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Fifth Generation Fixed Network (F5G)
F5G High-Quality Service Experience Factors
Release #1

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Reference

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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

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document studies the end-to-end Quality of Experience (QoE) factors for services over the broadband network. High-QoE reflects the overall performance at the service level from the perspective of the end user. The present document analyses the general factors that impact service performance and identifies the overall high-QoE dimensions for each service. The key services discussed in the present document are typical Internet applications and Virtual Reality (VR). Other services and applications QoE are for further study.

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 004: "F5G Architecture Release 1".

[2] Recommendation ITU-T Y.1540: "Internet protocol data communication service - IP packet transfer and availability performance parameters".

[3] Recommendation ITU-T P.863: "Perceptual objective listening quality prediction".

[4] ETSI TS 103 222-1: "Speech and multimedia Transmission Quality (STQ); Reference benchmarking, background traffic profiles and KPIs; Part 1: Reference benchmarking, background traffic profiles and KPIs for VoIP and FoIP in fixed networks".

[5] ETSI TS 103 222-2: "Speech and multimedia Transmission Quality (STQ); Reference benchmarking, background traffic profiles and KPIs; Part 2: Reference benchmarking and KPIs for High speed internet".

[6] Recommendation ITU-T J.247: "Objective perceptual multimedia video quality measurement in the presence of a full reference".

[7] IETF RFC 3357: "One-way Loss Pattern Sample Metrics".

[8] IETF RFC 768: "User Datagram Protocol".

[9] IETF RFC 3550: "RTP: A Transport Protocol for Real-Time Applications".

[10] IETF RFC 793: "Transmission Control Protocol".

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

[12] Recommendation ITU-T G.988: "ONU management and control interface (OMCI) specification".

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] ETSI TR 102 505: "Speech and multimedia Transmission Quality (STQ); Development of a Reference Web page".

[i.2] ETSI EG 202 057 (Part 1 to 4): "Speech Processing, Transmission and Quality Aspects (STQ); User related QoS parameter definitions and measurements".

[i.3] Broadband Forum (BBF) TR-126: "Triple-play Services Quality of Experience (QoE) Requirements".

[i.4] ETSI GR F5G 002: "F5G Use Cases Release 1".

[i.5] ETSI White Paper No. 47, "Fibre Development Index: Driving Towards an F5G Gigabit Society", ISBN No. 979-10-92620-41-1.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in F5G Architecture [1] and the following apply:

Key Quality Indicators (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 [11].

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

Quality of Service (QoS): description or quantitative measurements of the overall performance of the F5G system at the network, service, and application domain

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in F5G Architecture [1] and the following apply:

AP	Wi-Fi® Access Points
Cloud VR	Cloud Virtual Reality
DRTT	Downstream Round-Trip Time
DSLR	Downstream Segment Loss Rate
FoV	Field of View

KQI	Key Quality Indicators
MOS	Mean Opinion Score
NPS	Net Promoter Score
USLR	Upstream Segment Loss Rate
VoD	Video on Demand

4 Introduction

4.1 Overview of High-Quality of Experience (QoE)

This clause provides an introduction to Quality of Experience (QoE) and the distinction between QoE and QoS as used in the present document.

The QoE (Quality of Experience) and QoS (Quality of Service) terminology (see clause 3.1 for the term) are often used interchangeably, but are actually two separate concepts.

The QoE is a combination of objective measurable components (as metrics on the conditions in the network and service platforms that are required for a specific service to work properly) and subjective components (as user expectancy on the service, user previous experience or user personal preferences).

Mean Opinion Score (MOS) is one often used QoE measurement metric typically used to quantify the perceptual impact (the users' QoE) for various forms of service degradation.

QoE can also be assessed based on objective QoS metrics. There are different QoS metrics, which can be gathered, some easy to collect other more difficult. Depending on the specific service different combinations of these metrics may be needed for QoE assessment. The availability and understanding of these QoS metrics determine QoE assessment in different levels of detail. This QoE assessment based on QoS metrics is the focus of the present document.

QoS is a measure of the performance of networked services at the network or application level. QoS also refers to a set of techniques that enable the network administrator to manage the network performance differentiating between different users. QoS metrics may include network layer measurements such as packet loss, delay or jitter or application level measurements such as video frame loss, frame freezing, image distortion. The Key Quality Indicators (KQI) are the QoS metrics, which have the largest impact on QoE.

