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Fifth Generation Fixed Network (F5G); F5G Residential Services Quality Evaluation and Classification Release 2

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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 present document specifies the service KQIs for evaluating user experience for residential services. The corresponding evaluation criteria and the calculation methodology are specified using MOS values. To achieve a good user experience, network KQIs are specified and dedicated network KQI thresholds are defined for different network services.

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.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

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 necessary for the application of the present document.

[1] ETSI GS F5G 005: "Fifth Generation Fixed Network (F5G) F5G High-Quality Service Experience Factors Release#1".

[2] Recommendation ITU-T P.10: "Vocabulary for performance, quality of service and quality of experience".

[3] European Union EUR 30789 (2021): "Code of Conduct on Energy Consumption of Broadband Equipment".

[4] IEEE 802.11™/1234r0-2018: "Real-time Mobile Game vs Wi-Fi".

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] Recommendation ITU-T P.800: "Methods for subjective determination of transmission quality".

[i.2] Broadband Development Alliance (BDA) 2021: "White paper: QoE classification of Residential network service".

[i.3] BBF TR126: "Triple-play Services Quality of Experience (QoE) Requirements".

[i.4] Broadband Development Alliance (BDA) 2021: "White paper: Gigabit high quality service experience and network optimization".

[i.5] ETSI GS F5G 004: "Fifth Generation Fixed Network (F5G); F5G Network Architecture".

[i.6] CCSA YD/T 1154-2020: "Network Technical Requirements of Cloud VR based on Telecommunication Networks".

[i.7] Recommendation ITU-T G.107: "The E-model: a computational model for use in transmission planning".

[i.8] Recommendation ITU-T P.863: "Perceptual evaluation of speech quality (PESQ): An objective method for end-to-end speech quality assessment of narrow-band telephone networks and speech codecs".

[i.9] ISO/IEC 29199-2:2020: "Information technology -- JPEG XR image coding system -- Part 2: Image coding specification".

[i.10] CNNIC 2021: "The 47th China statistical report on internet development".

[i.11] ETSI GR F5G 001: "Fifth generation fixed network (F5G); F5G generation definition release #1".

[i.12] CCSA YD/T 3341-2018: "Scoring method for evaluating the quality of broadband web/video/bandwidth-measurement service and network".

[i.13] CCSA YD/T 1071-2006: "Technical requirements for IP telephony gateway".

[i.14] CCSA YD/T 3778-2020: "The live algorithm and parameter for the user experience assessment of broadband video service".

[i.15] CCSA YD/T 3779-2020: "The VOD algorithm and parameter for the user experience assessment of broadband video service".

[i.16] CCSA YD/T 2026-2009: "The technical requirement and evaluation method for quality of IP telephony".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

Key Quality Indicator (KQI): QoS metrics, which are important and have a major impact on the QoE of applications and networks

Mean Opinion Score (MOS): mean of the values on a predefined scale that users assign to their opinion of the performance of a system quality

NOTE: See Recommendation ITU-T P.10 [2].

Network KQI: quantitative indicator of the functionality and performance of the F5G network

Quality of Experience (QoE): subjective measure of performance of applications or services that relies in human opinion on the perceived quality

service KQI: quantitative indicator of service or application experience in F5G network

3.2 Symbols

Void.

3.3 Abbreviations

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

AP Access Point
APFF Average Percentage of Frame Freezing
BES Black Edge and Smearing

