IEEE P802.15

Wireless Personal Area Networks

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| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) | |
| Title | Privacy Frame Formats | |
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| Re: | TG4ac draft | |
| Abstract | Frame formats needed to provide privacy on 802.15.4 | |
| Purpose | Create TG4ac draft | |
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1. Frame formats
   1. Generic format

Most of the messages are delivered using MAC commands, but the net announcement and request feature uses IEs so they can be included in the Beacon or other frames.

* 1. Sending list of addresses (Address List MAC Command frame)

This MAC command is used to announce list of addresses used by the sender of the frame. This may be sent to unicast or multicast address. The source address of this should be either short private address, or extended private address. If this is sent to multicast address then Confirmation Required field shall be set to zero.

Address List MAC Command frame shall be formatted as illustrated in Figure 1.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Octets: 1** | **0/8** | **0/1** | **0/2** | **0/1** | **0/varies** | **0/1** | **0/varies** |
| Flags | Sender ID | Address List Sequence Number | PAN ID | Number of Short Addresses | List of Short Addresses | Number of Extended Addresses | List of Extended Addresses |

Figure 1—Format of the Address List MAC Command frame

Flags field shall be formatted as illustrated in Figure 2.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Bit: 0** | **1** | **2** | **3** | **4** | **5** | **6-7** |
| Sender ID Present | Address List Sequence Number Present | PAN ID Present | Short Address List Present | Extended Address List Present | Confirmation Required | Reserved |

Figure 2—Flags field of the Address List MAC Command frame

The Sender ID Present, Address List Sequence Number Present, and PAN ID Present fields specify whether the corresponding fields in the Address List MAC Command frame are present. If the field is set to one, the field shall be present, and if it is set to zero, the field shall be omitted.

Sender ID field identifiers the actual sender using senders Device identifier.

If the Address List Sequence Number field is present, it has the sequence number of the address list. The upper layer will manage the sequence numbers of the address lists. The upper layer uses the Address List Sequence Number to detect Address List MAC Command replays.

The PAN ID Present field shall be set to one only if Short Address List Present field is also one.

If the Short Address List Present field is set to one, then both Number of Short Addresses and List of Short Addresses shall be present. If it set to zero, both are omitted.

List of Short Address contains the list of short addresses, and its length is Number of Short Addresses times two.

If the Extended Address List Present field is set to one, then both Number of Extended Addresses and List of Extended Addresses shall be present. If it set to zero, both are omitted.

List of Extended Address contains the list of extended addresses, and its length is Number of Extended Addresses times eight.

If the Confirmation Required field is set to one, then the sender of this frame expects the Address List Confirm MAC Command frame as a response to this command.

When the device sends a list the new list received in this message replaces the old address list if the address list field is present.

If the Short Address List field is not present, the previous short address list is used. If the Short Address List field is present, but Number of Short Addresses field contains zero, then device is no longer using short addresses.

If the PAN ID field is not present, then PAN ID of the previous short list is used. If the PAN ID field is not present, and this frame was sent using private short address then PAN ID of the MHR is used. If no previous PAN ID is known, then PAN ID of 0xffff is used.

If the Extended Address List field is not present, the previous extended address list is used. If the Extended List field is present, but Number of Extended Addresses field contains zero, then device is no longer using extended addresses.

* 1. Confirmation of receipt of address list (Address List Confirm MAC Command frame)

This frame shall be sent in unicast frame to the sender of the Address List MAC Command frame as a response to the Address List MAC Command frame. This shall not be sent if the destination address of the address list was not unicast address.

Address List Confirm MAC Command frame shall be formatted as illustrated in Figure 3.

|  |  |
| --- | --- |
| **Octets: 1** | **0/1** |
| Flags | Address List Sequence Number |

Figure 3—Format of the Address List Confirm MAC Command **frame**

Flags field of the Address List Confirm MAC Command frame shall be formatted as illustrated in Figure 4.

|  |  |
| --- | --- |
| **Bit: 0** | **1-7** |
| Address List Sequence Number Present | Reserved |

Figure 4—Flags of the Confirmation of Address List MAC Command frame

The Address List Sequence Number Present field specify whether the Address List Sequence Number field are present. If the field is set to one, the field shall be present, and if it is set to zero, the field shall be omitted.

