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

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10-Gigabit-capable passive optical network (XG-PON) systems: Definitions, abbreviations and acronyms

Recommendation ITU-T G.987

ITU-T

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Recommendation ITU-T G.987

10-Gigabit-capable passive optical network (XG-PON) systems: Definitions, abbreviations and acronyms

Summary

Recommendation ITU-T G.987 contains the common definitions, acronyms, abbreviations and conventions of the ITU-T G.987.x-series Recommendations.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.987	2010-01-29	15
2.0	ITU-T G.987	2010-10-07	15
3.0	ITU-T G.987	2012-06-13	15

FOREWORD

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10-Gigabit-capable passive optical network (XG-PON) systems: Definitions, abbreviations and acronyms

1 Scope

This Recommendation contains the common definitions, acronyms, abbreviations and conventions of the ITU-T G.987.x series Recommendations.

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.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.987.1] Recommendation ITU-T G.987.1 (2010), *10 Gigabit-capable passive optical networks (XG-PON): General requirements*.

[ITU-T G.987.2] Recommendation ITU-T G.987.2 revised (2010), *10 Gigabit-capable passive optical networks (XG-PON): Physical media dependent (PMD) layer specification*.

[ITU-T G.987.3] Recommendation ITU-T G.987.3 (2010), *10 Gigabit-capable passive optical networks (XG-PON): Transmission convergence (TC) layer specification*.

[ITU-T G.988] Recommendation ITU-T G.988 (2010), *ONU management and control interface (OMCI) specification*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 access network (AN) [ITU-T G.902]: An implementation comprising those entities (such as cable plant, transmission facilities, etc.) which provide the required transport bearer capabilities for the provision of telecommunications services between a service node interface (SNI) and each of the associated user-network interfaces (UNI).

3.1.2 Ethernet LAN service (E-LAN) [b-MEF 6.1]: An Ethernet service type that is based on a multipoint-to-multipoint Ethernet virtual connection.

3.1.3 Ethernet line service (E-Line) [b-MEF 6.1]: An Ethernet service type that is based on a point-to-point Ethernet virtual connection.

3.1.4 Ethernet tree service (E-Tree) [b-MEF 6.1]: An Ethernet service type that is based on a rooted-multipoint Ethernet virtual connection.

3.1.5 Ethernet virtual connection (EVC) [b-MEF 6.1]: An association of UNIs to which the exchange of service frames is limited.

3.1.6 service node (SN) [ITU-T G.902]: A network element that provides access to various switched and/or permanent telecommunication services.

3.1.7 service node interface (SNI) [ITU-T G.902]: An interface which provides customer access to a service node.

3.1.8 user-network interface (UNI) [b-ITU-T I.112]: The interface between the terminal equipment and a network termination at which interface the access protocols apply.

3.1.9 1:1 VLAN [b-DSLF TR-101]: A VLAN forwarding paradigm involving a one-to-one mapping between user port and VLAN. The uniqueness of the mapping is maintained in the access node and across the aggregation network.

3.1.10 N:1 VLAN [b-DSLF TR-101]: A VLAN forwarding paradigm involving many-to-one mapping between user ports and VLAN. The user ports may be located in the same or different access nodes.

3.2 Optical access architecture terms

This Recommendation defines the following terms:

3.2.1 gigabit-capable passive optical network (G-PON): A PON system supporting transmission rates in excess of 1.0 Gbit/s in at least one direction, and implementing the suite of protocols specified in the ITU-T G.984.x series Recommendations.

3.2.2 next generation PON (NG-PON): In the context of ITU-T standards development activity, a generic term referencing the PON system evolution beyond G-PON. The concept of NG-PON currently includes NG-PON1, where the ODN is maintained from B-PON and G-PON, and NG-PON2, where a redefinition of the ODN is allowed from that defined in B-PON and G-PON.

3.2.3 optical access network (OAN): A part of an access network whose network elements are interconnected by optical communication channels.

NOTE – An OAN may or may not extend all the way to the UNI, so that the user-side interface of the OAN does not necessarily coincide with the UNIs of the AN.

3.2.4 optical distribution network (ODN): A point-to-multipoint optical fibre infrastructure. A *simple* ODN is entirely passive and is represented by a single-rooted point-to-multipoint tree of optical fibres with splitters, combiners, filters, and possibly other passive optical components. A *composite* ODN consists of two or more passive *segments* interconnected by active devices, each of the segments being either an optical trunk line segment or an optical distribution segment. A passive optical distribution segment is a simple ODN itself. Two ODNs with distinct roots can share a common subtree.

3.2.5 optical distribution segment (ODS): A simple ODN, that is, a point-to-multipoint optical fibre infrastructure that is entirely passive and is represented by a single-rooted tree of optical fibres with splitters, combiners, filters, and possibly other passive optical components.

3.2.6 optical line termination (OLT): A network element in an ODN-based optical access network that terminates the root of at least one ODN and provides an OAN SNI.

3.2.7 optical network terminal (ONT): An ONU supporting a single subscriber.

3.2.8 optical network unit (ONU): A network element in an ODN-based optical access network that terminates a leaf of the ODN and provides an OAN UNI.

3.2.9 optical trunk line (OTL): A passive point-to-point segment of a composite ODN.

