

Supplement

## **ITU-T L Suppl. 58 (12/2023)**

SERIES L: Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant

Supplements to ITU-T L-series Recommendations

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### **ITU-T L.250 – National experiences for FTTx network architectures**



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**Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant**

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## Supplement 58 to ITU-T L-series Recommendations

### ITU-T L.250 – National experiences for FTTx network architectures

#### Summary

Supplement 58 to ITU-T L-series Recommendations presents national experiences on fibre to the x (FTTx) network architectures which could be used for reference during the construction of FTTx networks.

#### History\*

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## **Introduction**

Over the past decades the world has seen profound development of optical access networks, and a significant volume of useful experience has been amassed relating to the architectures of access networks from countries where access networks are already mature. This Supplement summarizes the national experiences for fibre to the x (FTTx) network architectures presented as the references for Recommendation ITU-T L.250 "*Topologies for optical access network*", aiming to share best practices and useful information, in particular for developing countries, and so help to extend the optical network to end users worldwide.

Fibre to the x (FTTx) is an alternative to traditional copper loop technology, that takes fibre closer to the end-user and provides last-mile connectivity. FTTx technology comprises fibre to the building (FTTB), fibre to the curb (FTTC) and fibre to the home (FTTH).

# Supplement 58 to ITU-T L-series Recommendations

## ITU-T L.250 – National experiences for FTTx network architectures

### 1 Scope

This Supplement provides information on national experiences of fibre to the x (FTTx) network architectures as the references for Recommendation ITU-T L.250 "*Topologies for optical access network*".

### 2 References

- [ITU-T G.694.1] Recommendation ITU-T G.694.1 (2020), *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.698.4] Recommendation ITU-T G.698.4 (2023), *Multichannel bi-directional DWDM applications with port agnostic single-channel optical interfaces*.
- [ITU-T G.872] Recommendation ITU-T G.872 (2024), *Architecture of the optical transport network*.
- [ITU-T L.250] Recommendation ITU-T L.250 (2024), *Topologies for optical access network*.

### 3 Definitions

#### 3.1 Terms defined elsewhere

None.

#### 3.2 Terms defined in this Supplement

None.

### 4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

AAU	Active Antenna Unit
CO	Central Office
C-RAN	Centralized Radio Access Network
CU	Centralized Unit
CWDM	Coarse Wavelength Division Multiplexing
DSL	Digital Subscriber Line
DU	Distributed Unit
DWDM	Dense Wavelength Division Multiplexing
FAT	Fibre Access Terminal
FSOC	Free Space Optical Communication
FTTB	Fibre to the Building
FTTC	Fibre to the Curb

FTTH	Fibre to the Home
FTTx	Fibre to the x
GPON	Gigabit Passive Optical Network
HEE	Head End Equipment
IPTV	Internet Protocol Television
LWDM	LAN Wavelength Division Multiplexing
OD	Optical Demultiplexer
ODF	Optical Distribution Frame
ODN	Optical Distribution Network
OLT	Optical Line Terminal
OM	Optical Multiplexer
ONT	Optical Network Terminal
ONU	Optical Network Units
OTB	Optical Termination Box
PON	Passive Optical Network
RAN	Radio Access Network
ROI	Return on Investment
RRU	Remote Radio Unit
TEE	Tail End Equipment
UI	User Interfaces
WDM	Wavelength Division Multiplexing

## **5 Conventions**

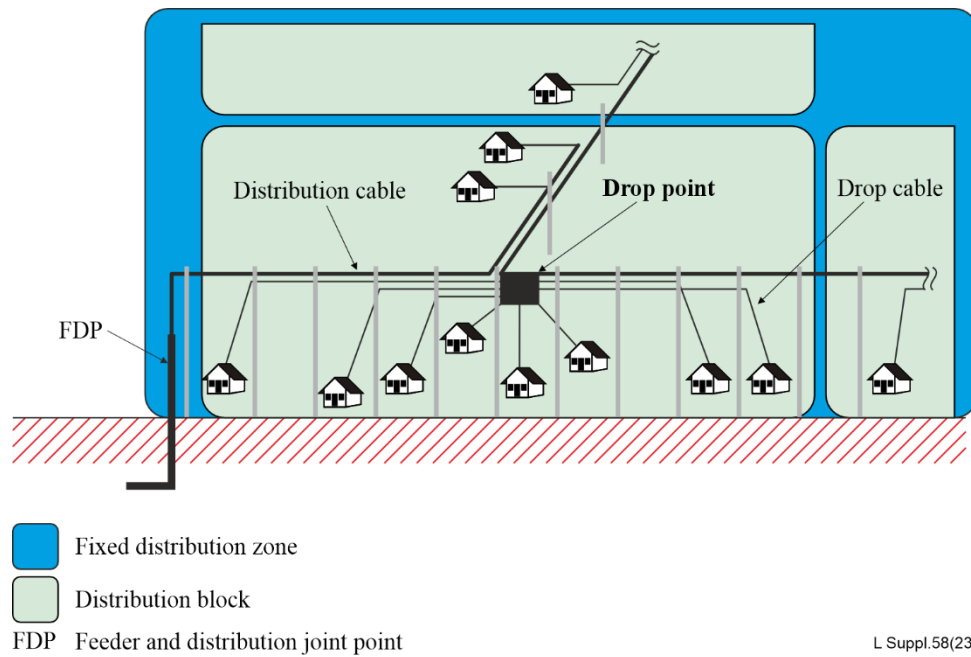
None.

## **6 Japanese experience**

### **6.1 Customer drop area size optimization (distribution area)**

A distribution zone is divided into several distribution blocks based on service demand using optical fibres. A drop point is established in a distribution block. The subscribers in the same block are dropped from the same drop point as shown in Figure 1.





**Figure 1 – Distribution block configuration**

The optimum size of the distribution block should be obtained in terms of the minimum cost of construction between a feeder point and a subscriber. When there are many distribution blocks and the number of drop points increases, the cost of construction between the feeder point and the subscriber is too high to allow the use of multiple closures for drop and high count distribution cables. However as shown in Table 1, when there are few distribution blocks and the number of drop points decreases, the cost of construction between a feeder point and a customer is also too high to allow installation of multiple long drop cables. Therefore, the number of distribution blocks in the distribution zone is being investigated to minimize the cost of construction between the feeder point and the subscriber.

**Table 1 – Difference due to distribution block size**

		Large	Small
		Number of distribution blocks	
Cost	a) Drop cable	Low	High
	b) Drop closure	High	Low
	c) Distribution cable	High	Low

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## 6.2 Optical fibre distribution of access networks

### 6.2.1 Introduction

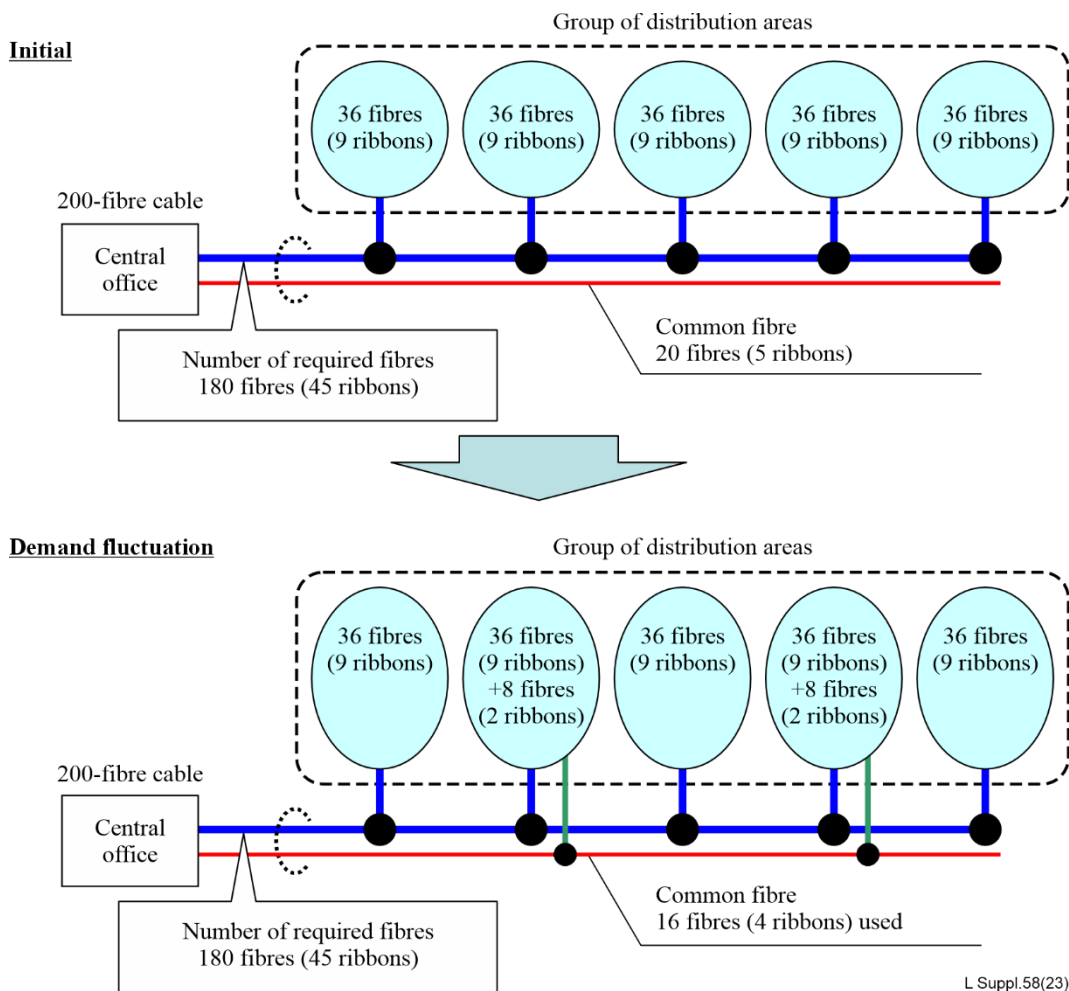
Fibre to the home (FTTH) in Japan has grown rapidly in recent years. The number of FTTH subscribers had exceeded 37 million at the end of 2022. It seems that FTTH has moved from the

growth stage to the mature stage. Some design techniques have been developed in order to construct the access network effectively during the growth stage. This clause describes the optical fibre network design method in Japan for the growth stage.

### 6.2.2 Design of optimum margin for demand fluctuation for the feeder area

The total number of fibres for a feeder area depends on the number of fibres required for each distribution area. In this case, the number of fibres for each distribution area must be more than the expected user demand in order to be able to cope with demand fluctuations. However, it is less cost effective if additional fibres are distributed for every distribution area. On the other hand, cost effectiveness is also reduced by the additional construction time and cost required if the fibres in a feeder cable are distributed and connected to the fibres in a distribution cable to meet every new user demand. Thus, optimizing the margin for demand fluctuation is important for feeder areas.

