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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

Gigabit-capable passive optical networks (GPON): General characteristics

Recommendation ITU-T G.984.1

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Recommendation ITU-T G.984.1

Gigabit-capable passive optical networks (GPON): General characteristics

Summary

Recommendation ITU-T G.984.1 describes a flexible optical fibre access network capable of supporting the bandwidth requirements of business and residential services and covers systems with nominal line rates of 2.4 Gbit/s in the downstream direction and 1.2 Gbit/s and 2.4 Gbit/s in the upstream direction. Both symmetrical and asymmetrical (upstream/downstream) gigabit-capable passive optical network (GPON) systems are described. This Recommendation proposes the general characteristics for GPON based on operators' service requirements.

Source

Recommendation ITU-T G.984.1 was approved on 29 March 2008 by ITU-T Study Group 15 (2005-2008) under Recommendation ITU-T A.8 procedure.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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Recommendation ITU-T G.984.1

Gigabit-capable passive optical networks (GPON): General characteristics

1 Scope

This Recommendation addresses the general characteristics of gigabit-capable passive optical network (GPON) systems in order to guide and motivate the physical layer and the transmission convergence layer specifications. The general characteristics include examples of services, user-network interfaces (UNIs) and service node interfaces (SNIs) that are requested by network operators. Also, this Recommendation shows the principle deployment configuration.

As much as possible, this Recommendation maintains characteristics from [ITU-T G.982] and ITU-T G.983.x-series Recommendations. This is to promote backward-compatibility with existing optical distribution networks (ODNs) that complies with those Recommendations.

GPON systems are characterized, in general, by an optical line termination (OLT) system and an optical network unit (ONU) or optical network termination (ONT) with a passive optical distribution network (ODN) interconnecting them. There is, in general, a one-to-many relationship between the OLT and the ONU/ONTs, respectively.

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.652] Recommendation ITU-T G.652 (2003), *Characteristics of a single-mode optical fibre cable*.
- [ITU-T G.808.1] Recommendation ITU-T G.808.1 (2006), *Generic protection switching – Linear trail and subnetwork protection*.
- [ITU-T G.902] Recommendation ITU-T G.902 (1995), *Framework Recommendation on functional access networks (AN) – Architecture and functions, access types, management and service node aspects*.
- [ITU-T G.982] Recommendation ITU-T G.982 (1996), *Optical access networks to support services up to the ISDN primary rate or equivalent bit rates*.
- [ITU-T G.983.1] Recommendation ITU-T G.983.1 (1998), *Broadband optical access systems based on Passive Optical Networks (PON)*.
- [ITU-T G.983.2] Recommendation ITU-T G.983.2 (2002), *ONT management and control interface specification for B-PON*.
- [ITU-T G.983.3] Recommendation ITU-T G.983.3 (2001), *A broadband optical access system with increased service capability by wavelength allocation*.
- [ITU-T G.984.2] Recommendation ITU-T G.984.2 (2003), *Gigabit-capable Passive Optical Networks (GPON): Physical Media Dependent (PMD) layer specification*.
- [ITU-T G.984.3] Recommendation ITU-T G.984.3 (2008), *Gigabit-capable Passive Optical Networks (GPON): Transmission convergence layer specification*.

- [ITU-T G.984.4] Recommendation ITU-T G.984.4 (2008), *Gigabit-capable Passive Optical Networks (GPON): ONT management and control interface specification*.
- [ITU-T G.984.5] Recommendation ITU-T G.984.5 (2007), *Gigabit-capable Passive Optical Networks (GPON): Enhancement band*.
- [ITU-T I.112] Recommendation ITU-T I.112 (1993), *Vocabulary of terms for ISDNs*.

3 Definitions

This Recommendation makes frequent use of the terms defined in [ITU-T G.983.1] and [ITU-T G.983.3]; some terms have been added. For convenience, the main definitions related to the GPON service requirements are reported in this clause.

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 service node interface (SNI): [ITU-T G.902]

3.1.2 user-network interface (UNI): [ITU-T I.112]

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 adaptation function (AF): AF is additional equipment and/or function to change an ONT/ONU subscriber-side interface into the UNI. Functions of AF depend on the ONT/ONU subscriber-side interface and UNI interface. AF is also used to change an OLT network interface into the SNI interface that is required by an operator.

