**IEEE P802.15**

**Wireless Personal Area Networks**

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| Re: | TG12 Architecture: PDE, MMI, MPM, and PTM operation | |
| Abstract | [Description of the mandatory ULI elements: PDE, MMI, MPM, and PTM] | |
| Purpose | [Provide a basis for drafting the 802.15.12 standard] | |
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# Operational Details of ULI Mandatory Elements

As shown in Figure 0.1, the mandatory elements of the ULI are the Protocol Discrimination Entity (PDE), Multiplexed MAC Interface (MMI), Management Protocols Module (MPM), and the Passthru Module (PTM).



Figure 1‑1

## Protocol Discrimination Entity

### Purpose:

For information received via the 802.15.4 device; the PDE directs that information from the protocol module SAP to the appropriate higher layer SAP or to another protocol module SAP.

For information from a higher layer SAP, the PDE will direct that information to the designated protocol module.

### Overview

The PDE is responsible for determining if the higher layer entity’s SAP is a legacy SAP (i.e. intended to directly interface to the 802.15.4 MAC SAPs) or a ULI capable SAP. This allows the ULI to work with higher layer entities that were designed to interface directly to 802.15.4 MAC SAPs as well as higher layer entities designed to interface to the ULI.

For data from higher layer entity to be transmitted to a remote device via the 802.15.4 local device:

* If the higher layer entity’s SAP is a legacy SAP, the PDE will attach origination EtherType/Dispatch information to the data and then send the data to the protocol module dictated by a prior configuration by the MPM or the PTM.
* If the higher layer entity’s SAP is a ULI capable SAP, the PDE will attach origination EtherType/Dispatch information and Profile information to the data and then send that data to the protocol module designated by the EtherType/Dispatch code.

For data received from a remote device via the 802.15.4 local device:

* From PTM – send frame payload to the application designated by the EtherType/Dispatch code or the default application as configured by the MPM
* From non-PTM– send frame payload to designated higher layer SAP as dictated by EtherType/Dispatch code attached by the protocol module

#### Protocol Discrimination

Protocol discrimination is based on either EtherTypes or dispatch codes.

##### EtherType

EtherType protocol identification values, examples are shown in Table 1‑1, are assigned by the IEEE RA and are used to identify the protocol that is to be invoked to process the user data in the frame. An EtherType is a sequence of 2 octets, interpreted as a 16-bit numeric value with the first octet containing the most significant 8 bits and the second octet containing the least significant 8 bits.

Table 1‑1 EtherType Examples

| EtherType | Organization/ Address | Protocol |
| --- | --- | --- |
| 0800 | Xerox | IPv4 Internet Protocol Version  A Standard for the Transmission of IP Datagrams over Ethernet Networks, RFC-Internet Society, Apr. 1984. http://www.ietf.org/rfc/rfc894.txt |
| 86DD | USC/ISI 4676 Admiralty Way, Marina del Rey, CA | IPv6 Internet Protocol Version 6 Transmission of Packets over Ethernet Networks, RFC-2464, Internet Society, Dec. 1998. http://www.ietf.org/rfc/rfc2464.txt |
| 888E | IEEE 802.1  802.1 Chair c/o IEEE  Piscataway, NJ | IEEE Std 802.1X - Port-based network access control |
| 88B7 | IEEE 802.1 IEEE 802.1 Chair c/o IEEE Piscataway, NJ | 802 - OUI Extended Ethertype. This Ethertype value is available for public use and for prototype and vendor-specific protocol development, as defined in Amendment 802a to IEEE Std 802. |
| 88F0 | IEEE P1451.0 700 King Farm Blvd., Rockville, MD | IEEE P1451.0 Smart Transducer Interface for Sensors and Actuators http://grouper.ieee.org/groups/1451/0/private/ |
| A0ED | IETF 6lo working group c/o Internet Society, Reston, VA | When carried over layer 2 technologies such as Ethernet, this EtherType will be used to identify IPv6 datagrams using LoWPAN encapsulation as defined in IETF RFC 4944 Transmission of IPv6 Packets over IEEE 802.15.4 Networks |

##### Dispatch code

Values in the 0–1535 range are not available for use as EtherTypes, rather they designate dispatch codes. Dispatch codes are assigned by the IEEE 802.15 ANA.

##### Multiplex ID field

The Multiplex ID field used in the MPX IE is used to multiplex different upper-layer protocols. The Multiplex ID field, as shown in Table 1‑2, takes one of two meanings, depending on its numeric value as follows:

1. If the value of this field is less than or equal to 1500, the Multiplex ID field takes Dispatch code values.
2. If the value of this field is greater than 1500, the Multiplex ID field indicates the EtherType of the MAC client protocol.