A design method that overcomes the above problem is shown in Figure 2. In the feeder area, the fibres are divided into two groups. In the first group, the number of fibres corresponds to the expected user demand for each distribution area. In the second group, some fibres are used in common for the whole distribution area. This design is cost effective and highly reliable with a minimum number of fibres using the common fibre when there is demand fluctuation.

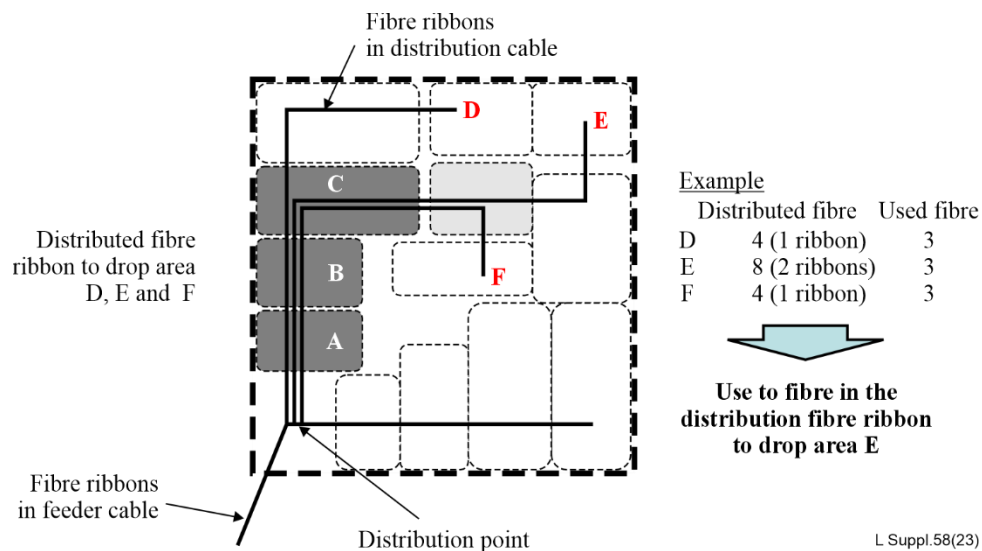


**Figure 2 – Configuration of the fibre distribution method for demand fluctuation (with 200-fibre cable (4-fibre per ribbon × 50 ribbons))**

For example, 10% to 20% of the total distributed fibre is provided to meet demand fluctuations, although the number of fibres (or fibre ribbons) that are required depends on factors such as the size of each distribution area.

### 6.2.3 Balanced use of distributed fibre to each drop area in aerial distribution areas

An aerial distribution area is divided into several drop areas based on user demand of the growth stage. Since the user demand is large in the growth stage, it is effective to distribute the optical fibre ribbons to every drop area. However, it is not effective to distribute the optical fibre ribbons to every drop area in the initial stage, when user demand is not great. Thus, in order to prevent the excessive distribution of optical fibres, each optical fibre ribbon is distributed to a limited number of drop points serving each specific drop area. An example distribution area is shown in Figure 3. Distribution cables branch to some drop areas and fibre ribbons must be distributed to each drop point. In this case, the fibre ribbons are distributed to drop areas D, E and F through drop areas A, B and C. Therefore, if the user demand rises and additional fibres are needed, any of the fibres in the fibre ribbon that passes through these areas can be used. The effective use of fibres is achieved by first selecting the fibre in a distributed fibre ribbon with a low use rate. This can prevent the need for reconstruction due to a shortage of fibres.



**Figure 3 – Configuration of balanced use in aerial distribution area**

If the above technique is used, it is very important to establish an operation database and a management system. In addition, a fibre ribbon separation technique at mid-span without cutting the fibre ribbon is required.

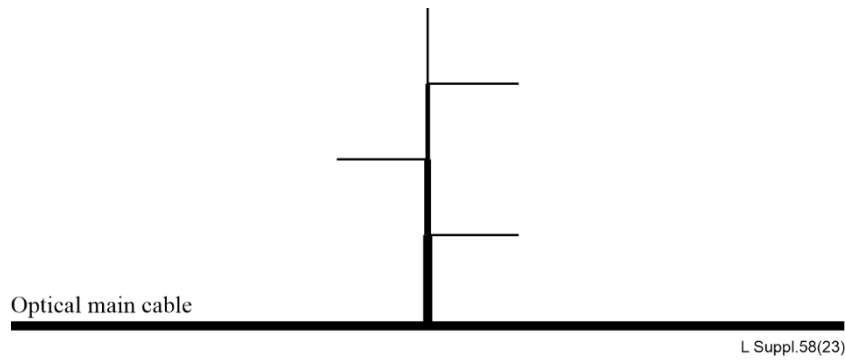
## 7 Korean experience

### 7.1 Distribution methods

There are five distribution methods for the access network: tree distribution, ring distribution, cross-connect distribution, link distribution and star distribution. Each method has particular characteristics and applications.

#### 7.1.1 Tree distribution method

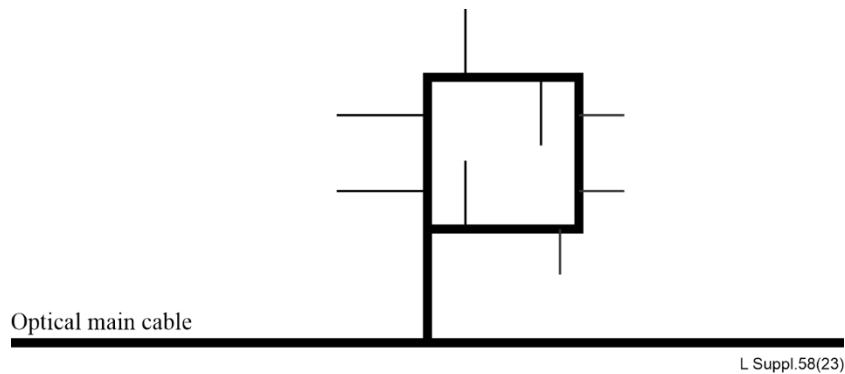
With the tree distribution method, as shown in Figure 4, distribution cables are simply deployed at demand areas and reduced material and installation costs can be achieved at the same time. However, this distribution method means it is difficult to meet unexpected demands and it is not easy to restore services when breakdowns occur. Thus this method is very effective in developed or stabilized areas such as areas with apartment complexes, especially when these demands are dispersed linearly along the distribution routes.



**Figure 4 – Tree distribution method**

### 7.1.2 Ring distribution method

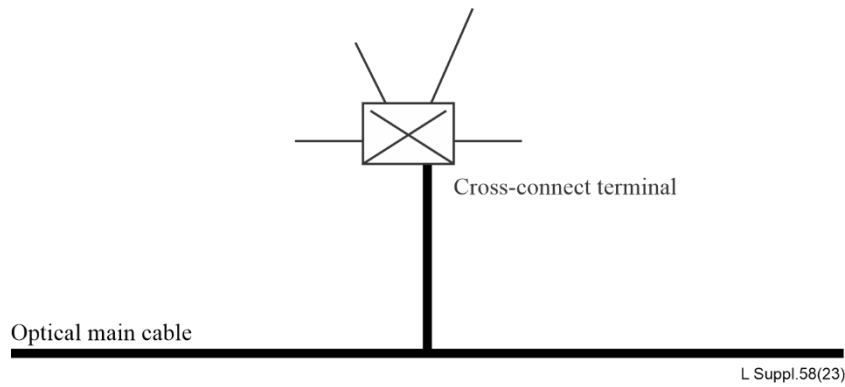
The ring distribution method, as shown in Figure 5, is cost effective for optical distribution networks, especially in residential areas with a high population density as well as in optical feeder networks. This method can be employed in residential blocks consisting of rows of houses and detached dwellings that are dispersed uniformly in terms of demand. The demand for high-speed services from users in residential areas is increasing rapidly, and this method has the advantage of being flexible in response to these demands and in obtaining high reliability at the same time.



**Figure 5 – Ring distribution method**

### 7.1.3 Cross-connect distribution method

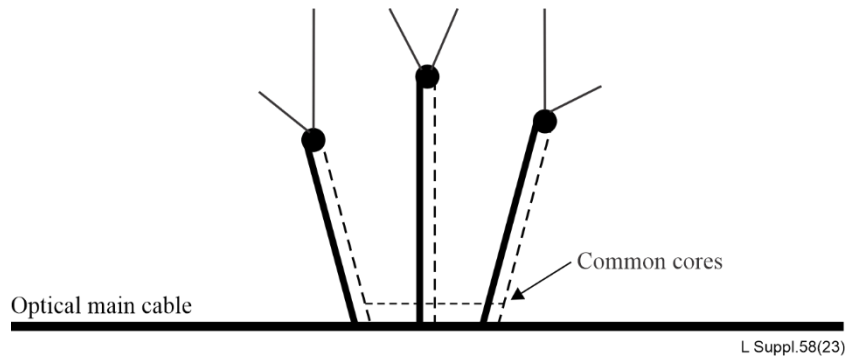
The cross-connect distribution method, as shown in Figure 6, is very useful regarding reliability and can operate using cross-connect cabinets. When new cables must be deployed to meet increasing demand, deployment work is convenient and efficient because it can be undertaken above ground in a cross-connect cabinet. However, it is difficult to secure the space of cross-connect cabinets in distribution areas and to keep the cabinets safe from vandalism. When this method is employed in residential blocks far from feeder networks, it may also achieve cost effectiveness.



**Figure 6 – Cross-connect distribution method**

#### 7.1.4 Link distribution method

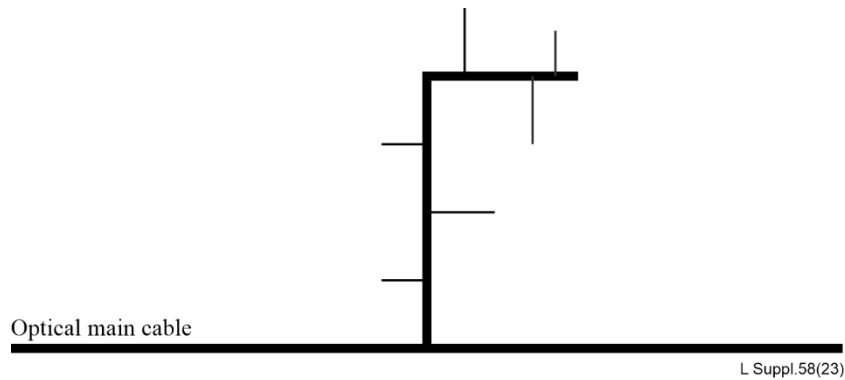
Common cores can be used when unexpected demands arise at any distribution points at which they are linked. However, if the number of linked distribution cables is increased, the material cost of, for example, distribution cables will increase. Cost analysis indicates that 3 to 5 is the economical number for linked distribution cables. Cost analysis also suggests that this method could be 15% more economical for distances less than 1 km from the feeder network than the tree distribution or the cross-connect distribution. While it is related to the number of optical fibre cores managed in a distribution point, it is more economical when the number of cores increases. So, this link distribution method, as shown in Figure 7, is applicable when it is difficult to install a cross-connect cabinet, or the distribution areas are at a distance of less than about 1 km from the feeder networks.



