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TECHNICAL SPECIFICATION

Access, Terminals, Transmission and Multiplexing (ATTM); Fibre deployment for fibre-based in-premises networking

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

The present document is effective when single mode fibre is used for in-premises networking and fibre is deployed for multiple network operators. Besides the fibre-based in-premises networking deployment, the present document also provides tools and methods for fibre cabling in different use cases.

1 Scope

The present document will briefly introduce Fibre-To-The-Room (FTTR) application in home and business building, FTTR system architecture and general requirements of the fibre infrastructure, analyse and evaluate energy consumption, environmental impacts and security, provide guidance for FTTR system design and network planning, FTTR fibre deployment in home and business building (Green, Brown). The present document will also introduce some methods and tools for fibre deployment in premises and acceptance requirements of fibre deployment as practice reference.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] Recommendation ITU-T G.652: "Characteristics of a single-mode optical fibre and cable".

[2] Recommendation ITU-T G.657: "Characteristics of a bending-loss insensitive single-mode optical fibre and cable".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI GR F5G 001: "Fifth Generation Fixed Network (F5G); F5G Generation Definition Release #1".

[i.2] ETSI GS F5G 012: "Fifth Generation Fixed Network (F5G); Security; F5G Security Countermeasure Framework Specification".

[i.3] NIST FIPS-197: "NIST Federal Information Processing Standards Publication 197 (2001), Advanced Encryption Standard (AES)".

[i.4] ISO/IEC 18033-3:2010: "Information technology - Security techniques - Encryption algorithms - Part 3: Block ciphers".

3 Definition of terms, symbols and abbreviations

3.1 Terms

Void.

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AC	Alternating Current
AES	Advanced Encryption Standard
AP	Access Point
DC	Direct Current
F5G	Fifth Generation Fixed Network
FDU	Fibre Distribution Unit
FTTP	Fibre-To-The-Premises
FTTR	Fibre To The Room
HFC	Hybrid Fiber Coax
IFDN	In-premises Fibre Distribution Network
LC	Little Connector
MFU	Main FTTR Unit
O&M	Operation and Management
OFDM	Orthogonal Frequency-Division Multiplexing
OOK	On-Off Keying
OTDR	Optical Time Domain Reflectometer
OTN	Optical Transport Network
P2MP	Point to Multi-Point
PAM	Pulse-Amplitude Modulation
PON	Passive Optical Network
PVC	PolyVinyl Chloride
SC	Standard Connector
SFU	Sub FTTR Unit
SME	Small and Medium-sized Enterprises
SMF	Single Mode Fibre
UHR	Ultra High Definition
VR	Virtual Reality
Wi-Fi®	Wireless Fidelity

4 Fibre-to-the-Room application for home area and small and medium-sized enterprises networking

4.1 FTTR for home area networking

The development of fixed networks, driven by service requirements and supported by technology development, has experienced era of voice, web, video, and 4K ultra-high definition. The Fifth Generation Fixed network (F5G) is represented by technologies such as 10G PON, Wi-Fi® 6, 200G/400G, and next-generation OTN.

In the fixed broadband network, home networking is an important part and is also the most complex and diverse part, with increasing Internet access requirements, different home networking methods such as Ethernet cables, Wi-Fi relay and power line appear for each household in combination with their respective environmental conditions.

In order to support high reliable, large bandwidth bearing capabilities and long-term involution compatible, the transmission medium is a key factor. Based on the successful experience of fibre used in transmission and access network, ETSI GR F5G 001 [i.1] proposes a new-generation solution based on fibre networking which is called Fibre-To-The-Room (FTTR) in-premises networking.

The fibre is characterized by small size, light weight, 30-year ultra-long service life, no electromagnetic interference, and unlimited bandwidth evolution. This feature provides a new option for on-premises networking. Fibre-to-room extends fibre into each room of the house which is a further step of Fibre-To-The-Premises (FTTP).

As to the extension of fibre from FTTP, FTTR should satisfy the network requirements of in-door applications. Wi-Fi technology is widely utilized in home networks for the connection of end devices, such as mobile phone, television, home appliances and so on. To have a full home coverage of Wi-Fi signals and overcome the attenuation due to wall penetration, the FTTR technology can provide a stronger backhaul link and enough Wi-Fi access points in-premises.

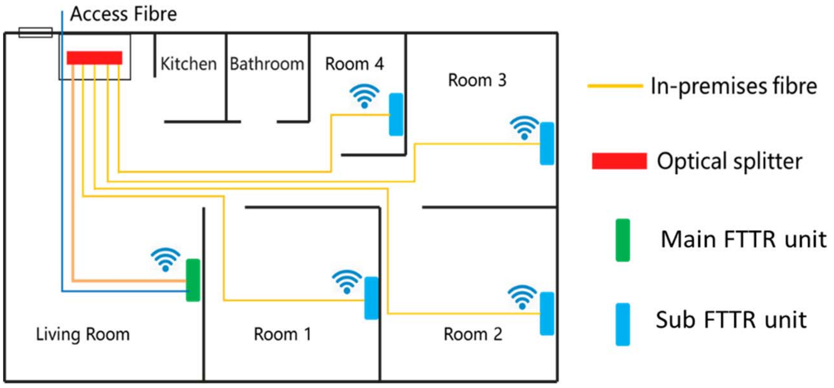


Figure 1: Fibre network deployment for an apartment with 4 rooms

Figure 1 shows a typical case for an apartment with 4 rooms. The access fibre is deployed to the entrance or the multi-medium access box of the apartment. From the multi-medium access box, branch fibre is deployed to every room of the apartment.

The Main FTTR Unit (MFU) is always deployed at the living room or the entrance of the apartment. In each room, sub FTTR units are deployed and providing high speed Wi-Fi access ability. In order to connect the main FTTR unit and multiple sub FTTR units, an optical power splitter can be deployed in the multi-medium access box.

In multi-storey house, a cascaded fibre network can be applied. The access fibre is deployed to the main FTTR unit. From the main FTTR unit, fibre is deployed to the power splitter in the multi-medium access box at the first floor. At the first floor, fibre is deployed to every room and connects the sub FTTR unit.

In order to simply the fibre deployment, one fibre cable is deployed to the second floor and a second power splitter is deployed at the second floor. From the second power splitter, fibre is deployed to every room and connects the sub FTTR unit at the second floor. The example illustrates four access points from the cascading port at the first power splitter. In order to utilize the optical power fully, the cascading port of the power splitter shall have large splitting ratio than all other ports. Then each access points may have relative equal splitter ratio from the main FTTR unit.

