3. Media access control frame structure

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Revision History:
Draft 0.1, March 2005 Initial draft for FE Task Force review.

3.1 Overview

This clause defines in detail the frame structure for data communication systems using the CSMA/CD MAC. It defines the syntax and semantics of the various components of the MAC frame.

~~Two frame formats are specified in this clause:~~

~~a) A basic MAC frame format, and~~
~~b) An extension of the basic MAC frame format for Tagged MAC frames, i.e., frames that carry QTag Prefixes.~~

3.1.1 MAC frame format

Figure 3–2 shows the nine fields of a frame: the preamble, Start Frame Delimiter (SFD), the addresses of the frame's source and destination, a length or type field to indicate the length or protocol type of the following field that contains the MAC ~~Client~~ client data, a field that contains padding if required, the frame check sequence field containing a cyclic redundancy check value to detect errors in a received frame, and an extension field if required (for 1000 Mb/s half duplex operation only). Of these nine fields, all are of fixed size except for the 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 CSMA/CD MAC. See 4.4 for particular implementations.

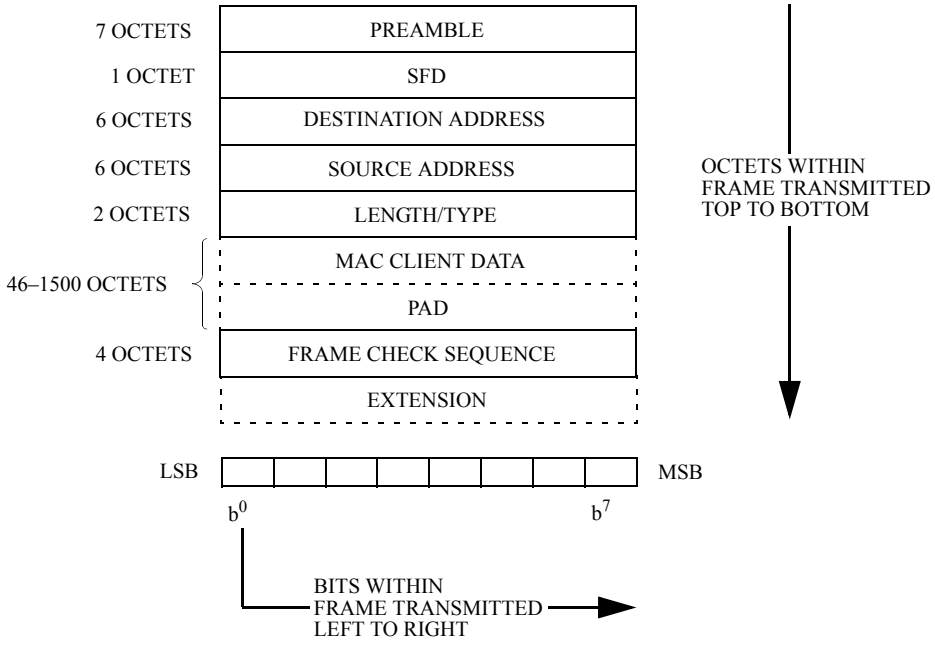

Figure 3–1—MAC frame format

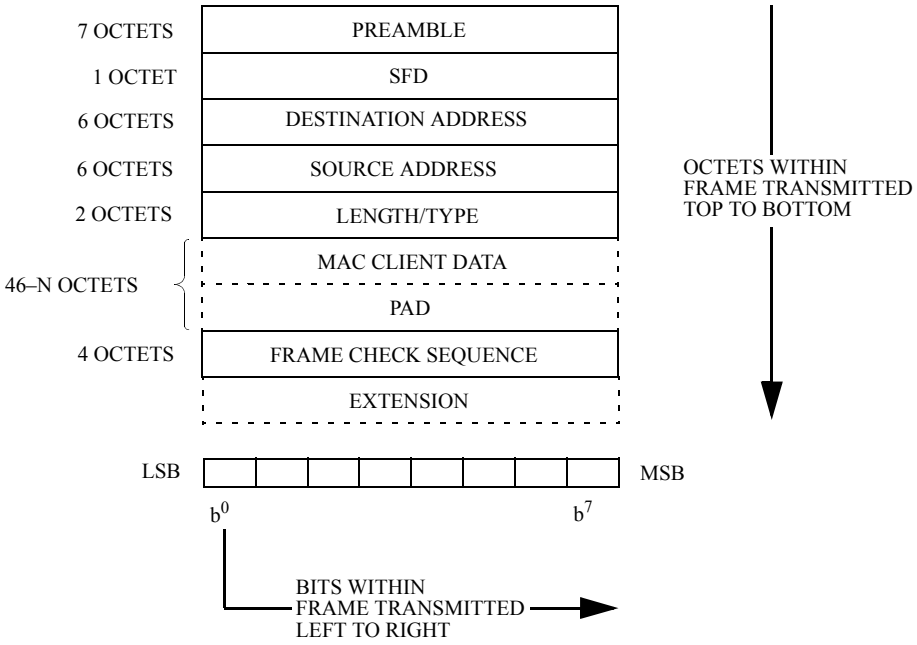

Figure 3–2—MAC frame format

The minimum and maximum frame size limits in 4.4 refer to that portion of the frame from the destination address field through the frame check sequence field, inclusive.

Relative to Figure 3–2, the octets of a frame 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 3–3 shows the mapping of service interface parameters to the fields of a MAC frame.

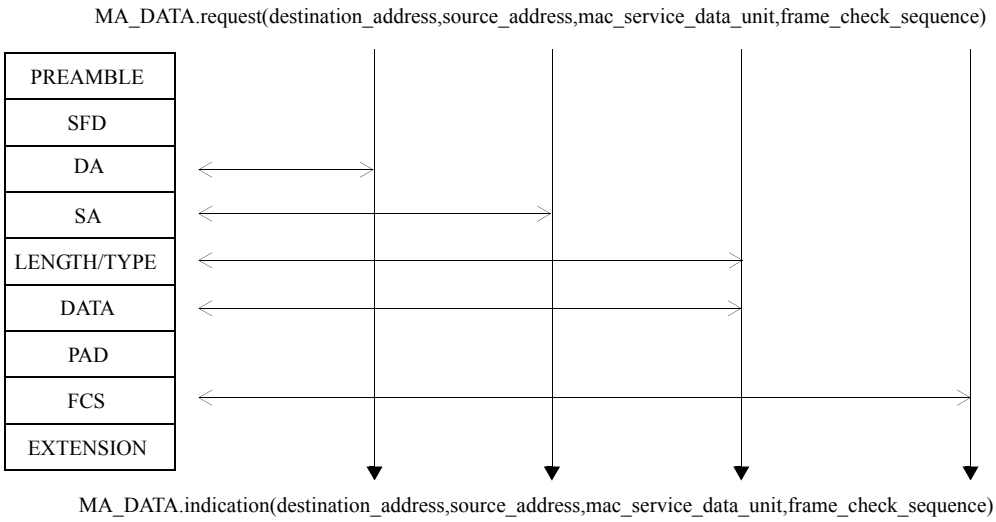

Figure 3–3—Service primitive mappings to frame fields

3.2 Elements of the MAC frame

