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International Telecommunication Union
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Supplement

ITU-T G Suppl. 78 (09/2022)

SERIES G: Transmission systems and media, digital systems and networks

Use case and requirements of fibre-to-the-room for small business applications

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Supplement 78 to ITU-T G-series Recommendations

Use case and requirements of fibre-to-the-room for small business applications

Summary

This Supplement 78 to ITU-T G-series Recommendations collects the use cases and summarizes the corresponding network requirements for fibre-to-the-room (FTTR) in small business applications. The value of this in-premises fibre-based technology networking for small businesses is also analysed.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G Suppl. 78	2022-09-30	15	11.1002/1000/15224

Keywords

FTTR, network requirement, small business, use case.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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1 Scope

This Supplement 78 to ITU-T G-series Recommendations collects the use cases and requirements of fibre-to-the-room (FTTR) technology (G.fin) for small business applications. The advantages of the fibre-based technology are also analysed.

2 References

[European Commission] European Commission (2003), *Internal Market, Industry, Entrepreneurship and SMEs*.

<https://single-market-economy.ec.europa.eu/smes/sme-definition_en>

[IEEE 802.3bt] IEEE 802.3bt-2018, *IEEE Standard for Ethernet Amendment 2: Physical Layer and Management Parameters for Power over Ethernet over 4 pairs*. <https://standards.ieee.org/ieee/802.3bt/6749/>

[Cho] Cho, K and Bahn, H. (2021), Design and Implementation of a Distributed Versioning File System for Cloud Rendering, IEEE Xplore®, Vol. 9, pp. 138716-138723.

<https://doi.org/10.1109/ACCESS.2021.3119077>

[BDA] Broadband Development Alliance (2021), *White paper: QoE classification of Residential network service.*

3 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

AC	Access Controller
AP	Access Point
CAT	Category
DIY	Do It Yourself
E2E	End to End
FTTO	Fibre-to-the-Office
FTTR	Fibre-to-the-Room
FTTx	Fibre-to-the-X
HD	High Definition
HQ	Headquarters
ICT	Information and Communications Technology
LAN	Local Area Network
MDM	Mode Division Multiplexing
O&M	Operation & Management
ODN	Optical Distribution Network

OLT	Optical Line Terminal
P2MP	Point-to-Multipoint
P2P	Point-to-Point
PD	Powered Device
PMD	Physical Media Dependent
PoE	Power-over-Ethernet
PoF	Power-over-Fibre
PSE	Power Sourcing Equipment
QoS	Quality of Service
SD	Standard Definition
SME	Small and Medium sized Enterprises
SO	Small Office
SSID	Service Set Identifier
UHD	Ultra-High Definition
VFX	Visual Special Effects
VPN	Virtual Private Network
WAN	Wide Area Network
WDM	Wavelength Division Multiplexing
WLAN	Wireless Local Area Network
XG-PON	10-Gigabit-Capable Passive Optical Network

4 Introduction

A technical paper on FTTR2H use cases and requirements has been published to guide the development of G.fin technology in home applications. In general, G.fin specification intends to target the in-premises application, not limited to homes but also small businesses. This Supplement document collects the use cases and corresponding network requirements for the fibre-to-the-room (FTTR) in small business applications. To further help to identify the value of fibre-based technology for small business applications, the typical and deployed Ethernet switching-based technology is also analysed.

5 Limitations when using Ethernet switching-based technologies for small business applications

The scale of the enterprise could be classified according to the staff headcount, turnover and balance sheet total. The staff headcount mainly impacts the necessary networking capability inside the company. In this Supplement document, small business covers the enterprise scale from micro to medium-sized (see Table 5-1).

Table 5-1 – Micro, small and medium-sized enterprises [European Commission]

Company category (CAT)	Staff headcount	Turnover	Balance sheet total
Medium-sized	< 250	≤ €50 million	≤ €43 million
Small	< 50	≤ €10 million	≤ €10 million
Micro	< 10	≤ €2 million	≤ €2 million

5.1 Description of Ethernet switching-based technologies

Typically, the network within the small business is built up by self-installation, which brings a lot of practical problems throughout the life cycle of the network. Figure 5-1 shows a typical example of a networking infrastructure in a small business:

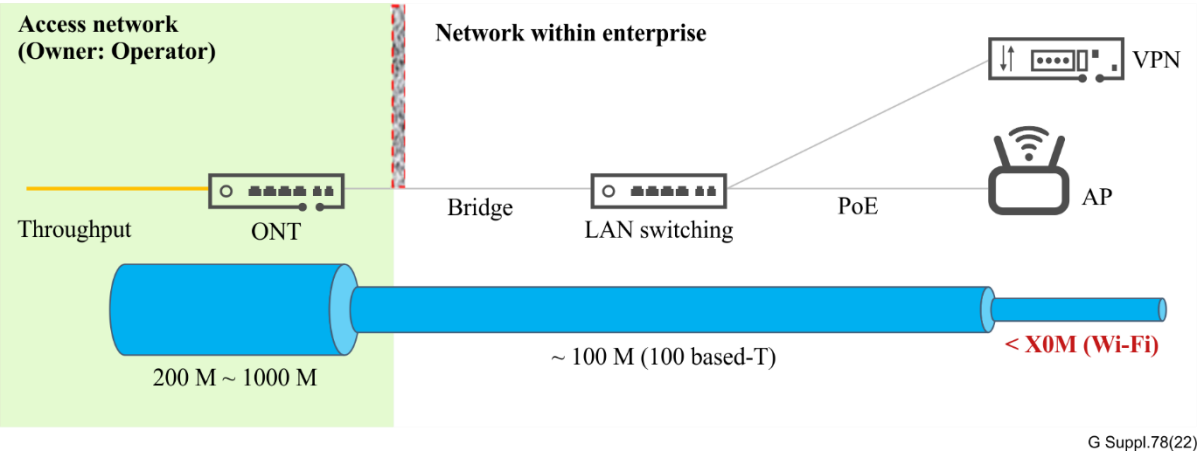

Figure 5-1 – Typical networking infrastructure in a small business

1) The small business needs to purchase the network devices, including local area network (LAN) switches, virtual private networks (VPNs), and access points (AP). This do it yourself (DIY) process should consider the good match of the interfaces of the devices and adapt to the medium that was deployed or will be deployed.

2) Many already deployed mediums (like CAT 5 cable) may be limited to support low data rates (like 100BASE-T, 100 Mbps) due to the quality of the cable. Replacing the cable with a high quality (like CAT 6) is necessary to support higher throughput. However, cable length, weight, and size are also important factors.

3) Multiple devices are sequentially connected to the network terminal of the access network (provided by the service operator). This requires a large space to locate the devices.

4) The end users suffer from the management and maintenance risks. Generally, there is no network expert in a small business. More time is needed to recover the network failure when it takes place. False complaints to operators bring additional operating complexity to the network.

LAN switching is the most popular technology used to form the in-premises networking. The typical network architecture can be seen in Figure 5-1. The Ethernet link is a point-to-point (P2P) connection providing multiple data rates based on different physical profiles, such as 10BASE-T, 100BASE-T, and 1G/2.5G/5G/10GBASE-T. The cable type and length determine the channel quality, supporting different data rates.

In the small business application, power-over-Ethernet (PoE) is always required, under which the access point (AP) can be flexibly deployed, such as in the ceiling. Figure 5-2 shows an example of a PoE by using two twisted pairs to inject the power. The common point of each twisted pair is

connected to the two polarities of the power sourcing equipment (PSE) and powered device (PD). To connect more APs, multiple Ethernet ports are necessary.