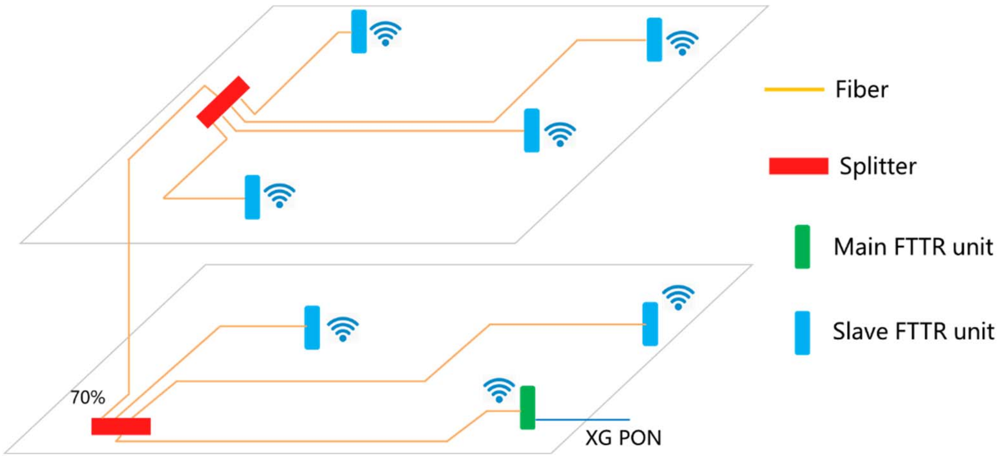


Figure 2: An example of fibre network deployment in a multi-storey house

4.2 FTTR for small and medium-sized enterprises networking

More and more Small and Medium-sized Enterprises (SME) are integrating digital and intelligent tools into their offices and services. All industries are actively embracing innovation technologies such as the Internet, big data, and cloud computing to enhance their market competitiveness and improve operation indicators. Many services of SMEs are carried out online, for example, some collaborative and innovative services require highly consistent networks to ensure efficient collaboration among employees in each location. In addition, SME usually do not have their own IT teams. Therefore, intelligent O&M capabilities are critical to their choice.

FTTR provides ultra-gigabit, low-latency, and highly reliable Wi-Fi networks for each room, ensuring network coverage in every corner of the room . In addition, FTTR, can quickly diagnose and locate various network faults.

Figure 3 shows a typical case in a small enterprise office. In this case, a main FTTR unit is deployed in the reception room. In order to simplify the fibre networking, an optical splitter is deployed at the centre of the office and branch fibre are deployed to each room from the optical splitter. As the open office area is quite large, multiple sub FTTR units can be deployed to provide good Wi-Fi coverage.

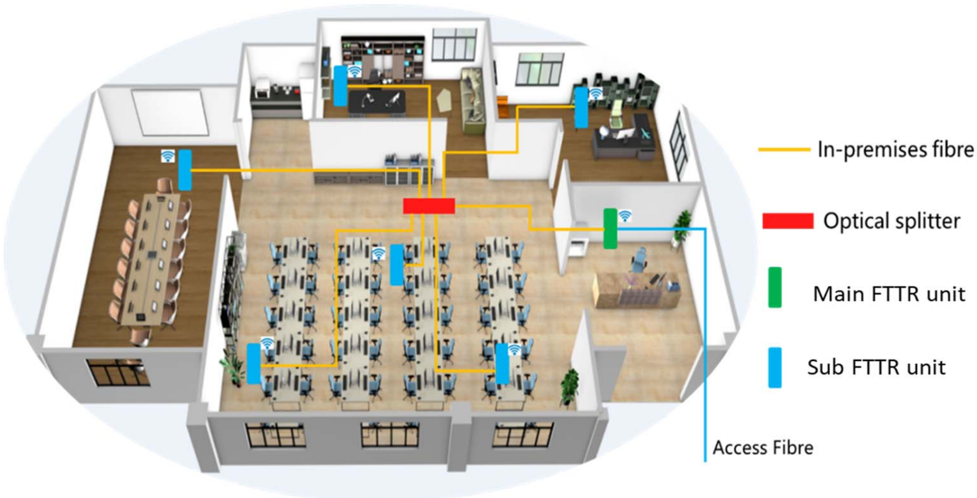


Figure 3: Fibre network deployment in a small office

In the business building, fibre cables are usually deployed at the top space of the room, and Wi-Fi access points are installed in the ceiling. In this case, a power supply of the sub FTTR units shall be considered. Optical and electrical hybrid fibre can be used to provide remote power supply for the sub FTTR units. Figure 4 shows an example of optical and electrical hybrid fibre and its connector.

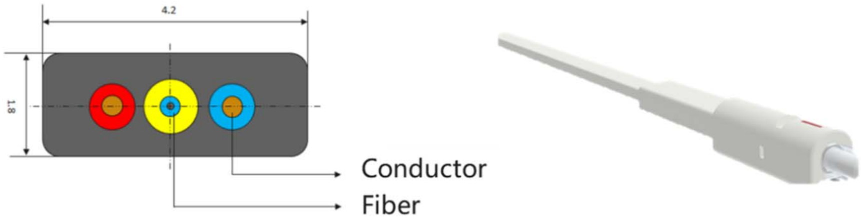


Figure 4: An example of optical and electrical hybrid fibre

5 Energy consumption, environmental impacts and security of FTTR system

5.1 Energy consumption analyse of FTTR system

Energy consumption refers to all energy used to access and utilise a service via the in-premises network. As in-premises Wi-Fi® is not impacted by the networking technology used, this clause will analyse the power consumption of different backhauling solutions. There are mainly 2 parts that contribute to the total power consumption: basic processing consumption, transmission medium attenuation and modems.

1) Basic processing consumption

The basic processing includes the basic operation of the device such as maintenance of operating status, data processing and forwarding. The maximal basic processing consumption will be similar for all solutions with the same system capability.

A power saving solution can be implemented to reduce the basic processing consumption when the traffic is low. There are always some overlap areas of the Wi-Fi signal coverage. When the traffic is quite low, parts of the SFUs can be turned off and the connection of all users' devices can be still kept active as following Figure 5. Besides, the operating clock frequency of main processor can also be reduced when the data rate is low.

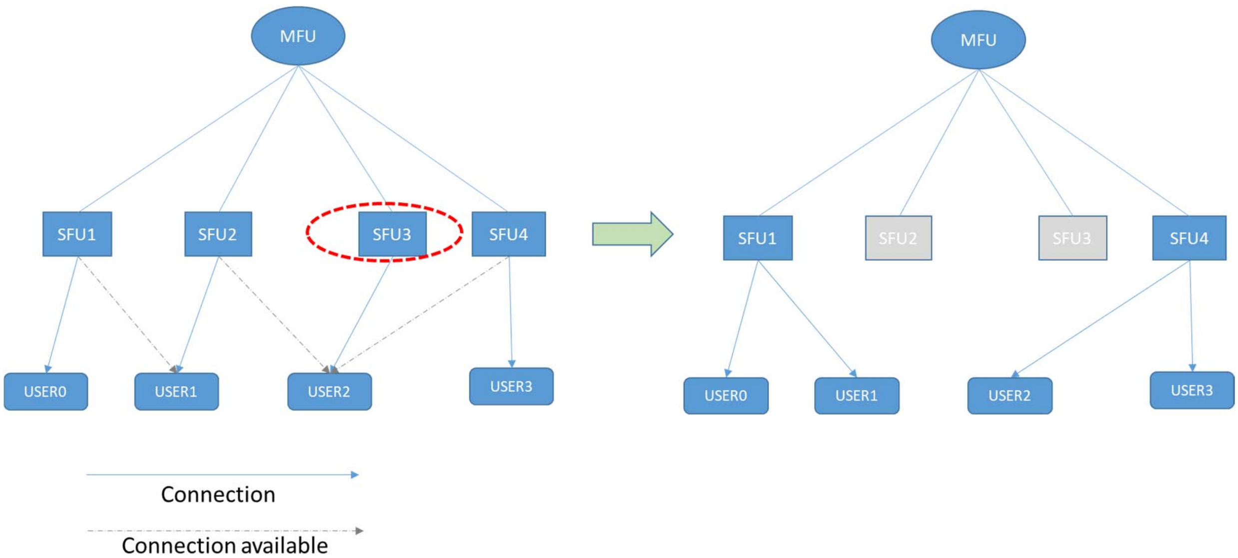


Figure 5: An example of power saving mode in FTTR network

2) Transmission medium attenuation and modems.

