



INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

L.90

(02/2012)

SERIES L: CONSTRUCTION, INSTALLATION AND
PROTECTION OF CABLES AND OTHER ELEMENTS OF
OUTSIDE PLANT

Optical access networks topologies for broadband services

CAUTION !

PREPUBLISHED RECOMMENDATION

This prepublication is an unedited version of a recently approved Recommendation. It will be replaced by the published version after editing. Therefore, there will be differences between this prepublication and the published version.

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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.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Recommendation ITU-T L.90

Optical access networks topologies for broadband services

Summary

Recommendation ITU-T L.90 describes the optical access network to be used in the design and construction of Fibre to the Home (FTTH). It deals mainly with access network architectures and the upgrading or new deployment of optical fibre to optical access networks.

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Recommendation ITU-T L.90

Optical access networks topologies for broadband services

1. Introduction

Progress on multimedia technologies has led to the active development of many kinds of broadband services such as data and video communication using access networks. It is important that high-speed broadband networks be developed economically to provide such services to all subscribers. In order to provide these services in a timely way, it is necessary to construct optical access networks quickly, efficiently and cost-effectively. However, recent progress in the application of optical plant technology in local access networks has provided substantial technical and economical experiences in several countries. Considering this, the network design must take into account planning, construction, maintenance and operation.

The development of optical fibre access networks for broadband services can largely be divided into four stages based on the increasing number of customers, namely the initial stage, the growth stage, the mature stage and the final stage.

Here, an optical access network is defined as a network of optical fibre cables that extend from a carrier's central office into FTTC, buildings, individual homes, apartment houses or business offices for broadband services.

2. Scope

This Recommendation deals mainly with important considerations concerning optical singlemode fibre access network architectures and the ability to upgrade or new deployment of the optical networks, which are the most important items at each stage in terms of designing, constructing, operating and maintaining optical access networks quickly, effectively and economically for broadband services. Moreover, this Recommendation describes the optical transmission performance, the maintenance system and power supply required for the design and construction of an optical access network for broadband services.

Furthermore this recommendation covers:

- physical network architectures that have been used to meet different system objectives
- environmental conditions in customer serving areas
- passive optical components used for construction of the network
- installation and maintenance issues
- safety requirements
- use of standardised material

3. 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.657] Recommendation ITU-T G.657 (2009), *Characteristics of a bending-loss insensitive single-mode optical fibre and cable for the access network*.
- [ITU-T G.662] Recommendation ITU-T G.662 (1998), *Generic characteristics of optical amplifier devices and subsystems*.
- [ITU-T G.664] Recommendation ITU-T G.664 (2003), *Optical safety procedures and requirements for optical transport systems*.
- [ITU-T G.671] Recommendation ITU-T G.671 (2002), *Transmission characteristics of optical components and subsystems*.
- [ITU-T G.694.1] Recommendation ITU-T G.694.1 (2002), *Spectral grids for WDM applications: DWDM frequency grid*.
- [ITU-T G.694.2] Recommendation ITU-T G.694.2 (2003), *Spectral grids for WDM applications: CWDM wavelength grid*.
- [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.983.4] Recommendation ITU-T G.983.4 (2001), *A broadband optical access system with increased service capability using dynamic bandwidth assignment (DBA)*.
- [ITU-T G.983.5] Recommendation ITU-T G.983.5 (2002), *A broadband optical access system with enhanced survivability*.
- [ITU-T G.984.1] Recommendation ITU-T G.984.1 (2003), *Gigabit-capable Passive Optical Networks (GPON): General characteristics*.
- [ITU-T G.985] Recommendation ITU-T G.985 (2003), *100 Mbp/s point-to-point Ethernet based optical access system*.
- [ITU-T G.986] Recommendation ITU-T G.986 (2010), *10 Gbp/s point-to-point Ethernet based optical access system*.
- [ITU-T G.987] Recommendation ITU-T G.987 series, *10 Gigabit-capable passive optical network (XG-PON)*.
- [ITU-T G.987.1] Recommendation ITU-T G.987.1 (2010), *10 Gigabit-capable passive optical network (XG-PON): general requirements*.
- [ITU-T G.988] Recommendation ITU-T G.988 (2010), *ONU management and control interface specification (OMCI)*.
- [ITU-T K.51] Recommendation ITU-T K.51 (2009), *Safety criteria for telecommunication equipment*.

