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ODN Quick Construction and Digitalization;
Part 1: General and Guidance

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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

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1 Scope

The present document describes the general guidance on Optical Distribution Network (ODN) quick construction and digitalization. The digitalized Quick ODN enables the carriers to improve the fibre deployment efficiency, achieve digital resource management, and consequently improve the operation and management efficiency.

The present document describes the composition of the digitalized quick ODN and the general requirements on physical label, digitalized quick ODN devices, intelligent management terminal, intelligent optical path analysis equipment and intelligent management system.

The present document is mainly based on intelligent optical distribution networks that can collect the ODN device information through intelligent optical path analysis equipment or intelligent management terminal (such as a smart phone with the ODN management application). It can also be used as a reference for other networks with optical fibre connections.

For optical distribution networks that collect label information in other methods, it is possible to refer to the present document similarly.

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.

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Not applicable.

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

Digitalized quick Optical Distribution Network (ODN): digitalized quick ODN is a methodology that uses physical labels or optical path labels to uniquely identify ODN passive devices to enable the implementation of intelligent management functions such as automatic storage of optical information, automatic identification of optical fibre connection, information calibration of optical fibre resources and visualized onsite operation guide

NOTE: The network is constructed based on QuickConnect cables and terminals, the network connection can be done by plug-and-play operation on site.

3.2 Symbols

Void.

3.3 Abbreviations

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

CO	Central Office
EMS	Element Management System
FAT	Fibre Access Terminal LC
FDB	Fibre Distribution Box
GIS	Geographic Information System
ODN	Optical Distribution Network
OLT	Optical Line Terminal
ONT	Optical Network Terminal
ONU	Optical Network Unit
OSS	Operation Support Systems
PON	Passive Optical Network
QR	Quick Response
RH	Relative Humidity
RTT	Round Trip Time
SN	Serial Number
UV	Ultraviolet

4 Composition of Digitalized Quick ODN

4.1 General

During the entire lifecycle including planning, construction, acceptance, operation, and maintenance, by adopting new technologies such as digitalization and artificial intelligence, digitalized Quick ODN can build an intelligent ODN management mechanism to implement highly automatic and self-calibrated resource management and fast service provisioning on passive ODN networks, improving operation and maintenance efficiency and quality.

DQ ODN mainly has digital and quick features. Through digitally encoding technology, digitalization can make ODN network data flow paperless, resource changes can be automatically collected, and optical path status can be visualized. Quick means rapid network construction and high reliability of the ODN network.

In the construction phase, the Digitalized Quick ODN shall be able to enrol ODN resources to the system through digitalized information technologies such as scanning codes, and bind GIS information and addresses of resources. In the project acceptance phase, the digitalized Quick ODN shall be able to remotely inspect ODN optical paths, identify optical path quality and optical path length, and assist home broadband services, new community ODN lines in quick network access, capacity expansion, etc.

In the operation phase, the digitalized Quick ODN shall be able to automatically construct the optical link topology, identify the occupation status of key optical path resources, and assist in resource utilization planning and management; besides, it shall be able to automatically establish the association between logical optical paths and service devices.

The digitalized Quick ODN shall support routine inspection, fault demarcation and locating. In routine inspection mode, the system shall automatically and periodically inspect each optical paths. The inspect item should include the optical power and generates an alarm if it exceeds the threshold. The system shall be able to identify and accurately locate potential optical path faults, such as continuous optical attenuation, abnormal optical path attenuation, and optical passing length, and provide warnings in advance. When the user triggers the start, the system supports the user to start temporary fault locating. The system shall be able to identify whether the user complaint is caused by the optical path in minutes, whether the fault is group fault or individual fault, and accurately locate the fault. After the optical path fault is rectified, the quality of the optical path shall be accepted.

4.2 Position in the Access Network

As figure 4-1 shows, the Digitalized Quick ODN system connects the OLT and ONU through the digital ODN hardware, connects to the carrier's Operation Support System (OSS) upwards (including the resource management system and fault management system), and collects optical path information from the ODN network downwards, restores the optical path topology, and demarcates and locates faults.