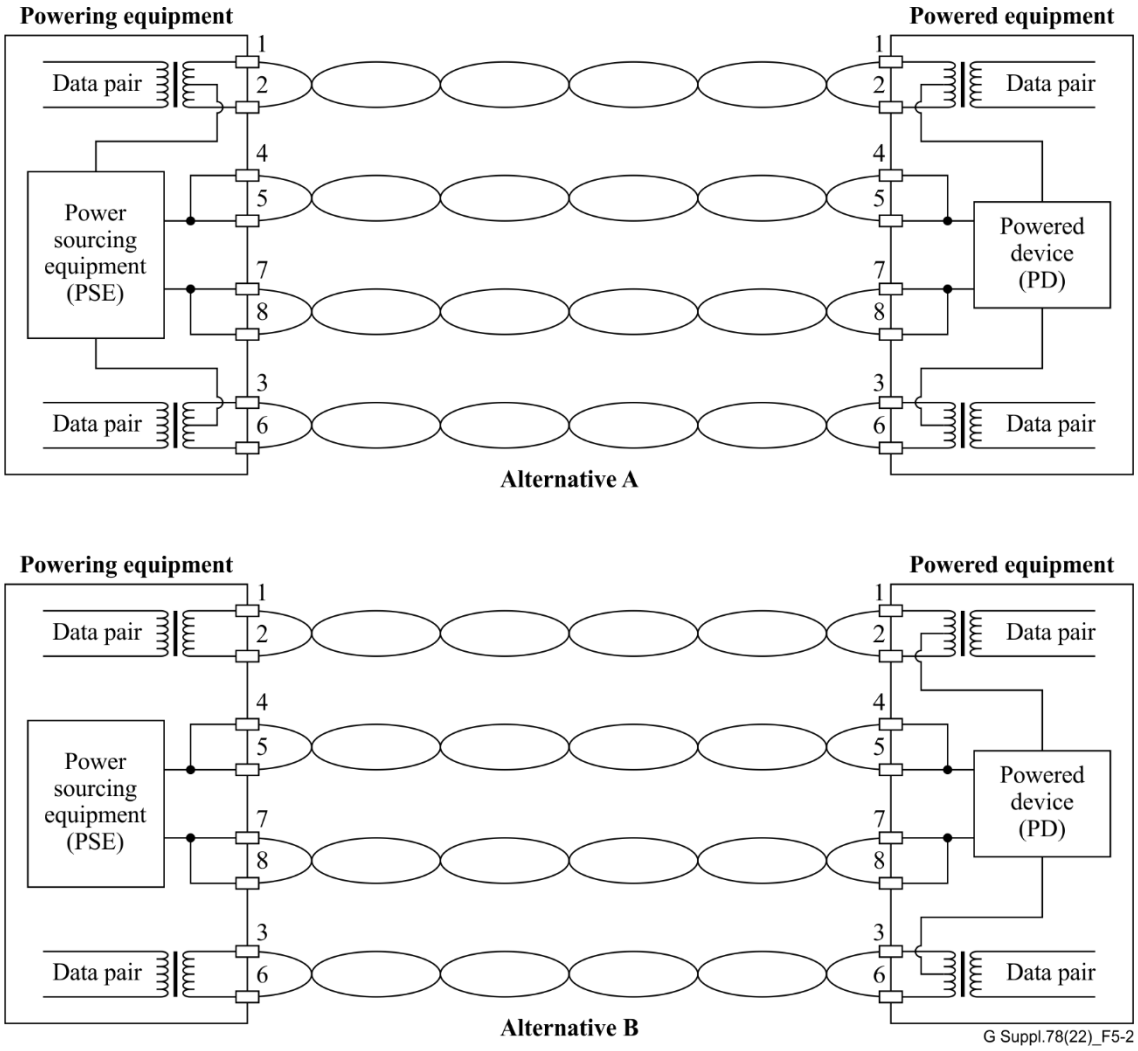

Figure 5-2 – 10BASE-T/100BASE-TX 2-pair endpoint PSE location overview [IEEE 802.3bt]

5.1.1 Challenges

The challenges of the current Ethernet technology include:

1) High complexity of the cable: high-quality copper cable (supporting higher data rate) leads to an increment in the cable weight and size.

2) Large size of the head end: due to the P2P connection, an increasing number of connections will require an increasing number of ports in the head end.

3) Communication length: channel quality decrease significantly in the copper wire, like the typical Ethernet cable.

4) Controller is independent of the physical layer: an additional access controller (AC) functional module (could be within LAN switching or an independent device) is necessary to dynamically adjust the data streams and Wi-Fi configuration since the Ethernet connection is mainly addressing the physical layer.

6 Motivations of applying FTTR technology in a small business scenario

Compared to Ethernet technology, fibre-based technology may solve the issues mentioned above by:

1) Light-weight optical fibre: optical fibre has been proven to support kilometre-level communication due to low insertion loss of the optical signal. Various multiplexing methodologies, such as wavelength division multiplexing (WDM), mode division multiplexing (MDM), etc. could significantly increase the data throughput.
2) Integrated functions in layer 1 and layer 2: typical point-to-multipoint (P2MP) topology will decrease the size of the head end. In addition, the layer 2 definition could help to integrate the control function for multiple network terminals.
3) The development and application of power-over-fibre (PoF) technology in the future will further reduce the copper wire of powering.
4) Communication over fibre reduces the system power consumption compared to copper-based technology.

7 Use cases and Requirements of FTTR4B

7.1 Live applications

7.1.1 Description

Live applications (see Figure 7-1) become more popular since customers can deeply and interactively be engaging in such services. Live selling, as one of the important online shopping methodologies, nowadays has gradually and partially replaced traditional offline shopping. Live broadcasting from a cyber star can attract hundreds and thousands of audiences. Real-time and fluent interaction is the core of a good user experience. Game studios make use of computer programming to remotely control tens and hundreds of mobile phones for gaming, therefore, the up-link control packet needs to guarantee transmission latency.

These live applications mainly occupy the up-link network channel. As can be seen, in some of these typical applications, simultaneous hundreds of up-link Wi-Fi data streams exist. Due to the real-time interaction demand, end to end (E2E) network latency should also be optimized to avoid any uncomfortable feelings.

Figure 7-1 – Popular live applications – live selling, live broadcasting and live gaming

7.1.2 Requirements

To support live applications (such as live broadcasting or live gaming), it is considered that one hundred end devices are connected to the network, sharing up-link video in standard format standard definition (SD): ~2 Mbps, high definition (HD): ~4 Mbps, ultra-high definition (UHD): ~8 Mbps, basic 4K: ~15 Mbps).

1) The upper bound of the up-link data range could reach 1.5 Gbps.
2) Stable data rate of the up-link should be provided since buffering is not allowed in real-time interaction.

3) The E2E requirements of latency for a basic 4K video is around 50 ms. If multiple FTTR endpoints exist, the latency should be considered across all the endpoints [BDA].

4) The round trip latency (<50 ms) should also be guaranteed for live gaming [BDA].

7.2 Small office (SO)

7.2.1 Description

The small office is one of the typical small business scenarios, which maintains a certain number of employees (dozens to a few hundred) and generally has a restricted office size (e.g., one floor in an office building).

With the development of optical access networks, as one of the developed fibre-to-the-x (FTTx) technologies, fibre-to-the-office (FTTO) is widely deployed in recent years, providing relatively good access experiences, bringing convenience for SOs, and changing the way that people work.

The typical SO network is a hybrid network with both wireline and wireless connections, as illustrated in Figure 7-2. The optical fibre access is terminated in the network entrance of the building, connecting to a self-designed and self-deployed internal network. CAT 5 or higher category Ethernet cable is often deployed for high-speed Ethernet transmission, while PoE technology is used for AP-based wireless networking. It is capable of providing hundreds of Mbps throughput for various network services of an office.

