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**Access, Terminals, Transmission and Multiplexing (ATTM);
Optical Distribution Network (ODN)
Quick Construction and Digitalization**

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Foreword

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

Modal verbs terminology

In the present document "**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

Fibre to Everywhere is the vision of the Fifth Generation Fixed Network (F5G). Easy deployment of fibre infrastructure, fast and flexible ODN network construction and clear, visible and manageable ODN network are the key to the construction of the new fibre infrastructure. Traditional ODN networking and construction face the following challenges:

- low construction efficiency;
- high costs and disordered resource management.

Especially in the low density access scenarios, the high deployment cost and low efficiency of optical fibres are more obvious. The ODN development in the F5G era should be able to avoid the preceding construction problems and implement flexible networking, fast deployment, visualized and manageable ODN.

1 Scope

The present document describes the ODN quick construction and digital management solutions, which enable 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 system structure of the digitalized quick ODN and the general requirement of pre-connectorized ODN product modules, digital labels, intelligent management terminals and intelligent optical distribution network management systems.

The present document is mainly applicable to the intelligent optical distribution network in access network. It can also be used as a reference for other networks with optical fibre connections.

The present document is mainly based on intelligent optical distribution networks that can collect the ODN information through a smart terminal device (such as a smart phone with the ODN management application) and the digital label in the ODN device. For optical distribution networks that collect electronic label information in other methods, it is possible to refer to the present document similarly.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

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2.2 Informative references

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

[i.1] IEC 61300 (all parts): "Fibre optic interconnecting devices and passive components - Basic test and measurement procedures".

[i.2] IEC 61753-1: "Fibre optic interconnecting devices and passive components - Performance standard-Part 1: General and guidance".

[i.3] IEC 60068-2-17: "Basic environmental testing procedures - Part 2-17: Tests - Test Q: Sealing".

[i.4] ISO 1998-1:1998: "Petroleum industry-Terminology- Part 1: Raw materials and products".

[i.5] EN 590:2009: "Automotive fuels-Diesel-Requirements and test methods", (produced by CEN).

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

digitalized Optical Distribution Network (ODN): methodology that uses electronic labels to uniquely identify ODN passive elements to enable the implementation of intelligent management functions such as automatic storage of optical fibre information, automatic identification of optical fibre connection, information on calibration of optical fibre resources and visualized onsite operation guide

intelligent management terminals: portable devices that provide management GUIs and visualized onsite operation instructions and provide transmission channels for digitalized ODN facilities to access the digitalized ODN management system

pre-connection optical distribution network: ODN network deployment methodology that uses cables, block terminals and other components that are pre-manufactured in factory with connectors and adapters, enabling that the network connections can be done by plug-and-play operation on site

3.2 Symbols

Void.

3.3 Abbreviations

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

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APC	Angled Physical Contact
APP	Application
DQ ODN	Digitalized & Quick Optical Distribution Network
DQ	Digitalized & Quick
EN	European Norm
FAT	Fibre Access Terminal
FDT	Fibre Distribution Terminal
FTTH	Fibre To The Home
FTTX	Fibre To The X
GIS	Geographic Information System
GUI	Graphical User Interface
HC	Home Connection
IL	Insertion Loss
LC	Lucent Connector
O&M	Operations and Maintenance
ODF	Optical Distribution Frame
ODN	Optical Distribution Network
OLT	Optical Line Terminal
OMS	ODN Management System
ONT	Optical Network Terminal
ONU	Optical Network Unit
OPEX	Operating Expenses
OSP	Outside Plant
OSS	Operation Support System
P2P	Point to Point
PON	Passive Optical Network
QR code	Quick Response code
QR	Quick Response
RH	Relative Humidity
RL	Return Loss
RT	Room Temperature

SC	Standard Connector
SN	Serial Number
SSC	Splitting and Splicing Closure
SUS304	Stainless Steel 304
UPC	Ultra Physical Contact
UV	Ultraviolet

4 Overview of Digitalized Quick ODN

FTTH has been recognized by the majority of fixed network operators worldwide as a strategic approach for the deployment of broadband access. Every year tens of millions of fibre access ports are deployed. The most popular technology for FTTH is Passive Optical Network (PON) which is based on a point-to-multi-point Optical Distribution Network (ODN). As the infrastructure of FTTH, ODN consumes the biggest part of investments from operators in constructing its FTTH network; it also takes long time for the construction and significant OPEX costs for operation and maintainance. Hence, a solution to build and operate an ODN quickly and efficiently with low cost is very important for every FTTH operator.