In general, there is a non-linear relationship between the subjective QoE as measured by the MOS or other metrics and various parameters used to measure network performance (e.g. encoding bit rate, packet loss, delay, availability, etc.).Typically there will be multiple service or network level performance (QoS) metrics that will impact overall QoE. The relationship between QoE and service and network performance (QoS) metrics is typically derived empirically. Having identified the QoE/QoS relationship, if it is possible, it can be used to predict the expected QoE for a user, given the QoS parameters, or given a target QoE, the required network and service requirements can be derived.

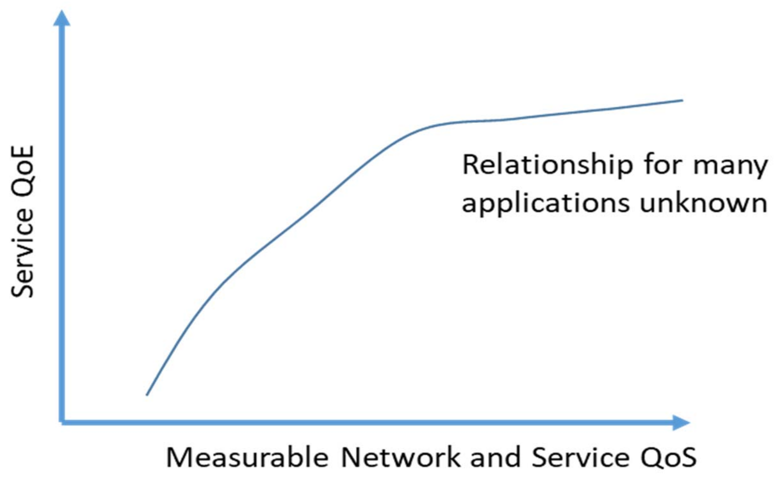

Figure 4-1: Example QoS/QoE non-linear relationship

The Key Quality Indicators (KQI) are composed by the QoS metrics, which have the largest impact on QoE, namely user centric and service specific quality patterns that directly influence the user perception for each service category. The definition of these quality patterns poses a challenge where Artificial Intelligence correlation techniques may play an important role.

QoE targets are needed for each service and application and should be included from the beginning in system design and engineering processes where they are translated into objective service level performance metrics.

QoE requirements shall be considered from a complete end-to-end system perspective. All end-systems (client and servers), application services and networks (nodes, links) that can contribute to the user experience using a service shall be taken into account. But also several stakeholders are contributing to a high end-to-end QoE. Those include the network service provider, the application provider, and the server/client device providers among others.

QoE-oriented engineering includes processes to analyses user requirements, derive measurable parameters, having the different configuration aspects of the components in the end-to-end service delivery chain, and identify the relationship between the measurable parameters and the subjective user quality of experience.

Quality of Experience is an important factor in the success of F5G services and is expected to be a key differentiator with respect to competing service offerings. Subscribers to network services and applications are increasingly sensitive to how well a service meets their expectations for performance, operability, availability, and ease of use.

4.2 Structure of the present document

User assessment of application and service quality has some subjective aspects, however the present document focuses on QoE assessment based on measurements. These measurements are made at network and at application level.