BNG	Broadband Network Gateway
BSAR	Blurred Screen Area Ratio
BSR	Blurred Screen Ratio
CCR	Call Completion Rate
CDN	Content Delivery Network
CDR	Call Drop Rate
CoC	Code of Conduct
CPU	Central Processing Unit
CSD	Channel Switching Delay
CST	Call Setup Time
DDoS	Distributed Denial of Service
DNS	Domain Name Server
DRR	Download Rate Ratio
DTR	Desynchronization Time Ratio
E2E	End to End
E-ONU	Edge ONU
EPG	Electronic Programme Guide
ETH	Ethernet
FFT	Frame Freezing Times
FFTR	Frame Freezing Time Ratio
FLT	Full Load Time
FOV	Field Of View
FSDT	First Screen Display Time
FTTR	Fibre-To-The-Room
GE	Gigabit Ethernet
GI	Guard Interval
GUI	Graphical User Interface
HD	High Definition
IBD	Initial Buffering Duration
ID	Interaction Delay
IE	Interactive Experience
ILD	Initial Loading Duration
IP	Internet Protocol
IPTV	Internet Protocol Television
KQI	Key Quality Indicator
LAN	Local Area Network
LQID	Low Quality Image Display
MOS	Mean Opinion Score
MPEG	Moving Picture Experts Group
NCBPS	Number of Coded Bits Per Symbol
NST	Network Start-up Time
O&M	Operation & Management
OLT	Optical Line Termination
ONU	Optical Network Unit
ORD	Operation Response Delay
PESQ	Perceptual Evaluation of Speech Quality
PON	Passive Optical Network
P-ONU	Primary ONU
PRT	Page Response Time
QoE	Quality of Experience
QoS	Quality of Service
RGW	Residential Gateway
RTT	Round-Trip Time
RWV	Relative Weighted Value
SD	Standard Definition
SDR	Stalling Duration Ratio
STA	Station
TCP	Transmission Control Protocol
TV	Television
URL	Uniform Resource Locator
URR	Upload Rate Ratio
USB	Universal Serial Bus

VE	Viewing Experience
VOD	Video On Demand
VoIP	Voice over Internet Protocol
VR	Virtual Reality
WAN	Wide Access Network
XGPON	10-Gigabit Passive Optical Network

4 Introduction

4.1 Overview

The present document specifies the service KQIs for a set of residential applications and services. Such service KQIs reflect the service quality. To have a quantitative evaluation of service KQIs, a corresponding MOS calculation and evaluation criteria are specified. To achieve good service quality, a certain level of F5G network performance and functionality is necessary. Network KQIs are specified to quantify the network in terms of F5G network performance and functionality. Depending on the service, a certain level of network performance is required.

There are a number of service KQIs specified by other organizations or newly defined in the present document:

a) Voice [1], [2]: call completion rate, call setup time, conversational quality, call drop rate.

b) Web browsing [i.2]: page response time, first screen display time, full load time.

c) Data upload/download: download rate ratio, upload rate ratio.

d) IPTV [i.2]: indicators of interactive experience, indicators of viewing experience.

e) On-line game [1], [i.2]:

- terminal-based rendering game: network start-up time, Operation Response Delay (ORD), desynchronization time;
- cloud-based rendering game: frame freezing time ratio, Operation Response Delay (ORD).

f) On-line education/telework [i.2]: frame freezing times, frame freezing time ratio, interaction delay.

g) Cloud VR [1]:

- Cloud VR video: initial buffering duration, Average Percentage of Frame Freezing (APFF), low quality image display.
- Cloud VR game: black edge and smearing, Average Percentage of Frame Freezing (APFF), operation response latency.

NOTE: The KQI for data upload/download is newly defined in the present document.

The method to quantify service KQIs is based on MOS values, which reflect the user experience. They are defined in clause 7.

A number of network KQIs are used to support the measurement of the services quality which are as follows:

a) Throughput: the maximum transmission data rate of residential system.

b) Latency: the E2E communication time interval between request and response.

c) Connectivity: the connected number of stations to the access point.

d) Handover: the connection switch between different access points.

e) Green: the power consumption of devices.

f) Security: network security of residential network.

g) Smart O&M: smart operation & management of residential network.

Based on the network demand of different service, the network service has been classified into different levels. For example, typical 100 Mbps throughput is enough for the service in L0 while gigabit throughput is necessary for the service L1 and L2. More strict latency boundary is required in L2 service:

a) Level 0 (L0): voice, web browsing, SD&HD video, upload/download.

b) Level 1 (L1): terminal-based on-line game, 4K video, on-line education/Telework.

c) Level 2 (L2): cloud VR, 8K video, cloud-based on-line game.

The detailed network requirements are specified in clause 8.

The framework of user experience evaluation for residential broadband services is shown in Figure 1. To achieve the evaluation, several aspects are considered as follows:

1) The service KQI for residential services listed above is used to estimate the user experience from a user's perspective, shown in the upper left corner of Figure 1.

2) MOS value as quality scoring mechanism is used to quantify the service KQI, shown in the right-hand side of Figure 1. First, MOS value is calculated for each KQI in a dedicated service. Second, a comprehensive MOS value is created for the dedicated service. Finally, the MOS value for the residential network could be estimated by the combination of the MOS value of different service.

