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7 **IEEE Standard for Information technology—**
8 **Telecommunications and information exchange between systems—**
9 **Local and metropolitan area networks—**
10 **Specific requirements—**

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12 **Part 3: Carrier Sense Multiple Access with**
13 **Collision Detection (CSMA/CD) Access Method**
14 **and Physical Layer Specifications—**

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18 **Amendment: Media Access Control (MAC)**
19 **Parameters, Physical Layers, and Management**
20 **Parameters for 10 Gb/s Operation**

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25 **44. Introduction to 10 Gb/s baseband network**

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27 **44.1 Overview**

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29 **44.1.1 Scope**

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32 10 Gigabit Ethernet uses the IEEE 802.3 MAC sublayer, connected through a 10 Gigabit Media Independent
33 Interface (XGMII) to Physical Layer entities such as 10GBASE-SR, 10GBASE-LX4, 10GBASE-CX4,
34 10GBASE-LR, 10GBASE-ER, 10GBASE-SW, 10GBASE-LW, and 10GBASE-EW.

35
36 10 Gigabit Ethernet extends the IEEE 802.3 MAC beyond 1000 Mb/s to 10 Gb/s. The bit rate is faster and
37 the bit times are shorter—both in proportion to the change in bandwidth. The minimum packet transmission
38 time has been reduced by a factor of ten. A rate control mode (see 4.2.3.2.2) is added to the MAC to adapt
39 the average MAC data rate to the SONET/SDH data rate for WAN-compatible applications of this standard.
40 Achievable topologies for 10 Gb/s operation are comparable to those found in 1000BASE-X full duplex
41 mode and equivalent to those found in WAN applications.

42
43 10 Gigabit Ethernet is defined for full duplex mode of operation only.

44
45 **44.1.2 Objectives**

46 The following are the objectives of 10 Gigabit Ethernet:

- 47
48 a) Support the full duplex Ethernet MAC.
49 b) Provide 10 Gb/s data rate at the XGMII.
50 c) Support LAN PMDs operating at 10 Gb/s, and WAN PMDs operating at SONET STS-192c/SDH
51 VC-4-64c rate.
52 d) Support cable plants using optical fiber compliant with ISO/IEC 11801: 1995.
53 e) Allow for a nominal network extent of up to 40 km.
54 f) Support operation over 15m of copper cable as specified in section 54.x.

- g) Meet or exceed FCC/CISPR Class A operation.
- h) Support a BER objective of 10^{-12} .

44.1.3 Relationship of 10 Gigabit Ethernet to the ISO OSI reference model

10 Gigabit Ethernet couples the IEEE 802.3 (CSMA/CD) MAC to a family of 10 Gb/s Physical Layers. The relationships among 10 Gigabit Ethernet, the IEEE 802.3 (CSMA/CD) MAC, and the ISO Open System Interconnection (OSI) reference model are shown in Figure 44–1.