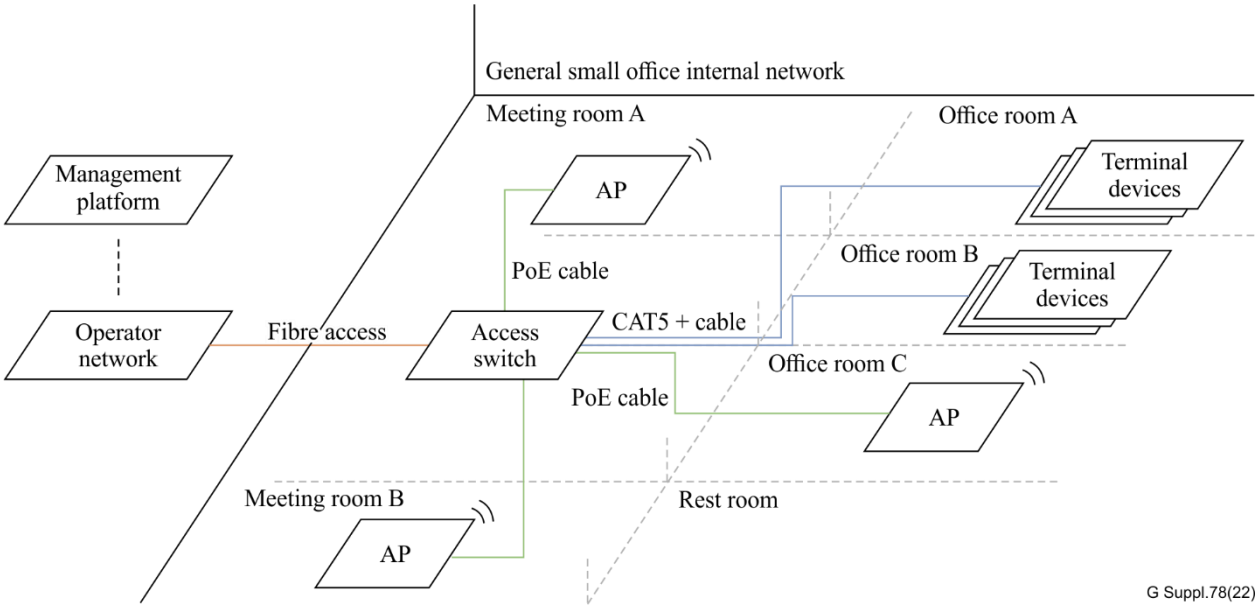

Figure 7-2 – A general internal network of small office

Despite the high-quality access network provided by operators, problems are still observed, such as:

1) Improper self-design and self-deployment of the internal network: the maximum transmission rate is limited sometimes by cable quality. The transmission rate drops due to the issues, such as an unqualified cable or an aged cable. Besides, the irregular deployment of AP devices may lead to wireless signal confliction, significantly impacting the user experience.

2) Lack of unified and referential standards or specifications for those terminal devices from multiple vendors: this may lead to unstable device connection and channel interference due to interoperability issues. Further, there is no unified management capability to achieve overall and real-time network monitoring and efficient troubleshooting.

3) Inability of supporting high data concurrency: a limit on user numbers due to limited transferring and processing ability of the access switch device. The future throughput enhancement is also difficult for this network due to copper cables.

FTTR is a novel in-premises networking technology based on a full optical fibre connection. The detailed network characteristics among different technologies are summarised in Table 7-1. By taking the advantages of optical fibre, the FTTR network can support higher throughput, and provide better reliability and network Operation & Management (O&M) capabilities.

Table 7-1 – Comparison of different network characteristics in an SO

Criteria	FTTR	FTTO Wireline	FTTO Wireless
Throughput	1G ~ 10G (future evolution > 10 Gbps)	CAT 5+: ~ 1 Gbps	Wi-Fi 5+: ~ 1.2 Gbps mesh networking
Transmission distance	Kilometres level	< 100 m	Passing ≤ 2 walls
Installation	Need to deploy optical fibre: relatively complex	Need to deploy Ethernet cable: relatively complex	Utilization of air interface: relatively simple
Reliability	Very long lifetime, with easy operation and high stability	Ethernet cable quality-depending	Stable operation
O&M	Simple, transparent, and intelligent	AP may have an independent O&M platform	AP may have an independent O&M platform

In recent years, cloud office, real-time E-meeting, on-line education, etc. have been growing rapidly, consuming a large amount of throughput in an SO. A stable network is also necessary for the SO scenario. Moreover, the communication medium should be capable of supporting future networks with higher data rates. The desired solution is to use fibre to build up the in-premised network for SO applications.

An example of the fibre-based network for SO is illustrated in Figure 7-3. The access network is connected to the network terminal (also the main device of fibre-based technology) in the office lobby. Inside the office, different types of sub-devices are allocated in each separate room, with optical fibre connecting to the main device. For the device type like an AP that needs a power supply, the optical and electrical hybrid cable can be used for remote power feed. In the future, power over fibre technology may apply. Besides, distributed box-type sub-device is also available for independent use, introducing a better experience and point-to-point O&M.

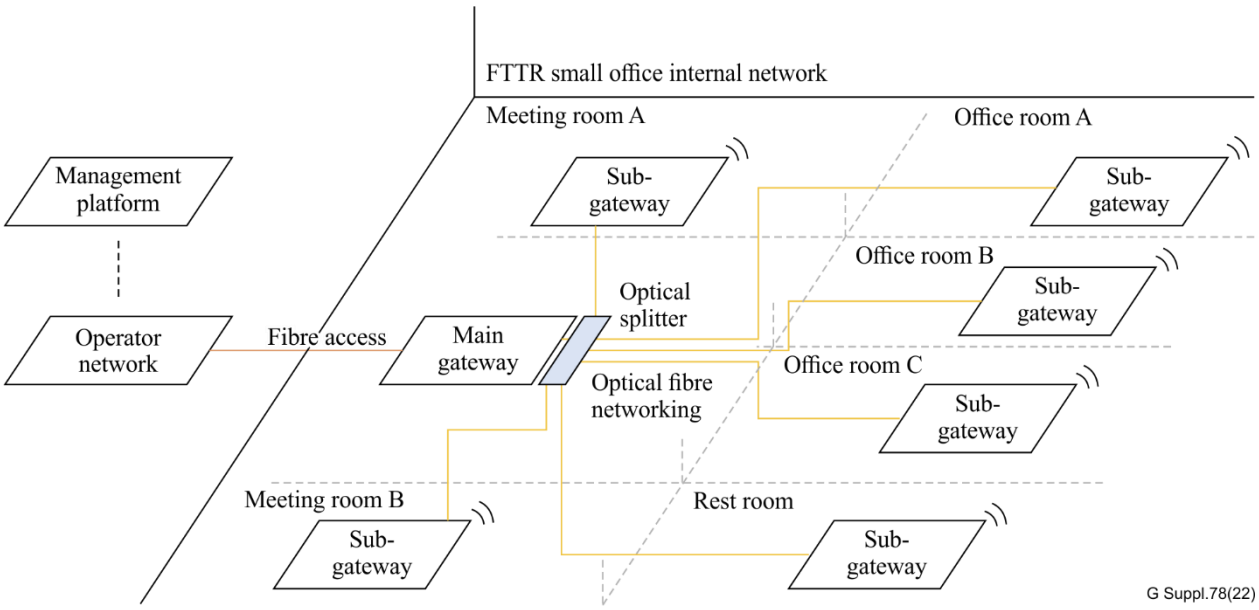

Figure 7-3 – FTTR network for small office application

By enabling FTTR for small office applications, user experience can be improved. The advantages are as the following:

1) The spectrum efficiency of the air interface can be optimized. The throughput requirements of various services can be better satisfied in individual rooms. The number of concurrency users can be increased.

2) The FTTR network can support a larger number of AP connections, with a split ratio of 32 ~ 128 by using the appropriate optical module. In addition, the network coverage can be extended to at least a kilometre level, providing high flexibility and low complexity for network planning.

