**IEEE P802.15**

**Wireless Personal Area Networks**

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| Re: | [Response to LB #50 comments] | |
| Abstract | [This document describes the final text for color function support] | |
| Purpose | [To complete the text for color function support] | |
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**This document is based on DCN 10/348/r0 which describes the comment resolution on CIDs 177, 247, 635, 645, 660, 798, 799, 800, 792, 793, 794, 796, 797, 785, 786, 787, 788, 790, and 791.**

**Agreements on color frame**

* **Merge visibility frame and color frame definition in Clause 3 and rename to CVD frame.**
* **Add CVD to list of acronyms.**
* **Global search and replace of visibility frame to CVD frame 🡪 Sridhar**
* **Merge 4.5.4.5 and 4.5.4.6 (information about visibility frame and color frame) in latest version that the editor has.**
* **PPDUlinkQuality should be referenced for changing the color status indication**

3. Definitions

CVD frame: A frame used for color, visibility and dimming support. The CVD frame visually provides information such as communication status and channel quality to the user, via the various colors. The CVD frame is also sent during idle or receive modes of operation for continuous visibility and dimming support. During the CVD frame transmission, the device is still emitting light while not communicating, and it is thus able to fulfill its lighting function. The payload of the frame consists of visibility patterns of appropriate intensity and color.

4. Acronyms and abbreviations

CVD Frame color-visibility dimming frame

5.1 Introduction

a)Star, peer-to-peer or broadcast operation

b)Allocated 16-bit short or 64-bit extended addresses

c)Scheduled or random access with collision avoidance transmission

d)Fully acknowledged protocol for transfer reliability

e)Color quality indication (CQI)

f)Dimming support

g)Visibility support

h)Color function support

**5.5.4 Frame structure**

The frame structures have been designed to keep the complexity to a minimum while at the same time mak­ing them sufficiently robust for transmission on a noisy channel. Each successive protocol layer adds to the structure with layer-specific headers and footers. This standard defines five frame structures, which are defined in 5.5.4.1 through 5.5.4.5

a)A beacon frame, used by a coordinator to transmit beacons

b)A data frame, used for all transfers of data

c)An acknowledgment frame, used for confirming successful frame reception

d)A MAC command frame, used for handling all MAC peer entity control transfers

e)A CVD frame, used to maintain the proper light intensity between data packets, support dimming and for visually providing information such as communication status and channel quality to the user

**5.5.4.5 CVD frame**

Add in this subclause:

A user can perceive intuitively information such as the cur­rent step of communication procedure, the data transmission quality, the transferred file size or remaining file size. The CVD frame can also be used to inform link status such as misalignment between the two devices, light direction or sending data status.

**7.1.1.1 MCPS-DATA.request**

The MCPS-DATA.request primitive requests the transfer of a data SPDU (i.e. MSDU) from a local SSCS entity to a single peer SSCS entity.

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

MCPS-DATA.request(

SrcAddrMode,

DstAddrMode,

DstWPANId,

DstAddr,

msduLength,

msdu,

msduHandle,

TxOptions,

SecurityLevel,

KeyIdMode,

KeySource,

KeyIndexDataRate

ColorReceived,

ColorNotReceived

)

Table 30 specifies the parameters for the MCPS-DATA.request primitive.

|  |  |  |  |
| --- | --- | --- | --- |
| Add below table to table 30Name | Type | Valid range | Description |
| ColorReceived | BOOLEAN | TRUE/FALSE | ColorReceived shall be set as TRUE, if CVD frame is sent when data frame is successfully received. |
| ColorNotReceived | BOOLEAN | TRUE/FALSE | ColorNotReceived shall be set as TRUE, if CVD frame is sent when data frame is not received. |

**7.1.3.1 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,

CoordAddrMode,

CoordWPANId,

CoordAddress,

CapabilityInformation,

SecurityLevel,

KeyIdMode,

KeySource,

KeyIndex,

ColorAssoc)

Table 37 specifies the parameters for the MLME-ASSOCIATE.request primitive.