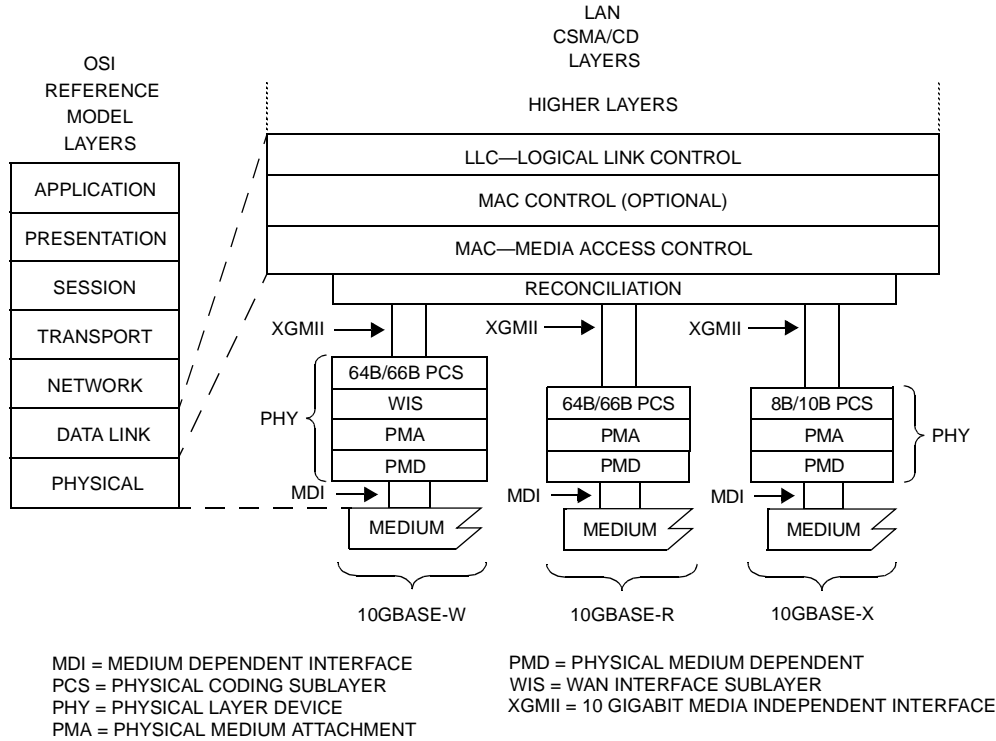


Figure 44–1—Architectural positioning of 10 Gigabit Ethernet

It is important to note that, while this specification defines interfaces in terms of bits, octets, and frames, implementations may choose other data-path widths for implementation convenience. The only exceptions are as follows:

- a) The XGMII, which, when implemented at an observable interconnection port, uses a four octet-wide data path as specified in Clause 46.
- b) The management interface, which, when physically implemented as the MDIO/MDC (Management Data Input/Output and Management Data Clock) at an observable interconnection port, uses a bit-wide data path as specified in Clause 45.
- c) The PMA Service Interface, which, when physically implemented as the XSBI (10 Gigabit Sixteen Bit Interface) at an observable interconnection port, uses a 16-bit-wide data path as specified in Clause 51.
- d) The MDI as specified in Clause 53 for 10GBASE-LX4, Clause 54 for 10GBASE-CX4 and in Clause 52 for other PMD types.

44.1.4 Summary of 10 Gigabit Ethernet sublayers

44.1.4.1 Reconciliation Sublayer (RS) and 10 Gigabit Media Independent Interface (XGMII)

The 10 Gigabit Media Independent Interface (Clause 46) provides an interconnection between the Media Access Control (MAC) sublayer and Physical Layer entities (PHY). This XGMII supports 10 Gb/s operation through its 32-bit-wide transmit and receive data paths. The Reconciliation Sublayer provides a mapping between the signals provided at the XGMII and the MAC/PLS service definition.

While the XGMII is an optional interface, it is used extensively in this standard as a basis for functional specification and provides a common service interface for Clauses 47, 48, and 49.

44.1.4.2 XGMII Extender Sublayer (XGXS) and 10 Gigabit Attachment Unit Interface (XAUI)

The 10 Gigabit Attachment Unit Interface (Clause 47) provides an interconnection between two XGMII Extender sublayers to increase the reach of the XGMII. This XAUI supports 10 Gb/s operation through its four-lane, differential-pair transmit and receive paths. The XGXS provides a mapping between the signals provided at the XGMII and the XAUI.

44.1.4.3 Management interface (MDIO/MDC)

The MDIO/MDC management interface (Clause 45) provides an interconnection between MDIO Manageable Devices (MMD) and Station Management (STA) entities.

44.1.4.4 Physical Layer signaling systems

This standard specifies a family of Physical Layer implementations. The generic term 10 Gigabit Ethernet refers to any use of the 10 Gb/s IEEE 802.3 MAC (the 10 Gigabit Ethernet MAC) coupled with any IEEE 802.3 10GBASE physical layer implementation. Table 44–1 specifies the correlation between nomenclature and clauses. Implementations conforming to one or more nomenclatures shall meet the requirements of the corresponding clauses.

