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TITLE: ETHERNET FRAME OVER SDH/WDM

Summary
Transferring Ethernet Frames (including those of Ethernet, Fast Ethernet and Gigabit Ethernet) over SDH or WDM is a simple and cheap technique to connect LANs within a private and public network. This Recommendation specifies a protocol suite structure of Ethernet Frame (defined by IEEE802.3, IEEE802.3u and IEEE802.3z) over SDH/WDM for the purpose of providing the future protocol compatibility among peer systems, and applies to Synchronous Digital Hierarchy or Optical Interfaces of Multichannel Optical Line Systems. The capabilities of supporting the LAPS protocol procedure at high speed, and IEEE802.3/802.3u/802.3z frame directly mapping to LAPS are mainly included. This Recommendation will be used to data network and open system communications related to private and public network.

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Introduction

Internet market has been growing at a greater rate. Growth is a basic issue which caused there to be a need for expanding the scope of Ethernet area. What are the existing transmission resources to be used? One of the best Telecom resources is SDH or WDM in the world. SDH and related WDM (Wavelength Division Multiplex) optical transport network are considered to be the foundation for the physical layer of the broadband IP and B-ISDN. SDH have been deployed all over the world in recent ten years.

Transferring Ethernet Frame (defined by IEEE802.3, IEEE802.3u and IEEE802.3z) over SDH or WDM is a simple and cheap technique to connect LANs within a private and public network. This Recommendation expands the scope of LAPS which was introduced in draft Recommendation X.ipos (using LAPS) to adapt Ethernet frame to SDH or WDM. The full transparency is guaranteed for mapping Ethernet frame to LAPS, and mapping LAPS to SDH/WDM. The model of Ethernet over SDH/WDM shall be particularly well suited for the network resource of existing SDH and Ethernet/Fast-Ethernet/Gigabit-Ethernet.

Ethernet Frame over SDH/WDM

1. Scope

This Recommendation specifies a protocol suite structure of Ethernet Frame (defined by IEEE802.3, IEEE802.3u and IEEE802.3z) over SDH/WDM for the purpose of providing the future protocol compatibility among peer systems, and applies to Synchronous Digital Hierarchy or Optical Interfaces of Multichannel Optical Line Systems (Maximum number of Channels: 4,8,16,32; Signal channel types: STM-4, STM-16, STM-64; Transmission over a single fibre: unidirectional or bi-directional). LAPS protocol and specification which was introduced in X.ipos, continue to be used to address its capabilities of providing the adaptation from Ethernet frame to SDH or WDM. LAPS describes an HDLC-like framing structure to encapsulate MAC frame as shown in Figure 2, provide a point-to-point full-duplex simultaneous bi-directional operations. Connecting Ethernet Switches to a SDH or WDM network is a very attractive way to provide Ethernet Frame over a Wide Area Network It is transparent to the Ethernet switch that one or more Ethernet switch ports is or are connected. The relationship between LAPS and Ethernet and SDH/WDM physical layer, together with relative primitives shall present as following diagram (see Figure 1).

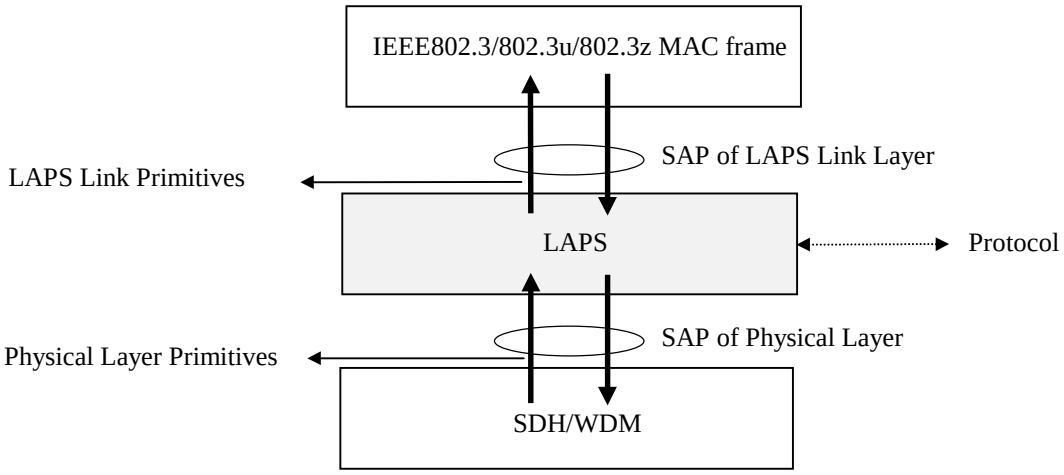


Figure 1 - The relationship between Ethernet frame and LAPS and SDH/WDM

This Recommendation does not specify the method of mapping LAPS to SDH or WDM. No change is made for all Ethernet-based protocols (including IEEE802.3, IEEE802.3u and IEEE802.3z) and all SDH or WDM standards.

