

Interpretation Number: 1-11/09
Topic: Specifications of allowable inter packet gap values in IEEE 802.3
Relevant Clause: Clause 4
Classification: Request for Interpretation

Interpretation Request

Topic: Specifications of allowable inter packet gap values in IEEE 802.3

Source: IEEE 802.3 Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications: 9 December 2005

Relevant clause: Section 1: 4.4.2

Applicable condition: GbE connection through OTN transport system

Contact: koike.yoshinori@lab.ntt.co.jp, murakami.makoto@lab.ntt.co.jp

NTT Network Service Systems Laboratories

1. Interpretation requests

When we read IEEE 802.3, we noticed that some descriptions about inter packet gap (IPG) need to be clarified to avoid misunderstandings or miss-implementations. We would like to ask the following questions regarding section 4.4.2 in IEEE 802.3.

If specific values can not be given in reply to any question, it would be highly appreciated if the answer would clarify the fact that the specification can not be clearly regulated in IEEE 802.3 and show some limit values or conditions at both the sender side and the receiver side that are considered within the degree of freedom for the interpretation. This is because people can design network performance and guarantee quality levels on the basis of the limit values.

1.1 Questions on IPG in table in section 4.4.2

- (1) To which part(s) is (are) the described specification of IPG values (96 bits) applied: sender side, receiver side, or both?
- (2) At which point is the allowable IPG value (96 bits) in the table of 4.4.2 specified? (GMII in GbE case?) Figure 1 shows a basic network scenario and LAN CSMA/CD layer structure that includes a 1000-Mb/s repeater unit. According to Note3 below the table in 4.4.2, IPG values seem to be regulated at GMII at the DTE. Point A seems to be applicable; however, points B, C, and D do not seem to be applicable. There do not seem to be clear descriptions in the main body of 4.4.2 regarding at which point the values are regulated.

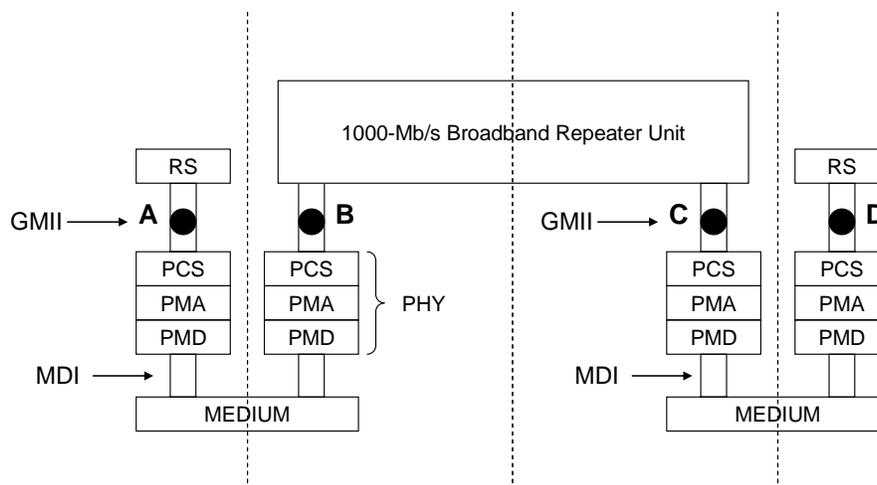


Figure 1: Basic network scenario and LAN CSMA/CD layer structure including repeater set reference model of Gigabit Ethernet (1000-Mb/s operation)

- (3) Is the following condition assumed for the allowable value for 96-bit IPG in GbE? That is, the signal is sent or received at the point that would be given in answer to question (2) with continuous 96-bit IPG values. If not, what conditions were assumed?

