Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Simplifying color-function and blinking-notification support in IEEE 802.15.7

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Re: N/A

Abstract: In this contribution we address CIDs 312 and 308 from the second sponsor-ballot round. We propose a major revision and unification of the color-function and blinking-notification support that puts most of the functionality where it belongs, i.e. in the next higher layer.

Purpose: To resolve CIDs 308 and 312 (and implicitly 313, 314, 80, 81, 82, 83, 84, 316, 317, 5, 85, 309, and 310).

Simplifying color-function and blinking-notification support in IEEE 802.15.7

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History of CID 312 and 308

❑ **CID 117 in sponsor ballot 1 against 5.1.12: "I very much like the color-function support, but the implementation is rather scattered and not easily extendible. First, the MAC PIB attributes, e.g. macDuringASSOCColor, have different color resolutions. Some can only be chosen from the bandplan, others, for instance macColorReceived use the phyColorFunction."**

  ➢ Fixes to 5.1.12 were implemented
  ➢ Joachim took a closer look at the changed 5.1.12 during sponsor ballot 2
  ➢ Joachim noticed a similar functionality in 5.3.9 (Blinking-notification command)
  ➢ He concluded that:
   • Generalized, "uncluttered" implementation of color-function support needed
   • Blinking notification command does not make sense as a MAC command

❑ **Submitted CIDs 308 and 312 against 5.2.9 and 5.1.12, respectively**

CID 308

- ❑ **Comment: "There are two places in the standard at which a functionality relaying information to the human eye via a change of the modulation characteristics is describeb. This subclause, viz. the blinking-notification command, and subclause 5.1.12 (color-function support). Since both adopt the same philosophy (visualisation of communication states), and the current version of the color-function support actually offers another approach for visualising the link quality (sub-clause 5.1.12.3, "CVD-frame usage for channel-quality indcation2) it would be prefereable to merge both sections. At least, a reference linking both would be beneficial."**

- ❑ **Proposed change: "Do as suggested in my comment."**

CID 312

- ❑ **Comment: "The color-function support (similar to the dimming support) burdens the MAC sublayer with a task that is not pertinent to the data transmission. From my perspective, color-function support offers a valuable add on, that can make this technology more user-friendly and intuitive. However, after reading this thoroughly reading the subclause for a second time, and with two months distance in time, I still do not understand why the implementation needs to be so, hm, cluttered. It should be the philosophy of this standard, to supply as much functionality and flexibility with a minmum of overhead, especially in time-critical (sub-)layers. Also, it is very much feasible, to entirely substitute the blinking-notification command with the color-function support. Talking about a free lunch ..."**

- ❑ **Proposed change: "I will present a resolution of this issue during the IEEE-802 plenary meeting in Singapore (March 2011)."**

In the meanwhile …

- ❑ **Michael and Joachim spent some "quality time" together**

- ❑ **Michael (fluent in 802.15 and 802.11 MAC) confirmed Joachim's suspicions**

- ❑ **Worked on a unified solution to CID 308 and CID 312 → this contribution**

Color function (CID 312) first!

Recap of color function

❑ **Intuitive visualization of VLC states to the user**

❑ **Use color of light emitted from VLC TX**

❑ **Currently implemented in MAC sublayer**

Recap of color function in D6
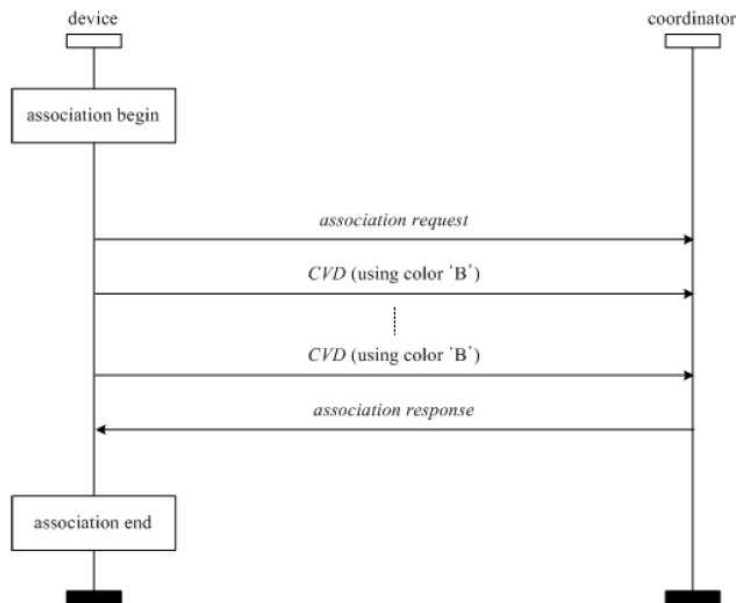
5.1.12.1 CVD frame usage for MAC state indication