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 frame'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 and indicates the start of a frame.

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 frame is intended. The Source Address field shall identify the station from which the frame was initiated. The representation of each address field shall be as follows (see Figure 3–4):

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 3–4—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 address:
   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.[1]

3.2.4 Destination Address field

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

3.2.5 Source Address field

The Source Address field specifies the station sending the frame. The Source Address field is not interpreted by the CSMA/CD 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.

[1]For information on how to use MAC addresses, see IEEE Std 802-2001, 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/.

a) If the value of this field is less than or equal to ~~the value of maxValidFrame (as specified in 4.2.7.1)~~1500 decimal, then the Length/Type field indicates the number of MAC client data octets contained in the subsequent data field of the frame (Length interpretation).

b) If the value of this field is greater than or equal to 1536 decimal (equal to 0600 hexadecimal), then the Length/Type field indicates the nature of the MAC client protocol (Type interpretation).[2]

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 data, as discussed in 3.2.7.

Regardless of the interpretation of the Length/Type field, if the length of the data field is less than the minimum required for proper operation of the protocol, a PAD field (a sequence of octets) will be added at the end of the 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 12 of IEEE Std 802a-2003 (an amendment to IEEE Std 802) defines a set of Type values and associated mechanisms for use in prototype and vendor-specific protocol development.