NOTE 1 - It is intended that Ethernet Frame over SDH can be extended, in future amendments, to support additional new type of data service.
NOTE 2 - LAPS used within Ethernet Frame over SDH is not used to coexist with HDLC (ISO 3309 or RFC 1662), LAPB/ITU-T X.25, LAPD/ITU-T Q.921 and LAPF/ITU-T Q.922 within the same physical layer in future.
NOTE 3 - This Recommendation shall be applied to 10BASE-T, 100BASE-T, 1000BASE-T, 1000BASE-CX, 1000BASE-SX and 1000BASE-LX. The full duplex mode of 1000BASE-SX and 1000BASE-LX over WDM is optional. The repeater of IEEE 802.3u and IEEE 802.3z should be as an exception.

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: all 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 currently valid ITU-T Recommendations is regularly published.

2.1 ITU-T Recommendations

[1] Draft Recommendation X.ipos, *IP over SDH using LAPS*

[2] ITU-T Recommendation X.200 (1994), *Data Network and Open System Communications - Open System Interconnection - Model and Notation.*

[3] ITU-T Recommendation X.212 (1988), *Open System Interconnection -Service Definitions - Data Link Service Definition for Open Systems Interconnection for ITU-T Applications.*

[4] ITU-T Recommendation G.707 (1996), *Network node interface for the synchronous digital hierarchy (SDH).*

[5] ITU-T Recommendation G.692 (1998), *Optical Interface for Multichannel Systems with Optical Amplifiers.*

2.2 IEEE Specifications

[1] IEEE802.3 *CSMA/CD Access Method and Physical Layer Specifications*

[2] IEEE802.3u *Media Access Control(MAC) Parameters, Physical Layer, Medium Attachment Units, and Repeater for 100Mb/s Operation, Type 100BASE-T*

[3] IEEE802.3z *Media Access Control(MAC) Parameters, Physical Layer, Medium Attachment Units, and Repeater for 1000Mb/s Operation, Type 1000BASE-LX, 1000BASE-SX, 1000BASE-CX*

3. Definitions

For the purposes of this Recommendation, the following definitions apply:

3.1 Ethernet Frame over SDH/WDM: The data communication architecture of combination Ethernet (IEEE802.3/802.3u/802.3z) with SDH or WDM network. The physical layer is defined as SDH or WDM, the second layer is LLC/MAC/LAPS.

3.2 LAPS: A type of HDLC, including data link service and protocol specification which have been used to IP over SDH using LAPS.

4. Abbreviations

4.1 Abbreviations specified in IEEE 802.3, IEEE 802.3u and IEEE802.3z

This Recommendation makes use of the following abbreviations specified ISO/IEC 8802-3 and ISO 8802-2.

a) LAN Local area network

b) LLC Logical link control

c) MAC Media access control

4.2 Abbreviations specified in ITU-T G.707 and G.692

This Recommendation makes use of the following abbreviations specified in ITU-T G.707 and G.692.

a) SDH Synchronous Digital Hierarchy

b) STM Synchronous Transfer Module

c) sSTM Sub-STM

d) VC Virtual Container

e) WDM Wave Division Multiplex

4.3 Abbreviations specified by this Recommendation

a) EOS Ethernet Frame over SDH/WDM

b) LAPS Link Access Procedure - SDH

5. The protocol framework of Ethernet Frame over SDH/WDM

The layer/protocol stack for Ethernet frame over STM-N, the layer/protocol stack for Ethernet frame over sSTM-n and the layer/protocol stack over WDM are shown in Figure 2, Figure 3 and Figure 4 respectively. The Figure 5 and Figure 6 illustrate protocol configuration and possible network example for SDH respectively.

