  | √ | √ |
| Type 2 | √ | √ | √ |  |
| Type 3 | √ | √ | √ | √ |

# PHY Layer Operating mode(s)

**Dear Proposer: please fill in this section with your PHY operating mode(s). You may modify this table as you see fit.**

See table 73, 74 or 75 from IEEE802.15.7-2011 for an example table.

|  |
| --- |
| **PHY Operating Modes** |
| **Modulation** | **RLL Code** | **Optical Clock Rate** | **FEC** | **Data Rate** |
|  |  |  |  |  |
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|  |  |  |  |  |
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# PHY specifications

**Dear Proposer: please fill in this section with your PHY specifications**

See IEEE802.15.7-2011 sections 10, 11 or 12 for current specifications.

**< Enter PHY specifications here >**

# PHY Layer Dimming Method

**Dear Proposer: in this section we need you to describe your dimming method. If you proposed one or more OCC PHY modes that support dimming than please write a paragraph to describe how the dimming works. You may include figures and drawings as needed.**

**< Enter paragraph here >**

# PPDU format

**Dear Proposer: for each of the PHY modes of interest, please describe to the best of your ability your envisioned PPDU format. You can take the present PPDU and modify it accordingly. If possible, describe what you envision for each of the PPDU fields.**

Current IEEE802.15.7-2011 PPDU



< Enter PPDU format here >

# PHY PIB attributes

**Dear Proposer: add any anticipated PHY PIB attributes here**

See IEEE802.15.7-2011 Table 100 for the current PHY PIB Table

|  |
| --- |
| **PHY PIB Table 100 Additions** |
| **Attribute** | **Identifier** | **Type** | **Range** | **Description** |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

# Superframe Structure

This standard allows the optional use of a superframe structure. A coordinator on a VPAN can bound its channel time using a superframe structure. The format of the superframe is configured by the coordinator and varies with the network topologies. The superframe is bounded by beacons sent by the coordinator and is divided into equally sized time slots (TS). The duration of the superframe for star mode and coordinated mode shall be fixed and set to Tsuperframe. Each superframe can have two or three portions: beacon period (BP), contention access period (CAP) and optional contention-free period (CFP), as shown in Figure 7‑1.

BP starts from the first TS of a superframe. The BP is further divided into multiple beacon slots as shown in Figure 7‑2. The duration of each beacon slot is equal to the sum of the duration of a beacon physical layer data unit (PPDU) and the subsequent beacon-to-beacon inter-frame space. In peer-to-peer mode and star mode, the BP shall contain only one beacon slot. In coordinated network, the BP consists one to a maximal of *MaxBeaconSlot* beacon slots. Coordinator transmits a beacon in one of the multiple beacon slots every superframe. The structure of a BP is notified in the beacon frame (see 9.2). The beacons are used to synchronize the attached devices, to convey the information and parameters of the VPAN operation (e.g., channel access information).

The CAP shall immediately following the BP and complete before the CFP. If the CFP is zero length, the CAP shall complete at the end of the superframe. The CAP shall be at least *aMinCAPLength* and shall shrink or grow dynamically to accommodate the size of the CFP. Any device wishing to communicate during the CAP competes with other devices via CSMA/CA (see 8.2.1.1).

The CFP may be present in star mode and coordinated mode. For low-latency applications or applications requiring specific data bandwidth, the coordinator is allowed to dedicate portions during the CFP to that application. These portions are called guaranteed time slots (GTSs). The GTSs forms the CFP, which always appears at the end of the superframe starting at a TS boundary immediately following the CAP. More information on the CFP and GTSs is provided in 8.2.6 and 8.3.6. All contention-based transactions shall be completed before the CFP begins. Also each device transmitting in a GTS ensures that its transaction is complete before the time of the next GTS or the end of the CFP.

All transactions are completed by the time of the next beacon.



Figure 7‑1 Superframe structure of different network topologies



Figure 7‑2 structure of the beacon period

# MAC specifications

In this section, MAC specifications for different topologies, i.e. peer-to-peer, star, coordinated, are specified.

## Peer-to-peer

TBD

## Star

### Channel access

Both contention access and contention-free access are supported. Contention access is based on random access and shall be used for transmissions in CAP. Contention-free access is used for transmissions of beacon frames as well as transmissions in CFP.

#### Channel access in CAP

CSMA/CA mechanism is used during the channel access in CAP, which supports prioritized access. To reduce the probability of collisions among contending devices, a random back-off algorithm is used to separate the timing that the different devices attempt to transmit. Prioritized access is achieved by assigning differentiated contention parameters to different access priorities, which allows frames associated with higher access priorities to win the contention with higher probabilities.

Since the coordinator and the devices in the VPAN may support different modulation bandwidths and the coordinator has no prior knowledge of which device will win during the contention in the CAP, it may not configure the receiver operating on a proper bandwidth to receive the uplink frames. In addition, the hidden node problems exist during the uplink communications in a VPAN. The coordinator shall adopt one of the following approaches to solve these issues.

* Approach 1: The coordinator may divide the CAP into multiple regions according to the modulation bandwidths that the associated devices use. Each region is assigned to the transmissions that use a particular modulation bandwidth.
* Approach 2: The coordinator does not specify the allowed modulation bandwidth for the transmissions in the CAP in advance. In this case, an improved RTS/CTS mechanism shall be used in the CAP.

##### Approach 1

Since the coordinator records the supported modulation bandwidth of each associated device in its VPAN during association (see 9.5.1 ), it can determine the modulation bandwidth information of each associated device and divide the CAP into multiple regions and specify a bandwidth for each region according to the modulation bandwidth information. The bandwidth information can be the maximum bandwidth that each associated device supports, and the maximum bandwidth supported by the coordinator may also be considered. For each region, only the transmissions of the signals that modulated on the specified bandwidth are allowed. The coordinator shall distribute the schedule of the CAP in the beacon frame, indicating a modulation bandwidth for each region respectively in the CAP descriptor subfield (see 9.2).

For each region, the RTS/CTS mechanism may be used in addition. The decisions on whether the RTS/CTS protocol should be used for each region is out of the scope of this standard. The coordinator shall indicate whether RTS/CTS protocol is used in the beacon frame (see 9.2).

A device shall transmit and receive in a particular region using the modulation bandwidth as indicated in the beacon frame, if Approach 1 is adopted. When a device in the VPAN that adopts Approach 1 attempts to transmit a frame, it shall locate the region that it is allowed to transmit according to the modulation bandwidths it can support. If a device using a higher modulation bandwidth loses the contention of the channel, it may switch to a lower modulation bandwidth and try to compete in the region that assigned to the transmission using that modulation bandwidth.

At least one region for the transmission using the minimum modulation bandwidth shall be preserved, which can be used for the association of new devices.

The coordinator and a device shall set the operation modulation bandwidth according to the following rules:

The downlink PPDUs shall be modulated with the modulation bandwidth of min{max COODINATOR\_Tx\_modulation\_bandwidth, max DEVICE\_Rx\_modulation\_bandwidth}[[1]](#footnote-1), the PPDU carrying the corresponding ACK frames shall be modulated on the modulation bandwidth of min{max COODINATOR\_Rx\_modulation\_bandwidth, max DEVICE\_Tx\_modulation\_bandwidth} [[2]](#footnote-2).

The uplink PPDUs shall be modulated on the modulation bandwidth lower than or equal to min{max COODINATOR\_Rx\_modulation\_bandwidth, max DEVICE\_Tx\_modulation\_bandwidth}, and the PPDU carrying the corresponding ACK frames shall be modulated on the modulation bandwidth min{max COODINATOR\_Tx\_modulation bandwidth, max DEVICE\_Rx\_modulation bandwidth}.

Both the coordinator and the devices shall receive with the modulation bandwidth indicated for each region.

If the coordinator indicates that the RTS/CTS protocol is used in a region of the CAP, transmission on uplink in this region shall use the RTS/CTS protocol. The RTS/CTS protocol should not be used for the downlink transmissions.

A device that gains the right for transmission after contention shall transmit an RTS frame prior to the transmission of the data/command frame. After receiving the RTS frame successfully, the coordinator shall transmit a CTS frame to the device that sourced the RTS frame. The device shall continue to transmit the data/command frame only if it has received the corresponding CTS frame after the RTS frame it has sent.

If the device does not receive the CTS frames during [TBD ms] after it sent the RTS frame, it shall not transmit the data/command frame and shall try to compete to resend the RTS frame. Transmission of a frame sequence including a data/command frame with ACK using RTS/CTS is illustrated in Figure 8‑1.

The RTS/CTS/ACK frames shall be transmitted using the modulation bandwidth that is indicated for the region by the coordinator.



Figure 8‑1 An example of the usage of RTS/CTS

#####  Approach 2

Unlike approach 1, the coordinator may not divide the CAP into multiple regions and does not indicate a specific modulation bandwidth that can be used for the transmissions in the CAP. The coordinator shall indicate in the beacon if the following improved RTS/CTS protocol shall be used (see 9.2).

A device shall determine if the improved RTS/CTS protocol shall be used according to the beacon frames. If this improved RTS/CTS protocol shall be used, a device shall compete for the transmission of the RTS frame first. When the device gains the right for transmission after contention shall transmit an RTS frame. RTS is transmitted using the minimal bandwidth. The RTS frame shall include the modulation bandwidth, which can be used by the coordinator to determine the bandwidth for its receiver.

After receiving the RTS frame successfully, the coordinator shall transmit a CTS frame to the device that sourced the RTS frame. The coordinator shall record the modulation bandwidth that indicated in the received RTS frame, and use this modulation bandwidth to receive the following data/command frame.

The device shall continue to transmit the data/command frame using the modulation bandwidth indicated in previous RTS frame, only if it has received the corresponding CTS frame after the RTS frame it has sent. If the device does not receive the CTS frames during [TBD ms] after it sent the RTS frame, it shall not transmit the data/command frame and shall try to compete to resend the RTS frame. The coordinator may send an ACK frame following the data/command frame, if needed.

Transmission of a frame sequence including a data/command frame with ACK using RTS/CTS is presented in Figure 8‑1.

In this improved RTS/CTS mechanism, the coordinator and a device shall set the operation modulation bandwidth according to the following rules:

* The PPDU carrying a RTS/CTS/ACK frame shall be modulated on the minimum modulation bandwidth.
* The PPDUs carrying data/command shall be modulated on the modulation bandwidth that is indicated in the RTS frame. The criteria for a device to determine this modulation bandwidth is out of the scope of this standard.
* Both the coordinator and the devices shall be ready for receiving frames using the appropriate modulation bandwidth.

For the downlink transmissions, the coordinator shall use the same RTS/CTS protocol described above except that the frames are modulated on the minimum bandwidth. Regarding the broadcast downlink transmission, the coordinator shall modulate the frames on the minimum bandwidth.

#### Channel access in CFP

The coordinator can divide the CFP of a superframe into multiple GTSs and assign them to itself or the associated devices that have traffic requiring guaranteed quality of service (QoS).

A device can request GTS allocations through flow establishment procedure, which is controlled by the coordinator (see 8.2.6).

The coordinator shall inform the GTS allocations to devices in the beacon frame. Each GTS is described by at least one GTS descriptor (see 9.2.5). The GTS descriptor indicates the length and position of the GTS and the device assigned to the GTS. The GTS descriptor may supply additional information, such as the subcarriers/frequencies/wavelengths that the device is allowed to use in the GTS, which can be used in the case that the interference coordination among neighboring VPANs (see 8.3.9).

### VPAN establishment

#### Scan procedure

A scan procedure shall be performed by a device or a prospective coordinator to detect any VPANs and coordinators that are operating in its vicinity. Three types of scanning are specified, i.e. passive scan, active scan and scan-over-backhaul.

* Passive scan

Passive scan is performed by a devices before association. Passive scan is also performed by a prospective coordinator that plans to establish a VPAN if inter-coordinator communication over backhaul is infeasible.

During a passive scan, the MAC sublayer shall discard all frames received over the PHY data service that are not beacon frames.

A passive scan is requested by the next higher layer using the MLME-SCAN.request primitive (see 10.2.3.1) with the ScanType parameter set to indicate a passive scan. On reception of the primitive, the MLME shall enable its receiver to receive beacon frames sent by other coordinators for ScanDuration. Every time when the MLME receives a beacon frame, it shall record the information contained in the unique beacon frame in a local neighboring VPAN descriptor list. A beacon frame is assumed unique if it contains both a VPAN ID and a source address that has not been seen before. When the scan is complete, the MLME shall report the VPAN descriptor list to the next higher layer by issuing a MLME-SCAN.confirm primitive (see 10.2.3.2).

* Active scan

An active scan allows a device to locate any coordinator transmitting beacon frames within its coverage area. It can be used by a device when it is requested by the coordinator to report a neighboring VPANs descriptors list.

During an active scan, the MAC sublayer shall process all frames rather than just the frames of its own VPAN.

An active scan is requested by the next higher layer using the MLME-SCAN.request primitive with the ScanType parameter set to indicate an active scan. On reception of the primitive, the MLME of the device shall generate a beacon request command (see 9.5.7) and broadcast it. It shall enable its receiver to receive beacon frames sent by other coordinators for ScanDuration. If a coordinator of a peer-to-peer VPAN receives the beacon request, the coordinator shall transmit a beacon frame to the device as a response; if a coordinator of a star VPAN or coordinated VPAN receives the beacon request, it shall ignore it and continue transmitting its periodical beacons as usual.

When the MLME of the device receives a unique beacon frame, it shall update its local neighboring VPAN descriptor list based on the information contained in the unique beacon frame. A beacon frame shall be assumed to be unique if it contains both a VPAN ID and a source address that has not been seen before. When the ScanDuration time expires, the MLME of the device shall report the local neighboring VPAN descriptor list to the next higher layer by issuing a MLME-SCAN.confirm primitive.