3.2.2 differential fibre distance: An OLT is connected to several ONU/ONTs. The differential fibre distance is the difference in the distance between the nearest and furthest ONU/ONT from the OLT.

3.2.3 logical reach: Logical reach is defined as the maximum distance that can be achieved for a particular transmission system, regardless of the optical budget.

3.2.4 mean signal transfer delay: The mean signal transfer delay is the average of the upstream and downstream delay values between reference points; this value is determined by measuring round-trip delay and then dividing by 2.

3.2.5 optical access network (OAN): The OAN is the set of access links sharing the same network-side interfaces and supported by optical access transmission systems. The OAN may include a number of ODNs connected to the same OLT.

3.2.6 optical distribution network (ODN): In the PON context, a tree of optical fibres in the access network, supplemented with power or wavelength splitters, filters or other passive optical devices.

3.2.7 optical line termination (OLT): A device that terminates the common (root) endpoint of an ODN, implements a PON protocol, such as that defined by [ITU-T G.984], and adapts PON PDUs for uplink communications over the provider service interface. The OLT provides management and maintenance functions for the subtended ODN and ONUs.

3.2.8 optical network termination (ONT): A single subscriber device that terminates any one of the distributed (leaf) endpoints of an ODN, implements a PON protocol, and adapts PON PDUs to subscriber service interfaces. An ONT is a special case of an ONU.

3.2.9 optical network unit (ONU): A generic term denoting a device that terminates any one of the distributed (leaf) endpoints of an ODN, implements a PON protocol, and adapts PON PDUs to subscriber service interfaces. In some contexts, an ONU implies a multiple-subscriber device.

3.2.10 physical reach: Physical reach is defined as the maximum physical distance that can be achieved for a particular transmission system.

3.2.11 service: Service is defined as a network service required by operators. Service is described by a name that is clearly recognized by everyone, regardless of whether it is a frame structure name or a general name.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AF	Adaptation Function
BRI	Basic Rate Interface
DSL	Digital Subscriber Line
FTTB	Fibre to the Building
FTTC	Fibre to the Curb
FTTCab	Fibre to the Cabinet
FTTH	Fibre to the Home
ISDN	Integrated Services Digital Network
LT	Line Terminal
MDU	Multi-Dwelling Unit
NT	Network Termination
OAM	Operation, Administration and Maintenance
OAN	Optical Access Network
ODN	Optical Distribution Network
OLT	Optical Line Termination
ONT	Optical Network Termination
ONU	Optical Network Unit
OpS	Operations System
PDH	Plesiochronous Digital Hierarchy
PON	Passive Optical Network
POTS	Plain Old Telephone Service
PRI	Primary Rate Interface
PSTN	Public Switched Telephone Network
SDH	Synchronous Digital Hierarchy
SN	Serial Number
SNI	Service Node Interface
TC	Transmission Convergence

UNI	User-Network Interface
VOD	Video On Demand
WDM	Wavelength Division Multiplexing

5 Architecture of the optical access network

5.1 Network architecture

The optical section of a local access network system can be either active or passive and its architecture can be either point-to-point or point-to-multipoint. Figure 1 shows the architectures considered, which range from fibre to the home (FTTH), through fibre to the building/curb (FTTB/C) to fibre to the cabinet (FTTCab). The optical access network (OAN) is common to all architectures shown in Figure 1, hence the commonality of this system has the potential to generate large worldwide volumes.