1.2 Questions on IPG in Note3 of table in section 4.4.2

- (1) Is the following condition assumed for the allowable value for 64-bit IPG in GbE? That is, the signal is sent or received at the GMII with continuous 64-bit IPG values. If not, what conditions were assumed?
- (2) Was the minimum value of a 64-bit IPG decided on the basis of the discussion in the following minutes^{*2} of the IEEE 802.3 meeting? (This question is related to 1.1 (2) because the “nominal IPG” that is described in the following minutes seems to be related to the IPG value in the table in 4.4.2.,that is 96-bit)

“Reviewed note concerning IPG shrinkage. No objection to adding note. Agreed to change minimum value in note to 64 bit times, based on the calculation:

$$\begin{aligned} \text{Minimum IPG} &= \text{Nominal IPG} - \text{repeater clock tolerance} - \text{preamble growth} - \text{guard band} \\ &= 96 - 16 - 8 - 8 \\ &= 64 \text{ bit times} \end{aligned}$$

Note as written applies to both full and half duplex operation. “

- (3) How and where can “preamble growth”, described in the minute above, remove 8 bits?

Note: It is conjectured that it is related to section 41.2.1.3.2 Preamble regeneration and section B.1.5.3 Interpacket Gap (IPG) shrinkage.

- (4) Why and where can “variable network delays” that is clearly described as one of the factors in 4.4.2 Note3 cause IPG shrinkage? How was the factor considered when the minimum IPG value 64-bit in the Note3 was calculated? That is a factor that is not clearly described or explained in the above minutes of 1.2.(2).

1.3 Question on usage of wording

- (1) What is meant by “Note” in the IEEE rules (Mandatory, Arbitrary, Recommendation, or another term)?
- (2) Is there any difference in meaning between “interFramGap”, which seems to be described only in section 4.4.2, and “Inter-Packet Gap (IPG)”, which is clearly specified in section 1.4 Definitions?

Note: In this document, “IPG” is tentatively used as a unified definition.

2. Background

2.1 Importance of specification of allowable IPG value

The inter-packet gap (IPG) specification is one of the most important factors to guarantee service level agreement and high-quality service from the network perspective. We would like to explain the reason we are concerned with IPG specifications in IEEE 802.3.

Figure 2 shows one example of a GbE connection through an optical transport network (OTN) transport system, which adopts a generic framing procedure (GFP) mapping scheme regulated in G.7041^{*1}. In this case, device under test (DTE) 1 and DTE2, such as a Layer 2-Switch or an IP router, are interconnected with 1000BASE-SX through a transport system, which consists of network element (NE) 1 and NE2. DTE1 and DTE2 were made by different vendors. A GbE signal is mapped into transparent GFP (GFP-T), which in turn is mapped into virtual concatenation (VC)-4-7v. Moreover, those VC-4s are multiplexed into synchronous transfer mode (STM)-64. NE1 and NE2 are connected through an STM-64 interface. It is also mapped into optical channel data unit (ODU) 2, but ODU2 is not described in this figure for simplicity.

