3. Media Access Control (MAC) frame and packet specifications

3.1 Overview

This clause defines the mapping between MAC service interface primitives and Ethernet packets, including the syntax and semantics of the various fields of MAC frames and the fields used to form those MAC frames into packets.

During Ethernet's history, capabilities have been added to allow data link layer (layer 2) protocol encapsulations within the MAC Client Data field. As a result, there are now more than one type of MAC frame.

The frame format specified in this clause includes the following three types of MAC frames:

a) A basic frame
b) A Q-tagged frame
c) An envelope frame

All three frame types use the same Ethernet frame format.

3.1.1 Packet format

Figure 3–1 shows the fields of a packet: the Preamble, Start Frame Delimiter (SFD), the addresses of the MAC frame's destination and source, a length or type field to indicate the length or protocol type of the following field that contains the MAC client data, a field that contains padding if required, and the Frame Check Sequence (FCS) field containing a cyclic redundancy check value to detect errors in a received MAC frame. An Extension field is added, if required (for 1000 Mb/s half duplex operation only). Of these fields, all are of fixed size except for the MAC Client Data, Pad and Extension fields, which may contain an integer number of octets between the minimum and maximum values that are determined by the specific implementation of the MAC. See 4.4 for particular MAC parameters.

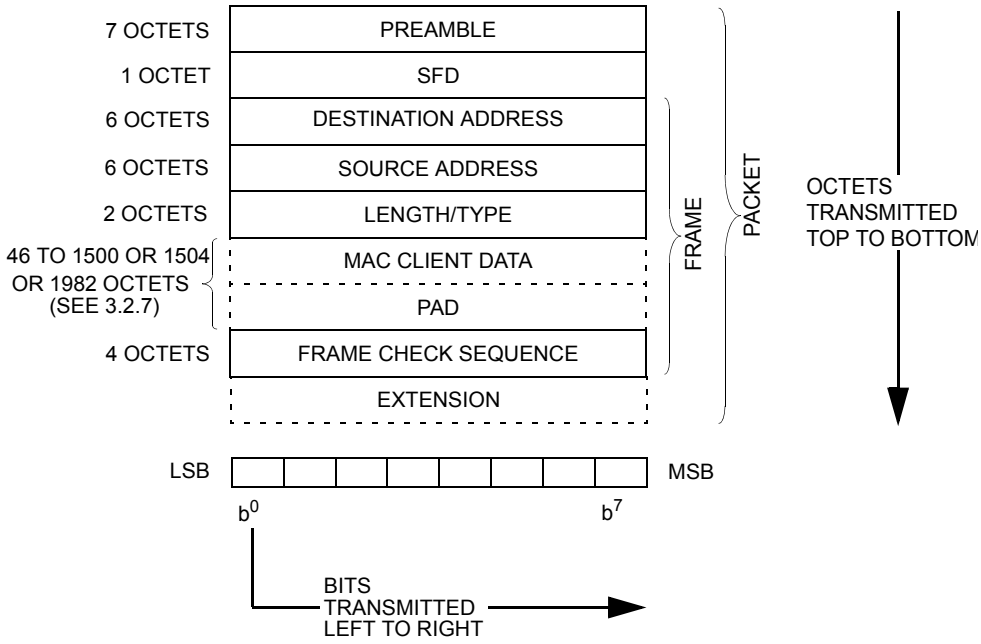

Figure 3–1—Packet format

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The minimum and maximum MAC frame size limits in 4.4 refer to that portion of the packet from the Destination Address field through the Frame Check Sequence field, inclusive (i.e., the MAC frame).

Relative to Figure 3–1, the octets of a packet are transmitted from top to bottom, and the bits of each octet are transmitted from left to right.

3.1.2 Service interface mappings

Figure 3–2 shows the mapping of service interface parameters to the fields of a MAC frame within a packet. The MAC client may or may not supply Pad and FCS. For this reason the mappings for Pad and FCS are shown with dashed lines.