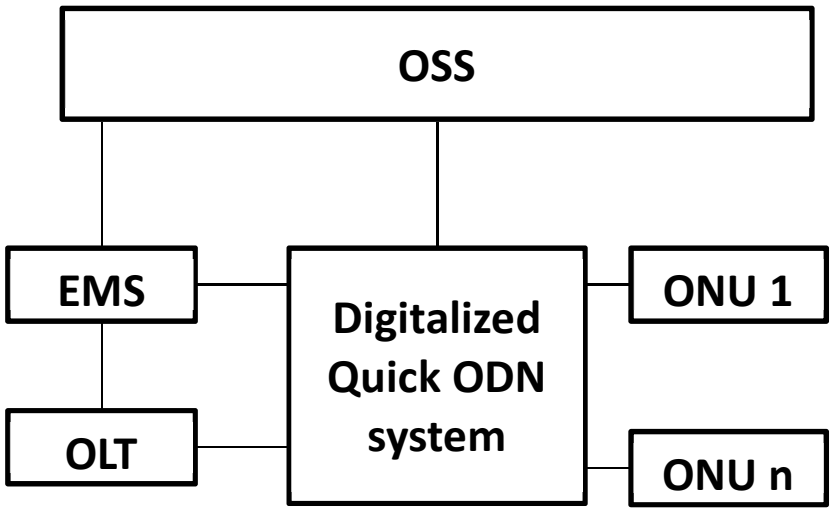

Figure 4-1: Composition Reference Model

4.3 Composition Reference Model

The Digitalized Quick ODN system consists of Physical label, Digitalized Quick ODN devices, Intelligent optical path analysis equipment, Intelligent management terminal and Intelligent management system. They can interconnect with a third-party Operations Support System (OSS). Figure 4-2 shows the composition reference model, with description of each part in clause 4.4 and interface definitions in clause 4.5.