5.1.12.2 CVD frame usage for acknowledgment indication

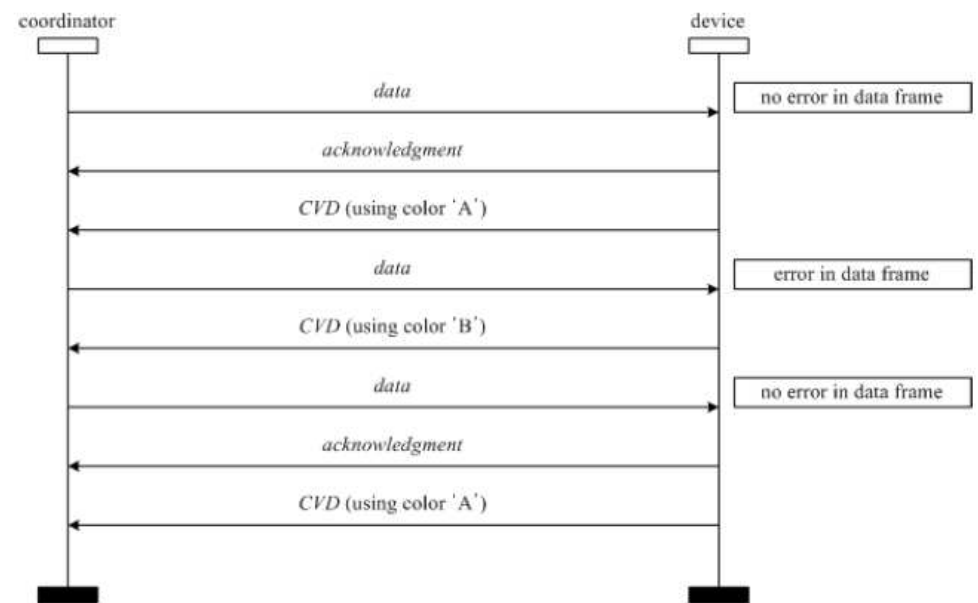Figure 35—Example of CVD frame usage MSC for association

Figure 36—CVD frame usage for acknowledgment indication

Noteworthy:
- ❑ **5.1.12.1: Association etc. initiated in the next higher level above MAC (→ MLME).**
- ❑ **5.1.12.2: ACK/noACK signaled to next higher layer via "status" in MCPS-DATA.confirm.**

Explicit color-function support in D6, cont'd

5.1.12.3 CVD frame usage for channel quality indication

Table 6—Color table for channel quality indication

Color of CVD frame	Channel quality
Color "A"	current FER<FER #1
Color "B"	FER #1 ≤ FER ≤ FER #2
Color "C"	current FER ≥ FER #2

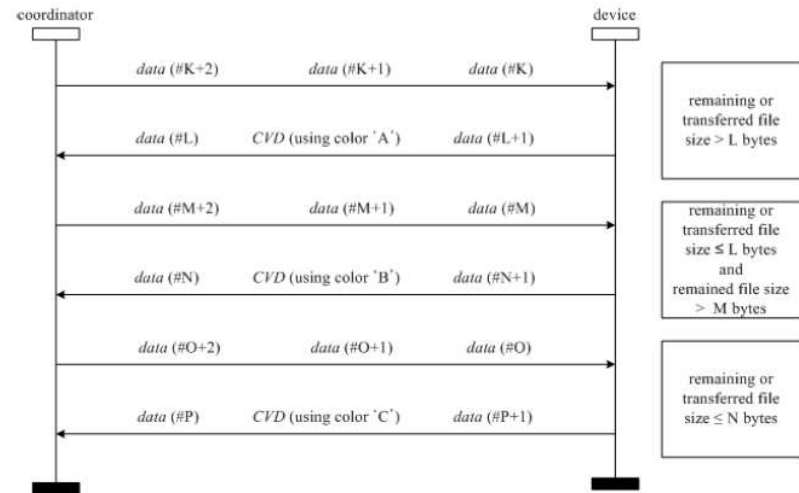### 5.1.12.4 CVD frame usage for file-transfer status indication

