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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital sections and digital line system – Optical line systems for local and access networks

1 Gbit/s point-to-point Ethernet-based optical access system

Recommendation ITU-T G.986

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Recommendation ITU-T G.986

1 Gbit/s point-to-point Ethernet-based optical access system

Summary

Recommendation ITU-T G.986 describes a 1 Gbit/s point-to-point Ethernet-based optical access system for the optical access services including the optical distribution network (ODN) specification, the physical layer specification and the operation, administration and maintenance (OAM) specification.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.986	2010-01-13	15

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1 Gbit/s point-to-point Ethernet-based optical access system

1 Scope

This Recommendation describes a 1 Gbit/s point-to-point Ethernet-based optical access system for the optical access services including the optical distribution network (ODN) specification, the physical layer specification and the operation, administration and maintenance (OAM) specification.

For an effective use of optical fibres cited in [ITU-T G.985], this Recommendation specifies only a single fibre bidirectional transmission system, dual-fibre systems being out of the scope of this Recommendation.

This Recommendation describes the case of a single domain managed ONT and related OLT requirements. The case of a dual domain managed ONT and related OLT requirements are for future study.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.984.4] Recommendation ITU-T G.984.4 (2008), *Gigabit-capable passive optical networks (G-PON): ONT management and control interface specification*.

[ITU-T G.985] Recommendation ITU-T G.985 (2003), *100 Mbit/s point-to-point Ethernet based optical access system*.

[IEEE 802] IEEE Standard 802-2001, *Local and Metropolitan Area Networks: Overview and Architecture*.

[IEEE 802.3] IEEE Standard 802.3-2008, *Information technology – Local and metropolitan area networks – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 optical access network (OAN) [ITU-T G.985]: The set of access links sharing the same network-side interfaces and supported by optical access transmission systems.

3.1.2 optical distribution network (ODN) [ITU-T G.985]: An ODN provides the optical transmission means from the OLT towards the users, and vice versa. It utilizes passive optical components.

3.1.3 optical line termination (OLT) [ITU-T G.985]: An OLT provides the network-side interface of the OAN, and is connected to the ODN.

3.1.4 optical network termination (ONT) [ITU-T G.985]: An ONT provides the user-side interface of the OAN, and is connected to the ODN.

3.1.5 wavelength division multiplexing (WDM) [ITU-T G.985]: Bidirectional multiplexing using different optical wavelength for up and downstream signals.

4 Abbreviations

This Recommendation uses the following abbreviations:

ANI Access Node Interface
GEM G-PON Encapsulation Method
GMII Gigabit Media Independent Interface
MAC Media Access Control
MIB Management Information Base
MLM Multi-Longitudinal Mode
OAM Operation, Administration and Maintenance
OAN Optical Access Network
ODN Optical Distribution Network
OLT Optical Line Termination
OMCC ONT Management and Control Channel
OMCI ONT Management and Control Interface
ONT Optical Network Termination
OUI Organizationally Unique Identifier
PCS Physical Coding Sub-layer
PMA Physical Medium Attachment
PMD Physical Medium Dependent
RMS Root Mean Square
RS Reconciliation Sub-layer
SLM Single Longitudinal Mode
UNI User Network Interface
WDM Wavelength Division Multiplexing

5 Configuration of an OAN

5.1 System configuration

See clause 5.1 of [ITU-T G.985].

5.2 Fibre type

See clause 5.2 of [ITU-T G.985].

5.3 Transmission methodology

Bidirectional transmission is accomplished by use of the wavelength division multiplexing (WDM) technique of the 1310 nm band (1260-1360 nm) and the 1490 nm band (1480-1500 nm) wavelengths on a single fibre, allowing the connection to be a point-to-point type ODN.

5.4 Wavelength allocation

For downstream, the operating wavelength range should be 1480-1500 nm.

For upstream, the operating wavelength range should be 1260-1360 nm.

These wavelength ranges are compatible with 1000BASE-BX10 specified in clause 59 of [IEEE 802.3].

5.5 ODN model

See clause 5.5 of [ITU-T G.985].

5.6 Classes for optical path loss

Recommended classes for optical path loss are shown in Table 1.

Table 1 – Classes for optical path loss

	Class S	Class A	Class B
Minimum loss	0 dB	4 dB	12 dB
Maximum loss	15 dB	20 dB	25 dB

5.7 Reflectance in ODN

See clause 5.7 of [ITU-T G.985].

