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IEEE Standard for

Local and metropolitan area networks—

Media Access Control (MAC) Service Definition

IEEE Computer Society

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IEEE Standard for
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Abstract: The MAC service provided by all IEEE 802® MACs along with the Internal Sublayer Service (ISS) that is provided by IEEE 802 MACs to the relay function of a Media Access Control (MAC) Bridge are defined in this standard.
Keywords: IEEE 802, IEEE 802.1AC, Internal Sublayer Service, ISS, local area networks, MAC Service, metropolitan area networks

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Introduction

This introduction is not part of IEEE Std 802.1AC-2012, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

During the history of IEEE 802, several different MAC types have been developed, all of which have a core of functionality that is common to IEEE 802 MACs in general, but all of which also provide functionality that extends beyond that common core. An example can be found in the way priority information is conveyed in different MACs; some have no means of conveying priority, some can convey two different priority code points, some can convey eight priority code points.

While such differences are not an issue in a Local Area Network (LAN) that employs a single MAC technology, they can become an issue in LANs where more than one MAC technology is employed, for example in Bridged LANs. It was therefore important at an early stage of MAC Bridge development to develop a clear definition of the MAC service that would facilitate the definition of a common Bridging technology that could apply to all MAC types.

The MAC service definition was first standardized as ISO/IEC 15802-1:1995 [B8]; when the ISO/IEC standard reached its 5-year revision point, IEEE 802 was asked to take over the document and revise it to reflect changes since publication.[a] This revision emphasizes the fundamental relayable nature of the MAC service provided to end stations by defining it in terms of the service, common to bridges and end stations, previously documented as the Internal Sublayer Service (ISS) in IEEE Std 802.1D™.[b] In addition to the material that was contained in ISO/IEC 15802-1, this standard documents the ISS that was originally defined in IEEE Std 802.1D.

This standard contains state-of-the-art material. The area covered by this standard is undergoing evolution. Revisions are anticipated within the next few years to clarify existing material, to correct possible errors, and to incorporate new related material. Information on the current revision state of this and other IEEE 802 standards may be obtained from

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[a]The numbers in brackets correspond to those of the bibliography in Annex A.
[b]Information on references can be found in Clause 2.

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IEEE Standard for
Local and metropolitan area networks—

Media Access Control (MAC) Service Definition

1. Scope

The scope of this standard is to define the Media Access Control (MAC) Service provided by all IEEE 802® MACs, and the Internal Sublayer Service (ISS) provided within MAC Bridges, in abstract terms of the following:

a) Their semantics, primitive actions, and events; and

b) The parameters of, interrelationship between, and valid sequences of these actions and events.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in the text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 802®, IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture.[1, 2]

IEEE Std 802.1D™, IEEE Standard for Local and Metropolitan Area Networks—Media Access Control (MAC) Bridges.

IEEE Std 802.1Q™, IEEE Standard for Local and Metropolitan Area Networks—Media Access Control (MAC) and Virtual Bridged Local Area Networks.

ISO/IEC 7498-1, Information technology—Open Systems Interconnection—Basic Reference Model: The Basic Model.[3]

ISO/IEC 7498-3, Information technology—Open Systems Interconnection—Basic Reference Model: Naming and addressing.

ISO/IEC 10731, Information technology—Open Systems Interconnection—Basic Reference Model—Conventions for the definition of OSI services.

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3. Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.[4]

3.1 Basic reference model definitions

Although the MAC Service is not identified or defined in the Open Systems Interconnection (OSI) Basic Reference Model, this standard is based on the concepts developed in the Basic Reference Model and makes use of the following terms defined in ISO/IEC 7498-1 and ISO/IEC 7498-3, as they might apply to the MAC Sublayer:[5]

a) Entity

b) Sublayer

c) Service

d) Service access point (SAP)

e) Service data unit (SDU)

f) Subnetwork address

3.2 Service conventions definitions

Although the MAC Service is not identified or defined in the OSI Basic Reference Model, this standard makes use of the following terms defined in ISO/IEC 10731, as they might apply to the MAC Sublayer:

a) Service user

b) Service provider

c) Primitive

d) Request

e) Indication

[4] *IEEE Standards Dictionary Online* subscription is available at: http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html.

[5] Information on references can be found in Clause 2.

4. Acronyms and abbreviations

For the purposes of this standard, the following acronyms and abbreviations apply:

ISS	Internal Sublayer Service
LAN	Local Area Network
LLC	Logical Link Control
MAC	Media Access Control
MSAP	Media Access Control Service access point
MSDU	Media Access Control Service data unit
OSI	Open Systems Interconnection
QoS	Quality of Service
SAP	service access point
SDU	service data unit

5. Conformance

This standard does not specify individual implementation or products, nor does it constrain the implementation of MAC entities and interfaces within an information processing system.

There is no conformance of equipment to this standard. Instead, conformance is achieved through implementation of conforming MAC Protocols that fulfil the ISS and MAC Service defined in this standard.

6. Conventions

6.1 General considerations

This standard uses the descriptive conventions given in ISO/IEC 10731.

The service model, service primitives, and time-sequence diagrams used are entirely abstract descriptions; they do not represent a specification for implementation.

6.2 Parameters

Service primitives, used to represent service user/service provider interactions (ISO/IEC 10731), convey parameters that indicate information available in the user/provider interaction, and have a global significance.

7. Basic architectural concepts and terms

The architectural concepts used in this and other IEEE 802.1™ standards are based on the layered protocol model introduced by the OSI Reference Model (ISO/IEC 7498-1) and used in the MAC Service Definition (this standard), in IEEE Std 802, in other IEEE 802 standards, and elsewhere in networking. IEEE 802.1 standards in particular have developed terms and distinctions useful in describing the MAC Service and its support by protocol entities within the MAC Sublayer.[6]

7.1 Protocol entities, peers, layers, services, and clients

The fundamental notion of the model is that each protocol entity within a system is instantiated at one of a number of strictly ordered layers, and communicates with peer entities (operating the same or an interoperable protocol within the same layer) in other systems by using the service provided by interoperable protocol entities within the layer immediately below, and thus provides service to protocol entities in the layer above. The implied repetitive stacking of protocol entities is essentially unbounded at the lowest level and is bounded at the highest level by an application supported by peer systems. In descriptions of the model, the relative layer positions of protocol entities and services are conventionally referred to by N, designating a numeric level. The N-service is provided by an N-entity that uses the (N – 1) service provided by the (N – 1) entity, while the N-service user is an (N + 1) entity. Figure 7-1 illustrates these concepts with reference to the MAC Sublayer, which contains MAC entities that provide the MAC Service, to MAC Service users.

