NG.147 Quality of Experience

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1 Introduction

1.1 Purpose of this document

This document is an extension to the existing Global Roaming Quality (GRQ) definitions, which are specified within the GSMA PRD IR.81. In this document, the focus is purely on Quality of Service (referred to as “QoS” within this document), only in the chapter “*2.1.2 - Use of smartphone for QoS test”* and “*2.2.2 - User, device, application layer Monitoring”* the term QoE monitoring has already been touched upon. Quality of Experience (referred to as “QoE” within this document) is playing an increasingly significant role in the roaming sector, as it refers to a customer's overall satisfaction with a service and encompasses a variety of factors such as performance, functionality, and ease of use. Within this document we would like to clarify the terms, explain the differences between QoS and QoE (Quality of Experience) in more detail and define corresponding QoE KPIs (key performance indicator), that will make it possible to take this aspect into account within the Global Roaming Quality.

Content of this document is not related to MNO (Mobile Network Operator) services covered by roaming agreements and/or MoUs (Memorandum of Understanding) between parties: it is therefore to be intended for information only.

1.2 Scope

This reference document provides the information, methods, and conditions necessary to perform QoE verification of roaming services complementing the GRQ framework.

The document will provide an overview and comparison of QoS & QoE, discuss respective terms and differences, and explain the importance of QoE within today’s technology landscape.

Then it talks about crucial factors influencing QoE such as *“Device Diversity and Fragmentation”*, *“Network Variability & Conditions”* and *“User behaviour and preferences”*.

After that the role of the customer end device – usually smartphones - is discussed, as these play a significant role in QoE testing along with respective challenges of traditional testing methods.

Last chapter *“Services, KPIs and Thresholds”* focuses on performance measurements following a similar approach like in the GRQ framework.

1.3 Definition of Terms

Term	Description
API	Application Programming Interface
CLI	Calling Line Identification
CPU	Central Processing Unit
DRB	Data Radio Bearer
GPU	Global Processing Unit
GRQ	Global Roaming Quality
KPI	key performance indicator
LTE	Long Term Evolution
IMS	IP Multimedia Subsystem
IP	Internet Protocol
MoU	memorandum of understanding
MMS	Multimedia Service
NSA	Non-Standalone
OTT	Over the Top
OS	Operating System
PDP	Packet Data Protocol
PDU	Packet Data Protocol
PMN	Public Mobile Network
PLT	Pagel Load Time
QoE	Quality of Experience
QoS	Quality of Service
SA	Stand Alone
STK	SIM Application Toolkit
VPN	Virtual Private Network
WAP	Wireless Application Protocol
SoC	System on a Chip
SMSC	Short Message Service Center
UE	User Equipment
USAT	USIM Application Toolkit
VPMN	Visited Public Mobile Network
VoLTE	Voice over LTE

1.4 Document Cross-References

Ref	Document Number	Title
1	GSMA PRD IR.81	EPS Roaming Guidelines

2 Definition of QoE Testing

The next section will provide deeper insights regarding the terms and definitions of QoE and QoS and explain them in more detail to recognise the fundamental differences.

2.1 QoE vs QoS

While QoS and QoE represent different perspectives, they are interconnected and aim to provide an optimal user experience. By ensuring effective QoS measures, network operators can lay a foundation for good QoE. A well-managed network with reliable performance (QoS) is more likely to deliver satisfying user experiences (QoE).

In short, QoS deals with technical parameters, optimizing network performance, while QoE focuses on user perception and satisfaction. In consequence, a proper testing concept needs to combine both aspects to provide an optimal understanding of the network conditions. Ideally one solution can provide both, QoE related KPIs considering Voice, Video or messaging services along with L3 based network traces supporting deep technical analysis of the call flow and generate also respective QoS KPIs as defined in IR.81. Understanding and balancing both aspects is crucial for delivering high-quality services that meet user expectations in the ever-evolving technology landscape.

Definition of QoS

QoS focuses on managing and optimizing the network's performance to meet specific requirements and objectives. It pertains to the technical aspects of data transmission and communication, ensuring reliable and efficient delivery of services within the network infrastructure.