**Figure 7 – Link distribution method**

#### 7.1.5 Star distribution method

The star distribution method, as shown in Figure 8, can respond more flexibly to demand than the tree distribution method. Also, it can be expanded into ring distribution if necessary. It is, therefore, applicable to developing areas where the demand has not stabilized. Ring distribution and star distribution are very flexible in terms of meeting unexpected user demands without cross-connect cabinets.



**Figure 8 – Star distribution method**

In addition, if we select and apply the distribution method suitable for the local environment, optical fibre cores can quickly be provided and used efficiently when requested. Finally, the described distribution methods and guidelines for these optical distribution networks can be applied to the design of optical networks for access areas such as fibre to the home (FTTH).

## 7.2 Number and size of rings in the feeder network

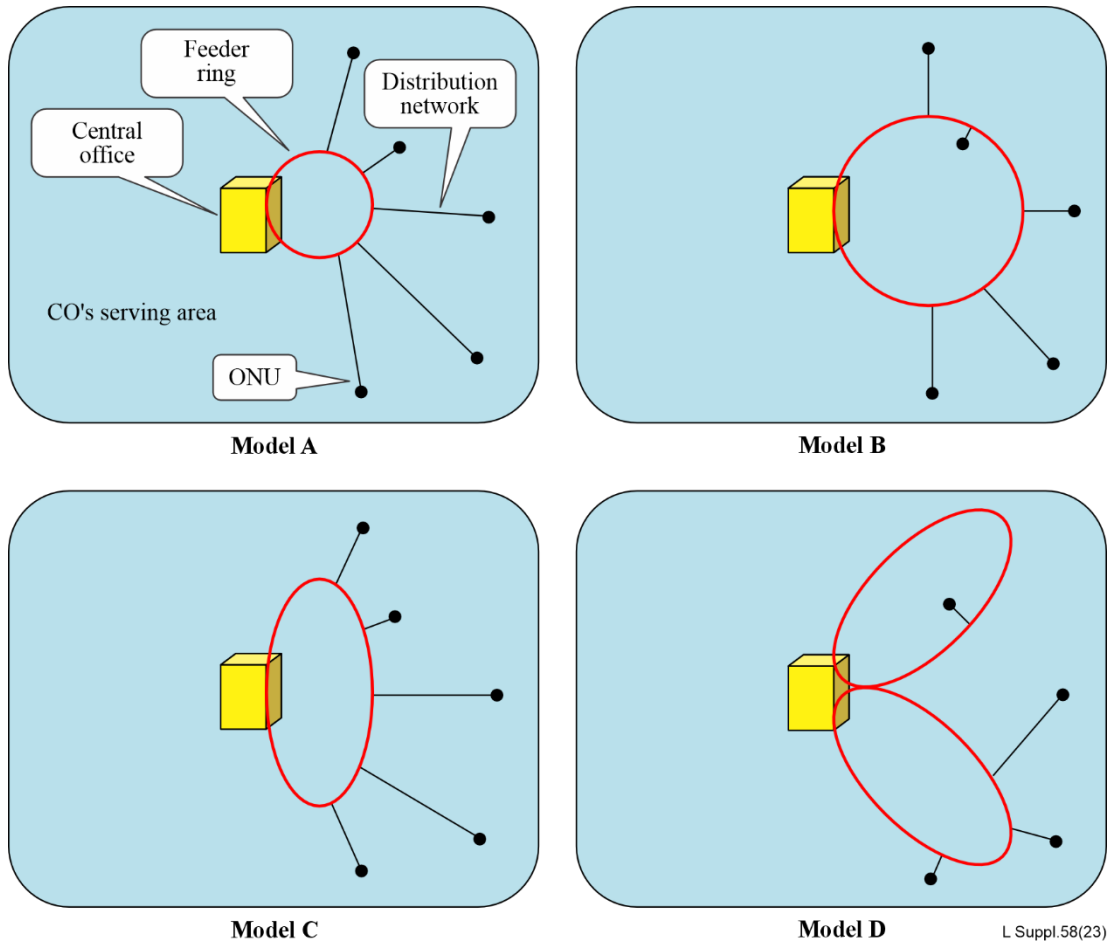
An access network consists of a feeder network and a distribution network. The construction cost of an access network is the total cost of the combined construction costs of the feeder and distribution networks. It is assumed that the number and size of rings in the feeder network are optimized in order to minimize the construction costs of the access network. Simulations on the different models shown in Figure 9 and Table 2 allowed the establishment of relationships between the number and size of rings in the feeder network and the construction costs of the access network. Table 2 indicates the possibility of a trade-off between the construction cost of a feeder network and a distribution network.

We assume that the serving area of central office (CO) and feeder ring are square, and that the CO is centred in the serving area. In the model,  $K$  is defined as the ratio of the side length of the feeder ring ( $d$ ) divided by the side length ( $D$ ) of the CO's serving area. Figure 10 shows the calculated construction costs for some selected models and  $K$  values.

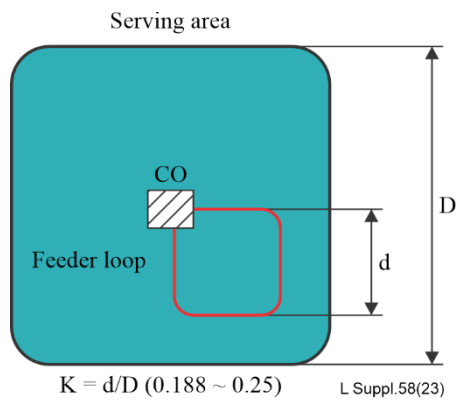
When  $K$  increases, construction costs of the feeder network increase and those of the distribution network decrease. The Korean experience concluded that optimal  $K$  could be about 0.188 to 0.25 and that the optimal number of rings could be up to 5 or 6 in the CO's serving area. For information, the average serving area is  $16 \text{ km}^2$  in Korean urban areas. In that case, the optimal length of one feeder ring may be about 3 to 4 km. Figure 11 shows the relative construction costs on some selected  $K$ .

**Table 2 – Cost variation on the numbers and size of rings in feeder network**

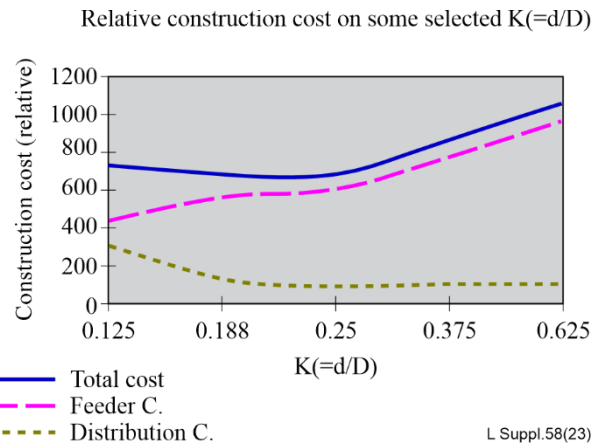
		Size of ring		Number of rings	
		Small (Model A)	Large (Model B)	Few (Model C)	Many (Model D)
Cost	Feeder network	Low	High	Number and size of rings in feeder network	High
	Distribution network	High	Low	High	Low



**Figure 9 – Some models of feeder ring configuration**



**Figure 10 – K, one side length ratio of feeder ring (d) versus the boundary (D) of CO's serving area**

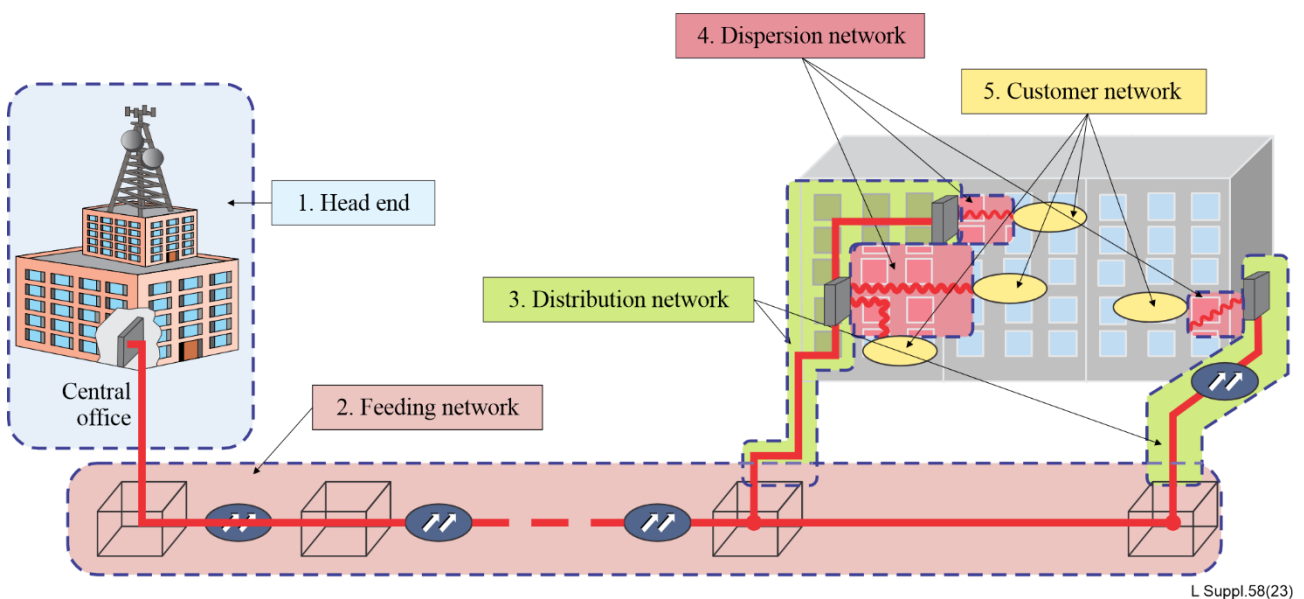


**Figure 11 – Relative construction costs on some selected K**

## 8 Spanish experience

### 8.1 Introduction

Two branching components are used per optical line terminal (OLT) port. The first splitter is usually installed in the maintenance hole or hand hole closest to the customer, and the second splitter is usually installed in the optical termination box.



**Figure 12 – Schematic of FTTH access network**

Figure 12 describes the main concepts of the access network.