3.2.10 passive optical network (PON) system: A combination of network elements in an ODN-based optical access network that includes an OLT and multiple ONUs and implements a particular coordinated suite of physical medium dependent layer, transmission convergence layer, and management protocols.

3.2.11 10-gigabit-capable passive optical network (XG-PON): A PON system supporting nominal transmission rates on the order of 10 Gbit/s in at least one direction, and implementing the suite of protocols specified in the ITU-T G.987.x series Recommendations. XG-PON is a subclass of NG-PON1.

3.2.12 XG-PON1: A variant of XG-PON system that operates at a nominal line rate of 10 Gbit/s downstream and 2.5 Gbit/s upstream.

3.2.13 XG-PON2: A variant of XG-PON system that operates at a nominal line rate of 10 Gbit/s downstream and upstream.

3.3 Optical parameters, power and loss budget terms

3.3.1 attenuation: The total relative optical power loss of an optical signal propagating through the ODN. Attenuation is caused by absorption and scattering of light in the fibre (caused by fibre impurities and imperfections, fluctuations of the refractive index, material dispersion), as well as connectors, splices, splitters, wavelength couplers, attenuators, and other passive optical components.

3.3.2 differential fibre distance: The absolute difference between the fibre distances of two particular ONUs connected to the same OLT PON interface.

3.3.3 dispersion: A physical phenomenon comprising the dependence of the phase or group velocity of a light wave in the medium on its propagation characteristics such as optical frequency (wavelength) or polarization mode.

3.3.4 dynamic range: An optical receiver characteristic that represents the difference between the worst-case sensitivity (i.e., maximum over the operating conditions) and the worst-case overload (i.e., minimum over the operating conditions), and is usually expressed as a ratio of the former to the latter.

3.3.5 extinction ratio: With respect to a digital signal generated by an optical source (laser diode), the ratio of the two optical power levels corresponding to the high and low intensities of light emission.

3.3.6 fibre distance: The overall length of fibre (and, if applicable, equivalent fibre runs representing delay-inducing components) between the R/S and S/R reference points.

3.3.7 mean optical launch power: An optical transmitter characteristic expressing the average optical power of an optical signal transmitted into the fibre and carrying a given digital sequence. When specified as a range, the minimum mean launch power provides the power level that the transmitter should guarantee at all times, and the maximum mean launch power provides the power level that the transmitter should never exceed. When applied to burst mode transmission, the term pertains to the time interval during which the transmitter is fully active, and excludes possible starting and ending transient behaviour.

3.3.8 nominal line rate: The total number of bits that can be physically transferred per unit of time over a communication link. Nominal line rate accounts for useful data as well as for all possible protocol overheads and necessarily exceeds the effective data rate on any given protocol level.

3.3.9 optical path penalty (OPP): The apparent reduction of receiver sensitivity due to distortion of the signal waveform during its transmission over the optical path. The optical path penalty accounts for total degradations including the effects of reflections, intersymbol interference, mode partition noise, and laser chirp.

3.3.10 optical return loss (ORL): The total reflection at the source reference point of the optical signal propagation path associated with both discrete reflections at the refractive index discontinuities and distributed backscattering, such as Rayleigh scattering, along the path. Optical return loss is measured as a ratio of the transmitted power to the reflected power.

3.3.11 overload: A receiver parameter that characterizes the maximum value of the average received optical power to achieve the BER at or below the specified reference level.

3.3.12 reflectance: The reflection from any single discrete reflection point in the optical signal propagation path, which is defined to be the ratio of the reflected optical power present at a point, to the optical power incident to that point.

3.3.13 sensitivity: A receiver parameter that characterizes the minimum value of the average received optical power to achieve the BER at or below the specified reference level.

3.3.14 tolerance to reflected power (receiver): A receiver parameter that characterizes the minimum admissible ratio of the average optical input power incident at the receiver to the average reflected power regarded as a noise.

3.3.15 tolerance to reflected power (transmitter): A transmitter parameter that characterizes the maximum admissible ratio of the average reflected optical transmit power incident at the transmitter to the average optical transmit power.

3.3.16 wavelength conversion (WC): A technology used to convert the frequency (wavelength) of the input optical signal into an output frequency (wavelength) from a predefined wavelength grid. In the case that the input and output frequencies (wavelengths) are distinct, *true wavelength conversion* takes place, whereas if the input and output frequencies are identical, *wavelength-transparent* WC function is used, where the frequency of the optical signal does not change when passing through the WC function.

3.4 Transmission convergence layer terms

3.4.1 activation: A set of distributed procedures executed by the OLT and the ONUs that allows an inactive ONU to join or resume operations on the PON. The activation process includes three phases: parameter learning, serial number acquisition, and ranging.

3.4.2 activation cycle: A time interval between ONU's consecutive entries into the initial state (O1).

3.4.3 bandwidth allocation: An upstream transmission opportunity granted by the OLT for a specified time interval to a specified traffic-bearing entity within an ONU.

3.4.4 dynamic bandwidth assignment (DBA): A process by which the OLT distributes upstream PON capacity between the traffic-bearing entities within ONUs, based on dynamic indication of their traffic activity and their configured traffic contracts.

3.4.5 effective key length: The number of randomly generated bits of a cryptographic key. The effective key length may be less than the nominal key length of a particular cryptosystem, if a part of the key is replaced by a well-known bit pattern.