Key characteristics of QoS within the GRQ include:

- **Network Accessibility:** Considering the successful registration of a user on the VPMN (Visited Public Mobile Network) . In 5G, accessibility refers to the ability for the users to register to the network and to a network slice.

- **Service Accessibility:** Considering the service access related integrations like end-to-end bearer connection is provided to the customer. For voice services, the customer hears the ring tone; for data services, the end-to-end packet data protocol (PDP) context is activated; for SMS, the connection is established between the end-user terminal and the Short Message Service Centre (SMSC).

- **Connection Establishment:** Considering the connection related integration. For voice service it describes the call setup end-to-end (even in case of call forward to voicemail). For data services, this describes the connection establishment for Multi Media Service (MMS) or accesses to a Wireless Application Protocol (WAP) portal or web server, for newest technologies 3G/LTE/5G, http(s) successful connection to a public web site.

- **Service Retainability:** Service Retainability describes the termination of services (in accordance with or against the will of the user), for example the customer terminates his voice call or data connection without cut-off. In 5G, retainability refers to abnormally loss of a QoS flow during the time the QoS flow is used, abnormal loss of a Data Radio Bearer (DRB) during the time the DRB is active.

- **Integrity:** In 5G, Integrity refers to network latency and delays, throughput and used network slice.

- **Utilization:** In 5G, Utilization refers to KPIs such as “Mean number of PDU sessions” of network and network slice instance or “PDU session establishment time”.

In summary, QoS focuses primarily on network infrastructure and aims to optimize technical parameters to provide an efficient and reliable data transmission and communication environment.

Definition of QoE

QoE, on the other hand, shifts the focus from technical aspects to the end user's perception and satisfaction while using a particular service or application.

Key factors influencing QoE include:

- **User Perception:** QoE considers the user's subjective perception of factors like responsiveness, ease of use, and the overall satisfaction with the service.

- **Content Quality:** The quality of media content, such as audio, video, or images, significantly impacts the user's experience. QoE considers factors like resolution, clarity, and absence of artifacts.

- **Service Reliability:** Reliability is crucial to QoE. Users expect consistent service availability without frequent disruptions or outages.

- **Interactivity:** Applications that require user interaction, like online gaming or video conferencing, should offer minimal delays and smooth responsiveness for a satisfactory experience.

In essence, QoE shifts the focus from technical metrics to the end user's perception and satisfaction, acknowledging that user experience is subjective and influenced by various non-technical aspects.

3 Key Considerations in QoE Testing

This chapter talks about the most important aspects impacting QoE testing and respective testing methodologies.

3.1 Device Diversity and Fragmentation

Device diversity and fragmentation happens because of the rapid evolution and innovation in the mobile industry. Manufacturers release new models of devices with different screen sizes, resolutions, processors, memory, sensors, and features. Operating systems and platforms also update frequently, introducing new versions, APIs (Application Programming Interface), and frameworks. Users have different preferences and behaviours, choosing different devices, operating systems, browsers, apps, and network providers. All these factors lead to a complex and dynamic landscape of mobile devices that need to be harmonised with the developments and the evolution on the mobile network side. To ensure a perfect user experience within this complex and dynamic landscape all components must work together seamlessly.

3.2 Network Variability & Conditions

As far as network variability is concerned, let us take a closer look at a real-life example, many operators are currently in the process of switching off their 2G & 3G networks (sunsetting) to free up frequencies and reclaim spectrum to increase bandwidth, add capacity and prepare the transition towards 5G. This step has also a major impact on roaming and therefore VoLTE (Voice over LTE) roaming agreements must be in place accordingly, to guarantee customers an alternative coverage if one of the legacy technologies is no longer available. *Meaning that 2G/ 3G sunsetting is leading to a significant push towards VoLTE in the current situation.*

However, VoLTE brings a lot of complexity as VoLTE generically stands for the delivery of VoIP calls over LTE (Long Term Evolution), using IMS to provide IP connectivity and act as the service control architecture. IMS uses the SIP protocol for registration and control of the service sessions, not being only used between the terminal and the IMS but also among multiple IMS internal nodes. Through IMS (IP Multimedia Subsystem) the UE (User Equipment) specifies its characteristics and sets its QoS requirements by specifying parameters, like media type, direction of traffic, packet size and rate, bit rate for each media type and bandwidth specifications. That means in that case much more logic happens in the device itself and many operators had to implement their own VoLTE firmware on the smartphone, which now must be verified and implemented considering the different configurations and scenarios within the roaming area.