Table 1‑2

|  |  |  |
| --- | --- | --- |
| Multiplex ID (decimal) | Multiplex ID (hex) | Description |
| 1 | 0x0001 | KMP |
| 2 | 0x0002 | WiSUN |
| 3–1279 | 0x0003–0x04ff | Reserved |
| 1381 | 0x0565 | Vendor specific, OUI extended |
| 1280–1380, 1382–1500 | 0x0500–0x0564, 0x0566–0x05dc | Reserved |

The Multiplex ID field is present if the Frame number is 0x00 and the Transfer type is 0b010, or if the Transfer type is 0b000. If the Transfer type is 0b001, the Multiplex ID is stored inside the Transaction ID field and the Multiplex ID field is omitted.

### PDE Primitives

The PDE service consists of four primitives as shown in Table 1‑3.

Table 1‑3 Summary of PDE primitives

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Request | Indication | Response | Confirm |
| PDE-DATA | X | X |  | X |
| PDE-MGMT-CREATE | X |  |  | X |
| PDE-MGMT-COMBINE | X |  |  | X |
| PDE-MGMT-DELETE | X |  |  | X |
| PDE-MGMT-RCVEXEC | X |  |  | X |
| PDE-MGMT-GET | X |  |  | X |
| PDE-PURGE | X |  |  | X |
| PDE-OP-LIST | X |  |  | X |
| PDE-OP-GETSTATUS | X |  |  | X |
| PDE-OP-SETSTATUS | X |  |  | X |
| PDE-OP |  | X | X |  |

PM-DATA.request

Next Higher Layer

PDE-DATA.request

MMI-DATA.request

Protocol Module

MAC

MMI

MCPS-DATA.request

PDE

PM-DATA.confirm

PDE-DATA.confirm

MMI-DATA.confirm

MCPS-DATA.confirm

IEEE802.15.12

IEEE802.15.4

Figure 1‑2

#### PDE-DATA

The PDE-DATA primitive supports the transport of data from the higher layer or to the higher layer.

##### PDE-DATA.request

The PDE-DATA.request primitive is a request from a higher layer SAP to transport a data payload to a remote device. Specifically, the PDE-DATA.request primitive requests the transfer of a PDE payload (PdeData) to the designated protocol module (DstProtocolModuleId). The semantics of this primitive are as follows:

(  
DstAddr,

DstProtocolId,

ProfileId,

PdeData,

PdeHandle,

)

The primitive parameters are described in Table 1‑4.

Table 1‑4

| Name | Type | Valid range | Description |
| --- | --- | --- | --- |
| DstAddr | — | Any valid extended address | The extended address of the receiving (destination) device. |
| DstProtocolId | Integer | 0x0000–0xffff | The destination protocol module’s ID of the remote device, i.e. either the protocol module’s EtherType or Dispatch code |
| ProfileId | Integer | 0x0000–0xffff | The ULI Profile ID identifying the desired configuration parameters for ULI protocol modules and MAC/PHY |
| PdeData | Set of octets | — | The set of octets forming the PDE data payload. |
| PdeHandle | Integer | 0x00–0xff | An identifier that can be used to refer to the particular primitive transaction, used to match a confirm primitive with the corresponding request. |

##### PDE-DATA.confirm

The PDE-DATA.confirm primitive reports the results of a request to transport data from a higher layer SAP to a remote device. The semantics of this primitive are as follows:

(  
PdeHandle,  
MaxTransferSize,   
Status  
)

The primitive parameters are described in Table 1‑5. If there is no capacity to store the transaction, the Status will be set to TRANSACTION\_OVERFLOW. In case the remote device aborts the transaction then the status will be set to TRANSACTION\_ABORTED and the MaxTransferSize is set to the value returned from the remote device.

Table 1‑5 PDE-DATA.confirm parameters

| Name | Type | Valid range | Description |
| --- | --- | --- | --- |
| PdeHandle | Integer | 0x00–0xff | An identifier that can be used to refer to a particular primitive transaction; used to match a confirm primitive with the corresponding request. |
| MaxTransfer- Size | Integer | 0x0000–0xffff | In case of an aborted transaction this parameter can be returned from the remote device to indicate the maximum size of transaction it can handle. In case the remote device did not give a maximum size, this is set to zero. |
| Status | Enumeration | SUCCESS, TRANSACTION\_ OVERFLOW, TRANSACTION\_ EXPIRED, CHANNEL\_ACCESS\_ FAILURE, INVALID\_ADDRESS,  NO\_ACK,  COUNTER\_ERROR, FRAME\_TOO\_LONG,  UNAVAILABLE\_KEY, UNSUPPORTED\_ SECURITY, INVALID\_PARAMETER. TRANSACTION\_ ABORTED | The status of the last PDE data transmission. |

##### PDE-DATA.indication

The PDE-DATA.indication primitive is invoked from a protocol module to deliver a payload to a higher layer SAP. The semantics of this primitive are as follows:

(  
SrcAddr,   
DstAddr,   
DstSapId,  
PdeData,   
PdeHandle

)

The primitive parameters are described in Table 1‑6.