7.2 Service interface primitives, parameters, and frames

Each N-service is described in terms of service primitives and their parameters, each primitive corresponding to an atomic interaction between the N-service user and the N-service provider, with each invocation of a primitive by a service user resulting in the service issuing corresponding primitives to peer service users. The purpose of the model is to provide a framework and requirements for the design of protocols while not unnecessarily constraining the internal design of systems; primitives and their parameters are limited to (but include all of) the information elements conveyed to corresponding peer protocol entities or required by other systems (and not supplied by protocols in lower layers) to identify (address) those entities and deliver the information. The parameters of service primitives do not include information that is used only locally, i.e., within the same system, to identify entities or organize resources for example.[7]

The primitives of the MAC Service comprise a data request and a corresponding data indication, each with MAC destination address, MAC source address, a MAC Service Data Unit (MSDU) comprising one or more octets of data, and priority parameters. Taken together these parameters are conveniently referred to as a *frame,* although this does not imply that they are physically encoded by a continuous signal on a communication medium, that no other fields are added or inserted by other protocol entities prior to transmission, or that the priority is always encoded with the other parameters transmitted.

[6]Drawing on prior network layer standards, including ISO/IEC 7498-1, wherever possible.

[7]These points are frequently misunderstood by those unfamiliar with the reference model, who take it as simply restating common sense principles of modular engineering. Early variants of the MAC Service, for example, omitted the source MAC address parameter on the grounds that it was a fixed property of the transmitting station and should be supplied by the MAC entity itself, despite the fact that communicating peer service users (and the protocols they operate) required that information. The introduction of MAC Bridges necessitated the development of a MAC ISS with the required parameter and has led to a restatement of the service definition included in a number of standards. However the source address parameter would still have been required even if MAC Bridges did not exist. Similarly, versions of the MAC Service have included local acknowledgment primitives or status return codes for primitives issued. These play no part in defining the peer-to-peer communication and do not conform to the reference model. The scope of some IEEE 802 standards does include the definition of interfaces, particularly electrical interfaces, within systems. These play a valuable role in defining components used to build those systems, but should not be confused with OSI service interfaces.

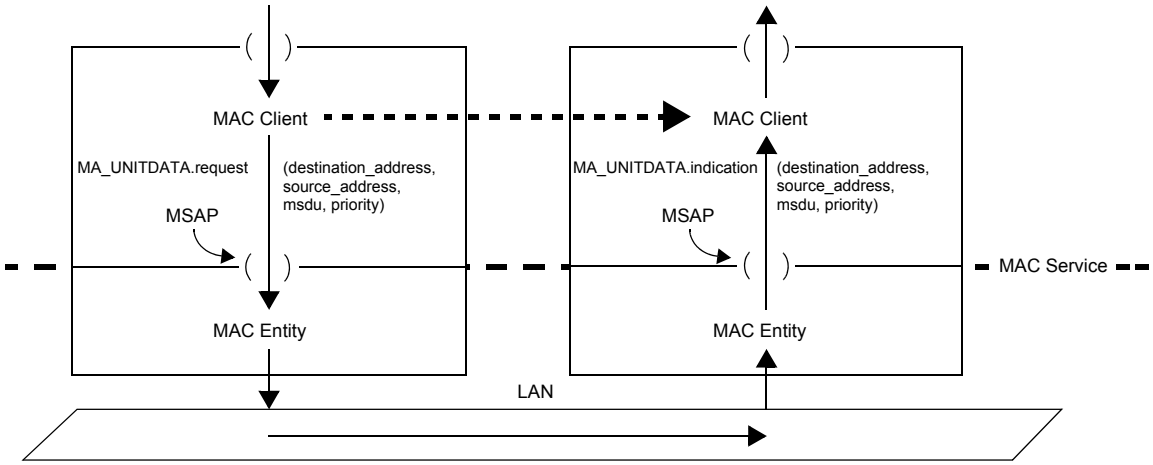

Figure 7-1—MAC entities, the MAC Service, and MAC Service users (clients)

7.3 Layer management interfaces

A given N-entity can have many associated management controls, counters, and status parameters that are not communicated to its user's peers and whose values are either not determined by its user or not required to change synchronously with the occurrence of individual N-service primitives to ensure successful (N + 1)-protocol operation. Communication of the values of these parameters to and from local entities, i.e., within the same system, is modeled as occurring not through service primitives[8] but through a layer management interface. One protocol entity, for example a simple network management protocol (SNMP) entity, can be used to establish the operational parameters of another. Communication of the results of Fault Alarms to entities responsible for managing the network is one of the uses of layer management interfaces.

7.4 Service access points, interface stacks, and ports

Each service is provided to a single protocol entity at a service access point (SAP) within a system. A given N-entity can support a number of N-SAPs and use one or more (N – 1)-SAPs. The SAP serves to delineate the boundary between protocol specifications and to specify the externally observable relationship between entities operating those protocols. A SAP is an abstraction and does not necessarily correspond to any concrete realization within a system, but an N-entity often associates management counters with the SAP and provides status parameters that can be used by the (N + 1)-entity using the SAP. Examples include the MAC_Operational and operPointToPointMAC status parameters (6.6.2, 6.6.3 in IEEE Std 802.1Q-2011). Each SAP has an identifier with a value that is local to the system and uniquely identifies the SAP within the system.

The network and link layers[9] of the reference model accommodate many different real networks, subnetworks, and links with the requirements for bandwidth, multiplexing, security, and other aspects of communication differing from network to network. A given service, e.g., the MAC Service, is often

[8]This would require considerable enlargement and continuous modification of service interfaces, obscuring their original purpose, not to mention the creation of many additional interfaces and the addition of "pass-through" functions to others.

[9]The data link layer, as originally envisaged in the OSI reference model, contained no addressing and caused some involved in its development to reject the idea of LANs at the link layer. There is a sound argument for regarding LANs as simply subnetworks within the network layer, and in practice this is how they are treated. However this would have been unpalatable to many more people at a time when correspondence between LLC (ISO/IEC 8802-2:1998 [B7]) and high-level data link control (HDLC) was sought, together with the adoption of a unique network layer protocol [ITU-T X.25 (1996)]. Continuing to regard the MAC Sublayer as part of the OSI Data Link Layer does relatively little harm (except when duplication of network layer functionality is proposed) and is convenient given the mass of historic documentation.

provided by a number of protocols, layered to achieve the desired result. Together the entities that support a particular SAP compose an interface stack. Figure 7-2 provides an example, showing the use of Link Aggregation (IEEE Std 802.1AX™-2008 [B2]).

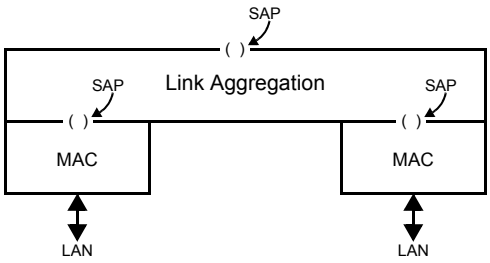

Figure 7-2—An interface stack

The term *port* is used to refer to the interface stack for a given SAP. Often the interface stack comprises a single protocol entity attached to a single Local Area Network (LAN), and port can be conveniently used to refer to several aspects of the interface stack, including the physical interface connector for example. In more complex situations—such as that in Figure 7-2, where the parts of the interface stack provided by the MAC entities effectively compose two ports that are then used by link aggregation to provide a single port to its user—the port has to be clearly specified in terms of the particular SAP supported.