If received Address List MAC Command frame had Address List Sequence Number field, then that field shall be copied to the Address List Sequence Number field of the outgoing Address List Confirm MAC frame.

* 1. Request to get list of addresses (Request Addresses MAC Command frame)

This frame may be sent to unicast or multicast address. This message is used when the device does not know the currently used private address for remote device, or where it thinks the list might be out of sync. Can be sent to last known unicast address, or to the multicast address. The source address is typically extended private address.

Request Addresses MAC Command frame shall be formatted as illustrated in Figure 5.

|  |  |  |  |
| --- | --- | --- | --- |
| **Octets: 1** | **0/8** | **0/8** | **0/1** |
| Flags | Sender ID | Recipient ID | Address List Sequence Number |

Figure 5— Format of the Request Addresses MAC Command from

Flags field of the Request Addresses MAC Command frame shall be formatted as illustrated in Figure 6.

|  |  |  |  |
| --- | --- | --- | --- |
| **Bit: 0** | **1** | **2** | **3-7** |
| Sender ID Present | Recipient ID Present | Sequence Number Present | Reserved |

Figure 6—Flags of the Request Addresses MAC Command from

The Sender ID Present, Recipient ID Present, and Sequence Number Present fields specify whether the corresponding field in the Request Addresses MAC Command frame is present. If the field is set to one, the field shall be present, and if it is set to zero, the field shall be omitted.

Sender ID field identifiers the actual sender using senders Device identifier.

Recipient ID field identifiers the actual receiver using receivers Device identifier. If frame is sent to multicast address then this field shall be included, and Recipient ID Present field shall be set to one.

Address List Sequence Number field specifies the sequence number of the last address list the sending device has seen.

This message may be sent after or during orphan scan, i.e., where the device thinks remote peer has changed address, and device do now know currently used addresses. The recipient of this will reply to that with Address List MAC Command.

* 1. Assignment of addresses to remote peer (Assign Addresses MAC Command frame)

This message may sent by the owner of the network to assign short addresses to devices. It is usually sent to the unicast address of the intended recipient, but if the network owner thinks remote peer might be out of sync it may also send this to multicast address.

Assign Addresses MAC Command frame shall be formatted as illustrated in Figure 7.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Octets: 1** | **0/8** | **0/8** | **0/1** | **0/2** | **0/1** | **0/varies** |
| Flags | Sender ID | Recipient ID | Address List Sequence Number | PAN ID | Number of Short Addresses | List of Short Addresses |

Figure 7—Format of the Assign Addresses MAC Command frame

Flags field of the Assign Addresses MAC Command frame shall be formatted as illustrated in Figure 8.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Bit: 0** | **1** | **2** | **3** | **4** | **5-7** |
| Sender ID Present | Recipient ID Present | Address List Sequence Number Present | PAN ID Present | Confirmation Required | Reserved |

Figure 8—Flags of the Assign Addresses MAC Command frame

The Sender ID Present, Recipient ID Present, Address List Sequence Number Present, and PAN ID Present fields specify whether the corresponding field in the Assign Addresses MAC Command frame are present. If the field is set to one, the field shall be present, and if it is set to zero, the field shall be omitted.

Sender ID field identifiers the actual sender using senders Device identifier.

Recipient ID field identifiers the actual receiver using receivers Device identifier. If frame is sent to multicast address then this field shall be included, and Recipient ID Present field shall be set to one.

If the Address List Sequence Number field is present, it has the sequence number of the address list. The upper layer will manage the sequence numbers of the address lists.