3) Unified and high-quality networking management for the FTTR system can be achieved with the specifications defined. Management, monitoring, maintenance and upgrading of the SO network can be well supported. Networking topology can be analysed. Intelligent O&M functions such as troubleshooting, performance monitoring and network optimization can be designed. Seamless roaming for wireless connecting can be supported, enabling the automatic switching between APs without perception (expected at millisecond level), protecting services from being disconnected when moving terminal devices.

4) The future evolution of the optical fibre network is smoother. Due to extremely low path loss and long lifetime of the optical fibre, the network can be easy for upgrading in order to support a much better network with higher throughput. To complete such a goal, the main and sub device is simply replaced without any changes to the fibre topology.

7.2.2 Requirements

The following requirements of the FTTR network have been identified to support the SO scenario:

1) Full optics infrastructure is required to support a 15 ~ 20 years lifecycle for usage.

2) Capability and flexibility at the physical media department (PMD) level are required, including

   – 32 ~ 128 connections and 1 ~ 2 km level reach, to satisfy the deployment requirement in differential SO scenarios.

– Line rate is required to support 2.5 Gbit/s ~ 10 Gbit/s (in several classes), with the potential capability for future evolution to a higher throughput without rebuilding the optical infrastructure.

3) E2E latency and jitter should be considered for time-sensitive services, including target performance and measurement tools.

4) The network should support Ethernet traffic.

5) Support to use optical-electrical hybrid cable for remote power feed.

6) Simultaneous access to dense Wi-Fi and end devices is required.

7) Unified FTTR recommendations are needed to support the management, monitoring, and maintenance of the FTTR network and seamless roaming of Wi-Fi.

8) Support east-to-west streaming for offices.

7.3 Smart service hall

7.3.1 Description

With the application of communication technologies, the digitalisation and intellectualisation of service halls is fast developed over the past few decades. In a smart service hall, different functional departments work together in a centralized manner, improving land usage and work efficiency. The smart hall enables multiple service provisions for customers, like end device purchases, and the plan of mobiles or fixed networks.

The topology of the smart service hall is illustrated in Figure 7-4. The fibre deployment of FTTR reduces the wiring cost with the long lifetime and simplifies the topology of the network. The network, providing high speed, low latency and stable transmission help guarantee good coordination of different functional departments.

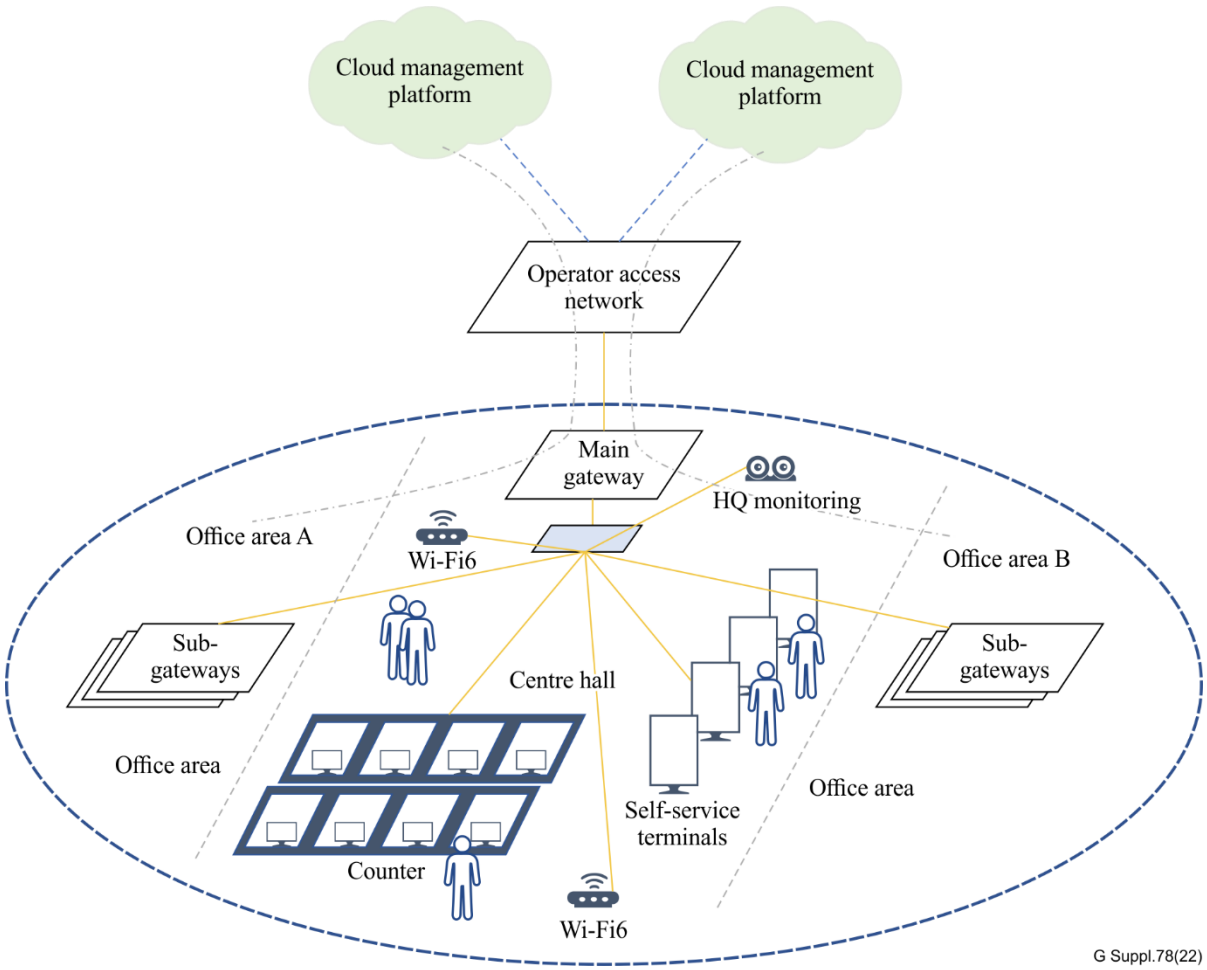

Figure 7-4 – FTTR for smart service hall

In the centre hall, a wireless network (isolated from the network of the office area) is needed to provide a high-speed connection for the customer. The smart self-service terminals are deployed for self-service by the customer. A fibre connected counter is set for customers to do remote face-to-face service. For security monitoring, a stable and high-speed backhauling fibre channel is expected.

In the office area, the fibre topology is similar to the small office scenario discussed in clause 7.2. However, the local area network (LAN) and the cloud management platform of different departments in the same smart hall may be isolated, which requires network isolation and wide area network (WAN) scheduling for the main device.

Besides, to ensure the throughput for different applications, priority-based resource assignments should be supported. For example, when an important meeting is held in the office, the quality of service for the meeting should be guaranteed.

7.3.2 Requirements

The following requirements of the FTTR network have been identified to support the smart service hall scenario:

1) Wireless networks for different services of customers should be isolated from the office's internal network.

2) The main device should enable isolation between departments. Guaranteeing the quality of service (QoS) flows for different management cloud platforms is required.

7.4 FTTR for school scenarios

7.4.1 Description

With the improvement of teaching facilities, smart terminals such as personal computers, tablets, PC and smartphones are brought into the campus. Teachers and students are more dependent on the campus network. Getting information anytime and anywhere has become a new demand for teachers and students. The rapid development and application of wireless campus networks will have a profound impact on the teaching mode, teaching concept and management of the school. It will also have a positive impact on the learning and lifestyle of the school teachers and students. Wireless local area network (WLAN), such as Wi-Fi coverage is needed in classrooms, dormitories, laboratories, libraries and so on. Besides, on campus, the device can connect to the campus network at anytime, anywhere, and access the campus network resources uninterruptedly.

Based on the campus application, different wireless internet services are provided for different user groups. For example, teaching staff can access educational network resources while students can obtain the speed based on the selected internet service package.