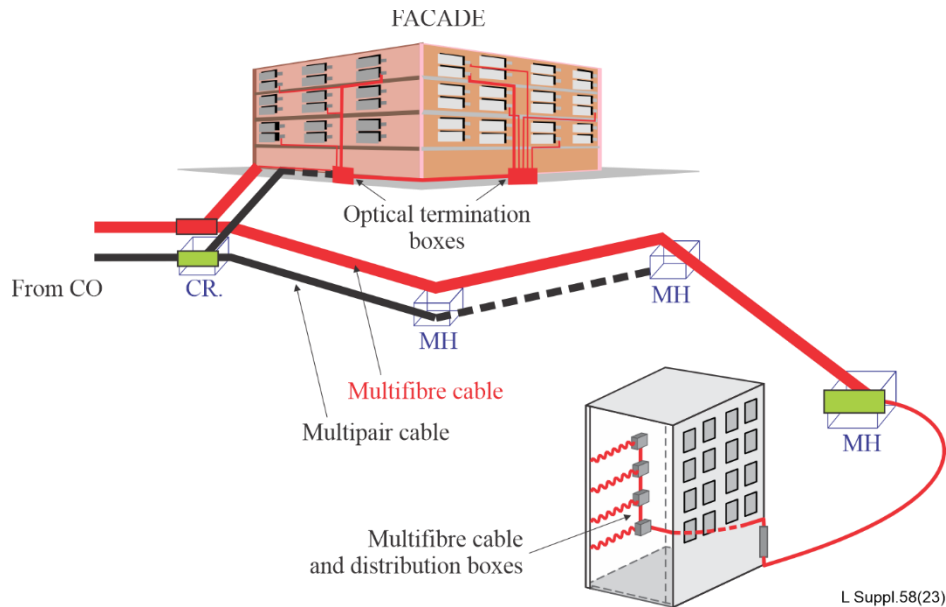
- 1) Head end: Local exchange where gigabit passive optical network (GPON) devices (OLT and fibre frame) will be installed. An FTTH area includes one or more copper areas.
- 2) Feeding network: The network between the fibre frame and the last maintenance hole, where the fibre has been installed underground.
- 3) Distribution network: The network between the first splitter and the optical termination box (OTB). Splitters will be installed in the maintenance hole and the optical termination box into the buildings or on the facade.



- 4) Dispersion network: This is the final part of the FTTH access network. It includes everything from the OTB to the optical network terminal (ONT). This part will be installed only when a customer wants to enjoy the benefits of an FTTH network (connected to home).
- 5) Customer network: A network for the distribution of services at customer premises. This network is directly after the ONT.

## 8.2 Scenarios

Figure 13 illustrates the main scenarios: indoor and facade.



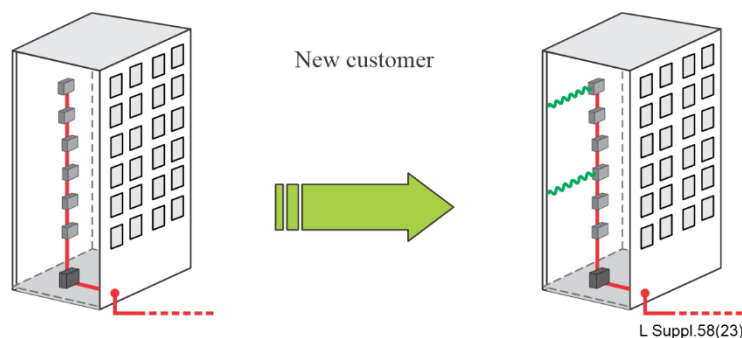
**Figure 13 – Main scenarios for FTTH**

### 8.2.1 Indoor

For an indoor scenario, as shown in Figure 14, OTBs are located inside the building. It is mandatory for new buildings to have a common telecommunication infrastructure, with a room to accommodate these OTBs.

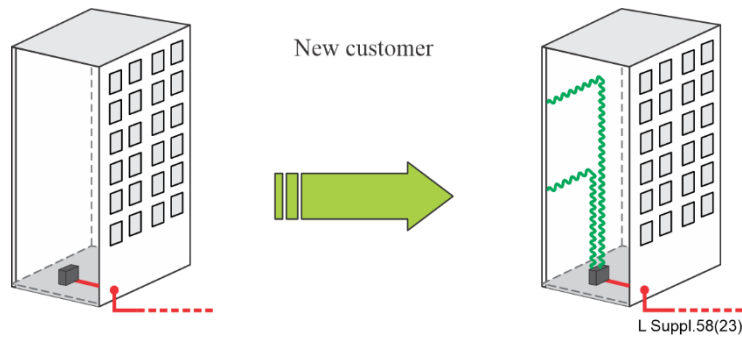
It is necessary to find space for the OTBs in existed buildings. Depending on the number of potential customers, the cabling from the OTB can be done in two different ways:

- 1) For high customers density, a structural cabling is installed vertically with several floor boxes. To connect a new customer, an optical drop must be installed from the floor box to the outlet.



**Figure 14 – Connecting a customer for high density buildings: indoor**

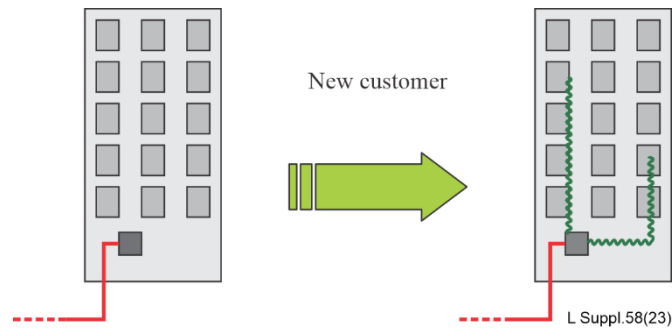
- 2) For low customers density, as shown in Figure 15, all drops are installed on demand from the OTB.



**Figure 15 – Connecting a customer for low density buildings: indoor**

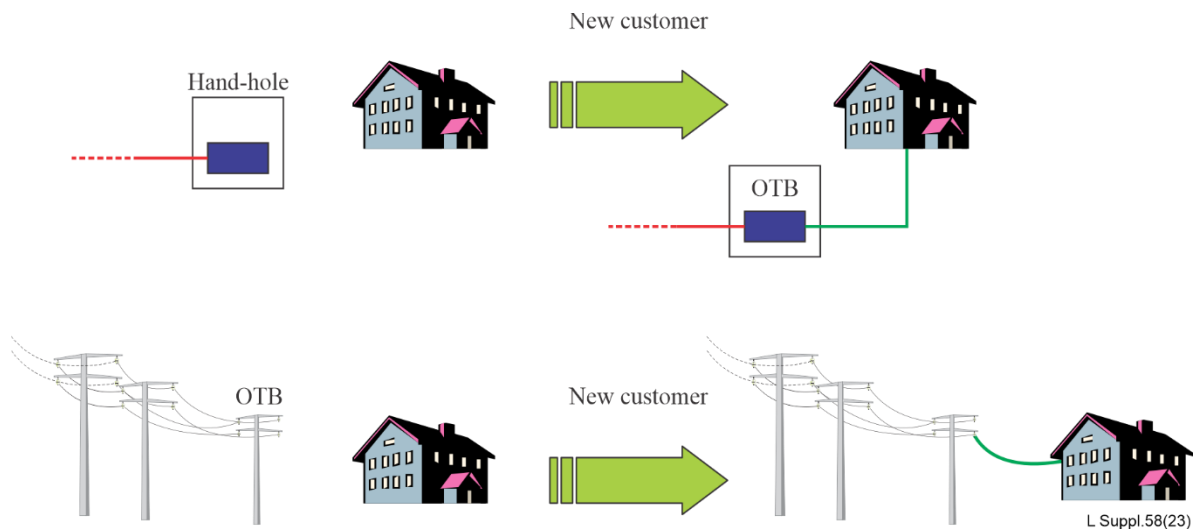
### 8.2.2 Outdoor

For an outdoor scenario, as shown in Figure 16, an OTB is installed in the facade of the building. Due to environmental conditions, robust materials must be used for outdoor equipment. Drop cables are installed on demand.



**Figure 16 – Connecting a customer: outdoor**

Single family units can be considered for this scenario, because OTBs are installed outside. The last drop is installed from a maintenance hole/hand hole or a pole as shown in Figure 17.



**Figure 17 – Connecting a single family unit customer**

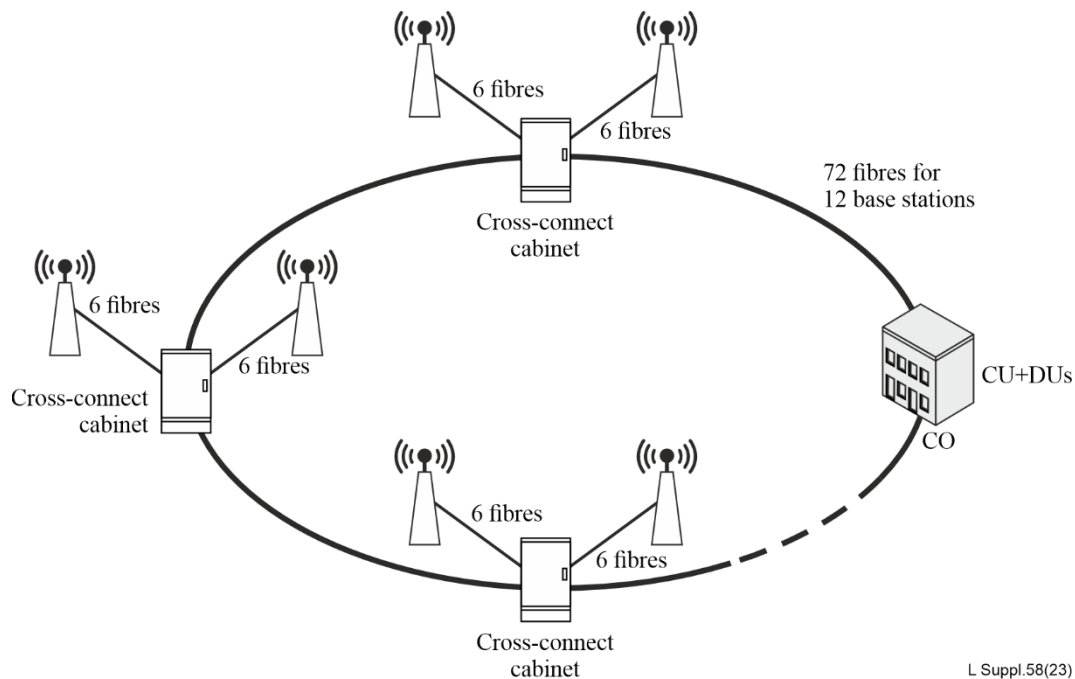
## 9 Chinese experience

### 9.1 Introduction

In the construction of mobile communications, centralized radio access network (C-RAN) mode saves significant costs on base station equipment rooms, supporting facilities and energies. The transmission distance from distributed units (DU) to active antenna units (AAU) in C-RAN for 5G fronthaul is up to 10 km (typically 5-10 km). Optical outside plants are required to support the transmission. Compared with FTTH broadband services, 5G RAN requires a much higher data rate (i.e., 10 Gbit/s, 25 Gbit/s, etc.) and symmetric duplex transmission for each terminal. Normally, a central office with centralized DUs and a centralized unit (CU) covers 6 to 10 mobile communication base stations. There have been many types of solutions for 5G C-RAN.