- [ITU-T L.10] Recommendation ITU-T L.10 (2002), *Optical fibre cables for duct and tunnel application.*
- [ITU-T L.12] Recommendation ITU-T L.12 (2000), *Optical fibre joints.*
- [ITU-T L.13] Recommendation ITU-T L.13 (2003), *Performance requirements for passive optical nodes: Sealed closures for outdoor environments.*
- [ITU-T L.15] Recommendation ITU-T L.15 (1993), *Optical local distribution networks – Factors to be considered for their construction.*
- [ITU-T L.26] Recommendation ITU-T L.26 (2002), *Optical fibre cables for aerial application.*
- [ITU-T L.31] Recommendation ITU-T L.31 (1996), *Optical fibre attenuators.*
- [ITU-T L.36] Recommendation ITU-T L.36 (1998), *Single mode fibre optic connectors.*
- [ITU-T L.37] Recommendation ITU-T L.37 (1998), *Fibre optic (non-wavelength selective) branching devices.*
- [ITU-T L.40] Recommendation ITU-T L.40 (2000), *Optical fibre outside plant maintenance support, monitoring and testing system.*
- [ITU-T L.41] Recommendation ITU-T L.41 (2000), *Maintenance wavelength on fibres carrying signals.*
- [ITU-T L.43] Recommendation ITU-T L.43 (2002), *Optical fibre cables for buried application.*
- [ITU-T L.44] Recommendation ITU-T L.44 (2000), *Electric power supply for equipment installed as outside plant.*
- [ITU-T L.50] Recommendation ITU-T L.50 (2010), *Requirements for passive optical nodes: Optical distribution frames for central office environments.*
- [ITU-T L.51] Recommendation ITU-T L.51 (2003), *Passive node elements for fibre optic networks – General principles and definitions for characterization and performance evaluation.*
- [ITU-T L.53] Recommendation ITU-T L.53 (2003), *Optical fibre maintenance criteria for access networks.*
- [ITU-T X.200] Recommendation ITU-T X.200 (1994) ISO/IEC 7498-1:1994.

4. Definitions

This recommendation defines the following terms:

4.1 Access point: A drop optical cable from subscriber premises is connected to a distribution cable at this point.

4.2 Distribution point: Optical cables from some access points in a distribution area are gathered to this point and connected to the feeder cable from the central office.

4.3 Central office area: The area means the section from OLT to ODF in the central office.

4.4 Feeder area: The area is between ODF and the distribution point.

4.5 Distribution area: The area is between the distribution point and the access point.

4.6 User area: The area is between the access point and ONU/ONT in subscriber premises.

4.7 BEP: allows the transition from outdoor to indoor cable. The type of transition may be a splice or a removable connection.

4.8 FD: The floor distributor is an optional element which allows the transition from the vertical to the horizontal indoor cable.

4.9 OTO: is a fixed connecting device where the fibre optic indoor cable terminates. The optical telecommunications outlet provides an optical interface to the equipment cord of the ONT/CPE.

4.10 ONT: terminates the optical network at the customer premise. It includes an electro-optical converter. The ONT and CPE may be integrated.

4.11 CPE: is any active device, e.g. set-top-box, that provides the end-user with certain services (high-speed data, TV, telephony, etc.). The ONT and CPE may be integrated.

4.12 User equipment: the user equipment TV, Phone, personal computer, etc. allows the user to access the services.

For the purpose of this Recommendation, the definitions given in Recommendations [ITU-T G.652], [ITU-T G.662], [ITU-T G.664], [ITU-T G.671], [ITU-T G.694.1], [ITU-T G.694.2], [ITU-T G.982], [ITU-T G.983.1] to [ITU-T G.983.5], [ITU-T G.984.1], [ITU-T K.51], [ITU-T L.13], [ITU-T L.26] and [ITU-T L.51] apply.

5. Abbreviations

This Recommendation uses the following abbreviations:

BEP	Building Entry Point
FD	Floor Distributor
CATV	Cable Television
CPE	Customer Premises Equipment
CWDM	Coarse Wavelength Division Multiplexing
DWDM	Dense Wavelength Division Multiplexing
FTTH	Fibre to the Home
ODF	Optical Distribution Frame
OLT	Optical Line Terminal
OMDF	Optical Main Distribution Frame
ONU	Optical Network Unit
ONT	Optical Network Termination
OTO	Optical Telecommunications Outlet
POP	Point of Presence
WDM	Wavelength Division Multiplexing
ONT	Optical Network Termination

6. Concept of layers within a network architecture

The layer classification is according to [ITU-T X.200] OSI ISO Reference model.