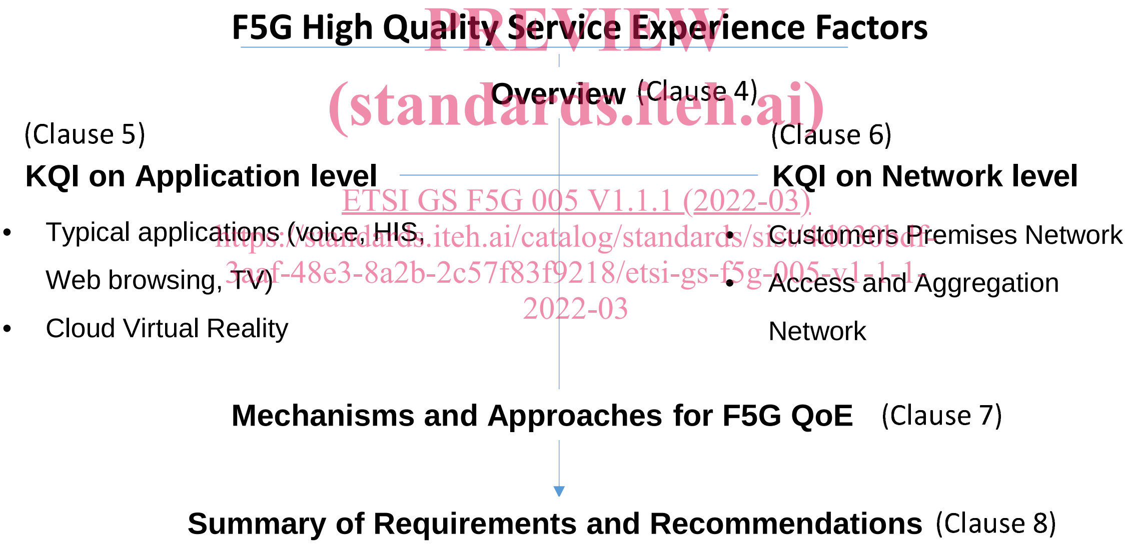

Figure 4-2: Structure of the present document

The present document is structured as follows:

- Clause 5: Specification of the measurable Key Quality Indicators (KQI) on the application level (typical applications by referencing the appropriate specifications and Cloud VR as a new application with new sets of KQIs enabled by F5G).
- Clause 6: Specification of the measurable Key Quality Indicators on the network level in the different segments of the network.
- Clause 7: Specification of different mechanisms and approaches to either measure or improve QoE. Several measurement approaches for key performance indicators and QoE assessment methods are specified and the use of novel concepts like network slicing and AI-based QoE assessment are described.
- Clause 8: Finally, the present document is summarizing the requirements and recommendation for a F5G QoE.

5 Application Services and related QoE factors

5.1 QoE of Typical Applications

5.1.1 General Description

In the present document, the term typical application is used for applications that are well established, which have standardized quality metrics. These applications include Voice, High-speed Internet, Web browsing, and TV.

The Key Quality Indicators for the typical applications considered are not described in the present document, but existing specifications are referenced.

5.1.2 QoE Factors of Typical Applications

5.1.2.1 Introduction

QoE factors are described by various standardization organizations. In the following clauses only a few specifications examples are given in order to refer to existing work in the area of QoE for well-known applications.

5.1.2.2 Voice

A list of voice application QoE factors are described in Recommendation ITU-T P.863 (POLQA) [3] and ETSI EG 202 057 (Parts 1 to 4) [i.2]. The key performance indicators for voice services are described in ETSI TS 103 222-1 [4].

5.1.2.3 High-speed Internet

ETSI EG 202 057 (Part 4) [i.2] shows key performance indicators for the High-speed Internet Service and ETSI TS 103 222-2 [5] the QoS parameters for the High-speed Internet service.

5.1.2.4 Web Browsing

For web browsing application many of the parameters for high-speed internet apply, however, for testing purposes there is also a reference standard for a web page with reference content as defined in ETSI Kepler Reference Web-page [i.1]

5.1.2.5 TV

For perceived video quality, Recommendation ITU-T J.247 [6] shows a set of parameters. For the user interface of TV services, IETF RFC 3357 [7] defines One-way Loss Pattern Sample Metrics. Finally, the overall triple play service QoE requirements are shown in BBF TR-126 [i.3].

5.1.3 Generic Measurement Methodology

The measurement of QoE parameters is typically performed through emulation of the full application with client and servicer running over a network under test. This requires having the test systems, application client and server, which are located at different positions in the network under test. The QoE is measured at the client application user interface. The results of these QoE measurements show a level of QoE in a particular situation. However, it is difficult to generalize these results, since they depend on the location of the clients and application servers and they depend of the actual traffic in the network under test.

For other applications, the measurements are performed by emulating an application client, using a real implementation of the application server. Again that runs over a network under test, but also using an application server under test. For performing these measurements, the location of the application client and application server matters. Furthermore, the traffic of other users in the network and/or users using a particular application server matters.

Finally, the content of the application might have an impact on the measurement. For some applications there exists sample content in order to receive comparable measurement results.

5.1.4 Generic QoE management

QoE management can generically have two approaches:

- The network is dimensioned to ensure that the applications quality requirements are fulfilled. QoE depends on the network characteristics.
- The applications adapt to the QoS of the network to achieve the best possible QoE. This includes managing the applications in terms of capacity, response times and other parameters.

This is particularly difficult, since different applications are running on the same network and therefore compete for the same resources, and the services and network resources to be used are difficult to know in advance. In a few cases the applications can be modelled and network configuration parameters can be derived. But in many cases, the QoE needs to be assessed and re-configurations of the network maybe required to improve the QoE.