3.4.6 embedded OAM: An operation and management channel between the OLT and the ONUs that utilizes the structured overhead fields of the downstream XGTC frame and upstream XGTC burst and supports time-sensitive functions.

3.4.7 equalization delay (EqD): The requisite delay assigned by the OLT to an individual ONU in order to ensure that the ONU's transmissions are precisely aligned on a common OLT-based upstream frame reference. The ONU's equalization delay is assigned as a result of ranging and is subject to in-service updates in the course of burst arrival phase monitoring.

3.4.8 ONU management and control interface (OMCI): An operation and management channel between the OLT and an ONU that is message-based and employs an extendable management information base.

3.4.9 physical layer OAM (PLOAM): An operation and management channel between the OLT and the ONUs that is close to real time and is based on a fixed set of messages.

3.4.10 quiet window: A time interval during which the OLT suppresses all bandwidth allocations to in-service ONUs in order to avoid collisions between their upstream transmissions and the transmissions from ONUs whose burst arrival time is uncertain. The OLT opens a quiet window to allow new ONUs to join the PON and to perform ranging of specific ONUs.

3.4.11 ranging: A procedure of measuring the logical distance between the OLT and any of its subtending ONUs with the objective to determine and assign the appropriate equalization delay, which is necessary to align the ONU's upstream transmissions on a common OLT-based upstream frame reference. Ranging is performed during ONU activation and may be performed while the ONU is in service.

3.4.12 ranging grant: An allocation structure that is addressed to the default Alloc-ID of the ONU and has the PLOAMu flag set. A ranging grant does not specify a data allocation and has the GrantSize of zero.

3.4.13 requisite delay: A general term denoting the total extra delay the OLT may require an ONU to apply to the upstream transmission beyond the ONU's regular response time. The purpose of requisite delay is to compensate for variation of propagation and processing delays of individual ONUs, and to avoid or reduce the probability of collisions between upstream transmissions.

3.4.14 serial number grant: An allocation structure that is addressed to the broadcast Alloc-ID and has the PLOAMu flag set. A serial number grant does not specify a data allocation and has the GrantSize of zero.

3.4.15 status reporting DBA (SR-DBA): A method of dynamic bandwidth assignment that infers the dynamic activity status of the traffic-bearing entities within ONUs based on explicit buffer occupancy reports communicated over the embedded OAM channel.

3.4.16 traffic-monitoring DBA (TM-DBA): A method of dynamic bandwidth assignment that infers the dynamic activity status of the traffic-bearing entities within ONUs based on observation of idle XGEM frame transmissions during upstream bursts.

3.4.17 transmission container (**T-CONT)**: A traffic-bearing object within an ONU that represents a group of logical connections, is managed via the ONU management and control channel (OMCC), and, through its TC layer Alloc-ID, is treated as a single entity for the purpose of upstream bandwidth assignment on the PON.

3.4.18 XG-PON encapsulation method (XGEM): A data frame transport scheme used in XG-PON systems that is connection-oriented and that supports fragmentation of user data frames into variable sized transmission fragments.

3.4.19 XG-PON transmission convergence (XGTC) layer: A protocol layer of the XG-PON protocol suite that is positioned between the physical media dependent (PMD) layer and the XG-PON clients. The XGTC layer is composed of the XGTC service adaptation sublayer, the XGTC framing sublayer, and the XGTC PHY adaptation sublayer.

3.4.20 XGEM port: An abstraction in the XGTC service adaptation sublayer representing a logical connection associated with a specific client packet flow.

3.4.21 XGTC framing sublayer: A sublayer of the XG-PON transmission convergence layer that supports the functions of XGTC frame/burst encapsulation and delineation, embedded OAM processing, and Alloc-ID filtering.

3.4.22 XGTC PHY adaptation sublayer: A sublayer of the XG-PON transmission convergence layer that supports the functions of physical synchronization and delineation, forward error correction (FEC), and scrambling.

3.4.23 XGTC service adaptation sublayer: A sublayer of the XG-PON transmission convergence layer that supports the functions of SDU (user data and OMCI traffic) fragmentation and reassembly, XGEM encapsulation, XGEM frame delineation, and XGEM Port-ID filtering.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AES	Advanced Encryption Standard
AIS	Alarm Indication Signal
Alloc-ID	Allocation Identifier
AN	Access Network
ANI	Access Node Interface
AO	Allocation Overhead
APS	Automatic Protection Switching
ASE	Amplified Spontaneous Emission
ATA	Analog Telephony Adaptor (VoIP)
ATM	Asynchronous Transfer Mode
AVC	Attribute Value Change
BCH	Bose-Chaudhuri-Hocquenghem (code)
BE	Best Effort (service category)
BER	Bit-Error Ratio
BES	Block Errored Second
BITS	Building Integrated Timing Source
BM-to-CM	Burst Mode to Continuous Mode
B-PON	Broadband Passive Optical Network
BW	Bandwidth
BWmap	Bandwidth Map
CAS	Channel Associated Signalling
CBS	Committed Block Size
CBU	Cell-site Backhauling Unit (ONU type)
CES	Circuit Emulation Service
CID	Consecutive Identical Digits
CIR	Committed Information Rate
CLEI	Common Language Equipment Identification