Table 1‑6-PDE\_DATA.indication parameters

| Name | Type | Valid range | Description |
| --- | --- | --- | --- |
| SrcAddr | — | Any valid extended address | The extended address of the transmitting (source) device. |
| DstAddr | — | Any valid extended address | The extended address of the receiving (destination) device. |
| DstSapId | Integer | 0x0000–0xffff | The destination’s higher-layer SAP ID, i.e. either its EtherType or Dispatch code |
| PdeData | Set of octets | — | The set of octets forming the PDE data payload. |
| PdeHandle | Integer | 0x00–0xff | An identifier that can be used to refer to a particular primitive transaction; used to match a confirm primitive with the corresponding request. |

#### PDE-MGMT

The PDE-MGMT primitives support the transport of configuration information and profiles for the protocol modules or 802.15.4 MAC/PHY to the MPM.

##### PDE-MGMT-CREATE.request

This request transports from a higher layer to the MPM, the configuration information (PdeMgmtData) for protocol modules or an 802.15.4 MAC/PHY. The MPM creates a profile and stores this information in its MIB. The identification of the Profile created will be returned in the .confirm primitive. The semantics of this primitive are as follows:

(

PdeMgmtData,

Handle

)

##### PDE-MGMT-CREATE.confirm

This primitive reports the results of the PDE-MGMT-CREATE.request to the higher layer SAP. The semantics of this primitive are as follows:

(

ProfileId,

Handle,

Status

)

##### PDE-MGMT-GET.request

This primitive requests the configuration information stored in ProfileId. The semantics of this primitive are as follows:

(

ProfileId,

Handle

)

##### PDE-MGMT-GET.confirm

This primitive reports the results of the PDE-MGMT-GET.request to the higher layer SAP. The semantics of this primitive are as follows:

(

PdeMgmtData,

Handle,

Status

)

##### PDE-MGMT-COMBINE.request

This primitive creates a new ProfileId that is a combination of two or more existing ProfileIds. Changes to any of the ProfileIds used to create the new ProfileId will also change the new ProfileId. The semantics of this primitive are as follows:

(

ProfileIdList,

Handle

)

##### PDE-MGMT-COMBINE.confirm

This primitive reports the results of the PDE-MGMT-COMBINE.request to the higher layer SAP. The semantics of this primitive are as follows:

(

ProfileId,

Handle,

Status

)

##### PDE-MGMT-RCVEXEC.request

This primitive loads the configuration information stored in ProfileId into the 802.15.4 MAC & PHY and other modules. After the configuration information has been loaded into the 802.15.4 MAC & PHY and other modules, the primitive enables the operation using the configuration information The semantics of this primitive are as follows:

(

ProfileId,

Handle

)

##### PDE-MGMT-RCVEXEC.confirm

This primitive reports the results of the PDE-MGMT-RCVEXEC.request to the higher layer SAP. The semantics of this primitive are as follows:

(

Handle,

Status

)

##### PDE-MGMT-DELETE.request

This primitive deletes the configuration information stored in ProfileId. ProfileIds that are in use (either being used in a module or 802.15.4 MAC&PHY, or in use for other ProfileId) shall not be deleted. The semantics of this primitive are as follows:

(

ProfileId,

Handle

)

##### PDE-MGMT-DELETE.confirm

This primitive reports the results of the PDE-MGMT-DELETE.request to the higher layer SAP. The semantics of this primitive are as follows:

(

Handle,

Status

)

The parameters for the PDE-MGMT primitives are described in Table 1‑7.

| Name | Type | Valid range | Description |
| --- | --- | --- | --- |
| ProfileId | Integer | 0x0000–0xffff | The Profile ID for the configuration parameters stored in the MPM |
| ProfileIdList | List of integers | 0x0000-0xffff | List of ProfileIds to be combined |
| PdeMgmtData | Set of octets | --- | Configuration information for the 802.15.4 MAC and PHY and/or module(s) to be configured |
| Handle | Integer | 0x00–0xff | An identifier that can be used to refer to the particular primitive transaction; used to match a confirm primitive with the corresponding request. |
| Status | Enumeration | SUCCESS, TRANSACTION\_ OVERFLOW,  INVALID\_PARAMETER, TRANSACTION\_ ABORTED | The status of the last primitive. |

Table 1‑7 PDE-Mgmt primitives

### PDE-PURGE

The PDE-PURGE primitives provide a means to remove or abort pending transfers and operations from the PDE transaction queue of the originator.