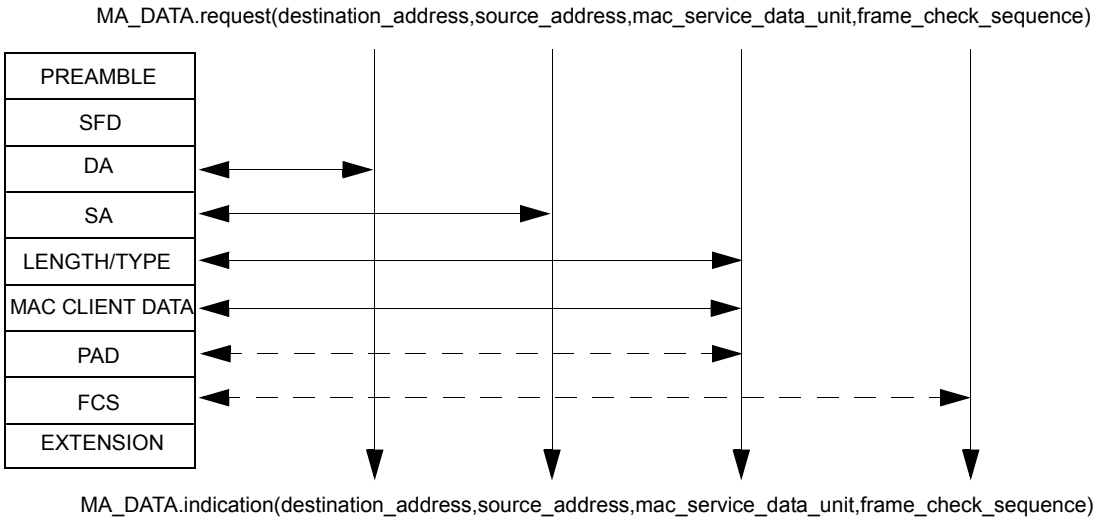

Figure 3–2—Service primitive mappings

3.2 Elements of the MAC frame and packet

A MAC frame is encapsulated in a packet by the MAC. This subclause describes in detail the fields of the MAC frame and the additional fields that the MAC creates to encapsulate the MAC frame. These fields are described in order of transmission.

3.2.1 Preamble field

The Preamble field is a 7-octet field that is used to allow the PLS circuitry to reach its steady-state synchronization with the received packet's timing (see 4.2.5).

3.2.2 Start Frame Delimiter (SFD) field

The SFD field is the sequence 10101011. It immediately follows the preamble pattern. A MAC frame starts immediately after the SFD.

3.2.3 Address fields

Each MAC frame shall contain two address fields: the Destination Address field and the Source Address field, in that order. The Destination Address field shall specify the destination addressee(s) for which the MAC frame is intended. The Source Address field shall identify the station from which the MAC frame was initiated. The representation of each address field shall be as follows (see Figure 3–3):

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a) Each address field shall be 48 bits in length.
b) The first bit (LSB) shall be used in the Destination Address field as an address type designation bit to identify the Destination Address either as an individual or as a group address. If this bit is 0, it shall indicate that the address field contains an individual address. If this bit is 1, it shall indicate that the address field contains a group address that identifies none, one or more, or all of the stations connected to the LAN. In the Source Address field, the first bit is reserved and set to 0.
c) The second bit shall be used to distinguish between locally or globally administered addresses. For globally administered (or U, universal) addresses, the bit is set to 0. If an address is to be assigned locally, this bit shall be set to 1. Note that for the broadcast address, this bit is also a 1.
d) Each octet of each address field shall be transmitted least significant bit first.

I/G = 0 INDIVIDUAL ADDRESS
I/G = 1 GROUP ADDRESS
U/L = 0 GLOBALLY ADMINISTERED ADDRESS
U/L = 1 LOCALLY ADMINISTERED ADDRESS

Figure 3–3—Address field format

3.2.3.1 Address designation

A MAC sublayer address is one of two types:

a) *Individual Address*. The address associated with a particular station on the network.
b) *Group Address*. A multidestination address, associated with one or more stations on a given network. There are two kinds of multicast addresses:
   1) *Multicast-Group Address*. An address associated by higher-level convention with a group of logically related stations.
   2) *Broadcast Address*. A distinguished, predefined multicast address that always denotes the set of all stations on a given LAN.