CM	Continuous Mode
CMAC	Cipher-based Message Authentication Code
CM-to-BM	Continuous Mode to Burst Mode
CMXGPON_D	Continuous Mode XG-PON downstream bit-stream signal
CMXGPON_U	Continuous Mode XG-PON upstream bit-stream signal
CO	Central Office
CPE	Customer Premises Equipment
CRC	Cyclic Redundancy Check
CTR	Counter (block cipher mode)
CW	Continuous Wave
DA	Destination Address
DBA	Dynamic Bandwidth Assignment
DBRu	Upstream Dynamic Bandwidth Report (indicator bit)
DF	Deactivation Failure
DFB	Distributed Feedback (laser type)
DG	Dying Gasp
DHCP	Dynamic Host Configuration Protocol
DOW	Drift of Window
DSL	Digital Subscriber Line
DWDM	Dense Wavelength Division Multiplexing
EAP	Extensible Authentication Protocol
ECB	Electronic CodeBook (block cipher mode)
EDFA	Erbium-Doped Fibre Amplifier
E-LAN	Ethernet LAN service
E-Line	Ethernet Line service
EMS	Element Management System
EONU	Embedded Optical Network Unit
EPON	Ethernet Passive Optical Network
ER	Extinction Ratio
ESMC	Ethernet Synchronization Messaging Channel
E-Tree	Ethernet Tree Service
EVC	Ethernet Virtual Connection
FCAPS	Fault, Configuration, Accounting, Performance, Security management
FCS	Frame Check Sequence
FEC	Forward Error Correction
FFS	For Further Study
FSM	Finite State Machine

FTTCell	Fibre to the Cell site base stations
FTTx	Fibre to the x (B – building, business; H – home; C – cabinet, curb, P –premises)
FWI	Forced Wakeup Indication
GEM	G-PON Encapsulation Method
G-PON	Gigabit-capable Passive Optical Network
GTC	G-PON Transmission Convergence (protocol layer)
HEC	Hybrid Error Correction
HLend	Header Length – downstream
IANA	Internet Assigned Numbers Authority
ID	Identifier
IFC	Intra-Frame Counter
IGMP	Internet Group Management Protocol
IK	Integrity Key
ILOS	Intermittent Loss of Signal
IP	Internet Protocol
IPTV	Internet Protocol TV
KEK	Key Encryption Key
LAN	Local Area Network
LF	Last Fragment
LoB	Loss of Burst
LoDS	Loss of Downstream Synchronization
LoOC	Loss of OMCI Channel
LoPC	Loss of PLOAM Channel
LoS	Loss of Signal
LSB	Least Significant Bit (not to be used when the meaning is least significant byte)
MAC	Media Access Control
MDU	Multi Dwelling Unit (ONU type)
ME	Managed Entity
MEF	Metro Ethernet Forum
MIB	Management Information Base
MIC	Message Integrity Check
MLD	Multicast Listener Discovery (protocol)
MLM	Multi Longitude Mode (laser type)
MoCA	Multimedia over Coax Alliance
MSB	Most Significant Bit (not to be used when the meaning is most significant byte)
MSK	Master Session Key

MTU	Maximum Transmission Unit
NA	Non-Assured (service category)
NAT	Network Address Translation
NGA	Next Generation Access
NMS	Network Management System
NRZ	Non-Return to Zero (line code)
NTP	Network Timing Protocol
OA	Optical Amplifier
OAM	Operation, Administration, and Management
OAN	Optical Access Network
OBF	Optical Bandpass Filter
ODF	Optical Distribution Frame
ODN	Optical Distribution Network
ODS	Optical Distribution Segment
OEO	Optical-Electronic-Optical (conversion)
OFDR	Optical Frequency-Domain Reflectometer
OLT	Optical Line Terminal
OMCC	ONU Management and Control Channel
OMCI	ONU Management and Control Interface
ONT	Optical Network Terminal
ONU	Optical Network Unit
OPEX	Operational Expenditure
OPP	Optical Path Penalty
ORL	Optical Return Loss
OSS	Operations Support System
OSSP	Organizational Specific Slow Protocol
OTDR	Optical Time-Domain Reflectometer
OTL	Optical Trunk Line
PBS	Peak Block Size
PDU	Protocol Data Unit
PHY	Physical interface
PIR	Peak Information Rate
PIT	PON-ID type
PLI	Payload Length Indication
PLOAM	Physical Layer Operations, Administration and Maintenance
PM	Performance Monitoring
PMD	Physical Medium Dependent (protocol layer)

PON	Passive Optical Network
PON-ID	Passive Optical Network Identifier
POTS	Plain Old Telephone Service
PPPoE	Point-to-Point Protocol over Ethernet
PRC	Primary Reference Clock
PSBd	Downstream Physical Synchronization Block
PSBu	Upstream Physical Synchronization Block
PSK	Pre-shared Secret Key
PSN	Packet Switched Network
PST	PON Section Trace (PLOAM message)
PSync	Physical Synchronization Sequence
PTP	Precision Timing Protocol
QoS	Quality of Service
R/S	Reference point at the interface of the ONU to the ODN
R'/S'	Reference point at the interface of the Reach extender to the OTL
RE	Reach Extender
RF	Radio Frequency
RG	Residential Gateway
RMS	Root Mean Square
RNC	Radio Network Controller
RS	Reed-Solomon (block code)
RSOA	Reflective Semiconductor Optical Amplifier
RTC	Real Time Clock (protocol)
RTCP	RTP Control Protocol
RTD	Round-Trip Delay
RTP	Real-time Transport Protocol
Rx	Receiver
S'/R'	Reference point at the interface of Reach extender to ODN
S/R	Reference point at the interface of the OLT to the ODN
SA	Sleep Allowed (PLOAM message)
SA	Source Address
SBU	Small Business Unit (ONU type)
SD	Signal Degrade
SDU	Service Data Unit
SeqNo	Sequence Number
SES	Severely Errored Second (-L: -line, -P: path, -FE: far-end)
SF	Signal Fail