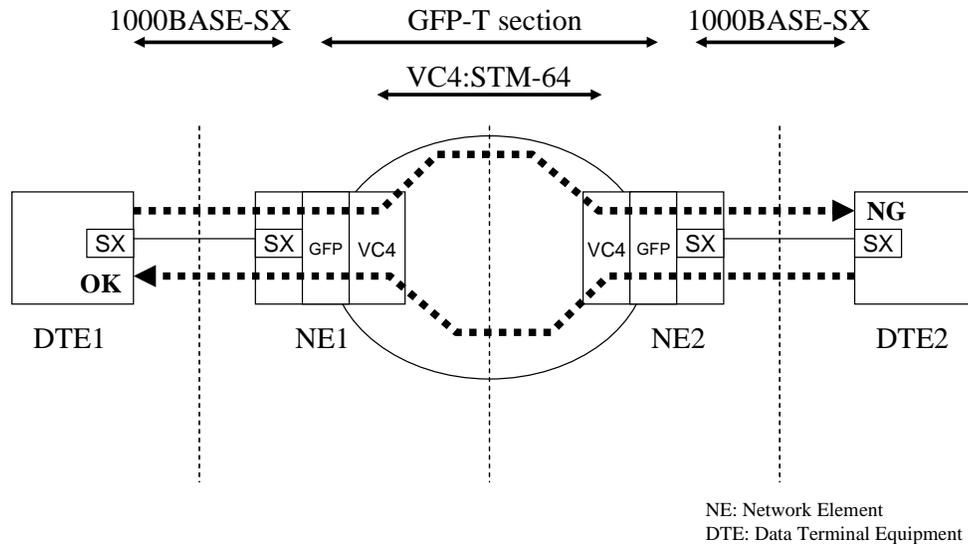


Figure 2: One example of GbE connection through OTN including GFP-T section

First, we need to consider IPG shrinkage in 2-byte units. We would like to consider the rate adaptation process specified in G.7041. If there is frequency deviation between the output signal from DTE1 and input signal to DTE2, rate adaptation needs to be applied. Then, NE1 and NE2 can be regarded as repeater, and the maximum frequency deviation is 200 ppm, according to Table 38–3 in IEEE 802.3. For example, when the output signal from DTE1 is +100 ppm and the input signal from DTE2 is –100 ppm, the IPGs have to be removed using rate adaptation. The client-specific rate adaptation is specified in section 8.4.1.2.4 in G.7041. The minimum unit that can be removed from a GbE signal is /I2/, which is one of the 2-byte order sets. Therefore, if the frequency offset of the DTE1 output signal is larger than that of the DTE2 input signal, a 2-byte Idle removal has to be done for rate adaptation at certain intervals.

For example, assuming that relative frequency deviation between input and output signals is +200 ppm, that is, when the output signal from DTE1 is +100 ppm and the input signal from DTE2 is –100 ppm, if the packet size is 1518 bytes with a continuous 12-byte IPG interval, the probability of a 2-byte IPG shrinkage per one frame cycle (=1538 bytes) will be about 15% (= (1518: data+8: preamble+12: IPG) bytes * 200 ppm / 2 bytes / 100). This means that the size of an IPG in a GbE signal can change from 12 to 10 bytes at certain intervals. The actual size of the IPG seems to show some distribution because of clock tolerance. The point here is that IPG shrinkage could happen in 2-byte units for rate adaptation irrespective of the size of the frequency difference if there is a frequency deviation.

Second, we need to further consider the IPG shrinkage by 8-bit. According to the description in section 41.2.1.3.2 and B.1.5.3, a repeater set seems to be able to remove IPG because of “Preamble

regeneration”. This might happen at point C in Fig. 1. Therefore, additional removal of 8-bit IPG seems to be able to be designed in the GFP-T section.

It is estimated that the 24-bit IPG might be removed when the two above cases of shrinkage are simultaneously applied in the intermediate NEs. Moreover, there is no description about the 8-bit guard band in the formal IEEE 802.3 standardization, it is also estimated that the total 32-bit IPG might be removed. If the receiver side can not receive a GbE signal correctly, it leads to packet losses. Therefore, we need to design or guarantee the allowable IPG size at NEs.

We tested the network scenario in Fig. 2 in our laboratory; GbE traffic was sent from DTE1 to DTE2 and also from DTE2 to DTE1. As a result, packet loss was detected once per few minutes in the direction of DTE1 to DTE2 and not in DTE2 to DTE1. The traffic rate was 990 Mbps in which IPv4 (64, 256, 1518 bytes): 495 Mbps and IPv6 (82, 256, 1518 bytes): 495 Mbps were mixed. In this case, the received IPGs at the DTE2 can be minimum 64-bit, because the NE2 can send 64-bit IPGs to the DTE2, following the Note3 of table in section 4.4.2 of IEEE 802.3.

2.2 Interpretation of allowable IPG value of IEEE 802.3 in G.7041 in ITU-T

The standard of section 8.4.1.2.4 in G.7041 reads as follows.

Output signals will normally be generated with a minimum IPG of 12 octets, per IEEE 802.3, section 4.4.2.3. GbE Idle characters are two octets, as defined in IEEE 802.3, section 36.2.4.12. If rate adaptation is performed using full-duplex GbE Idle insert/removal, any number of /I/s may be removed in any IPG, such that their removal shall not result in no /I/ and not less than 8 octets including /T/, /R/, and /I/ remaining between frames, as required for successful frame delineation according to IEEE 802.3, Figures 36-7a and 36-7b.