7.5 MAC method independent protocols and shims

Protocols specified in IEEE Std 802.3™-2008 [B3], IEEE Std 802.11™-2012 [B4], and other IEEE 802 standards, can be specific to their LAN media or to the way access to that media is controlled. Other protocols and functions within the MAC sublayer, such as link aggregation and bridging, are MAC method independent—thus providing consistent management and interoperability across a range of media.

Definition of a service facilitates the specification of shims, i.e., protocol entities that use the same service as they provide. Protocol shims can be inserted into an interface stack to provide aggregation (e.g., IEEE Std 802.1AX [B2]), security (e.g., IEEE Std 802.1AE™-2006 [B1]), or multiplexing.

7.6 MAC Service clients

The protocol entity that uses the service provided at a MAC Service access point (MSAP) is commonly referred to as the *client* of the MAC Service or of the entity providing the service. Within a Bridge, the MAC Relay Entity is a client of the Internal Sublayer Service (ISS), and the Logical Link Control (LLC) Entity is a client of the MAC Service. The LLC Entity is specified in ISO/IEC 8802.2 and provides protocol identification, multiplexing, and demultiplexing to and from a number of clients that use a common MSAP. The clients of LLC are also often referred to as *clients of the MAC*.

NOTE—For the purposes of this standard, the terms *LLC* and *LLC Entity* include the service provided by the operation of entities that support protocol discrimination using an EtherType, i.e., protocol discrimination based on the Type interpretation of the Length/Type field as specified in IEEE Std 802a™-2003.

7.7 Stations and systems

A LAN station comprises a single media access method specific entity, operating the MAC procedures specified in the applicable IEEE 802 standard, together with other protocol entities mandated by those standards (e.g., an LLC Entity) or commonly used in conjunction with that entity.

A system is a collection of hardware and software components whose intercommunication is not directly externally observable and outside the scope of the IEEE 802 standards that specify the system behavior as a whole. Management of a system, when supported, is typically provided through a single management entity. A system (such as a bridge) can contain many media access method specific entities, of the same or a variety of types, attached to different LANs. A system can therefore be said to comprise one or more LAN stations.

7.8 Connectionless connectivity

The MAC Service supported by an IEEE 802 LAN provides connectionless connectivity, i.e., communication between attached stations occurs without explicit prior agreement between service users. The potential connectivity offered by a connectionless service composes a connectivity association that is established prior to the exchange of service primitives between service users. The way in which such a connectivity association is established depends on the particular protocols and resources that support it, and can be as simple as making a physical attachment to a wire. However simple or complex, the establishment of a connectivity association for connectionless data transfer involves only a two-party interaction between the service user and the service provider (though it can result in exchanges between service providing entities in several systems) and not a three-party user-service-user interaction as is the case for connection-oriented communication. With the continual increase in the number of ways that IEEE 802 LAN connectivity can be supported, it is no longer useful to regard a LAN as a definite set of physical equipment. Instead, a LAN is defined by the connectivity association that exists between a set of MSAPs.[10]

[10]A LAN is thus defined in terms of its external observable behavior, not by an abstraction of its internal operation.

8. Overview of the MAC Service

The MAC Service provides a connectionless-mode service for the transparent transfer of data between MAC Service users. It makes invisible to these MAC Service users the way that supporting communications resources are used to achieve this transfer.

In particular, the MAC Service provides for the following:

a) Independence of the underlying MAC Sublayer and Physical Layer—the MAC Service relieves MAC Service users from all concerns, with the exception of Quality of Service (QoS) considerations, regarding the MAC technology that is available.

b) Transparency of transferred information—the MAC Service provides for the transparent transfer of MAC Service user data. It does not restrict the content, format, or coding of the information, nor does it ever need to interpret its structure or meaning. It may however restrict the maximum number of octets of MAC Service user data that can be supplied in a user/provider interaction.

c) Priority selection — the MAC Service makes available to MAC Service users a means to request the transfer of data at a specified priority.

d) Addressing — the MAC Service provides the means for the MAC Service user to identify its MSAP and to specify the MSAP or MSAPs to which data is to be transferred. This standard uses 48-bit MAC addresses to identify the MSAP. MAC address formats and encoding are specified in IEEE Std 802.

e) Connectionless data transfer — the MAC Service provides a means by which MSDUs of limited length are delimited and transparently transmitted from one source MSAP to one or more destination MSAPs in a single MAC Service access, without establishing or later releasing a connection.

9. Model of the MAC Service

Although the MAC Service is not identified or defined in the OSI Basic Reference Model, this standard uses the abstract model for a layer service defined in ISO/IEC 10731:1994, Clause 5, as it might apply to the MAC Sublayer. The model defines the interactions between the MAC Service users and the MAC Service provider that take place at the two MSAPs. Information is passed between the MAC Service user and the MAC Service provider by service primitives that may convey parameters.

9.1 Model of a MAC connectionless-mode transmission

A defining characteristic of MAC connectionless-mode service is a preexisting connectivity association amongst a set of MSAPs.

Only one type of object, the unitdata object, can be handed over to the MAC Service provider via an MSAP. In Figure 9-1, MAC Service User A represents the MAC Service user that passes objects to the MAC Service provider. MAC Service User B represents the MAC Service user that accepts objects from the MAC Service provider.

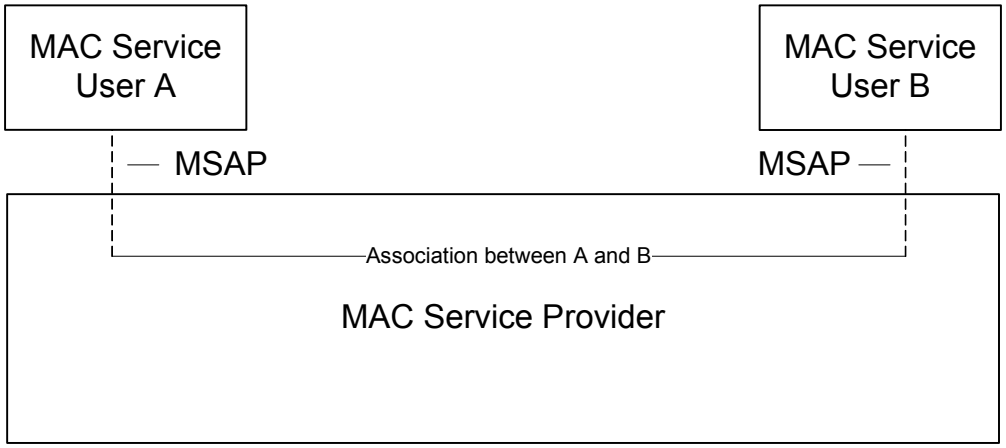

Figure 9-1—Model for a MAC Service Connectionless-mode Transmission

9.2 Service provided by the connectionless-mode MAC Service

In general, the MAC Service provider may perform any or all of the following actions:

a) Discard objects

b) Change the order of the objects

The MAC Service exhibits a negligible rate of the following:

c) Object duplication

d) Reordering of objects for a given priority

Awareness of the characteristics of the MAC Service provided, e.g., the rate at which objects may be discarded, duplicated, or misordered, is part of the MAC Service user's a priori knowledge of the environment.

