IEEE P802.15

**Wireless Personal Area Networks**

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| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) | |
| Title | 802.15.9 Fragmentation Replacement Text | |
| Date Submitted | 14 January 2015 | |
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| Re: | [802.15.9 Draft 1.0] | |
| Abstract | [This document describes improvements to 802.15.9 draft 1.0.] | |
| Purpose | [To improve Key Management Protocol 802.15.9] | |
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Replaces Clauses 5 & 7 in Draft-D1.0 802.15.9 (X=5, Y=7)

Note that the following uses the standard MCPS-DATA Service which should not require any modification.

## X.x Data Transfer Control Service

The Data Transfer Control Service provides for:

1. Protocol dispatch using a Protocol Identifier (Protocol ID)
2. Fragmentation/reassembly with Request to Send (RTS)/Clear to Send (CTS) support

One Payload Information Element is defined for the Data Control Service, implementing a Frame Control Field that allows signaling of the Transfer Type. The Protocol ID associated with the MSDU is in support of the protocol dispatch feature. The RTS/CTS feature can be used to negotiate transfer of a single MSDU or a fragmentation/reassembly sequence. An initial Fragment Transaction Request handshake containing the RTS/CTS is used to ensure the destination device is available to receive a fragmented MSDU.

### X.x.1 MSDU Protocol ID

For any MSDU transfer, a Data Transfer Control IE (DTC IE) is included in the frame to declare a protocol identifier associated with the MSDU. The Protocol ID is the {insert reference to Protocol ID standard database} value for the source and destination protocol handler for the content of the MSDU.

For an MSDU transferred in a single frame the DTC IE will also contain the MSDU payload. An optional RTS/CTS handshake may be requested in a frame preceding the frame carrying the MSDU.

For an MSDU transferred as a fragment sequence, the Protocol ID declared in the DTC IE is associated with the Transaction ID carried in the DTC IEs in the subsequent fragment sequence transfer.

## X.x.2 Fragmentation

The Fragmentation Service is invoked by the MAC to deliver an MSDU exceeding the macFragmentThreshold octet count value. Since this value, by definition, indicates a long frame, the Fragmentation Service applies an RTS/CTS handshake to ensure the destination device is available and able to receive the MSDU transfer.

An initial Request-to-Send (RTS) transmission carries a DTC IE describing the intended MSDU size together with the Protocol ID of the intended recipient protocol entity within the destination device and a Transaction ID.

If the recipient of the frame carrying the RTS is available and able to receive the MSDU a Clear-to-Send (CTS) transmission carrying a DTC IE is transmitted to the RTS source.

Each device shall maintain a monotonically increasing counter which is incremented after each value is assigned to a Transaction ID. All fragments in the same fragment sequence shall carry the same Transaction ID. The combination of {Device Source Address, Transaction ID and Fragment Count} uniquely identifies any fragment in any fragment sequence.

If a device is unable to accept the fragment sequence offered in a received fragment RTS, it may respond with a CTS with:

* a value of zero in the Total MSDU Size to indicate inability to receive the fragment sequence
* different Total MSDU Size field value indicating total octet count it is able to accept.

If the values of these fields in a received CTS differ from the corresponding RTS field values, the source of the RTS must abandon the fragment transaction and may attempt a new transaction which would satisfy the indicated limits.

The transmission of fragments shall not commence until a CTS has been received with Transaction ID and Total MSDU Size fields matching a corresponding RTS.

Each fragment in the fragment transaction shall be sent in a Data Transfer Control IE using the Initial Fragment or More Fragments frame control. Frames for which the requested acknowledgement is not received shall be retransmitted using standard frame re-transmission services.

Acknowledgement of the preceding fragment in a fragment sequence shall be received before the next fragment in the fragment sequence is transmitted.

If the requested acknowledgement for the frame carrying a fragment is not received after macFragmentRetryCount attempts the fragment transaction is abandoned and the corresponding MCPS-DATA.confirm shall indicate failure in the same manner as for a failed un-fragmented transfer request.

If the next fragment in a fragment sequence is not received macFragmentTimeOut after the last received fragment, the recipient of the fragment sequence may abandon the reassembly operation and discard any received fragment data.

## Y.y Information Elements (IEs)

### Y.y.1. Data Transfer Control IE (DTC IE)

The DTC IE shall be formatted as a Payload IE as defined in { see 802.15.4e-2012 5.2.4.3} with Element ID set to DTC {*request an assigned Header IE ID from 802.15 ANA*} and Length field set to the appropriate value for the Transfer Type. .

Since both the control and data transfer are implemented from the same Payload Information Element, the following sections describe the frame exchanges supported using the DTC IE.

Y.y.1.1 DTC IE General Frame Format

The DTC IE consists of a Frame Control Field followed by a Data Transfer Frame Field. The Transfer Type field of the Frame Control Field determines the fields present in the Data Transfer Frame.