Later, when 5G gains more importance on the market, there is also the need to check registration in 5G network slice according to *IR.81 / Network Accessibility*. The only option to combine QoE/ QoS in that scenario is to use a real smartphone in combination with Layer 3 Tracing, as it can also happen that an application requests its own slice (e.g. video application which needs a high bandwidth slice...). The same will happen for a VoNR call, as without that approach it cannot be identified for the end user if the call setup was done in 5G SA or 5G NSA (Non Stand Alone), as the only way to determine this is by analysing the communication between the device and the network.

In general, it can be said that technology is constantly advancing, and each technology has its own requirements and conditions that must be met to ensure quality.

3.3 User behaviour and preferences

Also user behaviour is changing. While in the last decades there was a strong move from landlines to mobile phones and hence landlines have become less important now one can observe the trend for data only, also with regards to voice services.

Hence, the demand for high-speed data is growing significantly and consumers are becoming increasingly dependent on devices running data-intensive applications. Video and OTT (Over the Top) applications are on the rise and with 5G this will certainly increase in the area of virtual reality as well.

Regarding to voice, also a lot has changed in terms of QoE with the introduction of VoLTE. The benefits of VoLTE over traditional cellular voice are compelling as VoLTE offers faster call-setup times, high-definition (HD) voice, improved battery life, seamless handovers to legacy voice and VoWiFi. Furthermore, users can benefit from faster LTE data rates, and an increased service to more users from the same cell sites. A simplified LTE architecture and better spectral efficiency are additional benefits for the network operators which need to be highlighted here as well.

To summarise, it can be said that customers have high demands on high-speed data rates to use their OTT & video services without interruption, and that excellent voice quality with fast call setup times are a prerequisite in the voice sector. It is further assumed that the services are available as quickly as possible, this also refers to the registration of the device within the network and the attach into a high-speed network domain (4G/ 5G).

4 Testing with real smartphones

Networks are becoming increasingly complex and various technologies are currently being used in parallel all over the world. This complexity and the rapid pace of technology naturally also has an impact on the development of end devices. Hardware, operating systems, and applications must keep pace with the state of the art and changes are much more frequent.

Especially in the VoLTE area, it has been seen that the device firmware can have a massive influence on the service functionality, and it is therefore crucial to consider the customer's end device for testing QoE. And OTT applications can only be tested using a real smartphone, as it must be installed and verified on a phone using the respective operating system (OS).

4.1 Smartphone characteristics

Smartphones are complicated systems consisting of different components that influence the user's experience:

SIM/ UICC (and related components on the SIM like SIM Application Toolkit (STK), USIM Application Toolkit (USAT) or Card Application Toolkit (CAT)

Single-chip systems, also called system-on-a-chip (SoC) on the processor unit

Operation System of the phone itself (Android, iOS, HarmonyOS,..)