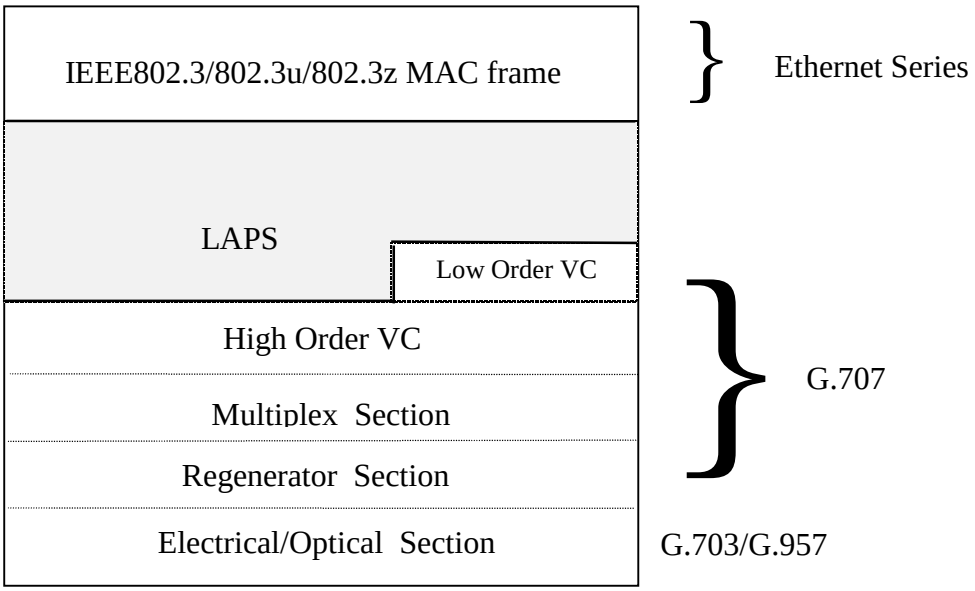


Figure 2 - Layer/Protocol Stack for Ethernet Frame over STM-N

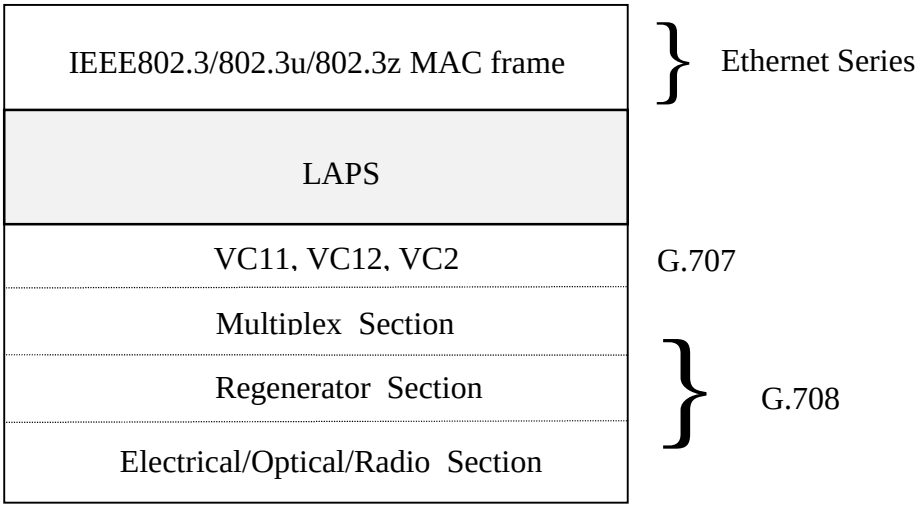


Figure 3 - Layer/Protocol Stack for Ethernet Frame over sSTM

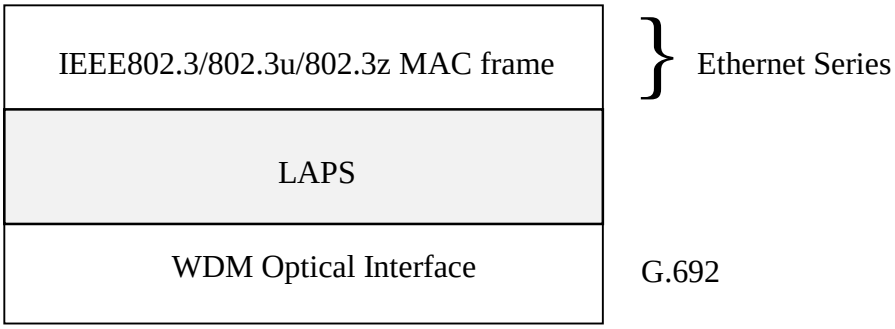


Figure 4 - Layer/Protocol Stack for Ethernet Frame over WDM

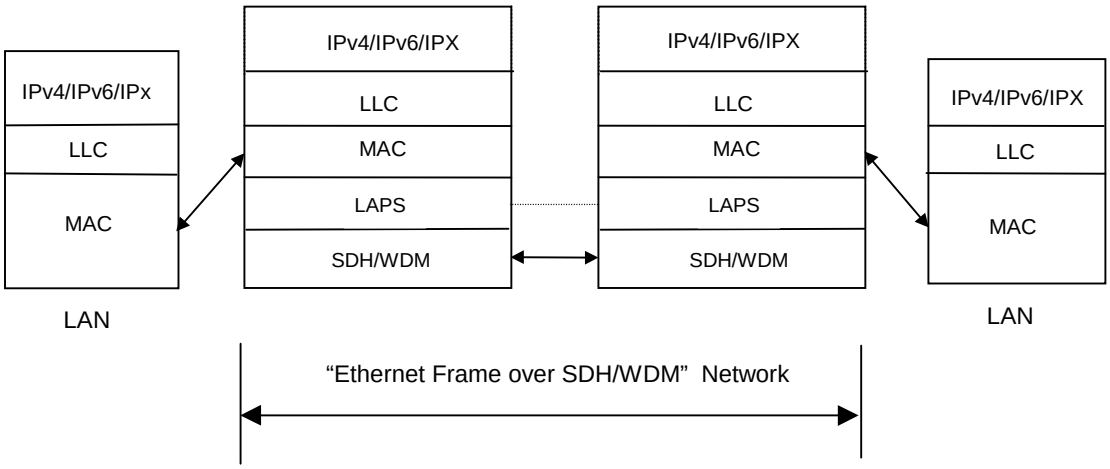


Figure 5 - The Protocol Configuration of Ethernet Frame over SDH/WDM

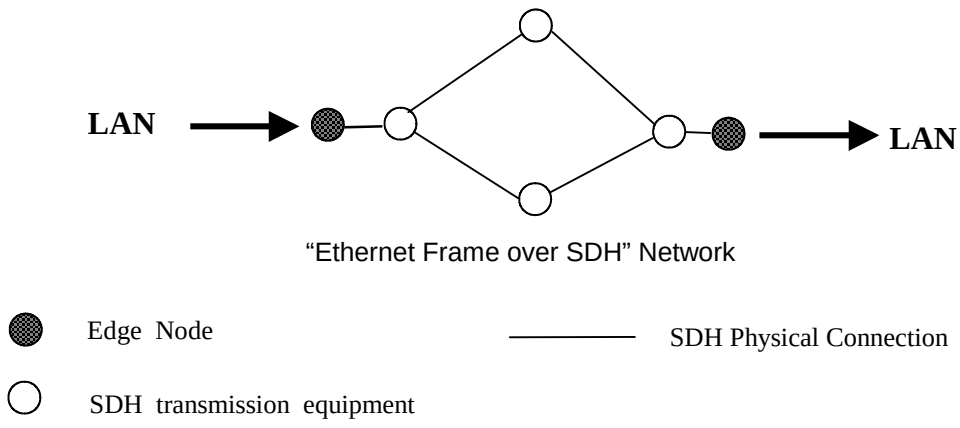


Figure 6 - "Ethernet Frame over SDH" network example

6. The SDH/WDM Physical layers

This Recommendation treats SDH transports as octet-oriented synchronous point-to-point links. The SDH frames are an octet-oriented synchronous multiplex mapping structure which specifies a series

of standard rates, formats and mapping method. Table 1 shows the bandwidth value of the VCs and Table 2 of the STMs which are currently specified. The use of control signals is not required. The self-synchronous scrambling/descrambling ($x^{43} + 1$) function is applied during insertion/extraction into/from the synchronous payload envelope (see Annex C). This Recommendation uses the future concatenation of virtual containers as defined in the ner version of ITU-T Recommendation G.707.