SFC	SuperFrame Counter
SFD	Start Frame Delimiter
SFU	Single Family Unit (ONU type)
SIP	Session Initiation Protocol
SK	Session Key
SLM	Single Longitude Mode (laser type)
SN	Serial Number
SN	Service Node
SNI	Service Node Interface
SNMP	Simple Network Management Protocol
SNR	Signal to Noise Ratio
SOA	Semiconductor Optical Amplifier
SR	Sleep Request (PLOAM message)
SR	Status Reporting
SRS	Stimulated Raman Scattering
SUF	Start-up Failure
TBD	To be defined
TC	Transmission Convergence
T-CONT	Transmission Container
TCP	Transmission Control Protocol
TDM	Time Division Multiplexing
TIW	Transmission Interference Warning
TLS	Transparent LAN Service
TM	Traffic Monitoring
ToD	Time of Day
TOL	Transmit optical level
Tx	Transmitter
UDP	User Datagram Protocol
UI	Unit Interval
UNI	User Network Interface
VBES	VLAN-based Business Ethernet Services
VDSL	Very high speed Digital Subscriber Line
VID	VLAN Identifier
VLAN	Virtual Local Area Network
VoIP	Voice over IP
VPN	Virtual Private Network
V-Rx	Video Receiver

VSSN	Vendor-Specific Serial Number
V-Tx	Video Transmitter
WBF	Wavelength Blocking Filter
WC	Wavelength Conversion
WC-RE	WC-enabled Reach Extender
WDM	Wavelength Division Multiplexing
WDM1	Wavelength Division Multiplexor 1 (coexistence device)
WDM1r	Wavelength Division Multiplexor 1 revised (coexistence device)
WDM1rn	Wavelength Division Multiplexor 1 revised – narrow-band (coexistence device)
WFQ	Weighted Fair Queuing
WRR	Weighted Round Robin
X/S	Crosstalk-to-Signal ratio
XGEM	XG-PON Encapsulation Method
XG-PON	10-Gigabit-capable Passive Optical Network
XGTC	XG-PON Transmission Convergence (protocol layer)

5 Conventions

5.1 Optical access concepts

This Recommendation adopts the basic definition of access network (AN) provided by [ITU-T G.902] and formalizes the definition of optical distribution network, deriving the key PON-related definitions based on these two concepts. An example of an access network architecture satisfying the ITU-T G.987 definition system is shown in Figure 5-1.