6 Physical layer specification

The optical interface of optical network termination (ONT) and optical line termination (OLT) should follow the transmission and coding specification in conformance with physical medium attachment (PMA), physical coding sub-layer (PCS), gigabit media-independent interface (GMII), reconciliation sub-layer (RS) for 1000BASE-X. PMA and PCS are defined in clause 36 of [IEEE 802.3]. GMII and RS are defined in clause 35 of [IEEE 802.3]. This physical layer specification should have functionalities based on the physical medium dependent (PMD) sublayer defined in clause 59 of [IEEE 802.3]. The operation of the optical interface shall be full-duplex. Physical layer specification is also specified for each of the following applicable areas:

– Class S: optical path loss 15 dB, power penalty 1 dB for transmission within 10 km.

– Class A: optical path loss 20 dB, power penalty 1 dB for transmission within 20 km.

– Class B: optical path loss 25 dB, power penalty 1 dB for transmission within 30 km.

NOTE – The distance described above is not a standard, but for classification.

All parameters are specified as follows, and should be in accordance with Table 2 for an ONT, and Table 3 for an OLT. Transmit wavelength, receive wavelength, line code, maximum RMS width for MLM laser, pulse mask and bit error ratio specified in Tables 2 and 3 are compatible with 1000BASE-BX10 specified in clause 59 of [IEEE 802.3]. Either the damage threshold included in Tables 2 and 3 shall be met, or, the receiver shall be labelled to indicate the maximum optical input power level to which it can be continuously exposed without damage.

Table 2 – Physical layer specification for ONT

Items	Unit	Specification		
ODN class		**Class S**	**Class A**	**Class B**
Nominal bit rate	Gbit/s	1.25		
Transmit wavelength	nm	1260-1360		
Receive wavelength	nm	1480-1500		
Line code	–	8B10B block coding		
Spectral characteristic				
If MLM laser – Maximum RMS width	nm	See Table 59-4 of [IEEE 802.3] (Note)	– (Note)	– (Note)
If SLM laser – Maximum –20 dB width	nm	Less than 1 (Note)		
If SLM laser – Minimum side mode suppression ratio	dB	More than 30 (Note)		
Mean launch power MAX	dBm	0	+4	+4
Mean launch power MIN	dBm	–6	–3	–3
Minimum overload	dBm	0	0	–8
Minimum sensitivity	dBm	–22	–24	–29
Damage threshold MAX	dBm	–	+4	–7
Power penalty	dB	1		
Extinction ratio	dB	More than 8.2		
Pulse mask {X1,X2,Y1,Y2,Y3}	UI	0.22,0.375,0.2,0.2,0.3 See Figure 59-4 of [IEEE 802.3]		
S/X				
Optical return loss condition	dB	More than 14		
Bit error ratio	–	Less than 10^{-12}		
Optical return loss of the interface	dB	More than 14		
NOTE – Either MLM laser or SLM laser will be selected for Class S. Only SLM laser will be selected for Class A and Class B.				

Table 3 – Physical layer specification for OLT

Items	Unit	Specification		
ODN class		**Class S**	**Class A**	**Class B**
Nominal bit rate	Gbit/s	1.25		
Transmit wavelength	nm	1480-1500		
Receive wavelength	nm	1260-1360		
Line code	–	8B10B block coding		
Spectral characteristic				
If MLM laser – Maximum RMS width	nm	– (Note)	– (Note)	– (Note)
If SLM laser – Maximum –20 dB width	nm	Less than 1 (Note)		
If SLM laser – Minimum side mode suppression ratio	dB	More than 30 (Note)		
Mean launch power MAX	dBm	0	+4	+4
Mean launch power MIN	dBm	–6	–3	–3
Minimum overload	dBm	0	0	–8
Minimum sensitivity	dBm	–22	–24	–29
Damage threshold MAX	dBm	–	+4	–7
Power penalty	dB	1		
Extinction ratio	dB	More than 8.2		
Pulse mask {X1,X2,Y1,Y2,Y3}	UI	0.22,0.375,0.2,0.2,0.3 See Figure 59-4 of [IEEE 802.3]		
S/X				
Optical return loss condition	dB	More than 14		
Bit error ratio	–	Less than 10^{-12}		
Optical return loss of the interface	dB	More than 14		
NOTE – Only SLM laser will be selected for Class S, Class A and Class B.				

6.1 Transmit wavelength/Receive wavelength

The transmit and receive wavelengths are described in clauses 5.3 and 5.4.

6.2 Bit rate and line coding

Bit rate of both upstream and downstream is 1.25 Gbit/s, but its effective bandwidth is 1 Gbit/s because the line coding scheme is 8B10B block coding, which is compatible with PMA and PCS of 1000BASE-X defined in clause 36 of [IEEE 802.3].