Figure 37—Example of MSC for CVD frame usage for file-transfer status indication

Noteworthy:
- **Channel-quality indication (MpduLinkQuality) signaled to higher layer via MCPS-DATA.indication**
- **File size remaining usually only known above MAC.**

Observations and issues

- ❑ **Do we need a MAC implementation?**
  - ➢ Arguments for choosing implementation in MAC sublayer commonly are
    - • MAC-specific task
    - • Needs to access MAC-internal parameters
    - • High processing speed
  - ➢ Color-function support does not mediate medium access (MAC!)
  - ➢ Information for invoking and configuring color-function support has to be known above MAC
  - ➢ Due to very low time resolution of human eye (~ 10 ms) execution of color function not time critical
- ❑ **Thus: implementation in MAC NOT necessary, even more it is an APPLICATION!**
- ❑ **Similarity: dimming support**
- ❑ **Advocate the same philosophy: unified, small footprint in MAC in order to support higher-layer functionality**
- ❑ **Other issue: Elusive part in D6. How to exactly enable color-function support for other non-MAC and non-PHY state changes? (5.1.12.3 nor 5.1.12.5 do specify MAC-PIB attributes.)**
- ❑ **Also, one feature is currently missing: how the change frequency and duration of the CVD-frame emission (→ length of CVD frames)?**
- ❑ **Thus: current implementation rather ill fit from a systems-point of view and it is also missing some features.**
- ❑ **How to unify all usages, to minimize the mandatory functionality in the MAC, and to accommodate timer functionality?**
- ❑ **Escape route: let higher layer invoke ONE (!) standardized interface to MAC (one size does fit all!).**

Proposed changes

- ❑ **Enable invocation CVD-frame transmission through next higher layer**
- ❑ **Create unified interface between MAC and next higher layer**
- ❑ **Needed**
  - ➤ "Send CVD frames" primitive. Input: color code; number of frames; duration; repetition frequency; also: feedback as output
- ❑ **Suggested features**
  - ➤ Input: number of frames, color code, duration, repetition time
  - ➤ Output: feedback from MAC on whether
    - Color function is supported
    - Request was heeded
    - Color-function temporarily not possible
    - …

MLME interface

❑ **MLME-CF.send(CVDRepetitions,CVDColor,CVDDuration,CVDCycleLength)**

❑ **Issued from next higher layer to MAC**

❑ **Primitive for requesting transmission of CVD frames**

  ➢ If arguments empty → default/current settings are used

  ➢ Default settings can be inquired with MLME-GET and can be changed with MLME-SET

MLME interface (cont'd)

Name	Type	Valid range	Description
CVDRepetitions	Integer	0 to 255	Number of times CVD frames are sent.
CVDColor	Column vector of n_1 integers	Elements range from 0 to 255	Each element is a pointer to the look-up table *phyColorFunction* (see Table 99, PHY PIB attributes). Color of the CVD frame during the pertinent repetition.

MLME interface (cont'd)

Name	Type	Valid range	Description
CVDDuration	Column vector of n_2 integers	Elements range from 1 to 10000	Each element describes the duration of the CVD frame in increments of 10 ms during the pertinent repetition.
CVDCycleLength	Column vector of n_3 integers	Elements range from 1 to 65 536	Time between the beginning of transmission of two adjacent CVD frames during the pertinent repetition. Increments: 10 ms.

- ❑ **Repetition *i*: Use elements *i* in CVDcolor, CVDDuration, and CVDCycleLength**
- ❑ **If n_j < # repetitions: once at end of field start again from beginning**
- ❑ **Suggested upper bound for n_i: 256**

MLME interface (cont'd)

❑ **MLME-CF.confirm(Status)**

❑ **Issued from MAC to next higher layer after execution of MLME-CF.send**

| Name	Type	Valid range	Description
Status	Enumeration	TRANSMISSION_SUCCESS, FAILURE, CVD_FRAME_NOT_SUPPORTED, CURRENTLY_NOT_POSSIBLE, INVALID_PARAMETERS	The status of attempting to invoke color-function support

MAC-PIB attributes for color-function support

| Name	Type	Valid range	Description
macCVDRepetitions	Integer	0 to 255	Number of times CVD frames are sent. Factory default: 0.
macCVDColor	Column vector of n_1 integers	Elements range from 0 to 255	Each element is a pointer to the look-up table *phyColorFunction* (see Table 99, PHY PIB attributes). Color of the CVD frame during the pertinent repetition. Factory default: (0).