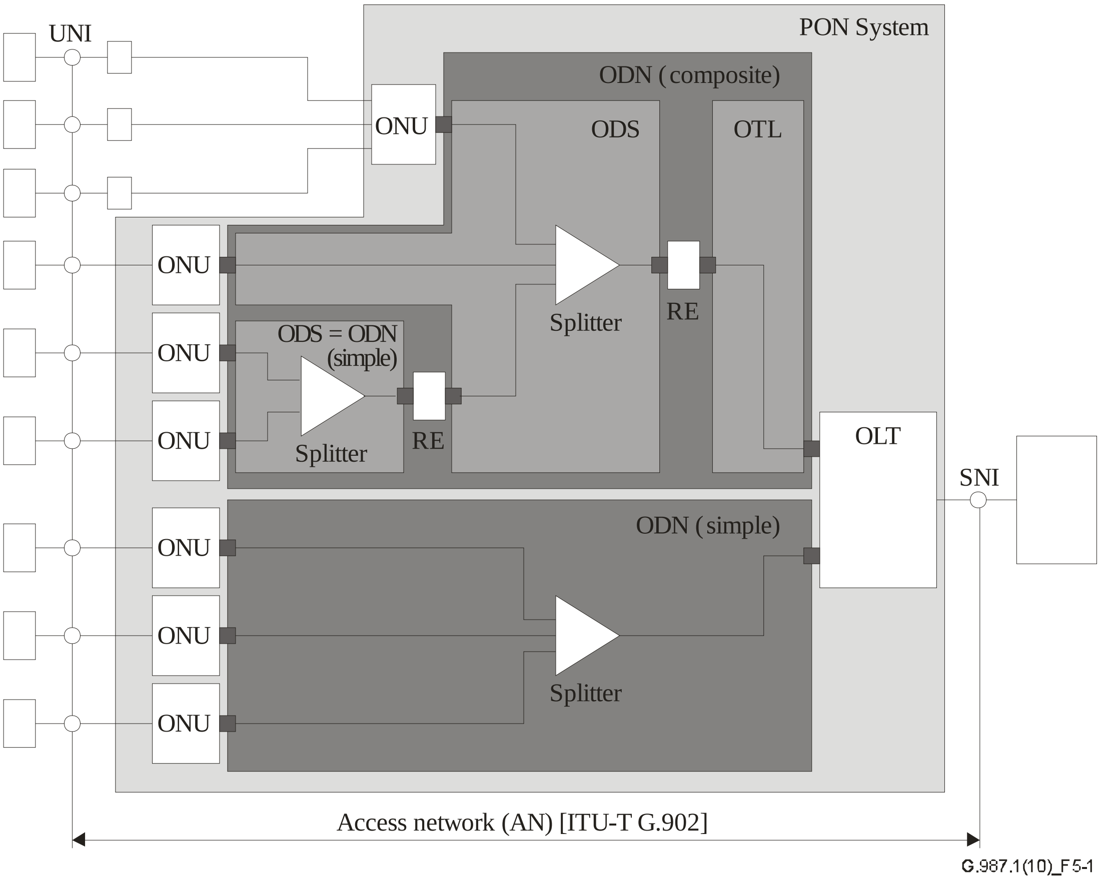

Figure 5-1 – Reference access network architecture

5.2 Power and loss budget parameters

The relationships between power and loss budget parameters are captured in Figure 5-2.

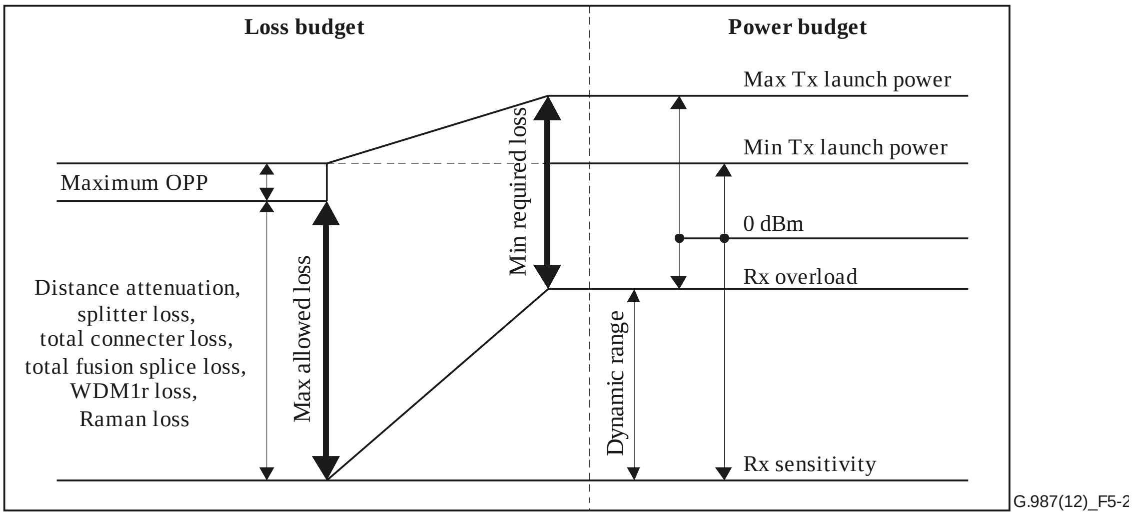

Figure 5-2 – Relationship between power budget and loss budget parameters

The details of the dynamic range concept definition are illustrated in Figure 5-3. The receiver sensitivity and overload are defined, respectively, as the minimum and maximum average received optical power at which the BER at the receiver output remains at or below the specified reference level. The observed values of receiver sensitivity and overload may vary as the operating conditions change. The operation conditions that affect receiver sensitivity and overload may include the transmitter extinction ratio, connector degradations, effects of ageing, etc. In definition of the dynamic range, both receiver sensitivity and receiver overload are represented by their respective worst-case values, i.e., maximum sensitivity and minimum overload over the range of operating conditions.

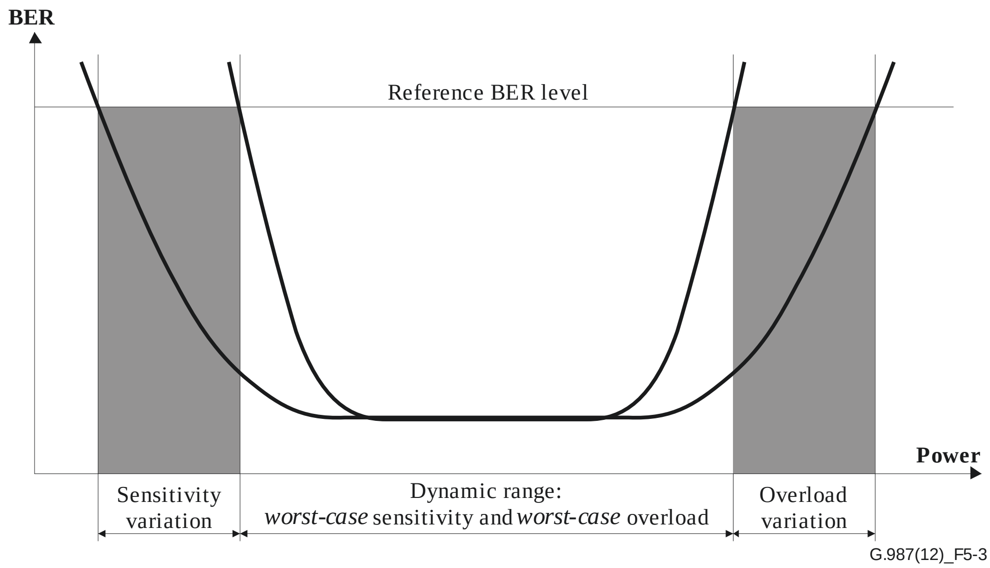

Figure 5-3 – Rx output BER as a function of received optical power, and the definition of dynamic range

5.3 Sensitivity and overload in the presence of FEC

To simplify optical component verification, [ITU-T G.987.2] specifies the sensitivity and overload at the high reference BER level, which corresponds to the Rx output and the FEC decoder input. It is assumed that the FEC algorithms specified, respectively, for continuous mode downstream and burst mode upstream transmission are sufficiently strong to achieve the BER level of 10^{-12} or better at the FEC decoder output. See [b-ITU-T G-Sup.39] for further discussion.