A typical ODN contains fibres, cross-connecting and splitting devices such as Optical Distribution Frame (ODF), Fibre Distribution Terminal (FDT), Splitting and Splicing Closure (SSC) and Fibre Access Terminal (FAT). Its topology and components are illustrated below in Figure 4-1.

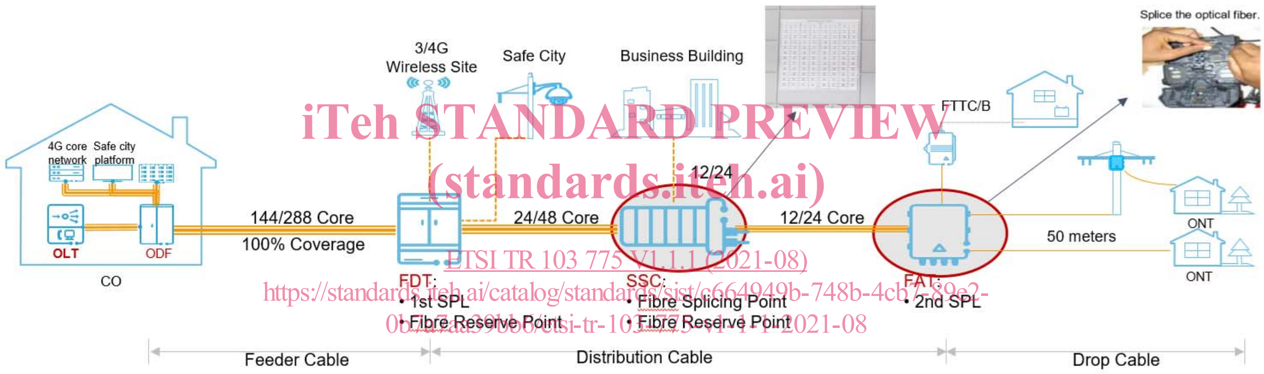

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Figure 4-1: ODN Network Structure in FTTx Scenario

The ODN provides a physical optical transmission channel between the Optical Line Terminal (OLT) and the Optical Network Terminals (ONTs). It usually consists of optical fibre cables/optical connectors/optical splitters and box equipments for mounting and connecting these devices. During the construction, it generally can be divided into three parts as shown in Figure 4-1. The first part is the feeder segment, usually from the Optical Distribution Frame (ODF) in the Central Office up to the Fibre Distribution Terminal (FDT), and serves as the trunk optical cable to realize long-distance coverage. The second part is the distribution segment from the FDT to the user access point at the Fibre Access Terminal (FAT) . It allocates optical fibres near the user area along with the feeder optical cable and completes the optical splitting function. The third part is the drop cable segment, from the FAT to the user premise, and connects the end users to the ODN network.

The current network construction process can be classified into high-density scenario and low-density scenarios based on user density scenario.

High-density user scenario: Users live in a densely populated area, where optical splitting is performed at FDTs to form an even-distributed ODN network architecture. The centralized splitting usually includes one-stage splitting or two-stage splitting. For one stage-splitting, there is only a high splitting ratio (such as 1:32 or 1:64) splitter in the whole ODN network. The advantages of one-stage optical splitting are simple network topology, low line attenuation, easy management and maintenance. Therefore it is usually used in the scenarios where the user's density is very high, such as the business and residential campuses.

The advantages of two-stages optical splitting are the flexibility of the networking structure and the saving in distribution cables. Therefore, it is recommended to use two-stages optical splitting for the access of a small group of users. In the two-stage optical splitting scenarios, the first-stage optical splitter is usually deployed in the central office, equipment room or optical cable distribution box, and the second-stage optical splitter is implemented near the users.