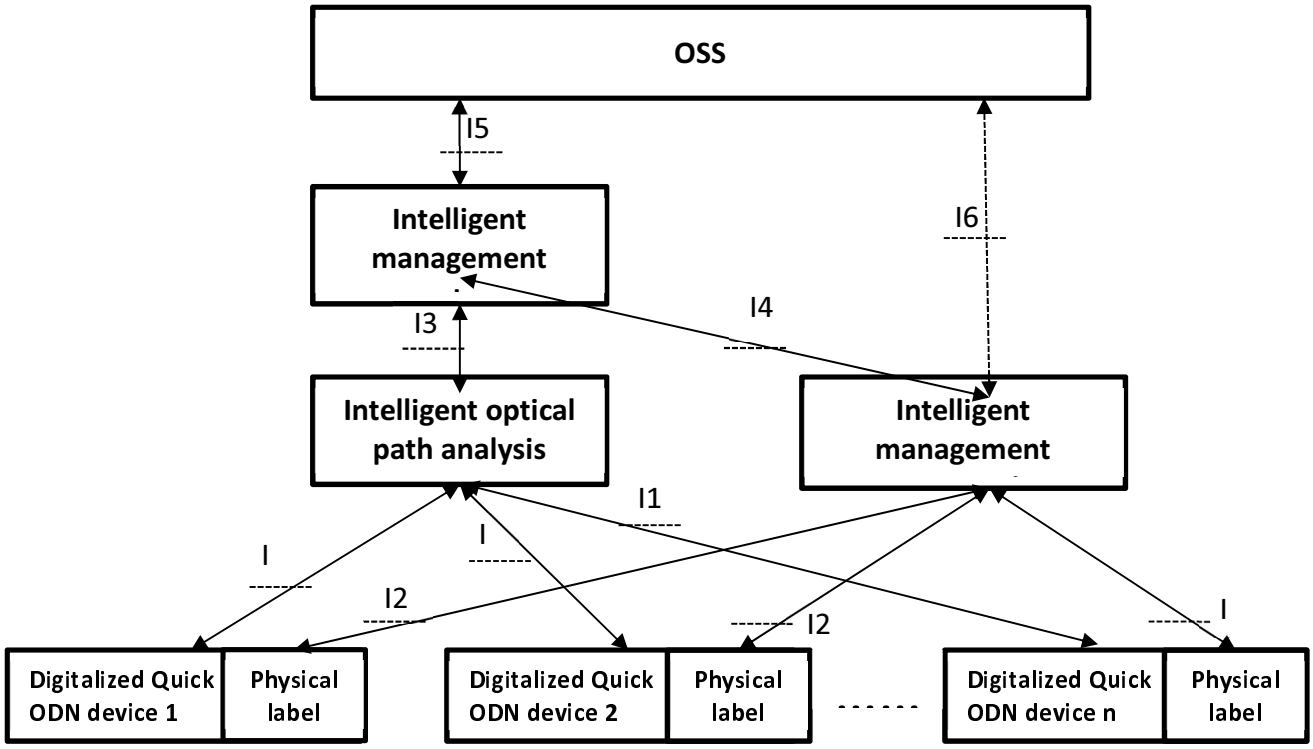

Figure 4-2: Composition Reference Model

4.4 Functional Entity

4.4.1 Physical label

Labels used to identify Digitalized Quick ODN devices features, such as QR codes and RFID, generally used on the surface of optical splitters, patch cords, pigtails, or terminals (including closures, FAT, FDB, etc.).

4.4.2 Digitalized Quick ODN devices

ODN devices with digital functions, including optical splitter, optical fibre, cables, closures and so on. The digital functions include optical path labels on optical splitter which modulates the optical path information, and physical labels on optical cables, connectors, terminals, etc.

Digital Quick ODN devices provide digital capabilities in passive mode.

4.4.3 Intelligent optical path analysis equipment

Equipment which can read and analyse ODN resource data and optical path quality data, and report to the Intelligent management system on demand.

4.4.4 Intelligent management terminal

As a portable device with an ODN management software application, like a smart phone, tablet computer, it provides a management operation interface to identify intelligent ODN devices and manage onsite operations. It communicates with the intelligent management system through the I4 interface and communicates with the OSS through the I6 interface.

The intelligent management terminal provides the following functions:

a) Scan physical labels on ODN devices and obtain related information (including the device type, device specification, production date, GIS, etc.).

b) Scan the physical labels of the cables and terminals to identify the status of the ports (Occupied or idle) and the connection relationship between cables and terminal ports.

4.4.5 Intelligent management system

The intelligent management system mainly implements the function of managing the digitalized quick ODN devices through the intelligent optical path analysis equipment or intelligent management terminal, communicates with intelligent optical path analysis equipment through the I3 interface, and communicates with the intelligent management terminal through the I4 interface, and communicates with the OSS through the I5 interface. The intelligent management system provides the following functions:

a) Visualized optical network topology (including device connection relationship and port connection status).

b) ODN optical path quality inspection capability and inspection report.

c) ODN optical path fault diagnosis capability located in PON ports.

d) Manages on digitalized quick ODN devices, and stores, inputs, and outputs correspondent information.

e) Receives, processes, and forwards work orders.

f) Manages alarm information and reports it to the OSS.

4.5 Interface

4.5.1 I1 interface

The I1 interface is located between the intelligent optical path analysis equipment and the digitalized quick ODN devices. The intelligent optical path analysis equipment reads the optical path information of the PON network (including the OLT and ONU) and the Digitalized Quick ODN devices through the I1 interface.

4.5.2 I2 interface

The I2 interface is located between the physical label and the intelligent management terminal. The Intelligent management terminal reads the information on the physical label through the I2 interface. The I2 interface provides the following functions:

a) Scan physical labels on ODN devices and obtain related information (including the device type, device specification, production date, GIS, etc.).

b) Scan the physical labels of the cables and terminals, and to identify the status of the terminal ports (occupied or idle) and connection relationship between cables and terminal ports.

4.5.3 I3 interface

The I3 interface is located between the intelligent optical path analysis equipment and the intelligent management system. The intelligent management system collects optical path information from the intelligent optical path analysis device through the I3 interface, including ONU receive/transmit optical power, ONU RTT information, and optical path information of the ODN network.

4.5.4 I4 interface

The I4 interface is located between the intelligent management system and the intelligent management terminal. The intelligent management system communicates with the intelligent management terminal through the I4 interface. The interactive information on the I4 interface includes the device type, device specifications, production date, GIS, etc.

4.5.6 I5 interface

The I5 interface is the northbound interface of the intelligent management system. It is located between the intelligent management system and the OSS. The interaction information on the I5 interface includes ODN topology data and ODN optical path fault data.

4.5.7 I6 interface (optional)

The I6 interface is located between the intelligent management terminal and the OSS. The interaction information on the I6 interface includes:

a) Order information received by the intelligent management terminal from the OSS.

b) The order processing result sent from intelligent management terminal to the OSS.