* Scan-over-backhaul

Scan-over-backhaul shall be performed by a prospective coordinator that plans to establish a VPAN if inter-coordinator communication over backhaul is feasible.

Scan-over-backhaul is requested by the next higher layer of the prospective coordinator using the MLME-SCAN.request primitive with the ScanType parameter set to indicate a scan-over-backhaul, as defined in 10.2.3.1. On reception of the primitive, the MLME of the prospective coordinator shall generate a scan-over-backhaul request command (see 9.5.9) and send it to neighboring coordinators that are connected to the prospective coordinator through the backhaul. After the prospective coordinator transmitted the scan-over-backhaul request command, it shall enable its receiver (on the backhaul) to receive scan-over-backhaul confirmation commands (as specified in 9.5.10) sent by other coordinators for ScanDuration. Coordinators that have received the scan-over-backhaul request command through the backhaul shall respond with a scan-over-backhaul confirmation command, with its own VPAN descriptor embedded in it. When the MLME of the prospective coordinator receives a scan-over-backhaul confirmation command, it shall record the information contained in the unique scan-over-backhaul confirmation command in a local neighboring VPAN descriptor list. A scan-over-backhaul confirmation command frame shall be assumed to be unique if it contains both a VPAN ID and a source address that has not been seen before. When the ScanDuration time expires, the MLME of the prospective coordinator shall report the local neighboring VPAN descriptor list to the next higher layer by issuing a MLME-SCAN.confirm primitive.

#### Establish a VPAN

A prospective coordinator shall perform the following procedures to establish a VPAN.

On receipt of the primitive MLME-RESET.request (see 10.2.11.1), the MLME of the prospective coordinator shall turn off the transceiver by issuing a PLME-SET-TRX-STATE.request to the PHY layer, and then the MAC sublayer is set to its initial conditions, clearing all internal variables to their default values.

The MLME of the device shall respond with a MLME-RESET.confirm primitive (see 10.2.11.2) to notify the next higher layer the result of the reset operation.

After the reset, the next higher layer of the prospective coordinator shall issue a MLME-SCAN.request primitive (see 10.2.3.1) to require the MLME to perform a scan to discover other VPANs in its vicinity. Two types of scan may be performed. If inter-coordinator communication over backhaul is feasible, then a scan-over-backhaul is performed. Otherwise, a passive scan shall be performed. The specific scan type shall be indicated by the next higher layer in the MLME-SCAN.request primitive. After the requested scan is done, the MLME shall issue a MLME-SCAN.confirm primitive (see 10.2.3.2) to report the result of the scan.

The next higher layer of the prospective coordinator shall select a VPAN ID and the short address of the coordinator based on the VPAN IDs and the short addresses recorded in the local neighboring VPANs descriptor list obtained via the scan once it has received the MLME-SCAN.confirm. The MLME of the prospective coordinator shall select a VPAN ID and short address that are different from the VPAN IDs and short addressed obtained via the scan. Then the next higher layer shall provide the selected VPAN ID and short address to the MLME by issuing a MLME-START.request primitive (see 10.2.7.1).

On receipt of the MLME-START.request, the MLME of the prospective coordinator shall start a superframe and broadcast beacon frames with the selected parameters (e.g., VPAN ID, short address) periodically.



Figure 8‑2 VPAN establishment procedure

### Association and disassociation

#### Association

A device shall perform a passive scan procedure (see 8.2.2.1) after it is powered on. The results of the channel scan would have then been used for choosing a suitable VPAN. The algorithm for selecting a suitable VPAN with which to associate from the neighboring VPANs descriptor list returned from the passive scan procedure is out of the scope of this standard.

Following the selection of a VPAN with which to associate, the next higher layers shall request through the MLME-ASSOCIATE.request primitive (see 10.2.1.1) that the MLME configures the PHY and MAC PIB attributes to the values necessary for association.

A coordinator shall allow association only if macAssociationPermit is set to TRUE. Similarly, a device should attempt to associate only with a VPAN through a coordinator that is currently allowing association, as indicated in the results of the scanning procedure. If a coordinator with macAssociationPermit set to FALSE receives an association request command from a device, the command shall be rejected.

The MAC sub-layer of an unassociated device shall initiate the association procedure by sending an association request command (see 9.5.1) to the coordinator of an existing VPAN.

Upon the reception of the association request command, the coordinator shall determine if it will accept the association request and reply an association response command (see 0) to the device within [TBD ms]. The coordinator shall indicate if it accepts the request in the association response command. If the the request is accepted, a unique short address is assigned for the device in the association response command.

If the device does not receive the association response command [TBD ms] after it sent the association request command, it shall resend the request. The maximal retry times is [4].

During the association process, the PPDU carrying the association request command and the association response command and the corresponding ACK frames shall be modulated using the minimum bandwidth and be sent in the CAP following the channel access rules as described in 8.2.1. The device and the coordinator can exchange the capabilities information via the association process, such as the modulation bandwidths a device can support.

#### Disassociation

The disassociation procedure is initiated by the next higher layer by issuing the MLME-DISASSOCIATE.request primitive (see 10.2.2.1) to the MLME.

When a coordinator wants one of its associated devices to leave the VPAN, the coordinator shall send a disassociation notification command frame (see 9.5.5) to the device. The device shall reply a disassociation response command frame (see 9.5.6) to the coordinator within [TBD ms].

If an associated device wants to leave the VPAN, the MLME of the device shall send a disassociation notification command frame to the coordinator. The coordinator shall reply a disassociation response command frame to the device within [TBD ms].

After the device disassociated from the VPAN, the coordinator shall release the short address, the Flow\_IDs, GTS allocations that has been assigned to the device.

### VPAN Maintenance

#### VPAN ID conflict

In some instances a situation could occur in which two VPANs exist in the same operating space are with the same VPAN ID. If this conflict happens, the coordinator and its devices shall perform the VPAN ID conflict resolution procedure.

##### VPAN ID conflict detection

The VPAN coordinator shall conclude that a VPAN ID conflict is present if either of the following applies:

* A beacon frame is received by the VPAN coordinator with the VPAN coordinator subfield set to one and the VPAN ID equal to macVPANId
* A VPAN ID conflict notification command (see 9.5.11) is received by the VPAN coordinator from an associated device on its VPAN.

A device that is associated through the VPAN coordinator shall conclude that a VPAN ID conflict is present if the following applies;

* A beacon frame is received by the device with the VPAN coordinator subfield set to one, the VPAN ID equal to macVPANId, and an address that is equal to neither macCoordShortAddress nor macCoordExtendedAddress.

##### VPAN ID conflict resolution

On the detection of a VPAN ID conflict by a device, it shall generate the VPAN ID conflict notification command (see 9.5.11) and send it to its coordinator. The coordinator shall confirm its reception by sending an ACK frame. Once the device has received the ACK frame from the coordinator, the MLME shall issue an MLME-SYNC-LOSS.indication primitive (see 10.2.8.1) with the LossReason parameter set to VPAN\_ID\_CONFLICT. If the device does not receive an ACK frame, the MLME shall not inform the next higher layer of the VPAN ID conflict.

On reception of the VPAN ID conflict notification command by the coordinator, the coordinator is notified of the VPAN ID conflict and the MLME shall issue an MLME-SYNC-LOSS.indication to its next higher layer with the LossReason parameter set to VPAN\_ID\_CONFLICT.

On receipt of the MLME-SYNC-LOSS.indication primitive with the LossReason parameter set to VPAN\_ID\_CONFLICT by the next higher layer of the coordinator, it may issue a MLME-NeighborReport.request primitive (see 10.2.5.1) to its MLME to trigger a neighboring VPAN report.

On receipt of the MLME-NeighborReport.request primitive, the MLME of the coordinator shall generate a neighboring VPAN report request command (see 9.5.12) and send it to the device(s) indicated in the ReportDevicesList of the MLME-NeighborVPANReport.request primitive. To which device(s) the neighboring VPAN request command shall be sent is determined by the next higher layer and is out of the scope of the specification. Then the coordinator shall wait for the neighboring VPAN report indication commands (see 9.5.13) sent by the devices for [TBD ms].

Devices that have received the neighboring VPAN report request command from the coordinator may first perform an active scan. The device updates its local neighboring VPAN descriptors list according to the result obtained from the active scan. When the active scan requested by the coordinator is done, the device shall generate a neighboring VPAN report indication command based on its updated local neighboring VPAN descriptor list and send the neighboring VPAN report indication command to the coordinator.

If the device choose not to perform the active scan after it receives the neighboring VPAN report request command, it shall generate a neighboring VPAN report indication command which include its local neighboring VPAN descriptor list and send the command to the coordinator.

When the coordinator has received a unique neighboring VPAN report indication command from the device, it shall update its global neighboring VPAN descriptor list. When [TBD ms] elapsed, the MLME of the coordinator shall notify its next higher layer the result of the requested neighboring VPAN report by issuing a MLME-NeighborReport.confirm primitive (see 10.2.5.3). The next higher layer of the coordinator shall select a new VPAN ID based on the VPAN IDs recorded in its updated global neighboring VPAN descriptor list. The MLME of the coordinator shall select a new VPAN ID that is different from the VPAN IDs that are recorded in its updated global neighboring VPAN descriptor list. The next higher layer of the coordinator shall provide the new VPAN ID to its MLME by issuing a MLME-START.request primitive with the CoordRealignment parameter set to TRUE. The MLME shall perform a VPAN realignment on receipt of the MLME-START.request primitive with the CoordRealignment parameter set to TRUE.

#### VPAN realignment

A coordinator shall generate a coordinator realignment command (see 9.5.20) on reception of a MLME-START.request primitive (see 10.2.7.1) with the CoordRealignment parameter set to TRUE. The coordinator shall broadcast the coordinator realignment command containing the new VPAN parameters (e.g., the selected VPAN ID) and the effective time. When a device receives the coordinator realignment command, the MLME of the device shall notify its next higher layer the VPAN realignment by issuing a MLME-SYNC-LOSS.indication primitive (see 10.2.8.1).

The coordinator realignment command shall indicate in which superframe the new parameters will take effect by setting a proper value to the Effective Time field. The coordinator shall also indicate it by setting the CountDown field in the following beacon frames (see 9.2). Both the coordinator and devices shall make sure the new parameters are properly set and start to use the new parameters (e.g., the selected VPAN ID) when the effective time comes. The coordinator and the devices shall set the new parameters by issuing a MLME-SET.request primitive (see 10.2.10.1) to the MLME from the next higher layer.

### Neighboring VPAN status monitoring

Neighboring VPANs status monitoring procedure allows the coordinator and the devices to detect and maintain neighboring VPANs information. Neighboring VPAN status monitoring maybe performed for the purposes of VPAN maintenance, interference coordination and handover.

Both coordinators and the devices shall participate in the neighboring VPANs status monitoring procedure.

The information of neighboring VPANs that can be detected shall be recorded in a neighboring VPANs descriptor list.

Both the coordinator and the devices shall each maintain a local neighboring VPANs descriptor list respectively. The local neighboring VPAN descriptor list is shown in Table 8‑1. The local neighboring VPAN descriptor list is maintained by receiving beacon frames or other frames from the neighboring VPANs. When a beacon frame or any other frame from neighboring VPANs is received for the first time, a new record corresponding to the neighboring VPAN shall be added to the list. The record in the list has an ageing time of [TBD] ms. Whenever a beacon frame or any other frame from a neighboring VPAN corresponding to a record in the list has been received, the device shall update the LastTimeDetected of the record instead of adding a new record. Once the beacon frames or any other frame from a neighboring VPAN corresponding to a record in the list has not been received within the ageing time since last time it was detected, the record corresponding to that neighboring VPAN shall be deleted from the list.

Table 8‑1 Local neighboring VPANs descriptor list

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| Number NeighboringVPANRecords | Integer | 0x00-0xff. | The number of records of neighboring VPANs that are maintained by the device. |
| VPANDescriptor [0] |  | Refer to Table 8‑2 | The record of the first neighboring VPAN that can be detected by the device. |
| LinkQuality[0] | Integer | 0x00-0xff | The measured RSS of the first neighboring VPAN. |
| LastTimeDetected | Integer | 0x00-0xff | The sequence number of the superframe during which the device received a frame from the first neighboring VPAN for the last time. |
| …… |  |  |  |
| VPANDescriptor [N-1] |  | Refer to Table 8‑2 | The record of the N-th neighboring VPAN that can be detected by the device. |
| LinkQuality[N-1] | Integer | 0x00-0xff | The measured RSS of the N-th neighboring VPAN. |
| LastTimeDetected | Integer | 0x00-0xff | The sequence number of the superframe during which the device received a frame from the N-th neighboring VPAN for the last time. |

Table 8‑2 the format of the VPAN descriptor

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| VPANId | integer | 0x0000-0xffff | The VPAN ID of the neighboring VPAN as specified in the received beacon frames. |
| CoordShortAddress | Integer |  | The 16 bits short address of the coordinator as specified in the received beacon frames. |
| CoordExtendedAddress | Integer |  | The 64 bits extended address of the coordinator as specified in the received beacon frames. |
| AssociationPermit | Boolean | TRUE or FALSE | Indicates whether a coordinator is currently allowing association. A value of TRUE indicates that association is permitted. |

The devices shall update their local neighboring VPANs descriptor list and send a neighboring VPAN report indication command (see 9.5.12) to the coordinator to report its local neighboring VPANs descriptor list whenever any of the following events occurs:

* It has received a beacon frame or any other frames sent by the neighboring coordinators or devices for the first time;
* It has been [TBD] superframes since the neighboring VPAN was detected last time;
* A neighboring VPAN report request command (see 9.5.12) is received by the device from the coordinator;

The coordinator shall update its local neighboring VPAN descriptor list whenever any of the following events occurs:

* It has received a beacon frame or any other frames sent by the neighboring coordinators or devices for the first time;
* It has been [TBD] superframes since the neighboring VPAN was detected last time;

The coordinator shall also maintain a global neighboring VPAN descriptor list. The global neighboring VPAN descriptor list is maintained and updated by gathering the reported local neighboring VPAN descriptor lists from devices and its own local neighboring VPAN descriptor list. The global neighboring VPANs descriptor list is shown in Table 8‑3.

