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INTERNATIONAL STANDARD

Information technology – Wireless beacon-enabled energy efficient mesh network (WiBEEM) standard for wireless home network services – Part 2: MAC layer

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CONTENTS

FOREWORD 5
INTRODUCTION 6
1 Scope 7
2 Normative reference 7
3 Terms, definitions and abbreviations 7
3.1 Terms and definitions 7
3.2 Abbreviations 8
3.3 Conventions 9
4 Conformance 10
5 Overview of the WiBEEM technology 10
6 MAC layer specifications 10
6.1 General 10
6.2 MAC layer service specifications 10
6.2.1 Service overview 10
6.2.2 MAC data service 11
6.2.3 MAC management service 17
6.2.4 Association primitives 17
6.2.5 Disassociation primitives 22
6.2.6 Beacon notification primitive 24
6.2.7 Primitives for reading PIB attributes 27
6.2.8 RAP management primitives 28
6.2.9 Primitives for orphan notification 31
6.2.10 Primitives for resetting the MAC layer 34
6.2.11 Primitives for specifying the receiver enable time 35
6.2.12 Primitives for channel scanning 37
6.2.13 Communication status primitive 39
6.2.14 Primitives for writing MAC PIB attributes 41
6.2.15 Primitives for updating the superframe configuration 42
6.2.16 Primitives for synchronising with a WRC 45
6.2.17 Primitives for requesting data from a WRC 47
6.3 MAC frame formats 49
6.3.1 General 49
6.3.2 General MAC frame format 50
6.3.3 Beacon frame format 52
6.3.4 MAC command frame format 52
Bibliography 62

Figure 1 – MAC layer structure 11
Figure 2 – Message sequence chart describing the MAC data service 16
Figure 3 – Message sequence chart for association 22
Figure 4 – Message sequence chart for disassociation 24
Figure 5 – Message sequence chart for RAP allocation initiated by a device 31
Figure 6 – Message sequence chart for RAP deallocation initiated by a device and the WMC 31

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Figure 7 – Beacon lost (orphan notification) message sequence chart 33
Figure 8 – Message sequence chart for updating the superframe configuration 45
Figure 9 – Message sequence chart for synchronising to a WRC in a beacon-enabled WPAN 47
Figure 10 – Message sequence chart for requesting data from the WRC 49
Figure 11 – General MAC frame format 50
Figure 12 – Beacon frame format 52

Table 1 – MLDE-DATA.request parameters 12
Table 2 – MLDE-DATA.confirm parameters 13
Table 3 – MLDE-DATA.indication parameters 14
Table 4 – MLDE-ERASE.request parameters 15
Table 5 – MLDE-ERASE.confirm parameters 16
Table 6 – Summary of the primitives accessed through the MLME-SAP 17
Table 7 – MLME-ASSOCIATE.request parameters 18
Table 8 – MLME-ASSOCIATE.indication parameters 19
Table 9 – MLME-ASSOCIATE.response parameters 20
Table 10 – MLME-ASSOCIATE.confirm parameters 21
Table 11 – MLME-DISASSOCIATE.request parameters 22
Table 12 – MLME-DISASSOCIATE.indication parameters 23
Table 13 – MLME-DISASSOCIATE.confirm parameters 24
Table 14 – MLME-BEACON-NOTIFY.indication parameters 25
Table 15 – Elements of mesh descriptor 26
Table 16 – MLME-READ-MIB.request parameters 27
Table 17 – MLME-READ-MIB.confirm parameters 28
Table 18 – MLME- RAP-MANAGEMENT.request parameters 29
Table 19 – MLME-RAP-MANAGEMENT.confirm parameters 29
Table 20 – MLME-RAP-MANAGEMENT.indication parameters 30
Table 21 – MLME-BEACON-LOST.indication parameters 32
Table 22 – MLME-BEACON-LOST.indication parameters 33
Table 23 – MLME-RESET.request parameters 34
Table 24 – MLME-RESET.confirm parameters 35
Table 25 – MLME-RX-ON.request parameters 35
Table 26 – MLME-RX-ON.confirm parameters 36
Table 27 – MLME-SCAN.request parameters 37
Table 28 – MLME-SCAN.confirm parameters 39
Table 29 – MLME-COMM-RESULT.indication parameters 40
Table 30 – MLME-WRITE-MIB.request parameters 41
Table 31 – MLME-WRITE-MIB.confirm parameters 42
Table 32 – MLME-START.request parameters 43
Table 33 – MLME-START.confirm parameters 44
Table 34 – MLME-SYNC.request parameters 45
Table 35 – MLME-SYNC-LOSS.indication parameters 46