To ensure the link performance between the MFU and the SFUs, the transceivers in the networking need to transmit sufficient power to compensate for the medium loss. Compared with Ethernet cable and coaxial cable, optical fibre has the smallest medium loss. For single mode fibre, the insertion loss is very low, around 0,4 dB/km. This means the loss of fibre for in-premises networking is negligible.

Different modulation and demodulation technologies are used according to the channel characteristics of different transmission medium. Optical fibre-based transmission always uses OOK modulation when the line rate is lower than 25 Gbps, and Ethernet lines use complex PAM modulation which is high-order amplitude modulation. If Wi-Fi cascading is used, the modulation technology of Wi-Fi is more complex, such as OFDM modulation of Wi-Fi 6.

In terms of modulation and demodulation, the OOK modulation of fibre transmission system is the simplest and most energy efficient.

Overall, optical fibre-based transmission system is greener than copper and HFC. In terms of energy saving, optical fibre is more energy-efficient than copper-based technology.

5.2 Environmental impacts analyse of FTTR system

Ethernet cables or coaxial cables are made of copper. The transmission performance of copper-based cables deteriorates under high-temperatures and in high-humid environments.

Optical fibre is made of silica. Optical fibre is oxidation , and corrosion resistant . The diameter of optical fibre is 125 µm which is much smaller than copper-based cable. Fibre cables are future proof, enabling higher bandwidth and lower latency as required by emerging services e.g. Ultra High Definition (UHR), Virtual Reality (VR) and Cloud services. The deployment of fibre solutions reduces the need for replacement by obsolescence, ensuring a long lifecycle solution.

Therefore, in new buildings or renovations, optical fibre is recommended as the in-premises networking medium.

5.3 Security analyse of FTTR system

The security of the network includes the security of the network infrastructures and the security of the user data.

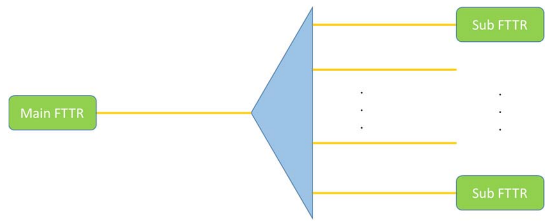
For an in-premises network, the devices and transmission medium of the network are inside the users' building. and an attacker cannot connect a malicious device to the network without the users' knowledge. In addition, an authentication mechanism can be applied to the newly connected devices as described in ETSI GS F5G 012 [i.2]. Unauthorized devices cannot access the FTTR network and acquire users' data.

Even in case that transmitted data can be captured by a malicious device, data encryption technologies can be used to protect the security of users' data. As the encryption keys can be dynamically changed, the malicious device cannot crack encrypted data in a certain period of time. Besides, a longer encryption key could provide better security for users' data. For example, AES-256 [i.3] and Camellia -256 [i.4] can be used for users with high security requirements.

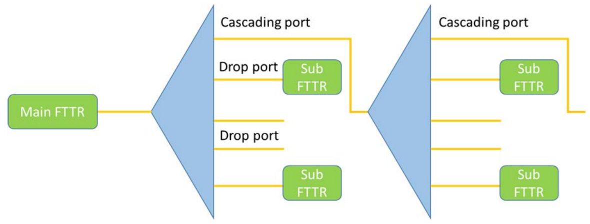
6 FTTR framework and system design of In-premises fibre distribution network

6.1 Topology of FTTR system

The FTTR network includes a Main FTTR Unit (MFU), In-premises Fibre Distributed Network (IFDN), and Sub FTTR Units (SFUs). The MFU is directly connected to an access network through a PON system, and MFU is connected to SFUs through IFDN. The MFU and SFUs can provide wireless and wired network interface for users' terminal device. From the MFU to the SFUs, the IFDN is a Point to Multi-Point (P2MP) topology. In order to achieve P2MP topology, different IFDN solution can be selected. Figure 6 shows 2 typical solutions of IFDN with symmetric optical power splitter and asymmetric optical power splitter. Both can provide a P2MP connections and can be used for different scenarios.



(a) IFDN with symmetric optical power splitter



(b) IFDN with asymmetric optical power splitter

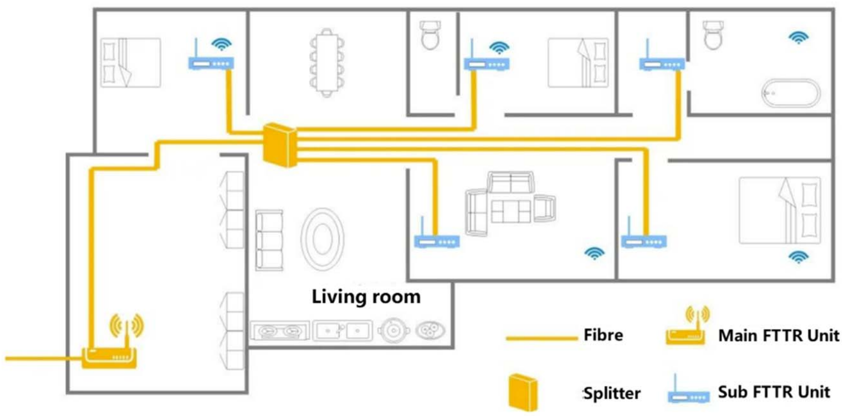
Figure 6: P2MP topology of FTTR system with different IFDN solutions

The MFU is the core role of the FTTR network, it connects access network and provides P2MP optical connections to the SFUs. The MFU is a terminal of the access network, but a main controller of the FTTR network.

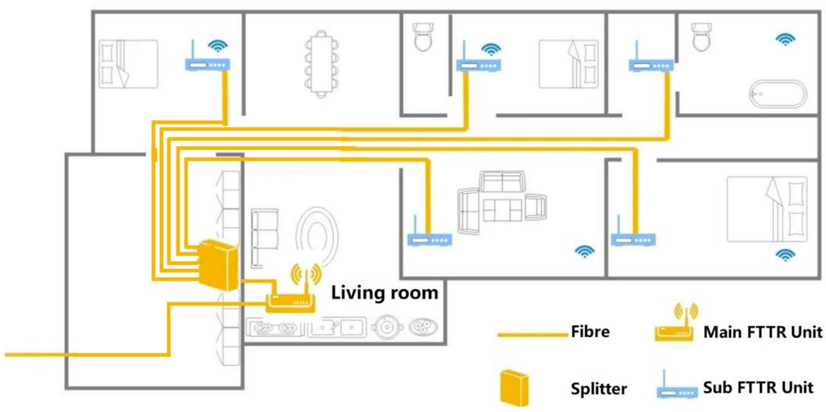
6.2 System design of IFDN

6.2.1 General requirements

The IFDN of the FTTR system consists of an in-premises optical cable, an optical splitter and a fibre socket. As the lead-in optical cable of the access network is terminated at the multi-medium access box, the main FTTR unit can be deployed at the multi-medium access box at the beginning of the IFDN. Deployed in the living-room according to the floor plan, an additional fibre shall be deployed back to the multi-medium access box to connect to the optical splitter.