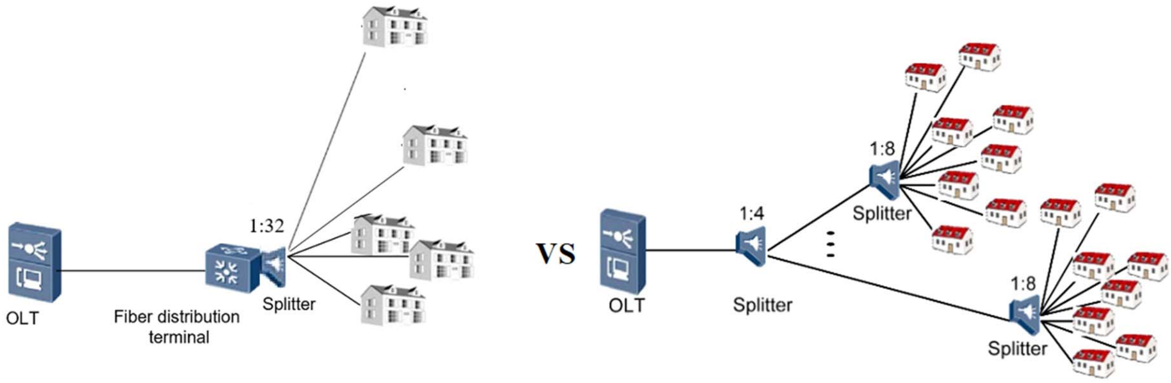

Figure 4-2: Centralized optical splitter ODN construction

Low-density user scenario: For users living in sparsely populated areas, the uneven chain networking solution can be used to deploy the ODN network, to save optical fibre resources. And such solution is also very suitable for the smart city scenarios, where the network is mainly constructed along the road, for example the ONTs are likely installed on the street light poles.

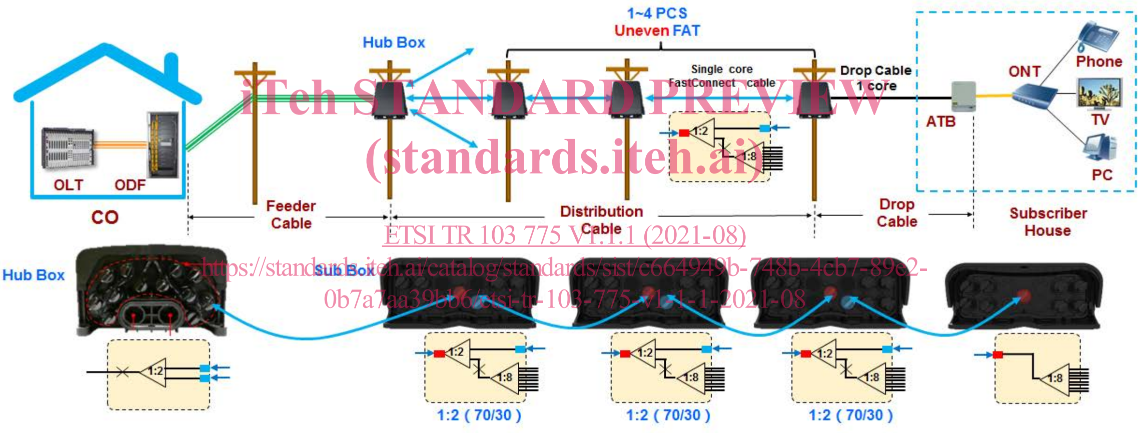

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Figure 4-3: Uneven chain networking solution

In low-density scenarios, the uneven ratio chain ODN network scheme can make better use of fibre network resources. In this scheme, compared with the traditional mode that all splitters are equal splitting, uneven splitter is used in the main chain, and different stages splitter are cascaded by the uneven splitters. Generally speaking, the feeder branch can be used to connect next stage splitters, and the drop branch can be used to connect the nearest subscribers. All boxes are connected in series instead of in parallel and this enables the box installation be decoupled from the distribution cable deployment. Comparing to traditional scenario where boxes are connected with 24/36-core optical fibres, in such uneven splitting chain all boxes are connected with a single-core distribution cable, which greatly saves the number of distribution fibres and improve deployment efficiency.

Besides scenario-oriented network deploy mode, network construction efficiency and ODN resource management are also very important to operators. In the traditional ODN network construction, there are a lot of connections points which are mainly realized by fusion or mechanical splicing on site. This procedure is very time consuming and also needs well-trained technicians, which impact the ODN construction efficiency and costs dramatically. On the other hand, ODN is a pure passive network which does not contain any active parts and therefore the connection relationship is normally illustrated by paper or plastic labels. After the connection is made, the relationship will be recorded manually, hence it is prone to mistakes, and label is prone to fall and be damaged as well. Moreover, for ODN troubleshooting, a technician needs to access the database to retrieve the connection data and to look for the corresponding labelled fibre. This makes the management and operation of ODN dependent on non-reliable network data.