10. Quality of connectionless-mode service

The term *Quality of Service* (QoS) refers to certain characteristics of a connectionless-mode transmission as observed between the MSAPs. QoS describes aspects of a connectionless-mode transmission that are solely attributable to the MAC Service provider; it can only be properly determined in the absence of MAC Service user behavior (which is beyond the control of the MAC Service provider) that specifically constrains or impedes the performance of the MAC Service.

Whether the QoS provided for each instance of the connectionless-mode transmission is the same for each MAC Service user depends on information concerning the nature of the service made available to the MAC Service user(s) by the MAC Service provider prior to the invocation of the service.

10.1 Determination of QoS for connectionless-mode service

A basic characteristic of a connectionless-mode service is that, unlike a connection-mode service, no specific association similar to that provided by a connection establishment is set up between the parties involved. Thus, characteristics of the service to be provided during the transfer are not negotiated between the MAC Service user and the MAC Service provider.

Associated with each MAC connectionless-mode transmission, certain measures of QoS are requested by the transmitting MAC Service user when the primitive action is initiated. The requested measures (or parameter values and options) are based on prior knowledge by the MAC Service user of the service(s) made available to it by the MAC Service provider. Knowledge of the characteristics and type of service provided (i.e., the parameters, formats, and options that affect the transfer of data) is made available to a MAC Service user through some layer management interaction prior to (any) invocation of the MAC connectionless-mode service. Thus, the MAC Service user not only has knowledge of the parties with which it may communicate, it also has explicit knowledge of the characteristics of the service it can expect for each invocation of the service.

10.2 Definition of connectionless-mode QoS parameters

QoS comprises the following:

a) Service availability
b) Frame loss
c) Frame misordering
d) Frame duplication
e) Frame transit delay
f) Frame lifetime
g) Undetected frame error rate
h) Maximum SDU size
i) Frame priority
j) Throughput

These parameters are discussed in detail in 6.5 in IEEE Std 802.1Q-2011.

11. Internal Sublayer Service

The Internal Sublayer Service (ISS) forms the basis of the MAC Service, providing elements necessary both to the performance of data transfer between MSAPs and the provision of MAC relay in IEEE 802.1D MAC Bridges and IEEE 802.1Q VLAN Bridges. Within an end-station, a subset of these elements provides the MAC Service specified in Clause 13. Within an IEEE 802.1Q VLAN Bridge, these elements are augmented to identify a VLAN as specified in 6.8 of IEEE Std 802.1Q-2011. The ISS excludes MAC-specific features and procedures whose operation is confined to an individual LAN.

11.1 Service primitives and parameters

The ISS is specified by two unit-data primitives, an M_UNITDATA.indication and an M_UNITDATA.request, together with the parameters of those primitives. Each M_UNITDATA indication corresponds to the receipt of an error-free MAC frame from a LAN. A data request primitive is invoked to transmit a frame to an individual LAN.

NOTE 1—Detailed specifications of error conditions in received frames are contained in the relevant MAC standards; for example, Frame Check Sequence (FCS) errors, length errors, and non-integral number of octets.

M_UNITDATA.indication (
destination_address,
source_address,
mac_service_data_unit,
priority,
drop_eligible,
frame_check_sequence,
service_access_point_identifier,
connection_identifier
)

M_UNITDATA.request (
destination_address,
source_address,
mac_service_data_unit,
priority,
drop_eligible,
frame_check_sequence,
service_access_point_identifier,
connection_identifier
)

The **destination_address** parameter is the address of an individual MSAP or a group of MSAPs. If the local MSAP is designated by the destination address parameter of an M_UNITDATA.request primitive, the indication primitive is not also invoked by the MAC entity (see Clause 7) to the MAC Service user. For example, all frames transmitted to the broadcast address invoke M_UNITDATA.indication primitives at all MSAPs in the LAN except at the MSAP that generated the request.

NOTE 2—This non-reflective behavior is a change from that previously specified in ISO/IEC 15802-1 [B8], where an indication primitive was invoked by the MAC entity to the originating MAC service user if the local MSAP was designated by the destination_address parameter. Consequently, if the former behavior is desired, it would be necessary to provide it locally. This change was made to bring the definition of the MAC service into line with the requirements of MAC bridging. In an underlying MAC whose natural behavior is for such local indications to be invoked, the MAC entity is the only point at which this reflection can be suppressed.

The **source_address** parameter is the individual address of the source MSAP.

The **mac_service_data_unit** parameter is the service user's data. This parameter allows the transmission of the MAC Service user data between MAC Service users, without modification by the MAC Service provider. The MAC Service user may transmit any integral number of octets greater than zero, up to a limit determined by the MAC Service provider. The value of this limit is made available to the MAC Service user by the use of management facilities or prior knowledge.

The default **priority** value is 0. Values 1 through 7 form an ordered sequence of user_priorities, with 1 being the lowest value, 7 the highest, and 0 falling between 1 and 2. If the MAC Service user does not explicitly state a value for the priority parameter, or requests a value not supported by the provider, the MAC Service provider uses default values. The value of the priority parameter in the two primitives are related so that

a) In the request primitive, any defined value is allowed; and

b) In the indication primitive, the priority indicated is the value requested or as modified by the MAC Service provider.

The **drop_eligible** parameter provides guidance to the recipient of the service request or of an indication corresponding to the service request, and takes the values True or False. If drop_eligible is True, the parameters of the request are discarded in preference to others with drop_eligible False that result in frames in the same queue. The default **drop_eligible** value is False.

The **frame_check_sequence** parameter is explicitly provided with the M_UNITDATA.indication so that it can be used in a related M_UNITDATA.request. The parameter comprises the Frame Check Sequence (FCS) value and sufficient information to determine whether the FCS value can be used. If the frame_check_sequence parameter is provided with an M_UNITDATA.request and the receiving and the transmitting service providers

1) Use the same algorithm to determine the FCS; and
2) Apply that algorithm to the same fields of the frame, i.e., the FCS coverage is the same; and
3) The data that is within the coverage of the FCS remains the same;

then the transmitting service provider uses the supplied FCS value.

NOTE 3—There are two possibilities for recreating a valid FCS. Annex F of IEEE Std 802.1D-2004 discusses these possibilities in more detail.

Unlike the other parameters of the service primitives, the **service_access_point_identifier** and **connection_identifier** are not parameters of the peer-to-peer service. The values of the **service_access_point_identifier** and **connection_identifier** are purely local to the system within which a given service request or service indication occurs, and are not conveyed to the communicating peer system. The values are opaque to the user of the ISS and are not manipulated by that service user, thus permitting independent operation of entities within the MAC sublayer as well as extending capabilities by the addition of protocol shims. The values are not conveyed in any external protocol, including management protocols; however, management protocols can convey externally visible data related to the SAP or connection. For example, there is a one-to-one association between **service_access_point_identifier** of a Bridge Port used by the MAC Relay Entity and the port number identifying that Bridge Port in management and control protocols.