(a) MFU is deployed at the multi-medium access box



(b) MFU is deployed in the living room of the house

Figure 7: Different deployments of FTTR system for home application

The optical splitter is installed in the home multi-medium access box, and the fibre sockets are deployed in each room of the house. Form the splitter to each fibre socket, single mode single-core fibre is deployed.

For multi-floor house, a cascading splitting mode can be used, and an asymmetric splitter can be deployed at each floor. Form the splitter, the single mode single-core fibre is deployed to each room at the floor.

The extended splitter connects the cascading port of the previous splitter through the cascading optical port using a single-mode fibre shown as Figure 8.

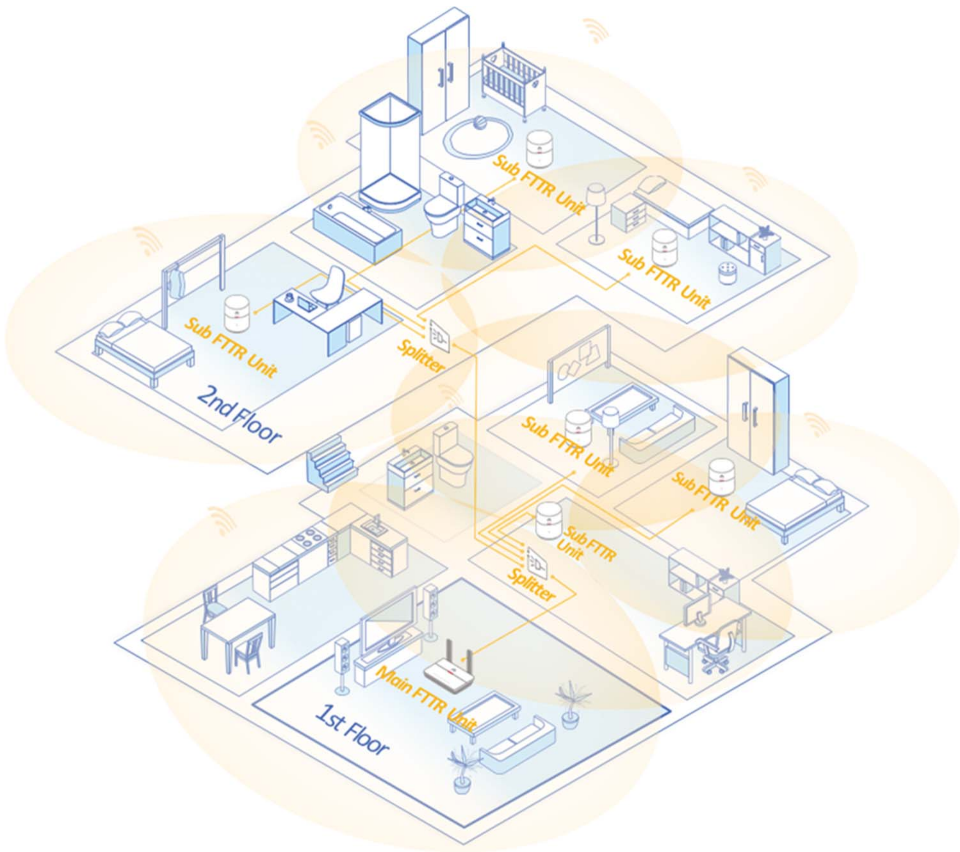


Figure 8: Deployment of FTTR system in cascading splitting mode

As an in-wall style sub FTTR unit can be deployed at the optical socket, the power socket shall be installed near the optical socket. Optical and electrical hybrid fibre cable can also be used for remote power supplier to the sub FTTR unit.

For home area networking applications, the maximal recommended splitting ratio is 16. For SMEs' networking application, the maximal recommended splitting ratio is 32.

6.2.2 Planning of IFDN

The planning of IFDN is subject to active FTTR devices. Each device of the FTTR system is recommended to be located according to the types of building such as residential buildings and commercial buildings. The deployments of active FTTR devices are recommended with the following regulations:

1) Main FTTR unit:

    a) For a single villa, the Main FTTR unit is recommended to be installed in the home multi-medium access box where the user optical cable is led into the building room. It can also be deployed at the drawing-room or living room according to the floor plan.

    b) For low-rise, multi-storey and high-rise residential buildings and single-family residential buildings, main FTTR unit is recommended to be installed in the multi-medium access box installed in the house.

c) For the business building, it is recommended that the main FTTR unit is installed in the multi-medium access box installed at the optical cable entrance of the subscriber unit.

2) Optical splitter

A single optical splitter or the main optical splitter of cascaded modules should be installed in the same installation position as the main FTTR unit. The cascaded extended optical splitters should be installed in the house of the subscriber unit.

3) Sub FTTR units (with built-in Wi-Fi® APs) is recommended to install in each room according to the network requirement.

6.3 Optical component requirements

6.3.1 Fibre cable

For in-premises fibre distribution network, different types of fibre cable such as multi-core or single core optical fibre, transparent optical cables, and optical/electrical hybrid fibre cables can be used.

The selection of optical fibre shall meet the following requirements:

1) Recommendation ITU-T G.652 [1] optical fibres shall be used for vertical subscriber optical cables between the entrance facilities and the multi-medium access box on the floor.

2) Recommendations ITU-T G.657.A2/G.657.B3 [2] optical fibres shall be used for horizontal subscriber optical cables between the optical multi-medium access box on the floor and the home multi-medium access box, and for in-premises subscriber optical cables and optical jumpers in the FTTR system.

3) On the specifications of power supply wires in electric/electrical hybrid cables, the recommendations are as following:

   a) When the main FTTR unit supplies power to hybrid optical and electrical splitter, the outer diameter of the conductor shall not be less than 0,813 mm.

   b) When the hybrid optical and electrical splitter supplies power to the sub FTTR units, the outer diameter of the conductor shall not be less than 0,404 mm.

4) Transparent invisible optical cables shall support the application of exposed laying and long-term reliable bonding.

6.3.2 Fibre connector

The connector shall match the type of the cable and shall meet the following requirements:

1) The type of the optical fibre connector should match the type of optical fibre, and SC, LC or other micro fibre connectors are recommended.

2) Optical/electrical hybrid cables shall be terminated by optical/electrical composite micro-connector. The copper wire terminals shall be connected to the copper wire with an outer diameter of not less than 0,404 mm.

6.3.3 Optical splitter

Optical splitters with asymmetric splitting ratio are recommended for FTTR system:

1) The cascaded extension link of optical splitters should be connected by single core fibre, and normally should not exceed three stages (including main optical splitter and extended optical splitters).

2) If optical/electrical hybrid fibre cable is applied, the optical splitter shall support DC power input port and optical/electrical integrated output ports.

Figure 9 shows a typical example of FTTR cabling system with asymmetric optical splitters.