6.3 Spectral characteristics

For multi-longitudinal mode (MLM) lasers, the spectral width is specified by the maximum root mean square (RMS) width under standard operating conditions. The RMS width means the standard deviation (σ) of spectral distribution. As to the measurement method for RMS width, all modes should be within 20 dB range from the peak mode.

For single longitudinal mode (SLM) lasers, the maximum spectral width is specified by the maximum full width measured at the point of 20 dB lower than the maximum amplitude of the central wavelength under standard operating conditions. Additionally, for control of mode partition noise in SLM systems, a minimum value for the laser side-mode suppression ratio is specified.

6.4 Mean launched power

See clause 6.4 of [ITU-T G.985].

6.5 Receiver characteristics

See clause 6.5 of [ITU-T G.985].

6.6 Extinction ratio

See clause 6.6 of [ITU-T G.985].

6.7 Pulse mask

Pulse mask at reference points is in conformance with the mask of the transmitter eye diagram for 1000BASE-BX10 specified in clause 59 of [IEEE 802.3].

6.8 S/X

See clause 6.8 of [ITU-T G.985].

6.9 Optical return loss of the interface

The optical return loss of the interface means the ODN reflection of its received light. Therefore, the optical return loss of the interface is defined by the wavelength of 1490 nm band (1480-1500 nm) for the ONT, and by the wavelength of 1310 nm band (1260-1360 nm) for the OLT.

6.10 Test pattern

The data pattern to be used in measuring wavelength or spectral characteristics is not specified in this Recommendation, but the test patterns defined in clause 59.7.1 of [IEEE 802.3] may be referred.

6.11 Signal detect

See clause 6.12 of [ITU-T G.985].

7 OAM specification for single domain ONT management

7.1 OAM structure

The following combined OAM structure is applied. ONT management and control interface (OMCI) specifications were optimized for single domain ONT management and the managed entities are specified in [ITU-T G.984.4].

– OAM for link operation: The OAM functions specified in clause 57 of [IEEE 802.3] are applied.

– OAM for ONT equipment and service management: The OMCI specifications optimized for this section are applied.

Table 4 summarizes the OAM functions and indicates whether the specifications from clause 57 OAM of [IEEE 802.3], or the OMCI specifications optimized for this section, would be applied to each of them.

Table 4 – OAM functions and applicable specifications

OAM functions		Applicable specifications
ONT status notification	ANI status	Clause 57 OAM of [IEEE 802.3]
	ONT vendor code and ONT model number	OMCI for this section ONT-E defined in clause 9.1.13 of [ITU-T G.984.4]
	UNI status	OMCI for this section Physical path termination point of Ethernet UNI defined in clause 9.5.1 of [ITU-T G.984.4]
ONT remote setting	UNI status	OMCI for this section Physical path termination point of Ethernet UNI defined in clause 9.5.1 of [ITU-T G.984.4]
Fault management	Power supply	Clause 57 OAM of [IEEE 802.3]
	ONT failure	Clause 57 OAM of [IEEE 802.3] and/or OMCI for this section ONT-E defined in clause 9.1.13 of [ITU-T G.984.4]
	Received signal	Clause 57 OAM of [IEEE 802.3]
	UNI status	OMCI for this section Physical path termination point of Ethernet UNI defined in clause 9.5.1 of [ITU-T G.984.4]
Loop-back test	ONT loop-back status	OMCI for this section Physical path termination point of Ethernet UNI defined in clause 9.5.1 of [ITU-T G.984.4]

7.2 OMCI Ethernet frame

7.2.1 Frame structure

For OAM for ONT equipment and service management, each ONT management and control protocol packet is encapsulated into the protocol data field as the OMCI message field in a MAC (media access control) frame with the OUI extended ethertype in the Length/Type field defined in clause 2.3 of [IEEE 802]. The frame is called the OMCI Ethernet frame in this Recommendation. Figure 1 shows the OMCI Ethernet frame structure where the ONT management and control protocol packet is assumed to be taken from a GEM (G-PON encapsulation method) packet.

The OMCI Ethernet frame contains a single 40-byte long OMCI message field. It is for further study for the frame structure with multiple and flexible length OMCI message fields.