The **service_access_point_identifier** parameter always identifies the SAP at which the service indication occurs or the service request is made, in the context of the receiving or transmitting system. In the common case of direct support of the ISS by a specific MAC procedure, it identifies the attached individual LAN.

When a protocol entity in the interface stack either uses or supports multiple SAPs, the **service_access_point_identifier** parameter associates the service primitive with the appropriate SAP.

The **connection_identifier** can be null and is ignored by any specific MAC procedures except as explicitly specified in those procedures (6.7 of IEEE Std 802.1Q-2011). The **connection_identifier** is used where this standard specifically provides for efficient support of a single SAP by a number of connections, i.e., by dynamically created connectivity associations between peer entities. For example, a Provider Instance Port (6.10 of IEEE Std 802.1Q-2011) creates connections with peer Provider Instance Ports, and uses the **connection_identifier** to associate the backbone MAC address of the peer Provider Instance Port with Customer MAC Addresses that can be reached through that peer Provider Instance Port (26.4 of IEEE Std 802.1Q-2011). Following an M_UNITDATA.indication at a given SAP with a given **source_address** and **connection_identifier**, a subsequent M_UNITDATA.request at the same SAP with that source address as its **destination_address** and with the same **connection_identifier** will result in an M_UNITDATA.indication at the peer entity selected by the connection_identifier (in the absence of frame loss or reconfiguration of network components). The value of a **connection_identifier** is significant only at a single SAP. Any protocol entity in the interface stack that does not specify use of the **connection_identifier** assigns the **connection_identifier** value (if any) supplied with a request from the user of the protocol entity (or with an indication from the provider of the service used by the protocol entity) to the **connection_identifier** on associated requests made (or indications generated) by the protocol entity.

NOTE 4—The ISS specification in this standard omits the frame_type and access_priority parameters that are included in the ISS specification in IEEE Std 802.1D. The frame_type is not required as the receipt of a frame other than a user data frame does not cause a data indication, nor are such frames transmitted by the media independent bridge functions. The mapping of the ISS to particular access methods specified by this standard includes derivation of the access_priority parameter (for those media that require it) from the ISS priority parameter.

11.2 Status parameters

The ISS also makes available status parameters that reflect the operational state and administrative controls over each instance of the service provided.

The **MAC_Enabled** parameter is TRUE if use of the service is permitted; and is otherwise FALSE. The value of this parameter is determined by administrative controls specific to the entity providing the service.

The **MAC_Operational** parameter is TRUE if the entity providing the service is capable of transmitting and receiving frames and its use is permitted by management, i.e., MAC_Enabled is also TRUE. Its value is otherwise FALSE. The value of this parameter is determined by the specific MAC procedures.

NOTE—These status parameters provide a common approach across MACs for handling the fact that:

a) A MAC can inherently be working or not;

b) If the MAC is working, its operational state can be administratively overridden.

11.3 Point-to-point parameters

The ISS also makes available status parameters that reflect the point-to-point status of each instance of the service provided and provide administrative control over the use of that information.

If the **operPointToPointMAC** parameter is TRUE, the service is used as if it provides connectivity to at most one other system; if FALSE, the service is used as if it can provide connectivity to a number of systems.

The **adminPointToPointMAC** parameter can take one of three values. If it is

a) **ForceTrue**, operPointToPointMAC is always TRUE, regardless of any indications to the contrary generated by the service providing entity.

b) **ForceFalse**, operPointToPointMAC is always FALSE.

c) **Auto**, operPointToPointMAC is determined by the service providing entity.

The value of operPointToPointMAC is determined dynamically; i.e., it is reevaluated whenever adminPointToPointMAC or the status of the service providing entity changes.

12. Support of the Internal Sublayer Service

12.1 Support of the Internal Sublayer Service by specific MAC procedures

This subclause specifies support of the Internal Sublayer Service (ISS) by MAC Entities that use specific IEEE 802 media access methods, including the mapping to the MAC protocol and procedures for each access method, and the encoding of the parameters of the service in MAC frames. The mapping is specified by reference to the IEEE 802 standards that specify each access method. The mapping draws attention to any special responsibilities of Bridges attached to LANs of that type. MAC control frames, typically frames that control some aspect of the operation of the MAC, i.e., frames that do not convey MAC user data, do not give rise to ISS data indications and are therefore not forwarded by a Bridge to any LAN other than that on which they originated.

Each MAC Entity examines all frames received on the LAN to which it is attached. All error-free received user data frames give rise to M_UNITDATA indication primitives. A frame that is in error, as defined by the relevant MAC specification, is discarded by the MAC Entity without giving rise to any M_UNITDATA indication.

12.1.1 Support of the Internal Sublayer Service by IEEE Std 802.3-2008 (CSMA/CD)

The CSMA/CD access method is specified in IEEE Std 802.3-2008 [B3]. Clause 3 of that standard specifies the MAC frame structure, and Clause 4 specifies the MAC method.

On receipt of an M_UNITDATA.request primitive, the local MAC Entity performs Transmit Data Encapsulation, assembling a frame using the parameters supplied as specified below. It prepends a preamble and a Start Frame Delimiter before handing the frame to the Transmit Media Access Management Component in the MAC Sublayer for transmission (4.2.3 in IEEE Std 802.3-2008 [B3]).

On receipt of a MAC frame by Receive Media Access Management, the MAC frame is passed to Receive Data Decapsulation, which validates the FCS and disassembles the frame, as specified below, into the parameters that are supplied with an M_UNITDATA.indication primitive (4.2.4 in IEEE Std 802.3-2008 [B3]).

The **destination_address** parameter is encoded in the destination address field (3.2.4 in IEEE Std 802.3-2008 [B3]).

The **source_address** parameter is encoded in the source address field (3.2.5 in IEEE Std 802.3-2008 [B3]).

The number of octets of data in the **mac_service_data_unit** parameter is either:

a) Encoded in the Length/Type field of the MAC frame if the frame makes use of the Length interpretation of the Length/Type field (3.2.6 in IEEE Std 802.3-2008 [B3]), or
b) Determined from the length of the received MAC frame, if the frame makes use of the Type interpretation of the Length/Type field (3.2.6 in IEEE Std 802.3-2008 [B3]).

The octets of data are encoded in the data field (3.2.7 in IEEE Std 802.3-2008 [B3]). The Length/Type field forms the initial octets of the mac_service_data_unit parameter.

The **priority** and **drop_eligible** parameters provided in a data request primitive are not encoded in MAC frames. The priority parameter provided in a data indication primitive shall take the value of the Default Priority parameter for the Port through which the MAC frame was received. The default value of this parameter is 0. This parameter may be set by management in which case the capability to set it to any of the values 0 through 7 shall be provided.

The **frame_check_sequence** parameter is encoded in the FCS field of the MAC frame (3.2.9 in IEEE Std 802.3-2008). The FCS is computed as a function of the destination address, source address, length, data, and PAD fields. If an M_UNITDATA.request primitive is not accompanied by this parameter, it is calculated in accordance with 3.2.9 in IEEE Std 802.3-2008 [B3].