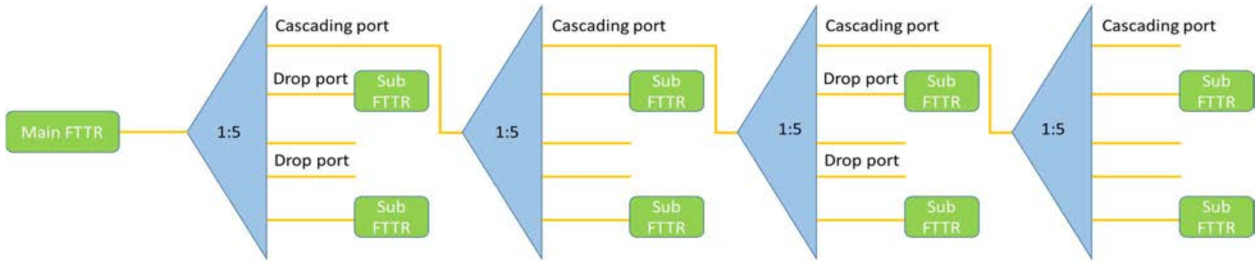


Figure 9: An example of FTTR cabling system with asymmetric optical splitters

7 Installation and deployment of fibre network

7.1 Distribution pipe network design

The distribution pipeline network of the FTTR system shall follow the following recommendations:

1) The pipeline network of FTTR system shall be coordinated with the generic cabling system in the building.

2) Distribution ducts shall be safe and economical, and with short routing path.

3) Pipeline and trough boxes shall not be set in elevators or vertical shafts of water supply, gas supply and heating pipes, and shall not be set in strong-current vertical shafts.

4) When optical cables are laid openly, corner protectors shall be installed at the corners to ensure the protection of optical fibres. Self-adhesive invisible optical cables are recommended.

5) Concealed conduits shall not pass through rooms other than home/users' units.

6) The optical splitter should be located in the area that is not easily accessible to personnel.

The setting of the cable-through box shall meet the following requirements:

1) When the conduit is laid in a straight route path, a cable-through box shall be added at every 30 m.

2) When the conduit is bent, if the route path has one bend, the length of the conduit shall be less than 20 m; if there are two bends, the length of the duct shall be less than 15 m.

3) In case of 2 or more continuous bends, a cable-through box shall be added.

The bending part of the pipe shall be arranged at the end of the routing path, and the included angle of the pipe shall not be less than 90°.

The radius of curvature of conduit shall not be less than 10 times the outer diameter of the pipeline, and the radius of curvature of inlet conduit shall not be less than 6 times the outer diameter of the pipeline.

No less than one towing rope shall be placed in the conduit, and there shall be no joint in the middle of the towing rope.

7.2 Equipment Installation Requirements

According to the application scenario, the FTTR devices can be installed on the wall, on the ceiling, on the desktop or in embedded multi-medium access box.

Indoor fibre distribution equipment shall include distribution cabinets and wall-mounted distribution boxes. Installation positions shall meet the following requirements:

1) The fibre distribution cabinet (rack) should be installed in the equipment room, telecom room or weak-current room.

2) Wall-mounted distribution box shall be installed in building corridors, common areas of floors or inlets of pipelines to facilitate the laying of conduits and trough boxes and facilitate the installation and maintenance of distribution equipment.

3) Wall-mounted distribution box shall not be installed on the side walls of footsteps.

The installation design of the distribution box shall follow the following requirements:

1) Selection of distribution box shall be based on the number of information points and FTTR devices, number of drop fibre and number of indoor optical fibre.

2) The installation position shall meet the Wi-Fi® signal coverage requirements.

3) It can be concealed installed in the corridor, hallway or living room for easy maintenance and it is close to the inlet pipeline side. The height of the bottom edge of the box to the ground is suggested to be 500 mm.

4) AC power socket with protective grounding should be reserved at the position 150 mm ~ 200 mm from the distribution box.

5) When the AC socket is inside the distribution box, strong and weak current isolation measures (e.g. keep enough distance between strong and weak current) shall be taken.

7.3 In-premises Fibre Cabling Recommendations

Pre-connectorized optical fibre cable can be used for quick in-premises installation.

Indoor optical fibre can also be can also be terminated by splicing onsite which should meet the following requirements:

1) Optical fibre should be protected at the splicing point.

2) It is recommended that pigtails (with connectors) be spliced for the termination of optical fibre cable.

3) The same type of fibre connectors should be used for one fibre channel.

The laying of subscriber optical fibre cables should follow the following requirements:

1) Concealed laying through conduit is recommended to be adopted.

2) A short, safe and economical route path should be selected.

3) Protection pipe should be set when passing through the wall.

4) The fibre should be marked at the termination position.

5) The utilization of the pipeline (cross-section) for routing optical fibre cables should not exceed 30 %.

The reserved length of indoor optical fibre should meet the following requirements:

1) The reserved length of optical fibre at the distribution cabinet (rack) should be 3 m to 5 m.

2) The reserved length of the optical fibre at the distribution box should be 1 m to 1,5 m.

3) If the fibre is not terminated, enough length shall be reserved for termination construction.

4) Protective measures should be taken for fibre connectors.

The minimum curvature radius for optical fibre laying and installation shall comply with Table 1.

Table 1: Minimum curvature radius for optical fibre laying and installation

Fibre type	Static bending
G.652D	10D/10H and not less than 30 mm
G.657A	5D/5H and not less than 15 mm
G.657B	5D/5H and not less than 10 mm
NOTE: D is the outer diameter of the round jacket of the fibre, H is the height of the short axis of the flat jacket of the fibre.	

7.4 Acceptance requirements of fibre deployment

Acceptance requirements of fibre deployment includes product quality inspection, project implementation quality control and project completion acceptance.

The construction and acceptance of fibre deployment project can be performed as a sub-project of the weak current system project.

The construction of fibre deployment should be undertaken by the construction unit with the corresponding qualification level and safety production license.

Project implementation quality control should include construction site quality management inspection, design document quality review and acceptance, product quality inspection, installation quality inspection and acceptance, and project completion acceptance, etc.

The performance parameter testing should meet the following requirements:

1) The connectivity of each fibre channel should be tested.

2) In the test, attenuation of optical fibre is tested with 1 310 nm wavelength, as shown in Figure 10.

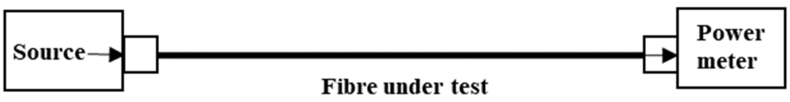


Figure 10: Fibre attenuation testing setup

3) OTDR can be used to test the attenuation and return loss of fibre to analyse and eliminate the fault points of the link.

4) The calculation formulas and specifications of the channel loss should meet the following requirements:

- Channel loss = Fibre loss + Connector loss + Fibre connection point loss + Optical splitter attenuation.
- Fibre loss = Fibre loss coefficient (dB/km) × Fibre length (km).
- Connector loss = Connector loss × number of connectors.
- Fibre splicing point loss = Splicing point loss × number of splicing points.
- Optical splitter attenuation = Optical splitter loss × number of optical splitters.