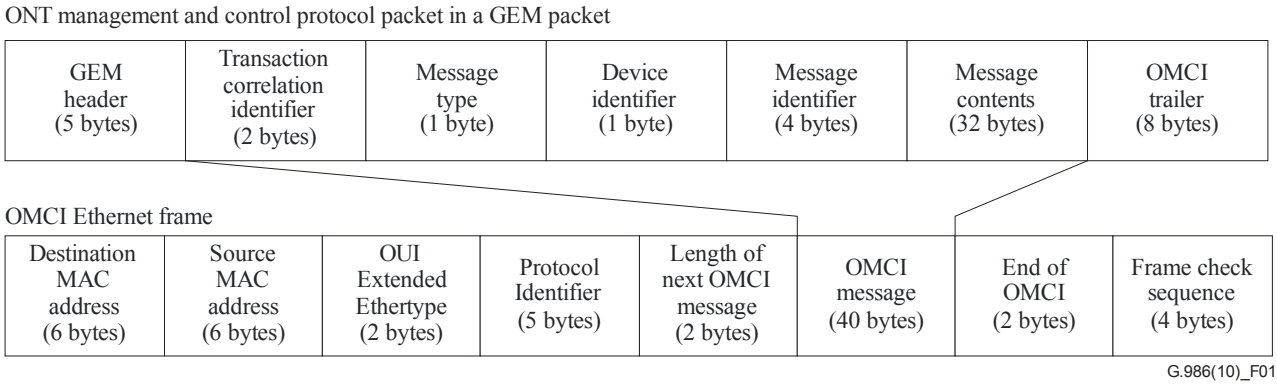

Figure 1 – OMCI Ethernet frame structure

7.2.2 Frame format and messages

The OMCI Ethernet frame format and messages are defined in Figure 2.

Field	Length	Definition	Value
Destination MAC address	6 bytes	Destination MAC address	See 7.2.2.1
Source MAC address	6 bytes	Source MAC address	See 7.2.2.1
OUI extended ethertype	2 bytes	OUI extended ethertype defined in [IEEE 802]	0x88-B7
Protocol identifier	5 bytes	Protocol ID defined in [IEEE 802]	
OUI	3 bytes	ITU-T OUI	0x00-19-A7
ITU-T Subtype	2 bytes	ITU-T Subtype reserved by Q.2/15 for OMCI	0x00-02
Length of next OMCI message	2 bytes	Indication of the length of a following OMCI message field	0x00-28
OMCI message	40 bytes		It is for further study for the flexible length message.
Transaction correlation identifier	2 bytes	Defined in clause 11.2.1 of [ITU-T G.984.4]	
Message type	1 byte	Defined in clause 11.2.2 of [ITU-T G.984.4]	
Device identifier	1 byte	Defined in clause 11.2.3 of [ITU-T G.984.4]	0x0A
Message identifier	4 bytes	Defined in clause 11.2.4 of [ITU-T G.984.4]	
Message contents	32 bytes	Defined in clause 11.2.6 and Appendix II of [ITU-T G.984.4]	
End of OMCI	2 bytes	Indication of no OMCI message following	0x00-00
Frame check sequence	4 bytes	FCS defined in [IEEE 802.3]	

Figure 2 – OMCI Ethernet frame format and messages

7.2.2.1 Destination MAC address and source MAC address

In the OMCI Ethernet frame format shown in Figure 2, the destination MAC address shall be the broadcast address or the unicast MAC address of the far end equipment, which is not defined in this Recommendation. Source MAC address shall be the source equipment MAC address.

7.2.3 Frame termination rule

The following frame termination rule shall be applied to the OMCI Ethernet frame.

1) Frame termination rule at ANI:

   When a frame with destination MAC address, OUI extended ethertype and protocol identifier, all of which satisfy the values defined in Figure 2, is received,

   - the received frame shall not be transferred to UNI nor to SNI.

2) Frame termination rule at UNI or SNI:

   When a frame with OUI extended ethertype and protocol identifier, both of which satisfy the values defined in Figure 2, is received,

   - the received frame shall not be transferred to ANI;
   - messages contained in the received frame shall be ignored.

7.3 Activation process

Figure 3 shows the activation process. As described in clause 9.1, the ONT shall follow the silent start function first. After confirming that the opposite side is the expected OLT, the ONT starts transmitting Idle and/or signals (i.e., MAC frames) to link up between the two. Then, the ONT management and control channel (OMCC) handshaking process begins.

During the process, the OLT should check if the OMCI and which managed entities are supported by the ONT: The OLT performs a get action on the ONT data managed entity. When the OLT receives a proper get response from the ONT, the OLT recognizes that the ONT supports a proper OMCI. It is out of the scope of this Recommendation if the OLT should perform get actions on other entities.

When the OMCC handshaking is done, the OMCC is established. Before, during, or after the OMCC handshaking process, the OAM discovery process for link operation begins. The OAM discovery process is specified in clause 57 of [IEEE 802.3].

