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Fifth Generation Fixed Network (F5G); F5G Generation Definition Release #1

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Foreword

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

Modal verbs terminology

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Introduction

The present document investigates the historical evolution path of fixed networks, including aggregation, access and customer on-premises networks. Their main characteristics are identified, including technology basis and performance levels. These can be used to demarcate different generations of fixed networks. Typical examples for each generation (relevant standards and deployments, relevant use cases) are provided.

1 Scope

In the past, the lack of a clear fixed network generation definition has prevented a wider technology standards adoption and prevented the creation and use of global mass markets. The success of the mobile and cable networks deployments, supported by clear specifications related to particular technological generations, has shown how important this generation definition is.

The focus of the 5th generation fixed networks (F5G) specifications is on telecommunication networks which consist fully of optical fibre elements up to the connection serving locations (user, home, office, base station, etc.). That being said, the connection to some terminals can still be assisted with wireless technologies (for instance, Wi-Fi®).

The main assumption behind the present document foresees that, in the near future, all the fixed networks will adopt end-to-end fibre architectures: Fibre to Everywhere.

The present document addresses the history of fixed networks and summarizes their development paths and driving forces. The factors that influence the definition of fixed, cable and mobile network generations will be analysed. Based upon this, the business and technology characteristics of F5G will be considered.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

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.

[i.1] IEEE 802.11™ series: "Wireless Local Area Networks (WLAN)".

[i.2] Recommendation ITU-T I.100-I.699 series: "ISDN".

[i.3] Recommendation ITU-T G.992.x series: "Asymmetric digital subscriber (ADSL) transceivers".

[i.4] Recommendation ITU-T G.993.x series: "Very high speed digital subscriber line transceivers 2 (VDSL2)".

[i.5] Recommendation ITU-T G.984.x series: "Gigabit-capable passive optical networks (GPON)".

[i.6] Recommendation ITU-T G.9701: "Fast access to subscriber terminals (G.fast) - Physical layer specification".

[i.7] Recommendation ITU-T G.987.x series: "10-Gigabit-capable passive optical networks (XG-PON)".

[i.8] Recommendation ITU-T G.9807.x series: "10-Gigabit-capable symmetric passive optical network (XGS-PON)".

[i.9] Recommendation ITU-T J.112 series: "Transmission systems for interactive cable television services".

[i.10] Recommendation ITU-T J.122 series: "Second-generation transmission systems for interactive cable television services - IP cable modems".

[i.11] Recommendation ITU-T J.222 series: "Third-generation transmission systems for interactive cable television services - IP cable modems".

[i.12] Recommendation ITU-T J.225 series: "Fourth-generation transmission systems for interactive cable television services - IP cable modems".

[i.13] Recommendation ITU-T J.224 series: "Fifth-generation transmission systems for interactive cable television services - IP cable modems".

[i.14] 3GPP TS 45 series: "GSM radio specifications series".

[i.15] 3GPP TS 25 series: "UMTS radio specifications series".

[i.16] 3GPP TS 36 series: "LTE radio specifications series" (if only LTE radio access technology is covered).

[i.17] 3GPP TS 37 series: "LTE radio specifications series" (if UMTS or GERAN radio access technologies are also covered).

[i.18] 3GPP TS 38 series: "5G new radio specifications series".

[i.19] Recommendation ITU-T G.702: "Digital hierarchy bit rates".

[i.20] Recommendation ITU-T G.707: "Network node interface for the synchronous digital hierarchy (SDH)".

[i.21] Recommendation ITU-T Y.1731: "OAM functions and mechanisms for Ethernet based networks".

[i.22] Recommendation ITU-T G.996.x series: "Unified high-speed wireline-based home networking transceivers)".

[i.23] IEEE 802.1ag™: "Connectivity Fault Management".

[i.24] IEEE 1901™ series: "Power Line Communications for Smart Grid Applications".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

Aggregation Network (AggN): telecommunication network segment that connects the Optical Access Network (OAN) and the Core Network or Data Centres, which comprises the IP Network (IPN) and/or the Optical Transport Network (OTN)

auto-healing: ability of systems or environments to detect and resolve problems automatically

NOTE: Sometimes also known as self-healing.

C-band: optical "Conventional wavelength-band" (1 530-1 565 nm)

closed-loop: refers to network automation and management capabilities that use (big) data and analytics to monitor and access network events (such as faults and congestion) and act appropriately to correct any issues

NOTE: Usually known as closed-loop automation.

Continuous Integration/Continuous Delivery (CI/CD): set of operating principles and a collection of practices that enable application development teams to deliver code changes more frequently and reliably

NOTE: Also known as CI/CD pipeline, it is an agile methodology best practice for DevOps teams to implement.