Loss values of optical fibres, connectors and connection points shall meet the requirements in Tables 2 and 3.

Table 2: Fibre loss (maximum)

SMF	Wavelength（nm）	1 310	1 550
OS2	Loss（dB/km）	0,4	0,4

Table 3: Loss of fibre connectors and splicing points

Type	Connector loss (dB)	Splicing loss (dB)
Single mode	0,5	0,15

Annex A (informative): In-premises fibre deployment methods and tools

A.1 Construction Tools

Table A.1 shows some typical tools that could be used for in-premises fibre deployment.

Table A.1: List of construction tools

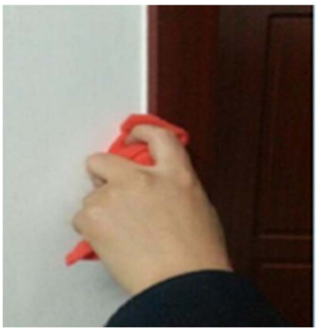
Line finder 	Diagonal pliers 	Needle-nose pliers 	Scissors 	Duster 
Gloves 	Shoe covers 	Pipe threader 	Cable lubricant 	Traction sling 
Cloth tape 	Measuring tape 	Splicing tool kit 	Fibre connector cleaner 	Ladder 
Hammer drill 	Drill bit (φ6 mm)	Phillips screwdriver 	Rubber mallet 	Double-sided adhesive 
FTTR cabling tool (with a telescopic rod) 	Single-sided waterproof tape 	Hot-melt glue tool 	Glass adhesive 	Corner protector 
Optical power meter + light source 	Pen-style visual fault locator 	Rubber heat insulation finger cot 	Adhesive spreader 	

A.2 Routing the transparent optical fibre cable

A.2.1 Confirming and Cleaning the Cable Route

1) Based on the multi-medium access box position, residence decoration, and user requirements, determine the cabling route (preferably the route along the baseboard, door frame, cabinet door, eave, and ceiling, avoid cracks and aging walls and places that need to be cleaned frequently). Ensure that the route is safe and concealed, and away from heat sources and potential hazards.

2) Clean the indoor cabling route and remove the dust. It is recommended that dry rags and kitchen paper be used for cleaning.

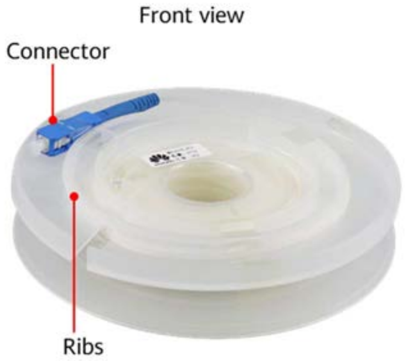


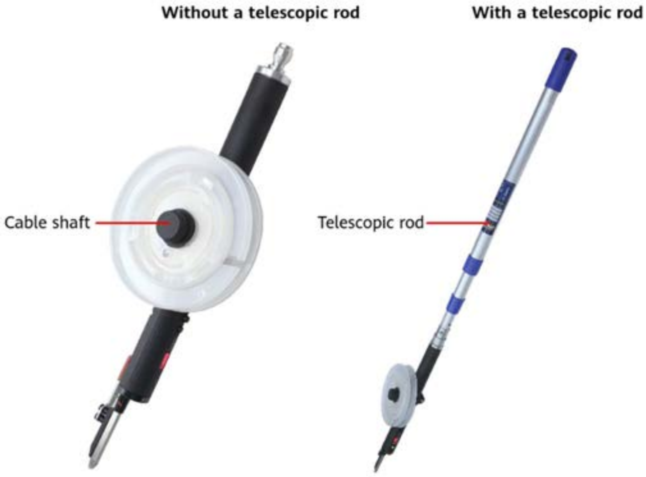
A.2.2 Using Cabling Tool to deploy optical fibre cable

A.2.2.1 Tool and Optical Cable Preparation

1) Measure the distance between the MFU and the FDU, and select a transparent optical fibre cable with an appropriate length.

2) Install the cable drum on the cable spool of the cabling tool. The side of the cable drum with connector and ribs faces upwards.



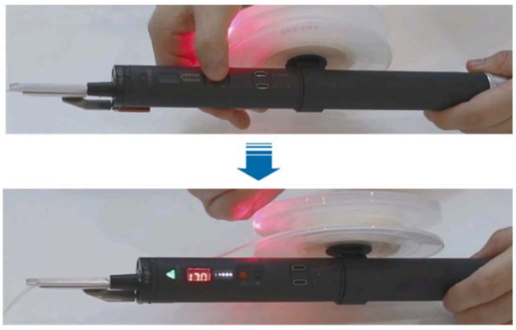


3) Insert the connector of the transparent optical cable into the **FTTR** port of the MFU. The **FTTR** port is the downstream optical port.

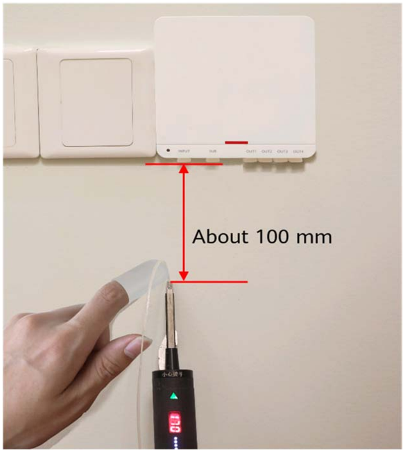
4) Place the optical cable at the groove of the heating head of the cabling tool.

5) Connect a pen-style visual fault locator to the input optical fibre cable. This allows to monitor the optical conductivity during cabling to promptly find out any fibre cuts. If the bending radius of the optical cable is too small, red light leakage occurs on the optical cable. In this case, adjust the bending radius of the optical fibre cable.

6) Turn on the switch of the cabling tool and wait until the temperature rises to the construction temperature.



7) Start routing the optical cable about 100 mm away from the device port. This distance is reserved to facilitate subsequent insertion and removal operations. When routing an optical fibre cable, press the optical cable head to avoid loose contact. After the optical cable is routed for about 50 mm and securely attached, release the optical cable head. It is recommended that single-sided waterproof tape be used to secure the reserved length.