DTC

Figure 1 provides the General Frame Control Field for the DTC IE and Figure 2 provides the General Data Transfer Frame.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Bit:0-1 | 2 | 3 | 4 | 5-7 |
| Transfer Type  {0b00 = MSDU  0b01 = Fragment Transaction Request  0b10 = Initial Fragment  0b11=More Fragments} | RTS/CTS Control | RTS/CTS  0 = RTS  1 = CTS | Re-Try | Reserved |

Figure 1: General Frame Control Field

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Octets: 0/2 | 0/2 | 0/2 | 0/1 | 0/2 | 0/n |
| Protocol ID | Transaction ID | Total MSDU Size (Octets) | Fragment  Count | MSDU Size Delivered in this payload (Octets) | MSDU Payload |

Figure 2: General Data Transfer Frame

Y.y.1.2 Transfer Type processing

Four Transfer Types are defined within the Frame Control Field of the DTC IE:

1. MSDU – The MSDU Transfer Type supports single MSDU transfer of the size indicated in the Single MSDU Transfer Frame. There are two forms of this transfer:
   1. Using RTS/CTS – If RTS/CTS Control is asserted, the MSDU Payload shall be omitted for the RTS and CTS exchanges until agreement is reached on the Total MSDU Size in this Payload or the exchange is abandoned
   2. Without RTS/CTS – When RTS/CTS is not used, the MSDU Payload must be included in the Single MSDU Transfer Frame

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Single MSDU Transfer Frame | | | | |
| Bit: 0-1 | 2 | 3 | 4 | 5-7 |
| Transfer Type {0b00 = MSDU } | RTS/CTS Control | RTS/CTS  0 = RTS  1 = CTS | Re-Try | Reserved |

1. Figure 3: Single MSDU– Frame Control Settings

|  |  |  |  |
| --- | --- | --- | --- |
| Octets: 1 | 2 | 2 | 0/n |
| Single MSDU Frame Control (see ) | Protocol ID | Total MSDU Size (Octets) | MSDU Payload |

1. Figure 4: Single MSDU Transfer Frame
2. Fragment Transaction Request – For Fragment Transaction Request Transfer Type, the RTS/CTS mechanism must be used. Only after agreement is reached on the Total MSDU Size will the Initial Fragment and More Fragments Transfer Type effect transfer of the fragmented MSDU. There are two forms of this transfer:
   1. RTS – This is the request from the sender to the destination proposing the Total MSDU Size to transfer
   2. CTS – This is the response from the destination either agreeing to the Total MSDU Size to transfer or offering a counter-proposal on the size. Note that fragment transfer will not occur until a CTS is received at the sender matching the last RTS sent.

Note that the final agreement on the Total MSDU Size must be noted at the destination for processing of the Initial Fragment and More Fragments frames. The subsequent Initial Fragment and More Fragments frames will deliver the MSDU Size Delivered in this Payload and the Fragment Count, however, the Total MSDU Size only appears in the Fragment Transaction Request.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Fragment Transaction Request (RTS)  Frame Control | | | | |
| Bit: 0-1 | 2 | 3 | 4 | 5-7 |
| Transfer Type {0b01 = Fragment Transaction Request } | RTS/CTS Control  {1 = RTS/CTS} | RTS/CTS  0 = RTS  1 = CTS  {0 = RTS} | Re-Try | Reserved |

Figure 5: Fragment Transaction Request (RTS) – Frame Control Settings

|  |  |  |  |
| --- | --- | --- | --- |
| Octets: 1 | 2 | 2 | 2 |
| Fragment Transaction Request Frame Control (see Figure 5) | Protocol ID | Transaction ID | Total MSDU Size (Octets)  {Proposed from Sender} |

Figure 6: Fragment Transaction Request (RTS) Transfer Frame

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Fragment Transaction Request (CTS)  Frame Control | | | | |
| Bit: 0-1 | | 2 | 3 | 4 | 5-7 |
| Transfer Type {0b01 = Fragment Transaction Request } | | RTS/CTS Control  {1 = RTS/CTS} | RTS/CTS  0 = RTS  1 = CTS  {1 = CTS} | Re-Try | Reserved |

Figure 7: Fragment Transaction Request (CTS) – Frame Control Settings

|  |  |  |  |
| --- | --- | --- | --- |
| Octets: 1 | 2 | 2 | 2 |
| Fragment Transaction Request Frame Control (see Figure 5) | Protocol ID | Transaction ID | Total MSDU Size (Octets)  {Confirmed from Destination or Counter Proposal to Sender} |

Figure 8: Fragment Transaction Request (CTS) Transfer Frame

1. Initial Fragment - Once the Fragment Transaction Request completes successfully (defined as the sender receiving a CTS matching Total MSDU Size from the last RTS sent), the Initial Fragment is sent with a Fragment Count of 1. The Initial Fragment frame contains:
   1. Protocol ID and Transaction ID – The destination must associate these values in processing the Initial Fragment since the subsequent More Fragments frame(s) will omit the Protocol ID
   2. Frame Count must be 1 for this frame
   3. MSDU Size Delivered in this payload – The number of octets (along with the MSDU payload) delivered by this Initial Fragment frame. Note the destination must store the Total MSDU Size from the Fragment Transaction Request (since the total number of fragments is not provided to the destination in the request)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Initial Fragment Frame Control | | | | |
| Bit: 0-1 | | 2 | 3 | 4 | 5-7 |
| 0b10 = Initial Fragment | | RTS/CTS Control  {0 = No RTS/CTS} | RTS/CTS  0 = RTS  1 = CTS  {Ignored} | Re-Try | Reserved |