Customer Premises Network (CPN): telecommunication network segment that comprises the customer on-premises locations and its equipment and infrastructureswhere the network terminal equipment and the end-user customer premises equipment are connected via the CPN

digital twin: digital replica of a living or a non-living physical entity, i.e. a virtual model

NOTE: Digital twins integrate artificial intelligence, machine learning and software analytics with spatial network graphs. This integration creates a living digital simulation model that updates as their physical counterparts change. Digital twins are being used to optimize the operation and maintenance of physical assets and systems.

End-to-End (E2E) slicing: refers to running multiple virtualized and independent logical networks on the same physical network infrastructure where each network slice is an isolated end-to-end network tailored to fulfil the diverse requirements of a particular application

IP Network (IPN): telecommunication network segment that uses the Internet Protocol (IP) for network layer communication between network nodes/equipment

L-band: optical "Long wavelength-band" (1 565-1 625 nm)

Optical Access Network (OAN): optical telecommunication network segment that gives the end-user access to the telecommunications service and connects the Customer Premises Network (CPN) to the Aggregation and Transport Network (ATN)

Optical Transport Network (OTN): optical telecommunication network segment comprised by a set of optical network nodes/equipment connected through optical fibres that provide the functionality of transport, multiplexing, switching, management, supervision and survivability of the optical channels carrying the end-user's client signals

NOTE: Also known as Optical Transportation Network.

3.2 Symbols

Void.

3.3 Abbreviations

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

ADM	Add-Drop Multiplexer
ADSL	Asymmetric Digital Subscriber Line
AggN	Aggregation Network
AI	Artificial Intelligence
AMPS	Advanced Mobile Phone System
API	Application Programming Interface
ATM	Asynchronous Transfer Mode
C450	C-Netz 450 MHz analog cellular network
CAT	Category
CATV	Community Antenna Television
CCAP	Converged Cable Access Platform
CCTV	Closed-Circuit Television
CDMA	Code Division Multiple Access
CMTS	Cable Modem Termination System
CO	Central Office
CPN	Customer Premises Network
CRAN	Cloud-RAN (sometimes referred also as Centralized-RAN)
CS	Circuit Switching
CSFB	CS Fall Back
DC	Data Centre
D-CCAP	Distributed-CCAP
DOCSIS	Data Over Cable Service Interface Specification
DRAN	Distributed-RAN
DSL	Digital Subscriber Line

DSLAM	Digital Subscriber Line Access Multiplexer
DWDM	Dense WDM
E2E	End-to-End
EDGE	Enhanced Data rates for GSM Evolution
eFBB	enhanced Fixed Broadband
F4G	Fixed Fourth Generation
F5G	Fixed Fifth Generation
FDD	Frequency-Division Duplexing
FDM	Frequency Division Multiplexing
FFC	Full-Fibre Connection
FOADM	Fixed Optical ADM
FTTB	Fibre To The Building
FTTC	Fibre To The Curb
FTTD	Fibre To The Desk
FTTdp	Fibre To The distribution point
FTTH	Fibre To The Home
FTTLA	Fibre To The Last Amplifier/Active
FTTM	Fibre To The Machine
FTTO	Fibre To The Office
FTTR	Fibre To The Room
FTTx	Fibre To The x
G.fast	Gigabit fast access to subscriber terminals
GERAN	GSM Edge RAN
GPON	Gigabit Passive Optical Network
GPRS	General Packet Radio Service
GRE	Guaranteed Reliable Experience
GSM	Global System for Mobile communications
HD	High-Definition (video) - resolution of 1 366 x 768 pixels
HFC	Hybrid Fibre-Coaxial
HPNA	Home Phoneline Network Alliance
HSI	High-Speed Internet
HSPA	High-Speed Packet Access
HW	Hardware
IMT	International Mobile Telecommunications
IP	Internet Protocol
IPTV	Internet Protocol Television
IS	Interim Standard
ISDN	Integrated Services Digital Network
IT	Information Technology
LAN	Local Area Network
LTE	Long Term Evolution
MIMO	Multiple-Input Multiple-Output
MMS	Multimedia Messaging Service
MoCA	Multimedia over Coax Alliance
MPLS	Multiprotocol Label Switching
MS-OTN	Multi-Service OTN
MSTP	MultiService Transport Platform
MU-MIMO	Multi-User MIMO
NFV	Network Functions Virtualisation
NGA	Next-Generation Access network
NG-PON	Next-Generation PON
NMT	Nordic Mobile Telephone
NR	New Radio
O&M	Operation & Management
OAN	Optical Access Network
ODN	Optical Distribution Network
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OLT	Optical Line Termination
OTN	Optical Transport Network
OXC	Optical Cross-Connect
PaaS	Platform as a Service