The coordinator shall update its global neighboring VPAN descriptors list whenever it has received a neighboring VPAN report indication command from devices in the VPAN, or when its own local neighboring VPAN descriptors list has been updated. The coordinator shall also update the global neighboring VPAN descriptors list by deleting the corresponding information if the device which has reported the corresponding information is disassociated from the VPAN.

Table 8‑3 Global neighboring VPANs descriptor list

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| Number NeighboringVPANRecords | Integer | 0x00-0xff. | The number of records of neighboring VPANs that are maintained by the coordinator. |
| VPANDescriptor [0] |  | Refer to Table 8‑2 | The record of the first neighboring VPAN that can be detected by devices. |
| NumberDetectDevice | Integer | 0x00-0xff. | The number of devices that have detected the neighboring VPAN specified by VPANDescriptor [0]. Assuming the total number is K. |
| DeviceAddr[0] | Integer |  | The short address of the first device that has reported it can detect the neighboring VPAN specified by VPANDescriptor [0]. |
| LinkQuality[0] |  |  | The RSS at which the first device receives the beacon frame or other frames from the VPAN specified by VPANDescriptor [0]. |
| …… |  |  |  |
| DeviceAddr[K-1] | Integer |  | The short address of the Kth device that has reported it can detect the neighboring VPAN specified by VPANDescriptor [0]. |
| LinkQuality[K-1] |  |  | The RSS at which the Kth device receives the beacon frame or other frames from the VPAN specified by VPANDescriptor [0]. |
| …… |  |  |  |
| VPANDescriptor [N-1] |  | Refer to Table 8‑2 | The record of the Nth neighboring VPAN that can be detected by devices. |
| NumberDetectDevice | Integer | 0x00-0xff. | The number of devices that have detected the neighboring VPAN specified by VPANDescriptor [N-1]. Assuming the total number is L. |
| DeviceAddr[0] | Integer |  | The short address of the first device that has reported it can detect the neighboring VPAN specified by VPANDescriptor [N-1]. |
| LinkQuality[0] |  |  | The RSS at which the first device receives the beacon frame or other frames from the VPAN specified by VPANDescriptor [N-1]. |
| …… |  |  |  |
| DeviceAddr[L-1] | Integer |  | The short address of the Lth device that has reported it can detect the neighboring VPAN specified by VPANDescriptor [N-1]. |
| LinkQuality[L-1] |  |  | The RSS at which the Lth device receives the beacon frame or other frames from the VPAN specified by VPANDescriptor [N-1]. |

### GTS allocation and management

A GTS allows a device to operate on the channel within a portion of the superframe that is dedicated (on the VPAN) exclusively to that device. A GTS shall be allocated only by the coordinator, and it shall be used only for communications between the coordinator and a device associated with the VPAN through the coordinator. A single GTS may extend over one or more superframe slots. The coordinator may allocate a number of GTSs at the same time, provided there is sufficient capacity in the superframe.

One or more flows can be setup between the coordinator and a device, the flows can be either downlink or uplink. The allocated GTSs for a flow should meet the QoS constraints specified in the TSpec (see 9.5.14). The way in which the coordinator manages the available resources and the particular schedules it generates are out the scope of this standard. The scheduling of GTS is indicated by the coordinator in the beacon frame.

The TSpec describes the set of parameters that define the characteristics and QoS expectations of a particular flow.

#### Flow establishment

A flow can be originated by a coordinator or a device. The originator shall send a flow establishment request command (see 9.5.14) to the recipient to establish a flow. The recipient shall reply a flow establishment response command (see 9.5.15) to the originator to notify if it accepts the flow establishment request. Both the coordinator and a device can originate a bidirectional flow, in this case, the TSpec of the reverse flow shall be included in the flow establishment response command.

When a coordinator originates a flow, it shall reserve sufficient resources for the flow before it sends the flow establishment request to the recipient device. When a coordinator receives a flow establishment request from a device, it shall first check if there is sufficient resource to meet the QoS requirements. If it accepts the request, it shall reserve sufficient resources for the flow and assign a GTS for this flow. If the coordinator denies the request from a device means that no QoS guarantees can be given, the medium access may still be performed on a priority-basis in the CAP.

The coordinator shall assign a unique Flow\_ID for each flow in the VPAN. In case of the bi-directional flow, the coordinator shall assign different Flow\_IDs for the forward and reverse flows respectively.



Figure 8‑3 Flow establishment procedure

#### Flow maintenance

The coordinator can monitor the status of the link between a device and itself. The uplink channel status can be measured by the coordinator while the downlink channel status through the CSI feedback mechanism (see 8.2.8). The coordinator may change the flow parameters by sending a flow modify request command (see 9.5.16) to the device if it decides that the TSpec of the current flow cannot be supported. The device can transmit a flow modify response command (see 9.5.17) to the coordinator indicating whether the offered flow parameters can be accepted or not.

If the coordinator changes the GTS allocation for a flow, the new allocation for the flow will be conveyed in the following beacons.

#### Flow termination

If the originator of a flow decides that the flow is required to be released, it shall send a flow terminate request command (see 9.5.18) to the recipient. The recipient shall reply a flow terminate response command (see 9.5.19) to the originator. The coordinator shall then stop assigning the GTS allocations for the flow.



Figure 8‑4 Flow termination procedure

### Acknowledgement and retransmission

Both Transmissions with acknowledgement or without acknowledgement are supported. The next higher layer shall provide the indication whether acknowledgement is required or not when issuing the MCPS-DATA.request primitive (see 10.1.1) to the MAC sublayer. All MAC command frame shall be transmitted with acknowledgement. All broadcast frames, e.g., beacons, shall be transmitted without acknowledgement.

When ACK is not required, the transmission is always assumed to be successful.

If ACK frame is not received or an ACK frame is received with an error when ACK is required, then the device shall conclude the transmission has failed and retransmission is needed.

### CSI feedback and link adaptation

#### CSI feedback with MCS suggestion

The CSI responder may use CSI feedback with MCS suggestion to indicate a suggested MCS level to the CSI requester. Link adaptation control subfield in the MHR (see 9.1.1) can be used to request CSI feedback or provide suggest MCS level.

Both solicited feedback and unsolicited feedback are supported.

* Solicited feedback: a CSI requester request a CSI responder to feedback CSI.
* Unsolicited feedback: a coordinator/device report CSI to another device/coordinator without a request.

For solicited feedback, the CSI requester may set the MCS request field in link adaptation control subfield to ‘0b1’ to request a responder to provide MCS recommendation. In each MCS request, the requester shall set the MSI (MCS sequence index) subfield in the link adaptation control field to a value in the range 0 to 6. How the requester chooses the MSI value is implementation dependent.

On receipt of a frame with the MCS request subfield equal to ‘0b1’, a CSI responder initiates computation of the MCS estimate and labels the result of this computation with the MSI value. The MFB responder includes the received MSI value in the feedback sequence index field of the corresponding response frame. The suggested MCS level is transmitted in MCS feedback field.

For unsolicited feedback, a device/coordinator feedbacks a suggested MCS level without being requested. In this case, feedback sequence index is set to ‘0b111’, and suggested MCS level is transmitted in MCS feedback field.

After CSI feedback is obtained by the transmitter, it selects a MCS level for future transmissions. The selected MCS level may or may not be the one suggested by the receiver.

The selected MCS level for data transmission is indicated in PHY header.

#### CSI feedback for bit-loading

TBD

#### CSI feedback for MIMO operation

TBD

### Interference coordination

TBD

### Mobility and handover

TBD

## Coordinated

### Channel access

Same as 8.2.1.

### VPAN establishment

When the prospective coordinator is turned on, it should try to determine whether it is connected to a global controller through the backhaul link. The specific protocol for the prospective coordinator to detect the global controller through the backhaul link is out of the scope of this specification. If the global controller has been detected through the backhaul, the next higher layer of the prospective coordinator shall start a VPAN in the coordinated mode. If the global controller has not been detected through the backhaul, the next higher layer of the prospective coordinator shall start a VPAN in star mode, which has been specified in clause 8.2.2.2.

The prospective coordinator shall perform the following procedures to start a VPAN in the coordinated mode.

Once the prospective coordinator detects the presence of the global controller through the backhaul link, it shall exchange messages with the global controller to obtain all the necessary parameters (e.g., the VPAN ID, the short address of the coordinator, etc.) to start a VPAN. The global controller shall provide the parameters to the prospective coordinator through the message exchanges. These messages exchanged between the prospective coordinator and the global controller shall be transmitted through the backhaul link and are out of the scope of the specification.

Once the prospective coordinator has obtained the parameters from the global controller, it shall reset the MAC sublayer and PHY layer. The next higher layer of the prospective coordinator shall issue a MLME-RESET.request primitive (see 10.2.11.1) to its MLME. On receipt of the primitive MLME-RESET.request, the MLME of the prospective coordinator shall turn off the transceiver by issuing a PLME-SET-TRX-STATE.request to the PHY layer, and then the MAC sublayer is set to its initial conditions, clearing all internal variables to their default values.

The MLME of the prospective coordinator shall respond with a MLME-RESET.confirm primitive (see 10.2.11.2) to notify its next higher layer the result of the reset operation.

The next higher layer of prospective coordinator shall issue a MLME-START.request primitive (see 10.2.7.1) to its MLME on receipt of the MLME-RESET.confirm primitive (see 10.2.7.2). The next higher layer of the prospective coordinator shall provide the necessary parameters (e.g., the VPAN ID, the short address of the coordinator, etc.) to its MLME through the MLME-START.request primitive. On receipt of the MLME-START.request, the MLME shall start to broadcast beacon frame periodically and a VPAN is established.

### Association and disassociation

#### Association

A device shall perform a passive scan procedure (see 8.2.2.1) after it is powered on.

If no VPAN is detected, the next higher layer of the device may request the MLME to send an additional beacon request command (see 9.5.8). After sending the additional beacon request command, the device shall continue to scan the channel to discover beacon frames or additional beacon frames during Tcoordscan. If the device cannot detect any beacon when the Tcoordscan expires, it may attempt to send another additional beacon request command.

The device that detects beacon frames during either the passive scan period or the continued Tcoordscan, shall attempt to associate to a coordinator by sending association request command (see 9.5.1). The results of the scan would have then been used for choosing a suitable VPAN. The algorithm for selecting a suitable VPAN with which to associate from the VPAN descriptors list returned from the scan procedure is out of the scope of this standard.

Following the selection of a VPAN with which to associate, the next higher layers shall request through the MLME-ASSOCIATE.request primitive (see 10.2.1.1) that the MLME configures the PHY and MAC PIB attributes to the values necessary for association. The device shall indicate in the type of the beacon that triggers the association request of the device in the association request command.

A coordinator shall allow association only if macAssociationPermit is set to TRUE. Similarly, a device should attempt to associate only with a VPAN through a coordinator that is currently allowing association, as indicated in the results of the scanning. If a coordinator with macAssociationPermit set to FALSE receives an association request command from a device, the command shall be rejected.

The MAC sub-layer of an unassociated device shall initiate the association procedure by sending an association request command to the coordinator of an existing VPAN. If the device does not receive the association response command after [TBD ms] it sent the association request command, it shall resend the request. The maximal retry times is 4.

A coordinator receives the additional beacon request commands from a device may start to send additional beacons in each superframe from the next superframe in addition to the original beacons. The coordinator shall allocate a GTS in the CFP to transmit the additional beacon frames. The content of the additional beacon frame shall be the same as the beacon sent in the BP in the same superframe except the beacon type and shall be modulated on the minimum bandwidth. The BeaconType field in the beacon frame can be used to identify the type of the beacons. If the coordinator receives another additional beacon request command from the same device, it may allocate a different GTS to transmit in the CFP to transmit additional beacon frames from the next superframe. If the coordinator receives an association request from the device that sent the additional beacon request command within [TBD ms], it shall handle the association request. If the coordinator does not receive any association request from the device that sent the additional beacon request command within [TBD ms], it may stop transmit the additional beacons and only transmit the original beacons.

Upon the reception of the association request command, the coordinator shall determine if the association request will be accepted and reply an association response command to the device within [TBD ms]. The coordinator shall indicate if it accepts the request in the association response command, and if it denies the request, it shall also indicate the reason. If the coordinator accepts the request, it shall assign a unique short address for the device and include it in the association response command.

If the received association request indicates that the request is sent based on the detection of only additional beacons, the coordinator may also infer that interference occurs between its VPAN and one or multiple neighboring VPANs, and execute the interference coordination. The Interference Info field included in the association request command can be used for the interference coordination. If the coordinator receives any association request indicating the request is based on the detection of original beacons, interference coordination is not needed for this device.

During the association process, the PPDU carrying the association request command and the association response command and the corresponding ACK frames shall be modulated using the minimum bandwidth and be sent in the CAP following the channel access rules as described in 8.3.1. The device and the coordinator can exchange the capabilities information via the association process, such as the modulation bandwidths a device can support.