TABLE 1 - The bandwidth of the VCs

VC type	**VC bandwidth** (kbit/s)	**VC payload** (kbit/s)
VC-11	1 664	1 600
VC-12	2 240	2 176
VC-2	6 848	6 784
VC-3	48 960	48 384
VC-4	150 336	149 760
VC-4-4c	601 304	599 040
VC-4-16c	2 405 376	2 396 160
VC-4-64c(*)	9 621 504	9 584 640

(*) For further study under SG15

TABLE 2 - STM interface rates

STM type	**STM bit rate** (kbit/s)
sSTM-11	2 880
sSTM-12	5 184
sSTM-14	9 792
sSTM-18	19 792
sSTM-116	37 444
sSTM-21	7 488
sSTM-22	14 400
sSTM-24	28 224
STM-0	51 840
STM-1	155 052
STM-4	622 080
STM-16	2 488 320
STM-64	9 953 280

If WDM physical layer is used, Optical Interface Features of Multichannel Optical Line Systems includes Maximum Number of Channels: 4,8,16,32, Signal Channel Types: STM-4, STM-16, STM-64, Transmission over a single fibre: unidirectional or bi-directional.

Communication service facilities between data link layer and physical layer are accomplished by means of primitives (see Table 3) in this Recommendation. Primitives specification of Table 3 specify the interaction between data link layer and physical layer to invoke and provide a service, and presents the elements and procedures.

TABLE 3 - The primitives of physical layer

Primitive name	Primitive type
PH-ACTIVE	Request Indication
PH-DEACTIVE	Indication
PH-DATA	Request Indication

7. Service facilities and protocol specifications of LAPS

The default maximum frame size of LAPS shall be capable of supporting an information field of 1600 octets (at least) for Ethernet frame over SDH/WDM. The SAPI is assigned to 0x1c (hexadecimal). The associated service facilities and protocol specifications of LAPS is included in Annex A of the draft Recommendation X.ipos.

NOTE - It is needed to replace “Layer 3 or network layer or IP based network”, “IP packet” and “Layer 2 or data link layer” with “MAC layer”, “MAC frame” and “LAPS “ respectively in Annex A of X.ipos.

8. Encapsulation

LAPS link entity accepts packets from the MAC layer through the Reconciliation sublayer and GMII(Gigabit Media Independent Interface) for Gigabit Ethernet or MII(Media Independent Interface) for 100Mb/s and 10Mb/s Ethernet. No address filtering function is used. The function unit of Ethernet Frame over SDH/WDM forwards all incoming packets to its peer connected link except the originating link, and is permitted to buffer one or more incoming frames before forwarding them. Figure 7 shows the relationship between the Reconciliation sublayer/GMII/MII and LAPS/SDH/WDM.

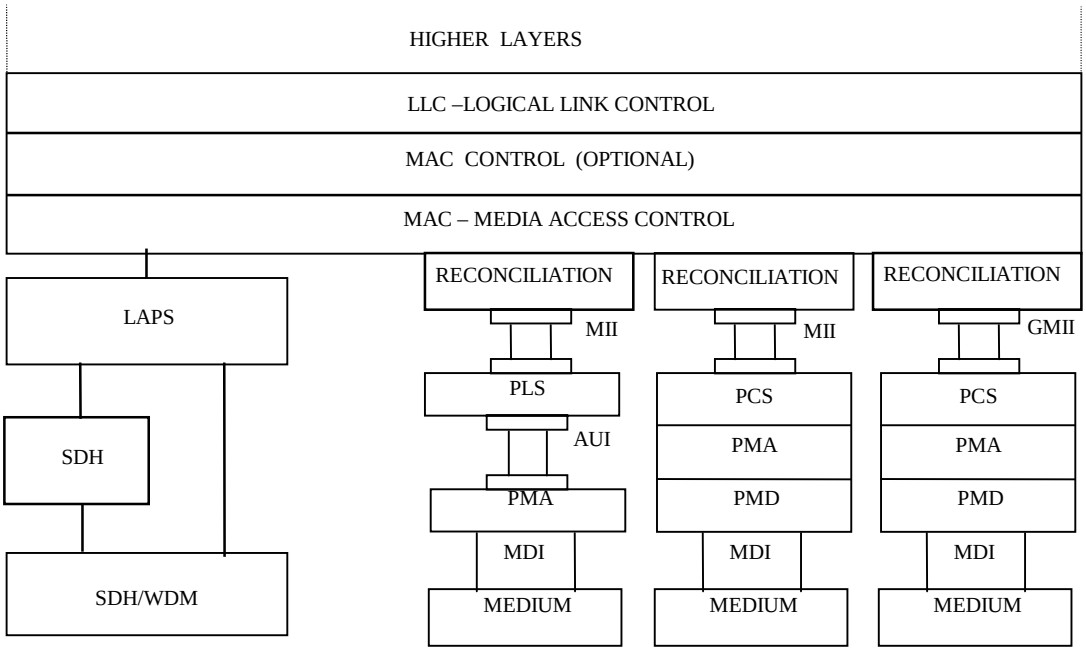
9. Functional elements of Gigabit Ethernet over SDH/WDM