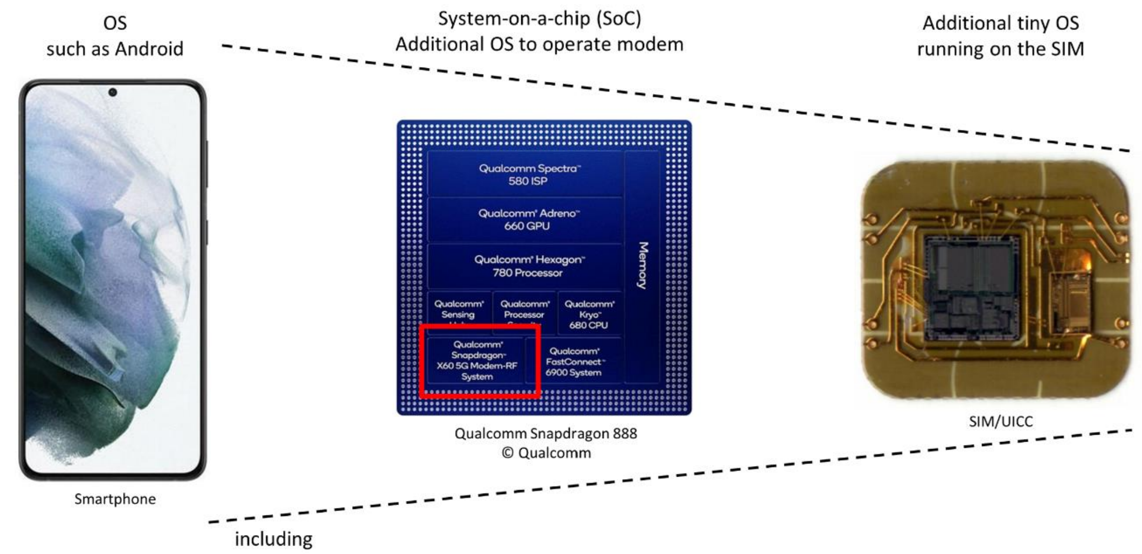

Figure 1: Smartphones are complex systems with different components

Mobile operating systems (OS) such as Android or iOS are specially designed for smartphones and act as an interface between the system hardware and the user covering functions like memory management, processor management/scheduling, device management, file management and of course also security related programs like user authentication. Further it enables the user to install and run different applications on the phone (e.g. inbuilt applications like call dialler and network settings as well as OTT applications).

The ***System-on-a-chip (SoC)*** is the centre piece of every smartphone containing components for power management, respective processor (CPU), memory, graphics unit (GPU), audio chip and input/output interfaces. Also the LTE or 5G modem for accessing mobile networks are part of the SoC. When a user initiates a command on the device, the processor in the SoC reads the instruction and carries out the corresponding task. The memory component stores data and programs, allowing the processor to access them when needed. The input/output interfaces connect the SoC to other devices or networks, enabling data transfer and communication.

SIM & SIM toolkit applications are used to utilise the SIM file system structure to store application variables and multi-IMSI functions. They further control the IMSI allocated in certain network areas and domains or trigger actions that can be used for various value-added services. Based on a set of commands programmed into the SIM card it can be determined how the SIM card should interact with the outside world and initiate commands independently of the handset and the network. This allows the SIM card to establish an interactive exchange between a network application and the end user and to access or control access to the network. The SIM card itself also forwards commands to the handset, e.g. displaying menus and/or requesting user input. It further includes standardized variables, such as the preferred network list, forbidden network list (e.g. for steering purposes), operator name and address book entries.

Smartphones are therefore complex systems and need to be verified in combination with all the different network functions and services to ensure a proper QoE.

4.1.1 Challenges in Traditional QoE Testing Methods

One major challenge in QoE testing is the difficulty to define appropriate KPIs reflecting user experience as users perceive services differently and hence are subjective. This topic is discussed in more detail in the chapter *“Services, KPIs and Thresholds”* of this document.

Another challenge is to select the proper method for verifying QoE. Certain methods rely on simulated networks that often have nothing to do with the real customer environment or use probes that do not correspond to the complexity of a real smartphone as previously described. Such methods are not suitable to identify true QoE as not replicating real user behaviours.

4.1.2 Importance of QoE Testing with real smartphones

As the customer's interaction with the network takes place exclusively via real end devices, a realistic simulation of the user experience can only be achieved by using a real end device (smartphone). Any other method would leave a lot of room for interpretation and cannot tell whether the test result really corresponds to the end user experience.

To emphasis the argument above you can find an extract of a study which was done by the department of Computer Science at Stony Brook University. Within that study the QoE of three of the most popular mobile applications was analysed:

- Web browsing
- Video streaming
- Video calling

Only hardware aspects were considered and already in this field significant differences in service utilisation could be identified. Up to 7 seconds in the average Page Load Time (PLT) between the low-end mobile phone and the high-end mobile phone were found even when simply loading web pages. The research also shows a significant difference around video applications (streaming and telephony). There is an increase of 4 seconds in startup latency and a 15% increase in the delay rate depending on the device used. The mentioned values are only based on the device itself, as the network and environmental conditions were unchanged.