3.2.7 Data ~~and PAD~~ fields

The data field contains a sequence of n octets. Full data transparency is provided in the sense that any arbitrary sequence of octet values may appear in the data field up to a maximum number specified by the implementation of the standard that is used. ~~A minimum frame size is required for correct CSMA/CD protocol operation and is specified by the particular implementation of the standard. If necessary, the data field is extended by appending extra bits (that is, a pad) in units of octets after the data field but prior to calculating and appending the FCS. The size of the pad, if any, is determined by the size of the data field supplied by the MAC client and the minimum frame size and address size parameters of the particular implementation. The maximum size of the data field is determined by the maximum frame size and address size parameters of the particular implementation.~~

The maximum size of the data field is determined by the application of the particular implemenation. The value of N in Figure 3–2 is enumerated for three applications as follows:

a) N=1500 decimal - basic frames that are either length or type encoded with no addtional tags (i.e., untagged)
b) N=1504 decimal - frames that contain a IEEE 802.1Q tag (i.e., QTagged)
c) N=1982 decimal - envelope frames

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The value of N for the envelope frames has not been decided by the 802.3 WG. However, for illustrative purposes the value of 1982 decimal has been used.

NOTE—The envelope frame is intended to allow inclusion of additional prefixes and suffixes required by encapsulation protocols such as P802.1ad, P802.1ah, P802.1AE and MPLS. These frames will contain at least one Ethertype within the data field in addition to the type field. However, these additional types or other encapsulation details not visible to this standard may follow the MAC Type field but are carried as MAC Client Data. Note that the original client data must not exceed 1500 bytes which is its size in the basic frame.

3.2.8 PAD field

A minimum frame size is required for correct CSMA/CD protocol operation and is specified by the particular implementation of the standard. If necessary, the data field is extended by appending extra bits (that

[2]Type field assignments are administered by the Registration Authority, IEEE Standards Department (see Footnote 1 for address).

is, a pad) in units of octets after the data field but prior to calculating and appending the FCS. The size of the pad, if any, is determined by the size of the data field supplied by the MAC client and the minimum frame size and address size parameters of the particular implementation.

The length of PAD field required for MAC client data that is n octets long is max [0, minFrameSize – (8 × n + 2 × addressSize + 48)] bits. The maximum possible size of the data field is ~~maxUntaggedFrameSize~~ maxFrameSize – (2 × addressSize + 48)/8 octets. See 4.4 for a discussion of implementation parameters; see 4.2.3.3 for a discussion of the minFrameSize.

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 frame check sequence (FCS) field contains a 4-octet (32-bit) cyclic redundancy check (CRC) value. This value is computed as a function of the contents of the source address, destination address, length/type, ~~LLC~~ data and pad (that is, all fields except the preamble, SFD, FCS, and extension). 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 frame is defined by the following procedure:

a) The first 32 bits of the frame are complemented.
b) The n bits of the frame 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 data field 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 frame check sequence 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},…, x^1, x^0.) See reference [B46].

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.

3.3 Order of bit transmission

Each octet of the MAC frame, with the exception of the FCS, is transmitted low-order 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.[3] The occurrence of invalid MAC frames may be communicated to network management.

~~3.5 Elements of the Tagged MAC Frame~~

~~Figure 3–5 shows the format of a Tagged MAC Frame. This format is an extension of the MAC Frame specified in 3.1.1 and 3.2. The octet and bit ordering of the fields are identical to that specified in 3.1.1 and 3.3. The extensions for tagging are as follows:~~

~~a) A 4-octet QTag Prefix is inserted between the end of the Source Address and the MAC Client Length/Type field of the MAC frame. The QTag Prefix comprises two fields:~~
~~1) A 2-octet constant Length/Type field value consistent with the Type interpretation and equal to the value of the 802.1Q Tag Protocol Type (802.1QTagType, see 3.5.4).~~
~~2) A 2-octet field containing Tag Control Information.~~
~~b) Following the QTag Prefix is the MAC Client Length/Type field, MAC Client Data, Pad (if necessary), FCS, and Extension (if necessary) fields of the basic MAC frame.~~
~~c) The length of the frame is extended by 4 octets by the QTag Prefix.~~