Gigabit Ethernet supports the full-duplex operation modes of switch-to-switch and switch-to-end-station connections, half-duplex operating modes of shared connections for repeater and the CSMA/CD access mechanism. 1000BASE-LX specifies operation over a pair of optical fibers using long wavelength optical transmission. 1000BASE-LX is targeted at longer multi-mode fiber backbones and single mode campus backbones. 1000BASE-SX specifies operation over a pair of optical fibers using short wavelength optical transmission. 1000BASE-SX is targeted at lowest cost multi-mode fiber runs in horizontal and shorter backbone applications.

There are also another two standards efforts for Gigabit Ethernet transmission over copper cabling. The first copper link standard is defined by the IEEE 802.3z task force and is referred to as 1000BASE-CX. It provides interconnection of equipment clusters with the physical interface of short-haul copper and supports a switching closet or computer room within the scope of 25 meter distance. The second copper link standard is intended to have the capabilities of using in horizontal cabling application engineering, provides 1 GBPS Ethernet signal transmission over four pairs of category 5 UTP (Unshielded Twisted Pair) cable, covering distances of up to 100 meters or networks with a diameter of 200 meters. The functional elements of four standards of Gigabit Ethernet, along with LAPS/SDH/WDM is illustrated in Figure 8.

With respect to Gigabit Ethernet over WDM and full duplex 1000Mb/s topology limitation, a pair of optical fibers using long or short wavelength optical transmission could be mapped directly over

WDM in the way of external modulation (which is outside the scope of this Recommendation). The single mode optical transmission distance of 1000BASE-LX can be reached 1575km according to the latest experiment resuilt. Unlike half duplex CSMA/CD networks, the physical size of full duplex 1000M/s networks is not limited by the round-trip collision propagation delay. Instead, the maximum link length between DTEs is limited only by the signal transmission characteristics of the specific link. In the case of the Ethernet Frame over WDM, the half duplex CSMA/CD networks and 1000BASE-CX were applied only for this Recommendation.



LAPS = LINK ACCESS PROCEDURE - SDH
SDH = Synchronous Digital Hierarchy
WDM = Wave Division Multiplxing
AUI = Attachment Unit Interface
MDI = Medium Independent Interface
MII = Media Independent Interface
GMII = Gigabit Media Independent Interface

MAU = Medium Attachment Unit
PLS = Physical Layer Signalling
PCS = Physical Coding Sub-layer
PMA = Physical Medium Attachment
PHY = Physical Layer Device
PMD = Physical Medium Dependent

Figure 7 - The relationship between the Reconciliation sublayer/GMII/MII and LAPS/SDH/WDM on Ethernet Frame over SDH/WDM