If the Confirmation Required field is set to one, then the sender of this frame requires the Assign Addresses Confirm MAC Command frame as a response to this command.

If the PAN ID field is not present, then PAN ID of the previous short list is used. If the PAN ID field is not present, and this frame was sent using private short address then PAN ID of the MHR is used. If no previous PAN ID is known, then PAN ID of 0xffff is used.

List of Short Address contains the list of short addresses, and its length is Number of Short Addresses times two.

If device is assigned zero addresses, then it cannot use any short addresses anymore.

* 1. Confirmation of address assignment (Assign Addresses Confirm MAC Command frame)

This frame shall be sent in unicast frame to the sender of the Assign Addresses Confirm MAC Command frame if confirmation was requested.

This is used to confirm the reception of the Assign Addresses MAC Command frame.

Assign Addresses Confirm MAC Command frame shall be formatted as illustrated in Figure 9.

|  |  |
| --- | --- |
| **Octets: 1** | **0/1** |
| Flags | Address List Sequence Number |

Figure 9—Format of the Assign Addresses Confirm MAC Command frame

Flags field of the Assign Addresses Confirm MAC Command frame shall be formatted as illustrated in Figure 10.

|  |  |
| --- | --- |
| **Bit: 0** | **1-7** |
| Address List Sequence Number Present | Reserved |

Figure 10—Flags of the Assign Addresses Confirm MAC Command frame

The Address List Sequence Number Present field specifies whether the Address List Sequence Number field is present. If the field is set to one, the field shall be present, and if it is set to zero, the field shall be omitted.

Address List Sequence Number Present, and Address List Sequence Number fields of the received Assign Addresses MAC Command frame shall be copied to the Address List Sequence Number field of the outgoing Assign Addresses Confirm MAC Command frame.

* 1. Updating key id (Key Id Update MAC Command frame)

This may be sent as unicast or multicast message. If sent as multicast message there shall not be confirmations.

Key Id Update MAC Command frame shall be formatted as illustrated in Figure 11.

|  |  |  |  |
| --- | --- | --- | --- |
| **Octets: 1** | **0/8** | **0/1/5/9** | **1/5/9** |
| Flags | Sender ID | Old Key Id | New Key Id |

Figure 11—Format of the Key Id Update MAC Command frame

Flags field of the Key Id Update MAC Command frame shall be formatted as illustrated in Figure 12.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bit: 0** | **1** | **2-3** | **4** | **5-7** |
| Sender ID Present | Old Key Id Present | Key Id Mode | Confirmation Required | Reserved |

Figure 12—Flags of the Key Id Update MAC Command frame

The Sender ID Present, and Old Key Id Present fields specify whether the corresponding field in the Key Id Update MAC Command are present. If the field is set to one, the field shall be present, and if it is set to zero, the field shall be omitted.

Sender ID field identifiers the actual sender using senders Device identifier.

If the Old Key Id Present is set to zero, then Key Id to be changed is taken from the MHR.

The Old and New Key Id fields are defined in 9.4.4.

Key Id Mode field is defined in 9.4.2.3.

If the Confirmation Required field is set to one, then the sender of this frame requires the Key Id Update Confirm MAC Command as a response to this command.

When this frame is received the recipient will update the key id to the new value defined, but will keep the old key id also in security PIB. When the new key id is first time used, the old id is removed.

* 1. Confirmation of updating key id (Key Id Update Confirm MAC Command frame)

This frame shall always sent in unicast frame to the sender of the Key Id Update MAC Command frame.

This is used to confirm the reception of the Key Id Update MAC Command.

Key Id Update Confirm MAC Command frame shall be formatted as illustrated in Figure 13.

|  |  |
| --- | --- |
| **Octets: 1** | **1/5/9** |
| Flags | Old Key Id |

Figure 13—Format of the Key Id Update Confirmation MAC Command frame

Flags field of the Key Id Update Confirm MAC Command frame shall be formatted as illustrated in Figure 14.

|  |  |
| --- | --- |
| **Bit: 0-1** | **2-7** |
| Key Id Mode | Reserved |

Figure 14—Flags of the Key Id Update Confirmation MAC Command frame

The Old Key Id fields are defined in 9.4.4.