In fact, the FTTR system can be used for deploying wireless coverage on campus and provides management functions for the network administrator. Figure 7-5 shows a typical FTTR application for student dormitories. Main FTTR devices are deployed in the equipment cabinet on each floor, and ceiling-type sub FTTR devices are deployed in the corridors for enabling Wi-Fi coverage for each room. The sub FTTR devices are connected to the optical splitter with optical and electrical hybrid cables. The traffic from the main FTTR devices on each floor is aggregated by a 10-gigabit-capable passive optical network (XG-PON) optical line terminal (OLT) port in the equipment room. Authentication, accounting, and firewall can be deployed in the equipment room of the campus.

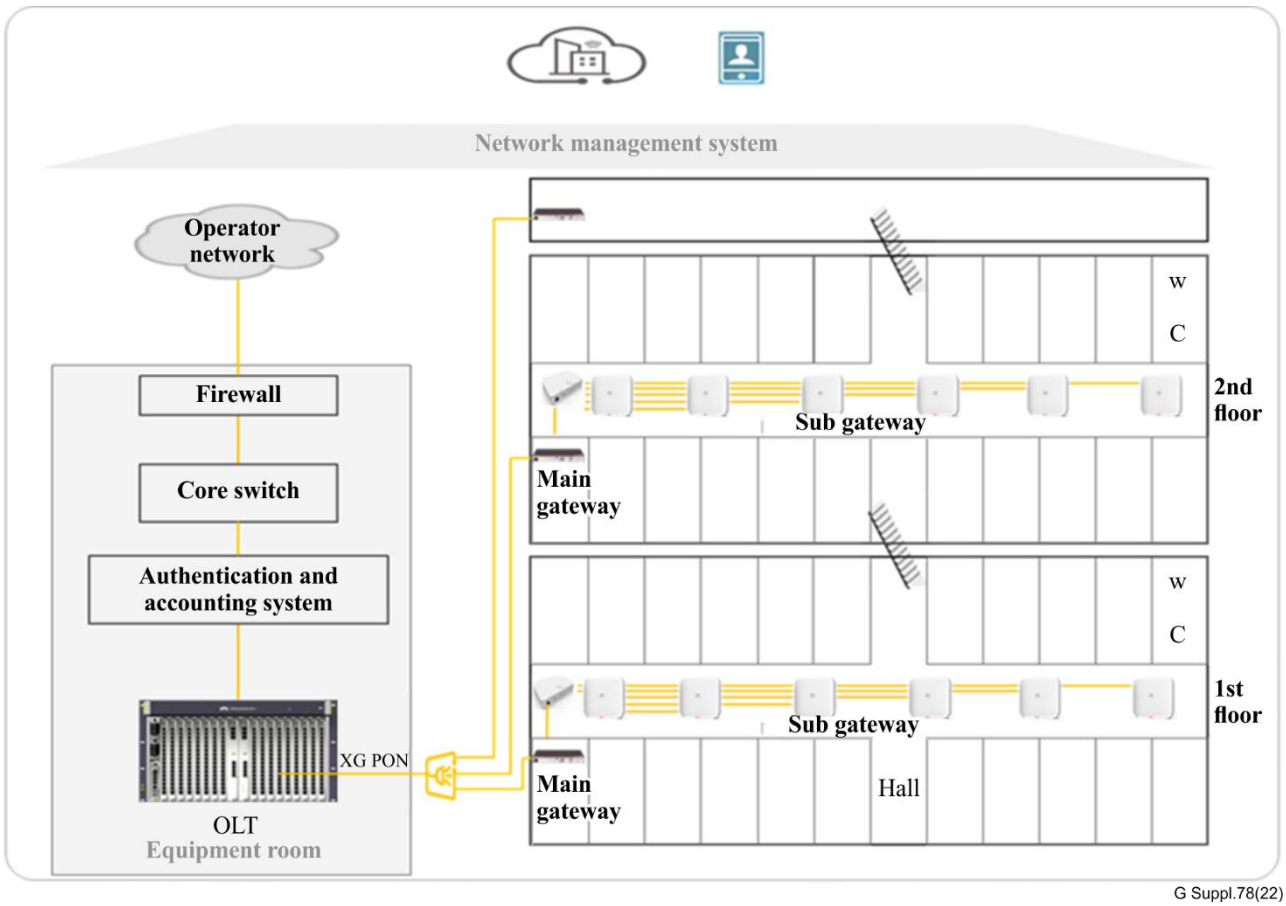

Figure 7-5 – FTTR system for student dormitories in college

Besides, the FTTR system can also be deployed in the classroom, lecture hall, library, laboratory and so on.

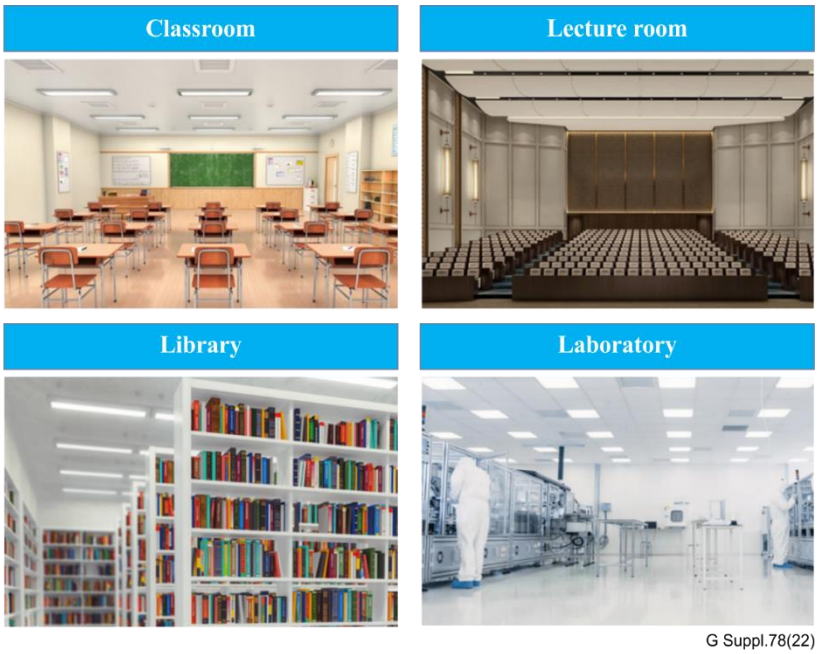

Figure 7-6 – FTTR system for school scenarios

7.4.2 Requirements

The following requirements of the FTTR network have been identified to support school scenarios:

1) Supports multiple authentication modes, such as domain authentication for teachers and static usernames with password authentication for dormitory students.
2) Supports different portal authentication based on different Wi-Fi service set identifiers (SSIDs). The multiple SSIDs (including guest SSID) are isolated.
3) Supports excessive user connections and a high concurrence rate for dedicated services such as online examination.
4) Supports multicast traffic for dedicated services such as multimedia teaching.
5) The network connectivity is completely controllable. For example, during examinations in certain rooms, access to the Internet is prohibited.
6) Supports easy management functions such as Internet access time, uploading and downloading speed, and authentication validity period of users.

7.5 FTTR for business buildings

7.5.1 Description

Business buildings, including supermarkets, shopping malls, etc., integrate shopping and entertainment functionalities. Customers utilize digital services to enjoy shopping, entertainment, and so on. The wireless network is a basic network used for bringing a comfortable experience to customers and push business advertisements. In addition, the wireless network provides a communication channel for business provisionings, such as mobile cashiers and wireless inventory counting which improves work efficiency. The following figures show some typical scenarios of the FTTR system in business buildings.