5 General requirements on physical label

The general requirements of physical label are as following:

a) The number information carried by the physical label shall be unique.

b) The information carried by the physical label shall be readable.

c) The physical label shall be firmly attached to the associated devices, such as fibre connectors, cables or terminals.

d) The label shall meet the same environmental performance requirements as the product, such as the change of temperature, water immersion, resistance to chemical solvents and other environmental tests, and there shall be no digital reading function failure after the above tests.

e) The label shall meet certain mechanical performance requirements, such as wear resistance, alcohol wiping resistance, and there shall be no digital reading function failure after the above tests.

f) Physical labels (such as QR code labels) in outdoor scenarios should meet the test requirements of long-term UV, high temperature and high humidity, and anti-mold aging, and there shall be no digital reading function failure after the above tests.

6 General requirements on Digitalized Quick ODN devices

6.1 Structure

Traditional ODN links, ODN system without Digital function, can use either a one-stage or a two-stage equal-ratio optical networking structure. Two-stage equal-ratio optical network is recommended for scenarios with high user density, while unequal-ratio optical networking structure is recommended for scenarios with low user density. This clause focuses on the key feature requirements of components related to unequal-ratio QuickConnect network.

Figure 6-1 illustrates that digitalized quick ODN devices are mainly including the QuickConnect Hubbox, QuickConnect Subbox, QuickConnect Endbox, QuickConnect distribution cable, QuickConnect drop cable, and adaptor.

Similar to the FDT in the traditional ODN network, the Hubbox is the transfer point between the feeder end and the distribution section in the ODN network, which realizes the conversion between the multi-core and the single-core distribution cable. The Subbox and the Endbox are used in the distribution and drop sections, which are similar to the second-stage box in the traditional ODN network. Their functions are similar, but the difference is as follows: the subbox has a built-in optical splitter with unequal ratio, which provides the functions of connecting users and cascading. The endbox has a built-in optical splitter with equal ratio, which is used at the end of the network and can only connect users without cascading. Both Subbox and Endbox are fully sealed.

Similar to the traditional ODN network, the distribution cable is used in the distribution section, but can be directly plugged into the terminal box with both ends pre-connected with hardened connectors. The drop cable is used in the home section to connect the access point and the user ONU.