When it comes to OTT applications, it becomes even more complicated, as the IP traffic between the client device and the service is usually encrypted and cannot be detected by the network operator in terms of QoS, further the following additional factors come into play:

- The server hosting the service is owned by a third party and cannot be controlled by the network operator or the company carrying out the measurement campaign
- Apps are consumer software with certain instabilities and are subject to frequent updates and must be compatible with the smartphones operating system
- Services can change and even with the same app version, network interaction can change suddenly due to server influences.

Meaning that throughput rates, transmission and response times and other technical metrics cannot be determined with certainty in case of OTT application usage and do not reflect network performance. A high data rate is not sufficient anymore alone to guarantee smooth experience for smartphone applications and to capture the true smartphone application experience, from end user perspective, the tests must be performed on application level rather than only on network level.

The mentioned facts within this chapter clearly emphasise how important real smartphone testing is within the QoE area.

5 Services, KPIs and Thresholds

To cover the real aspects of QoE, the KPI definitions focus on using scenarios that occur in the daily use of a customer. All QoS related aspects are already covered by the tests defined within the existing GRQ / IR.81 and the associated documents.

5.1 Network Accessibility QoE

Considering the QoE within a successful registration of a user on the PMN. In 5G, accessibility refer to the ability for the users to register to the network and to a network slice using a real smartphone.

5.1.1 KPIs needed for Network Registration

Phone needs to be initially registered within the HPMN and put to flight mode under HPMN coverage. Device is now moved into roaming VPMN coverage, and the flight mode is deactivated, or automatic network selection is selected. Based on this, a realistic user scenario can be verified when a customer e.g. boards a plane in his home country and then switches on his mobile phone in the destination country.

5.1.1.1 QoE Initial Registration in VPMN – Definitions

This QIREGVPMN describes the time needed to attach to the visited network from the time when pressing the “deactivate flight mode” button in the phone menu.

Trigger points:

Start:	Point of time when user is pressing the “deactivate flight mode” button or is enabling the “automatic network selection” on the smartphone
Stop:	Point of time when the mobile indicated that the attach procedure was successfully done

QoE 4G/5G Network Available – Definitions

This QI4G5GVPMN describes the period needed to attach to the visited network from the time when pressing the “deactivate flight mode” button in the phone menu.

Trigger points:

Start:	Point of time when user is pressing the “deactivate flight mode” button or is enabling the “automatic network selection”
Stop:	Point of time when the mobile shows the successful attach to 4G or 5G

Remarks:

In case of 5G and network slicing the stop trigger point will also include the successful slice selection according to additional definitions required.

5.2 Mobile to Mobile Calls

Considering the QoE within a successful mobile to mobile call of a user on the PMN.

5.2.1 KPIs needed for Mobile to Mobile Calls

To properly test this scenario two phone needs to be registered within the VPMN and one phone is under HPMN coverage. The defined KPIs verify the most common scenarios on mobile-to-mobile calls when roaming, meaning all possible interworking scenarios with other subscribers out of the home network.

5.2.1.1 QoE Call VPMN to HPMN

This QCALLVPHP describes the QoE when subscribers for the same network are making a call to each other, the originating subscriber is located in the VPMN and the terminating subscriber is located in the HPMN.

Trigger points:

Beginning of the call attempt:	Point of time when user is pressing the “Dial” button on the smartphone in the VPMN
Successful call establishment	Point of time when the HPMN mobile is showing the incoming call and the CLI is correctly shown
Successful call:	Call can be successfully answered and speech path and speech quality (MOS value ok)

Remarks:

MOS Definitions can be taken according to the available definitions and standards based on POLQA algorithm.

5.2.1.2 QoE Call HPMN to VPMN

This QCALLHPVP describes the QoE when subscribers for the same network are making a call to each other, the originating subscriber is located in the HPMN and the terminating subscriber is located in the VPMN.

Trigger points:

Beginning of the call attempt:	Point of time when user is pressing the “Dial” button on the smartphone in the HPMN
Successful call establishment	Point of time when the VPMN mobile is showing the incoming call and the CLI is correctly shown
Successful call:	Call can be successfully answered and speech path and speech quality (MOS are ok)

Remarks:

MOS Definitions can be taken according to the available definitions and standards based on POLQA algorithm.