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ISO/IEC 29145-2:2014
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Table 36 – MLME-INDIRECT-COMM.request parameters 48
Table 37 – MLME-INDIRECT-COMM.confirm parameters 48
Table 38 – MAC command frame 53
Table 39 – Association request command 53
Table 41 – Association response command 54
Table 42 – Association status field 55
Table 43 – Disassociation notification command format 55
Table 44 – Disassociation reason code 56
Table 45 – Data request command format 57
Table 46 – Mesh ID conflict notification command format 57
Table 47 – Orphan notification command format 58
Table 48 – Beacon request command format 58
Table 49 – Co-ordinator realignment command format 59
Table 50 – CFP request command format 60
Table 51 – CFP characteristics field format 60
Table 52 – Rate reconfiguration request format 60
Table 53 – Data rate 61
Table 54 – Rate reconfiguration request command format 61

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INFORMATION TECHNOLOGY – WIRELESS BEACON-ENABLED ENERGY EFFICIENT MESH NETWORK (WIBEEM) STANDARD FOR WIRELESS HOME NETWORK SERVICES –

Part 2: MAC layer

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International Standard ISO/IEC 29145-2 was prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

The list of all currently available parts of the ISO/IEC 29145 series, under the general title *Information technology – Wireless beacon-enabled energy efficient mesh network (WiBEEM) for wireless home network services*, can be found on the IEC web site.

This International Standard has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

INTRODUCTION

This International Standard specifies the WiBEEM (Wireless Beacon-enabled Energy Efficient Mesh network) protocol, which provides low-power-consuming mesh network functions by enabling the “beacon mode operation”. WiBEEM is based on IEEE 802.15.4 standard with additional upper layer protocols and a specific usage of the MAC layer protocol. Through the novel use of beacons, WiBEEM technology achieves longer battery life, larger network support, quicker response, enhanced mobility and dynamic reconfiguration of the network topology compared with other protocols such as ZigBee.

In the beacon mode, Beacon information propagates over the entire mesh network nodes during the BOP (Beacon-Only Period) of the superframe structure without any beacon conflicts by utilising a smart beacon scheduling technique in the BOP. It also provides location information about moving devices without spending extra time running a positioning and locating algorithm by using RSSI (Received Signal Strength Indication). These features allow the WiBEEM protocol to be widely used for wireless home network services in the ubiquitous network era.

One of the key features of the WiBEEM protocol is that it has a special time interval called BOP (Beacon-Only Period) in the superframe structure that allows more than two beacons to be transmitted. This unique time period is located at the beginning of the Superframe. Because the BOP does not use the CSMA/CA mechanism, the network will not work properly in the beacon mode unless an appropriate algorithm is applied. This algorithm needs to manage and control multiple beacons in a single superframe. The solution is the Beacon Scheduling method applied in the BOP to avoid collisions among beacons, providing synchronisation among all the nodes of the entire mesh network.