MAC-PIB attributes for color-function support (cont'd)

| Name	Type	Valid range	Description
macCVDDuration	Column vector of n_2 integers	Elements range from 1 to 10000	Each element describes the duration of the CVD frame in increments of 10 ms during the pertinent repetition. Factory default: (50).
macCVDCycleLength	Column vector of n_3 integers	Elements range from 1 to 65 536	Time between the beginning of transmission of two adjacent CVD frames during the pertinent repetition. Increments: 10 ms. Factory default: (100).

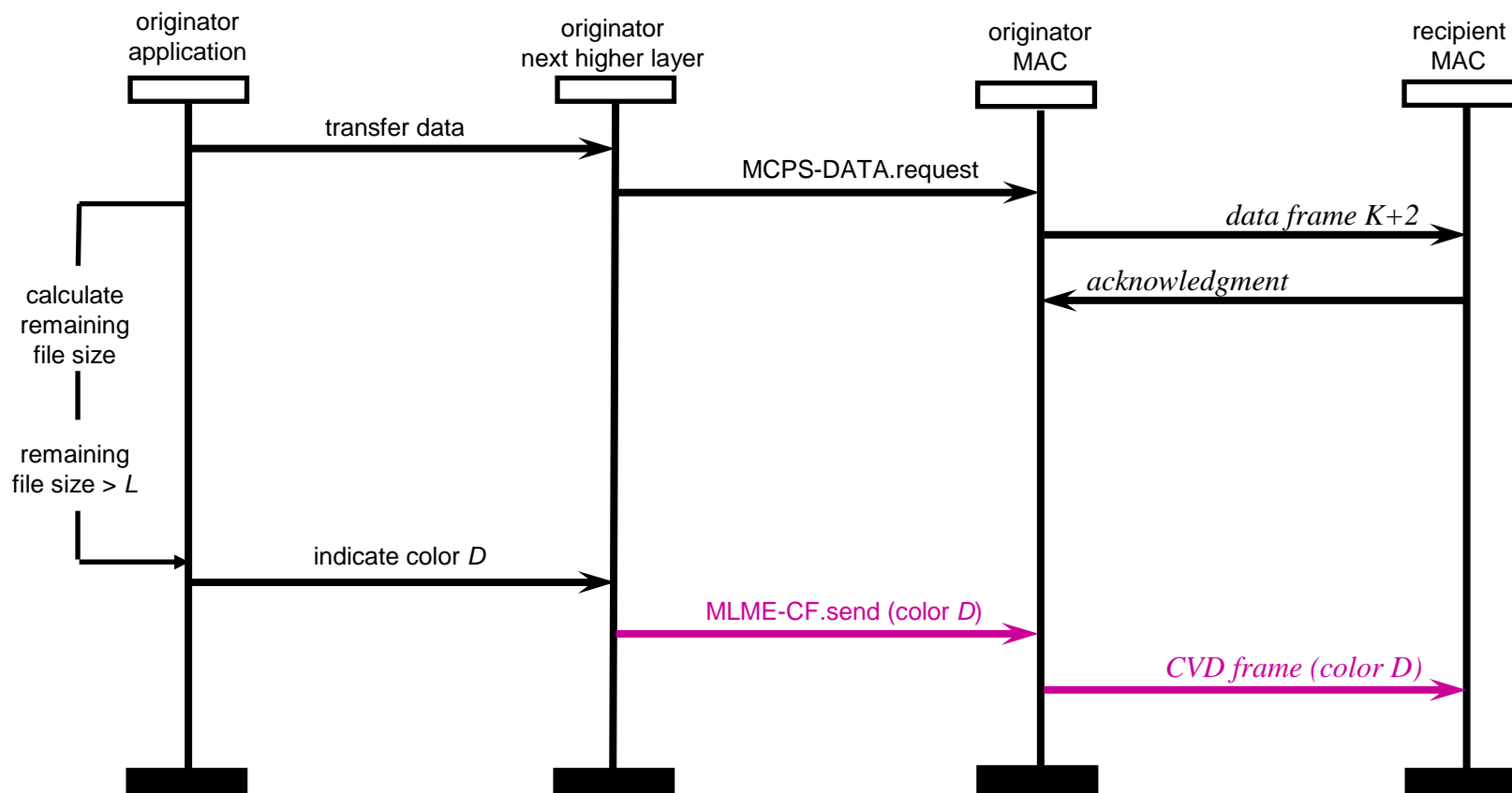# Example: color-function support for association (5.1.12.1)