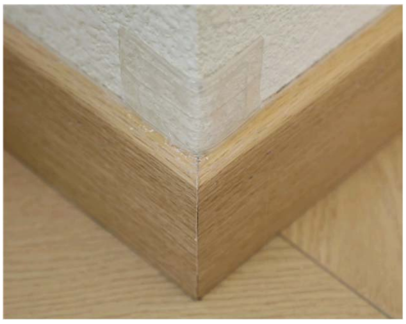
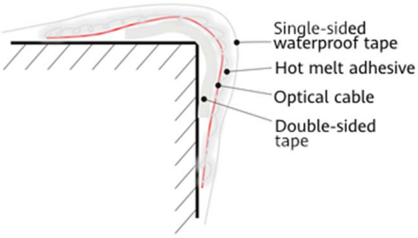
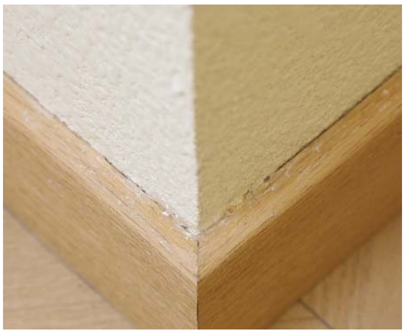
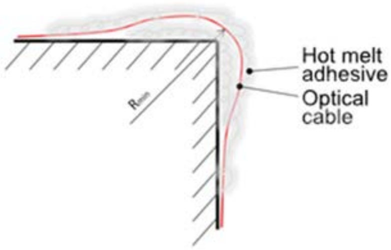
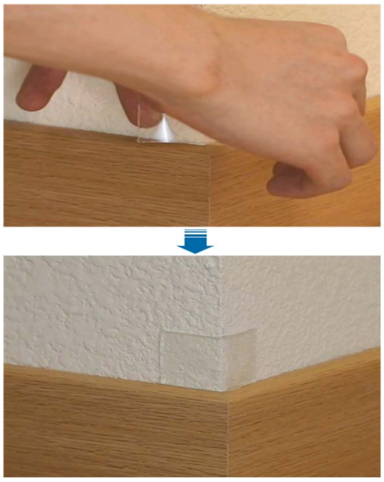
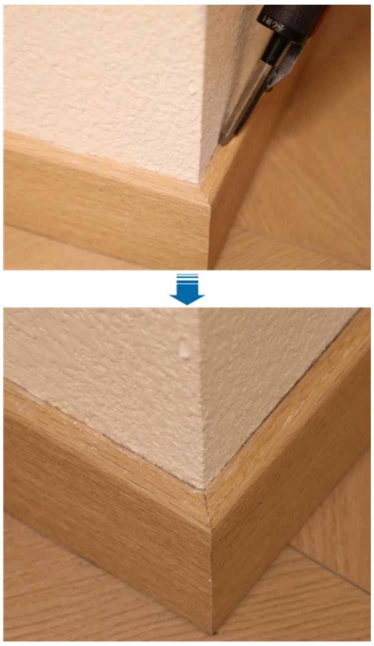
A.2.2.2 Cabling in Various Scenarios

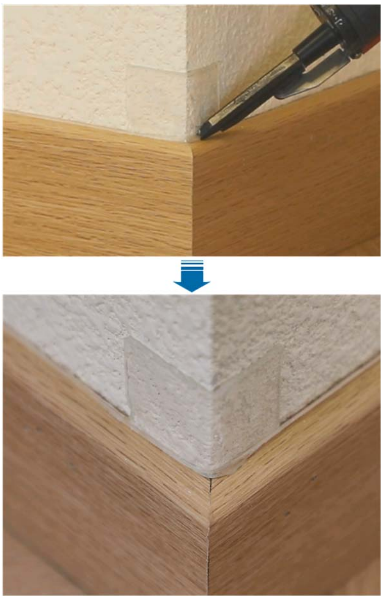
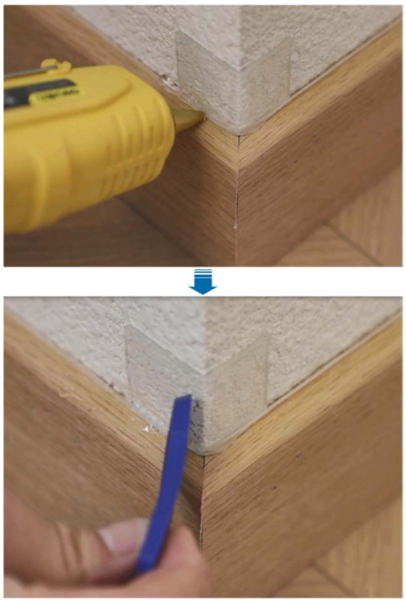
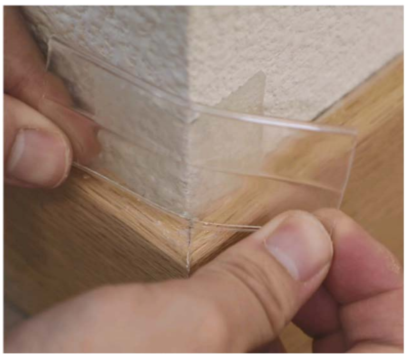
1) Baseboard Cabling

When routing the transparent optical cable along a baseboard, it is recommended to keep the tool perpendicular to the baseboard and move the tool slowly to ensure that the hot-melt adhesive on the optical cable fully melts. Ensure that the optical cable is closely attached to the baseboard or wall.

2) Exposed Corner Cabling

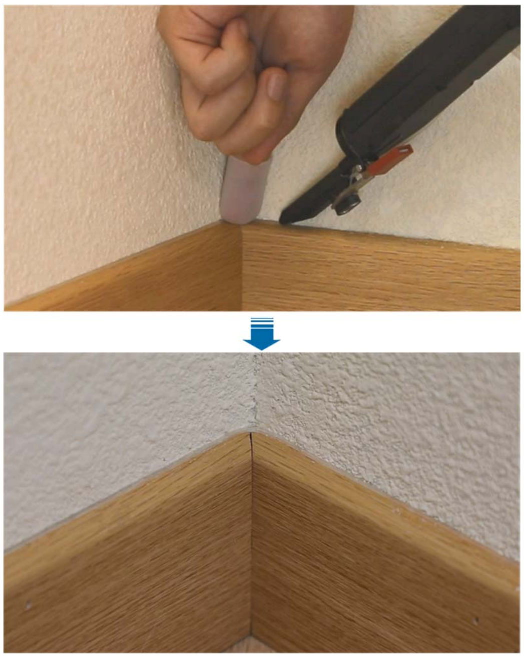
When routing cables at exposed corners, use the following method:

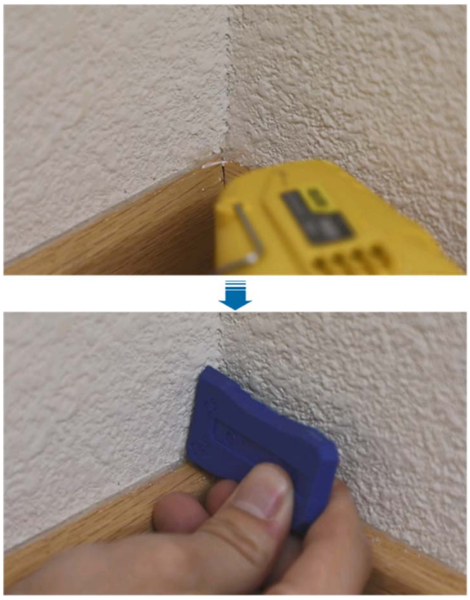
Solution	Two-layer adhesive tape	Dispensing adhesive for fixing
Picture	 	 
Construction Method	Attach the strong double-sided tape to the bending point of the exposed corner.  When the optical cable passes through, use strong double-sided tape to ensure the bending radius of the B3 optical cable.	When the optical fibre passes through, reserve a certain length to ensure a proper bending radius.  After the cable is routed, use a hot-melt glue tool to dispense adhesive on both sides, and then use an adhesive spreader to spread the hot melt adhesive evenly.

	 After the cable is routed, use a hot-melt glue tool to dispense adhesive on both sides, and then use an adhesive spreader to spread the hot melt adhesive evenly.  After the reinforcement, use single-sided waterproof tape as a supplement. 	