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For the network layer, the NAA (Next Address Available) mechanism, which is a short address allocation algorithm, has been adopted to provide an efficient way of utilising the complete 16-bit address space. The NAA algorithm does not limit the maximum number of children nodes that a node of a mesh network can have. Since the number of children nodes is unlimited, the NAA mechanism allows the WiBEEM protocol to be used not only for home network services, but also for community services. WiBEEM can be used where high network expandability through efficient use of short address spaces, device mobility and end-to-end QoS are required.

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This part of the standard ISO/IEC 29145 specifies the Medium Access Control (MAC) layer of the WiBEEM protocol.

INFORMATION TECHNOLOGY – WIRELESS BEACON-ENABLED ENERGY EFFICIENT MESH NETWORK (WIBEEM) STANDARD FOR WIRELESS HOME NETWORK SERVICES –

Part 2: MAC layer

1 Scope

This part of ISO/IEC 29145 specifies the MAC of the WiBEEM (Wireless Beacon-enabled Energy Efficient Mesh network) protocol for wireless home network services that supports a low power-consuming wireless mesh network as well as device mobility and QoS.

2 Normative reference

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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ISO/IEC 29145-1:2014, *Information technology – Wireless beacon-enabled energy efficient mesh network (WiBEEM) for wireless home network services – Part 1: PHY layer*

IEEE 802.15.4:2003, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (LR-WPANs)*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 29145-1, as well as the following apply.

3.1.1
association
service used to establish the membership of a device in a wireless mesh network

3.1.2
co-ordinator
wireless device configured to provide synchronisation services through the transmission of beacons

Note 1 to entry: If a co-ordinator is the principal controller of a wireless mesh network, it is called the WMC (WiBEEM Mesh Co-ordinator).

3.1.3
device
entity containing an implementation of the WiBEEM applications, NWK, MAC and physical interface to the wireless medium

3.1.4
disassociation
service that removes an existing association

3.1.5
frame
data format of aggregated bits from a medium access control (MAC) layer entity transmitted in a specified sequence

3.1.6
logical channel
abstract representation of a communications link independent of the physical implementation

Note 1 to entry: Defines "logical channel" as it is used this International Standard.

3.1.7
mobile device
device that uses network communications while in motion

3.1.8
orphaned device
device that has lost its parent node with its associated mesh network

3.1.9
packet
format of aggregated bits transmitted in a specified sequence across the physical medium

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3.1.10
payload data
contents of a data message that is being transmitted

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3.1.11
personal operating space
space of typically about 10 m around a person or an object, no matter whether this person or object is stationary or in motion

3.1.12
protocol data unit
unit of data exchanged between two peer entities

3.1.13
service data unit
information delivered as a unit through a service access point (SAP)

3.2 Abbreviations

The following acronyms and abbreviations are used in this standard. They are commonly used in other industry publications.

BI	Beacon Interval
BN	Beacon Number
BO	Beacon Order
BOP	Beacon Only Period
BSN	Beacon Sequence Number
BTTSL	Beacon Transmit Time Slot Length
CAP	Contention Access Period

CFP	Contention-Free Period
CRC	Cyclic Redundancy Check
CSMA-CA	Carrier Sense Multiple Access With Collision Avoidance
DSN	Data Sequence Number
ED	Energy Detection
ID	Identifier
IFS	Interframe Space or Spacing
LIFS	Long Interframe Spacing
LQ	Link Quality
LQI	Link Quality Indication
LR-WPAN	Low-Rate Wireless Personal Area Network
MAC	Medium Access Control
MFR	MAC Footer
MHR	MAC Header
MIB	MAC Information Base
MLME	MAC Layer Management Entity
MLME-SAP	MAC Layer Management Entity-Service Access Point
MPDU	MAC Protocol Data Unit
MSDU	MAC Service Data Unit
NAA	Next Address Available
PDU	Protocol Data Unit
PHY	Physical Layer
PIB	PAN Information Base
PLME	Physical Layer Management Entity
PLME-SAP	Physical Layer Management Entity-Service Access Point
POS	Personal Operating Space
PQP	Prioritised QoS Period
QoS	Quality of Service
RAP	Reservation-based Access Period
RSSI	Received Signal Strength Indication
RX	Receive or Receiver
SAP	Service Access Point
SD	Superframe Duration
SDL	Specification and Description Language
SDU	Service Data Unit
SO	Superframe Order
WED	WiBEEM End Device
WiBEEM	Wireless Beacon-enabled Energy Efficient Mesh network
WMC	WiBEEM Mesh Co-ordinator
WRC	WiBEEM Routable Co-ordinator