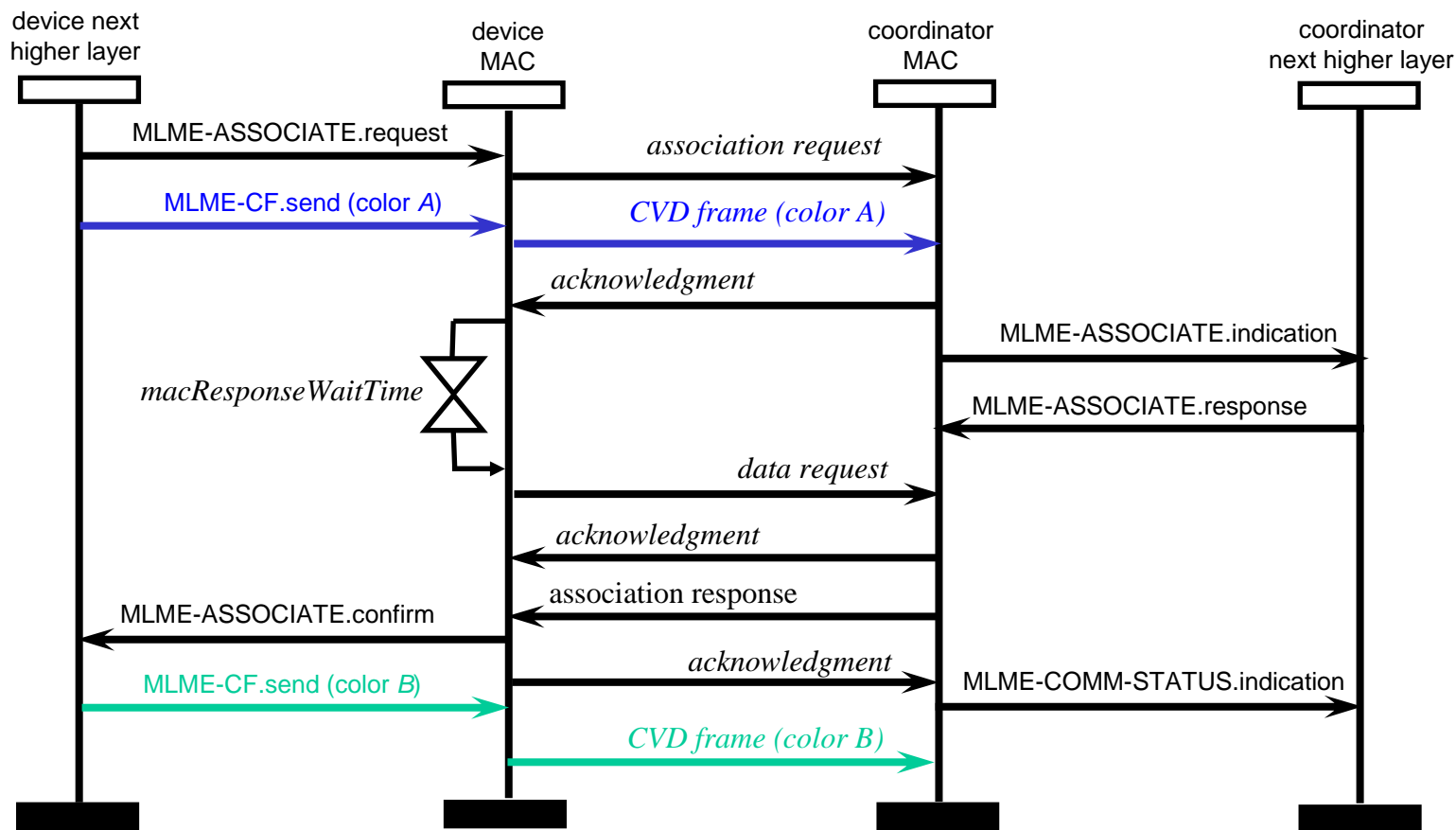
Example: acknowledgment indication (5.1.12.2)
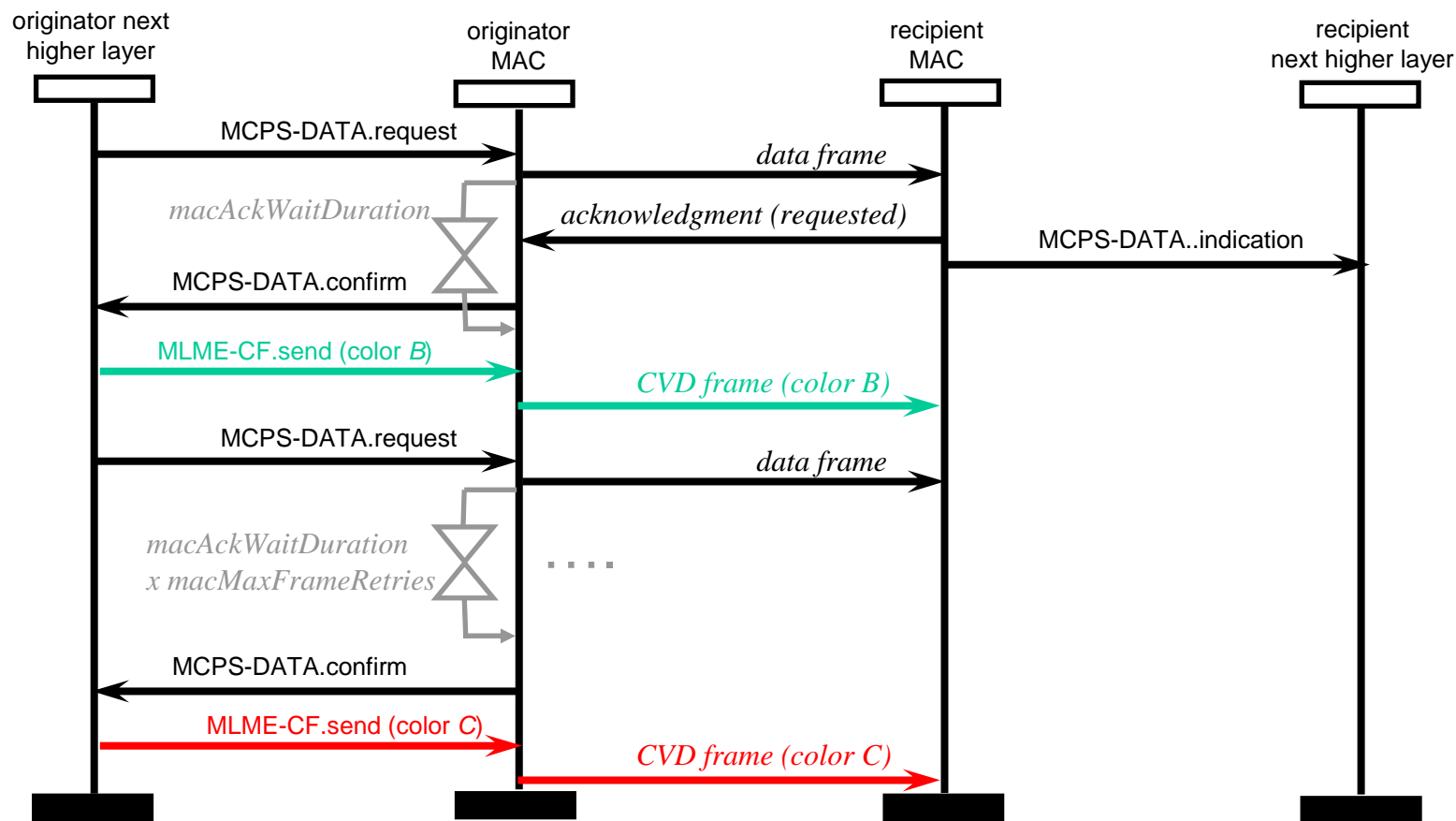
Example: channel-quality indication (5.1.12.3)
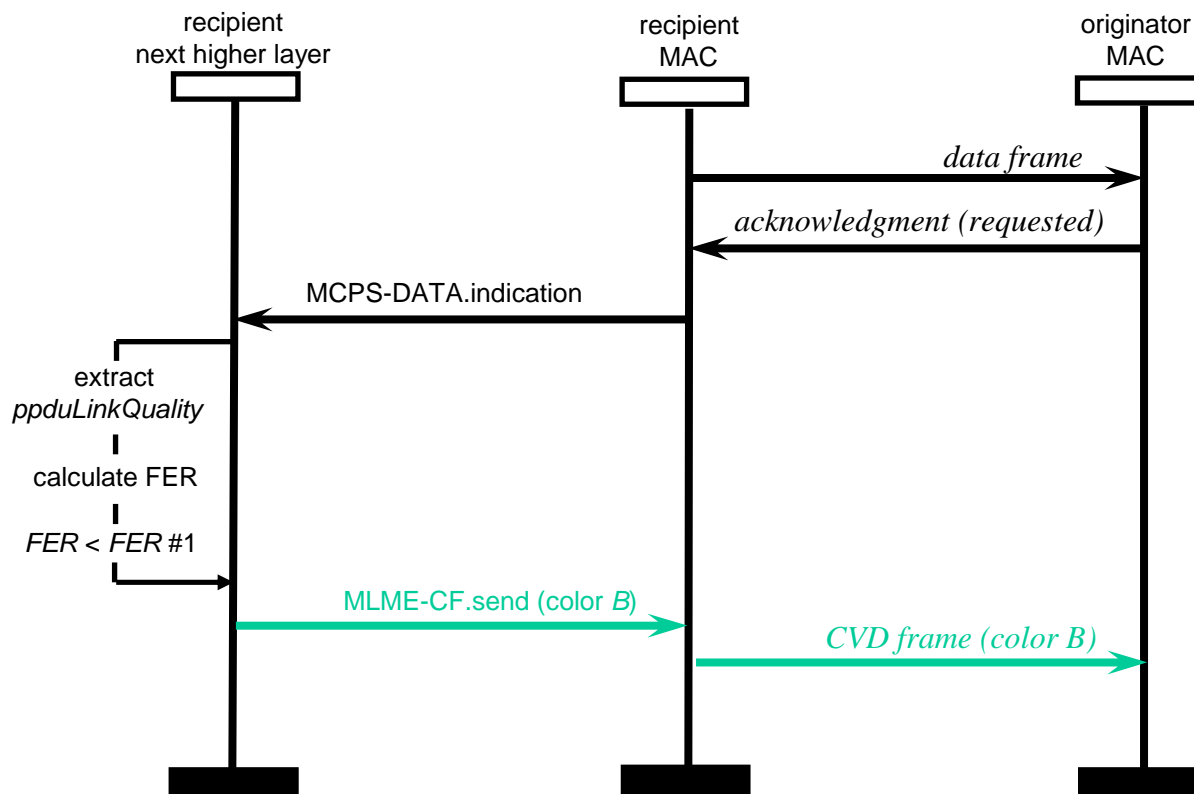
Example: indication of file-transfer status (5.1.12.4)

