**IEEE P802.15**

**Wireless Personal Area Networks**

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| Re: | [] |
| Abstract | Suggestion of modification of CSL based on Sponsor Ballot Comments |
| Purpose | Draft standard development |
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# Part 1: Modification of CSL parts based on 4e

***Add the following paragraphs before 5.1.11.1***

## 5.1.11.0 LE normal data transmission, reception and acknowledgment

When *macLEenabled* is set to TRUE, the LECIM LE mode is enabled, and the data transmission, reception and acknowledgment is illustrated in Figure 34na.



**Figure 34na—LE normal data transmission, reception and acknowledgment**

When *macLowEnergySuperframeSupported* is TRUE, an endpoint device shall send data frames using either slotted ALOHA or slotted CSMA-CA; when *macLowEnergySuperframeSupported* is FALSE, unslotted ALOHA or unslotted CSMA shall be used.

If the endpoint device received an acknowledgment frame from the coordinator indicating that the coordinator has a pending frame, the endpoint device shall send a data request command to the coordinator and wait for the corresponding data frame from coordinator.

***Modify the following paragraphs in 5.1.11.1.2***

## 5.1.11.1.2 CSL idle listening

During idle listening, CSL performs a channel sample every *macCSLPeriod* time. If the channel sample does not detect energy on the channel, CSL disables the receiver until the next channel sample time, and then performs the next channel sample. If the channel sample receives a wake-up frame, CSL checks the destination address in the wake-up frame. Retransmissions follow the same process as defined in 5.1.6.4.3 except that each transmission follows the process above.

If the destination address of wake-up frame matches *macShortAddress*, CSL checks the wake-up frame interval information in wake-up frame, if the wake-up frame interval is zero, CSL disables the receiver until the Rendezvous Time (RZ Time) in the wake-up frame, and then enables the receiver to receive the payload frame. Otherwise, CSL disable the receiver and transmit data request frame with the Acknowledge Request field in the payload frame set to one. Then CSL waits for up to *macEnhAckWaitDuration* (defined in Table 52j) symbol time for the enhanced acknowledgment frame. If the enhanced acknowledgment frame is received, update the Rendezvous Time (RZ Time) from the enhanced acknowledgment, and keep receiver up to *macMaxFrameTotalWaitTime* symbol time to receive the payload frame.

When wake-up frame interval is nonzero, the transmission, reception, and acknowledgment operation is illustrated in Figure 34oa.

***Add figure 34oa in 5.1.11.1.2***



**Figure 34oa—CSL operations when wake-up frame interval is nonzero**

If the destination address of wake-up frame dose not match *macShortAddress*, CSL disables the receiver until RZ Time plus the transmission time of the maximum length payload frame and the secure acknowledgment frame, and then resumes channel sampling.

***Modify the following paragraphs in 5.1.11.1.3***

## 5.1.11.1.3 CSL transmission

Each CSL transmission of a payload frame is preceded with a sequence of wake-up frames (wake-up sequence).

***Modify the following paragraphs in 5.1.11.1.4***

## 5.1.11.1.4 Unicast transmission

In unicast transmissions, the wake-up sequence length can be long or short based on the following two cases:

*Unsynchronized transmission*: This is the case when the MAC layer does not know the CSL phase and period of the destination device. In this case, the maximum wake-up sequence length is *macCSLMaxPeriod*.

*Synchronized transmission*: This is the case when the MAC layer knows the CSL phase and period of the destination device. In this case, the wake-up sequence length is only the guard time against clock drift based on the last time when CSL phase and period updated about the destination device.

If the next higher layer has multiple frames to transmit to the same destination, it can set the Frame Control field frame pending bit to one in all but the last frame to maximize the throughput.

CSL unicast transmission is performed in the following steps by the MAC layer:

1. Perform CSMA-CA to acquire the channel.
2. If the previous acknowledged payload frame to the destination has the frame pending bit set and is within *macCSLFramePendingWaitT* (defined in Table 52j), go to step e).
3. If it is a synchronized transmission, wait until the destination device’s next channel sample.
4. For the duration of wake-up sequence length (short or long)
5. Construct wake-up frame with the destination short address and remaining time to payload frame transmission (at the end of wake-up sequence)
6. Transmit wake-up frame
7. Wait for up to *macCSLInterval* symbol time for the data request frame from the corresponding destination device. If the data request frame is received, then stop the transmission of wake-up sequence, perform CSMA-CA to acquire the channel, transmit enhanced acknowledgment frame with the RZ Time updated to zero.
8. Transmit payload frame
9. Wait for up to *macEnhAckWaitDuration* (defined in Table 52j) symbol time for the enhanced acknowledgment frame if the Acknowledge Request field in the payload frame is set to one.
10. If the enhanced acknowledgment frame is received, update CSL phase and period information about the destination device from the Acknowledgment CSL Sync field.
11. If the enhanced acknowledgment frame is not received, start retransmission process.

Retransmissions follow the same process as defined in 5.1.6.4.3 except that each transmission follows the process above.

***Modify the following paragraphs in 5.1.11.1.5***

## 5.1.11.1.5 Broadcast transmission

Broadcast transmission is the same as unicast transmission except the following:

* It is always unsynchronized transmission.
* The destination address in wake-up frames is set to 0xffff.
* If the wake-up frame interval is nonzero, only after received data request frame from all of the destination devices, CSL will stop the sending of the wake-up sequence.
* Optionally include LE CSL IE.

Selectively the next higher layer may add LE CSL IE in the frame header to propagate CSL phase and period information among the neighboring devices.