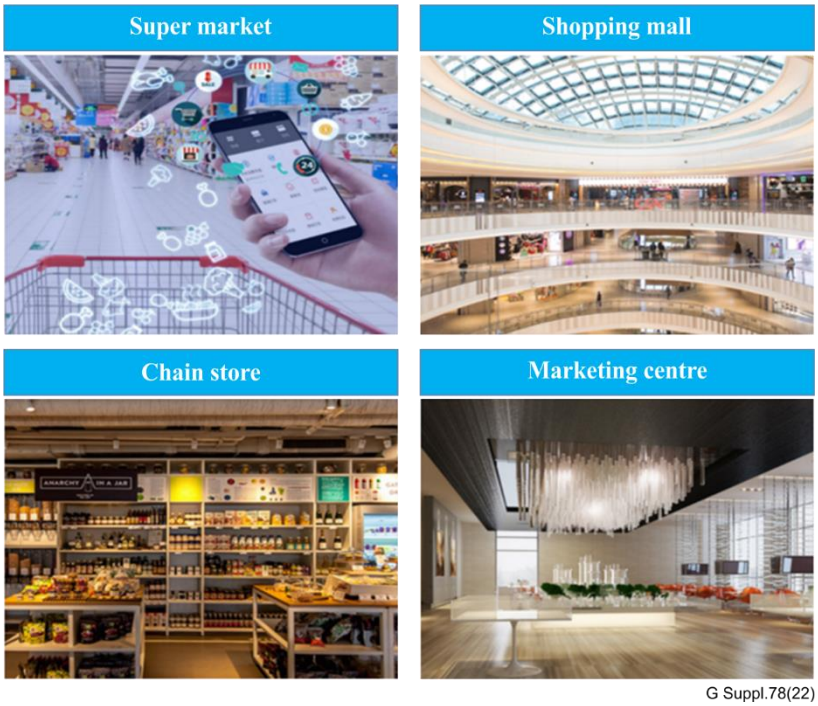

Figure 7-7 – FTTR system for a business building

7.5.2 Requirements

The following requirements of the FTTR network have been identified to support the business building scenario:

1) Supports network isolation between host users and guest users.

2) Supports guaranteed quality of service (QoS) for dedicated business applications such as collection / payment.

3) Supports automatic Wi-Fi channel band planning and optimization to avoid Wi-Fi interference among different APs.

4) Supports fast roaming mechanism among different APs.

7.6 Indoor leisure and entertainment

7.6.1 Description

Leisure and entertainment are an important part of people's daily life. It is reported that people spend around one hour (on average) per day in various styles of leisure and entertainment. For many of those scenarios, network quality is one of the essential aspects. As to indoor networking, FTTR is a potential solution to guarantee network quality.

Figure 7-8 shows some typical scenarios of indoor leisure and entertainment. For example, the coffee bar is becoming a popular place for people to meet, relax or even study. Popular coffee bars normally occupy a large area of space that serves tens to a hundred people. Therefore, multiple APs are necessary to provide full coverage of the space. A basic network connection for web browsing is required and a latency-sensitive network may be needed while people are playing online games there. Compared to a coffee bar, a tea house is another place for people to meet together but is more private. The whole area is divided into a few independent rooms. A video conference is a typical network service that takes place. In the fitness centre, the digital fitness equipment may link to the local network of the fitness centre and the people would require real-time music and video service while exercising. A bar is a popular place for leisure and entertainment. Large volume access can be expected in a busy bar.

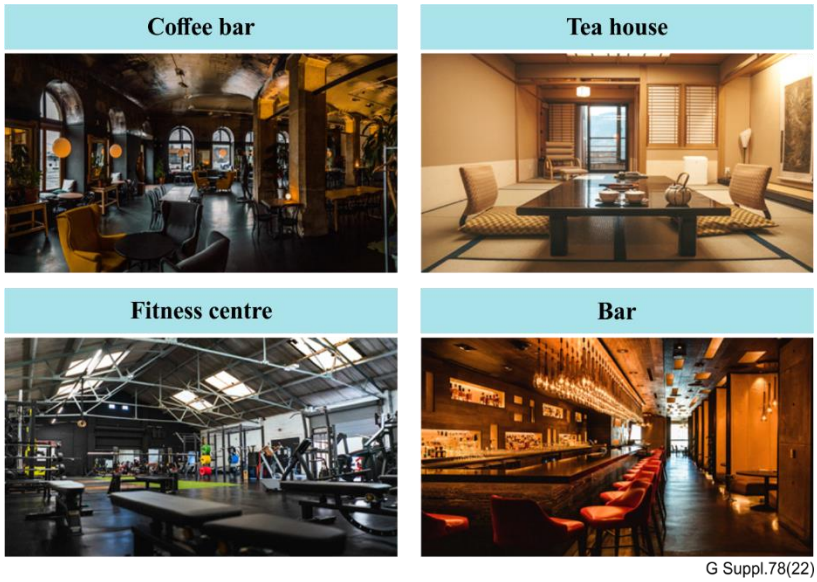

Figure 7-8 – Typical scenarios of indoor leisure and entertainment

7.6.2 Requirements

The following requirements of the FTTR network have been identified to support indoor leisure and entertainment:

1) Supports a large volume of stable wireless connection to the FTTR access point: up to tens or even hundreds of links in the same network.

2) Enable low latency connection for online gaming service (See clause 7.1.2).

7.7 Advertising design and virtual effect processing

7.7.1 Description

Multimedia, including video podcasts, audio slideshows, and animated videos are typical services provided by advertising design companies (see Figure 7-9). To leverage cloud computing capability, the local material is uploaded to the image or video processing tool in the cloud. Moreover, virtual effect processing, in which rendering 2D or 3D elements for animation, films, commercials, or video games is both compute- and time-intensive. It is reported that the total size of rendering input files reaches tens to hundreds of gigabytes and uploading these large data to the cloud increases the startup latency of rendering significantly [Cho].

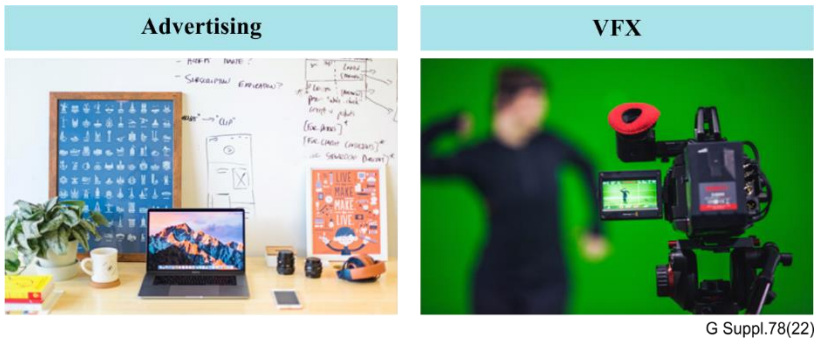

Figure 7-9 – Example of advertising design and visual special effects (VFX) process

Figure 7-10 shows a typical rendering procedure using a cloud platform. The local workstation initiates the transfer of files (pictures, video, etc.) through the network to the render worker (the computer engine). Since the multimedia file with high definition (HD) / high frame rate will have a large size (tens to hundreds of GByte). The transfer time significantly affects the processing efficiency.