#### The PDE-PURGE.request

The PDE-PURGE.request primitive allows the next higher layer to purge a PDE payload from the transaction queue.

The semantics of the PDE-PURGE.request are as follows:

(  
Handle,  
SendAbort  
)

The primitive parameters are described in Table 6.

Table 1‑8 PDE-PURGE.request parameters

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| Handle | Integer | 0x00–0xff | An identifier that can be used to refer to a particular primitive transaction; used to match a PDE-PURGE.request primitive with the corresponding PDE-DATA.confirm primitive. |
| SendAbort | Boolean | TRUE, FALSE | If this parameter is TRUE and the transaction is still active, the PDE data service requests that an abort code be sent to the remote device indicating that the transaction was aborted. If this parameter is FALSE, the transaction is just purged locally, and no information is sent to the remote device. |

On receipt of the PDE-PURGE.request primitive, the PDE data service attempts to find in the transaction queue the payload indicated by the Handle parameter. If a PDE payload has left the transaction queue, the handle will not be found, and the PDE payload can no longer be purged. If a PDE payload matching the given handle is found, the payload is discarded from the transaction queue, and optionally an abort message is sent to the other end, if the SendAbort parameter is TRUE. If an abort message is sent to the other end that will allow the other end to clear out its state immediately without waiting for the timeout.

The PDE-PURGE.request will also cause a corresponding MCPS-PURGE.request to be issued to the MAC data service, provided it has an MCPS-DATA.request in process when the PDE-PURGE.request is called.

#### PDE-PURGE.confirm

The PDE-PURGE.confirm primitive allows the PDE service to notify the next higher layer of the success of its request to purge a PDE payload from the transaction queue of the PDE.

The semantics of this primitive are as follows:

(  
Handle,   
Status  
)

The primitive parameters are described in Table 7.

Table 1‑9 PDE-PURGE.confirm parameters

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| Handle | Integer | 0x00–0xff | An identifier which can be used to refer to a particular primitive transaction; used to match a confirm primitive with the corresponding request. |
| Status | Enumeration | SUCCESS, INVALID\_HANDLE | The status of the request to purge PDE data from the transaction queue. |

### PDE-OP

The PDE-OP primitives specify operations such as commands to be done to specified protocol modules.

#### PDE-OP-LIST.request

This primitive requests a list of the modules’ IDs present in the ULI. The primitive is directed to the MPM which keeps the list of protocol modules present in the ULI.

The semantics of this primitive are as follows:

(  
Handle,   
)

#### PDE-OP-LIST.confirm

This primitive returns a list of the modules present in the ULI.

The semantics of this primitive are as follows:

(  
ModuleIdList,

Handle,   
Status  
)

#### PDE-OP-GETSTATUS.request

This primitive requests the status of the protocol module indicated by ModuleId

The semantics of this primitive are as follows:

(  
ModuleId,

Handle   
)

#### PDE-OP-GETSTATUS.confirm

This primitive returns with the status of the protocol module indicated by ModuleId

The semantics of this primitive are as follows:

(

Handle,   
StatusValue,

Status  
)

#### PDE-OP-SETSTATUS.request

This primitive sets the status of the protocol module indicated by ModuleId

The semantics of this primitive are as follows:

(  
ModuleId,  
StatusValue,

Handle,  
)

#### PDE-OP-SETSTATUS.confirm

This primitive reports the results of the request to set the status of the protocol module indicated by ModuleId

The semantics of this primitive are as follows:

(

Handle,

Status  
)

#### PDE-OP.indication

The PDE-OP.indication primitive indicates the presence of data from a designated protocol module that is to be sent to a higher layer. The semantics of this primitive are as follows:

(

DstSapId,

ModuleId,

PdeOpData,

Status

)

#### PDE-OP.response

The PDE-OP.response primitive allows the next higher layer of a device to respond to the PDE-OP.indication primitive. The semantics of this primitive are as follows:

(

DstSapId,

ModuleId,

PdeOpData,

Status

)

## Multiplexed MAC Interface (MMI)

### Purpose

* Directs and may modify information from a protocol module SAP to the MCPS or MLME SAP or another protocol module’s SAP
* Directs and may modify information from the MCPS or MLME SAP to a protocol module SAP
* Provides a fragmentation/defragmentation service to the data sent to or from the MCPS-SAP, the MLME-SAP, or another protocol module SAP.

### Overview

The mechanism for the MMI, i.e. the ability to send the data to the proper SAP and fragmentation/defragmentation is similar to the mechanism defined in IEEE Std 802.15.9 for the multiplexed data service.