According to this description, GFP-T is designed on the basis of the understanding of IEEE 802.3 that every DTE must be able to receive continuous IPG with a minimum of 8 octets, following Note3 of the table in section 4.4.2 of IEEE 802.3. That is, Note3 is a mandatory regulation. However, the meaning and some conditions regarding “Note” do not seem to be clear.

3.Reference

*1: ITU-T recommendation G.7041

*2: <http://grouper.ieee.org/groups/802/3/z/public/minutes/FtL0597.txt>

Interpretation for Specifications of allowable inter packet gap values in IEEE 802.3

Preamble

[a] This interpretation request references IEEE Std 802.3-2005. Since IEEE Std 802.3-2005 has now been superseded by IEEE Std 802.3-2008 we will not be providing a response in respect to IEEE Std 802.3-2005 but instead be providing an interpretation of IEEE Std 802.3-2008.

[b] Interpretations are a unique form of commentary on the standard. They are not statements of what the standard should have done or meant to say. Interpretations cannot change the meaning of a standard as it currently stands. Even if the request points out an error in the standard, the interpretation cannot fix that error. The interpretation can suggest that this will be brought up for consideration in a revision or amendment (or, depending on the nature of the error, an errata sheet might be issued).

However, an interpretation has no authority to do any of this. It can only discuss, address, and clarify what the standard currently says. The challenge for the interpreters is to distinguish between their expertise on what 'should be,' their interests in what they 'would like the standard to be,' and what the standard says. Interpretations are often valuable, though, because the request will point out problems that might otherwise have gone unaddressed.

Question 1.1 (1)

To which part(s) is (are) the described specification of IPG values (96 bits) applied: sender side, receiver side, or both?

The standard is unambiguous. Sub clause 4.2.7.2 'Transmit state variables' states that 'The following items are specific to packet transmission. (See also 4.4.)' and then goes on to define the constant 'interPacketGap = ...; {In bit times, minimum gap between packets, see 4.4}'. The value of the constant interPacketGap is defined in Table 4-2 'MAC parameters' for the various MAC data rates.

It should be noted that the constant value 'interPacketGap' defined in Clause 4 is distinct from the term 'Inter-Packet Gap' defined in sub clause 1.4.192.

Question 1.1 (2)

At which point is the allowable IPG value (96 bits) in the table of 4.4.2 specified? (GMII in GbE case?) Figure 1 shows a basic network scenario and LAN CSMA/CD layer structure that includes a 1000-Mb/s repeater unit. According to Note3 below the table in 4.4.2, IPG values

seem to be regulated at GMII at the DTE. Point A seems to be applicable; however, points B, C, and D do not seem to be applicable. There do not seem to be clear descriptions in the main body

of 4.4.2 regarding at which point the values are regulated.

The standard is unambiguous. Sub clause 4.4.2, Table 4-2, defines the value of the constant 'interPacketGap' for the various MAC data rates. As stated in sub clause 4.2.7.2 'Transmit state variables' the constant 'interPacketGap' defines the 'minimum gap between packets'. Sub clause 4.2.8 'Frame transmission' in 'process Deference' uses the constant 'interPacketGap' in full duplex operation, and the constants 'interPacketGapPart1' and 'interPacketGapPart2' derived from the constant 'interPacketGap', in half duplex, to control the minimum transmit gap between packets from the MAC. The use of the constant 'interPacketGap' to control the minimum gap between packets is further described in sub clause 4.2.3.2.1 'Deference'.

The 96 bit value defined in sub clause 4.4.2 therefore applies at MAC transmit, which is defined at the PLS service Interface. In the specific case of 1Gb/s MAC data rate, since the Reconciliation Sublayer (RS) does not define any allowed change in the value of the Inter-Packet Gap this value also applies at the GMII in the transmit direction. Note that this is not necessarily true for all other MAC data rates.

Question 1.1 (3)

Is the following condition assumed for the allowable value for 96-bit IPG in GbE? That is, the signal is sent or received at the point that would be given in answer to question (2) with continuous 96-bit IPG values. If not, what conditions were assumed?