This specification refers only to the physical layer (Layer 1).

6.1. Optical fibre

A suitable choice of fibre and splicing technology should be made. Single-mode fibre, normally to Recommendation [ITU-T G.652] and [ITU-T G.657] are the most appropriate for a wide range of telecommunications services in the local distribution network since this fibre benefits from an economy of scale and has long-term potential for future services. With current usage of single-mode fibre, splicing techniques will allow typical splice losses of less than 0.5dB to be achieved (see Recommendation [ITU-T L.12] for further information).

The user should note that only the Recommendation [ITU-T G.657A] fibres are compatible to G.652 fibres. Using other fibre types will increase the uncertainty regarding the splice values and compatibility issues.

6.2. Passive components and cables.

This requires cable design and fibre types to be determined appropriate to the network architecture adopted, see clause 7.

Passive components may be used in conjunction with optical fibre and thus are considered as part of the passive elements sublayer.

Other passive optical plant hardware such as splice closures, cabinets and housings for OPSs, WDMs, OFAs, connectors and patch panels, all of which have specific environmental constraints.

6.3. Structural facility

This optical access network architecture evolved from copper networks in the form of a star radiating from the exchange. Therefore, it will allow the introduction of optical spines to generate the network architectures. Hence, the changes required for optical networks concern mainly the manner in which the optical cables and optical fibres are deployed mainly within the outside plant. However, use of optical plant may lead to development of new structures and plant layout. For example, a duct installed for the copper network may be sub-divided, compartmented, using appropriately sized plastic tubes, each to accommodate one of the smaller diameter optical cables. Also, special consideration shall be given to aerial support structures for optical cables.

7. Features of access network architecture

In order to select or design an optical access network for FTTH, telecommunication companies and local service providers should mainly consider:

- 1) scalability (number of terminated fibres, total fibre length of network, etc.);
- 2) survivability (security, supervisory system, etc.);
- 3) functionality (bit rate, transmission distance, etc.);
- 4) construction and maintenance costs;
- 5) upgrading the optical network (increase transmission capacity, increase transmission length, increase number of customers including future demand).

When designing or constructing an optical access network, telecommunication companies should select and use one or more of the following architectures, based on the optical access network requirements in each region.

7.1. Point-to-point architecture

The basic configuration for a point-to-point architecture is shown in Figure 1. This distributes one or more fibres individually from an OLT in a central office to an ONU in buildings, apartment houses or residential premises. Therefore, a large number of fibres are installed and distributed from a central office to customers. The location of the active node is in a temperature controlled environment. Between a central office and building basement only splices are used in closures or in the street cabinets in outside plant.

This configuration has low optical loss and provides the maximum distance between central offices and customers. The insertion loss of the optical line is a sum of fibre, splice and connector losses. Moreover, this may be suitable for customers requiring large bandwidth and/or high security.

The cabling characteristics for the point-to-point network shall be defined in the following main parts of the network:

- OMDF in POP
- Feeder Cabling between OMDF and manhole
- Drop Cabling between manhole and BEP
- BEP
- Cabling between BEP and OTO
- OTO
- Equipment cord between OTO and ONT/ONU/CPE. A specific home cabling can be deployed in the apartment/ customer site instead of the equipment cord

Each customer is connected with one to four fibres from the building entry point to the optical telecommunication outlet. Typically one to four fibres are either collected in one indoor cable or they can also be taken from the multiple fibre cables. At least one fibre is connected between the central office (OMDF) and the customer site (OTO).