5.2.1.3 QoE Call VPMN to VPMN

This QCALLVPVP describes the QoE when subscribers for the same network are making a call to each other, the originating subscriber is located in the VPMN and the terminating subscriber is located in the VPMN.

Trigger points:

Beginning of the call attempt:	Point of time when user is pressing the “Dial” button on the smartphone in the VPMN
Successful call establishment	Point of time when the VPMN mobile is showing the incoming call and the CLI is correctly shown
Successful call:	Call can be successfully answered and speech path and speech quality (MOS are ok)

Remarks:

MOS Definitions can be taken according to the available definitions and standards based on POLQA algorithm.

5.3 Mobile to Mobile SMS

Considering the QoE within a successful mobile to mobile SMS sending/receiving of a user on the PMN.

5.3.1 KPIs needed for Mobile to Mobile SMS

To properly test this scenario two phones need to be registered within the VPMN and one phone is under HPMN coverage. The defined KPIs verify the most common scenarios on mobile-to-mobile SMS sending/receiving when roaming, meaning all possible interworking scenarios with other subscribers out of the home network.

5.3.1.1 QoE SMS VPMN to HPMN

This QSMSVPHP describes the QoE when subscribers for the same network are sending SMS to each other, the originating subscriber is located in the VPMN and the terminating subscriber is located in the HPMN.

Trigger points:

Start SMS service attempt:	Initiate sending a SMS from the subscriber located in the VPMLN via the real user equipment (smartphone)
Successful SMS delivery:	Receiving Short Message at the real user equipment (smartphone) located in the HPMN

Remarks:

The SMS end-to-end delivery time is the time between sending a short message from the VPMN till the smartphone located in the HPMN receiving the very same short message from the Short Message Centre. In that case the real end to end delivery time is calculated (time from A-Party to SMSC and the delivery from the SMSC to the B-Party).

5.3.1.2 QoE SMS HPMN to VPMN

This QSMSHPVP describes the QoE when subscribers for the same network are sending SMS to each other, the originating subscriber is located in the HPMN and the terminating subscriber is located in the VPMN.

Trigger points:

Start SMS service attempt:	Initiate sending a SMS from the subscriber located in the HPMLN via the real user equipment (smartphone)
Successful SMS delivery:	Receiving Short Message at the real user equipment (smartphone) located in the VPMN

Remarks:

The SMS end-to-end delivery time is the time between sending a short message from the HPMN till the smartphone located in the VPMN receiving the very same short message from the Short Message Centre. In that case the real end to end delivery time is calculated (time from A-Party to SMSC and the delivery from the SMS This QSMSVPVP describes the QoE when subscribers for the same network are sending SMS to each other, the originating subscriber is located in the VPMN and the terminating subscriber is located in the VPMN as well.

Trigger points:

Start SMS service attempt:	Initiate sending a SMS from the subscriber located in the VPMLN via the real user equipment (smartphone)
Successful SMS delivery:	Receiving Short Message at the real user equipment (smartphone) located in the VPMN

Remarks:

The SMS end-to-end delivery time is the time between sending a short message from the VPMN till the smartphone located in the VPMN receiving the very same short message from the Short Message Centre. In that case the real end to end delivery time is calculated (time from A-Party to SMSC and the delivery from the SMSC to the B-Party).

5.4 OTT Application Testing

Considering the QoE within the usage of an OTT Application (Video (Video Quality Verification will be done by using app with short (5-25 seconds) video and collecting and calculating KPIs for Video Quality Verification), Voice & Messaging) of a user on the PMN.

5.4.1 KPIs needed for OTT Application Testing

5.4.1.1 KPIs needed for Video Quality Verification

To properly test and verify the Video Quality the phone needs to be registered within the VPMN. The defined KPIs verify the most important indicators that are necessary, to make a proper statement regarding the received Video Quality from User perspective when subscribers are watching a Video on a smartphone.

QoE Video Success Rate

This QOYTVSR describes the QoE when a subscriber is watching a Video on the VMPLN.