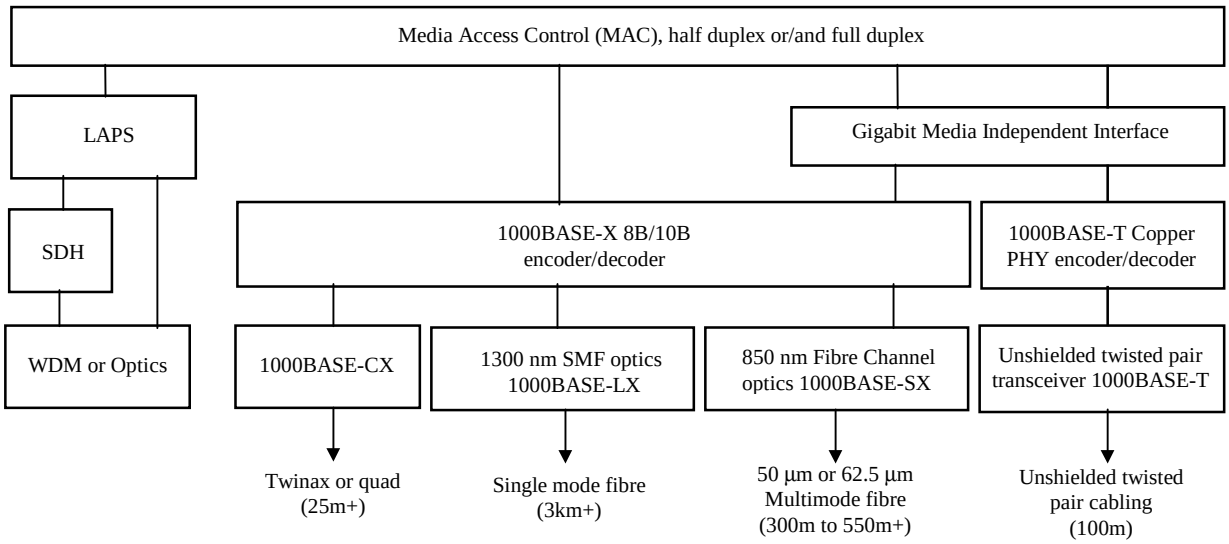


Figure 8 - Functional elements of Gigabit Ethernet over SDH/WDM

APPENDIX I

The possible application area of this technology

(This appendix I does not form an integral port of this Recommendation)

I.1 The SDH private network connection for the Layer 2 switch and Hubs of 10BASE-T and 100BASE-T, which is showed in Figure I.1.

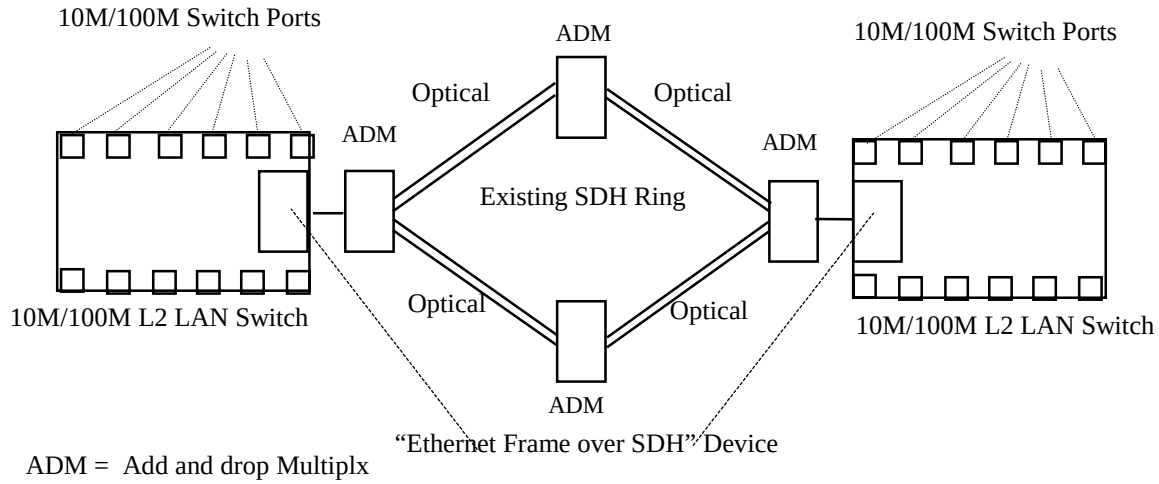


Figure I.1 - An example of private network of Ethernet Frame over SDH

I.2 The SDH public network connection with Layer 3 switches of Fast and Gigabit Ethernet (see Figure I.2)