**Table 37—MLME-ASSOCIATE.request parameters**

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| ColorAssoc | BOOLEAN | TRUE/FALSE | ColorAssoc shall be set as TRUE, if CVD frame is sent during association. |

**7.1.4.1 MLME-DISASSOCIATE.request**

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

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

MLME-DISASSOCIATE.request(

DeviceAddrMode,

DeviceWPANId,

DeviceAddress,

DisassociateReason,

TxIndirect,

SecurityLevel,

KeyIdMode,

KeySource,

KeyIndex,

ColorDisAssoc)

Table 41 specifies the parameters for the MLME-DISASSOCIATE.request primitive.

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| ColorDisAssoc | BOOLEAN | TRUE/FALSE | ColorDisAssoc shall be set as TRUE, if CVD frame is sent during disassociation. |

**7.1.10.1 MLME-SCAN.request**

The MLME-SCAN.request primitive is used to initiate a channel scan over a given list of channels. A device can use a channel scan to measure the energy on the channel, search for the coordinator with which it associ­ated, or search for all coordinators transmitting beacon frames within the POS of the scanning device.

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

MLME-SCAN.request(

ScanType,

ScanChannels,

ScanDuration,

SecurityLevel,

KeyIdMode,

KeySource,

KeyIndex,

ColorScan)

Table 55 specifies the parameters for the MLME-SCAN.request primitive.

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| ColorScan | BOOLEAN | TRUE/FALSE | ColorScan shall be set as TRUE, if CVD frame is sent during SCAN. |

**7.2.1.1.2 Frame type subfield**

The frame type subfield is 3 bits in length and shall be set to one of the unreserved values listed in Table 68.

|  |  |
| --- | --- |
| Table 68-Values of the Frame Type subfield | |
| Frame type value  b2 b1b0 | Description |
| 000 | Beacon |
| 001 | Data |
| 010 | Acknowledgment |
| 011 | MAC command |
| 100 | CVD |
| 101-111 | *Reserved* |

**7.2.3.2.1 Capability Information Field**

The Capability Information field is illustrated in Table 75.

The Power Source subfield is 1 bit in length and shall be set to one if the device is receiving power from the alternating current mains. Otherwise, the Power Source subfield shall be set to zero.

The Battery information subfield, shown in Table 76, is 2 bits in length. It is set to reserved (11) if the power source is set to 1.

|  |  |  |
| --- | --- | --- |
| Table 75 - Capability Information Field | | |
|  | Bit | Function |
| MAC layer capabilities | 0 | Power source |
| 1-2 | Battery information |
| 3 | Security capability |
| 4 | Co-ordinator capability |
| 5 | Traffic support |
| 6-7 | Topology support |
| 8-9 | Device type |
| 10 | Beacon support |
| 11 | Dimming support in MAC |
| 12 | Continuous visibility transmission (for infrastructure) |
| 13 | CVD support |
| 14-15 | Reserved |
| PHY layer capabilities | 16 | PHY I support |
| 17 | PHY II support |
| 18 | Alternate PHY (CSK) support |
| 19 | Dimming support in PHY (VPM) |
| 20-22 | Max supported TX clock |
| 23-25 | Max supported RX clock |
| 26 | Explicit clock notification request |
| 27-31 | Reserved |
| Band  capabilities | 8\*n | Aggregate channels |
| 8\*n | Guard channels |
| 32-39 | Bands used for CSK (any 3 bits of the bits set to 1 can be used) |
| Physical  device  capabilities | 40-42 | Number of optical source types |
| 43-45 | Multiple direction support |
| 46-55 | Number of LEDs per optical source type |