Ways to solve the abovementioned issues are:

1) To reduce or avoid onsite splicing by using plug-and-play devices and fibre cable assemblies, which reduces time and needs of trained technician and special equipment.

In this method, all ODN passive elements are pre-connectorized. Distribution cables and drop cables with quick connectors are pre-manufactured in factory and delivered with the system. Outdoor Fibre Access Terminals (FATs) are equipped with quick connectors and support plug-and-play operation. During the on-site construction, the technician can quickly complete the network connection by manually inserting and locking the cables, based on the network plan, which greatly simplifies deployment and improves deployment efficiency.

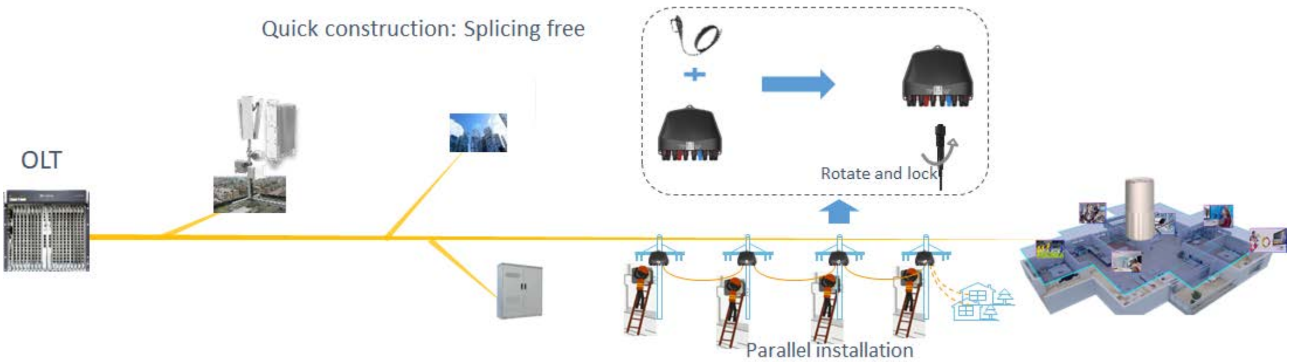

Figure 4-4: Quick ODN construction based on pre-connectorized passive elements

2) Using more robust digital labels which support being recorded/inquired with digital equipment to avoid possible human mistakes, and enable that all the ODN parts and network can be managed by the ODN Management System (OMS).

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In this case all ODN passive elements have digital labels for an easy identification, recording and management by the ODN digital management system. The OMS is able to identify and display automatically the distribution topology based on the uploaded position information, and manage the ODN resources, provide needed service accordingly. The labels should be robust and be input/inquired based on digital method.

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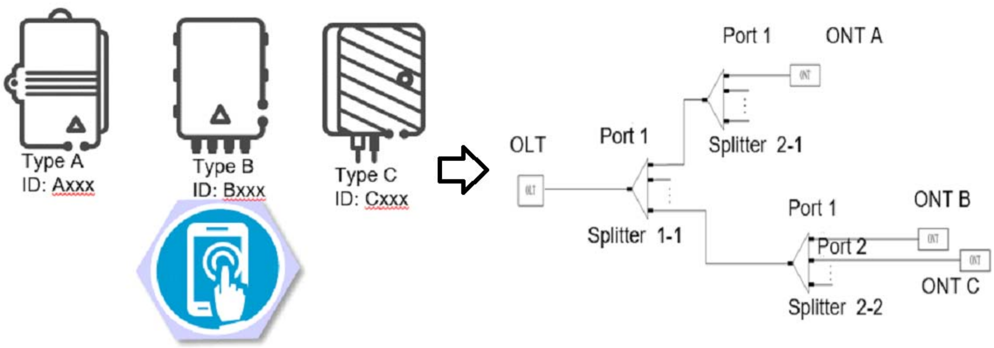

Figure 4-5: Digitalized ODN devices supported digital label and information automatic collection

The OMS uses the ODN passive element information contained in the digital label, and displays the information of connection relationship of each device port and the overall link connection topology, and quickly compares the information with the planning and design solution. In addition, port identification ensures efficient and quick port utilization and solves the problem of low efficiency and error-prone handling caused by paper labels. The details are shown in Figure 4-6.

