ETSI GS F5G 003 V1.1.1 (2021-09)

Fifth Generation Fixed Network (F5G);
F5G Technology Landscape

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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
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Foreword

This Group Specification (GS) has been produced by ETSI Industry Specification Group (ISG) Fifth Generation Fixed Network (F5G).

Modal verbs terminology

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1 Scope

The fixed network has developed to the 5th generation and many new use cases have been introduced. Some supporting technologies have been standardized and commercialized (e.g. XGS-PON and Wi-Fi 6), but enhancement and optimization may be needed to implement the new use cases. These gaps need to be identified and addressed in corresponding technical specifications.

The present document studies the technology requirements for the F5G use cases, explore existing technologies, and perform the gap analysis. The technology landscape of F5G will be defined addressing also the relevant SDOs.

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

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[2] Recommendation ITU-T G.8271: "Time and phase synchronization aspects of telecommunication networks".

[3] Recommendation ITU-T G.9807.1: "10-Gigabit-capable symmetric passive optical network (XGS-PON)".

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.

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.

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3 Definition of terms, symbols and abbreviations

3.1 Terms

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

PIN: type of Photodiode with P-I-N structure

3.2 Symbols

Void.

3.3 Abbreviations

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

AC	Alternating Current
AES	Advance Encyption Standard
AI	Artificial Intelligence
AIM	Automated and Intelligent Management
ANN	Artificial Neural Network
AP	Access Point
APD	Avalanche PhotoDiode
API	Application Programming Interface
AR	Augment Reality
BBU	Base Band Unit
BW	BandWidth
CAN	Controller Area Network
CMI	CNC-MDSC Interface
COAP	Constrained Application Protocol
CPE	Customer Premises Equipment
CPN	Customer Premises Network
CU	Central Unit
DC	Datacentre

DL	Deep Learning
DL/UL	DownLink/UpLink
DML	Directly Modulated Laser
DU	Distributed Unit
EMC	Electric Magnetic Compatibility
EML	Electro-absorption Modulated Laser
ENI	Experiential Networked Intelligence
EPC	Enhanced Packet Core
EPON	Ethernet Passive Optical Network
EVC	Ethernet Virtual Circuit
EVPL	Ethernet Virtual Private Line
FANS	Fixed Access Network Sharing
FDD	Frequency Division Diplexing
FEC	Feed-forward Error Correction
FFC	Full Fibre Connection
FP	Fabry-Perot laser diode
FSAN	Full Services Access Network organization
FTTH	Fibre-To-The-Home
FTTR	Fibre-To-The-Room
FWA	Fixed Wireless Access
GANA	Generic Autonomic Network Architecture
GI	Guard Interval
GPON	Gigabit Passive Optical Network
GRE	Guaranteed Reliable Experience
GSMA	Global System for Mobile Communication Association
HD	High Definition
HDTV	High Definition TV
HQ	Headquarters
HTTP	HyperText Transfer Protocol
ICT	Information & Communication Technology
INT	Interoperability Testing
IOAM	In-situ Operations, Administration, and Maintenance
IP	Internet Protocol
IPFIX	Internet Protocol Flow Information Export
ISG	Industry Specification Group
KPI	Key Performance Index
LAN	Local Area Network
LC	Little Connector
LTE-A	Long Term Evolution - Advanced
MAC	Media Access Control
MANO	Management and Orchestration
MEC	Mobile Edge Computing
MEF	Metro Ethernet Forum
ML	Machine Learning
MPLS	Multiprotocol Label Switching
MQTT	Message Queuing Telemetry Transport
MU-MIMO	Multi User Multiple Input Multiple Output
NBI	North Bound Interface
NFV	Network Function Virtualization
NR	New Radio
ODN	Optical Distribution Network
ODU	Optical Data Unit
OFDMA	Orthogonal Frequency Division mMultiple access
OLT	Optical Line Terminal
OMCC	OMCI Communications Channel
OMCI	ONU Management and Control Interface
ONU	Optical Network Unit
OPEX	OPeration EXpenditure
OSI	Open Systems Interconnection
OSS	Operating Support System
OTDR	Optical Time Domain Reflectometer
OTN	Optical Transport Network

OTT	Over the Top
OTU	Optical Transport Unit
P2MP	Point-to-Multi-Points
PDH	Plesiochronous Digital Hierarchy
PDN	Public Data Network
PMD	Physical Media Dependent
POL	Passive Optical LAN
PON	Passive Optical Network
PTP	Precision Time Protocol
QAM	Quadrature Amplitude Modulation
QoE	Quality of Experience
QoS	Quality of Service
RAM	Ramdom Access Memory
RAN	Radio Access Network
RFC	Requests for Comments
RG	Residential Gateway
RJ	Registered Jack
RP	Reference Point
RPC	Remote Procedure Call
RS	Reed Solomon
RTT	Round Trip Time
SC	Square Connector
SDH	Synchronous Digital Hierarchy
SDN	Software Defined Networking
SDO	Standard Organisation
SLA	Service Level Agreement
SME	Small and Medium Enterprises
SNMP	Signalling Network Management Protocol
TC	Technical Committee
T-CONT	Traffic Container
TDD	Time Division Duplexing
TDM	Time Division Multiplexing
TDMA	Time Division Multiple Access
TEAS	Traffic Engineering Architecture and Signaling
TEE	Trusted Execution Environment
TSN	Time-Sensitive Networking
UDP	User Data Protocol
UHDTV	Ultra High Definition TeleVision
UNI	User Network Interface
URLLC	Ultra Reliable Low Latency Communication
VCSEL	Vertical-Cavity Surface-Emitting Laser
vDBA	virtual Dynamic Bandwidth Assignment
VLAN	Virtual LAN
VNO	Virtual Network Operator
VR	Virtual Reality
VxLAN	Virtual Extensible LAN
WAN	Wide Area Network
WDM	Wavelength-Division Multiplexing
WG	Working Group
WT	Working Text
XGS-PON	10-Gigabit-capable Symmetric Passive Optical Network
YANG	Yet Another Next Generation data modelling language
ZSM	Zero-touch network and Service Management

4 Technology requirements and landscape

4.1 Executive summary

This clause is reliant on the use cases as defined in [i.14] and specifies per use case the technology requirements, the current available related standards, and describes the gaps in technology to implement those use cases.