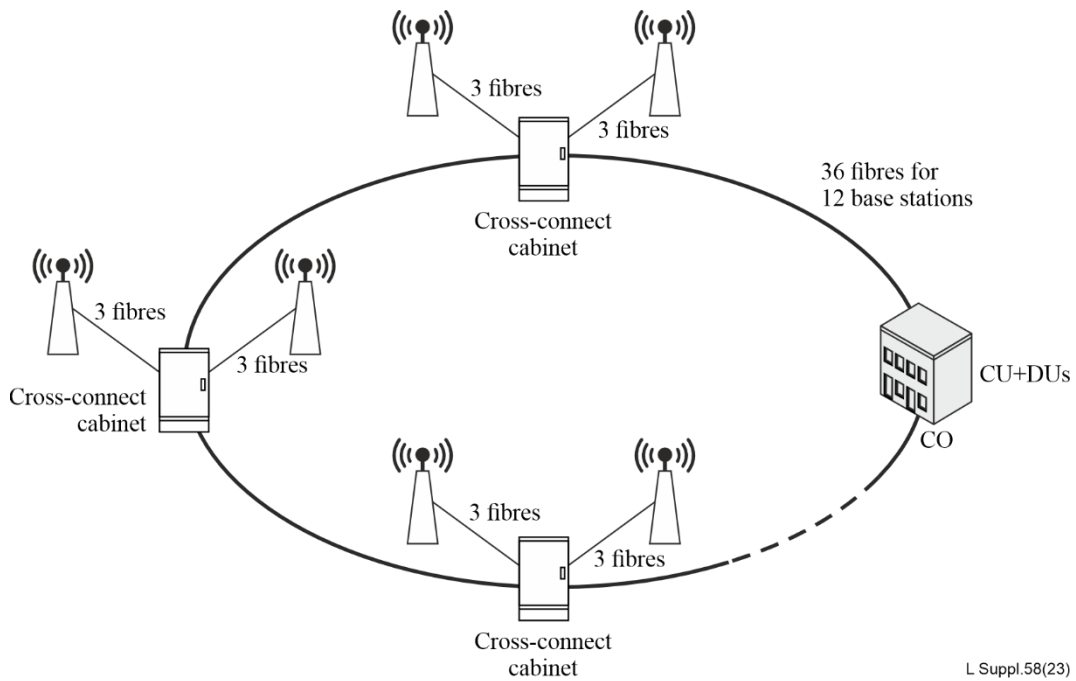
### 9.2 Dedicated – fibre solution

In areas with numerous pathways and spaces for fibre installation or installed fibres, dedicated fibre architecture can be used. If two fibres for each AAU is used for bi-directional transmission, a base station with 3 AAUs requires 6 fibres, as shown in Figure 18.



**Figure 18 – Example of dedicated – fibre C-RAN with 2 fibres for AAU bi-directional transmission**

If single fibre bi-directional optical modules are used in DUs and AAUs, half of the fibres can be economised, as shown in Figure 19.

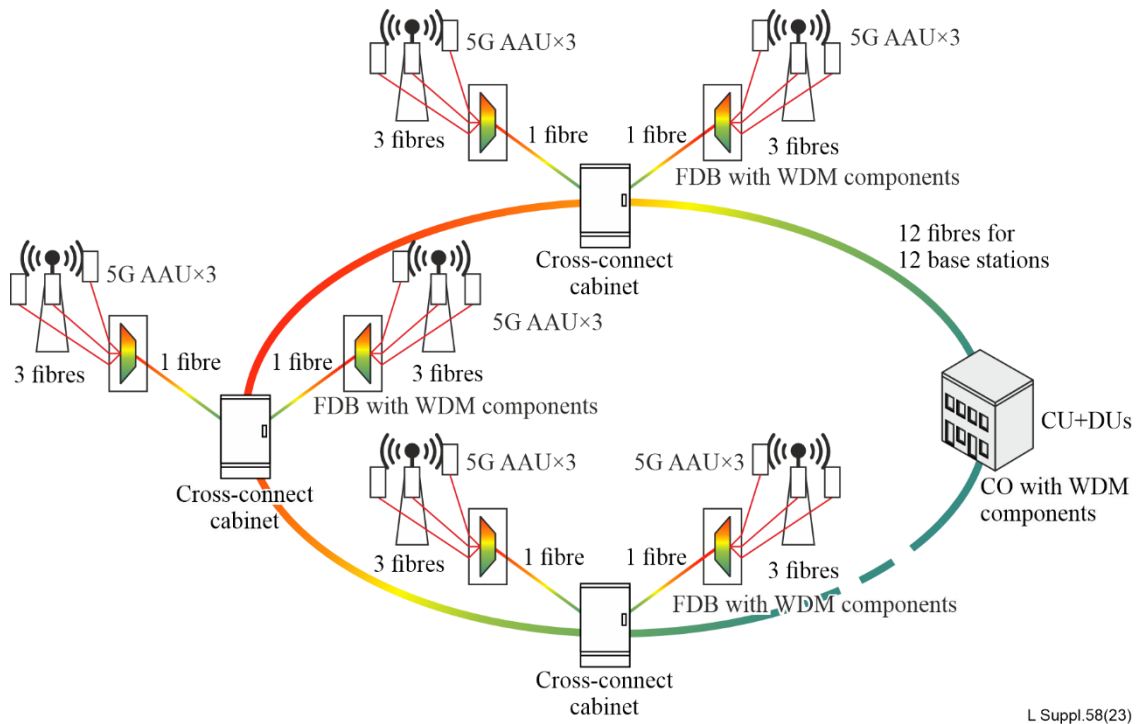


**Figure 19 – Example of dedicated – fibre C-RAN with single fibre for AAU bi-directional transmission**

### 9.3 Wavelength selective branching solution

In areas where there is a lack of installed fibres and installation of new fibres is limited, branching architecture could be used to save on the use of fibres. To support high-rate transmission of 5G, many wavelength selective branching solutions could be selected.

#### 9.3.1 Passive WDM solution



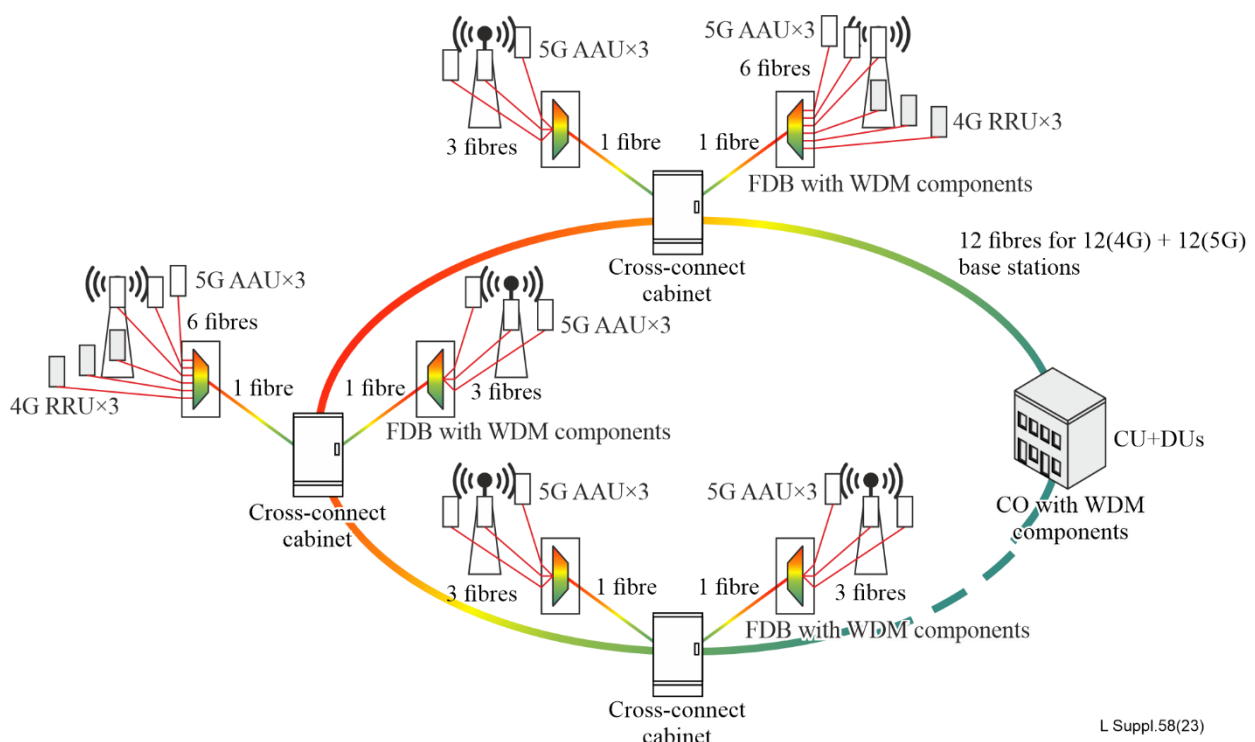
**Figure 20 – Example of passive CWDM C-RAN with single fibre bi-directional 6 channel OD/OM components**

In passive wavelength division multiplexing (WDM) solution, passive WDM optical demultiplexer (OD)/optical multiplexer (OM) components are used in both CO side and AAU side. Figure 20 shows an example of a passive CWDM C-RAN with single fibre bi-directional 6 channel OD/OM components.

Single fibre bi-directional coarse wavelength division multiplexing (CWDM) component with 6 channels could be used for base station with 3 AAUs, as shown in Figure 21. CWDM channels could be selected as in accordance with [ITU-T G.694.2], for example, 1271 nm, 1291 nm, 1311 nm, 1331 nm, 1351 nm and 1371 nm.

As 4G services will coexist with 5G for a long period, 4G remote radio units (RRUs) and 5G AAUs would share some of the towers. 12 channels CWDM OD/OM components could be used for convergence C-RAN of 4G and 5G. Additional CWDM channels for 4G could be selected as in accordance with [ITU-T G.694.2], for example, 1391 nm/1411 nm/1431 nm/1451 nm/1471 nm/1491 nm or 1471 nm/1491 nm/1511 nm/1531 nm/1551 nm/1571 nm.

DWDM solutions with a grid [ITU-T G.694.1] can also be used.