The standard is unambiguous. For a MAC rate of 1 Gb/s, the value defined for the constant 'interPacketGap' is used as a minimum value. The Inter-Packet Gap at any time at the transmit side of the PLS service interface may be equal to, or any value greater than, the constant 'interPacketGap'.

Question 1.2 (1)

Is the following condition assumed for the allowable value for 64-bit IPG in GbE? That is, the signal is sent or received at the GMII with continuous 64-bit IPG values. If not, what conditions were assumed?

The standard is unambiguous. As described in answer to Question 1.1 (2), for 1Gb/s MAC data rate the minimum permitted Inter-Packet Gap at GMII transmit signals is 96 bits. As stated in Sub clause 4.4.2 note 3 the minimum Inter-Packet Gap at the GMII receive signals may be as small as 64 bits. In both cases Inter-Packet Gap may be equal to, or any value greater than, the minimum value stated.

Your interpretation has highlighted a deficiency in the standard. The use of 'interPacketGap' in Note 3 is not correct and should be Inter-Packet Gap as a constant cannot shrink. This will be addressed in the next revision of the standard through our maintenance process.

Question 1.2 (2)

*Was the minimum value of a 64-bit IPG decided on the basis of the discussion in the following minutes*2 of the IEEE 802.3 meeting? (This question is related to 1.1 (2) because the "nominal IPG" that is described in the following minutes seems to be related to the IPG value in the table in 4.4.2.,that is 96-bit)*

As described in the beginning of this interpretation response, the interpretation process can only comment on the standard and not what is in the minutes.

Question 1.2 (3)

How and where can "preamble growth", described in the minute above, remove 8 bits?

Note: It is conjectured that it is related to section 41.2.1.3.2 Preamble regeneration and section B.1.5.3 Interpacket Gap (IPG) shrinkage.

As described in the beginning of this interpretation response, the interpretation process can only comment on the standard and not what is in the minutes.

Question 1.2 (4)

Why and where can "variable network delays" that is clearly described as one of the factors in 4.4.2 Note3 cause IPG shrinkage? How was the factor considered when the minimum IPG value 64-bit in the Note3 was calculated? That is a factor that is not clearly described or explained in the above minutes of 1.2.(2).

The variable network delays term captures a number of factors that could introduce shrinkage.

As described in the beginning of this interpretation response, the interpretation process can only comment on the standard and not what is in the minutes. Further, we can only interpret what the standard says not what the intent is/was of that requirement.

Question 1.3 (1)

What is meant by "Note" in the IEEE rules (Mandatory, Arbitrary, Recommendation, or another term)?

A "Note" is defined in the IEEE style manual (http://standards.ieee.org/guides/style/2009_Style_Manual.pdf). In the 2009 edition this is in section 18.1 of the manual and has been reproduced below for your convenience:

"18.1 Notes

Explanatory statements may be used in the text for emphasis or to offer informative suggestions about the technical content of the standard. These notes provide additional information to assist the reader with a

particular passage and shall not include mandatory requirements. A note in the text is an informative part of the approved standard; therefore, important information on safety, health, or the environment shall not be included. A note should follow that paragraph to which it belongs, and shall be set apart from the text by introducing the statement with the capitalized word "NOTE-." Within each subclause, multiple notes in

sequence should be numbered "NOTE 1-", "NOTE 2-", etc. (See Annex B for examples.)"

Question 1.3 (2)

Is there any difference in meaning between "interFramGap", which seems to be described only in section 4.4.2, and "Inter-Packet Gap (IPG)", which is clearly specified in section 1.4 Definitions?

Note: In this document, "IPG" is tentatively used as a unified definition.

The standard is unambiguous. "interFrameGap" shall be interpreted as "interPacketGap" per the footnote on Table 4-2. "interPacketGap" is a Pascal constant that is defined in Sub clause 4.2.7.2 as described in the answer to Question 1.1 (1). "Inter-Packet Gap (IPG)" is defined in section 1.4.