NOTE: Some clauses define requirements, standards, and gaps for several similar use cases together. Also a description of technologies, which can be used in many use cases is provided in clause 5.

The following use cases are handled, refer to [i.14] for a detailed description of the use case. In the following, only brief use case titles are given for reference.

- Use case PON on-premises & Passive Optical LAN
- Use case High Quality Low Cost private lines for SMEs
- Use case High Quality Private Line
- Use case PON for Industrial Manufacturing
- Use case Remote Attestation
- Use case Digitalized ODN/FTTX
- Use case Scenario Based Broadband
- Use case Multiple Access Aggregation over PON (MAAP)
- Use case Telemetry-based Enhanced Performance Monitoring in Intelligent Access Network
- Use case Cloud Virtual Reality

4.2 Use case PON on-premises & Passive Optical LAN

4.2.1 Use case briefing

PON has been accepted and deployed in the market as a major solution for optical Access Network. Because of the mass deployment, the cost of PON system and optics has reduced significantly. This brings the possibility to develop an optical system like PON for on-premises networking. For example, a 10G-PON system could be leveraged as a reference technology to achieve "fibre to everything or everywhere" in F5G.

One application is FTTR (Fibre-To-The-Room). A PON like system could be used for home networks, connecting end devices (like HDTV, HD surveillance cameras and VR/AR helmets), as well as for Wi-Fi backhauling. In comparison to the current on-premises networking technologies, such as Ethernet, Wi-Fi mesh, and so on, such a system could potentially provide higher data rate, better coordination, and controlled latency.

The other application is for business and corporate LAN. In general, these LANs are composed of multi-port switches (providing P2P links over Ethernet copper cable) connected to WAN routers. The cable infrastructure is very complex and the size of multi-port device is larger in these LANs. With passive optical devices, such as optical splitter, the PON like system would have several advantages, i.e. simple fibre deployment, wider coverage, immunity to EMI (Electro-Magnetic Interference), low power, and long life cycle.

4.2.2 Technical requirements

4.2.2.1 General

In the short term, a PON system can be directly used for on-premises LAN applications. However, the on-premises applications are quite different from that in an Access Network, leading to distinct technical requirements for network topology, optical components parameters, physical and data link layer protocol, network configuration and management should all be addressed for the fibre-based on-premises network.

4.2.2.2 Variety of data rate profile

A variety of devices connect to the home network and to the business & corporate LAN using different services. With the rapid home digitalization, more connected devices are emerging. For example, for an IoT application, the environmental sensor detects the physical conditions and communicates the data. High resolution television requires bandwidths of 10 to several 100 of Mbps per video stream. AR/VR applications require 100 Mbps to 1 Gbps data rate. In the future, new services (e.g. holographic communications) and network devices may require 10 or even several 100 of Gbps network capability.

With the evolution of technologies, it is obvious that multiple generations of network technologies could coexist in the same network. The fibre-based on-premises network should be capable to adapt to this co-existence.

[R-1] The fibre-based on-premises network shall support multiple profiles (in terms of data rate) for different types of network device.

[R-2] The fibre-based on-premises network shall support the coexistence of multiple generations of fibre-based on-premises technologies on the same LAN network.

[R-3] The fibre-based on-premises network shall support up to 10 Gbps date rate to deliver VR/AR service.

4.2.2.3 Lower optical link budget

In a PON system, the optical link budget depends on 3 factors, the fibre length, the split ratio and number of connectors. It is important to focus on the first two as they impact the architectural choice.

For PON on-premises, the fibre length is expected to be less than 1 km, therefore the related attenuation is small. Therefore the main factor becomes the split ratio, which depends on the number of connected points. For most apartments and detached houses, a split ratio of 1:8 is considered to be sufficient and lower than that in the Access PON Network, which means the optical link budget can be much lower than that of a typical PON in the Access Network.

For an apartment building or SME LAN, using PON technology, the split ratio could be 1:16 or 1:32 which is still lower than that of an Access PON FTTH scenario (the typical value is 1:64). Since on-premises fibre length is shorter than in an Access PON Network, again the link budget primarily depends on the split ratio.

[R-4] For home networking, a split ratio of 1:8 for fibre-based on-premises network shall be supported.

[R-5] For an apartment building or SME LAN, the fibre-based on-premises network shall support a split ratio up to 1:32.

4.2.2.4 Seamless roaming support for Wi-Fi connection

Wi-Fi is the most widely used technology for connecting end user devices. Mobility of users may require switching the connection between different Access Points (APs). The APs are connected by the fibre-based on-premises network for high capacity. If the switching time between APs exceeds that imposed by the QoS requirements of the service, this will result in poor user experience. In case a fibre-based on-premises network is used as a backhaul network, Wi-Fi handover requires priority.

In the handover process, a sequence of handover protocol messages are exchanged between access points. Any potential loss of the message will cause handover to stop or to retry, especially when Wi-Fi is used as the backhauling link for the AP. To achieve a guaranteed or robust exchange of handover messages, it is better to choose a fibre connection.