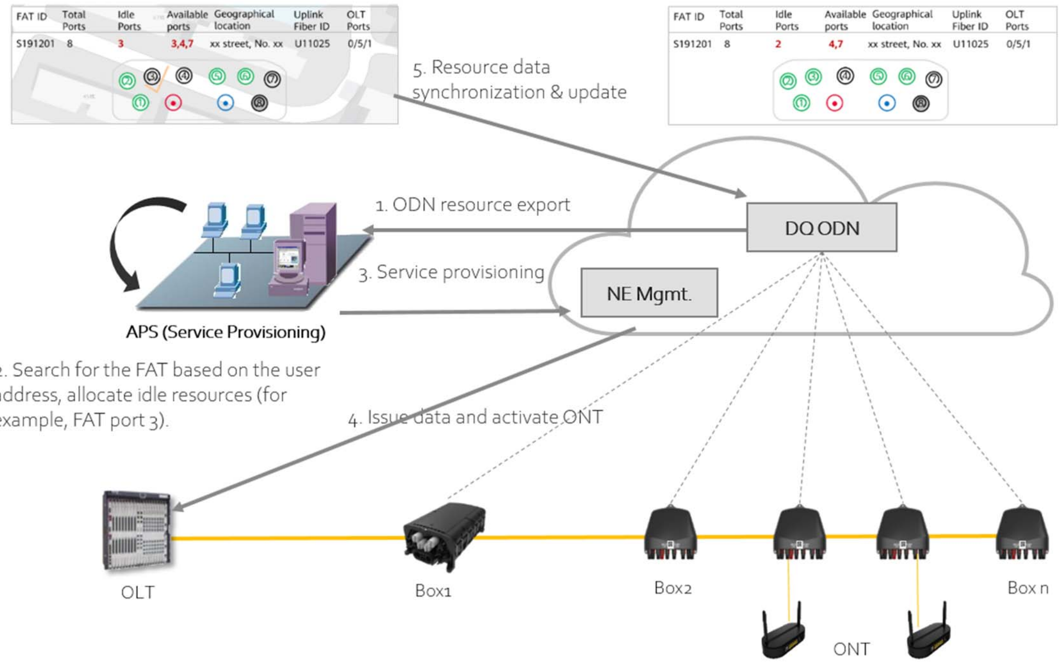

Figure 4-6: Digitalized ODN Management System

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In summary, the Digitalized ODN can help to solve the challenges in traditional ODN construction and maintenance. The pre-connection ensures that all nodes are pre-manufactured cable assemblies, connectors and splitters. The pre-connectorized cables are assembled in the factory before delivery and quality control is performed to guarantee the connection quality and prevent uncontrollable quality problems caused by manual splicing on site. It supports plug-and-play and allows in parallel construction, thereby increases the construction speed and supports fast and efficient FTTH deployment. The digital management system implements end-to-end ODN management based on image recognition and ODN digitalization, achieving accurate resource management, quick service provisioning, and improving network O&M efficiency.

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5 ODN Quick Construction

5.1 ODN quick construction method overview

Pre-connectorized ODN passive elements are a solution for FTTH infrastructure network architecture that enables a high efficiency network construction, high reliability and low deployment costs. Pre-connection ensures that the network passive elements are pre-manufactured with INGRESS PROTECTION (e.g. IP65, IP68) connectors and adapters. Before shipped from the factory, all network passive elements have been terminated with connectors and adapters, with an assured quality level and suitable for a variety of ODN network environment. Compared to the traditional ODN network, pre-connectorized ODN construction eliminates needs of fibre splicing on site, thus avoids issue of lacking of control and potential inefficiency of fibre fusion splices. At the same time, using this quick installation process and depending on the network structure, the construction mode can be changed from the typical serial construction into a parallel construction mode using several crews, supporting the quick and efficient deployment of ODN.

In simple words, a pre-connectorized based ODN solution is very efficient for ODN construction. Based on the ODN network planning, designing and coverage range, pre-connection can be applied into drop section pre-connection, distribution section pre-connection, and all ODN sections pre-connection. In all these options, the key is to have pre-connectorized passive elements and transfer the manual fibre splicing work onsite to the factory for batch processing and higher reliability.