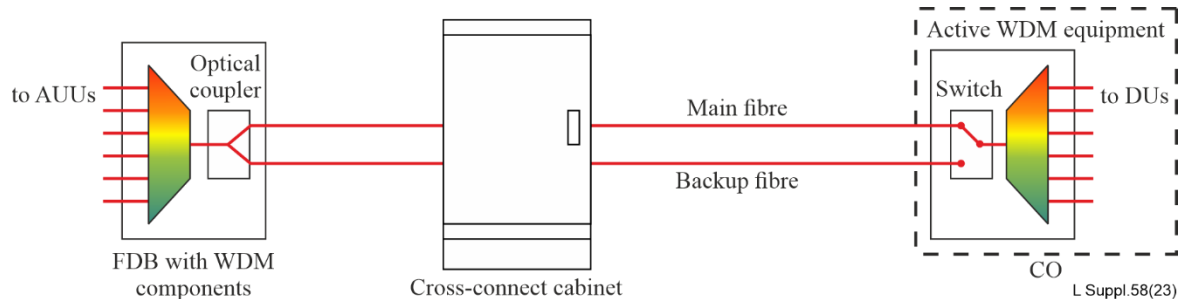
**Figure 21 – Example of passive CWDM convergence 4G/5G C-RAN with single fibre bi-directional 6 channel and 12 channel OD/OM components**

### 9.3.2 Semi-active WDM solution

The physical optical network topology of the semi-active WDM solution is similar to the passive WDM solution, the difference is the passive WDM OD/OM components in the CO side are replaced by active WDM equipment. The active WDM equipment, highly integrates WDM OD/OM and optical management functions, provides automatic management and monitoring abilities for the fibre connections, and greatly reduces operation and maintenance costs. Normally, a backup fibre could be used for the fibre link between the active WDM equipment and AAU side WDM components, as shown in Figure 22. In this case, the active WDM equipment could automatically switch between the main fibre and the standby fibre.

There are some main wavelength schemes for semi-active WDM solutions, including 6 channel CWDM (1271 nm, 1291 nm, 1311 nm, 1331 nm, 1351 nm and 1371 nm, as in [ITU-T G.694.2]), 12 channel modified wavelength division multiplexing (MWDM, 1267.5 nm, 1274.5 nm, 1287.5 nm,

1294.5 nm, 1307.5 nm, 1314.5 nm, 1327.5 nm, 1334.5 nm, 1347.5 nm, 1354.5 nm, 1367.5 nm, 1374.5 nm, by shifting the CWDM wavelengths  $\pm 3.5$  nm), and 12 channel lan-WDM (LWDM, 1269.23 nm, 1273.54 nm, 1277.89 nm, 1282.26 nm, 1286.66 nm, 1291.1 nm, 1295.56 nm, 1300.05 nm, 1304.58 nm, 1309.14 nm, 1313.73 nm, 1318.35 nm). 12 channel schemes could support future expansions of 5G base stations. DWDM solutions with a grid [ITU-T G.694.1] can also be used.



**Figure 22 – Example of semi-active WDM C-RAN fibre link with main and backup fibres**

### 9.3.3 Convergence metro WDM solution

This solution adopts a transversely compatible bidirectional DWDM system as presented in [ITU-T G.698.4]. DWDM network elements which contain OD/OM and OADM or OD/OM alone are installed in cabinets or telecommunication rooms, allow for multiplexing, demultiplexing, adding and dropping wavelength channels. These DWDM network elements make the topology of the access network flexible, and support a convergence access network for 3G/4G/5G mobile communications, FTTx and other metro applications. Single fibre between the head end equipment (HEE) and the DWDM network elements could support up to 20 or 40 bidirectional DWDM channels, and each tail end equipment (TEE) requires one fibre for bidirectional transmission.

## 10 Indian experience

### 10.1 Introduction

This clause presents the architecture for an optical access network through FTTx and is intended as supplementary material to [ITU-T L.250].

### 10.2 Scope

Traditional technologies, such as digital subscriber line (DSL) and cable modem technologies, commonly used for "broadband access", have access speeds to the order of a megabit per second, with actual rates strongly dependent on distance from the exchange (CO) and quality of copper infrastructure. They cannot fulfil today's customer demand for bandwidth hungry applications such as high-definition television, high-speed Internet access, video on demand, Internet protocol television (IPTV), online gaming, distance learning, etc.

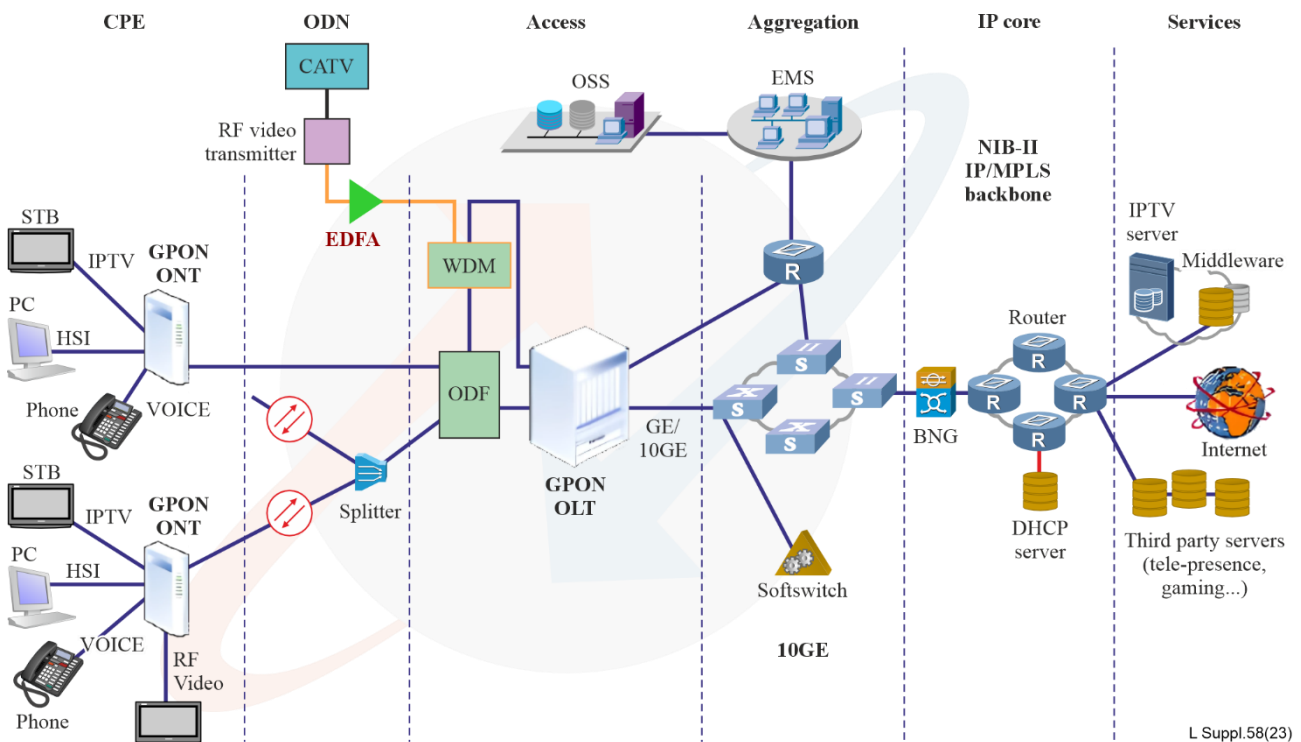
FTTx is an alternative to the traditional copper loop providing connectivity by taking fibre closer to the end-user and hence finds its use in last-mile connectivity. FTTx has many benefits related to speed and capacity and this is the reason legacy copper-based networks are being replaced with FTTx.

### 10.3 FTTx technology options

When deciding on which architecture to select a provider has much to consider including the existing outside plant, network location, the cost of deploying the network, subscriber density and the return on investment (ROI). At present different technology options are available for FTTx architecture. The

most common implementation of FTTx is through the passive optical network (PON). GPON is a leading standard of PON.

The term 'gigabit' in GPON denotes the maximum speed it provides in Gbit/s which is typically 2.5 Gbit/s downstream and 1.25 Gbit/s upstream, and 'passive' denotes that the optical fibre network does not rely on any electrically-powered equipment in its path. GPON technology is highly energy efficient when compared with a standard copper cable network. This makes it the optical network standard of choice for achieving last-mile connectivity in an efficient and cost-effective manner, as GPON reduces the number of fibre runs in a fibre optic network. The architecture of an optical access network deploying GPON is shown in Figure 23.



**Figure 23 – Optical access network deploying GPON**

#### 10.4 Architecture for GPON

A single network typically consists of an OLT, optical network units (ONU)/ONT and optical distribution network (ODN) including a passive optical splitter. For GPON two dedicated wavelengths may be used for downstream and upstream (~1490 nm & 1310 nm respectively) and the other one (1550 nm) may be used for downstream video. A typical GPON architecture is shown in Figure 24.

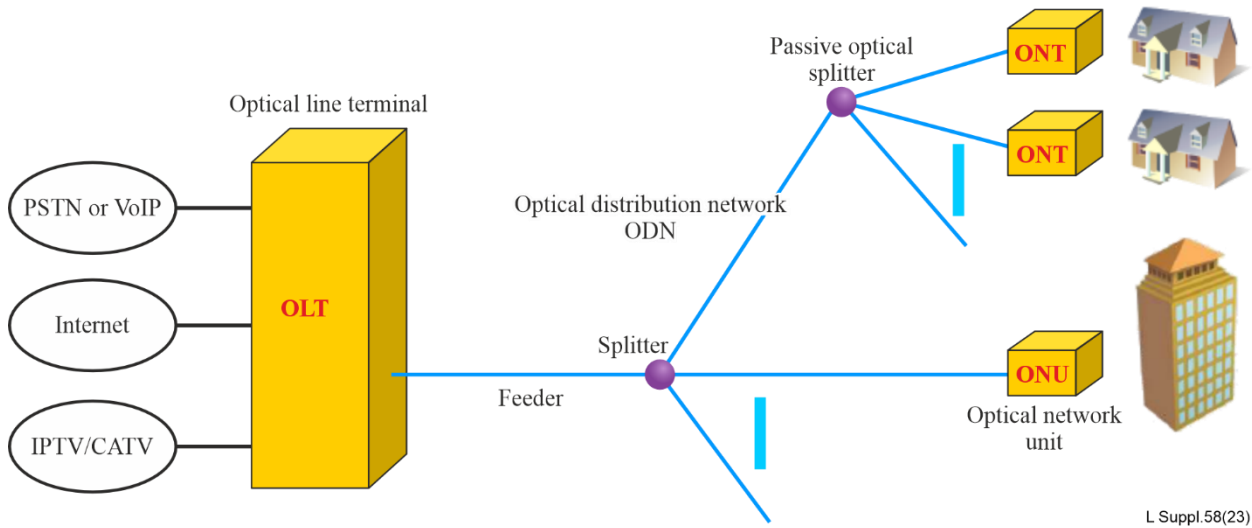
**OLT:** The OLT resides in the CO. The OLT system provides aggregation and switching functionality between the core network (various network interfaces) and PON interfaces. The network interface of the OLT is typically connected to the IP network and backbone of the network operator. Multiple services are provided to the access network through this interface.