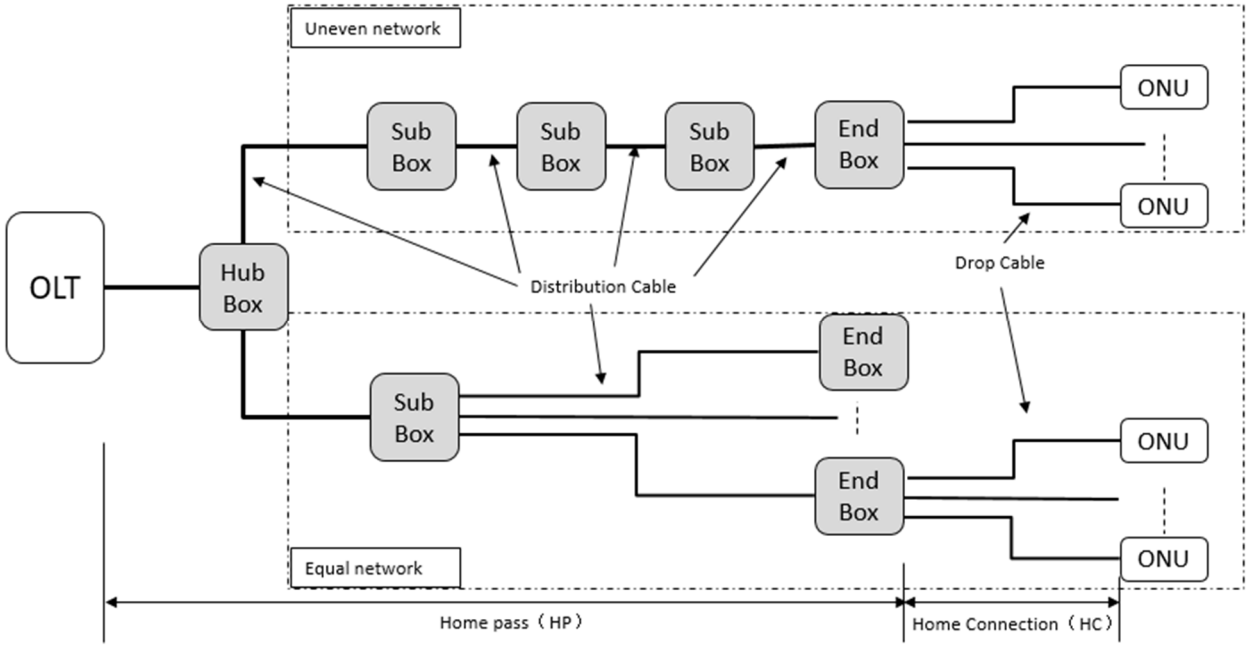

Figure 6-1: Schematic diagram of a structure of digitalized quick ODN devices

6.2 Requirements on components

6.2.1 Hubbox

Figure 6-2 illustrates the schematic diagram of a structure of QuickConnect Hubbox. The general requirements of QuickConnect Hubbox are the following:

a) Should support the access of multi-core optical cables or the access of QuickConnect cables. The output end is the QuickConnect distribution optical cable, which can be single-core or multi-core.

b) Should support splitting function.

c) Shall support readable physical labels on the surface of the boxes, which should be identified through the image recognition technology in order to get connection relationship between the cables and the box ports.

d) Shall support the optical path information collection function, and work with intelligent optical path analysis equipment and intelligent management system to realize the topology restoration of the network and the monitoring of the network status.

e) Shall meet the requirements of waterproof level IPx5 (overhead scenarios) or IPx8 (underground scenarios).

f) Shall test long-term reliability for 1 000 h under the condition of 75 °C, 95 % RH. After the above tests, there shall be no damage affecting the function, products shall meet the requirements of optical and waterproof performance, as well as impact level IK08 (overhead scenarios) or IK09 (underground scenarios).

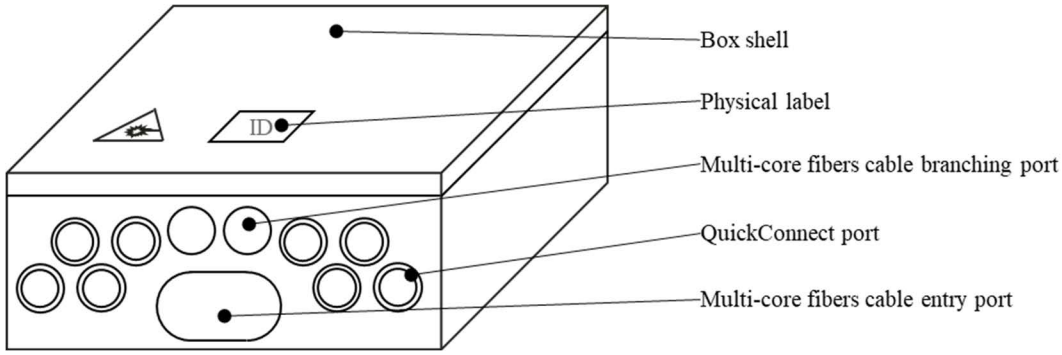

Figure 6-2: Schematic diagram of a structure of Hubbox

6.2.2 Subbox

Figure 6-3 illustrates the schematic diagram of a structure of QuickConnect Subbox. The general requirements of QuickConnect Subbox are the following:

a) The adapter ports shall be on the surface of the box body, and the QuickConnect cables can be plugged and unplugged without opening the box.

b) There shall be readable physical labels on the surface of the boxes, which should be identified through the image recognition technology in order to get connection relationship between the cables and the box ports.

c) Shall support the optical path information collection function, and work with intelligent optical path analysis equipment and intelligent management system to realize the topology restoration of the network and the monitoring of the network status.

d) Shall meet the requirements of waterproof level IPx5 (overhead scenarios) or IPx8 (underground scenarios).

e) Shall test long-term reliability for 1 000 h under the condition of 75 °C, 95 % RH. After the above tests, there shall be no damage affecting the function, products shall meet the requirements of optical and waterproof performance, as well as impact level IK08 (overhead scenarios) or IK09 (underground scenarios).