3) To support good user experience as perceived by the users, the network KQI listed above is specified as the basis to ensure enough network capability. The detailed network requirements are discussed for different levels of service classification.

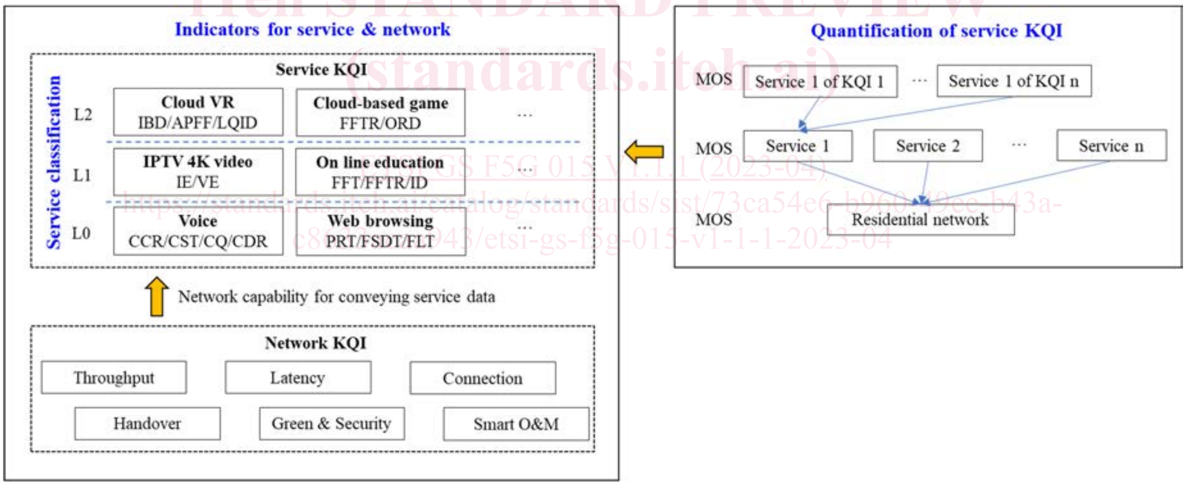

Figure 1: The framework of user experience evaluation

4.2 Motivation

The present document could be leveraged by the end user to evaluate their residential network and thus improve it by updating the network hardware, optimizing networking topology and so on. According to the service, providing to the end users, the service operator could utilize the present document as a reference to build up a residential network to enable good user experience. To target a good user experience, the system vendor or chipset vendor could develop specific technologies based on the experience issues. Obviously, further measurement methodology or measurement tool could be developed according to the content of the present document.

4.3 Document structure

Clause 4 introduces the context of the present document, including the motivation and framework. Clause 5 specifies the individual service KQIs for specific network services while network KQI is specified in clause 6. The evaluation methodology described in clause 7 specifies concrete formulas and algorithms for calculating the MOS value for each service KQI. In clause 8, the classification of network service and corresponding network requirements are then discussed based on the network demand of various service.

5 Service KQIs

5.1 General description

This clause describes the selected services for evaluation and their associated parameters. The present document focuses on the following types of services, for service quality evaluation:

- Voice.
- Web browsing.
- Upload/download.
- IPTV.
- On-line game:
  - Terminal-based rendered game: it is when the majority of computation of graphics rendering and data processing is conducted by the local terminal device.
  - Cloud-based rendered game: it is when the majority of computation of graphics rendering and data processing is conducted by the cloud server.
- On-line Education/Telework.
- Cloud VR:
  - Cloud VR Video.
  - Cloud VR Game.

The network influences the user experience. When determining service quality indicators, consideration is given to how the network affects the user experience. A number of service KQIs are defined in both ETSI and ITU, the present document refers to these relevant standards. Other service KQIs are defined in the present document in order to specify appropriate evaluation methods.

5.2 Voice

5.2.1 Voice service KQIs overview

Quality of Experience (QoE) indicators for voice are described in various standardization organizations such as ETSI GS F5G 005 [1], and ITU-T P series [2] and [i.1]. The present document describes indicators closely related to the user experience as the basis for service evaluation methods. Voice Service KQIs include:

- Call completion rate.
- Call setup time.
- Voice quality.
- Call drop rate.