The MMI is responsible for determining the capability of the Remote Nodes, i.e. whether they support ULI IEs.

The process of sending the data to the MCPS-SAP includes possibly fragmenting the data and formatting the ULI IE, i.e. inserting the appropriate headers into the payload of the frame for transmission.

The process of receiving the data from the MCPS-SAP includes possibly defragmenting that data (buffering all fragments until the data is completely received), removing the ULI IE headers, and passing the data to the appropriate protocol module SAP.

The interface between the MMI and the ULI protocol modules includes the EtherType/Dispatch code and the payload.

The MMI service consists of four primitives as shown in Table 1‑10.

Table 1‑10 Summary of MMI primitives

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Request | Indication | Response | Confirm |
| MMI-DATA | X | X |  | X |
| MMI-MGMT | X | X |  | X |
| MMI-CONFIG | X | X |  | X |
| MMI-PURGE | X |  |  | X |

### MMI-DATA primitives

The MMI data primitive delivers an MMI data payload from the protocol blocks to the MCPS-SAP after it packages them into a ULI IE or an MPX IE using the formats shown in Table 1‑11 and Table 1‑12. The dispatch or EtherType ID indicates the ULI destination of the data payload.

Table 1‑11

|  |  |
| --- | --- |
| Octets: 1 | Variable |
| ULI IE ID | Payload |

Table 1‑12

|  |  |  |
| --- | --- | --- |
| Octets: 1 | 2 | Variable |
| MPX IE ID | Dispatch/EtherType ID | Payload |

The formatted ULI IE or MPX IE is sent using the MCPS-DATA primitive via either Data or Multipurpose frames to the recipient device. At the recipient device, the ULI IE or MPX IE is delivered to the MCPS-SAP where the MMI data service delivers the data payload to the SAP of the protocol block or upper layer interface as identified by the dispatch/EtherType ID. Figure 2 illustrates this message sequence.

ULI

MAC This ULI IE is sent using the MCPS-DATA primitive via either Data or Multipurpose frames to the recipient device. At the recipient device, the ULI IE is delivered to the MCPS-SAP where the MMI data service delivers the data payload to the identified protocol block. Figure 2 illustrates this message sequence.

C

Protocol Bock

Protocol Block

MAC

ULI

MMI-DATA.request

MCPS-DATA.request

Data frame

MCPS-DATA.indication

ACK frame

MMI-DATA.indication

MCPS-DATA.confirm

MMI-DATA.confirm

Figure 1‑3 MMI message sequence



#### MMI-DATA.request

The MMI-DATA.request primitive requests the transfer of an MMI payload to a remote device via the IEEE 802.15.4 MAC/PHY. The semantics of this primitive are as follows:

(

SrcAddrMode,

DstAddrMode,

DstPanId,

DstAddr,

Msdu,

MsduHandle,

HeaderIeList,

PayloadIeList,

HeaderIeIdList,

NestedIeSubIdList,

AckTx,

GtsTx,

IndirectTx,

SecurityLevel,

KeyIdMode,

KeySource,

KeyIndex,

UwbPrf,

Ranging,

UwbPreambleSymbolRepetitions,

DataRate,

LocationEnhancingInformationPostamble,

LocationEnhancingInformationPostambleLength,

PanIdSuppressed,

SeqNumSuppressed,

SendMultipurpose

FrakPolicy,

CriticalEventMessage   
)

The primitive parameters are described in Table 1‑13.

Table 1‑13 MMI-DATA.request parameters

| Name | Type | Valid range | Description |
| --- | --- | --- | --- |
| SrcAddrMode | Enumeration | NONE, SHORT, EXTENDED | The source addressing mode for this MMI data. |
| DstAddrMode | Enumeration | NONE, SHORT, EXTENDED | The destination addressing mode for this MMI data. |
| DstPanId | Integer | 0x0000–0xffff | The PAN identifier of the entity to which the MMI data is being transferred. |
| DstAddr | — | As specified by the DstAddrMode parameter. | The address of the receiving (destination) device. |
| MultiplexId | Integer | 0x0000–0xffff | The higher-layer protocol using the MMI data service. ULI IE ID or MPX IE ID and the EtherType/Dispatch code |
| MmiData | Set of octets | — | The set of octets forming the IE data payload. |
| MmiHandle | Integer | 0x00–0xff | An identifier that can be used to refer to the particular primitive transaction; used to match a confirm primitive with the corresponding request. |
| SecurityLevel | Integer | 0–7 | The combination of Message Integrity Check and Encryption to be applied to the payload of the MMI data service. For encoding see Table 9-6 in IEEE Std 802.15.4. |
| KeyIdMode | Integer | As defined in Table 9-7 of IEEE Std 802.15.4. | The mode used to identify the key purportedly used by the originator of the received frame. This parameter is invalid if the SecurityLevel parameter is set to 0x00. |
| KeySource | Set of octets | As indicated by the KeyIdMode parameter. | The originator of the key purportedly used by the originator of the received frame. The KeySource field, when present, indicates the originator of a group key. If the Key Identifier Mode field indicates a 4-octet Key Source field, then the Key Source field shall be the macPanId of the originator of the group key right concatenated with the macShortAddress of the originator of the group key. If the Key Identifier Mode field indicates an 8 octet Key Source field, then the Key Source field shall be set to the macExtendedAddress of the originator of the group key. This parameter is invalid if the KeyIdMode parameter is invalid or set to 0x00 or set to 0x01. |
| KeyIndex | Integer | 0x01–0xff | The Key Index field allows unique identification of different keys with the same originator. It is the responsibility of each key originator to make sure that the actively used keys that it issues have distinct key indices and that the key indices are all different from 0x00. |
| Send-Multipurpose | Boolean | TRUE, FALSE | If TRUE, use the 802.15.4 Multipurpose frame type.  If FALSE, use 802.15.4 Data frame type. |