#### Disassociation

Same as 8.2.3.2

### VPAN Maintenance

#### VPAN ID conflict

In some instances a situation could occur in which two VPANs exist in the same operating space with the same VPAN ID. If this conflict happens, the coordinator and its devices shall perform the VPAN ID conflict resolution procedure.

##### VPAN ID conflict detection

Same as 8.2.4.1.1

##### VPAN ID conflict resolution

Same as 8.2.4.1.2

### Neighboring VPAN status monitoring

Same as 0.

### GTS allocation and management

#### Flow establishment

Same as 8.2.6.1

#### Flow maintenance

Same as 8.2.6.2.

#### Flow termination

Same as 8.2.6.3.

### Acknowledgement and retransmission

Same as 8.2.7.

### CSI feedback and link adaptation

#### CSI feedback with MCS suggestion

Same as 8.2.8.1.

#### CSI feedback for bit-loading

TBD

#### CSI feedback for MIMO operation

TBD

### Interference coordination

#### General description

The VPANs managed by the same global controller (GC) forms a VPAN cluster. In this clause, only intra-cluster interference coordination are specified.

At the beginning of the VPAN establishment, the boundary of the superframe of all the VPANs in the same cluster should be aligned, and different VPANs may use the same beacon slot for beacon frame transmission.

A device and the coordinator should be capable of detecting the presence of other neighboring VPANs that have the overlapped coverage with the VPAN it associated with. The coordinator is responsible for collecting the interference information from all devices associated with it and report to the global controller. The coordinator should be capable of receive the resource coordination information from the global controller, which will be used for scheduling the allocations in the superframe.

The interference coordination is executed based on the coordination period. The interference information that is reported in current coordination period should be used for the resource coordination during next coordination period. The duration of a coordination period Tcoordination shall equal to the length of [TBD] superframe.

The interference coordination procedure includes the following mechanisms.

* Interference measurement and report
* Resource coordination
* Interference parameters/resource coordination update

#### Interference measurement and report

The interference measurement and report shall follow the Neighboring VPANs status monitoring procedure specified in 0.

The coordinator shall report the interference information to the global controller every [TBD] superframes (i.e., a coordination period). The value of the coordination period can be determined by the global controller.

#### Resource Coordination

The resource coordination shall be executed for both BP and non-BP (i.e, CAP and CFP) by the global controller according to the interference information received from the coordinators. For the BP, the global controller shall coordinate the transmissions of beacons in a TDM manner and allocate different beacon slots for the VPANs that interfere with each other. The structure of the beacon period of a VPAN refers to section 7. For the non-BP part, the global controller may coordinate the resources in TDM/WDM/FDM manners, which is vendor discretionary. Other rules and criteria for resource coordination is out of the scope of this standard.

The global controller allocates resources for the VPANs that it manages and notify the coordinators about the allocations. The coordinator that does not receive the allocations information from the global controller can makes the scheduling by itself; the coordinator that receive the allocations information from the network controller shall take the allocation information into account for scheduling.

#### Interference coordination update

Both the device and the coordinator shall be capable of updating the interference information. The coordinator shall update the global record of neighboring VPANs according to the reports from the associated devices and its detection of neighboring VPANs (see 0). The coordinator shall report the updated interference information to the global controller for the coordination in the next coordination period. The global controller shall then update the resource coordination using the latest interference information.



Figure 8‑5 An example of the interference coordination

### Mobility and handover

Handover is used when a device moves from the coverage of one VPAN to other. Two types of handover procedures are specified,

* Type 1: handover initiated by device
* Type 2: handover initiated by global controller

#### Type 1: handover initiated by device

After association to a VPAN, a device may search the area for available neighboring coordinators and perform received signal strength (RSS) measurement. The measurement is based on beacons or reference signals.

A device may perform alpha-filtering on the measurements based on

$$RSS\_{n}=\left(1-α\right)RSS\_{n-1}+αM\_{n}$$

Where $M\_{n}$ is the latest received measurement result from the physical layer; $RSS\_{n}$ is the updated filtered measurement result, that is used for evaluation of reporting criteria or for measurement reporting; $RSS\_{n-1}$ is the old filtered measurement result; $α$ is a filtering-coefficient that can be configured.

If the RSS of neighbor cells satisfy

$$RSS\_{n, target}-RSS\_{n, associate}>∆\_{th1}$$

Then the device should initiate the handover to the target coordinator. Here $RSS\_{target}$ is the RSS of the target coordinator and $RSS\_{associate}$ is the RSS of the associated coordinator and $∆\_{th1}$ is a predefined threshold.

Once the handover is initiated by the device, it sends a re-association request command (see 9.5.3) to the target coordinator. The device uses the re-association request to request association as well as to send its preferred QoS requirements to the target coordinator.

In the reassociation response command (see 9.5.4), the target coordinator indicates whether the request is permitted. Besides, the target coordinator also inform the QoS resources allocated to the device, or suggests alternate level of QoS the target coordinator can support.

The previous coordinator may continue to send the packets that have been store in the buffer to the device. The device may receive these packets to its best effort. If the previous coordinator does not received acknowledgement from the device for N consecutive frames, then the previous coordinator consider the device has left the VPAN and the transmission is ceased.



Figure 8‑6 Handover initiated by device

#### Type 2: handover initiated by global controller

After association to a VPAN, a device may scan the area for available neighboring coordinators and perform received signal strength (RSS) measurement. The measurement is based on beacons or reference signals.

A device may perform alpha-filtering on the measurements based on

$$RSS\_{n}=\left(1-α\right)RSS\_{n-1}+αM\_{n}$$

Where $M\_{n}$ is the latest received measurement result from the physical layer; $RSS\_{n}$ is the updated filtered measurement result, that is used for evaluation of reporting criteria or for measurement reporting; $RSS\_{n-1}$ is the old filtered measurement result; $α$ is a filtering-coefficient that can be configured.

The device may report the measured RSS of neighboring VPANs to the coordinator using the procedure described in 8.3.5.

The coordinator can send the measurement report to the global controller together with the QoS requirement of the device. If the global controller decides to handover the device to the target coordinator, it sends its decision to the current coordinator. It also notify the target coordinator about the upcoming handover together with QoS requirement. The procedures for the communications between global controller and the coordinator are out the scope of this specification.

Current coordinator sends handover command frame to the device.

Then the device sends re-association request (see 9.5.3) to the target device.

In the re-association response command, the target coordinator confirms the handover. Besides, the target coordinator also informs the QoS resources allocated to the device, or suggests alternate level of QoS the target coordinator can support.



Figure 8‑7 Handover initiated by global controller

# MAC frame formats

The MAC frame format is composed of a MHR, a MSDU and a MFR. The specific fields of each component is for further study.

Five frame types are defined: beacon, data, ACK, command and control.

Beacon frame is transmitted by coordinators and contains information for VPAN management.

Multiple frames command frames are defined in this specification. Command frames shall only be transmitted in the CAP of the superframe.

Control frame refers to RTS frame and CTS frame.

## General MAC frame format

### Frame control field

Frame control field may include subfield such as, frame version, frame type, ACK request, etc. The details are TBD.

In addition, a link adaptation control subfield is included as shown in Figure 9‑1.

|  |  |  |  |
| --- | --- | --- | --- |
| Bits: 0 | 1-3 | 4-6 | 7 |
| MCS request | MCS sequence index | Feedback sequence index | MCS feedback |

Figure 9‑1 Link adaptation control subfield

MCS request indicates whether a MCS feedback is required. If a MCS feedback is required, MCS request is set to ‘0b1’, otherwise, it is set to ‘0b0’.

In each MCS request, the requester shall set the MSI (MCS sequence index) subfield to a value in the range 0 to 6. How the requester chooses the MSI value is implementation dependent.

The MFB responder includes the received MSI value in the feedback sequence index subfield of the corresponding response frame. If an unsolicited feedback is provided, feedback sequence index subfield is set to 0b111.

The suggested MCS level is transmitted in MCS feedback subfield.

### Sequence number field

TBD

### Destination VPAN Identifier field

TBD

### Destination Address field

TBD

### Source VPAN Identifier field

TBD

### Source Address field

TBD

### Auxiliary Security Header field

TBD

### Frame Payload field

TBD

### FCS field

TBD

## Beacon frame format

The beacon frame shall be formatted as illustrated in Figure 9‑2.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Octets:TBD | 1 | 4/10 | 0/5/6/10/14 | 2 | 0/1 | variable | Variable | Variable | 2 |
| Frame Control | Sequence Number | Addressing fields | Auxiliary Security Header | Superframe Spec | BP Descriptor | CAP Descriptor | CFP Descriptor | Beacon Payload | FCS |
| MHR | MSDU | MFR |

Figure 9‑2 Beacon frame format

### Beacon frame MHR fields

TBD

### Superframe Spec field

The Superframe Spec field shall be formatted as illustrated in Figure 9‑3.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Bits: 0-3 | 4-5 | 6 | 7 | 8 | 9-12 | 13-15 |
| Beacon Order | VPAN Mode | Beacon Type | Association Permit | CFP Presence Indication | Countdown | Reserved |

Figure 9‑3 Superframe Spec field

The Beacon Order subfield shall specify the transmission interval of the beacon. Refer to clause xx for an explanation of the relationship between the beacon order and beacon interval.

The VPAN Mode subfield specifies the topology mode of the VPAN, and shall be contain one of the nonreserved values listed in Table 9‑1.

Table 9‑1 Valid values of the VPAN Mode subfield

|  |  |
| --- | --- |
| **VPAN Mode** | **Description** |
| 0b00 | Peer-to-Peer Mode |
| 0b01 | Star Mode |
| 0b10 | Coordinated Mode |
| 0b11 | Reserved |

The Beacon Type subfield shall be set to one if the beacon frame is a normal beacon which is transmitted in the beacon period regularly, and set to zero if the beacon frame is an additional beacon which is transmitted in a GTS in the CFP period.

The Association Permit subfield shall be set to one if *macAssociationPermit* is set to TRUE (i.e., the coordinator is accepting association to the VPAN). The association permit bit shall be set to zero if the coordinator is currently not accepting association requests on its network.

The CFP Presence Indication subfield shall be set to one if the superframe includes a CFP region, otherwise, the CFP Presence Indication subfield shall be set to zero. If this subfield is set to 1, the beacon frame shall include the corresponding CFP descriptor field.

The Countdown field indicates the number of superframes after which the previously announced new configuration parameters of the VPAN shall take effect. The value of this field shall decrement by one in each superframe until the Countdown is complete.

### BP Descriptor field

The BP Descriptor field shall be formatted as illustrated in Figure 9‑4.

|  |  |
| --- | --- |
| Bits: 0-3 | 4-7 |
| Beacon Slot Number  | Beacon Slot Used |

Figure 9‑4 BP descriptor field

The Beacon Slot Number subfield shall contain the number of the beacon slots in the BP.

The Beacon Slot Used subfield shall indicates which beacon slot is used by this VPAN.

###  CAP Descriptor field

|  |  |  |  |
| --- | --- | --- | --- |
| Octets:1 | 2 | … | N |
| Section Number | Section[1] Descriptor | … | Section[N] Descriptor |

Figure 9‑5 CAP descriptor field

The Section Number subfield indicates the number of the sections that the CAP is divided into. The CAP Descriptor field shall include N Section Descriptor, and N is the value that the Section Number subfield represents.

The Section[i] Descriptor shall be formatted as illustrated in Table 9‑2.

Table 9‑2 Section descriptor

|  |  |
| --- | --- |
| **Bit position** | **Function** |
| 0-7 | The end time of this section. |
| 8-11 | The bandwidth that is allowed to use in this section.000 represents all bandwidth.001-111: Reserved |
| 12-13 | If RTS/CTS is used in this section00: No01:Normal RTS/CTS shall be used10: Improved RTS/CTS shall be used. If 10 is set, the bit 8-11 shall be set to 000. 11: Reserved |
| 14-15 | Reserved |

###  CFP Descriptor field

|  |  |  |  |
| --- | --- | --- | --- |
| Octets:1 | 2 | … | N |
| GTS Number | GTS[1] Descriptor | … | Section[N] Descriptor |

Figure 9‑6 CFP descriptor field

The GTS Number subfield indicates the number of the GTSs that the CFP is divided into. The CFP Descriptor field shall include N GTS Descriptor, and N is the value that the GTS Number subfield represents.

The GTS[i] Descriptor shall be formatted as illustrated in Table 9‑3.

Table 9‑3 GTS descriptor

|  |  |
| --- | --- |
| Bit position | Function |
| 0-7 | The end time of this section. |
| 8-15 | FLOW ID |
| 16-23 | Sub-band |
| 24-31 | wavelength |

###  Beacon Payload

The Beacon Payload field is an optional sequence of up to aMaxBeaconPayloadLength octets specified to be transmitted in the beacon frame by the next higher layer. The set of octets contained in macBeaconPayload shall be copied into this field.

## Data frames

TBD

## Acknowledgement frames

TBD

## Command frames

### Association request command

The association request command allows a device to request association with a VPAN through the coordinator. This command shall only be sent by an unassociated device that wishes to associate with a VPAN. A device shall only associate with a VPAN through the coordinator as determined through the scan procedure.

All devices shall be capable of transmitting this command, although a device is not required to be capable of receiving it.

The association request command shall be formatted as illustrated in Figure 9‑7.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Octets: see 5.8.x | 1 | 1 | 1 | TBD |
| MHR fields | Command Frame Identifier  | Capability Information | Auxiliary paratermeters  | Interference Info field |

Figure 9‑7 Association request command format

#### MHR fields

TBD

#### Capability Information field

TBD

#### Auxiliary parameters field

All allowed settings of Auxiliary parameters field are shown in Table 9‑4. Only association request in star/coordinated mode includes this auxiliary parameters field.