Trigger points:

Start Video Service:	Open a reference video via the real user equipment (smartphone)
Successful Video service access:	Video can be started successfully using the real user equipment (smartphone) located in the VPMN

Abstract formula:

QOYTVSR Success Ratio can be calculated with the following:

$$\text{QOYTVSR Success Ratio} = \frac{\text{NrSuccessfullVideoServiceAccessAttempts}}{\text{TotalNrVideoServiceAccessAttempts}} \text{X100\%}$$

5.4.1.1.1 QoE Video Quality Block Loss

The QOYTVQBLL describes the QoE when a subscriber is watching a Video on the VMPLN in terms of Block Loss.

Trigger points:

Start Video Service:	Open a reference video via the real user equipment (smartphone)
Successful Video service access:	Video can be started successfully using the real user equipment (smartphone) located in the VPMN
Successful Video service usage:	Video Quality indicator for Block Loss is in the pre-defined range needed to ensure proper QoE

Block loss Indicator Range (min. = 0, max. = 200), higher value → lower resolution, the acceptable value for an image without distortion is from 0 – 5.

QoE Video Quality Blur

The QOYTVQBLU describes the QoE when a subscriber is watching a Video on the VMPLN in terms of Blur.

Trigger points:

Start Video Service:	Open a reference video via the real user equipment (smartphone)
Successful Video service access:	Video can be started successfully using the real user equipment (smartphone) located in the VPMN
Successful Video service usage:	Video Quality indicator for Blur is in the pre-defined range needed to ensure proper QoE

Blur Indicator Range (min. = 0, max. = 70) , Greater value → more visible distortion, the acceptable value for an image without distortion is from 0 – 5.

QoE Video Quality Spatial Activity

The QOYTVQSPA describes the QoE when a subscriber is watching a Video on the VMPLN in terms of Spatial Activity.

Trigger points:

Start Video Service:	Open a reference video via the real user equipment (smartphone)
Successful Video service access:	Video can be started successfully using the real user equipment (smartphone) located in the VPMN
Successful Video service usage:	Video Quality indicator for Spatial Activity is in the pre-defined range needed to ensure proper QoE

Spatial Activity Indicator Range (min. = 0, max. = 270), Greater value → greater Spatial Activity, acceptable range 0 – 60

QoE Video Quality Freezing

The QOYTVQFRE describes the QoE when a subscriber is watching a Video on the VMPLN in terms of Freezing.

Trigger points:

Start Video Service:	Open a reference video via the real user equipment (smartphone)
Successful Video service access:	Video can be started successfully using the real user equipment (smartphone) located in the VPMN
Successful Video service usage:	Video Quality indicator for Freezing is in the pre-defined range needed to ensure proper QoE

Freezing Indicator Range (min. = 0, max. = 1), Greater value → greater Freezing, the acceptable value for an image without distortion is 0

QoE Video Quality Dropped Frames

The QOYTVQDRF describes the QoE when a subscriber is watching a Video on the VMPLN in terms of Dropped Frames.

Trigger points:

Start Video Service:	Open a reference video via the real user equipment (smartphone)
Successful Video service access:	Video can be started successfully using the real user equipment (smartphone) located in the VPMN
Successful Video service usage:	Video Quality indicator for Dropped Frames is in the pre-defined range needed to ensure proper QoE

Dropped Frames Indicator Range (min. = 0, max. = 1), Greater value → greater amount of Dropped Frames, the acceptable value for an image without distortion is 0

QoE Video Quality Frame Rate

The QOYTVQFRR describes the QoE when a subscriber is watching a Video on the VMPLN in terms of Frame Rate.

Trigger points:

Start Video Service:	Open a reference video via the real user equipment (smartphone)
Successful Video service access:	Video can be started successfully using the real user equipment (smartphone) located in the VPMN
Successful Video service usage:	Video Quality indicator for Frame Rate is in the pre-defined range needed to ensure proper QoE

Frame Rate Indicator Range (min. = 24, max. = 60), Greater value → greater number of Frames per second, i.e. clearer picture.

Attached the value definitions regarding the achieved frame rate depending on the required use case:

- 24fps: Movies and television shows
- 30fps: Live TV broadcasting
- 60fps: High-quality video

QoE Video Quality Resolution

The QOYTVQRES describes the QoE when a subscriber is watching a Video on the VMPLN in terms of Resolution.