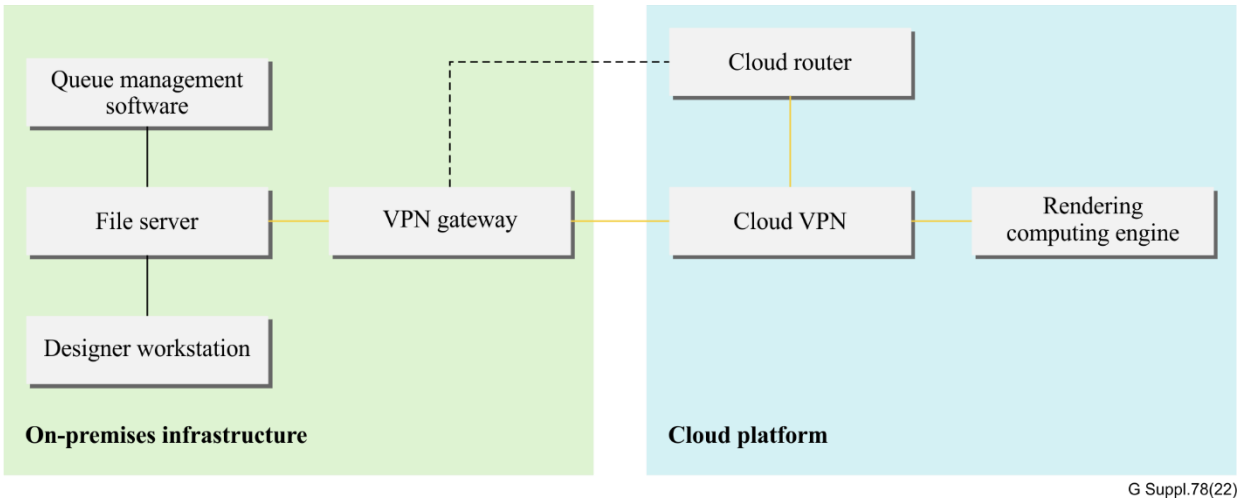

Figure 7-10 – An example of a cloud-based rendering service

Figure 7-11 provides an estimation of the transferring time. As seen, the uplink capability of the network determines the transfer time.

Physical transfer → Physical/on-line transfer → On-line transfer

	1 Mbps	10 Mbps	100 Mbps	1 Gbps	10 Gbps	100 Gbps
1 GB	3 hours	18 mins	2 mins	11 secs	1 sec	0.1 sec
10 GB	30 hours	3 hours	18 mins	2 mins	11 secs	1 sec
100 GB	12 days	30 hours	3 hours	18 mins	2 mins	11 secs
1 TB	124 days	12 days	30 hours	3 hours	18 mins	2 mins
10 TB	3 years	124 days	12 days	30 hours	3 hours	18 mins
100 TB	34 years	3 years	124 days	12 days	30 hours	3 hours
1 PB	340 years	34 years	3 years	124 days	12 days	30 hours
10 PB	3404 years	340 years	34 years	3 years	124 days	12 days
100 PB	34048 years	3404 years	340 years	34 years	3 years	124 days

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Figure 7-11 – Typical times for online and physical transfers

7.7.2 Requirements

The following requirements of the FTTR network have been identified to support advertising design and virtual effect processing:

1) Support multiple robust uplink connections with stable high throughput.

2) Support up to 1-10 Gbps uplink connection.

7.8 Workshop based on an unbalanced optical splitter

7.8.1 Description

As the topology is shown in Figure 7-12, guest wireless devices, and security cameras are distributed in the workshop. Most of the main devices are deployed in the full-optical office, similar to the small office described in clause 7.2. A cascaded unbalanced optical splitter can be used in the optical distribution network (ODN) to make equal optical path loss for each sub device. This way provides flexibility for network planning according to the service requirements. The complexity of constructing the fibre infrastructure could be significantly reduced.

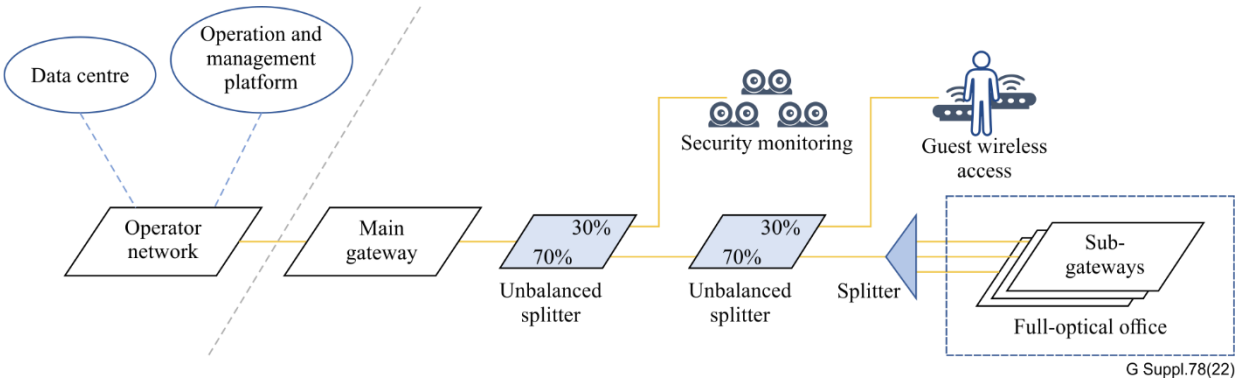

Figure 7-12 – Applying an unbalanced optical splitter in a workshop scenario

Besides, an independent control and management platform may be supported for the network of workshops.

7.8.2 Requirements

The following requirements of FTTR have been identified to support the workshop based on an unbalanced optical splitter:

1) Support unbalanced optical splitter in the FTTR network.

2) Support an independent operation and management (O&M) platform for different O&M functions.

7.9 FTTR for smart community scenarios

7.9.1 Description

A smart community is a digital methodology for community and society management innovation. The smart community intends to make good use of new information technologies such as the Internet of things, cloud computing, and mobile Internet, to provide a safe, comfortable, convenient and modern environment for residents. Smart communities can provide convenient services in government affairs, business, entertainment, education, medical care and mutual assistance. Figure 7-13 shows the architecture of the Information and Communications Technology (ICT) infrastructure of a smart community. The system consists of four different layers: perception layer, connection layer, platform layer, and application layer. The perception layer senses and collects information through various intelligent devices. Then the connection layer gathers the information from the perception layer and sends it to the management platform. The management platform analyses and processes the information and applies the service decision to the corresponding services, such as e-commerce, smart home and community communication.