Table 9‑4 Auxiliary parameters field

|  |  |
| --- | --- |
| **Bit position** | **Function** |
| 0-1 | The type of the beacon that triggers the association request of the device. A device shall set these two bits according to which kind of beacon it detected.00: original beacon01: additional beacon10-11: reserved |
| 2-3 | Number of retry times00: 1; 01:2, 10:3; 11:4 |
| 4 | Indicating if the Interference Info field is present0: There is no Interference Info field in this command.1: There is Interference Info field in this command. |
| 5-7 | Reserved |

#### Interference Info field

A device may detect and collect the potential interference information when searching for the beacons before association. If the additional beacon frames of a VPAN have been detected, the device may include this field in the association request command to indicate the interference information of this VPAN.

The details are for further study.

### Association response command

The association response command allows a coordinator to communicate the results of an association attempt back to the device requesting association. This command shall only be sent by a coordinator to a device that is currently trying to associate.

All devices shall be capable of receiving this command, although a device is not required to be capable of transmitting it.

The association response command shall be formatted as illustrated in Figure 9‑8.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Octets: see 5.8.x | 1 | 2 | 1 | 1 |
| MHR fields | Command Frame Identifier (as defined in Table 10) | Short Address | Association Status  | Capability-negotiation response |

Figure 9‑8 Association request response format

#### MHR fields

TDB

#### Short Address Field

If the coordinator was not able to associate this device to its VPAN, the Short Address field shall be set to 0xffff, and the Association Status field shall contain the reason for the failure. If the coordinator was able to associate the device to its VPAN, this field shall contain the short address that the device may use in its communications on the VPAN until it is disassociated.

A Short Address field value equal to 0xfffe shall indicate that the device has been successfully associated with a VPAN, but has not been allocated a short address. In this case, the device shall communicate on the VPAN using only its 64-bit extended address.

#### Association Status field

The Association Status field shall contain one of the non-reserved values listed in Table 9‑5.

Table 9‑5 Valid values of the Association Status field

|  |  |
| --- | --- |
| **Association status** | **Description** |
| 0x00 | Association successful |
| 0x01 | VPAN at capacity |
| 0x02 | VPAN access denied |
| 0x03-0x7f | Reserved |
| 0x80-0xff | Reserved for MAC primitive enumeration values. |

#### Capability negotiation response field

TBD

### Reassociation request

#### See section 7.2.3.6 of 802.11r

### Reassociation response

#### See section 7.2.3.7 of 802.11r

### Disassociation notification command

The VLC coordinator or an associated device may send the disassociate notification command. All devices shall implement this command.

The disassociation notification command shall be formatted as illustrated in Figure 9‑9.

|  |  |  |
| --- | --- | --- |
| Octets | 1 | 1 |
| MHR fields | Command Frame identifier | Disassociation reason |

Figure 9‑9 Disassociation notification command

#### MHR fields

TBD

#### Disassociation Reason field

The Disassociation Reason field shall contain one of the non-reserved values listed in Table 9‑6.

Table 9‑6 Valid disassociation reason codes

|  |  |
| --- | --- |
| **Disassociate reason** | **Description** |
| 0x00 | Reserved |
| 0x01 | The coordinator wishes the device to leave the VPAN |
| 0x02 | The device wishes to leave the VPAN |
| 0x03 | Device cannot support communications for the requested dimming value |
| 0x04-0x7f | Reserved |
| 0x80-0xff | Reserved for MAC primitive enumeration values |

### Disassociation response command

TBD

### Beacon request command

The beacon request command is used by a device to locate all neighboring VPANs during an active scan.

The beacon request command shall be formatted as illustrated in Figure 9‑10.

|  |  |
| --- | --- |
| Octets: | 1 |
| MHR fields | Command Frame identifier |

Figure 9‑10 Beacon request command

### Additional Beacon request command

The beacon request command is sent by a device to request a coordinator to send additional beacon frames.

The command is optional for a device.

The beacon request shall be formatted as illustrated in Figure 9‑11.

|  |  |  |
| --- | --- | --- |
| Octets | 1 | 1 |
| MHR fields | Command Frame identifier | Reason |

Figure 9‑11 Additional beacon request command

#### MHR fields

TBD

#### Reason field

The Reason field shall contain one of the non-reserved values listed in Table 9‑7.

Table 9‑7 Reason field

|  |  |
| --- | --- |
| **Value** | **Function** |
| 0x00 | A new device that may be located at the interferefering area of multiple VPANs fails to detect the beacon frame due to interference. |
| 0x01 | An associated device that is located at the interferefering area of multiple VPANs fails to detect the beacon frame due to interference. |
| 0x02-0xFF | reserved |

### Scan-over-backhaul request command

The scan-over-backhaul request command shall be send by a prospective coordinator to other coordinators through the backhaul link if inter-coordinator communication over backhaul is feasible.

The scan-over-backhaul request command shall be formatted as illustrated in Figure 9‑12.

|  |  |
| --- | --- |
| Octets:  | 1 |
| MHR fields | Command Frame identifier |

Figure 9‑12 Scan-over-backhaul request command

### Scan-over-backhaul confirmation command

The scan-over-backhaul confirmation command shall be sent by a coordinator as a response to a previous received scan-over-backhaul request command through the backhaul.

The scan-over-backhaul confirmation command shall be formatted as illustrated in Figure 9‑13.

|  |  |  |
| --- | --- | --- |
| Octets: | 1 | TBD |
| MHR fields | Command Frame identifier | VPANDescritorList  |

Figure 9‑13 Scan-over-backhaul confirmation command

#### MHR fields

TBD

#### VPANDescriptorList

VPANDescriptorList contains the information of the VPAN whose coordinator generates the scan-over-backhaul confirmation command.

### VPAN ID conflict notification command

The VPAN ID conflict notification command is sent by a device to the coordinator to report a VPAN ID conflict detected by the device.

The VPAN ID conflict notification command shall be formatted as illustrated in Figure 9‑14.

|  |  |
| --- | --- |
| Octets | 1 |
| MHR fields | Command Frame identifier |

Figure 9‑14 VPAN ID conflict notification command

### Neighboring VPAN report request command

The neighboring VPAN report request command is sent by the coordinator to devices to request a report of neighboring VPAN information detected by the devices.

The neighboring VPAN report request command shall be formatted as illustrated in Figure 9‑15.

|  |  |
| --- | --- |
| Octets | 1 |
| MHR fields | Command Frame identifier |

Figure 9‑15 Neigboring VPAN report request command

### Neighboring VPAN report indication command

The neighboring VPAN report indication command is sent by the device to the coordinator to report neighboring VPAN information. The neighboring VPAN information is recorded in a local neighboring VPAN descriptor list, each record in the list corresponding to the information of one neighboring VPAN that can be detected by the device.

The neighboring VPAN report indication command shall be formatted as illustrated in Figure 9‑16.

|  |  |  |
| --- | --- | --- |
| Octets: see 5.2.2.4 | 1 |  |
| MHR fields | Command Frame identifier | Local neighboring VPAN descriptor list |

Figure 9‑16 Neighboring VPAN report indication command

#### MHR fields

TBD

#### Local neighboring VPAN descriptor list

The local neighboring VPAN descriptor list field contains neighboring VPANs information that can be detected by the device. The detailed format is Table 8‑1.

### Flow Establishment Request command

The coordinator or an associated device can send this command to request establishing a flow. This command can be used by an associated device that is requesting allocation of a GTS from the coordinator.

The Flow Establishment Request command shall be formatted as illustrated in Figure 9‑17.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Octets:  | 1 | 1 | 0/1 | TBD | 0/1 | TBD |
| MHR fields | Command Frame identifier | Control Indication | FLOW ID \_F | TSpec\_F | FLOW ID \_R | TSpec\_R |

Figure 9‑17 Flow establishment request command

#### MHR fields

TBD

#### Control Indication field

All allowed settings of Control Indication field are shown in Table 9‑8.

Table 9‑8 Control indication field

|  |  |
| --- | --- |
| Bit position | Function |
| 0 | If this command includes the information related to the reverse flow.0: No1: Yes |
| 1 | 0: The coordinator originates the flow1: A device originates the flow |
| 2-7 | Reserved |

#### FLOW ID\_F field

FLOW ID\_F field indicates the FLOW ID of the forwarding flow, i.e., from the originator to the recipient.

The coordinator shall assign a unique FLOW ID to a flow in the VPAN. If this command is sent by the coordinator (Bit1 of Control Indication field is set to 0), the FLOWID \_F field shall be set to a non-zero value that has not been assigned to other flows. If this command is sent by a device, the FLOW ID\_F field does not exist.

#### TSpec\_F field

TBD

#### FLOW ID\_R field

FLOW ID\_F field indicates the FLOW ID of the reverse flow, i.e., from the recipient to the originator.

If this command is sent by the coordinator, the FLOWID \_R field shall be set to a non-zero value that has not been assigned to other flows. If this command is sent by a device, the FLOW ID\_Rfield shall be set to 0x00.

#### TSpec\_R field

TBD

### Flow Establishment Response command

The Flow Establishment Response command is sent in response to a Flow Establishment Request command. When used, the Flow Establishment Response command shall be formatted as illustrated in Figure xx.

The Flow Establishment Request command shall be formatted as illustrated in Figure xx.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Octets: see 5.2.2.4 | 1 | 1 | 1 | 1 | 1 | 1 |
| MHR fields | Command Frame identifier | ControlIndication | FLOW ID\_F | Status\_F | FLOW ID\_R | Status\_R |

Figure 9‑18 Flow establishment response command

#### MHR fields

TBD

#### Control Indication field

Same as 9.5.14.2.

#### FLOW ID\_F field

The coordinator shall assign a unique FLOW ID to a flow in the VPAN. If Bit1 of Control Indication field is set to 0, the FLOW ID\_F field does not exist. If Bit1 of Control Indication field is set to 1, the FLOWID \_F field shall be set to a non-zero value that has not been assigned to other flows.

#### Status\_F field

The Status\_F field indicates the status of the request to establish a forwarding flow, and shall contain one of the non-reserved values listed in Table 9‑9.

Table 9‑9 Status\_F field

|  |  |
| --- | --- |
| **Value** | **Description** |
| 0x00 | Success |
| 0x01 | Failure – Maximum number of flows already started by the recipient |
| 0x02 | Failure – Error in TSpec passed in Flow Establishment Request command |
| 0x03 | Failure – Insufficient resources |
| 0x04-0xFF | Reserved  |

#### FLOW ID\_R field

The coordinator shall assign a unique FLOW ID to a flow in the VPAN. If Bit1 of Control Indication field is set to 0, the FLOW ID\_R field does not exist. If Bit1 of Control Indication field is set to 1, the FLOWID \_R field shall be set to a non-zero value that has not been assigned to other flows.

#### Status\_R field

The Status\_R field indicates the status of the request to establish a reverse flow, and shall contain one of the nonreserved values listed in Table 9‑10.

Table 9‑10 Status\_R field

|  |  |
| --- | --- |
| **Value** | **Description** |
| 0x00 | Success |
| 0x01 | Failure – Maximum number of flows already started by the recipient |
| 0x02 | Failure – Error in TSpec passed in Flow Establishment Request command |
| 0x03 | Failure – Insufficient resources |
| 0x04-0xFF | Reserved  |

### Flow Modify Request Command

The Flow Modify Request Command is sent by the coordinator to a device to alter the traffic contract.

The Flow Modify Request Command shall be formatted as illustrated in Figure 9‑19.

|  |  |  |  |
| --- | --- | --- | --- |
| Octets:  | 1 | 1 | variable |
| MHR fields | Command Frame identifier | FLOW ID | Proposed TSpec |

Figure 9‑19 Flow Modify Request Command

#### MHR fields

TBD

#### FLOW ID field

This field shall be set to the FLOW ID of a flow, for which the coordinator wishes to alter the traffic contract.

#### Proposed TSpec field

TBD

### Flow Modify Response Command

The Flow Modify Response Command is sent by the device to the coordinator in response to GTS Modify Request Command.

The Flow Modify Response Command shall be formatted as illustrated in Figure 9‑20.

|  |  |  |  |
| --- | --- | --- | --- |
| Octets: | 1 | 1 | 1 |
| MHR fields | Command Frame identifier | FLOW ID | Status |

Figure 9‑20 Flow Modify Response Command

#### MHR fields

TBD

#### FLOW ID field

This field shall be set to the FLOW ID of a flow, for which the coordinator wishes to alter the traffic contract.

#### Status field

The Status field indicates the status of the request to modify the traffic contract of a flow, and shall contain one of the non-reserved values listed in Table 9‑11.

Table 9‑11 Status field

|  |  |
| --- | --- |
| **Value** | **Description** |
| 0x00 | Success |
| 0x01 | Failure – Device does not support this service |
| 0x02 | Failure – Error in the proposed TSpec passed in GTS modify Request command |
| 0x03 | Failure – Failure due to other reason |
| 0x04-0xFF | Reserved  |

### Flow Terminate Request Command

The coordinator or an associated device can send this Flow Release Request Command to request terminating a flow.

The Flow Release Request Command shall be formatted as illustrated in Figure 9‑21.

|  |  |  |  |
| --- | --- | --- | --- |
| Octets: see 5.2.2.4 | 1 | 1 | 1 |
| MHR fields | Command Frame identifier | FLOW ID | Reason |

Figure 9‑21 Flow terminate request command

#### MHR fields

TBD

#### FLOW ID field

This field shall be set to the FLOW ID of a flow, which the sender wishes to terminate.

#### Reason field

The Reason field indicates why the sender terminates the flow, and shall contain one of the non-reserved values listed in Table 9‑12.