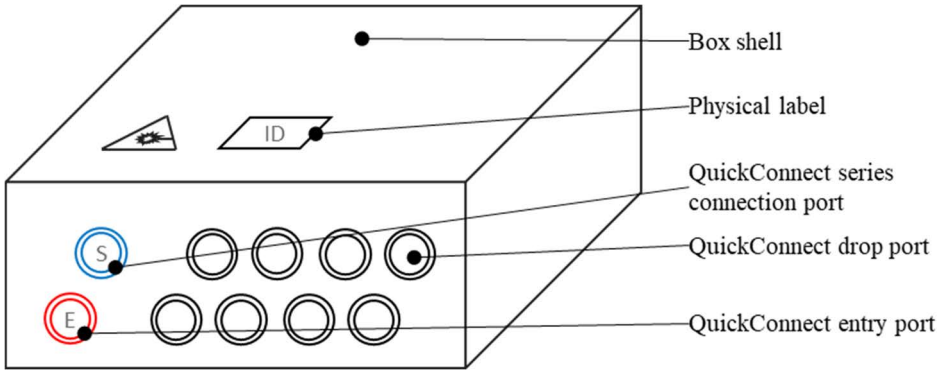

Figure 6-3: Schematic diagram of a structure of Subbox

6.2.3 Endbox

Figure 6-4 illustrates the schematic diagram of a structure of QuickConnect Endbox. The general requirements of the QuickConnected Endbox are the following:

a) The adapter ports shall be on the surface of the box body, and the QuickConnect cables can be plugged and unplugged without opening the box.

b) There shall be readable physical labels on the surface of the boxes, which should be identified through the image recognition technology in order to get connection relationship between the cables and the box ports.

c) Shall support the optical path information collection function, and work with intelligent optical path analysis equipment and intelligent management system to realize the topology restoration of the network and the monitoring of the network status.

d) Shall meet the requirements of waterproof level IPx5 (overhead scenarios) or IPx8 (underground scenarios).

e) Shall test long-term reliability for 1 000 h under the condition of 75 °C, 95 % RH. After the above tests, there shall be no damage affecting the function, products shall meet the requirements of optical and waterproof performance, as well as impact level IK08 (overhead scenarios) or IK09 (underground scenarios).

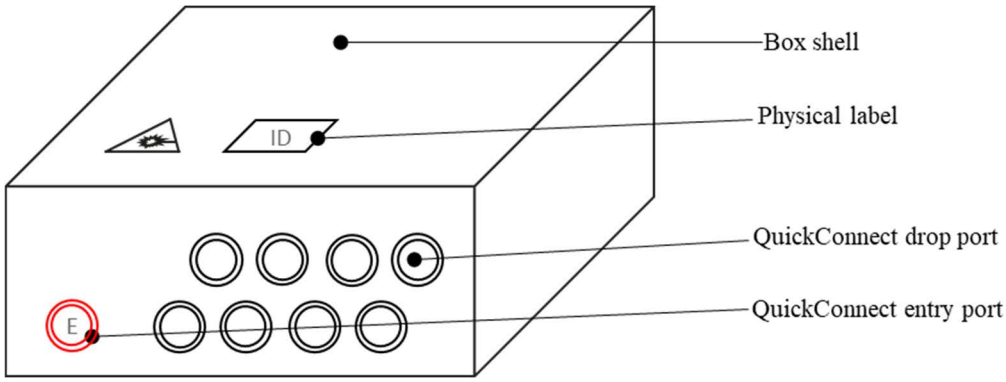

Figure 6-4: Schematic diagram of a structure of Endbox

6.2.4 QuickConnect distribution cables

Figure 6-5 illustrates the schematic diagram of a structure of QuickConnect distribution cables. The general requirements of QuickConnect distribution cables are the following:

a) The connector shall be hardened connectors, which meets the requirements of waterproof level IPx5 (overhead scenarios) or IPx8 (underground scenarios).

b) The connector shall attach physical labels and support digital identification. The physical label codes on connectors at both ends shall be the same.

c) Shall support the optical path information collection function, and work with intelligent optical path analysis equipment and intelligent management system to realize the topology restoration of the network and the monitoring of the network status.

d) The attenuation average value of random mated single-core hardened connectors shall be no more than 0,08 dB.

e) The tensile force of the hardened connectors shall be no less than 800 N to ensure high reliability during installation.

f) Shall test long-term reliability for 1 000 h under the condition of 75 °C, 95 % RH. After the above tests, there shall be no damage affecting the function, products shall meet the requirements of optical and waterproof performance.