#### MMI-DATA.confirm

The MMI-DATA.confirm primitive reports the results of a request to transfer data to another device. The semantics of the MMI-DATA.confirm are as follows:

MMI-DATA.confirm

(  
MmiHandle,  
MaxTransferSize,   
Status  
)

The primitive parameters are described in Table 1‑14. If there is no capacity to store the transaction, the Status will be set to TRANSACTION\_OVERFLOW. In case the other end aborts the transaction then the status will be set to TRANSACTION\_ABORTED and the MaxTransferSize is set to the value returned from the other end.

Table 1‑14 MPX-DATA.confirm parameters

| Name | Type | Valid range | Description |
| --- | --- | --- | --- |
| MmiHandle | Integer | 0x00–0xff | An identifier that can be used to refer to a particular primitive transaction; used to match a confirm primitive with the corresponding request. |
| MmiTransfer- Size | Integer | 0x0000–0xffff | In case of an aborted transaction this parameter can be returned from the other end to indicate the maximum size of transaction it can handle. In case another end did not give a maximum size, this is set to zero. |
| Status | Enumeration | SUCCESS, TRANSACTION\_ OVERFLOW, TRANSACTION\_ EXPIRED, CHANNEL\_ACCESS\_ FAILURE, INVALID\_ADDRESS,  NO\_ACK,  COUNTER\_ERROR, FRAME\_TOO\_LONG,  UNAVAILABLE\_KEY, UNSUPPORTED\_ SECURITY, INVALID\_PARAMETER. TRANSACTION\_ ABORTED | The status of the last MMI data transmission. |

#### MMI-DATA.indication

The MMI-DATA.indication primitive delivers a MMI payload from a remote device. The semantics of this primitive are as follows:

(  
SrcAddrMode,   
SrcPanId,  
SrcAddr,   
DstAddrMode,   
DstPanId,   
DstAddr,   
MultiplexId,   
MmiData,   
SecurityLevel,   
KeyIdMode,   
KeySource,   
KeyIndex  
)

The primitive parameters are described in Table 1‑15.

Table 1‑15 MMI-DATA.indication parameters

| Name | Type | Valid range | Description |
| --- | --- | --- | --- |
| SrcAddrMode | Enumeration | NONE, SHORT, EXTENDED | The source addressing mode for this MMI data payload. |
| SrcPanId | Integer | 0x0000–0xffff | The PAN identifier of the entity from which MMI data is being transferred. |
| SrcAddr | — | As specified by the SrcAddrMode parameter. | The address of the transmitting (source) device. |
| DstAddrMode | Enumeration | NONE, SHORT, EXTENDED | The destination addressing mode for this MMI data payload. |
| DstPanId | Integer | 0x0000–0xffff | The PAN identifier of the entity to which the MMI data is being transferred. |
| DstAddr | — | As specified by the DstAddrMode parameter. | The address of the receiving (destination) device. |
| MultiplexId | Integer | 0x0000–0xffff | The higher-layer protocol using the MMI data service. See 7.2.3 |
| MmiData | Set of octets | — | The set of octets forming the MPX data payload. |
| SecurityLevel | Integer | 0–7 | See Table 2. |
| KeyIdMode | Integer | 0x00–0x03 | See Table 2. |
| KeySource | Set of octets | As specified by the KeyIdMode parameter. | See Table 2. |
| KeyIndex | Integer | 0x01–0xff | See Table 2. |

### MMI-MGMT primitives

The MMI-MGMT primitive takes an MMI management payload from the protocol modules, packages it into a ULI IE or MPX IE as shown in Figure ?, delivers it to the MLME-SAP, and then using the MLME-IE-NOTIFY primitive it is sent via either Command or the Enhanced Ack frames to the remote device. At the remote device, the ULI IE or MPX IE is delivered to the MLME-SAP, where the MMI management service delivers the management payload to the identified ULI protocol module.