***Modify the following paragraphs in 5.2.1.1.3***

## 5.2.1.1.3 Frame Pending field

***Insert the following paragraphs before the last paragraph in 5.2.1.1.3:***

When operating in low-energy (LE) CSL mode, the frame pending bit may be set to one to indicate that the transmitting device has pending frames to send to the same recipient and expects the recipient to keep the radio on until the frame pending bit is reset to zero.

***Modify the following paragraphs in 5.2.2.8***

## 5.2.2.8 LE-multipurpose Wake-up frame

**5.2.2.8.1 General**

The LE Wake-up frame is a multipurpose frame containing an CSL Wake-up Time Header IE as described in 5.2.4.10.

The frame format is shown in Figure 48m.

The MHR for a wake-up frame shall contain the Frame Control field, the Sequence Number field, the Destination PAN ID, and the Destination Address field as shown in Figure 48m.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Octets:1** | **1** | **2** | **2** | **4** | **2** |
| Frame Control | Sequence Number | Dest. PAN ID | Dest. Address | CSL Wake-up Time Header IE | IE List Terminator |

**Figure 48m—Multipurpose Wake-up Frame**

***Modify Table 4b in 5.2.4.2***

## 5.2.4.2 Header Information Elements

**Table 4b—Element IDs, Header IEs**

|  |  |  |  |
| --- | --- | --- | --- |
| **Element ID** | **Content length** | **Name** | **Description** |
| 0x1d | 2 | CSL Wake-up Time | Defined in 5.2.4.10 |

***Modify the following paragraphs in 5.2.4.10***

## 5.2.4.10 CSL Wake-up Time IE

The CSL Wake-up Time IE shall be used in LE Wake-up frame, the format of this element is illustrated in Figure 48aaa.

|  |  |
| --- | --- |
| **Octets: 2** | **2** |
| RZ Time | Wake-up Interval |

**Figure 48aaa—Format of the CSL Wake-up Time element**

The Rendezvous Time (RZ Time) IE is 2 octets. The RZ Time is the expected length of time in units of 10 symbols between the end of the transmission of the wake-up frame and the beginning of the transmission of the payload frame. The RZ Time shall be set by the next higher layer when requesting the MAC sublayer to transmit. The last wake-up frame in a wake-up sequence shall have RZ Time set to the value zero. When CSL received data request frame from the corresponding destination device, MAC sublayer shall update the RZ time to zero.

The Wake-up Interval is 2 octets, is the length of interval between two successive LE wake-up frames in the wake-up sequence, in units of 10 symbols. The Wake-up Interval shall be set by *macCSLInterval* when requesting the MAC sublayer to transmit.

***Add subfields in Figure 48t in 5.2.4.7***

## 5.2.4.7 LE CSL IE

The LE CSL IE shall be used in all enhanced acknowledgements if *macLEenabled* is TRUE.

The structure of the LE CSL element as illustrated in Figure 48t.

|  |  |  |
| --- | --- | --- |
| **Octets: 2** | **2** | **2** |
| CSL Phase | CSL Perid | RZ Time |

**Figure 48t—Format of the LE CSL element**

***Add the following paragraphs before 5.2.4.8***

The RZ Tim is 2 octets, is the expected length of time in units of 10 symbols between the end of the transmission of the wake-up frame and the beginning of the transmission of the payload frame. When CSL received data request frame from the corresponding destination device, MAC sublayer shall send enchanced acknowledgements with the RZ time updated to zero.

***Add PIB attributes in Table52j in 6.4.3.7***

## 6.4.3.7 LE specific MAC PIB attributes

**Table 52j—LE-specific MAC PIB attributes**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Attribute** | **Type** | **Range** | **Description** | **Default** |
| *macCSLInterval* | Integer | *macMaxFrameTotalWaitTime*—65535 | Specifies the interval between two successive CSL wake-up frames in the wakeup sequence, in units of 10 symbols. | *macMaxFrameTotalWaitTime* |

***Modify the following paragraphs in I.7.2***

## I.7.2 MAC behaviors unique to LE

The following MAC command is specific to LE: LE-RIT data request. The following IEs are specific to LE: LE CSL, LE RIT, CSL Wake-up Time.

# Part 2: Modification of HWSL parts in 4k draft R3

***Delete*** “HWSL hybrid wakeup sample listening” in **3.2 Acronyms and abbreviations**.

***Delete***

“— *macHWSLMaxPeriod*

— *macHWSLPeriod*” in **5.1.1.7 LE-Functional description**.

***Delete*** modification of **5.1.1.7.1 LE Contention access period (LE CAP)** and **5.1.1.7.4 LE-Scan**.

***Modification of***

***Delete*** **5.1.11.3 HWSL**.

***Delete*** **5.1.11.4 Implicit receiver initiated transmission (I-RIT)**

***Delete*** modification of **5.2.2.1.1a Information Elements (IEs) field**

***Delete*** modification of **5.2.1.1.3 Frame Pending field**

***Delete*** ”HWSL wakeup” line of Table 5 in **5.3 MAC command frames**

***Delete*** modification of **5.3.4 Data request command**

***Delete* 5.3.12.2 HWSL wakeup command**

***Delete***

”*macHWSLEnabled*”,

“*macHWSLMaxPeriod*”,

“*macHWSLFramePendingWaitTime*”,

“*macHWSLWakeupInterval*”,

“*macIRITPeriod*”,

“*macIRITListenDurarion*”,

and “*macIRITEnabled*”

in **Table 52j of 6.4.3.7 LE-specific MAC PIB attributes**