All 1's in the Destination Address field shall be predefined to be the Broadcast Address. This group shall be predefined for each communication medium to consist of all stations actively connected to that medium; it shall be used to broadcast to all the active stations on that medium. All stations shall be able to recognize the Broadcast Address. It is not necessary that a station be capable of generating the Broadcast Address.

The address space shall also be partitioned into locally administered and globally administered addresses. The nature of a body and the procedures by which it administers these global (U) addresses is beyond the scope of this standard.[24]

3.2.4 Destination Address field

The Destination Address field specifies the station(s) for which the MAC frame is intended. It may be an individual or multicast (including broadcast) address.

[24]For information on how to use MAC addresses, see IEEE Std 802, Overview and Architecture. To apply for an Organizationally Unique Identifier for building a MAC address, contact the Registration Authority, IEEE Standards Department, P.O. Box 1331, 445 Hoes Lane, Piscataway, NJ 08855-1331, USA; +1 732 562 3813; fax +1 732 562 1571. URL: http://standards.ieee.org/develop/regauth/

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3.2.5 Source Address field

The Source Address field specifies the station sending the MAC frame. The Source Address field is not interpreted by the MAC sublayer.

3.2.6 Length/Type field

This two-octet field takes one of two meanings, depending on its numeric value. For numerical evaluation, the first octet is the most significant octet of this field.

a) If the value of this field is less than or equal to 1500 decimal (05DC hexadecimal), then the Length/Type field indicates the number of MAC client data octets contained in the subsequent MAC Client Data field of the basic frame (Length interpretation).
b) If the value of this field is greater than or equal to 1536 decimal (0600 hexadecimal), then the Length/Type field indicates the Ethertype of the MAC client protocol (Type interpretation).[25]
The Length and Type interpretations of this field are mutually exclusive.

When used as a Type field, it is the responsibility of the MAC client to ensure that the MAC client operates properly when the MAC sublayer pads the supplied MAC Client data, as discussed in 3.2.7.

Regardless of the interpretation of the Length/Type field, if the length of the MAC Client Data field is less than the minimum required for proper operation of the protocol, a Pad field (a sequence of octets) will be added after the MAC Client Data field but prior to the FCS field, specified below. The procedure that determines the size of the Pad field is specified in 4.2.8. The Length/Type field is transmitted and received with the high order octet first.

NOTE—Clause 2 of IEEE Std 802 defines a set of Ethertype values and associated mechanisms for use in prototype and vendor-specific protocol development.

3.2.7 MAC Client Data field

The MAC Client Data field contains a sequence of octets. Full data transparency is provided in the sense that any arbitrary sequence of octet values may appear in the MAC Client Data field up to a maximum field length determined by the particular implementation.

Ethernet implementations shall support at least one of three maximum MAC Client Data field sizes defined as follows:

a) 1500 decimal—basic frames (see 1.4.109)
b) 1504 decimal—Q-tagged frames (see 1.4.347)
c) 1982 decimal—envelope frames (see 1.4.195)

If layer management is implemented, frames with a MAC Client Data field larger than the supported maximum MAC Client Data field size are counted. It is recommended that new implementations support the transmission and reception of envelope frames, item c) above.

NOTE 1—The envelope frame is intended to allow inclusion of additional prefixes and suffixes required by higher layer encapsulation protocols (see 1.4.190) such as those defined by the IEEE 802.1 working group (such as Provider Bridges and MAC Security), ITU-T or IETF (such as MPLS). The original MAC Client Data field maximum remains 1500 octets while the encapsulation protocols may add up to an additional 482 octets. Use of these extra octets for other purposes is not recommended, and may result in MAC frames being dropped or corrupted as they may violate maximum MAC frame size restrictions if encapsulation protocols are required to operate on them.

[25]Ethertype assignments are administered by the Registration Authority, IEEE Standards Department, P.O. Box 1331, 445 Hoes Lane, Piscataway, NJ 08855-1331, USA; +1 732 562 3813; fax +1 732 562 1571. URL: http://standards.ieee.org/develop/regauth/.