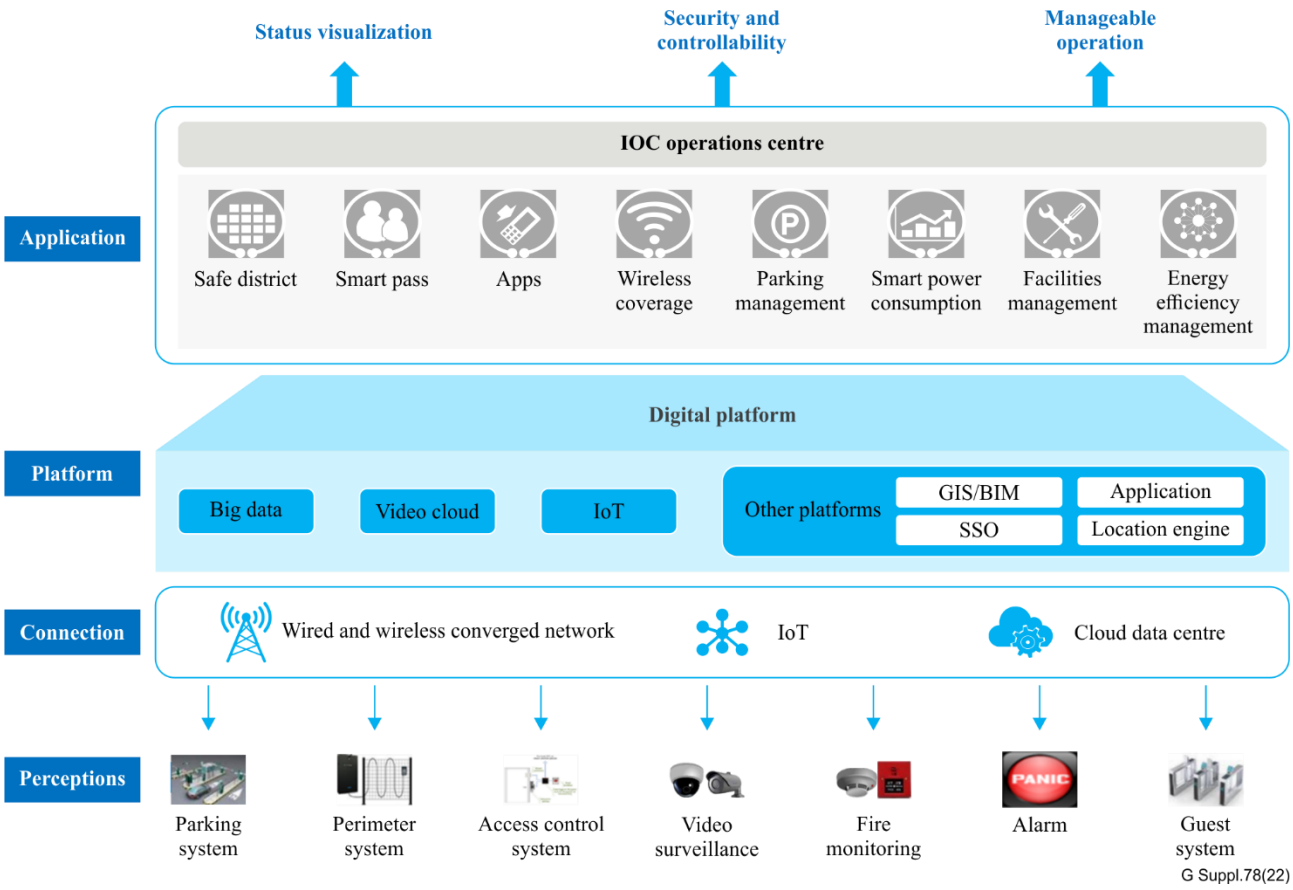

Figure 7-13 – ICT infrastructure of a smart community

As the network infrastructure, FTTR performs as the connection layer, providing high-speed, low latency and concurrent data transmission for the smart community. For dedicated fixed devices such as high-definition surveillance cameras or TVs, which generate high speed data traffic, the FTTR system should enable wired connections from the sub FTTR unit. For other devices with relatively low data rate transmission, the FTTR system must provide wireless connections. The data from different connections are centralized and processed by the main FTTR unit and are transferred to the platform layer.

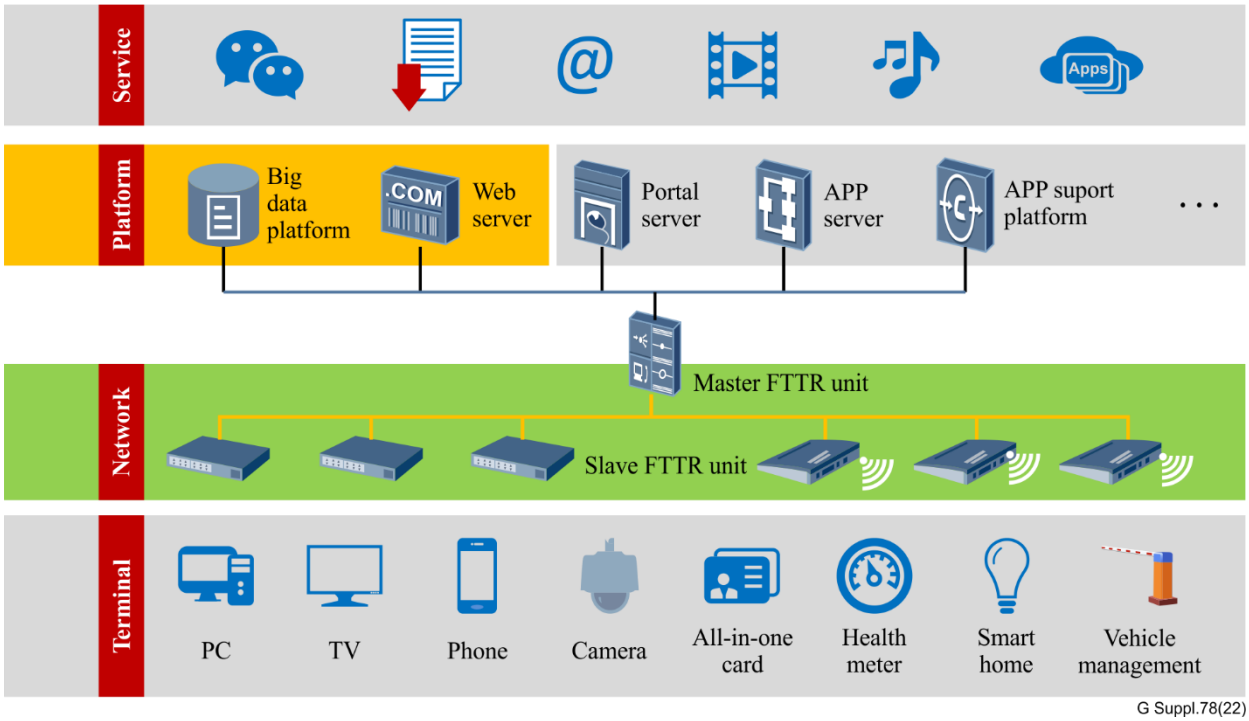

Figure 7-14 – FTTR system for smart community

7.9.2 Requirements

The following requirements of the FTTR network have been identified to support the smart community scenario:

1) Supports wired and wireless hybrid connections for different terminals.
2) Supports high speed transmission for dedicated services such as HD surveillance.
3) Supports low latency and stable connection for dedicated services such as fire monitoring and alarm.

8 Summary of use case requirements

The requirements from different use cases are shown in the following Table 8-1.

Table 8-1 – Requirement list

Use case	Requirements					
	Stability	**High throughput**	**Connectivity**	**Cloudification**	**Security**	**Operation & management (O&M)**
Live applications	• Guaranteed up-link latency (< 50 ms) for live gaming • Stable data rate is required for real-time applications • E2E latency for 4K video is < 20 ms	• Upper bound of up-link data rate up to 1.5 Gbps				
Small office	• Supports time-sensitive services with restricted E2E latency and jitter	• Supports 2.5-10 Gbps aggregated throughput • Unified network standards for O&M functions	• Supports 32 – 128 connections within 1 – 2 km level reach • Simultaneous access of dense end devices through Wi-Fi • Supports Ethernet traffic • Supports optical-electrical hybrid cable for remote power feed			• Full optical infrastructure for 15 – 20 years of usage

Table 8-1 – Requirement list

Use case	Requirements					
	Stability	**High throughput**	**Connectivity**	**Cloudification**	**Security**	**Operation & management (O&M)**
Small service hall				• Supports network slicing by the different cloud management platforms		• Supports isolated wireless service for different users (end device isolation) • Support isolated wireless isolation between different departments (access point isolation)
School			• Supports excessive user connections and a high concurrence rate	• Supports multiple authentication modes • Supports different portal authentication based on Wi-Fi SSIDs	• Supports multiple authentication modes • Supports different portal authentication based on Wi-Fi SSIDs	• Supports multicast traffic • Supports link access control • Supports flexible network configuration
Business buildings	• Guaranteed QoS for dedicated services such as payment • Fast roaming					• Supports isolated wireless service for the host and guest (end device isolation) • Automatic Wi-Fi channel planning and optimization

Table 8-1 – Requirement list

Use case	Requirements					
	Stability	**High throughput**	**Connectivity**	**Cloudification**	**Security**	**Operation & management (O&M)**
Indoor leisure and entertainment	• Supports low latency for online gaming	• Supports simultaneous connection for up to tens or hundreds of end device				
Advertising design and virtual effect processing	• Multiple robust uplinks with stable high throughput	• Supports up to 1-10 Gbps uplink				
Workshop			• Supports unbalanced power splitting			• Supports general operation and management through multiple O&M functions
Smart community	• Supports low latency and stable connection for time-sensitive services, such as fibre alarm and issue monitoring	• Supports high speed transmission for video service such as HD surveillance	• Supports wire and wireless connection for end devices			

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Published in Switzerland
Geneva, 2023