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3.3 Conventions

All the italicized words used in this standard represent relevant constants defined and stored in the MIB (Management Information Base) of each layer.

4 Conformance

A wireless device that claims conformance to this standard shall implement all the primitives that are specified in 6.2 and the MAC frame formats in 6.3. Each WiBEEM device shall be able to act as a WMC, a WRC and a WED. When operating in the role of a WMC it shall act as specified in 5.3.2 of ISO/IEC 29145-1:2014, when operating in the role of a WRC, it shall act as specified in 5.3.3 of ISO/IEC 29145-1:2014, and when operating in the role of a WED, it shall act as specified in 5.3.3 of ISO/IEC 29145-1:2014.

5 Overview of the WiBEEM technology

Clause 5 of ISO/IEC 29145-1:2014 presents an overview of the WiBEEM technology and the functionalities of the WiBEEM devices.

6 MAC layer specifications

6.1 General

This clause specifies the MAC layer of this standard. The MAC layer handles all access to the physical radio channel and is responsible for the following tasks:

– generating network beacons if the device is a co-ordinator;
– synchronising to network beacons;
– supporting the mesh network association and disassociation;
– supporting device security;
– employing the CSMA/CA mechanism for channel access;
– handling and maintaining the RAP mechanism;
– providing a reliable link between two peer MAC entities;
– providing multi-rate operation between PLME and MLME.

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Constants and attributes that are specified and maintained by the MAC layer are written in the text of this clause in italics. Constants have a general prefix of “a”. Attributes have a general prefix of “mac”.

6.2 MAC layer service specifications

6.2.1 Service overview

The MAC layer services provide an interface between the MAC layer and the PHY layer. The MAC layer conceptually includes a management entity called MLME. This entity shall provide the service interfaces through which layer management functions may be invoked. MLME is also responsible for maintaining a database of managed objects pertaining to the MAC layer. This database is referred to as the MIB representing the MAC layer information base. The MAC layer provides two services, accessed through two SAPs:

– MAC data service, accessed through the MAC layer data SAP (MLDE-SAP), and
– MAC management service, accessed through the MLME-SAP.

These two services provide the interface between the MAC and the PHY layers, via the PLDE-SAP and PLME-SAP interfaces shown in Figure 1. In addition to these external interfaces, an implicit interface also exists between the two layers.