Table 44–1—Nomenclature and clause correlation

Nomenclature	Clause								
	48 8B/10B PCS & PMA	49 64B/66B PCS	50 WIS	51 Serial PMA	52			53	54
					850 nm Serial PMD	1310 nm Serial PMD	1550 nm Serial PMD	1310 nm WDM PMD	PMD
10GBASE-SR		M ^a		M	M				
10GBASE-SW		M	M	M	M				
10GBASE-LX4	M							M	
10GBASE-CX4	M								M
10GBASE-LR		M		M		M			
10GBASE-LW		M	M	M		M			
10GBASE-ER		M		M			M		
10GBASE-EW		M	M	M			M		

^aM = Mandatory

1 The term 10GBASE-X, specified in Clauses 48, 53 and 54, refers to a specific family of physical layer
2 implementations based upon 8B/10B data coding method. The 10GBASE-X family of physical layer imple-
3 mentations is composed of 10GBASE-LX4 and 10GBASE-CX4.

4
5 The term 10GBASE-R, specified in Clauses 49, 51, and 52, refers to a specific family of physical layer
6 implementations based upon 64B/66B data coding method. The 10GBASE-R family of physical layer
7 implementations is composed of 10GBASE-SR, 10GBASE-LR, and 10GBASE-ER.

8
9 The term 10GBASE-W, specified in Clause 49 to Clause 52, refers to a specific family of physical layer
10 implementations based upon STS-192c/SDH VC-4-64c encapsulation of 64B/66B encoded data. The
11 10GBASE-W family of physical layer standards has been adapted from the ANSI T1.416-1999 (SONET
12 STS-192c/SDH VC-4-64c) physical layer specifications. The 10GBASE-W family of physical layer imple-
13 mentations is composed of 10GBASE-SW, 10GBASE-LW, and 10GBASE-EW.

14
15 All 10GBASE-R and 10GBASE-W PHY devices share a common PCS specification (see Clause 49). The
16 10GBASE-W PHY devices also require the use of the WAN Interface Sublayer, (WIS) (Clause 50).

17
18 Specifications of each physical layer device are contained in Clause 52 and Clause 53 and Clause 54.

19 20 **44.1.4.5 WAN Interface Sublayer (WIS), type 10GBASE-W**

21
22 The WIS provides a 10GBASE-W device with the capability to transmit and receive IEEE 802.3 MAC
23 frames within the payload envelope of a SONET STS-192c/SDH VC-4-64c frame.

24 25 **44.1.5 Management**

26
27 Managed objects, attributes, and actions are defined for all 10 Gigabit Ethernet components. Clause 30 con-
28 solidates all IEEE 802.3 management specifications so that 10/100/1000 Mb/s and 10 Gb/s agents can be
29 managed by existing network management stations with little or no modification to the agent code.

30 31 **44.2 State diagrams**

32
33 State machine diagrams take precedence over text.

34
35 The conventions of 1.2 are adopted, along with the extensions listed in 21.5.

36 37 **44.3 Delay constraints**

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39 Predictable operation of the MAC Control PAUSE operation (Clause 31, Annex 31B) demands that there be
40 an upper bound on the propagation delays through the network. This implies that MAC, MAC Control sub-
41 layer, and PHY implementers must conform to certain delay maxima, and that network planners and admin-
42 istrators conform to constraints regarding the cable topology and concatenation of devices. Table 44-2
43 contains the values of maximum sublayer round-trip (sum of transmit and receive) delay in bit time as spec-
44 ified in 1.4 and pause_quanta as specified in 31B.2.

45
46 Equation (44-1) specifies the calculation of bit time per meter of fiber based upon the parameter n , which
47 represents the ratio of the speed of light in the fiber to the speed of light in a vacuum. The value of n should
48 be available from the fiber manufacturer, but if no value is known then a conservative delay estimate can be
49 calculated using a default value of $n = 0.66$. The speed of light in a vacuum is $c = 3 \times 10^8$ m/s. Table 44-3
50 can be used to convert fiber delay values specified relative to the speed of light or in nanoseconds per meter.
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52
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Table 44-2—Round-trip delay constraints (informative)

Sublayer	Maximum (bit time)	Maximum (pause_quanta)	Notes
MAC, RS and MAC Control	8192	16	See 46.1.4.
XGXS and XAUI	4096	8	Round-trip of 2 XGXS and trace for both directions. See 47.2.2.
10GBASE-X PCS and PMA	2048	4	See 48.5.
10GBASE-R PCS	3584	7	See 49.2.15.
WIS	14336	28	See 50.3.7.
CX4 PMD	512	1	Includes 15m of 24AWG cable.
LX4 PMD	512	1	Includes 2 meters of fiber. See 53.2.
Serial PMA and PMD	512	1	Includes 2 meters of fiber. See 52.2.