CID 308 (blinking notification)

Blinking notification as MAC command frame does not make sense

- ❑ **In 5.3.9 no information is transferred from device to coordinator, device simply indicates broken link to user via blinking of emitted light**
- ❑ **So, why would we need to transmit MAC command frames? Answer: we wouldn't!**
- ❑ **This, again, is an APPLICATION (!), so let the higher layers take care of them**
- ❑ **Important: loss of link leads is indicated by, e.g. NO_ACK status in MCPS-DATA.confirm, to next higher layer!** → **All pertinent information for action provided.**
- ❑ **But …**

Do we need yet another functionality for blinking notification?

- ❑ **If color of CVD frames is chosen differently from that of data transmission, MLME-CF.send can be used for blinking by setting CVDRepetitions, CVDDuration, and CVDCycleLength accordingly. Even multi-color blinking is feasible!**

- ❑ **E.g., CVDDuration = (5), CVDCycleLenght = (10) to achieve default setting in current 5.3.9**

- ❑ **Further more, dimming and MLME-CF.send can be used in combination. If, e.g., transmitter is currently set at 90% dimming, dimming primitive can be used to increase radiant power of transmitter during emission of CVD frame**

- ❑ **Thus: no explicit functionality for blinking in MAC needed, only descriptive text (→ Appendix).**