**ONU/ONT:** The access node installed within user premises for network termination is termed as ONT, whereas access node installed at other locations i.e., curb/cabinet/building are known as ONU. The ONU/ONT provides user interfaces (UI) to the customers and uplink interfaces to uplink local traffic toward OLT.

**Optical splitter:** Distributed or single-staged passive optical splitters/combiners provide connectivity between OLT and multiple ONUs/ONTs through one or two optical fibres. The FTTH network may have two stages of splitting provisioned through primary splitters and secondary splitters. The primary splitter shall be placed at the feeder route in optical distribution frame (ODF). The ODF is



placed at the plinth/poles as per the execution methodology. The secondary splitter shall be placed inside fibre access terminal (FAT) box. FAT box can be placed on the building shaft/customer wall or pole. Optical splitters are capable of providing m: N splits where m = 1 or 2 and N = 2, 4, 8, 16, 32, 64 and 128. The exact requirement of optical interfaces for 1×N and 2×N splitters is decided based on the optical power budget calculation.

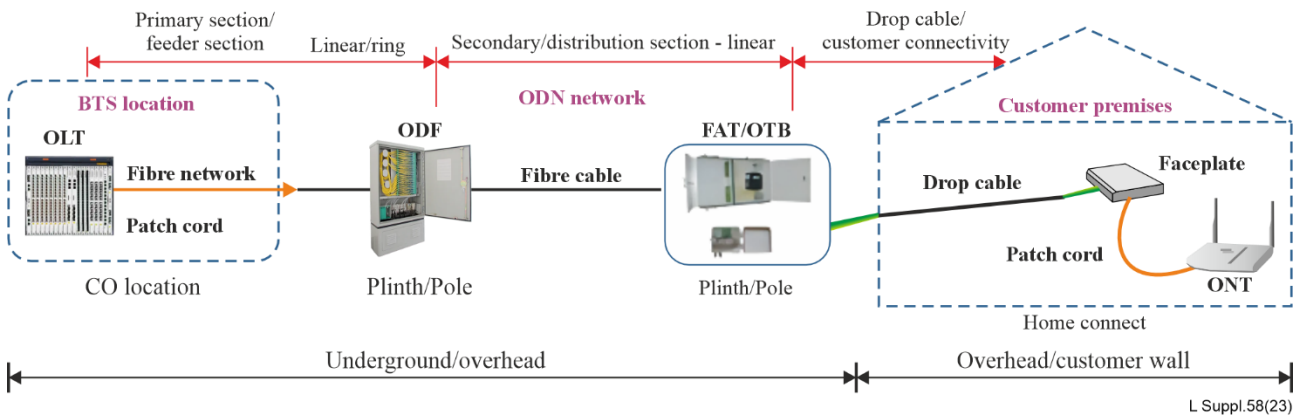


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**Figure 24 – GPON architecture**

### 10.5 ODN architecture

The optical distribution network primarily consists of a primary/feeder section (OLT location to ODF), secondary/distribution network (ODF to FAT) and last-mile connectivity to customer premises. A typical layout of ODN architecture is shown in Figure 25.



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**Figure 25 – Layout of optical distribution network (ODN) architecture**

Terms:

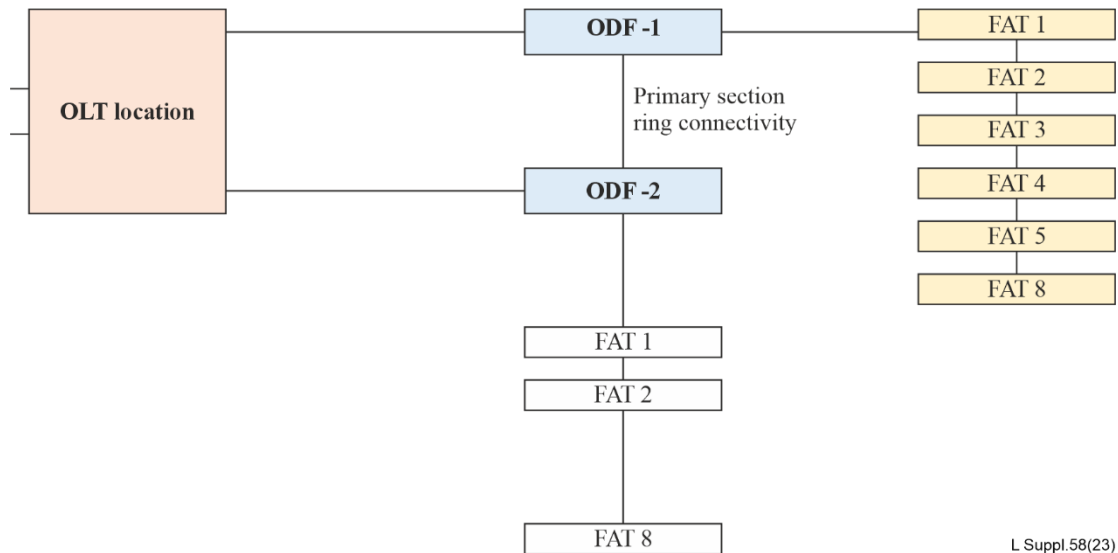
- 1) Primary section (fibre from OLT PON port to ODF – primary splitter)
- 2) Primary splitter
- 3) Secondary section (ODF – primary splitter to FAT – secondary splitter)
- 4) Secondary splitter
- 5) Secondary splitter to OTB
- 6) Drop section (OTB to customer premises)



ODF may also be installed elsewhere than the OLT location and also may be installed on pillars/poles as per the installation methodology of the network operator. Primary splitters may be placed at feeder route in ODF. The secondary splitter shall be placed inside FAT box and FAT box can be further placed on the building shaft/customer wall or pole as per the requirement.

### 10.6 Ring structure till primary/ feeder section

The ring topology between OLT and ODF section is shown in Figure 26.



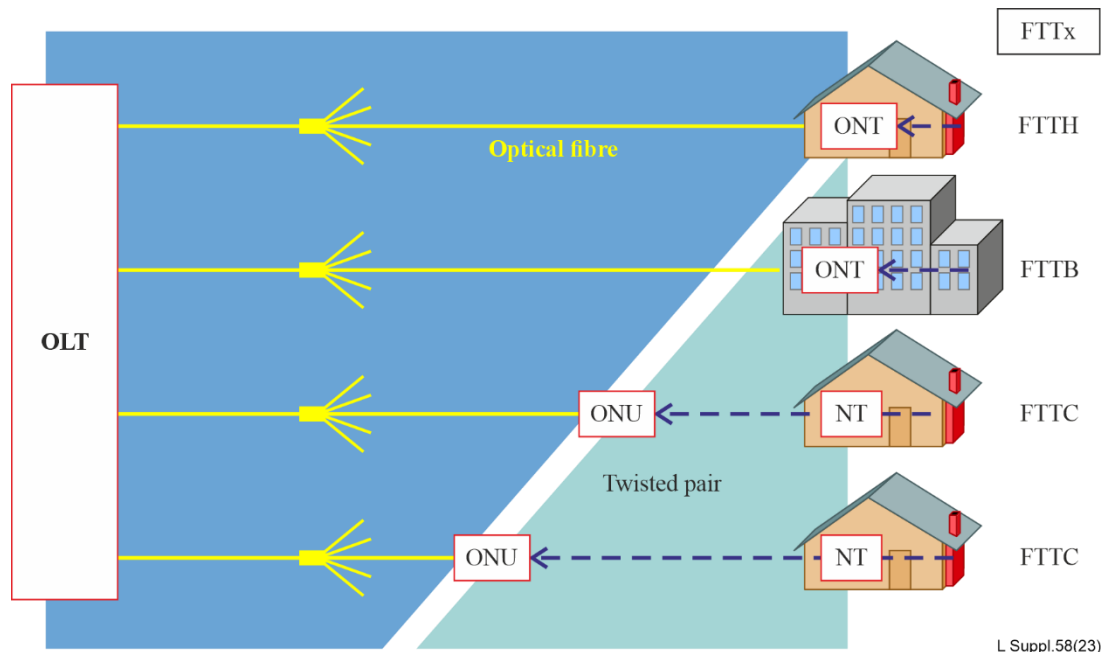
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**Figure 26 – Ring structure**

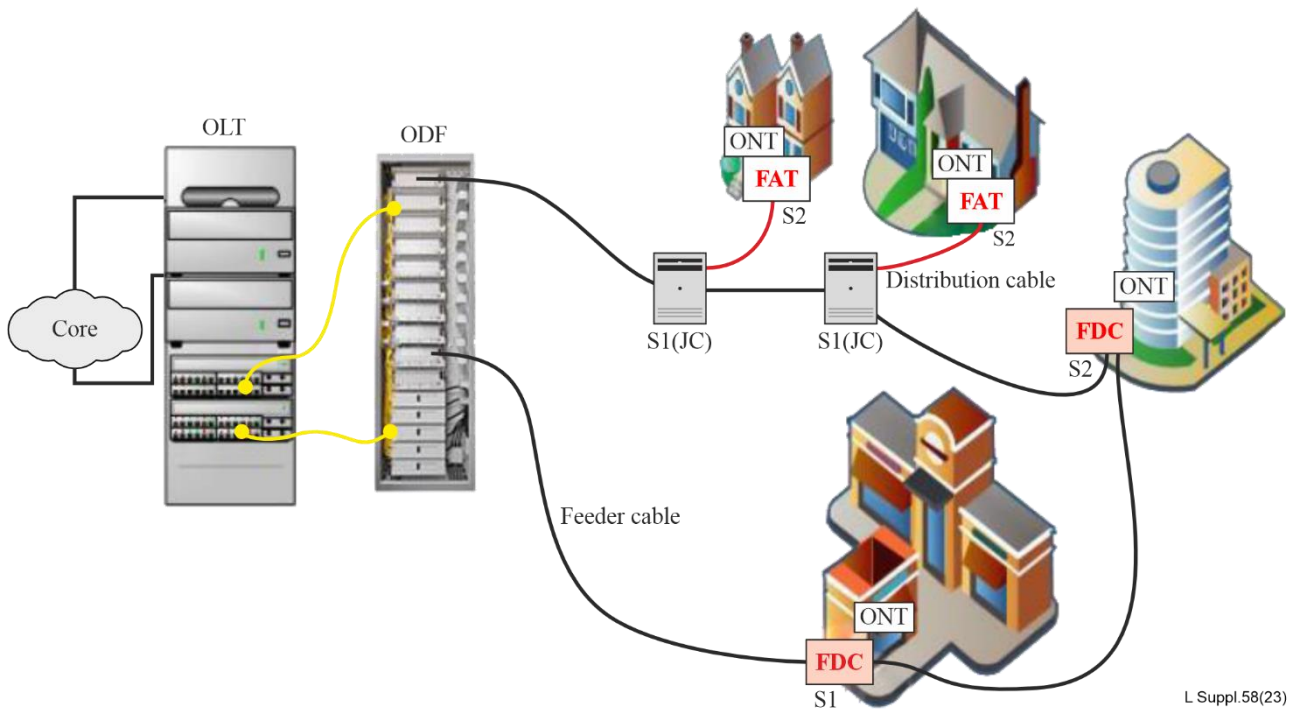
The primary splitter installed inside the ODF provides redundancy to the access network in the primary/feeder section. One ODF serves several FATs and connects to the number of secondary splitters.