5.2 Cloud VR

5.2.1 General Description

Cloud VR is a new application enabled by F5G networks and therefore the Key Quality Indicators of Cloud VR are described in the following clauses, addressing different use cases.

Cloud VR is a new cloud computing technology for VR services, which includes VR video, VR gaming, and VR industry applications, providing an unprecedented level of immersive experience for users. However, these Cloud VR services require extremely large bandwidth, low latency, and low packet loss rate, which is a huge challenge for the network. The large-scale deployment of Cloud VR services requires the joint effort from the industry partners to address E2E quality management and monitoring. Cloud VR is an ever expanding services area and are for further study.

Local rendering requires expensive high-performance devices to provide acceptable user experience. Fast and stable transport networks enable VR content to be stored and rendered in the cloud, and video and audio outputs are coded, compressed, and transmitted to the user terminals. With Cloud VR, users enjoy VR services without having to purchase expensive hosts or high-end PCs, promoting VR service popularity. Cloud VR services are further classified as having strong or weak interaction:

- Weak-interaction VR services: Full-view video, VR live broadcast, IMAX® theatre
- Strong-interaction VR services: VR games, VR home fitness, VR education, and VR social networking

NOTE: In the following, the focus is on a subset of VR services, but many of the key indicators can be generalized for other VR services and applications of a similar type.

5.2.2 Factors Affecting Cloud VR service

5.2.2.1 Factors Affecting Weak-Interaction Cloud VR Service Experience

Different transmission solutions have different factors affecting user experience. For the weak-interaction Cloud VR services, Cloud VR video has two transmission solutions.

a) Cloud VR Full-view Transmission solution

The full-view video transmission solution is widely adopted at the initial stage of service development. In this solution, the streaming media server transmits all 360-degree video content to the user terminal, which is responsible for tracking the user head motion as well as decoding and displaying locally cached video data.

Table 5-1: Full-view QoE Indicators

Service	Experience Indicator	Evaluation Indicator
Full-view Video	Initial buffering	Initial buffering duration
	Frame freezing	Average percentage/duration of frame freezing
		Number of freeze frame occurrences

Initial buffering

As with traditional online video, after the user clicks the Cloud VR video play button, there is a loading process for performing CDN scheduling, index downloading, and data caching. For this process, users generally only see the loading progress bar. The shorter the loading time, the sooner the user sees the video content and the better the experience.

Key Quality Indicators

- **Initial buffering duration:** Is the time from when the user clicks the Cloud VR video play button to when the user sees the normal play screen.

Frame freezing

During full view VR video playing, if the downloaded data is exhausted by the player and it cannot meet the real-time playing requirements, the terminal will choose to stop playing first and it will wait until the newly buffered video data reaches a certain level, then restart playing. The phenomenon of buffering and playing after stopping is called a freeze frame.

Because it will interrupt the user's viewing process, it has a greater impact on the user's experience. In general, the lower the number of freeze frames and the shorter their duration, the better the user's experience.

Key Quality Indicators

- **Average duration of frames freezing:** Is the average of multiple freezing time per time window during VR video playing.
- **Average percentage of frames freezing:** Is the ratio of the total freezing time to the total playing time per time window during VR video playing.
- **Number of frames freezing:** Is the number of frames freezing per second during VR video playing.

b) Cloud VR FoV Transmission solution

In contrast to the full-view transmission solution, the Field of View (FoV) transmission solution only downloads and plays the high-definition images within the user viewing angle. Although the FoV transmission solution is far less demanding on the terminal's decoding performance and network transmission bandwidth, it poses new requirements on service experience.

Table 5-2: FoV Video Indicators

Service	Experience Indicator	Evaluation Indicator
FoV Video	Initial buffering	Initial buffering duration
	Frame freezing	Average percentage/duration of frame freezing
		Number of freeze frame occurrences
	Low quality image display	Average percentage of the low quality image area
		Percentage of low quality image duration

For the Initial buffering and Frame freezing of FoV video, the experience indicators and evaluations indicators are the same defined for full-view service.

Low quality image display

In the Cloud VR use case of ETSI GR F5G 002 [i.4], the VR video source file is divided into multiple segments for storage in the cloud. Each segment corresponds to a different FoV. Based on the head motion of the user, the terminal locally calculates the current FoV. The terminal requests the corresponding high-definition segment. The cloud server responds by sending the requested segment and a low-definition full-view background video. The terminal displays the high-definition segments when available and fills the remaining portion of the screen with background video.

If these dynamic processes suffer network or application delay, the user will only see low-definition content.