3) Internal Corner Cabling

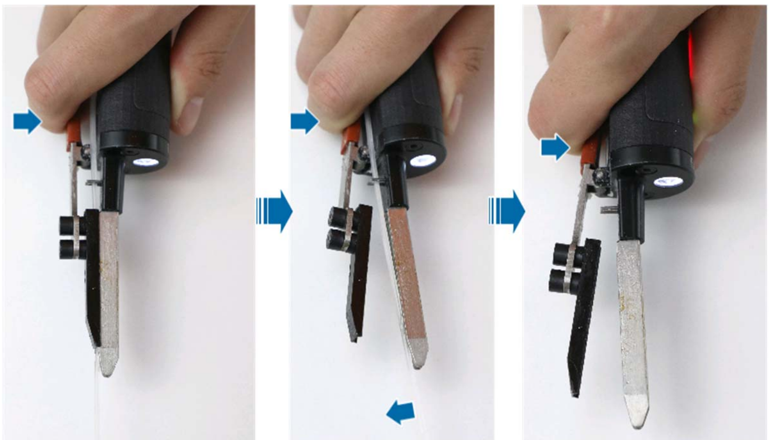
When routing cables at internal corners, use the following method:

Solution	Dispensing for fixing
Picture	
Construction Method	When optical fibres pass through, use a finger (wear a finger cot) to press the corner to prevent the optical cables from being pulled by tools and detached from the wall. In addition, press the optical cable with your finger to make a proper bending radius (avoid bending by 90°). 

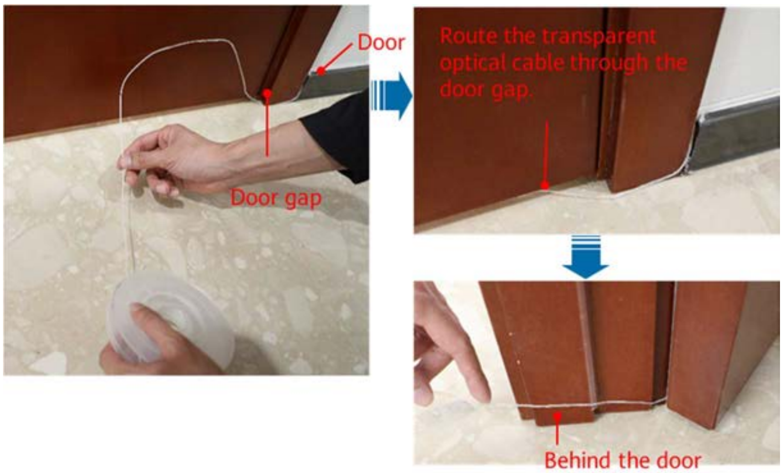
	After the cable is routed, use a hot-melt glue tool to dispense adhesive on both sides, and then use an adhesive spreader to spread the hot melt adhesive evenly. 

4) Door Gap Cabling

a) When the transparent optical cable needs to pass through a door gap, remove it from the cabling tool, and remove the cable drum from the cable spool.

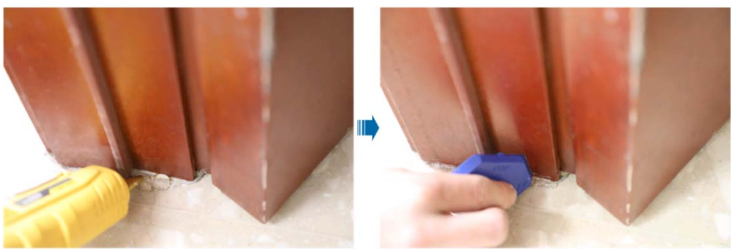


b) Route the transparent optical cable through the door gap.



c) Reinstall the cable drum back to the cable spool, secure the transparent optical cable to the heating head of the cabling tool, and continue to route the optical cable.

d) After the cable is routed, use a hot-melt glue tool to dispense adhesive along the routing path based on the actual situation, and then use an adhesive spreader to spread the hot melt adhesive evenly.



5) Cable Routing on a Door Frame

Route a cable along a door frame in the same way as routing a cable at an internal or external corner.

6) Cabling on the Ceiling

In the straight section of the ceiling, a telescopic rod can be used to facilitate cabling. At an internal or external corner, stand on a ladder to route the optical cable.

A.2.2.3 Checking and Reinforcing after Cabling

Check the entire cable route, and use the hot-melt glue tool or single-sided waterproof tape to reinforce the cable at corners and other parts where the cable does not stick reliably. In particular, the first and last segments of the cable, and positions where the cable is not securely attached can be reinforced to ensure long-term reliability. The following table uses a hot-melt glue tool as an example to describe the adhesive dispensing and reinforcement procedure.

Tools	Hot-melt glue tool and adhesive stick
Picture	
Construction Procedure	• Find the parts not securely attached, such as the internal and external corners, plane corners, straight sections where the adhesive is not fully melted, start and end sections, and sections where the optical cable is off the surface. • Use a hot-melt glue tool to dispense adhesive, and then use an adhesive spreader to spread the hot melt adhesive evenly. • Check whether the hot melt adhesive completely covers the optical cable.

Dispense adhesive at exposed or internal corner	Dispense adhesive at a plane corner
	
Dispense adhesive at the start and end of the cabling path	Dispense adhesive at the section where the optical cable is off the surface
	

A.2.3 Using Hot-melt Glue Tool

While dispensing glue with a hot-melt glue tool, lay the optical cable along the planned path.

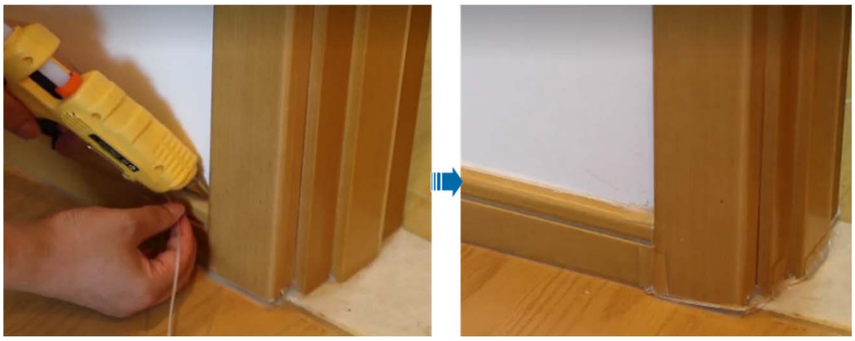
1) Baseboard cabling

Pull the optical cable straight along the cabling path, and secure it using glue every 15 to 20 mm.

2) Exposed corner cabling

When routing the optical cable over an exposed corner, ensure that the bending radius is greater than 5 mm, and that the optical cable is not twisted.

3) Door gap cabling



When routing the optical cable in a door gap, control the amount of glue to avoid bulges due to glue overflow, and use transparent waterproof PVC tape for reinforcement.

4) Door frame cabling

When routing the optical cable along a door frame, attach it on the wall near the door frame.

5) Internal corner cabling

When routing the optical cable over an internal corner, ensure that the bending radius is greater than 5 mm, and that the optical cable is not twisted.

Annex B (informative): Bibliography

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History

Document history		
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