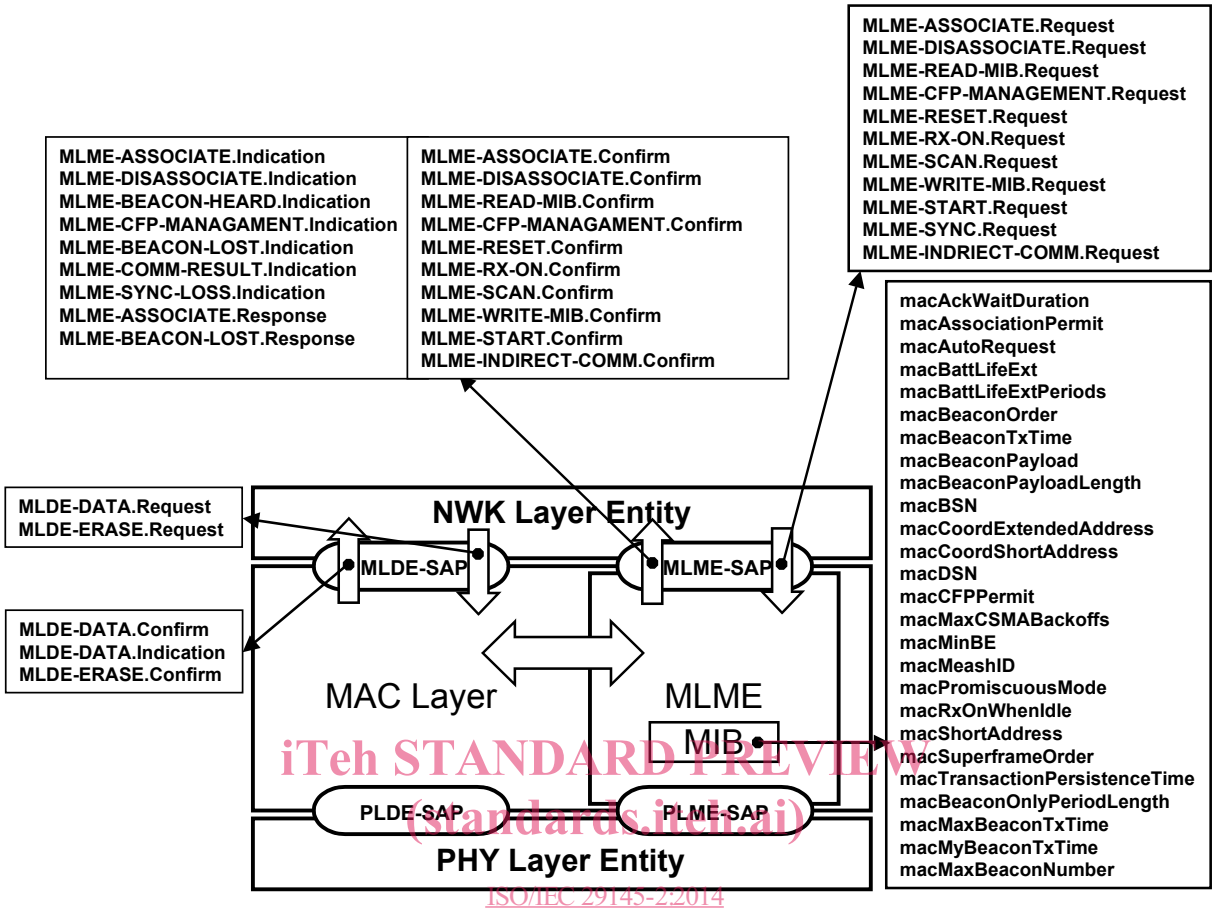

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Figure 1 – MAC layer structure

6.2.2 MAC data service

6.2.2.1 Overview

The MLDE-SAP supports the transport of MAC protocol data units (MPDUs) between peer MAC entities.

6.2.2.2 MLDE-DATA.request

6.2.2.2.1 Function

The MLDE-DATA.request primitive requests the transfer of a data MSDU from a local MAC entity to a single peer MAC entity.

6.2.2.2.2 Semantics of the service primitive

The semantics of the MCPS-DATA.request primitive are as follows:

```
MLDE-DATA.request (
                    SrcAddrMode,
                    SrcMeshId,
                    SrcAddr,
                    DstAddrMode,
                    DstMeshId,
                    DstAddr,
                    msduLength,
                    msdu,
                    msduHandle,
```

TxOptions

)

Table 1 specifies the parameters for the MLDE-DATA.request primitive.