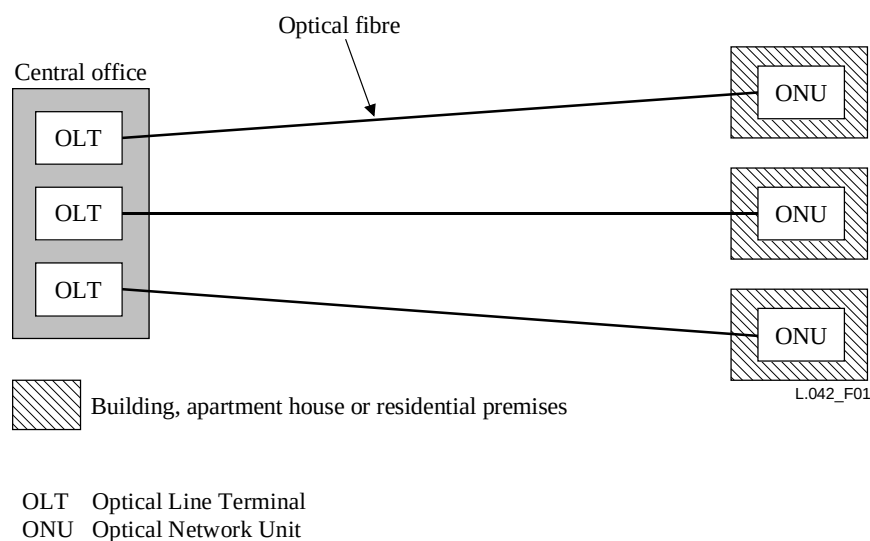


Figure 1 – Point-to-point network, simplified view

A more detailed reference model for point –to-point networks may be detailed as follows in figure 2:

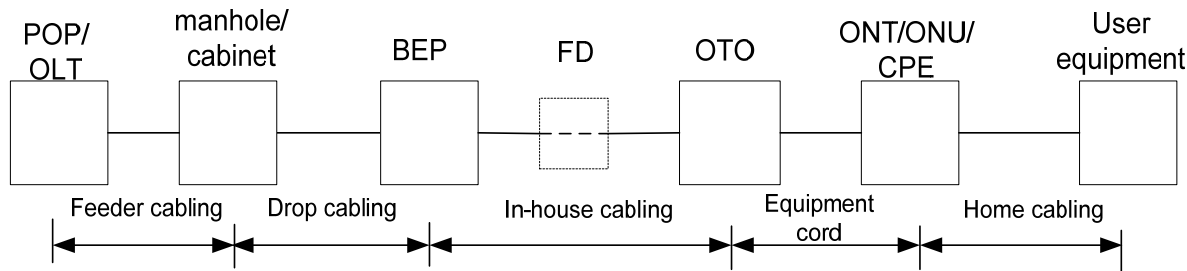


Figure 2 – Detailed reference point-to-point network

7.2. Ring architecture

The basic configuration of a ring network is shown in Figure 3. This starts and ends at the same central office and distributes two or more fibres to ONUs in buildings, apartment houses or residential premises. Therefore, for point-to-point ring networks as shown in Figure 3a, a very large number of fibres are installed and distributed from central offices to customers. By contrast, for multiple-type ring networks as shown in Figure 3b, the number of distributed fibres can be reduced compared to a point-to-point ring network. The advantages of the ring network are very high reliability and ease of maintenance for alternative routing.

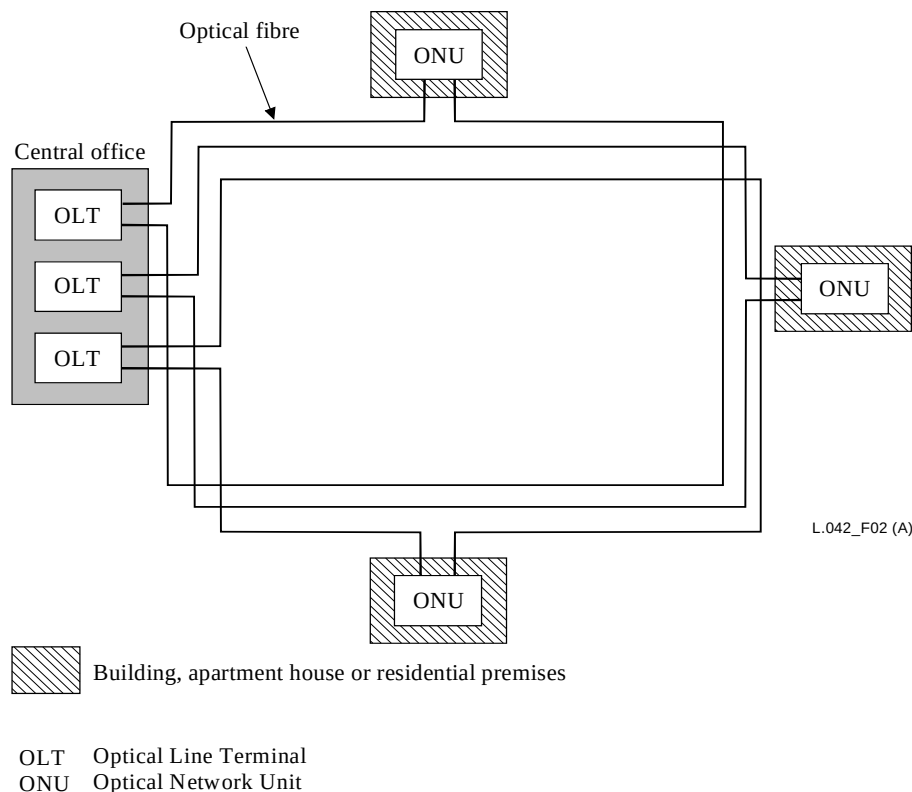


Figure 3a – Ring network (Point-to-point type)