- ❑ **Thus: our resolution for CID 312 also solves CID 308**

Implications for D7

Consequential changes to draft

- ❑ **Deletion of 5.3.9 and mention in command-frame list (Table 10)**
- ❑ **Deletion of content of 5.1.12**
- ❑ **Introduction of new content for 5.1.12 (usage of MLME-CF)**
- ❑ **Delete use-case specific MAC-PIB parameters (*macDuringASSOCColor, macDuringDISASSOCColor, macDuringSCANColor, macColorReceived, macColorNotReceived, macCFAppColor*) from Table 59**
- ❑ **Introduce MAC-PIB parameters for MLME-CF to Table 59**
- ❑ **Removal of use-case specific color-function parameters from MLME-ASSOCIATE.request, viz. ColorAssoc, as well as from MCPS-DATA.request and MCPS-DATA.indication, viz. ColorReceived, ColorNotReceived**
- ❑ **Introduction of new MLME primitives in 6.3: MLME-CF.send and MLME-CF.confirm**
- ❑ **Short description of blinking notification by use of MLME-CF in Appendix**

Perk

❑**Also solves CIDs 313, 314, 80, 81, 82, 83, 84, 316, 317, 5, 85, 309, and 310, since pertinent text gets deleted!**

❑**Sweet!**

Summary and next steps

❑ **Major simplification and unification of color-function support and blinking notification proposed**

  ➢ Much less overhead put on MAC sublayer

  ➢ Major "action" in next higher layer

  ➢ Very flexible and simple at the same time

❑ **In case this change proposal gets accepted (in principle) we will provide a "change document" to the TE before 2011-02-17, 1600 hrs local time, containing the changes outlined on the previous slide**

Appendix

MAC-PIB attributes associated to color-function support

- ❑ **5.1.12.1: 3 (*macDuringASSOCColor, macDuringDISASSOCColor, macDuringSCANColor*)**

- ❑ **5.1.12.2: 2 (*macColorReceived, macColorNotReceived*)**

- ❑ **5.1.12.3: none (?)**

- ❑ **5.1.12.4: 1 (*macCFAppColor*)**
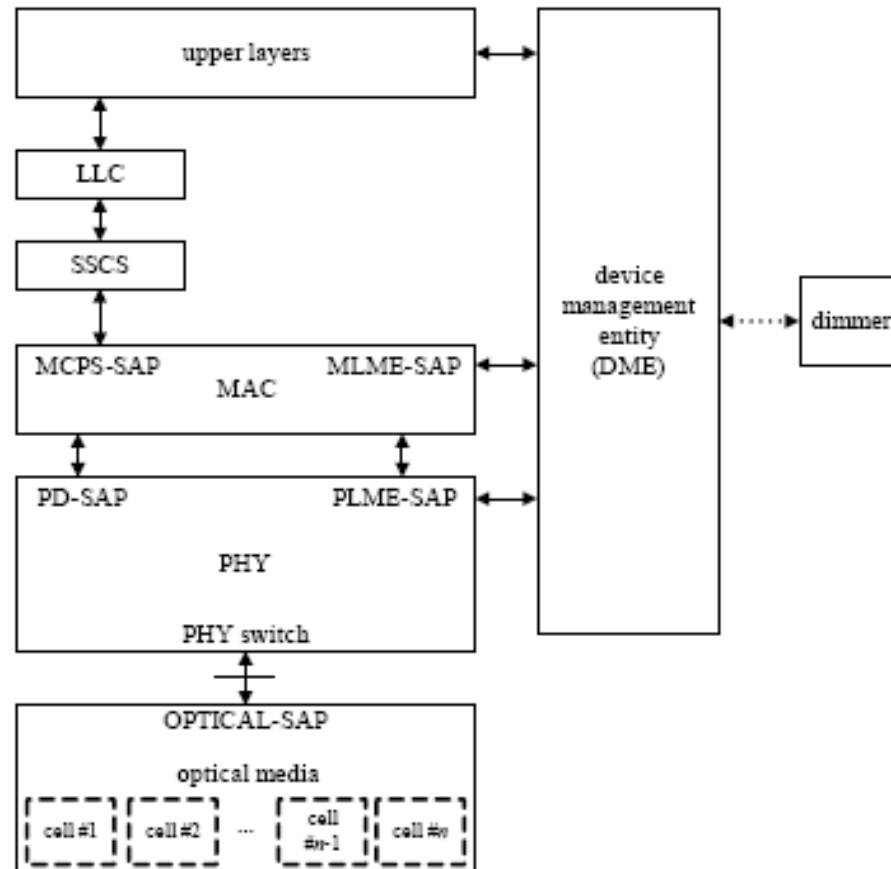
- ❑ **5.1.12.5: none (generic use case)**

802.15.7 architecture

Figure 3—VPAN device architecture