Figure 9: Initial Fragment– Frame Control Settings

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Octets: 1 | 2 | 2 | 1 | 2 | n |
| Initial Fragment Frame Control (see Figure 9) | Protocol ID | Transaction ID | Fragment Count | MSDU Size Delivered in this payload (Octets) | MSDU Payload |

Figure 10: Initial Fragment Frame

1. More Fragments – After the Initial Fragment frame, zero, one or more More Fragments frames are sent until the total of the MSDU Size Delivered in this payload fields for this Transaction ID match the Total MSDU Size provided in the original Fragment Transaction Request. The More Fragments frame contains:
   1. Transaction ID – as delivered in the Initial Fragment frame
   2. Frame Count – The Frame Count must increment by 1 for each received More Fragments frame for a given Transaction ID else the packets are out of order and the transfer must be abandoned by the destination
   3. MSDU Size Delivered in this payload – The number of octets (along with the MSDU Payload) delivered in this More Fragments frame. The destination should use the Total MSDU Size from the original Fragment Transaction Request to keep track of how many octets are outstanding for this Transaction ID.











|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | More Fragments Frame Control | | | | |
| Bit: 0-1 | | 2 | 3 | 4 | 5-7 |
| 0b11=More Fragments | | RTS/CTS Control  {0 = No RTS/CTS} | RTS/CTS  0 = RTS  1 = CTS  {Ignored} | Re-Try | Reserved |

Figure 11: More Fragments– Frame Control Settings

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Octets: 1 | 2 | 1 | 2 | n |
| More Fragments Frame Control (see Figure 11) | Transaction ID | Fragment Count | MSDU Size Delivered in this payload (Octets) | MSDU Payload |

Figure 12: More Fragments Frame

Y.y.1.3 – RTS/CTS Processing using DTC IE frames

If the Transfer Type field value indicates an MSDU in a single frame:

* The RTS/CTS Control field set to 0 indicates that no RTS/CTS handshake is required and the MSDU is carried in the current DTC IE frame. The RTS/CTS field is not used and should be set to 0.
* The RTS/CTS Control field set to 1 indicates that an RTS/CTS handshake is required before the MSDU can be sent:
  + The RTS/CTS field set to 0 indicates the current frame is an RTS handshake. The Total MSDU Size field must be set to the size of the entire proposed MSDU transmission. The MSDU payload field is omitted.
  + The RTS/CTS field shall be set to 1 to indicate the current frame is a CTS handshake. If the Total MSDU Size matches the field received in the RTS, the transfer is agreed. Otherwise, the CTS Total MSDU Size contains a counter proposal on transfer size from the destination. Transmission of the actual MSDU Payload must not occur until a CTS is received matching the RTS.
  + Once the RTS/CTS Total MSDU Size are in agreement, the sender shall use the Single MSDU frame with RTS/CTS Control set to 0 and the agreed Total MSDU Size to transfer the MSDU Payload to the destination.
* The Protocol ID field shall be set to the value of the {insert reference to Protocol ID Authority} identifier for the source/destination MAC Client protocol handler for the MSDU.

If the Transfer Type field value indicates an MSDU transaction in a sequence of fragments (Fragment Transaction Request):

* The RTS/CTS Control field shall be set to 1.
* The RTS/CTS field shall be set to 0 to indicate the current frame is an RTS handshake or shall be set to 1 to indicate the current frame is a CTS handshake.
* The Protocol ID field shall be set to the value of the {insert reference to Protocol ID Authority} identifier for the source/destination MAC Client protocol handler for the MSDU.
* If the RTS/CTS field value indicates an RTS:
  + The Transaction ID field shall be set to the next value of a monotonically increasing counter maintained by the device
  + The Total MSDU Size field shall be set to the number of octets in the un-fragmented MSDU.
* If the RTS/CTS field value indicates a CTS:
  + The Transaction ID field shall be set to the value of the corresponding RTS Transaction ID field
  + The Total MSDU Size field shall be set to:
    - 0 to indicate the device is not available to receive data. If received, the sender should abandon the fragmented transfer attempt.
    - the corresponding RTS Total MSDU Size field value to indicate the device is available to receive the fragment sequence
    - a value less than the corresponding RTS Total MSDU Size field value to indicate the device is available to receive a data transfer but has insufficient resources for the MSDU offered and the source device should attempt a new data transfer within the field value.



## Z.z MAC PIB Attributes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Attribute | Type | Range | Default Value | Description |
| macFragmentThreshold | Integer | - | 1023 | Largest un-fragmented MSDU size |
| macFragmentReTryCount | Integer | - | 2 | Maximum number of re-transmission attempts for a fragment |
| macFragmentTimeOut | Integer | - | 10 seconds | Maximum time between received fragments in a fragment sequence, as referenced to the end of the frame carrying the last received fragment |

Figure 14: MAC IB Attributes