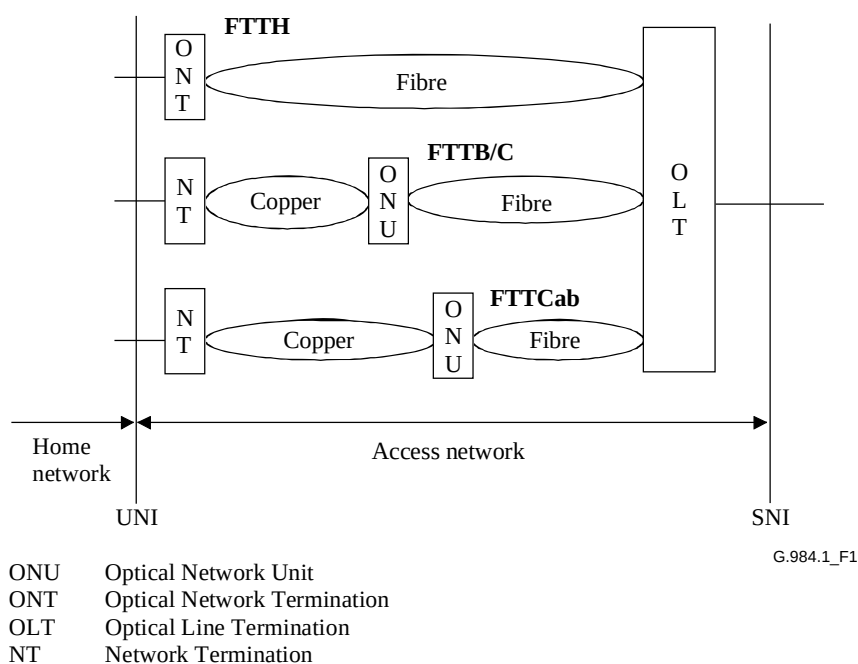


Figure 1 – Network architecture

The differences of the FTTB, FTTC, FTTCab and FTTH network options are mainly due the different services supported, so they can be treated the same in this Recommendation.

5.1.1 FTTB scenario

The FTTB scenario is divided into two scenarios, one for multi-dwelling units (MDUs) and the other for businesses. Each scenario has the following service categories.

5.1.1.1 FTTB for MDU

- Asymmetric broadband services (e.g., digital broadcast services, VOD, file download, etc.).
- Symmetric broadband services (e.g., content broadcast, e-mail, file exchange, distance learning, telemedicine, online-gaming, etc.).
- POTS and ISDN. The access network must be able to provide, in a flexible way, narrow-band telephone services with appropriate timing for the introduction.

5.1.1.2 FTTB for business

- Symmetric broadband services (e.g., group software, content broadcast, e-mail, file exchange, etc.).
- POTS and ISDN. The access network must be able to provide, in a flexible way, narrow-band telephone services with the appropriate timing for the introduction.
- Private line services. The access network must be able to provide, in a flexible way, private line services at several rates.

5.1.2 FTTC and FTTCab scenario

Within this scenario, the following service categories have been considered:

- Asymmetric broadband services (e.g., digital broadcast services, VOD, file download, online-gaming, etc.).
- Symmetric broadband services (e.g., content broadcast, e-mail, file exchange, distance learning, telemedicine, etc.).
- POTS and ISDN. The access network must be able to provide, in a flexible way, narrow-band telephone services with the appropriate timing for the introduction.
- xDSL backhaul.