PDH	Plesiochronous Digital Hierarchy
PON	Passive Optical Network
PS	Packet Switching
PSTN	Public Switched Telephone Network
QoE	Quality of Experience
QoS	Quality of Service
R	Release
RAN	Radio Access Network
RF	Radio Frequency
ROADM	Reconfigurable Optical ADM
ROI	Return On Investment
SDH	Synchronous Digital Hierarchy
SDN	Software-Defined Networking
SD-WAN	Software-Defined networking WAN
SLA	Service Level Agreement
SME	Small and Medium-sized Enterprise
SMS	Short Messaging Service
SOHO	Small Office Home Office
SONET	Synchronous Optical Networking
SW	Software
TACS	Total Access Communication System
TDD	Time-Division Duplexing
TSN	Time-Sensitive Networking
TV	Television
UHD	Ultra-High Definition (video) - resolution of 3 840 x 160 pixels
UMTS	Universal Mobile Telecommunications System
VDSL	Very high-speed Digital Subscriber Line
VPN	Virtual Private Network
VR	Virtual Reality
WAN	Wide Area Network
WCDMA	Wideband CDMA
WDM	Wavelength Division Multiplexing
Wi-Fi®	Wireless Fidelity
XG-PON	10-Gigabit-capable PON (also known as asymmetric 10G-PON)
XGS-PON	10-Gigabit-capable Symmetric PON (also known as symmetric 10G-PON)

4 Overview

At the time of publication, half of the world's 2 billion households have been connected to at least one fixed broadband network, and a lot of companies, enterprises, vertical industries and institutions rely on broadband networks to conduct operations and services. Broadband development has become a strong indicator of national economic progress. Being the cornerstone of global economic and technological development, fixed networks have become an indispensable part of political and economic life worldwide. The introduction of optical fibre communication technology has transformed the communications network. Since then, the global network has been exponentially expanding. It can be observed that the network has experienced five generations of technologies and capabilities: voice, broadband, ultra-broadband, 100 Mbit/s optical fibre broadband, and 1 000 Mbit/s optical fibre broadband, and is increasingly vigorous and changing. The present document will explore the historical evolution path of fixed network and define details of the 5th generation.

5 Generations definition

5.1 Historical fixed networks evolution

5.1.1 Introduction

Since the 19th century, the fixed network has developed for more than 100 years, from dedicated networks to each kind of service (voice, data, text) to the era of digital that enabled convergence of many services in the same network. Fibre technologies played an essential role in this evolution expanding network capacity and capabilities. This evolution can be mapped in five generations and more are yet to come in a flourishing ecosystem.

5.1.2 The first generation

The first generation of fixed networks were telephone networks. This period was from the birth of the telephone network until the end of the 20th century, and lasted for more than a century. The services were mainly audio services, while the application experience was no more than a dial-up call. Global communications experts worked together to establish a complete telephone network infrastructure, with a network architecture and control signaling suitable for a global network. The era of globalized telecommunication started. During this period, data services had their initial first steps using dial-up access and ISDN [i.2]; however, the technology was still voice band carrier, and progress was very slow in general.

5.1.3 The second generation

The fixed network entered the broadband era from the second generation. From the 1990's to the 2000's, the fixed network entered the second generation, which was the prelude of the broadband era and the high-speed development period of the fixed network. The Internet rapidly and globally developed in this era, with the wide adoption of personal computers and web browsers. Web browsing, email, and search engine became important applications of the fixed network. ADSL [i.3] technology also revitalized the 100-year-old copper line network and provided access rates of 2-20 Mbit/s via a system that was data-oriented. The global mainstream ADSL broadband network construction lasted for ten years from 1998 to 2008.

5.1.4 The third generation

Internet applications and broadband networks led to the third generation of fixed networks. Since 2005, leading operators had started to provide triple-play services that integrated telephone, Internet access, and video applications based on broadband networks. Carrier-class video services had become an important driving force for the development of broadband networks. Due to bandwidth restrictions, the ADSL network in the early stage supported only video services with standard resolution.

In 2008, the Federal Communications Commission (FCC) officially redefined the "broadband" as 25 Mbit/s or higher. In 2010, Europe announced the EU2020 and Digital Europe Plan, which defined the goal of 30 Mbit/s full coverage for the broadband network in Europe. The world had officially entered the third generation of fixed networks, that was called NGA (Next Generation Access network) era.

In this era, both fixed network services and network architecture were undergoing significant changes. IPTV became a powerful tool for carriers to improve market share and service differentiation. In terms of network architecture, the traditional ADSL technology carried over the original telephone network could not support the "new broadband" service of over 25 Mbit/s. Therefore, operators had to adopt the "fibre-deep" network architecture and introduce the new VDSL [i.4] technology on the twisted pair cable to achieve higher speed. The optical fibre communication technology, born in the 1970s, was applied to the access network for the first time to implement the FTTx network architecture, e.g. FTTC (Fibre To The Curb) and FTTB (Fibre To The Building). The original Central Office for copper line access was gradually reconstructed as the Central Office for optical fibre access. Based on the FTTC and FTTB architecture, operators also introduced enhanced copper-based technologies like VDSL2 and VDSL vectoring to reuse the twisted pair wire on the last mile and provide access bandwidths up to 100 Mbit/s. This provided the balance between higher bandwidth demand and the cost of implementing full fibre-based network architecture.