Table 9‑12 Reason field

|  |  |
| --- | --- |
| **Value** | **Description** |
| 0x00 | Normal termination initiated by the originator |
| 0x01 | Terminated by the coordinator due to lack of resources |
| 0x02-0xFF | Reserved  |

### Flow Terminate Response Command

This command is sent as a reply to a received Flow Release Response Command.

The Flow Release Response Command shall be formatted as illustrated in Figure 9‑22.

|  |  |  |  |
| --- | --- | --- | --- |
| Octets:  | 1 | 1 | 1 |
| MHR fields | Command Frame identifier | FLOW ID | Status |

Figure 9‑22 Flow terminate response command

####  MHR fields

TBD

####  FLOW ID field

This field shall be set to the FLOW ID of the terminated flow.

####  Status field

The Status field indicates the status of the termination, and shall contain one of the non-reserved values listed in Table 9‑13.

Table 9‑13 Status field

|  |  |
| --- | --- |
| **Value** | **Description** |
| 0x00 | Successful |
| 0x01 | Failed |
| 0x02-0xFF | Reserved  |

### Coordinator realignment command

See section 5.3.7 of 802.15.7-2011.

## Control frames

### RTS frame

TBD

### CTS frame

TBD

# MAC primitives

## Primitives for data service

### MCPS-DATA.request

The MCPS-DATA.request primitive requests the transfer of a MSDU from a local next higher layer entity to a peer next higher layer entity (or entities).

The semantics of the MCPS-DATA.request primitive are as follows:

MCPS-DATA.request (

DstAddr

DstVPANId

MSDULength

MSDU

MSDUHandle

TxOptions

)

Table 10‑1 specifies the parameters for the MCPS-DATA.request primitive.

Table 10‑1 MCPS-DATA.request parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| DstAddr | 16 bit short device addresses | From 0x0000-0xffff, 0x0000 represents without a short address assigned, 0xffff represents a broadcast transmission. | The destination address(or addresses) of the entity to which the MSDU is being transfered |
| DDstVPANId | Integer | 0x0000-0xffff | The 16-bit VPAN ID of the entity to which the MSDU is being transferred. |
| MMSDULength | Integer | $$\leq aMaxMACPayloadSize$$ | The number of octets contained in the MSDU to be transmitted by the MAC sublayer entity. |
| MMSDU | Set of octets |  | The set of octets forming the MSDU to be transmitted by the MAC sublayer entity. |
| MMSDUHandle | Integer | 0x00-0xff | The handle associated with the MSDU to be transmitted by the MAC sublayer entity. |
| TTxOptions | Bitmap | 2 bit field | The 2 bits (b0, b1) indicate the transmission options for this MSDU.For b0, 1=acknowledged transmission, 0=unacknowledged transmission.For b1, 1=contention-free transmission. 0=contention transmission. |

#### When generated

The MCPS-DATA.request shall be generated by the next higher layer entity and issued to the MAC sublayer when the next higher layer entity has a MSDU needed to be transmitted to the peer next higher layer entity.

#### Effect on receipt

On receipt of the MCPS-DATA.request primitive, the MAC sublayer entity begins the transmission of the supplied MSDU.

The MAC sublayer shall build a MAC frame to transmit from the supplied arguments. The DstAddr, DstVPANId, MSDULength, and b0 of the TxOption fields are used to construct the MAC frame header. The MSDU are used to construct the payload of the MAC frame. The b1 of the TxOptions indicates whether a contention-free transmission is expected or a contention transmission is expected. If a contention-free transmission is expected and a flow between the device and the peer device is already existed, then the MAC sublayer shall defer the transmission until the GTS for the flow begins, and if a flow between the device and the peer device is not existed, then the MAC sublayer shall start the flow establishment procedure so as to obtain GTSs for the transmission of the MAC frame. If the b1 of the TxOptions indicates a contention transmission, then the device shall start the random access procedure in the CAP of the superframe.

### MCPS-DATA.confirm

The MCPS-DATA.confirm primitive reports the results of a request to transfer a MSDU from a local next higher layer entity to a peer next higher layer entity.

The semantics of the MCPS-DATA.confirm primitive are as follows:

MCPS-DATA.confirm(

MSDUHandle

Status

Timestamp

)

Table 10‑2 specifies the parameters for the MCPS-DATA.confirm primitive.

Table 10‑2 MCPS-DATA.confirm primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| MsduHandle | Integer | 0x00-0xff | The handle associated with the MSDU being confirmed |
| Status | Enumeration | SUCCES,TRANSACTION\_OVERFLOW,TRANSACTION\_EXPIRED,CHANNEL\_ACCESS\_FAILURE,INVALID\_ADDRESS,NO\_ACK,COUNTER\_ERROR,FRAME\_TOO\_LONG, | The status of the last MSDU transmission. |
| Timestamp | Integer | 0x000000-0xffffff | Optional.The time at which the MSDU were transmitted. This parameter is valid only if the value of the status parameter is SUCCESS. |

#### When generated

The MCPS-DATA.confirm primitive is generated by the MAC sublayer entity in response to an MCPS-DATA.request primitive. The MCPS-DATA.confirm primitive returns a status of either SUCCESS, indicating that the requested transmission was successful or the appropriate error codes.

#### Effect on receipt

On receipt of the MCPS-DATA.confirm primitive, the local next higher layer of the device is notified of the result of its request to transmit based on the status value.

### MCPS-DATA.indication

The MCPS-DATA.indication primitive indicates the transfer of a MSDU from the MAC sublayer to the local next higher layer entity.

The semantics of the MCPS-DATA.indication primitive are as follows:

MCPS-DATA.indication(

SrcAddr

SrcVPANId

DstAddr

DstVPANId

MSDULength

MSDU

MSDUHandle

DSN

Timestamp

)

Table 10‑3 specifies the parameters for the MCPS-DATA.indication primitive.

Table 10‑3 MCPS-DATA.indication parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| SrcAddr | 16 bit short device addresses | From 0x0000-0xffff, 0x0000 represents without a short address assigned, 0xffff represents a broadcast transmission. | The source address of the entity from which the MSDU was received. |
| DSrcVPANId | Integer | 0x0000-0xffff | The 16-bit VPAN ID of the entity from which the MSDU was received. |
| DstAddr | 16 bit short device addresses | From 0x0000-0xffff, 0x0000 represents without a short address assigned, 0xffff represents a broadcast transmission. | The destination address (or addresses) of the entity to which the MSDU is being transferred. |
| DDstVPANId | Integer | 0x0000-0xffff | The 16-bit VPAN ID of the entity to which the MSDU is being transferred. |
| MMSDULength | Integer | $$\leq aMaxMACPayloadSize$$ | The number of octets contained in the MSDU being indicated by the MAC sublayer entity. |
| MMSDU | Set of octets |  | The set of octets forming the MSDU being indicated by the MAC sublayer entity. |
| MMSDUHandle | Integer | 0x00-0xff | The handle associated with the MSDU to be transmitted by the MAC sublayer entity. |
| DSN | Integer | 0x00-0xff | The DSN of the received MSDU. |
| Timestamp | Integer | 0x000000-0xffffff | The time at which the MSDU were received.  |

#### When generated

The MCPS-DATA.indication primitive is generated by the MAC sublayer and issued to the next higher layer on receipt of a data frame at the local MAC sublayer entity that passes the appropriate message filtering operation.

#### Effect on receipt

The next higher layer is notified of the MSDU on receipt of the MCPS-DATA.indication primitive and shall process the MSDU accordingly.

### Primitives for a heterogeneous network

As described in 1.2, ACK frames from type 2 devices to a coordinator shall be send trough RF link first and then relayed to the coordinator through a wired backhaul link (power line, Ethernet, cable, etc.) in a heterogeneous network, which is a different way than it is sent through the VLC link. Therefore, particular primitives are needed so as to send the ACK frame successfully through the RF link and backhaul link.

MCPS-SAP ACK primitives defines how an ACK frame shall be transmitted in a heterogeneous network when a type 2 device has an ACK frame that needs to be sent to the coordinator by the RF link and the backhaul link. For ACK frames sent by type 1 devices and type 3 devices, MCPS-SAP DATA primitives shall be used.

#### MCPS-ACK.indication

The MCPS-ACK.indication primitive allows the MAC sublayer of the device to provide an ACK frame to its next higher layer.

The semantics of the MCPS-ACK.indication primitive are as follows:

MCPS-ACK.indication(

DstAddr

SrcAddr

ACKFrame

)

Table 10‑4 specifies the parameters for the MCPS-ACK.indication primitive.

Table 10‑4 MCPS-ACK.indication primitive

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| DstAddr | Integer | From 0x0000-0xffff, 0x0000 represents without a short address assigned, 0xffff represents a broadcast transmission. | The short address of the coordinator that the ACK frame is designated to. |
| DSrcAddr | Integer | From 0x0000-0xffff, 0x0000 represents without a short address assigned, 0xffff represents a broadcast transmission. | The short address of the device that has generated the ACK frame. |
| ACKFrame | Set of octets |  | The set of octets forming the ACK frames to be transmitted. |

##### When generated

When the MAC sublayer of the device generates an ACK frame that needs to be sent to the coordinator, it shall generate a MCPS-ACK.indication primitive and issue the MCPS-ACK.indication primitive to its next higher layer.

##### Effect on receipt

On receipt of the MCPS-ACK.indication primitive, the next higher layer of the device may generate a next higher layer message based on the provided arguments and send it to the next higher layer of the coordinator through the RF link and backhaul link. The ACK frame generated by the MAC sublayer shall be embedded in the next higher layer message.

#### MCPS-ACK.resquest

The MCPS-ACK.request primitive allows the next higher layer of the coordinator to request its MAC sublayer to process an ACK frame received through the backhaul link.

The semantics of the MCPS-ACK.request primitive are as follows:

MCPS-ACK.request(

DstAddr

SrcAddr

ACKFrame

)

Table 10‑5 specifies the parameters for the MCPS-ACK. request primitive.

Table 10‑5 MCPS-ACK. request primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| DstAddr | Integer | From 0x0000-0xffff, 0x0000 represents without a short address assigned, 0xffff represents a broadcast transmission. | The short address of the coordinator that the ACK frame is designated to. |
| DSrcAddr | Integer | From 0x0000-0xffff, 0x0000 represents without a short address assigned, 0xffff represents a broadcast transmission. | The short address of the device that has generated the ACK frame. |
| ACKFrame | Set of octets |  | The set of octets forming the ACK frames to be transmitted. |

##### When generated

The next higher layer of the coordinator shall generate a MCPS-ACK.request primitive when it has received the next higher layer message through the backhaul link and issue the MCPS-ACK.request primitive to its MAC sublayer.

##### Effect on receipt

On receipt of the MCPS-ACK.request primitive, the MAC sublayer of the coordinator shall process the ACK frame provided in this primitive the same way as it was received through the VLC link.

## Primitives for management service

The MLME-SAP allows the transport of management commands between the next higher layer and the MLME. This subclause shall describe different primitives supported in the MLME-SAP.

### Association primitives

MLME-SAP association primitives define how a device becomes associated with a VPAN.

#### MLME-ASSOCIATE.request

The MLME-ASSOCIATE.request primitive allows a device to request an association with a coordinator.

The semantics of the MLME-ASSOCIATE.request primitive are as follows:

MLME-ASSOCIATE.request(

LogicalChannel

DeviceAddr

CoordAddr

VPANId

CapabilityInformation

)

Table 10‑6 specifies the parameters for the MLME-ASSOCIATE.request primitive.

Table 10‑6 MLME-ASSOCIATE.request primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| LlogicalChannel | Integer | Selected from the available logical channels supported by the PHY | The logical channel on which to attempt association. |
| CCoordAddress | Device address | TBD | The address of the coordinator with which to associate. |
| CVPANId | Integer | 0x00-0xff | The VPAN ID of the VPAN that the device needs to associate with. |
| CCapabilityInformation | Bitmap | TBD | Specifies the operational capabilities of the associating device. |

##### When generated

The MLME-ASSOCIATE.request primitive is generated by the next higher layer of an unassociated device and issued to request an association with a VPAN through a coordinator.

##### Effect on receipt

On receipt of the MLME-ASSOCIATE.request primitive, the MLME of an unassociated device first updates the appropriate PHY and MAC MIB attributes and then generate an association request command and send it to the coordinator of the target VPAN specified by the VPANId value.

#### MLME-ASSOCIATE.indication

The MLME-ASSOCIATE.indication primitive is used to indicate the reception of an association request command.

The semantics of the MLME-ASSOCIATE.indication primitive are as follows:

MLME-ASSOCIATE.indication(

DeviceAddress

CapabilityInformation

)

Table 10‑7 specifies the parameters for the MLME-ASSOCIATE.indication primitive.

Table 10‑7 MLME-ASSOCIATE.indication primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| DDeviceAddr | Device addresses | TBD | Device address of the associating device  |
| CCapabilityInformation | Bitmap | TBD | Specifies the operational capabilities of the associating device. |

##### When generated

The MLME-ASSOCIATE.indication primitive is generated by the MLME of the coordinator and issued to its next higher layer to indicate the reception of an association request command received by the PHY.

##### Effect on receipt

On receipt of the MLME-ASSOCIATE.indication primitive, the next higher layer of the coordinator is notified of the association request of the device and its capability information. The next higher layer shall then decide whether to accept or reject the association request of the device and provide the decision to the MLME by issuing a MLME-ASSOCIATE.response primitive.

#### MLME-ASSOCIATION.response

The MLME-ASSOCIATION.response primitive is used to initiate a response to an MLME-ASSOCIATE.indication primitive.