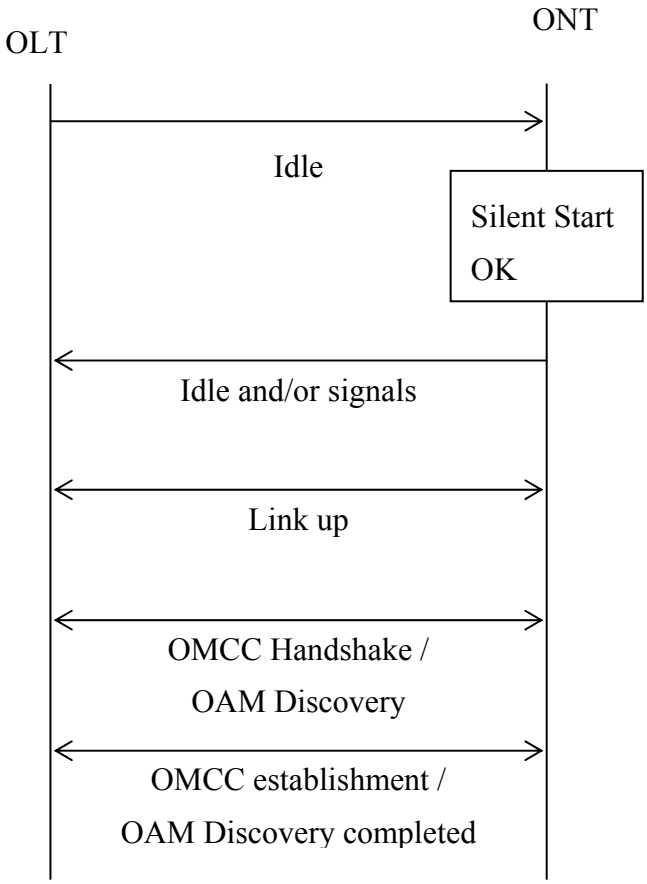

Figure 3 – Activation process

7.4 ONT with multiple UNI ports

The specification of the ONT having multiple user network interface (UNI) ports shall be specified in this Recommendation as optional. Figure 4 shows an image of the ONT having multiple UNI ports. The physical path termination point Ethernet UNI managed entity defined in clause 7.7.3 is specified to support multiple UNI ports also.

NOTE – Data forwarding permission rule between UNI ports is for further study.

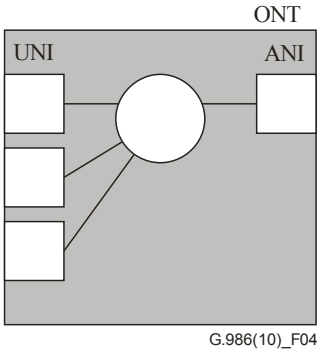

Figure 4 – ONT with multiple UNI ports

7.5 Managed entities

The possible managed entities are listed in Table 5.

Table 5 – Managed entities of the OMCI for this Recommendation

Managed entity	Required/ Optional	Description
ONT-E	R	Used for ONT equipment management
ONT data	R	Used for OMCI MIB management
Physical path termination point Ethernet UNI	R	Used for physical path termination point at the Ethernet UNI

7.6 Managed entity relation diagram

See clause 8.2.11 of [ITU-T G.984.4].

7.7 MIB description

7.7.1 ONT-E

See clause 9.1.13 of [ITU-T G.984.4].

7.7.2 ONT data

See clause 9.1.3 of [ITU-T G.984.4].

7.7.3 Physical path termination point Ethernet UNI

See clause 9.5.1 of [ITU-T G.984.4].

8 OAM specification for two-domain ONT management

The OAM structure of 1 Gbit/s point-to-point Ethernet-based optical access system for dual domain managed ONT is for future study.

9 Other requirements

9.1 Silent start function of ONT

The transmitter in ONT must be initially disabled in order to avoid disturbing other access systems in case of mis-connection. The ONT shall enable the transmitter to enter a handshaking process with OLT only after confirming that the frame structure and/or the line coding of the received downstream signal are matched with those the ONT complies with. This confirmation shall be done with both OLT and ONT being set the auto-negotiation function defined in clause 37 of [IEEE 802.3] disabled.

When the connection between ONT and OLT is disabled, the ONT shall return to the initial state in which the transmitter is disabled, after waiting at least 20 ms from the moment the disconnection is detected, so that the ONT can send notification signals to the OLT.

This is a unique function for the optical-access application that has directionality (i.e., having different parameter values for upstream and downstream). In this regard, the relevant PMD type to implement this function in [IEEE 802.3] is 1000BASE-BX10 (clause 59 of [IEEE 802.3]).

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