### 10.7 FTTx configurations/deployments

Depending on the termination point, the FTTx networks can be described as fibre to the building (FTTB), FTTH, fibre to the curb (FTTC), etc. As telecommunications providers consider the best method for delivering fibre to their subscribers, they have a variety of FTTx architectures to consider. FTTH, FTTB, and FTTC each have different configurations and characteristics. These FTTx configurations are shown in Figure 27. A typical FTTB connectivity scenario through GPON is shown in Figure 28.



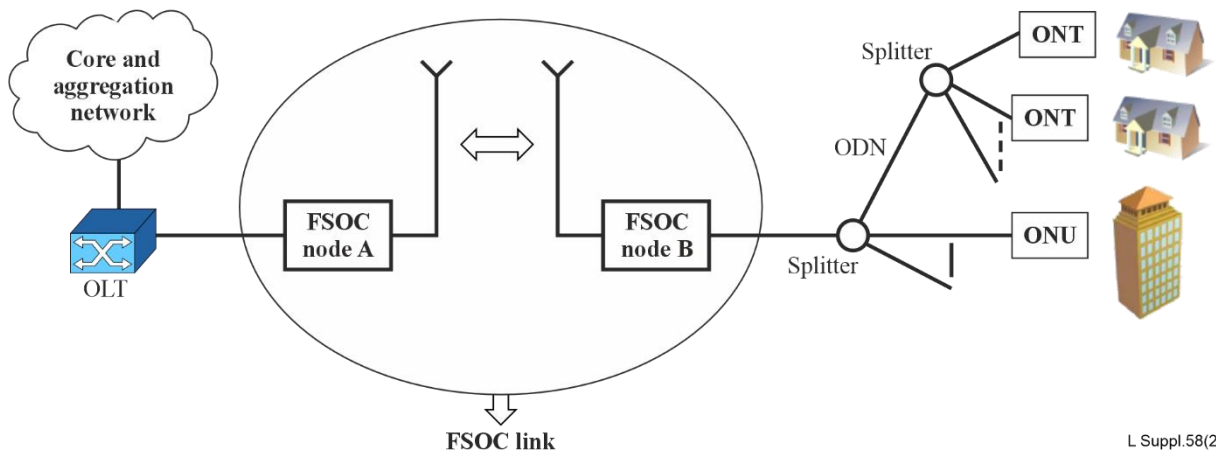
**Figure 27 – FTTx configurations**



**Figure 28 – FTTB connectivity scenario through GPON**

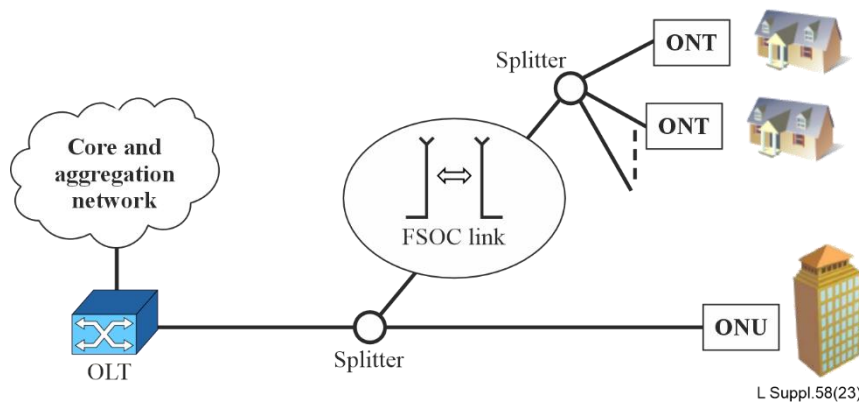
**10.8 Optical wireless access network connectivity**

Free space optical communication (FSOC) can effectively bridge the access network connectivity gaps in areas that are difficult to connect through optical fibre cables (like hills, lakes, etc.). Some possible scenarios in GPON deploying FSOC links are shown in Figures 29, 30 and 31. A combination of these scenarios may also be exercised depending on the requirements and constraints.



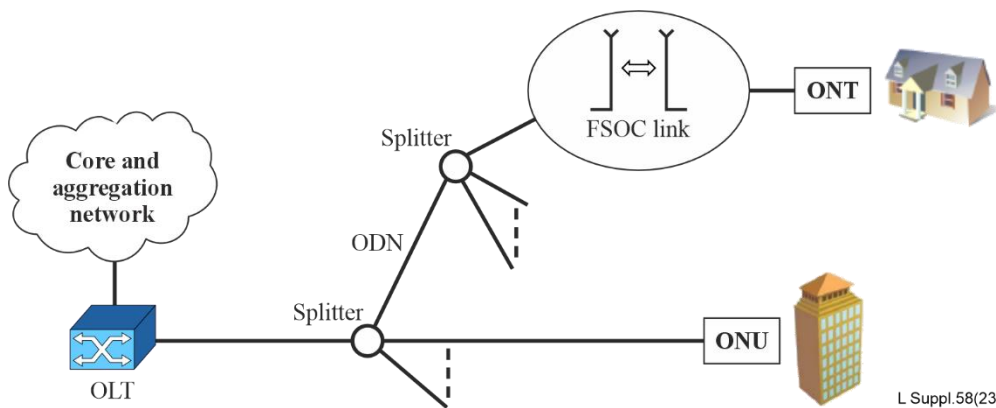
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**Figure 29 – FSOC link in GPON – scenario 1**



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**Figure 30 – FSOC link in GPON – scenario 2**

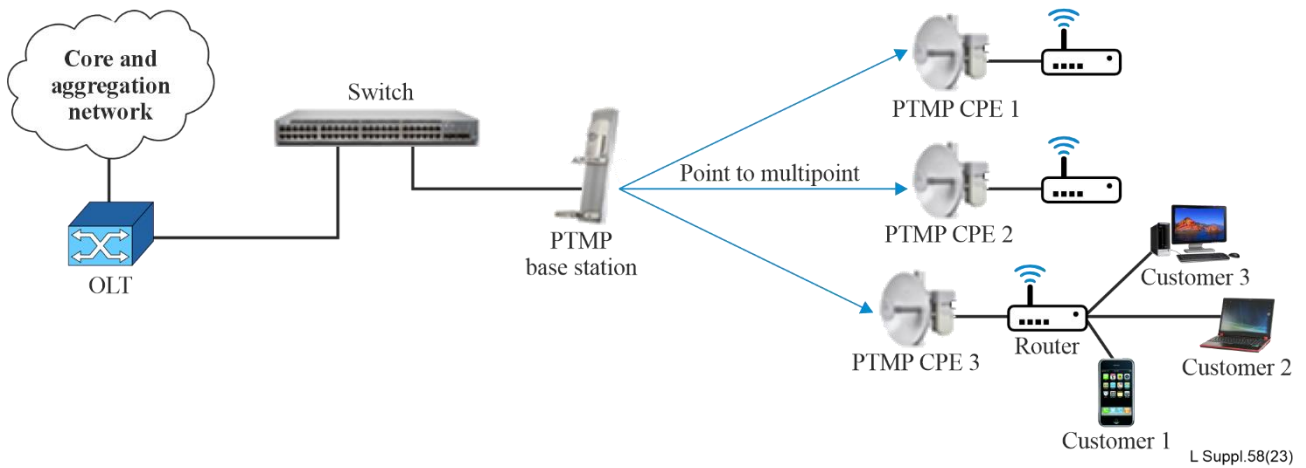


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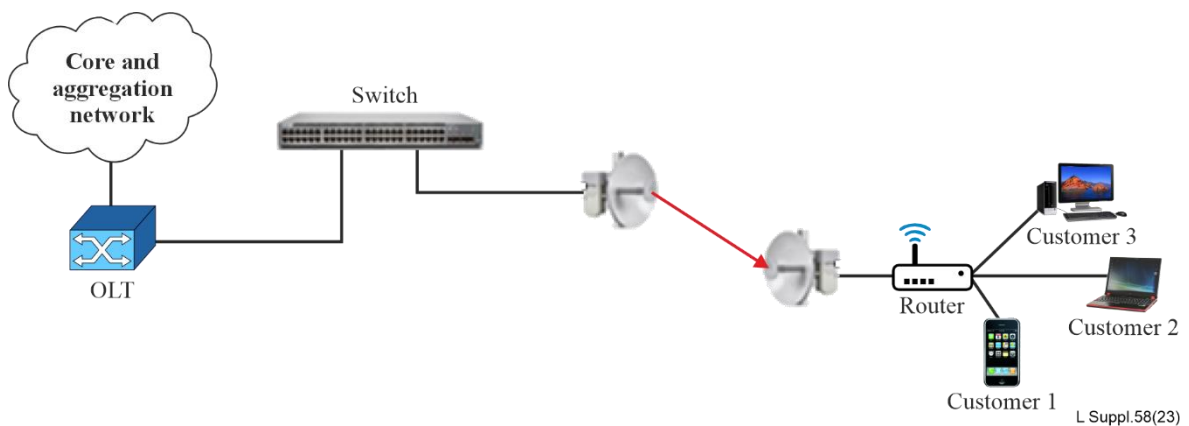
**Figure 31 – FSOC link in GPON – scenario 3**

### 10.9 Access network connectivity using radio infrastructure

In scenarios where geographically difficult terrains exist, access network connectivity to OLT in place of optical fibre, may be established by using radio broadband service. This access network connectivity solution is wireless and is provided by deploying radio infrastructure using an unlicensed spectrum band. Figures 32 and 33 show the access connectivity solution by deploying point-to-point/point-to-multipoint radio network integrated with the core and aggregation networks.



**Figure 32 – Point-to-multipoint connectivity diagram**



**Figure 33 – Point-to-point connectivity diagram**

Point-to-point radio network covers a maximum distance of up to 35 km and has a maximum bandwidth of 1 Gbit/s. Point-to-point/point-to-multipoint radios use antennas that are more directional and that have higher gain.



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