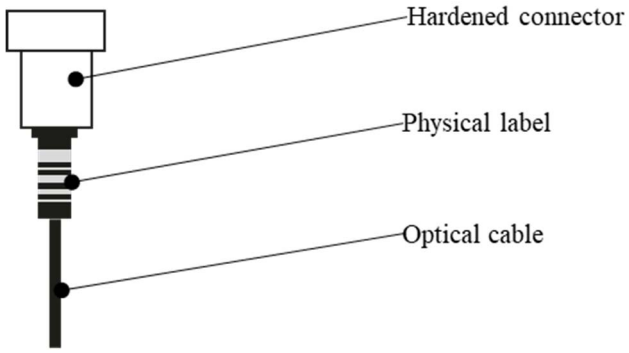

Figure 6-5: Schematic diagram of a structure of QuickConnect distribution cables

6.2.5 QuickConnect drop cables

The general requirements of QuickConnect drop cables are the following:

a) The connector shall be Hardened connectors, which meets the requirements of waterproof level IPx5 (overhead scenarios) or IPx8 (underground scenarios).

b) The connector shall attach physical labels and support digital identification. The physical label codes on connectors at both ends shall be the same.

c) Should support the optical path information collection function, and work with intelligent optical path analysis equipment and intelligent management system to realize the topology restoration of the network and the monitoring of the network status.

d) The tensile force of the hardened connectors shall be no less than 300 N.

e) Shall test long-term reliability for 1 000 h under the condition of 75 °C, 95 % RH. After the above tests, there shall be no damage affecting the function, products shall meet the requirements of optical and waterproof performance.

6.2.6 Adaptor

Figure 6-6 illustrates the schematic diagram of a structure of Adaptors. Adaptors are usually constructed with plug-socket type, with one end connected to the terminal and the other end connected to the QuickConnect drop cables. The general requirements of adaptors are the following:

a) Shall meet the requirements of waterproof level IPx5 (overhead scenarios) or IPx8 (underground scenarios).

b) Should attach physical labels and support digital identification.

c) Should support the optical path information collection function, and work with intelligent optical path analysis equipment and intelligent management system to realize the topology restoration of the network and the monitoring of the network status.

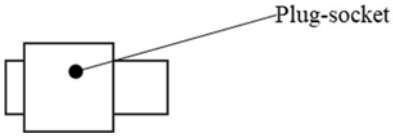

Figure 6-6: Schematic diagram of a structure of adaptors

7 General requirements on intelligent management terminal

The intelligent management terminal shall provide digital and visualized ODN resource management capabilities through the entire lifecycle of ODN construction, installation, and maintenance.

The general requirements of the intelligent management terminal are the following:

a) Automatic identification and recording of intelligent ODN devices information and port information by scanning digital labels.

b) Download, import, export, query, delete, and feedback work order processing results.

c) Provision of visualized onsite operation guide services through the management interface.

d) Communication with the intelligent management system.

e) Communication with the OSS (Optional).

8 General requirements on intelligent optical path analysis equipment

The general requirements of the intelligent optical path analysis equipment are the following:

a) Collects optical path information (such as scattering) of the backbone and branch in the ODN network as required.

b) Measures the end-to-end insertion loss of fibre links.

c) Demarcates and locates faults.

d) Continuously provides functions such as intelligent digital ODN topology restoration, fibre quality acceptance, and fault diagnosis.

9 General requirements on intelligent management system

9.1 General

Intelligent management system is located in the network management centre. It can realize visual resource management, optical path quality monitoring, fault diagnosis and provide northbound interface to OSS.

9.2 Topology restoration for passive optical network

The Digitalized Quick ODN shall provide topology restoration function. A topology restoration achieves ODN dumb resources inventory management and improve resource report accuracy. It supports planning and design of new ODN network construction or stock expansion and construction acceptance.

To realize logical topology restoration through optical path labels, the general requirements of intelligent management system are the following:

a) Shall support identification of first-stage optical splitter and its ports status which includes connect to second-stage splitter, connect to ONU, vacant and connect to cable (the other end of cable is not connected).