### MMI-CONFIG primitives

The MMI-CONFIG primitive delivers an MMI configuration payload from the MPM to the MLME-SAP or other protocol modules. The configuration payload is formatted as per the appropriate IEEE 802.15.4 primitive accessed through the MLME-SAP.

### MMI-PURGE primitives

The MMI-PURGE primitives provide a means to remove or abort pending transfers from the MMI transaction queue of the originator.

#### MMI-PURGE.request

The MMI-PURGE.request primitive allows the next higher layer to purge an MMI payload from the transaction queue.

The semantics of the MMI-PURGE.request are as follows:

(  
MmiHandle,  
SendAbort  
)

The primitive parameters are described in Table 1‑16.

Table 1‑16 MMI-PURGE.request parameters

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| MmiHandle | Integer | 0x00–0xff | An identifier that can be used to refer to a particular primitive transaction; used to match a MMI-PURGE.request primitive with the corresponding MMI-DATA.confirm primitive. |
| SendAbort | Boolean | TRUE, FALSE | If this parameter is TRUE and the transaction is still active, the MMI data service sends a MPX IE with an abort code to the other end indicating that the transaction was aborted. If this parameter is FALSE, the transaction is just purged locally, and no information is sent to the other end. |

On receipt of the MMI-PURGE.request primitive, the MMI data service attempts to find in the transaction queue the payload indicated by the MmiHandle parameter. If a MMI payload has left the transaction queue, the handle will not be found, and the MMI payload can no longer be purged. If a MMI payload matching the given handle is found, the payload is discarded from the transaction queue, and optionally an abort message is sent to the other end, if the SendAbort parameter is TRUE. If an abort message is sent to the other end that will allow the other end to clear out its state immediately without waiting for the timeout.

The MMI-PURGE.request will also issue a corresponding MCPS-PURGE.request to the MAC data service, provided it has an MCPS-DATA.request in process when the MMI-PURGE.request is called.

#### MMI-PURGE.confirm

The MMI-PURGE.confirm primitive allows the MMI data service to notify the next higher layer of the success of its request to purge a MMI payload from the transaction queue.

The semantics of this primitive are as follows:

MMI-PURGE.confirm

(  
MmiHandle,   
Status  
)

The primitive parameters are described in Table 1‑17.

Table 1‑17 MMI-PURGE.confirm parameters

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| MmiHandle | Integer | 0x00–0xff | An identifier which can be used to refer to a particular primitive transaction; used to match a confirm primitive with the corresponding request. |
| Status | Enumeration | SUCCESS, INVALID\_HANDLE | The status of the request to purge MMI data from the transaction queue. |

### MMI Management Service Primitives

#### MMI-MGMT.request

#### MMI-MGMT.indication

#### MMI-MGMT.confirm

### MMI Operation primitives

#### MMI-OPERATION.request

#### MMI- OPERATION.indication

#### MMI- OPERATION.confirm

## Management Protocol Module

### Purpose

The MPMprovides:

* Configuration parameters to the MAC and PHY using configuration data received from a higher layer
* Configuration parameters to other protocol modules received from a higher layer or stored in the management protocol module

Note: ULI Profile IDs, used to identify the device/module configuration, may need to be assigned by the 802.15 ANA for common profiles such as ULI device discovery, etc. However, proprietary configurations will be vendor specific. See 15-17-0050 for more information on ULI Profiles.

* Network device monitoring or management. The monitoring function defines managed objects to provide device monitoring metrics to a higher layer application. The management function uses data collected from the device to optimize the device’s configuration for better spectral use.
* Discovery services to detect other ULI-capable devices.

### ULI Profile Description

* Overview

A ULI profile is a set of configuration parameters required by the 802.15.4 MAC and PHY for operation. The ULI profile mechanism uses Yang modeling.