5.2 Pre-connectorized based ODN Network Construction

5.2.1 Drop section pre-connection

The drop section is the path from the last distributing point, usually the point of stage-2 optical splitting, to the user premises. In this clause, the traditional ODN fibre access terminal splicing operation on the stage-2 optical splitting FAT node is replaced with pre-connectorized cable assemblies, prefabricated in the factory, effectively improving the construction efficiency of the Home Connection section and implementing plug-and-play deployment.

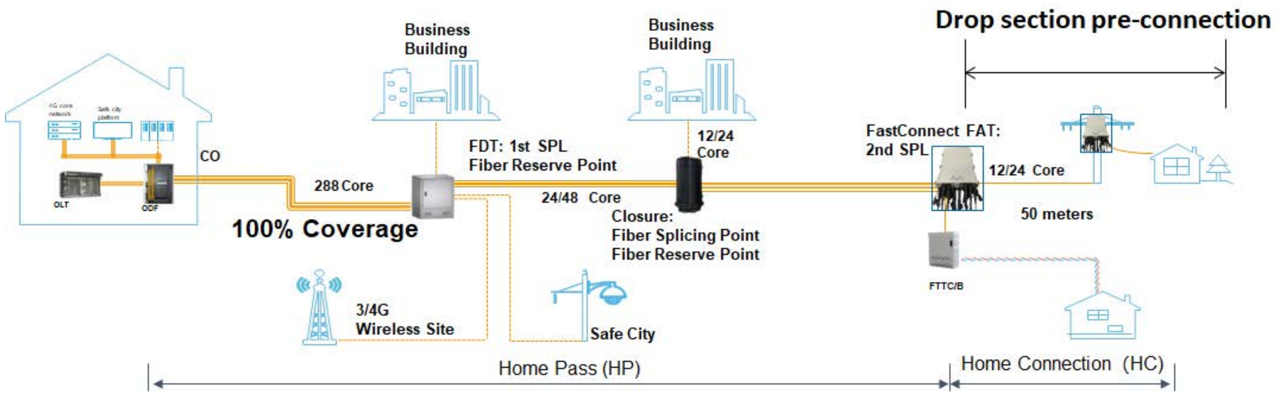

Figure 5-1: Drop section pre-connection network architecture

5.2.2 Distribution section pre-connection

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Cascaded unevenly distributed splitters can be used in the distribution section. Small-diameter single-core or dual-core distribution cables are used to implement cascading between Hub boxes and Sub boxes. This solves problems such as large diameters, difficult deployment, high costs, and time-consuming deployment of common 12-core or 24-core distribution cables. The pre-connection architecture that introduces the concept of pre-connection from the distribution section can be summarized as pre-connection of distribution sections.

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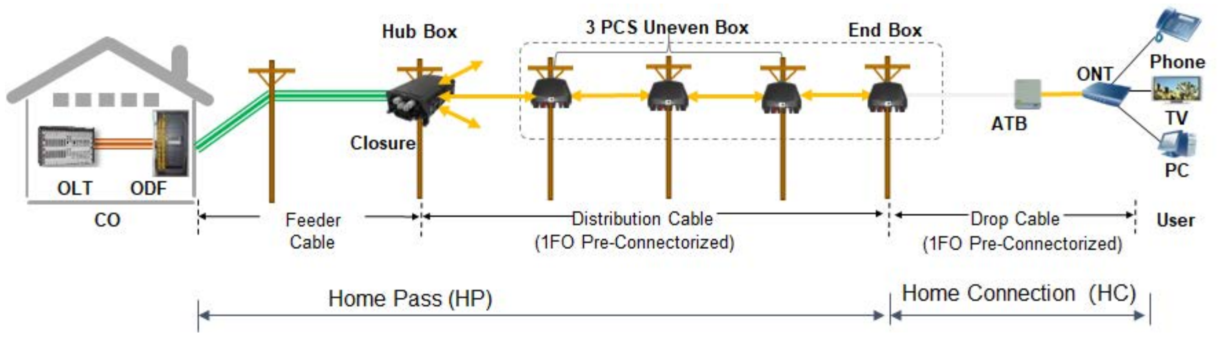

Figure 5-2: Distribution section pre-connection network architecture

5.2.3 All ODN sections pre-connection

The feeder, distribution, and drop cable assemblies from the OLT are prefabricated without need of splicing on field and are plug-and-play on the entire network. This type of architecture that introduces the concept of pre-connection from the feeder section can be summarized as full-process pre-connection.