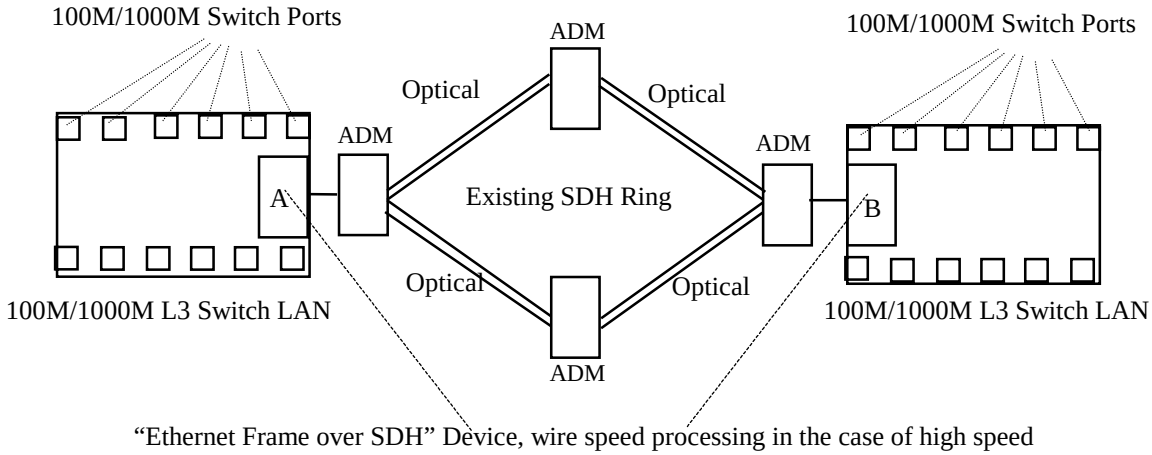


Figure I.2 - An example of public network of Ethernet Frame over SDH

I.3 The accessing unit of transmission system with Ethernet interface (see Figure I.3)

I.4 The Ethernet switch port with SDH channel (see Figure I.3).

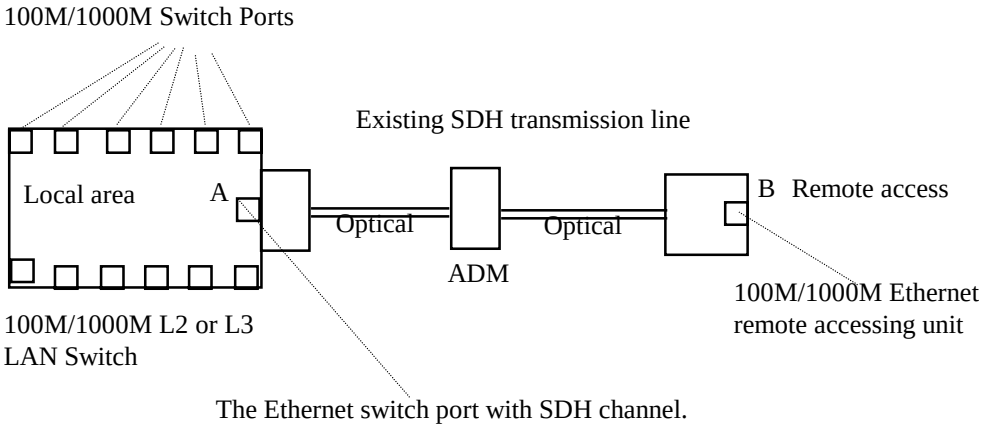
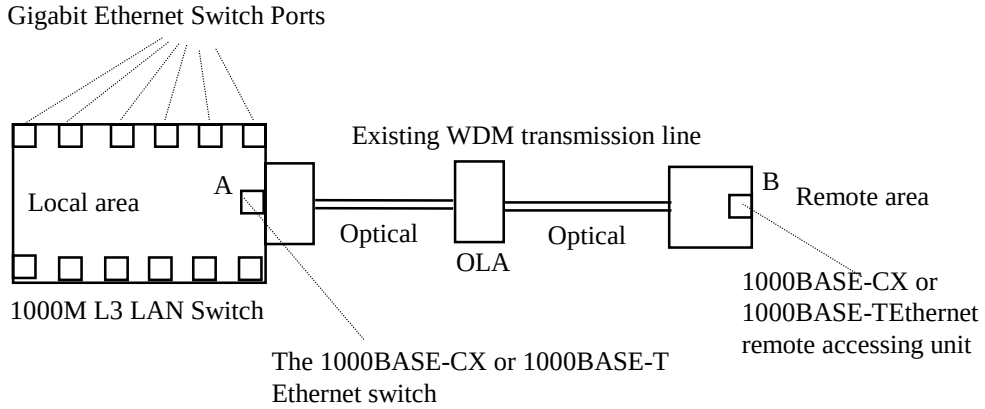


Figure I.3 - An example of public network of Ethernet Frame over SDH

I.5 The 1000BASE-CX and half duplex CSMA/CD Gigabit Ethernet switch port directly mapping into WDM channel (see Figure I.4)



OLA: Optical Line Amplifier

Figure I.4 - An example of public network of Ethernet Frame over WDM