$$\text{cable delay} = \frac{10^{10}}{nc} \text{ BT/m} \tag{44-1}$$

Table 44-3—Conversion table for cable delays

Speed relative to c	ns/m	BT/m
0.40	8.33	83.3
0.50	6.67	66.7
0.51	6.54	65.4
0.52	6.41	64.1
0.53	6.29	62.9
0.54	6.17	61.7
0.55	6.06	60.6
0.56	5.95	59.5
0.57	5.85	58.5
0.58	5.75	57.5
0.5852	5.70	57.0
0.59	5.65	56.5
0.60	5.56	55.6

Table 44–3—Conversion table for cable delays (continued)

Speed relative to c	ns/m	BT/m
0.61	5.46	54.6
0.62	5.38	53.8
0.63	5.29	52.9
0.64	5.21	52.1
0.65	5.13	51.3
0.654	5.10	51.0
0.66	5.05	50.5
0.666	5.01	50.1
0.67	4.98	49.8
0.68	4.90	49.0
0.69	4.83	48.3
0.7	4.76	47.6
0.8	4.17	41.7
0.9	3.70	37.0

44.4 Protocol Implementation Conformance Statement (PICS) proforma

The supplier of a protocol implementation that is claimed to conform to any part of IEEE 802.3, Clause 45 through Clause 54, demonstrates compliance by completing a Protocol Implementation Conformance Statement (PICS) proforma.

A completed PICS proforma is the PICS for the implementation in question. The PICS is a statement of which capabilities and options of the protocol have been implemented. A PICS is included at the end of each clause as appropriate. Each of the 10 Gigabit Ethernet PICS conforms to the same notation and conventions used in 100BASE-T (see 21.6).

44.5 Relation of 10 Gigabit Ethernet to other standards

Suitable entries for Table G1 of ISO/IEC 11801: 1995, Annex G, would be as follows:

- a) Within the section Optical Link:
CSMA/CD 10GBASE-SR ISO/IEC 8802-3/ PDAM 26
- b) Within the section Optical Link:
CSMA/CD 10GBASE-SW ISO/IEC 8802-3/PDAM 26
- c) Within the section Optical Link:
CSMA/CD 10GBASE-LR ISO/IEC 8802-3/PDAM 26

- d) Within the section Optical Link:
CSMA/CD 10GBASE-LW ISO/IEC 8802-3/PDAM 26
- e) Within the section Optical Link:
CSMA/CD 10GBASE-ER ISO/IEC 8802-3/PDAM 26
- f) Within the section Optical Link:
CSMA/CD 10GBASE-EW ISO/IEC 8802-3/PDAM 26
- g) Within the section Optical Link:
CSMA/CD 10GBASE-LX4 ISO/IEC 8802-3/PDAM 26

A suitable entry for Table G5 of ISO/IEC 11801: 1995, Annex G, is exemplified in Table 44-4.

Table 44-4—Table G5 of ISO/IEC 11801: 1995

	Fibre			Optical link per Clause 8								
	per Clauses 5, 7, and 8			Horizontal			Building backbone			Campus backbone		
	62.5/ 125 µm MMF	50/125 µm MMF	10/125 µm SMF	62.5/ 125 µm MMF	50/ 125 µm MMF	10/ 125 µm SMF	62.5/ 125 µm MMF	50/ 125 µm MMF	10/ 125 µm SMF	62.5/ 125 µm MMF	50/ 125 µm MMF	10/ 125 µm SMF
8802-3: 10GBASE-SR	I	I		I	N		I	I		I	I	
8802-3: 10GBASE-SW	I	I		I	N		I	I		I	I	
8802-3: 10GBASE-LR	I	I	I	I	I	N	I	I	N	I	I	N
8802-3: 10GBASE-LW	I	I	I	I	I	N	I	I	N	I	I	N
8802-3: 10GBASE-ER			I			N			N			N
8802-3: 10GBASE-EW			I			N			N			N
8802-3: 10GBASE-LX4	I	I	I	N	N	N	N	N	N	N	N	N

NOTE—"N" denotes normative support of the media in the standard.
"I" denotes that there is information in the International Standard regarding operation on this media.

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