Key Id Mode field is defined in 9.4.2.3.

This sent as an reply to the Key Id Update MAC Command frame to confirm that key id update was successful. Key Id Mode and Old Key Id fields of the received Key Id Update MAC Command frame shall be copied to the this Key Id Update Confirm MAC Command frame.

1. Information Elements
   1. Network announcement (Net Announcement IE)

This IE may be included in the frame that is sent to multicast address, for example in Beacon frames. This IE is often sent without encryption, as this is used to find existing networks, and devices wanting to join might not have security context. Source address this frame shall be extended private address of the sender.

Net Announcement IE shall be formatted as illustrated in Figure 15.

|  |  |  |
| --- | --- | --- |
| **Octets: 1** | **8** | **16/20/28** |
| Flags | Announcement Nonce | Encrypted Verifier |

Figure 15—Format of the Net Announcement IE

Flags field of the Net Announcement IE shall be formatted as illustrated in Figure 16.

|  |  |  |
| --- | --- | --- |
| **Bit: 0-2** | **3** | **4-7** |
| Security Level of Verifier | Reserved | Algorithm ID |

Figure 16—Flags of the Net Announcement IE

The Security Level of the Verifier field contains the security level used when generating the Encrypted Verifier field as defined in Table 9-4. Only security levels 5-7 shall be allowed.

Algorithm ID specifies the algorithm used when generating Encrypted Verifier field, as defined in Table 9-9.

The Announcement Nonce field shall be filled with random 64-bit number.

The Encrypted Verifier is generated by taking the data defined in Figure 17, and encrypting it using the specified encryption algorithm, the Network key, and the security level specified in the Security Level of the Verifier field.

|  |  |
| --- | --- |
| **Octets: 8** | **4** |
| Announcement Nonce | Sequence Number |

Figure 17—Verifier generation for Encrypted Verifier field of the Net Announcement IE

When encrypting the data in Figure 17 the nonce used shall be generated illustrated in Figure 18.

|  |  |
| --- | --- |
| **Octets: 8** | **8** |
| Extended private address | Announcement Nonce |

Figure 18—Nonce generation for Encrypted Verifier field of the Net Announcement IE

The Encrypted Verifier field shall contain the output of the encryption process, meaning that the data in Figure 17 shall be used as m data and a data is set to empty, and the output c data is used as Encrypted Verifier field content.

XXX TODO: Should we add additional data here, we could include rest of the beacon / frame, MHR etc to authenticate them too, this might make the frame generation more difficult.

Recipient of this message who know the Network key can decrypt and verify the Encrypted Verifier field inside the IE, and it can use it to verify that the Announcement Nonce inside matches that of outside, and that sequence number is not old.

If the device does not have security context with the network, it will start IEEE Std 802.15.9 KMP with the sender of this message to create security context, and join the network. This method requires that devices wanting to join the network needs to be configured with the 64-bit network identifier, and the 128-bit network key (if network key is used, if not only the network identifier is needed).

Devices who already have security context with the network, can use this message to see that network is available, and send Request Addresses MAC Command frame to sender in case the source address used in this message was not already known to them.

* 1. Network request (Net Request IE)

The Net Request IE may be sent in frame that is sent to the multicast address to see if there is known network nearby. This frame is usually sent in clear, as this is used to find existing networks, and device sending this might not have addresses that are recognized by the network anymore. Can also be sent encrypted in case device assumes the network owner recognizes source address, and can find security context based on that. Typically source address is extended private address.

The contents of the Net Request IE is exactly same as Net Announcement IE.

Processing is same as in the Net Announcement IE meaning if the recipient can verify the verifier, it can send Address List MAC Command frame to the sender of this message to update the addresses.