**7.4.2 MAC PIB attributes**

Add below table to Table 86

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Identifier | Type | Valid range | Description |
| macDuringASSOCColor | 0x5f | Unsigned integer | 0~6 | CVD frame is requsted using  macDuringASSOCColor bandplanID between MLME‐ASSOCIATE.request and MLME‐ASSOCIATE.confirm.if CVD frame is sent |
| macDuringDISASSOCColor | 0x61 | Unsigned integer | 0~6 | CVD  frame is transmitted using macDuringDISASSOCColor bandplanID between MLME‐DISASSOCIATE.request and MLME‐DISASSOCIATE.confirm if CVD frame is sent |
| macDuringSCANColor | 0x62 | Unsigned integer | 0~6 | CVD  frame is transmitted using macDuringSCANColor bandplanID between MLME‐SCAN.request and MLME‐SCAN.confirm if CVD frame is sent |
| macColorReceived | 0x63 | Unsigned integer | 0~6 | Use macColorReceived for CVD  Frame which denotes ‘received’ |
| macColorNotReceived | 0x64 | Unsigned integer | 0~6 | Use macColorNotReceived for CVD  Frame which denotes ‘not received’ |
| macCFAppColor | 0x65 | Unsigned integer | 0~6 | Color of CVD frame for Application-dependent information |

**7.6.12 Color function support (Replace this section)**

The CVD frame using various colors can be used to display various status of a device. The colors mapped for each status of devices are based on the bandplan ID (see Table 1). The colors chosen for different status are left to the discretion of the implementer. Multiple status may choose the same color, depending on the number of colors supported by the device.

**7.6.12.1 CVD frame usage for MAC state indication**

The CVD frame are used between state changes to provide visual information to the user regarding the communication status. The MLME primitives for association (7.1.3.1), scan (7.1.10.1) and disassociation (7.1.4.1) are used to support this functionality. The corresponding colors, as described in Table 88. can be used to display various states of a device.

|  |  |  |
| --- | --- | --- |
| Table 88-Connection State and Color Band Choice for Indication | |  |
| State | Color choice | Bandplan ID range |
| scan | Color “A” | 0-6 |
| association | Color “B” | 0-6 |
| disassociation | Color “C” | 0-6 |

For example, the device sends an association request to the coordinator (see Figure 119) using a chosen color. This information about the color choice is communicated using the MLME-ASSOCIATE.request primitive as in 7.1.3.1.

<use figure from Jason>



Figure 119 Example of CVD frame usage for association

**7.6.12.2 CVD-frame usage for file-transfer status indication**

<use figure from Jason>



Figure 120 CVD frame usage for file-transfer status indication

Figure 120 shows an example of how the user can infer the remaining or transferred file size through the color of the CVD frame. As shown in the example of Figure 120, the coordinator transfers files to the device. Different stages of the file transfer process can be represented with different choices of colors.

**7.6.12.3 CVD-frame usage for channel quality indication**

Table 89 describes how the user can know infer the quality of the data transmission or the communication quality, indicated by, through the CVD frame. The FER statistics need to be averaged over a long frame in order to choose the color of the CVD frame. This information can help provide misalignment indication to the user. Different colors can be used to indicate different states of misalignment. For example, green, blue, and red CVD frames can be used to visualize low, middle, and high data rates respectively. The choice of the colors and the data rate range is left to the implementer and is out of scope of the standard.

|  |  |  |
| --- | --- | --- |
| * Color status table for channel quality | | |
| Color of CVD frame | Data Transmission Quality | Action Item |
| Color “A” | Current FER < FER #1 | low data rate |
| Color “B” | FER #1<= FER <= FER #2 | medium data rate |
| Color “C” | Current FER => FER #2 | high data rate |

7.6.12.4 CVD-frame usage for acknowledgement indication

<use figure from Jason>



Figure 121 CVD frame usage for acknowledgement indication

Figure 121 shows an example of how the user can infer whether a receiver successfully receives some data or not. According to Figure 121, the receiver sends the CVD frame to the transmitter after the ACK frame has been sent to the transmitter when the receiver successfully receives some data. The CVD frame displaying that the received data has some errors can be also sent to the transmitter. Whether the received data includes some errors or not can be represented with different choices of colors.