5.2.2 Call completion rate

Call completion rate is the percentage of calls that are completed relative to the number of calls initiated by the calling subscriber. The total number of calls initiated by the calling subscriber does not include the calls lost due to the calling subscriber error, such as mis-dialling and quitting midway. The number of completed calls includes the number of calls in which the called subscriber answers, does not answer, is busy, is powered off, rejects the call, and the line is locked.

5.2.3 Call setup time

Call setup time is the time interval between when a calling subscriber dials the last called number and when the calling subscriber receives a network response. The network response can be signal tones such as ring tone and busy tone, terminal prompt tone, and recording notification.

5.2.4 Conversational quality

Recommendation ITU-T P10 [2] shows conversational quality as experienced in a bi- or multidirectional conversation. The Voice Service KQI shall use the Mean Opinion Score (MOS) method as defined in Recommendation ITU-T P.800 [i.1] to evaluate the conversational voice quality. In Recommendation ITU-T P.800 [i.1], a number of participants are invited to listen to the same speech sample and then the voice quality of this sample is evaluated. Through the MOS method, the voice quality can be evaluated subjectively, and a specific voice sample can be scored subjectively.

5.2.5 Call drop rate

The call drop rate is the percentage calls that are dropped after the network connection has been established which is shown in ETSI GS F5G 005 [1].

5.3 Web browsing

5.3.1 Web browsing service KQIs overview

Web browsing is one of the basic Internet applications from a user perspective. Page response time, first screen display time and full load time, described in BDA white paper [i.2] are key indicators that directly affect user experience.

5.3.2 Page response time

The page response time of the user accessing a web page (DNS resolution is required) is calculated between the time that user initiates an access instruction on the terminal (i.e. for desktop/mobile browser (via Wi-Fi®): entering the URL address with pressing enter) and the time the user receives the first response packet with a content payload.

5.3.3 First screen display time

The first screen display time is defined as follows. The user accesses the page (DNS resolution is required). The user initiates an access instruction on the terminal. (Enter the URL address in the desktop browser and press Enter, or Enter the URL address in the mobile browser (via Wi-Fi®) and press Enter.) The time period from when the browser sends a request message to when the data returned by the website fills the screen of the user terminal for the first time.

NOTE: For comparing measurements of this KQI, the same terminal device is recommended.

5.3.4 Full load time

The full load time of a user accessing a webpage (DNS resolution is required) is calculated between the time that user initiates an access instruction on the terminal (i.e. for desktop/mobile browser (via Wi-Fi®): entering the URL address with pressing enter) and the time that it takes for the entire page to be fully loaded on the browser.

NOTE: User may be interested in viewing any part of the webpage. Therefore, the webpage should be fully loaded as soon as possible.

5.4 Data upload/download

5.4.1 Upload/download service KQI overview

Upload/download is one of the basic Internet applications. Both download rate ratio and upload rate ratio are key indicators that directly affect user experience.

5.4.2 Download rate ratio

This measures the ratio of the download rate to the subscription bandwidth when speed testing software is used to access a specified server.

5.4.3 Upload rate ratio

This measures the ratio of the upload rate to the subscription bandwidth when speed testing software is used to access a specified server.

5.5 IPTV

5.5.1 IPTV service KQI overview

The BDA white paper [i.2] shows key factors affecting IPTV user experience include video/TV program source quality, interactive user experience, and viewing user experience.

The user experience of video viewing depends on the resolution, smoothness, and fidelity (tone and contrast) of the video. The service KQI is determined by the following parameters, resolution, frame rate, network bit rate, content type, encoding, and the end device (such as TV, laptop, pad with different screen resolution).

NOTE: IPTV includes watching videos/TV programs on any end devices, such as television, laptops or hand-held device.

The interactive user experience depends on the response time of the video/TV system to TV channel switching or video selection. It also depends on the performance of cloud platform, communication network, and the end device. It can be measured by a few key performance indicators such as response time to Electronic Programme Guide (EPG) interaction, initial video/TV program loading duration, channel switching duration, fast forward and rewind response.

The viewing user experience depends on the quality of the program signals during display of video/TV programs. The factors affecting the viewing user experience include screen artefact and frame freezing. Such factors can be measured by objective indicators such as the transmission performance and quality impairment of the video.

Generally service operators do not directly produce video/TV programs. Therefore, it is recommended to focus on interactive user experience and viewing user experience for IPTV service.