NOTE: Connect to second-stage splitter and connect to ONU can be called 'occupied', and vacant and connect to cable can be combined together as 'idle'.

b) Shall support identification of second-stage optical splitter and ONT group information. Shall be able to show the distance from OLT to second-stage splitter and the information of connected ONT including product ID, SN, LODI.

To realize physical topology restoration through physical labels, the general requirements of intelligent management system are the following:

a) Should support checking ODN resource location and connection relationship based on GIS information.

b) Overall resource status and proportion shall be displayed and queried.

c) Location stage of ODN devices shall be visualized.

d) ODN device port status (idle or occupied) and information including coordinate and name shall be visualized.

Interface definition of optical splitter resource and the connection relationship on ODN network are described in table 9-1.

Table 9-1: Interface definition of optical splitter resource and the connection relationship on ODN network

Field example	Null or not	Required / Optional	Description
deviceSN	N	Required	ODN device SN code
deviceName	N	Required	ODN device name
deviceAddress	N	Required	ODN device address information
deviceFloor	Y	Optional	ODN device floor information
deviceGis	N	Required	ODN device GIS information
deviceImages	Y	Optional	ODN device image information
devicePorts	N	Required	ODN device port information
deviceStatus	Y	Optional	ODN device acceptance status
deviceIP	Y	Optional	ODN device Internet Protocol(IP) information
portNumber	N	Required	ODN device port identifier
portCable	Y	Optional	ODN device port cable code
portOntSn	Y	Optional	ODN device port connected ONT code

9.3 Quality monitoring of passive optical network

The digitalized quick ODN shall provide ODN network quality monitoring function, support self-defined periodic automatic ODN network quality diagnosis, actively initiate optical network optimization and fault diagnosis. To realize above functions, the general requirements of intelligent management system are the following:

a) Shall support quality control of feeder optical network, including fibre break, high insertion loss.

b) Should support quality control of distribution optical network, including fibre break, high insertion loss.

c) Should support quality control of home connection optical network, including fibre break, high insertion loss.

Visualized interface definition of the optical network is described in table 9-2.

Table 9-2: Visualized interface definition of the optical network

Field example	Null or not	Required/Optional	Description
Name	N	Optional	Node name (corresponding to the optical splitter resource interface model) or connection name (corresponding to the ODN connection interface model)
Type	N	Optional	Connection relationship/Splitter
Attenuation	N	Optional	Attenuation of the network

9.4 Fault diagnosis of passive optical network

The Digitalized Quick ODN shall provide ODN network fault diagnosis function, supports initiating fault diagnosis of specific PON port network in case of sudden ODN network fault, guides fast demarcation, fast search for optical network fault location and fast repair, so as to provide high-quality network services. To realize above functions, the general requirements of intelligent management system are the following:

a) Shall support Fault diagnosis of feeder optical network. Shall provide diagnostic results such as the distance between the nodes before and after the failure location, the attenuation of the abnormal point, suggestions.

b) Should support Fault diagnosis of distribution optical network. Should provide diagnostic results such as fibre break, the distance between the nodes before and after the failure location, suggestions.

c) Should support Fault diagnosis of home connection optical network. Should provide diagnostic results such as fibre break, the distance between the nodes before and after the failure location, suggestions.

Interface definition of the fault diagnosis function is described in table 9-3.

Table 9-3: Interface definition of the fault diagnosis function

Field example	Null or not	Required / Optional	Description
OLT	N	Required	IP of OLT that the fault belongs to
PONPorts	N	Required	Port of OLT that the fault belongs to
DiagResult	N	Required	Diagnostic result
SugMeasure	N	Required	Suggest measurement
WeakONT	N	Required	ONT that the fault occurs
FailLoc	N	Required	failure location
DistFailtoCO(m)	N	Required	Distance from failure location to CO room(m)
DistFailtoFirst(m)	N	Required	Distance between failure location to first-stage splitter(m)
AttenuFail(dB)	N	Required	Attenuation in failure location (dB)
NbeforeFail	N	Required	Node before the failure location
DistFailtoNbefore(m)	N	Required	The distance from failure location to the Node before the failure location (m)
NafterFail	N	Required	Node after the failure location
DistFailtoNafter(m)	N	Required	The distance from failure location to the Node after the failure location (m)

History

Document history		
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