Table 1 – MLDE-DATA.request parameters

Name	Type	Valid range	Description
SrcAddrMode	Integer	0x00 to 0x03	The source addressing mode for this primitive and subsequent MPDU. This value can take one of the following values: 0x00 = no address (addressing fields omitted, see 6.3.2). 0x01 = reserved. 0x02 = 16-bit short address. 0x03 = 64-bit extended address.
SrcMeshId	Integer	0x0000 to 0xffff	The 16-bit Mesh identifier of the entity to which the MSDU is being transferred.
SrcAddre	Device address	As specified by theSrcAddrMode parameter	The individual device address of the entity to which the MSDU is being transferred.
DstAddrMode	Integer	0x00 to 0x03	The destination addressing mode for this primitive and subsequent MPDU. This value can take one of the following values: 0x00 = no address (addressing fields omitted, see 6.3.2). 0x01 = reserved. 0x02 = 16-bit short address. 0x03 = 64-bit extended address.
DstMeshId	Integer	0x0000 to 0xffff	The 16-bit mesh network identifier of the entity to which the MSDU is being transferred.
DstAddr	Device address	As specified by the DstAddrMode parameter	The individual device address of the entity to which the MSDU is being transferred.
msduLength	integer	≤ aMaxMAC-FrameSize	The number of octets contained in the MSDU to be transmitted by the MAC layer entity.
msdu	Set of octets	–	The set of octets forming the MSDU to be transmitted by the MAC layer entity.
msduHandle	integer	0x00 to 0xff	The handle associated with the MSDU to be transmitted by the MAC layer entity.
TxOptions	Bitmap	3-bit field	The 3 bits (b_0, b_1, b_2) indicate the transmission options for this MSDU. 0x01 = acknowledged transmission 0x02 = RAP transmission 0x04 = Indirect transmission 0x08 = security enabled transmission

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6.2.2.2.3 Appropriate usage

The MLDE-DATA.request primitive is generated by a local MAC entity when an MSDU is to be transferred to a peer MAC entity.

6.2.2.2.4 Effect on receipt

On receipt of the MLDE-DATA.request primitive, the MAC layer entity begins the transmission of the supplied MSDU.

6.2.2.3 MLDE-DATA.confirm

6.2.2.3.1 Function

The MLDE-DATA.confirm primitive reports the results of a request to transfer a data MSDU from a local MAC entity to a single peer MAC entity.

6.2.2.3.2 Semantics of the service primitive

The semantics of the MLDE-DATA.confirm primitive are as follows:

```
MLDE-DATA.confirm       (
                          msduHandle,
                          Status
                          )
```

Table 2 specifies the parameters for the MLDE-DATA.confirm primitive.

Table 2 – MLDE-DATA.confirm parameters

Name	Type	Valid range	Description
MsduHandle	Integer	0x00 to 0xff	The handle associated with the MSDU being confirmed.
Status	Enumeration	SUCCESS, TRANSACTION_OVERFLOW, TRANSACTION_EXPIRED, CHANNEL_ACCESS_FAILURE, INVALID_RAP, NO_ACK, UNAVAILABLE_KEY, FRAME_TOO_LONG, FAILED_SECURITY_CHECK, or INVALID_PARAMETER	The status of the last MSDU transmission.

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6.2.2.3.3 When generated

The MLDE-DATA.confirm primitive is generated by the MAC layer entity in response to an MLDE-DATA.request primitive. The MLDE-DATA.confirm primitive returns a status of either SUCCESS, indicating that the request to transmit was successful, or the appropriate error code including TRANSACTION_ OVERFLOW, TRANSACTION_EXPIRED, CHANNEL_ACCESS_FAILURE, INVALID_RAP, NO_ACK, UNAVAILABLE_KEY, FRAME_TOO_LONG, FAILED_SECURITY_CHECK, or INVALID_PARAMETER.

6.2.2.3.4 Appropriate usage

On receipt of the MLDE-DATA.confirm primitive, the MAC of the initiating device is notified of the result of its request to transmit. If the transmission attempt was successful, the status parameter will be set to SUCCESS. Otherwise, the status parameter will indicate the error.

6.2.2.4 MLDE-DATA.indication

6.2.2.4.1 Function

The MLDE-DATA.indication primitive indicates the transfer of an MSDU from the MAC layer to the local MAC entity.