5.4 Reach and distance

The ITU-T G.987.x series of Recommendations addresses the linear extent parameters of XG-PON using the single concept of fibre distance. An ONU is characterized by its fibre distance, and for each pair of ONUs on the same OLT PON interface, the differential fibre distance is the difference between the two individual fibre distances. Each specific PMD layer parameter set contains a provision to support a specific maximum fibre distance. The XG-PON TC layer specification contains a provision to support specific ranges of maximum fibre distance and maximum differential fibre distance. These ranges can be configurable for a given system. One can expect that for each XG-PON deployment, the configured TC layer maximum fibre distance will match the maximum fibre distance supported by the selected PMD layer parameter set. Fibre distance concepts are illustrated in Figure 5-4.

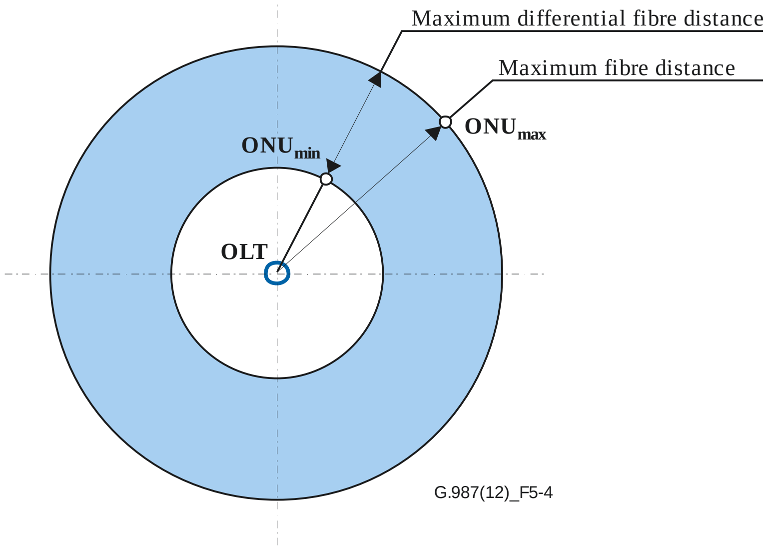

Figure 5-4 – Fibre distance concepts

The physical reach system parameter of the ITU-T G.984 series of Recommendations corresponds to the maximum fibre distance supported by the system PMD layer. The logical reach system parameter of the ITU-T G.984 series corresponds to the maximum fibre distance supported by the system TC layer.

5.5 Use of the term PON

Historically, the term PON was introduced to describe a point-to-multipoint fibre infrastructure composed of exclusively passive optical components. This strict-sense usage was soon naturally extended to include a fibre-in-the-loop communication system employing such an infrastructure and using time-division multiplexing to share the available digital bandwidth among many subscribers (TDM PON). As new types of PON-based systems were introduced, leveraging various TDM transport mechanisms (B-PON, G-PON, EPON) or alternative multi-access methods (WDM-PON), it became common to use the word PON with appropriate qualification in reference to the specific architectural variations. While the term remained overloaded, referring in different contexts to a network, a system, architecture or technology, all the referenced entities shared a common attribute of containing, using or relying upon a fibre infrastructure with no active (electronic) components between the central office interface and the user equipment interface. More recently, introduction of active reach extenders within the optical distribution network as defined in [b-ITU-T G.984.6] created a paradoxical situation when an infrastructural component of a G-PON system may not be entirely passive, that is, nominally, no longer a PON. Thus, it became apparent that the excessive overloading of what was once meant to be a precise term may adversely impact the clarity of a technical presentation.

This current series of Recommendations deliberately restricts the usage of the term PON to the contexts where it denotes a system, that is, a combination of network elements including at least one OLT and multiple ONUs interconnected by an ODN that implements a particular coordinated suite of physical medium dependent layer, transmission convergence layer, and management protocols. It also strives to provide a consistent, unambiguous, and extensible definition system that allows supporting efficient communication on the subject.

5.6 Use of the term ODN

In the ITU-T G.983 B-PON and ITU-T G.984 G-PON series of Recommendations (prior to [b-ITU-T G.984.6]), the term optical distribution network (ODN) refers to a passive point-to-multipoint distribution means extending from the user-facing interface of the OLT to the network-facing interfaces of the ONUs. The introduction of active reach extenders and the concept of dual-homing call for a revision of the term's scope and usage, as the fibre-based distribution network extending between the OLT and ONU interfaces may be neither point-to-multipoint nor strictly passive.