The semantics of the MLME-ASSOCIATE.response primitive are as follows:

MLME-ASSOCIATE.response(

DeviceAddr

Status

CapabilityNegotiationResponse

)

Table 10‑8 specifies the parameters for the MLME-ASSOCIATE.response primitive.

Table 10‑8 MLME-ASSOCIATE.response primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| DeviceAddr | 16-bit short device addresses or 64-bit extended address | TBD | 16 bit short device address assigned to the associating device or 64-bit EUI extended address of the associating device  |
| Status | Enumeration |  | The status of the associate attempt. |
| CapabilityNegotiationResponse | Integer | 00-11 | The coordinator indicates the acceptable operational parameters that the device can use. |

##### When generated

The MLME-ASSOCIATE.response primitive is generated by the next higher layer of a coordinator and issued to its MLME in order to respond the MLME-ASSOCIATE.indication primitive.

#####  Effect on receipt

On receipt of the MLME-ASSOCIATE.response primitive, the MLME of the coordinator shall generate an association response command based on the provided arguments and send the command to the device requesting association. The status value shall indicate the MLME whether the association attempt is accepted or rejected. If the status value indicates acceptance of the association request, then a valid short address ranged from 0x0001-0xfffe shall be provide in the primitive, too.

#### MLME-ASSOCIATE.confirm

The MLME-ASSOCIATE.confirm primitive is used to inform the next higher layer of the initiating device whether its request to associate was successful or unsuccessful.

The semantics of the MLME-ASSOCIATE.confirm primitive are as follows:

MLME-ASSOCIATE.confirm (

DeviceAddr

Status

CapabilityNegotiationResponse

)

Table 10‑9 specifies the parameters for the MLME-ASSOCIATE.confirm primitive.

Table 10‑9 MLME-ASSOCIATE.confirm primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| DeviceAddr | 16 bit short device addresses | From 0x0000-0xffff, 0x0000 represents without a short address assigned, 0xffff represents a broadcast transmission. | 16 bit short device address assigned to the associating device by the coordinator  |
| Status | Enumeration |  | The status of the associate attempt. |
| CapabilityNegotiationResponse | Integer | 00-11 | accepptable operational parameters that the device can use. |

##### When generated

The MLME-ASSOCIATE.confirm primitive is generated by the MLME of initiating device and issued to its next higher layer in response to an MLME-ASSOCIATE.request primitive. If the request was successful, the status parameter will indicate a successful association, as contained in the status field of the association response command.

##### Effect on receipt

On receipt of the MLME-ASSOCIATE.confirm primitive, the next higher layer of the initiating device is notified of the result of its request to associate with a coordinator. If the association attempt was successful, the status parameter will indicate a successful association, as contained in the status field of the association response command, and the device will be provided with a valid 16-bit short address. If the association attempt was unsuccessful, the valid short address will not be provided and the error codes will be provided. The next higher layer of the associating device shall not initiate another association attempt if the error has not been properly corrected.

### Disassociation primitives

The MLME-SAP disassociation primitives define how a device can disassociate from a VPAN.

#### MLME-DISASSOCIATE.request

The MLME-DISASSOCIATE.request primitive is used by an associated device to notify the coordinator of its intent to leave the VPAN. It is also used by the coordinator to instruct an associated device to leave the VPAN.

The semantics of the MLME-DISASSOCIATE.request primitive are as follows:

MLME-DISASSOCIATE.request(

DeviceAddr

DisassociationReason

)

Table 10‑10 specifies the parameters for the MLME-DISASSOCIATE.request primitive.

Table 10‑10 MLME-DISASSOCIATE.request primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| DeviceAddr | 16 bit short device addresses | 0x0000, which represents the device has not been assigned a valid short address yet. | 16 bit short device address  |
| DisassociationReason | Integer | 0x00-0xff | Reasons for disassociation  |

##### When generated

The MLME-DISASSOCIATE.request primitive is generated by the next higher layer of an associated device and issue to its MLME to request disassociation from the VPAN. It is also generated by the next higher layer of the coordinator and issued to its MLME to instruct an associated device to leave the VPAN.

##### Effect on receipt

On receipt of the MLME-DISASSOCIATE.request primitive, the MLME of the device or the coordinator shall generate a disassociation notification command and send it to the coordinator or the device.

#### MLME-DISASSOCIATE.indication

The MLME-DISASSOCIATE.indication primitive is used to indicate the reception of a disassociation notification command.

The semantics of the MLME-DISASSOCIATE.indication primitive are as follows:

MLME-DISASSOCIATE.indication(

DeviceAddr

DisassociationReason

)

Table 10‑11 specifies the parameters for the MLME-DISASSOCIATE.indication primitive.

Table 10‑11 MLME-DISASSOCIATE.indication primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| DeviceAddr  | 16 bit short device addresses | 0x0000, which represents the device has not been assigned a valid short address yet. | 16 bit short device address  |
| DisassociationReason | Integer | 0x00-0xff | Reason for disassociation |

##### When generated

The MLME-DISASSOCIATE.indication primitive is generated by the MLME and issued to its next higher layer on receipt of a disassociation notification command.

##### Effect on receipt

The next higher layer is notified of the reason for the disassociation.

#### MLME-DISASSOCIATE.confirm

The MLME-DISASSOCIATE.confirm primitive reports the results of an MLME-DISASSOCIATE.request primitive.

The semantics of the MLME-DISASSOCIATE.confirm primitive are as follows:

MLME-DISASSOCIATE.confirm (

DeviceAddr

Status

)

Table 10‑12 specifies the parameters for the MLME-DISASSOCIATE.confirm primitive.

Table 10‑12 MLME-DISASSOCIATE.confirm primitive

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| CDeviceAddr | 16 bit short device addresses | 0x0000, which represents the device has not been assigned a valid short address yet. | 16 bit short device address  |
| C Status | Numeration | SUCCESSNO\_ACKCHANNEL\_ACCESS\_FAILURE | The status of the disassociation attempt. |

##### When generated

The MLME-DISASSOCIATE.confirm primitive is generated by the initiating MLME and issued to its next higher layer in response to an MLME-DISASSOCIATE.request primitive. This primitive returns a status of either SUCCESS, indicating that the disassociation request was successful, or the appropriate error code.

##### Effect on receipt

On receipt of the MLME-DISASSOCIATE.confirm primitive, the next higher layer of the initiating device is notified of the result of the disassociation attempt.

### Scan primitives

MLME-SAP scan primitives define how a device or a coordinator can determine the presence or absence of VPANs in its vicinity.

#### MLME-SCAN.request

The MLME-SCAN.request primitive is used to initiate a scan. A device or a coordinator can use the scan to search for other coordinators which transmits beacon frames within the coverage of the scanning device.

The semantics of the MLME-SCAN.request primitive are as follows:

MLME-SCAN.request(

ScanType

ScanDuration

)

Table 10‑13 specifies the parameters for the MLME-SCAN.request primitive.

Table 10‑13 MLME-SCAN.request primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| ScanType | Integer | 0x00-0x10 | Indicates the type of the scan performed:0x00=passive scan0x01=active scan0x10=scan-over-backhaul |
| ScanDuration | Integer | TBD | The duration of the scan |

##### When generated

The MLME-SCAN.request primitive is issued to the MLME by the next higher when a device needs to associate with a coordinator, or when a device has been requested by the coordinator to perform an active scan, or when a prospective coordinator plans to establish a VPAN.

##### Effect on receipt

On receipt of the MLME-SCAN.request primitive, the MLME shall initiate the scan accordingly based on the scan type. If a passive scan is requested, then the MLME shall set a timer and enable its receiver to receive beacon frames. If a scan-over-backhaul is requested, then the MLME shall generate a scan-over-backhaul request command and send it to other coordinators through the backhaul. Then the MLME shall wait for other coordinators’ scan-over-backhaul confirmation command for ScanDuration. If an active scan is requested, the MLME shall generate a beacon request command and broadcast it. Then the MLME shall wait for other coordinators’ beacon frames for ScanDuration. The details of each type of scanning are specified in 8.2.2.1.

#### MLME-SCAN.confirm

The MLME-SCAN.confirm primitive reports the result of the scan request.

The semantics of the MLME-SCAN.confirm primitive are as follows:

MLME-SCAN.confirm(

Status

ScanType

ResultListSize

VPANDescriptorList

)

Table 10‑14 specifies the parameters for the MLME-SCAN.confirm primitive.

Table 10‑14 MLME-SCAN.confirm primitive

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| Status | Enumeration | SUCCESS, SCAN\_IN\_PROGRESS,NO\_BEACON,INVALID\_PARAMETER | The status of the scan request. |
| ScanType | Integer | 0x00-0x10 | Indicates the type of the scan performed:0x00=passive scan0x01=active scan0x10=scan-over-backhaul |
| NumberVPANDescriptors | Integer | 0x00-0xff | The number of VPAN descriptors returned in the VPAN descriptor list. |
| VPANDescriptorList | List of VPAN descriptor values | Refer to Table XX | The list of VPAN descriptors, one for each VPAN detected during a scan.  |

##### When generated

The MLME-SCAN.confirm primitive is issued to the next higher layer by the MLME when the requested scan has been completed. The MLME-SCAN.confirm primitive returns a status of either SUCCESS, indicating that the requested scan was successful, or the appropriate error code.

##### Effect on receipt

On receipt of the MLME-SCAN.confirm primitive, the next higher layer is notified of the results of the scan procedure. If the requested scan was successful, the status parameter will be set to SUCCESS and the next higher layer can proceed accordingly based on the scan type. If the requested scan was unsuccessful, the status parameter indicates the error.

### Additional Beacon primitives

MLME-SAP additional beacon primitive defines how an unassociated device request coordinators to send additional beacons before initiating an association with a VPAN.

##### MLME-AdditionalBeacon.request

The MLME-AdditionalBeacon.request primitive allows an unassociated device to generate and transmit an additional beacon frame request command.

The semantics of the MLME-AdditionalBeacon.request primitive are as follows:

MLME-AdditionalBeacon.request (

Reason

)

Table 10‑15 specifies the parameters for the MLME-AdditionalBeacon.request primitive.

Table 10‑15 MLME-AdditionalBeacon.request primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| Reason | Integer | 0x00-0xff | The reason for the additional beacon request (as defind in table xx) |

##### When generated

The MLME-AdditionalBeacon.request primitive is generated by the next higher layer of an unassociated device when the next higher layer of the unassociated device has obtained the result of a requested passive scan which indicates no beacon frames has been detected.

##### Effect on receipt

The MLME of the unassociated device shall generate and transmit an additional beacon request command, then it shall set a timer and enable its receiver to receive beacon frames.

#### MLME-AdditionalBeacon.indication

The MLME-AdditionalBeacon.indication primitive is used to indicate the reception of an additional beacon request command.

The semantics of the MLME-AdditionalBeacon.indication primitive are as follows:

MLME-AdditionalBeacon.indication (

 Reason

DeviceAddr

)

Table 10‑16 specifies the parameters for the MLME-AdditionalBeacon.indication primitive.

Table 10‑16 MLME-AdditionalBeacon.indication primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| Reason | Integer | 0x00-0xff | The reason for the additional beacon request (as defind in table xx) |
| DeviceAddr | Device address | 64-bit extended address | The address of the device sending this additional beacon request. |

##### When generated

The MLME-AdditionalBeacon.indication primitive is generated by the MLME of a coordinator and issued to its next higher layer to indicate the reception of an additional beacon request command received by the PHY.

##### Effect on receipt

On receipt of the MLME-AdditionalBeacon.indication primitive, the next higher layer of the coordinator is notified of the additional beacon request command sent by an unassociated device. The next higher layer may then allocate a GTS for additional beacon transmission.

### Neighbor report primitives

The MLME-SAP NeighborReport management primitives define how the coordinator triggers a neighboring VPAN report and how the requested devices to perform the report.

#### MLME-NeighborReport.request

The MLME-NeighborReport.request primitive allows the coordinator to generate and send a Neighboring VPAN report request command to devices.

The semantics of the MLME-NeighborReport.request primitive are as follows:

MLME-NeighborReport.request(

ReportDevicesList,

ReportType,

)

Table 10‑17 MLME-NeighborReport.request

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| ReportDevicesList | List of short address |  | Indicates to which device(s) the coordinator shall send a neighboring VPAN report command. |
| RReportType | Integer | 0x00-0x01 | 0x00= only update on neighboring VPAN status is requested;0x01=full report on neighboring VPAN status is requested; |

##### When generated

On receipt of the MLME-SYNC-LOSS.indication primitive with the LossReason parameter set to VPAN\_ID\_CONFLICT by the next higher layer of the coordinator, it shall issue a MLME-NeighborReport.request primitive to its MLME.

##### Effect on receipt

The MLME of the coordinator shall generate a neighboring VPAN report request command and send the command to the device specified by the ReportDeviceList. If multiple devices have been requested by the next higher layer, the MLME shall generate multiple neighboring VPAN report request command and send the command to the multiple devices respectively.

#### MLME- NeighborReport.indication

#### MLME-NeighborReport.confirm

The MLME-NeighborReport.confirm primitive provides the result of a requested neighboring VPAN report to the next higher layer of the coordinator.