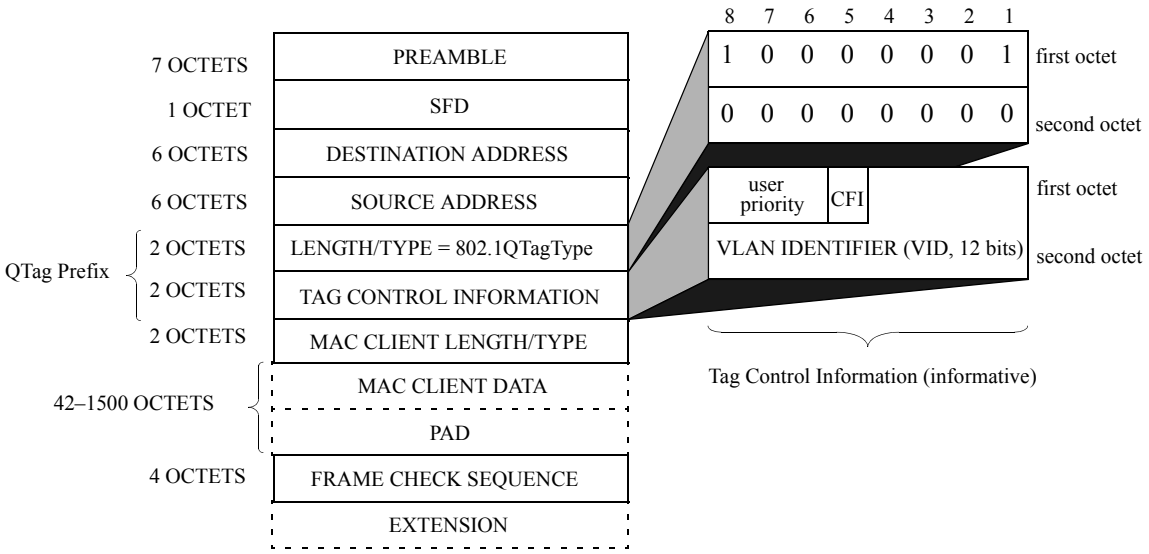

Figure 3–5—Tagged MAC frame format

~~NOTE—The normative definition of the Tag Control Information field shown in Figure 3–5 can be found in IEEE P802.1Q. Also, while Figure 3–2 uses the convention that the most significant bit of an octet is the rightmost bit, Figure 3–5 uses the opposite convention, i.e., the most significant bit is shown in the leftmost position. The latter convention is consistent with the specification of IEEE P802.1Q. This is a pictorial difference only; there is no difference in the actual order of bits transmitted on the LAN.~~

[3]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.

3.5.1 Preamble field

The Preamble field is identical in structure and semantics to the Preamble field of the basic MAC frame, described in 3.2.1.

3.5.2 Start Frame Delimiter (SFD) field

The SFD field is identical in structure and semantics to the SFD field of the basic MAC frame, described in 3.2.2.

3.5.3 Address fields

The address fields (both Destination address and Source address) are identical in structure and semantics to the address fields of the basic MAC frame, described in 3.2.3, 3.2.4, and 3.2.5.

3.5.4 Length/Type field

The Length/Type field of a tagged MAC frame always uses the Type interpretation, and contains the 802.1Q Tag Protocol Type: a constant equal to 0x81-00.

3.5.5 Tag Control Information field (informative)

The Tag Control Information field is subdivided as follows:

a) A 3-bit User Priority field,
b) A Canonical Format Indicator (CFI), and
c) A 12-bit VLAN Identifier.

The structure and semantics within the Tag Control Information field are defined in IEEE P802.1Q.

3.5.6 MAC Client Length/Type field

The MAC Client Length/Type field contains the original Length/Type field from the MAC frame prior to insertion of the QTag Prefix. The QTag Prefix offsets this field exactly 4 octets from its position in an untagged MAC frame.

3.5.7 Data and PAD fields

The Data and PAD fields are identical in structure and semantics to the Data and PAD fields of the basic MAC frame described in 3.2.7, except in the following respect: For tagged MAC frames, the value of n in the PAD field calculation may be either the length of the MAC Client Data or the combined length of MAC Client Data and QTag Prefix.

3.5.8 Frame Check Sequence (FCS) field

The FCS field is identical in structure and semantics to the FCS field of the basic MAC frame, described in 3.2.9.

3.5.9 Extension field

The Extension field is identical in structure and semantics to the Extension field of the basic MAC frame, described in 3.2.10.