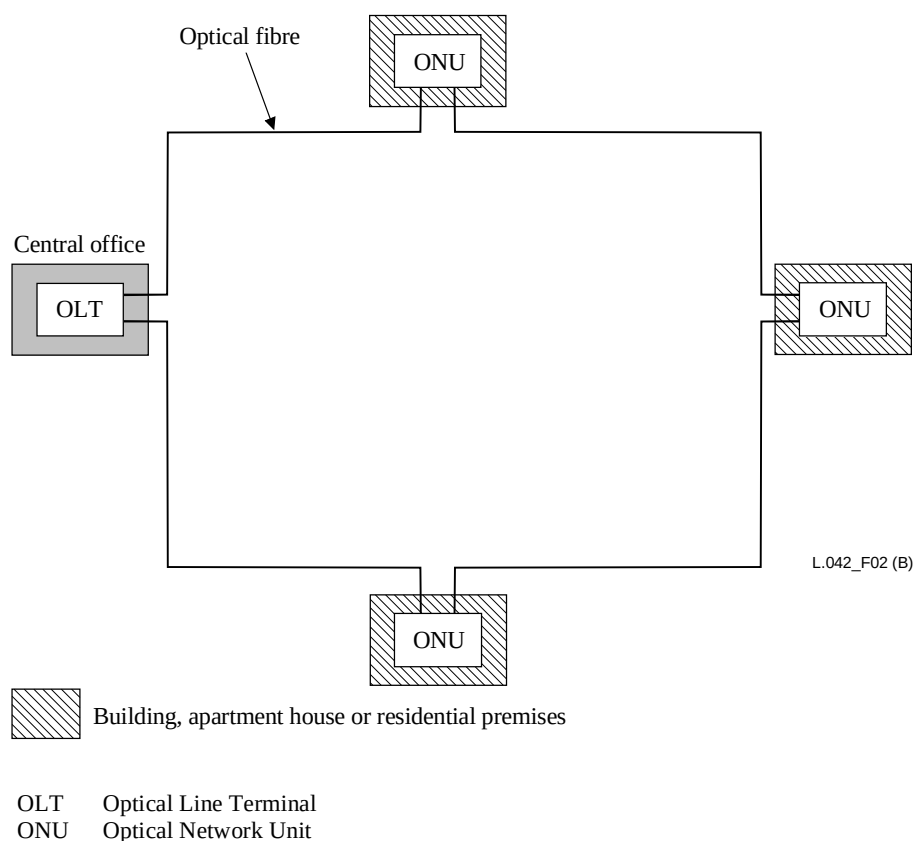


Figure 3b – Ring network (Multiple type)

7.3. Point-to-multipoint architecture

The basic configuration of a point-to-multipoint network is shown in Figure 4 with one branching component per OLT port. Figure 5 would be the configuration with two branching components per OLT port. The feature of the point-to-multipoint network is that a (fibre optic) branching component or an active node is placed between an OLT and several ONUs. The location which is installed for use with (fibre optic) branching components or active nodes is the most important item in terms of this network design and construction. Moreover, two types of (fibre optic) branching component can be used in this network. One type has a wavelength multiplexer and demultiplexer, the other does not. A (fibre optic) branching component without a wavelength multiplexer and demultiplexer increases the insertion loss and reduces the transmission distance as the number of branches is increased. By contrast, a (fibre optic) branching component with a wavelength multiplexer and demultiplexer is mainly used in WDM systems. The insertion loss does not increase greatly but it is difficult to control and manage the wavelength when the number of branches is increased.

When a (fibre optic) branching component is installed in a central office, at least one fibre is connected between the central office and a customer's building, apartment house or residential premises. Therefore, a large number of fibres are installed and distributed from the central office. Moreover, the environmental conditions for the (fibre optic) branching component are mild because it is installed inside a central office.

On the other hand, a (fibre optic) branching component can be installed in a closure or cabinet in the outside plant or inside a customer's building. In such cases, the number of fibres between an OLT and a fibre optic branching component can be reduced. However, the environmental