The semantics of the MLME-NeighborReport.confirm primitive are as follows:

MLME-NeighborReport.confirm (

Result,

UnacknowledgedDevices,

NumberNeighboringVPAN Descriptor,

NeighboringVPAN Descriptor[0],

DetectDeviceList[0],

……

NeighboringVPAN Descriptor[N-1],

DetectDeviceList[N-1],

)

Table 10‑18 MLME-NeighborReport. confirm

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| Result | Numeration | SUCCESS,PARTIAL\_ACKNOWLEDGED, | Indicates the result of the requested report. |
| UnacknowledgedDevicesList | List of short addresses |  | Indicates the short address of the devices from which the corresponding neighboring VPAN report indication commands have not been received by the coordinator within the TBD time.The field is valid only when the Result equals to “PARTIAL\_ACKNOWLEDGED”. |
| NumberNeighboringVPAN Descriptor | Integer | 0x00-0xff | Indicates the number of Neighboring VPAN Descriptors. |
| NeighboringVPAN Descriptor[x] |  | Refer to Table XXX | Indicates the basic information of the neighboring VPAN. |
| DetectDeviceList[x] | List of short addresses | 0x00-0x01 | Indicates the short addresses of the devices which can detect the Xth neighboring VPAN. |

##### When generated

When the neighboring VPAN report indication commands from each requested device have been received by the MLME of the coordinator, or when the TBD time expires, the MLME of the coordinator shall issue the MLME-NeighborReport.confirm primitive to its next higher layer to report the result of the requested report.

##### Effect on receipt

The next higher layer of the coordinator shall be notified of the result of the requested neighboring VPAN report on receipt of the MLME-NeighborReport.confirm primitive.

### GTS management primitives

The MLME-SAP GTS management primitives define how GTSs are requested and maintained. A device or a coordinator expecting a contention-free transmission shall use these primitives to establish, modify, or terminate a flow.

#### MLME-FlowEstablishment.request (TBD)

#### MLME-FlowEstablishment.indication (TBD)

#### MLME-FlowEstablishment.response (TBD)

#### MLME-FlowEstablishment.confirm (TBD)

#### MLME-FlowModify.request (TBD)

#### MLME-FlowModify.indication (TBD)

#### MLME-FlowModify.response (TBD)

#### MLME-FlowModify.confirm (TBD)

#### MLME-FlowTerminate.request (TBD)

#### MLME-FlowTerminate.indication (TBD)

#### MLME-FlowTerminate.response (TBD)

#### MLME-FlowTerminate.confirm (TBD)

### Primitives for updating the superframe configuration

The MLME-SAP start primitives define how a coordinator can initiate a new VPAN or to begin using a new superframe configuration.

#### MLME-START.request

The semantics of the MLME-START.request primitive are as follows:

MLME-START.request(

VPANId,

CoordShortAddr,

BPdescriptor,

CAP Descriptor,

CFPPresenceIndication,

CFP Descriptor,

SuperframeSequenceNumber,

CoordRealignment,

VPANMode,

Countdown

)

Table 10‑19 specifies the parameters for the MLME-START.request primitive.

Table 10‑19 MLME-START.request

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| VPANId | Integer | 0x00-0xff | The VPAN identifier to be used by the device |
| CoordShortAddr | Interger | 0x0000-0xffff. | 16-bit short device address of the coordinator  |
| BPdescriptor | Set of integers | As defined in [TBD] | As defined in [TBD] |
| CAP Descriptor  | Set of integers | As defined in [TBD] | As defined in [TBD] |
| CFPPresenceIndication | Integer | 0x00-0x01 | Indicating if the CFP is included in the superframe. |
| CFP Descriptor | Set of integers | As defined in [TBD] | As defined in [TBD]It is valid only when CFPPresenceIndication is set to 0x01 |
| SuperframeSequenceNumber | Interger | 0x0000-0xffff | The sequence number of the beacon frame. This number increase by one for each new superframe. |
| CoordRealignment | Numeration | TRUE,FALSE | TRUE if a coordinator realignment command is to be transmitted prior to changing the superframe configuration or FALSE otherwise. |
| VPANMode | Integer | 0x00-0x04 | Indicating the topology mode of the VPAN. |
| Countdown | Integer | 0x00-0x0F | Indicating after how many superframes the new superframe configuration shall take effect.It’s only valid when CoordRealignment is set to TRUE. |

##### When generated

The MLME-START.request primitive is generated by the next higher layer of a prospective coordinator when it has finished the scan procedure and needs to establish a new VPAN, or generated by the next higher layer of a coordinator when it needs to use a new superframe configuration for implementing the VPAN realignment.

#####  Effect on receipt

On receipt of the MLME-START.request primitive, the MLME of the coordinator shall generate a beacon frame based on the provided arguments and broadcast the beacon frame if the CoordRealignment is set to FALSE, or the MLME of the coordinator shall generate a coordinator realignment command and broadcast it if the CoordRealignment is set to TRUE.

#### MLME-START.confirm

The MLME-START.confirm primitive reports the results of the attempt to start a new VPAN or to use a new superframe configuration.

The semantics of the MLME-START.confirm primitive are as follows:

MLME-START. confirm (

status

)

Table 10‑20 specifies the parameters for the MLME-START. confirm primitive.

Table 10‑20 MLME-START. confirm

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| status | Enumeration | SUCCESSNO\_SHORT\_ADDRESSCHANNEL\_ACCESS\_FAILUREINVALID\_PARAMETER | The results of the attempt to establish a new VPAN or start to use a new superframe configuration. |

##### When generated

The MLME-START.confirm primitive is generated by the MLME and issued to its next higher layer in response to an MLME-START.request primitive. The MLME shall generate the MLME-START.confirm primitive when it has finished sending the beacon frame if the CoordRealignment in the corresponding MLME-START.request primitive is set to FALSE, or the the MLME shall generate the MLME-START.confirm primitive when it has finished sending the coordinator realignment command frame if the CoordRealignment in the corresponding MLME-START.request primitive is set to TRUE.

##### Effect on receipt

On receipt of the MLME-START.confirm primitive, the next higher layer of the coordinator is notified of the result of the attempt to establish a new VPAN or to use a new superframe configuration.

### Primitives for synchronization loss with a coordinator

#### MLME-SYNC-LOSS.indication

MLME-SYNC-LOSS.indication primitive indicates the loss of synchronization with a coordinator.

The semantics of the MLME-SYNC-LOSS.indication primitive are as follows:

MLME-SYNC-LOSS.indication(

LossReason,

VPANId

)

Table 10‑21 defines the parameters for the MLME-SYNC-LOSS.indication primitive.

Table 10‑21 MLME-SYNC-LOSS.indication

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| LossReason | Enumeration | VPAN\_ID\_CONFLICT,REALIGNMENT,BEACON\_LOST, | The reason that synchronization was lost. |
| VPANId | Integer | 0x0000-0xffff | The VPAN ID with which the device lost synchronization or to which it was realigned. |

##### When generated

The MLME-SYNC-LOSS.indication primitive is generated by the MLME of a device and issued to its next higher layer in the event of a loss of synchronization with the coordinator. It is also generated by the MLME of the coordinator and issued to its next higher layer in the event of a VPAN ID conflict.

##### Effect on receipt

On receipt of the MLME-SYNC-LOSS.indication primitive, the next higher layer is notified of a loss of synchronization or a VPAN ID conflict.

### primitive for a heterogeneous network

As described in 1.2, command frames (association request command, flow setup request, flow update request command, etc.) from type 2 devices to a coordinator shall be send trough RF link first and then relayed to the coordinators through a wired link (power line, Ethernet, cable, etc.) in a heterogeneous network, which is a different way than it is sent through the VLC link. Therefore, particular primitives are needed so as to send the command frame successfully through the RF link and wired link. MLME-SAP command primitives defines how a command frame shall be transmitted in a heterogeneous network when a type 2 device has a command frame that needs to be sent to the coordinator by the RF link and the backhaul link.

#### MLME-COMMAND.indication

The MLME-COMMAND.indication primitive allows the MLME of the device to provide a command frame to its next higher layer.

The semantics of the MLME-COMMAND.indication primitive are as follows:

MLME-COMMAND.indication (

DstAddr,

SrcAddr,

CommandFrame

)

Table 10‑22 specifies the parameters for the MLME-COMMAND.indication primitive.

Table 10‑22 MLME-COMMAND.indication primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| DstAddr | Integer | From 0x0000-0xffff, 0x0000 represents without a short address assigned, 0xffff represents a broadcast transmission. | The short address of the coordinator that the command frame is designated to. |
| DSrcAddr | Integer | From 0x0000-0xffff, 0x0000 represents without a short address assigned, 0xffff represents a broadcast transmission. | The short address of the device that has generated the command frame. |
| CommandFrame | Set of octets |  | The set of octets forming the command frames to be transmitted. |

##### When generated

When the MLME of the device generates a command frame that needs to be sent to the coordinator, it shall generate a MLME-COMMAND.indication primitive and issue the MLME-COMMAND.indication primitive to its next higher layer.

##### Effect on receipt

On receipt of the MLME-COMMAND.indication primitive, the next higher layer of the device may generate a next higher layer message based on the provided arguments and shall send the message to the the next higher layer of the coordinator through the RF link and backhaul link. The command frame generated by the MLME shall be embedded in the next higher layer message.

#### MLME-COMMAND.request

The MLME-COMMAND.request primitive allows the next higher layer of the coordinator to request its MLME to identify and process a command frame received through the RF link and backhaul link.

The semantics of the MLME-COMMAND.request primitive are as follows:

MLME-COMMAND.request (

DstAddr,

SrcAddr,

CommandFrame

)

Table 10‑23 specifies the parameters for the MLME-COMMAND. request primitive.

Table 10‑23 MLME-COMMAND. request primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| DstAddr | Integer | From 0x0000-0xffff, 0x0000 represents without a short address assigned, 0xffff represents a broadcast transmission. | The short address of the coordinator that the command frame is designated to. |
| DSrcAddr | Integer | From 0x0000-0xffff, 0x0000 represents without a short address assigned, 0xffff represents a broadcast transmission. | The short address of the device that has generated the command frame. |
| CCommandFrame | Set of octets |  | The set of octets forming the command frames to be transmitted. |

##### When generated

The next higher layer of the coordinator shall generate a MLME-COMMAND.request primitive when it has received the next higher layer message and issue the MLME-COMMAND.request primitive to its MLME.

##### Effect on receipt

On receipt of the MLME-COMMAND.request primitive, the MLME of the coordinator shall process the command frame provided in this primitive the same way as it was received through the VLC link.

### primitives for writing MIB attributes

MLME-SAP set primitives define how MIB attributes may be written.

#### MLME-SET.request

The MLME-SET.request primitive attempts to write the given value to the indicated MIB attribute.

The semantics of the MLME-SET.request primitives are as follows:

MLME-SET.request(

MIBAttribute,

MIBAttributeIndex,

MIBAttributeValue

)

Table 10‑24 specifies the parameters for the MLME-SET.request primitive.

Table 10‑24 MLME-SET.request primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| MIBAttribute | Integer | Refer to Table XXX. | The identifier of the MIB attribute to write. |
| MIBAttributeIndex | Integer | Attribute specific | The index within the table of the specified MIB attribute to write. |
| PMIBAttributeValue | Various | Attribute specific | The value to write to the indicated MIB attribute. |

##### When generated

The MLME-SET.request primitive is generated by the next higher layer when it needs to set some MIB attributes and issued to its MLME to write the indicated MIB attribute.

##### Effect on receipt

On receipt of the MLME-SET.request primitive, the MLME shall attempt to write the given value to the indicated MIB attribute.

#### MLME-SET.confirm

The MLME-SET.confirm primitive reports the results of an attempt to write a value to a MIB attribute.

The semantics of the MLME-SET.confirm primitive are as follows:

MLME-SET.confirm(

Status,

MIBAttribute,

MIBAttributeIndex

)

Table 10‑25 specifies the parameters for the MLME-SET.confirm primitive.

Table 10‑25 MLME-SET.confirm primitive

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| Status | Enumeration | SUCCESSREAD\_ONLYINVALID\_INDEXIN\_VALID\_PARAMETERUPSUPPORTED\_ATTRIBUTE | The result of the request to write the MIB attribute. |
| MIBAttribute | Integer | Refer to Table XXX. | The identifier of the MIB attribute to write. |
| MIBAttributeIndex | Integer | Attribute specific | The index within the table of the specified MIB attribute to write. |

##### When generated

The MLME-SET.confirm primitive is generated by the MLME and issued to its next higher layer when in response to an MLME-SET.request primitive. The MLME-SET.confirm primitive returns a status of either SUCCESS, indicating the requested value was written to the indicated MIB attribute, or the appropriate error code.

##### Effect on receipt

On receipt of the MLME-SET.confirm primitive, the next higher layer is notified of the result of its request to set the value of a MIB attribute.

### Primitives for resetting the MAC sublayer

MLME-SAP reset primitives specify how to reset the MAC sublayer to its default values.

All devices shall provide an interface for these reset primitives.

#### MLME-RESET.request

See section 6.3.6.1 of 802.15.7-2011

#### MLME-RESET.confirm

See section 6.3.6.2 of 802.15.7-2011

# MAC PIB attributes

**Dear Proposer: add any anticipated MAC PIB attributes here**

See table 60 in IEEE802.15.7-2011 for the current MAC PIB Table.

|  |
| --- |
| **MAC PIB Table 60 Additions** |
| **Attribute** | **Identifier** | **Type** | **Range** | **Description** | **Default** |
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1. NOTE – “max COODINATOR\_Tx\_modulation\_bandwidth” represents the maximum modulation bandwidth that the transmitter of the coordinator can support. “max DEVICE\_Rx\_modulation bandwidth” represents the maximum modulation bandwidth that the receiver of a device can support. [↑](#footnote-ref-1)
2. “max COODINATOR\_Rx\_modulation\_bandwidth” represents the maximum modulation bandwidth that the receiver of the coordinator can support. “max DEVICE\_Tx\_modulation\_bandwidth” represents the maximum modulation bandwidth that the transmitter of a device can support. [↑](#footnote-ref-2)