Figure 2 shows the key factors for video/TV program user experience in different experience categories.

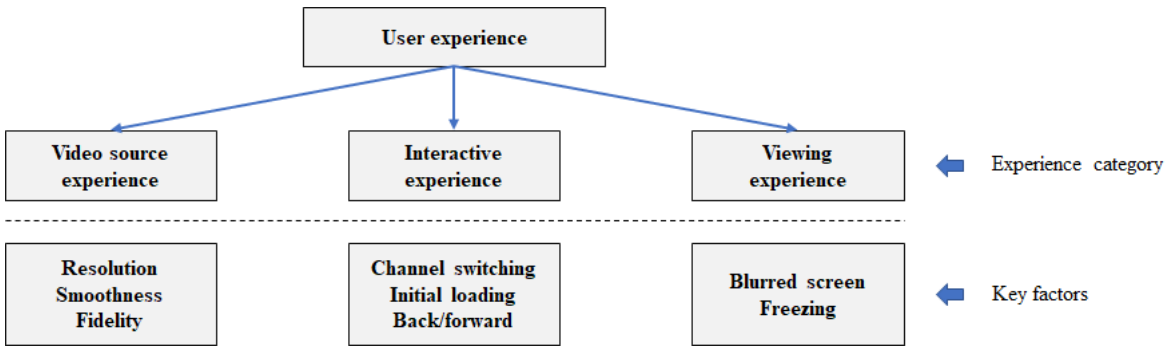

Figure 2: Experience category and key factors affecting user experience

5.5.2 Interactive user experience

Interactive indicators of live TV service include live TV channel switching delay, i.e. the time between closure of the previous channel and that the new channel is played.

Interactive indicators of VOD service include VOD initial loading duration, i.e. the time between that the VOD service request is initiated and that the video frame is resolved. (e.g. I frame in MPEG is decoded).

The initial loading duration is the key indicator for VOD. Other factors, such as fast-forwarding and fast-rewinding for VOD or pre-recorded TV programs may use the initial loading duration definition and details are left for further study.

5.5.3 Viewing user experience

The viewing indicators of Live TV include blurred screen duration ratio and blurred screen area ratio:

1) Blurred screen duration ratio: the duration of blurred screen over the total play time of the live TV.

2) Blurred screen area ratio: the percentage of average blurred screen area over the whole screen area when the blurred screen occurs.

NOTE 1: The blurred screen duration is determined by the duration of continuously received damaged frames. The blurred screen area is determined by the averaged over time of the accumulated damaged received frames.

The viewing indicator of the VOD service includes freezing video duration ratio, i.e. video pause duration caused by an empty buffer over the total play or playback duration of the video.

NOTE 2: When evaluating user experience, a fixed video source (for VOD) and viewing video resolution (for live TV and VOD) is recommended.

5.6 On-line game

5.6.1 Overview

ETSI GS F5G 005 [1] shows the game user experience is classified and explained in terms of graphics, sound, playability, difficulty, originality. For users who play on-line game over residential network, the quality of the broadband network can directly affect the game's playability. Good playability can give users a better on-line game visual and interactive user experience. The visual user experience will be affected by problems such as network transmission latency and server processing load (see clause 6 for more details). The interactive user experience is affected by real-time response due to the network transmission latency. The present document lists the key indicators of on-line game service related to the residential network.

5.6.2 Terminal-based rendered game

5.6.2.1 Overview of terminal-based rendered game KQIs

In terminal based rendered game, the computation of graphics rendering and data processing are conducted on the player's local terminal device. The terminal device transmits the basic state information of the game by interacting with the game server. The terminal device here includes a mobile phone, laptop etc. When running such games over residential network, network start-up time, game Operation Response Delay (ORD), and game desynchronization time are key indicators that are closely related to the network quality and will affect the user's experience. The key performance indicators for terminal-based rendering game are described in BDA white paper [i.2].

5.6.2.2 Game start-up time

Game start-up time is the time from when the user clicks to start the game until the user can operate the game interface. The lower the start-up time, the better. The game start-up time consists of terminal start-up time affected by terminal performance and network start-up time affected by network conditions. The present document focuses on the impact of network start-up time on game. The network start-up time is the delay from when the user clicks the login page of the game to the time when the user enters the operation page of the game.