This current series of Recommendations endorses a generalized usage of the term ODN to denote a point-to-multipoint fibre infrastructure, which is not required to be entirely passive. In the contexts where the internal structure of the ODN is not a concern, it is the ODN that interconnects the OLT and the ONUs to form a PON system. In the contexts where the internal structure of the ODN is relevant, two types of ODNs can be distinguished. A *simple* ODN is entirely passive and is represented by a single-rooted point-to-multipoint tree of optical fibres with splitters, combiners, filters, and possibly other passive optical components. A *composite* ODN consists of two or more *segments* interconnected by active devices, each of the segments being either an optical trunk line segment or an optical distribution segment. A passive optical distribution segment in is a simple ODN itself. The definition allows two ODNs with distinct roots to share a common subtree, thus supporting the notions of dual-homing and protection within the definition system.

5.7 Use of the terms ONU and ONT

Throughout the ITU-T G.987.x series of Recommendations, the network element interfacing the end-user access facilities and the ODN is referred to as an ONU, or an optical network unit, irrespective of the number and type of user interfaces or the depth of fibre deployment. Historically, the term ONT, or optical network terminal/termination, has been used either interchangeably with ONU or with the particular semantics of "an ONU that is used for fibre to the home (FTTH) and includes the user port function" (see [b-ITU-T G.983.1]), or "a single-subscriber ONU" (see [b-ITU-T G.984.1] and other documents of the ITU-T G.984 series). This Recommendation follows the latter approach in defining ONT. Note, however, that while this definition captures one established trade interpretation of the term, the concept itself is not used as a part of the ITU-T G.987 reference access architecture.

Outside of the ITU-T G.987.x series scope, alternative interpretations may apply and, therefore, the reader is advised to clarify the exact meaning of the term in each specific context. In particular, in some external contexts, the term ONT may be used generically to refer to any device terminating a leaf of the ODN.

5.8 Use of the terms T-CONT and Alloc-ID

A transmission container (T-CONT) is an OMCI managed entity representing a group of logical connections that appear as a single entity for the purpose of upstream bandwidth assignment in a PON system.

For a given ONU, the number of supported T-CONTs is fixed. The ONU autonomously creates all the supported T-CONT instances during ONU activation or upon OMCI MIB reset. The OLT uses the OMCC to discover the number of T-CONT instances supported by a given ONU and to manage those instances.

The *Allocation identifier* (*Alloc-ID*) is a 14 bit number that the OLT assigns to an ONU to identify a traffic-bearing entity that is a recipient of upstream bandwidth allocations within that ONU. Such a traffic-bearing entity is usually represented by a T-CONT, but may also be represented by an internal non-managed structure.

Each ONU is assigned at least its default Alloc-ID and may be explicitly assigned additional Alloc-IDs per OLT's discretion.

To activate a T-CONT instance for carrying the upstream user traffic, the OLT has to establish a mapping between the T-CONT instance and an Alloc-ID, which was previously assigned to the given ONU via the PLOAM messaging channel. Mapping of T-CONTs to Alloc-IDs is performed via the OMCC. The OMCC itself is mapped, in the upstream direction, to the default Alloc-ID. This mapping is fixed; it cannot be managed via the OMCI MIB and it should survive OMCI MIB reset.

In many cases the mapping between T-CONTs and Alloc-IDs is one-to-one, strictly speaking, it is the Alloc-ID, not a T-CONT, which is visible at the TC layer of the system.

5.9 Use of the terms bandwidth assignment and bandwidth allocation

The term "bandwidth assignment" refers to the distribution of the upstream PON capacity between the ONUs' traffic-bearing entities using certain isolation and fairness criteria. In static bandwidth assignment, the said criteria are based exclusively on the provisioned parameters of the traffic contracts, and the bandwidth is assigned on the timescale of the individual service provisioning. In dynamic bandwidth assignment, the activity status of the traffic-bearing entities is taken into consideration along with the parameters of the traffic contracts, and the bandwidth assignment is periodically refined.

The term "bandwidth allocation", on the other hand, denotes the process of granting individual transmission opportunities to the ONUs' traffic-bearing entities on the timescale of a single PHY frame. The process of bandwidth allocation uses the assigned bandwidth values as an input and produces the per-frame bandwidth maps as an output. It also accounts for PLOAM messaging and DBRu overhead requirements and the short-term disturbances associated with the creation of quiet windows for serial number acquisition and ranging purposes.

Bibliography

[b-ITU-T G.983.1] Recommendation ITU-T G.983.1 (2005), *Broadband optical access systems based on Passive Optical Networks (PON)*.

[b-ITU-T G.984.1] Recommendation ITU-T G.984.1 (2008), *Gigabit-capable passive optical networks (GPON): General characteristics*.

[b-ITU-T G.984.6] Recommendation ITU-T G.984.6 (2008), *Gigabit-capable passive optical networks (GPON): Reach extension*.

[b-ITU-T G-Sup.39] ITU-T G-series Recommendations – Supplement 39 (2008), *Optical system design and engineering considerations*.

[b-ITU-T I.112] Recommendation ITU-T I.112 (1993), *Vocabulary of terms for ISDNs*.

[b-DSLF TR-101] Broadband Forum (formerly, DSL Forum) Technical Report TR-101 (2006), *Migration to Ethernet Based DSL Aggregation*.

[b-MEF 6.1] MEF Technical Specification MEF 6.1 (2008), *Ethernet Services Definitions – Phase 2*.

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