NOTE—Since the PAD field, if present, contributes to the FCS, this parameter needs to include at least the contribution of the PAD field to the FCS in order for the original FCS to be preserved. (See Annex F in IEEE Std 802.1D-2004.)

No special action, above that specified for the support of use of the MAC Service by LLC, is required for the support of the MAC ISS by the CSMA/CD access method.

The values of the MAC_Enabled and MAC_Operational parameters are determined as follows:

c) For a MAC entity that contains a Link Aggregation sublayer, the value of MAC_Enabled is directly determined by the value of the aAggAdminState attribute (6.3.1.1.13 in IEEE Std 802.1AX-2008 [B2]), and the value of MAC_Operational is directly determined by the value of the aAggOperState attribute (6.3.1.1.14 in IEEE Std 802.1AX-2008 [B2]).

d) Otherwise, for IEEE 802.3 MAC entities that support the medium attachment unit (MAU) managed Object Class (30.5.1 in IEEE Std 802.3-2008 [B3]):

   1) The value of MAC_Enabled is TRUE.
   2) The value of MAC_Operational is TRUE if the attribute aMediaAvailable carries the value *available*.
   3) The value of MAC_Operational is FALSE if the attribute aMediaAvailable carries any value other than *available*.

e) Otherwise:

   1) The value of MAC_Enabled is TRUE.
   2) The value of MAC_Operational is TRUE.

From the point of view of determining the value of operPointToPointMAC (6.6.3 in IEEE Std 802.1Q-2011), the MAC is considered to be connected to a point-to-point LAN if any of the following conditions are true:

f) The MAC entity concerned contains a Link Aggregation sublayer, and the set of physical MACs associated with the Aggregator are all aggregatable; or

g) The MAC entity concerned supports auto negotiation (e.g., Clauses 28, 37, and 73 of IEEE Std 802.3-2008 [B3]), and the auto negotiation function has determined that the LAN is to be operated in full duplex mode; or

h) The MAC entity has been configured by management means for full duplex operation.

Otherwise, the MAC is considered to be connected to a LAN that is not point-to-point.

On receipt of an M_UNITDATA.request primitive that represents a tagged frame, the implementation is permitted to adopt either of the following approaches with regard to the operation of Transmit Data Encapsulation for frames whose length would, using the procedure as described earlier, be less than 68 octets:

i) Use the procedure as described in a) and b). This procedure can result in tagged frames of less than 68 octets (but at least 64 octets) being transmitted; or

j) Include additional octets before the FCS field in order for the transmitted frame length for such frames to be 68 octets. This procedure results in a minimum tagged frame length of 68 octets.

When a tagged frame of less than 68 octets in length is received on a CSMA/CD LAN, and is forwarded as an untagged frame, the procedure as described in a) and b) results in additional octets being included before the FCS field on transmission in order that the transmitted frame length meets the minimum frame size requirements of 3.2.8 in IEEE Std 802.3-2008 [B3].

12.1.2 Support by IEEE Std 802.11-2012 (Wireless LAN)

The wireless LAN access method is specified in IEEE Std 802.11-2012 [B4]. Clause 8 of that standard specifies frame formats, Clause 9 specifies the MAC sublayer function, and Clause 10 specifies the mandatory MAC sublayer management function.

A Bridge to an IEEE 802.11 LAN shall connect to an IEEE 802.11 Portal, which in turn connects to an IEEE 802.11 Distribution System. For the purposes of bridging, the service interface presented at the Portal is identical to the service interface presented at the IEEE 802.11 MAC SAP. An instance of an 8802-11 Distribution System can be implemented from IEEE 802 LAN components. IEEE 802.11 stations (STAs) attach to the Distribution System via an IEEE 802.11 Access Point. A bridge shall not connect to an IEEE 802.11 Independent basic service set (BSS). For a description of the IEEE 802.11 architecture, see Clause 4 of IEEE Std 802.11-2012 [B4].

On receipt of an M_UNITDATA.request primitive, the portal constructs a MSDU and passes it to the MAC Data service for transmission (in accordance with the frame formats and procedures specified in IEEE Std 802.11-2012, Clauses 5, 8, and 9 [B4]) using the parameters supplied as specified below.

On receipt of a valid MSDU (see IEEE Std 802.11-2012, Clauses 5, 8, and 9 [B4]), the portal generates an M_UNITDATA.indication primitive with parameter values derived from the frame fields as specified below.

When processing MSDU_from_LLC, the Type subfield of the Frame Control field specified in 8.2.4.1.3 of IEEE Std 802.11-2012 [B4] shall be encoded as *Data* in MAC frames (see Table 8-1 in IEEE Std 802.11-2012).

The destination_address parameter is encoded in MAC frames as the DA described in Table 8-19 of 8.3.2.1 of IEEE Std 802.11-2012 [B4].

The source_address parameter is encoded in MAC frames as the SA described in Table 8-19 of 8.3.2.1 of IEEE Std 802.11-2012 [B4].

The mac_service_data_unit parameter is encoded in the Frame Body field (8.2.4.7.1 of IEEE Std 802.11-2012 [B4]) of MAC frames. The length of the MSDU shall be ≤ 2304 octets. The length is not encoded in MAC frames; rather, it is conveyed in the PHY headers.

The priority parameter is not encoded in MAC frames. The priority parameter provided in an M_UNITDATA.indication primitive shall take the value of the Default Priority parameter for the port through which the MSDU was received. The default value of this parameter is 0, it may be set by management, in which case the capability to set it to any of the values 0 through 7 shall be provided.

The FCS field of MAC frames is calculated and encoded in accordance with 8.2.4.8 of IEEE Std 802.11-2012 [B4].

No special action, above that specified in IEEE Std 802.11-2012 [B4], is required for the support of the MAC ISS by the wireless LAN access method.

12.1.3 Support by IEEE Std 802.17™-2004 (RPR)

The resilient packet ring (RPR) MAC access method is specified in IEEE Std 802.17-2004 [B5]. Clause 6 of that standard specifies the MAC service interface and reference model. Clause 7 specifies the MAC transmission and reception procedures. Clause 9 specifies the MAC frame structure.

On receipt of an M_UNITDATA.request primitive, the local MAC entity performs transmit data encapsulation, which assembles a MAC frame (Clause 9 in IEEE Std 802.17-2004 [B5]) with the parameters supplied as specified in the paragraphs that follow.

On receipt of a valid MAC frame (Clause 9 in IEEE Std 802.17-2004 [B5]), an M_UNITDATA.indication primitive is generated, with parameter values derived from the frame fields as specified in the paragraphs that follow.

The **destination_address** parameter is encoded in the *da* field of the MAC frame (9.2.2.3 in IEEE Std 802.17-2004 [B5]). For request primitives from a client (e.g., MAC Relay Entity) where the source_address parameter does not equal the MAC's address, the destination_address parameter is encoded in both the da and the *daExtended* fields of the MAC frame (9.2.2.8 in IEEE Std 802.17-2004).