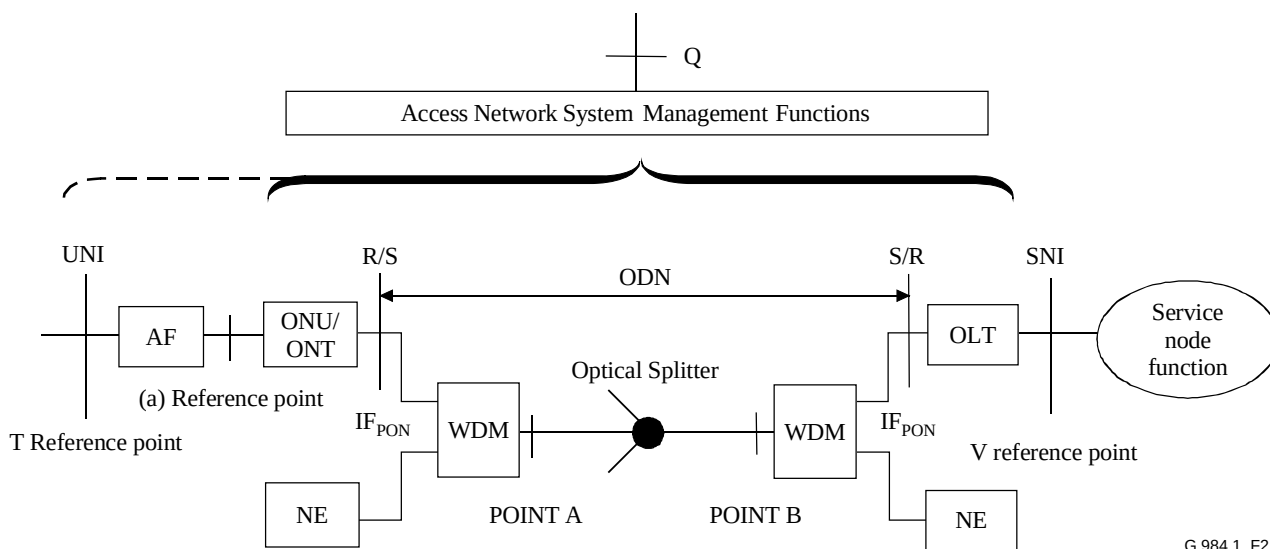
5.1.3 FTTH scenario

Within this scenario, the following service categories have been considered:

- Asymmetric broadband services (e.g., digital broadcast services, VOD, file download, etc.).
- Symmetric broadband services (e.g., content broadcast, e-mail, file exchange, distance learning, telemedicine, online-gaming, etc.).
- POTS and ISDN. The access network must be able to provide, in a flexible way, narrow-band telephone services with the appropriate timing for the introduction.

5.2 Reference configuration

The reference configuration is shown in Figure 2.



ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

Figure 2 – Reference configuration for GPON

5.2.1 Service node interface

See [ITU-T G.902].

5.2.2 Interface at the reference points S/R and R/S

The interface at reference points S/R and R/S is defined as IF_{PON}. This is a PON-specific interface that supports all the protocol elements necessary to allow transmission between OLT and ONUs.

6 Services, user-network interface and service node interface

6.1 Services

GPON is required to support all currently known services and new services being discussed for residential subscribers and business customers, because of such a broadband capability.

What specific services should be provided is clearer to some operators than to others and depends heavily on the particular regulatory conditions of each operator's markets, as well as on the market's own potential. How these services are delivered in a cost-effective way is a function not only of legal conditions, but also of factors including existing telecommunication infrastructure, dwelling distribution, and residential and business customers mix.

Some examples of services are described in clause I.1.

6.2 User-network interface (UNI) and service node interface (SNI)

ONU/ONT has UNI, as well as OLT, has an SNI as described in Figure 2. UNI/SNI depends on which services are provided by the service operator.

Some examples of UNI are described in clause I.2 and examples of SNI are described in clause I.3.

7 Bit rate

Basically, GPON aims at transmission speeds greater than or equal to 1.2 Gbit/s. Accordingly, GPON identifies two transmission speed combinations as follows:

- 1.2 Gbit/s up, 2.4 Gbit/s down;
- 2.4 Gbit/s up, 2.4 Gbit/s down.

The most important bit rate is 1.2 Gbit/s up, 2.4 Gbit/s down, constituting nearly all of the deployed and planned deployment of the GPON systems.

8 Logical reach

Logical reach is the maximum distance between ONU/ONT and OLT except for the limitation of the physical layer. In GPON, the maximum logical reach is defined as 60 km.

9 Physical reach

Physical reach is the maximum physical distance between the ONU/ONT and the OLT. In GPON, two options are defined for the physical reach: 10 km and 20 km. It is assumed that 10 km is the maximum distance over which FP-LD can be used in the ONU for high bit rates such as 1.25 Gbit/s or above.

10 Differential fibre distance

In GPON, the maximum differential fibre distance is 20 km. This affects the size of the ranging window and provides compliance with [ITU-T G.983.1].

11 Maximum mean signal transfer delay

GPON must accommodate services that require a maximum mean signal transfer delay of 1.5 ms.

Specifically, GPON system must have a maximum mean signal transfer delay time of less than 1.5 ms between T-V (or (a)-V, depending on the operator's preference). See clause 12 of [ITU-T G.982]. Delays introduced by the adaptation functions such as circuit emulation are not included in this value.

Although a section of the delay measurement is T-V for FTTH system, or (a)-V for the other application in [ITU-T G.982], in a GPON system the reference points are not restricted by the system configuration.

12 Split ratio

Basically, the larger the split ratio is for GPON, the more attractive it is for operators. However, a larger split ratio implies greater optical splitting which creates the need for an increased power budget to support the physical reach.

Split ratios of up to 1:64 are realistic for the physical layer, given current technology. However, anticipating the continued evolution of optical modules, the TC layer must consider split ratios up to 1:128.