* Use cases for ULI Profile
  + Use case 1: one-shot MAC/PHY configuration
  + Use case 2: 802.x <-> 802.y protocol translation
  + Use case 3: MAC/PHY configuration by higher layer applications

Table 1‑18 Use case 1

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| MAC Parameters |  |
| Device Type | FFD |
| PAN | Discovery |
| Operation mode | TSCH-BE |
| Channel Hopping |  |
| PHY Parameters |  |
| Modulation type | FSK |
| FCS | 4 |
| Data rate | 100kb/s |
| Transmit power | 20mW |



### Profile Operation

* Type of primitives
  + ULM-CREATE-PROFILE()
  + ULM-EXEC-PROFILE()
  + ULM-GET-PROFILE()
  + ULM-CHANGE-PROFILE()
  + ULM-DELETE-PROFILE()

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Name** | **Request** | **Indication** | **Response** | **Confirm** |
| ULM-CREATE-PROFILE | X |  | X |  |
| ULM-EXEC-PROFILE | X |  | X |  |
| ULM-GET-PROFILE | X |  | X |  |
| ULM-CHANGE-PROFILE | X |  | X |  |
| ULM-DELETE-PROFILE | X |  | X |  |

MPH-EXEC-PROFILE.request

Management

Protocols sublayer

PDE

sublayer

Next

higher layer

**ULM-EXEC-PROFILE.request**

MMI-MGMT.request

MAC PIB

Device

MAC

MLME-SRM.request

MMI

sublayer

MPH-EXEC-PROFILE.response

**ULM-EXEC-PROFILE.response**

MMI-MGMT.response

MLME-SRM.response

IEEE802.15.12

MLME-SET.request

MLME-SET.response

IEEE802.15.4

### ULI Protocol Module Discovery and Configuration Primitives

* Type of operations
  + ULM-LIST-MODULES(): retrieve supported protocol module(s)
  + ULM-GET-MODULE-STATUS(): get the status of the protocol module
  + ULM-SET-MODULE-STATUS(): set the status of the protocol module

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Name** | **Request** | **Indication** | **Response** | **Confirm** |
| ULM-LIST-MODULES | X |  | X |  |
| ULM-GET-MODULE-STATUS | X |  | X |  |
| ULM-SET-MODULE-STATUS | X |  | X |  |

### Usage of ULM-LIST-MODULES()

The entire list of module attributes are collected in a YANG store called “MODULE-DESCRIPTOR"

“ULM-LIST-MODULES” ULI() is an enumeration function:

**handle = ULM-LIST-MODULES( NULL, module\_descriptor\_result)**

the first module descriptor returned is in “module\_descriptor\_result”

the first module returned is always the “Management Module”

Then the caller makes additional calls as follows:

**handle = ULM-LIST-MODULES(handle, module\_descriptor\_result)**

Each time returning a module descriptor in “module\_descriptor\_result”

The caller can know it reached the end of the module list when “handle” returns NULL

Management Protocol

KMP

L2R

Ranging

NULL

## PTM Description

### Overview

The PTM provides:

* A conduit between the MMI and the PDE
* Allows applications/functions above the ULI to transparently access the 802.15.4 device
* Allows data from MCPS-SAP to be sent directly to those applications/functions above the ULI not using other protocol modules
* Allows legacy applications/functions (non-ULI capable) to be compatible with ULI devices
* Responds to primitives (i.e. MCPS.DATA.confirm and MCPS.DATA.indication) delivered via the data SAP, such as passing the MPDU to a higher layer function

### Design of (*and questions about*) the PTM

The interfaces of the PTM are shown in Figure 1‑2 as PTH-SAP and PTM-SAP.

*From one point of view, there should be very little specification required for such a module, since it does not seem to impose any process requirements on the data that it passes through to the next lower layer (for transmission) or next higher layer (for reception). Nevertheless, there are several possibilities that sense. Do we provide for all of them? If only one, how do we choose?*

For data to be transmitted, the PTM allows a higher layer to supply all 28 parameters for presentation of the payload (via PTM-SAP) to the MCPS-SAP. In order to reduce the number of parameters required by the PTM, it will also be allowed for a higher layer protocol to pass a profile identifier as one of the parameters. Then, most of the parameters would be implicitly available to the PTM by referring to the definition and current configuration state for that profile within the ULI layer.

Upon reception of a well-formed 802.15.4 frame, the PTM should be able to dispatch the frame by inspection of the frame fields following the MHR. But this is what the ULI must anyway do upon frame reception, so that it is not clear whether the PTM actually has any responsibility for handling incoming frames.

*Does the PTM bypass L2R routing operations? If so, then transmission could occur only to immediate neighbors. Similarly, if ranging is required prior to transmission, how does PTM know to make the request?*

*If profiles are not enabled for use with the PTM function, how does the function identify the proper MAC interface? Are the appropriate MAC and PHY layers associated with the source MAC address of the frame? Or, with the destination MAC address?*

*If profiles are enabled for use, then a table of profiles will be required, along with the MCPS-SAP interface parameters that each profile allows the PTM to infer from the profile definition. In this way, most of the PTM specification text actually would reside as part of the profile definitions. Each new profile will need a section within its specification for use by the generic PTM.*

*Some parameters aren’t simple data types, and can have substructure and refer to objects with nontrivial structure. We will need NULL (not present) parameters.*