The **source_address** parameter is encoded in the *sa* field of the MAC frame (9.2.2.4 in IEEE Std 802.17-2004 [B5]) when supplied in the request primitive and when the source_address is equal to the MAC's address. When the source_address is supplied in the request primitive, and when the source_address is not equal to the MAC's address, then the source_address is encoded in the *saExtended* field of the MAC frame (9.2.2.9 in IEEE Std 802.17-2004).

The **mac_service_data_unit** parameter is the service user data that includes the protocol type and is encoded in the *protocolType* and *serviceDataUnit* fields of the MAC frame (9.2.2.10 and 9.2.2.11 in IEEE Std 802.17-2004 [B5]).

The **priority** parameter provided in the data request primitive is encoded into the service class (*sc*) subfield of the *baseControl* field (9.6.4 in IEEE Std 802.17-2004 [B5]) of the MAC frame. This encoding is done in accordance with the priority to MAC service class mapping shown in Table 12-1.

Table 12-1—Priority to MAC service class mapping

Priority	MAC service class
0	classC
1	classC
2	classC
3	classC
4	classB
5	classB
6	classA
7	classA

In the case of the indication primitive, the **priority** parameter is directly derived from the *sc* subfield of the *baseControl* field of the MAC frame. The mapping between the service class and the priority parameter of the indication primitive is provided in Table 12-2.

Table 12-2—MAC service class to priority mapping

MAC service class	Priority
classC	0
classB	4
classA	6

The **frame_check_sequence** parameter found in the data request primitive is encoded in the *fcs* field of the MAC frame (9.2.2.12 in IEEE Std 802.17-2004 [B5]). The *fcs* is calculated as a 32-bit CRC starting from the first byte following the header checksum field (*hec*) (9.2.2.7 in IEEE Std 802.17-2004) to the end of the payload (9.2.2.11 of IEEE Std 802.17-2004) in accordance with E.2 in IEEE Std 802.17-2004. If an M_UNITDATA.request primitive is not accompanied by this parameter, it is calculated in accordance with E.2 in IEEE Std 802.17-2004.

No special action, above that specified in IEEE Std 802.17-2004 [B5], is required for the support of the MAC ISS by the RPR access method.

The IEEE 802.17 MAC service interface supports a number of optional parameters that are specific to the IEEE 802.17 MAC. These parameters take on default values in M_UNITDATA.request primitive during transmission, and they are ignored by the MAC Relay on reception. The default values and procedures for handling RPR specific parameters are defined in 6.4.1, Clause 7, and F.3.1 in IEEE Std 802.17-2004 [B5].

12.1.4 Support by IEEE 802.20™ Mobile Broadband Wireless Access Method (MBWA)

12.1.4.1 Support by Wideband Mode of IEEE Std 802.20-2008 (MBWA)

The Mobile Broadband Wireless Access Method for the IEEE 802.20 Wideband Mode is specified in 5.4 and Clause 6 through Clause 17 of IEEE Std 802.20-2008 [B6]. Clause 8 of the standard specifies the Wideband Mode Lower MAC Layer Frame structure and protocol procedures. Clause 7 specifies the Radio Link Sublayer protocol, and Clause 6 defines the Services Sublayer of the Wideband Mode. Clause 11 defines the Connection Control Plane that controls the state of the air-link by managing the states of individual Lower MAC Layer protocols, and by providing individual Lower MAC Layer protocols with operating parameters.

The Basic Packet Consolidation Protocol (8.2 in IEEE Std 802.20-2008 [B6]) provides packet consolidation on the transmit side and provides packet de-multiplexing on the receive side. It provides an interface for the Radio Link Sublayer to transport user information from the Services Sublayer.

For packets to be transmitted over the air interface (wireless medium) from either the Access Node (AN) or Access Terminal (AT), the Lower MAC Sublayer shall accept Radio Link Sublayer data and control packets and shall generate Lower MAC Sublayer control packets of its own. For packets leaving the air interface (wireless medium) for the AN or AT, the Lower MAC Sublayer shall de-multiplex the received packets and shall deliver the payload to the Radio Link Sublayer. The Radio Link Sublayer shall deliver the payload to the Services Sublayer, which includes support for different IEEE 802.3 frame-based protocols.

12.1.4.1.1 Support for Internal Sublayer Service under Wideband Mode of IEEE Std 802.20

The **destination_address**, **source_address**, **mac_service_data_unit**, and **priority** parameters of the M_UNITDATA primitive are encoded as described in 6.6.1 in IEEE Std 802.1Q-2011.

The value of **operPointToPointMAC** (6.6.3 in IEEE Std 802.1Q-2011) shall be TRUE.

The value of **MAC_Enabled** shall be determined by the procedure described in 6.6.2 in IEEE Std 802.1Q-2011.

After the IEEE 802.20 AT has registered with the AN, authenticated, and performed capabilities negotiation, and after the stream is established to carry IEEE 802 frames, then the value of the **MAC_Operational** parameter shall be determined by the procedure described in 6.6.2 in IEEE Std 802.1Q-2011. Beforehand, the value of **MAC_Operational** shall be FALSE.

Frame size limits are determined by IEEE Std 802.3-2008 [B3].

12.1.4.2 Support by 625k-MC mode of IEEE Std 802.20-2008 (MBWA)

The Mobile Broadband Wireless Access Method for 625k-MC mode is specified in 5.5, Clause 18 through Clause 31, and Annex A of IEEE Std 802.20-2008 [B6]. Clause 19 of the standard specifies 625k-MC Mode MAC Frame structure. Clause 23 specifies the MAC Protocol Sublayer function to implement the 625k-MC mode MAC service. Clause 25 specifies the L3 protocol, and Clause 26 defines all the primitives used in 625k-MC Mode.

The L3 protocol layer is made up of components with distinct roles in supporting a connection across the air interface. The L3 Connection Management (CM) module provides an application level interface to the higher layer. The L3 protocol creates logical connections to transport the higher layer L4 data packets. The L3 Registration Management (RM) module takes the L4 data packets provided by the higher layer (through L3 CM) and converts them into a form that can be sent over the air interface. On the receiving side, L3 RM converts packets received from the air interface back into network packets before giving them to L3 CM.

Clause 26 defines the higher layer to L3 CM Interface Primitives for the SAP that shall be provided by L3 CM for the use of the higher layer. Clause 26 defines L3 CM to L4 Interface Primitives for the SAP provided by the higher layer for the use of L3 CM.

For packets entering air interface (wireless medium) from either base station (BS) network or End User Device (EUD), L3 shall accept L4 data and L4 control packets and shall generate L3 control packets of its own, and shall then send them to L2 RLC. For packets leaving air interface (wireless medium) for BS network or EUD, L3 shall accept byte streams from L2 RLC, shall determine whether the packet is a data packet, an L3 control packet, or an L4 control packet, and shall route the L4 control and data packets to the higher layer.

12.1.4.2.1 Support for ISS under 625k-MC mode of IEEE Std 802.20-2008

The **destination_address**, **source_address**, **mac_service_data_unit**, and **priority** parameters of the M_UNITDATA primitive are encoded as described in 6.6.1 in IEEE Std 802.1Q-2011 and presented as an ISS-supported IEEE 802.3 MAC to the higher layer. The higher layer triggers the L3 protocol of 625k-MC. The L3 CM module state machine shall respond to requests from the higher layer for virtual connections across the air interface and requests registrations from the L3 RM to allow the virtual connections to use physical channels (streams).