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NOTE 2—All IEEE 802.3 MAC frames share a common format. The processing of the three types of MAC frames is not differentiated within the IEEE 802.3 MAC, except for management. However, they may be distinguished within the MAC client.

NOTE 3—All Q-tagged frames are envelope frames, but not all envelope frames are Q-tagged frames.

See 4.4 for a discussion of MAC parameters; see 4.2.3.3 for a discussion of the minimum frame size and minFrameSize.

3.2.8 Pad field

A minimum MAC frame size is required for correct CSMA/CD protocol operation (see 4.2.3.3 and 4.4). If necessary, a Pad field (in units of octets) is appended after the MAC Client Data field prior to calculating and appending the FCS field. The size of the Pad, if any, is determined by the size of the MAC Client Data field supplied by the MAC client and the minimum MAC frame size and address size MAC parameters (see 4.4).

The length of the Pad field required for MAC Client Data that is clientDatasize/8 octets long is max [0, minFrameSize – (clientDatasize + 2 × addressSize + 48)] bits.

3.2.9 Frame Check Sequence (FCS) field

A cyclic redundancy check (CRC) is used by the transmit and receive algorithms to generate a CRC value for the FCS field. The FCS field contains a 4-octet (32-bit) CRC value. This value is computed as a function of the contents of the protected fields of the MAC frame: the Destination Address, Source Address, Length/Type field, MAC Client Data, and Pad (that is, all fields except FCS). The encoding is defined by the following generating polynomial.

$$G(x) = x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$$

Mathematically, the CRC value corresponding to a given MAC frame is defined by the following procedure:

a) The first 32 bits of the frame are complemented.
b) The n bits of the protected fields are then considered to be the coefficients of a polynomial $M(x)$ of degree $n – 1$. (The first bit of the Destination Address field corresponds to the $x^{(n-1)}$ term and the last bit of the MAC Client Data field (or Pad field if present) corresponds to the x^0 term.)
c) $M(x)$ is multiplied by x^{32} and divided by $G(x)$, producing a remainder $R(x)$ of degree ≤ 31.
d) The coefficients of $R(x)$ are considered to be a 32-bit sequence.
e) The bit sequence is complemented and the result is the CRC.

The 32 bits of the CRC value are placed in the FCS field so that the x^{31} term is the left-most bit of the first octet, and the x^0 term is the right most bit of the last octet. (The bits of the CRC are thus transmitted in the order $x^{31}, x^{30},\ldots, x^1, x^0$.) See Hammond, et al. [B36].

3.2.10 Extension field

The Extension field follows the FCS field, and is made up of a sequence of extension bits, which are readily distinguished from data bits. The length of the field is in the range of zero to (slotTime–minFrameSize) bits, inclusive. The contents of the Extension field are not included in the FCS computation.

The Extension field may have a length of greater than zero under the conditions that are described in 4.2.3.4. The length of the Extension field will be zero under all other conditions. Implementations defined in 4.4.2 may ignore this field altogether if the number of bit times in the slotTime parameter is equal to the number of bits in the minFrameSize parameter.

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3.3 Order of bit transmission

Each octet of the MAC frame, with the exception of the FCS, is transmitted least significant bit first.

3.4 Invalid MAC frame

An invalid MAC frame shall be defined as one that meets at least one of the following conditions:

a) The frame length is inconsistent with a length value specified in the length/type field. If the length/type field contains a type value as defined by 3.2.6, then the frame length is assumed to be consistent with this field and should not be considered an invalid frame on this basis.
b) It is not an integral number of octets in length.
c) The bits of the incoming frame (exclusive of the FCS field itself) do not generate a CRC value identical to the one received.

The contents of invalid MAC frames shall not be passed to the LLC or MAC Control sublayers.[26] The occurrence of invalid MAC frames may be communicated to network management.

[26]Invalid MAC frames may be ignored, discarded, or used in a private manner by MAC clients other than LLC or MAC control. The use of such frames is beyond the scope of this standard.

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