The value of **operPointToPointMAC** (6.6.3 in IEEE Std 802.1Q-2011) shall be TRUE.

The value of **MAC_Enabled** shall be determined by the procedure described in 6.6.2 in IEEE Std 802.1Q-2011.

Initially, the value of **MAC_Operational** shall be FALSE. After the user terminal (UT) has registered with the BS, authenticated, and performed capabilities negotiation, and after the stream is established to carry IEEE 802 frames, then the value of the **MAC_Operational** parameter shall be determined by the procedure described in 6.6.2 in IEEE Std 802.1Q-2011. Frame size limits are determined by IEEE Std 802.3-2008 [B3].

13. MAC Service

13.1 Function

The MAC connectionless-mode transmission service (the MAC Service) is provided using a subset of the elements of the ISS (Clause 11). The primitives defined in this clause can be used to transmit an independent, self-contained MSDU from one MSAP to another MSAP in a single service access. It is self-contained in that all of the information required to deliver the MSDU is presented to the MAC Service provider in a single service access; thus no initial establishment or subsequent release of a connection is required.

An MSDU transmitted using MAC connectionless-mode transmission is not considered by the MAC Service provider to be related in any way to any previously transmitted MSDU. Although the MAC Service maintains the integrity of individual MSDUs, it does not necessarily deliver them to the receiving MAC Service user in the order in which they are presented by the transmitting MAC Service user, for example in cases where they have different priorities.

The MAC Service provider is not required to maintain state information for flow control between specific combinations of MSAPs.

13.2 Service primitives and parameters

Two unit-data primitives are specified for the connectionless-mode data transmission service, an MA_UNITDATA.indication and an MA_UNITDATA.request, together with the parameters of those primitives. Each MA_UNITDATA indication corresponds to the receipt of an error-free MAC frame from a LAN. A data request primitive is invoked to transmit a frame to an individual LAN.

NOTE 1—Detailed specifications of error conditions in received frames are contained in the relevant MAC standards; for example, FCS errors, length errors, and non-integral number of octets.

MA_UNITDATA.indication (
destination_address,
source_address,
mac_service_data_unit,
priority
)

MA_UNITDATA.request (
destination_address,
source_address,
mac_service_data_unit,
priority
)

The **destination_address** parameter is the address of an individual MSAP or a group of MSAPs. The **source_address** parameter is the individual address of the source MSAP.

The mac_service_data_unit parameter is the service user data. The default **priority** value is 0. Values 1 through 7 form an ordered sequence of user_priorities, with 1 being the lowest value, 7 the highest, and 0 falling between 1 and 2.

NOTE 2—The specification in this standard differs from that in IEEE Std 802.1D as it omits the frame_type and access_priority parameters. The frame_type is not required as the receipt of a frame other than a user data frame does not

cause a data indication. The mapping of these primitives to particular access methods specified by this standard includes derivation of the access_priority parameter (for those media that require it) from the priority parameter specified here.

NOTE 3—The remaining parameters associated with the M_UNITDATA.request and M_UNITDATA.indication primitives (frame_check_sequence, drop_eligible, service_access_point_identifier, and connection_identifier) are unspecified.

13.3 Status parameters

The connectionless-mode transmission service also makes available status parameters that reflect the operational state and administrative controls over each instance of the service provided.

The **MAC_Enabled** parameter is TRUE if use of the service is permitted, and is otherwise FALSE. The value of this parameter is determined by administrative controls specific to the entity providing the service.

The **MAC_Operational** parameter is TRUE if the entity providing the service is capable of transmitting and receiving frames and its use is permitted by management, i.e., MAC_Enabled is also TRUE. Its value is otherwise FALSE. The value of this parameter is determined by the specific MAC procedures.

NOTE—These status parameters provide a common approach across MACs for handling the fact that:

a) A MAC can inherently be working or not;

b) If the MAC is working, its operational state can be administratively overridden.

13.4 Sequence of primitives

The sequence of primitives in a successful MAC Sublayer connectionless-mode transmission is defined in the time sequence diagram in Figure 13-1.

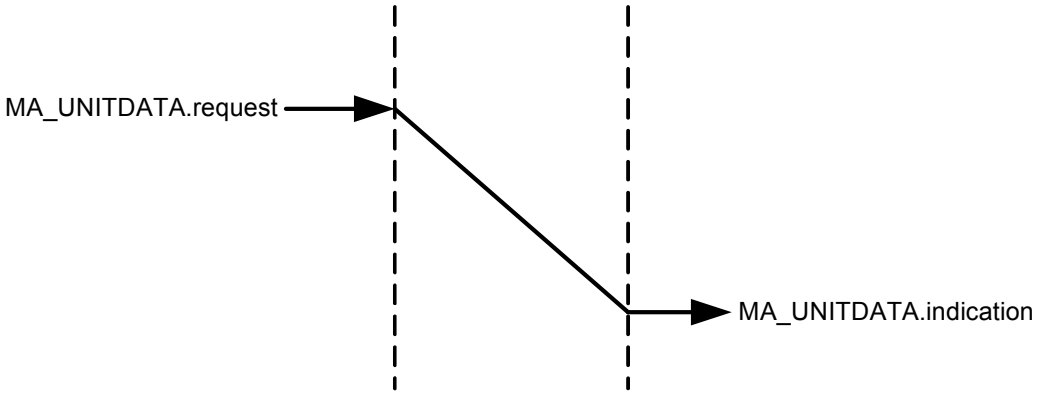

Figure 13-1—Sequence of primitives

Annex A

(informative)

Bibliography

[B1] IEEE Std 802.1AE™-2006, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Security.[11, 12]

[B2] IEEE Std 802.1AX™-2008, IEEE Standard for Local and Metropolitan Area Networks—Link Aggregation.

[B3] IEEE Std 802.3™-2008, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.

[B4] IEEE Std 802.11™-2012, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

[B5] IEEE Std 802.17™-2004, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 17: Resilient packet ring (RPR) access method and physical layer specifications.

[B6] IEEE Std 802.20™-2008, IEEE Standard for Local and metropolitan area networks—Part 20: Air Interface for Mobile Broadband Wireless Access Systems Supporting Vehicular Mobility—Physical and Media Access Control Layer Specification.

[B7] ISO/IEC 8802-2:1998, Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 2: Logical link control.[13]

[B8] ISO/IEC 15802-1, Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Common specifications—Part 1: Medium Access Control (MAC) service definition.

[11]IEEE publications are available from The Institute of Electrical and Electronics Engineers (http://standards.ieee.org/).

[12]The IEEE standards or products referred to in this annex are trademarks of The Institute of Electrical and Electronics Engineers, Inc.

[13]ISO/IEC publications are available from the ISO Central Secretariat (http://www.iso.org/). ISO publications are also available in the United States from the American National Standards Institute (http://www.ansi.org/).