Trigger points:

Start Video Service:	Open a reference video via the real user equipment (smartphone)
Successful Video service access:	Video can be started successfully using the real user equipment (smartphone) located in the VPMN
Successful Video service usage:	Video Quality indicator for Resolution is in the pre-defined range needed to ensure proper QoE

Attached the value definitions regarding the achieved resolution depending on the required use case:

720 resolution (HD 1280 x 720 pixels) - this is the lowest resolution to still be considered HD

1080 resolution (full HD 1920 x 1080 pixels) - has become the ***industry standard for a crisp HD digital video***

2k resolution (quad high definition 2560 x 1440 pixels) - larger displays, and reframing without lost quality

4k resolution (ultra-HD 3840 x 2160 pixels) - for theatrical viewing or intense colouring or graphics

8k resolution (7680 x 4320 pixels) - extremely high-res for big screens and zooming without pixelation

5.4.1.2 5.4.1.2 QoE OTT Voice VPMN to HPMN

This QOTTVVPHP describes the QoE when subscribers for the same network are making an OTT voice call to each other, the originating subscriber is located in the VPMN and the terminating subscriber is located in the HPMN.

Trigger points:

Beginning of the OTT voice call attempt:	Point of time when user is pressing the “Dial” button on the smartphone in the VPMN
Successful OTT call establishment	Point of time when the HPMN mobile is showing the incoming call and the CLI is correctly shown
Successful OTT call:	Call can be successfully answered and speech path and speech quality (MOS value ok)

Remarks:

MOS Definitions can be taken according to the available definitions and standards based on POLQA algorithm.

5.4.1.3 QoE OTT Voice HPMN to VPMN

This QOTTVHPVP describes the QoE when subscribers for the same network are making an OTT voice call to each other, the originating subscriber is located in the HPMN and the terminating subscriber is located in the VPMN.Trigger points:

Beginning of the OTT voice call attempt:	Point of time when user is pressing the “Dial” button on the smartphone in the HPMN
Successful OTT call establishment	Point of time when the VPMN mobile is showing the incoming call and the CLI is correctly shown
Successful OTT call:	Call can be successfully answered and speech path and speech quality (MOS are ok)

Remarks:

MOS Definitions can be taken according to the available definitions and standards based on POLQA algorithm.

5.4.1.4 QoE OTT Voice VPMN to VPMN

This QOTTVVPVP describes the QoE when subscribers for the same network are making an OTT voice call to each other, the originating subscriber is located in the VPMN and the terminating subscriber is located in the VPMN.

Trigger points:

Beginning of the OTT voice call attempt:	Point of time when user is pressing the “Dial” button on the smartphone in the VPMN
Successful OTT call establishment	Point of time when the VPMN mobile is showing the incoming call and the CLI is correctly shown
Successful OTT call:	Call can be successfully answered and speech path and speech quality (MOS are ok)

Remarks:

MOS Definitions can be taken according to the available definitions and standards based on POLQA algorithm.

5.4.1.5 5.4.1.5 QoE OTT Message VPMN to HPMN

This QOTTMVPHP describes the QoE when subscribers for the same network are sending OTT messages to each other, the originating subscriber is located in the VPMN and the terminating subscriber is located in the HPMN.

Trigger points:

Start OTT message service attempt:	Initiate sending an OTT message from the subscriber located in the VPMLN via the real user equipment (smartphone)
Successful OTT message delivery:	Receiving OTT message at the real user equipment (smartphone) located in the HPMN

5.4.1.6 5.4.1.6 QoE OTT Message HPMN to VPMN

This QOTTMHPVP describes the QoE when subscribers for the same network are sending OTT messages to each other, the originating subscriber is located in the HPMN and the terminating subscriber is located in the VPMN.

Trigger points:

Start OTT message service attempt:	Initiate sending an OTT message from the subscriber located in the HPMLN via the real user equipment (smartphone)
Successful OTT message delivery:	Receiving OTT message at the real user equipment (smartphone) located in the VPMN

5.4.1.7 QoE OTT Message VPMN to VPMN

This QOTTMVPVP describes the QoE when subscribers for the same network are sending OTT messages to each other, the originating subscriber is located in the VPMN and the terminating subscriber is located in the VPMN as well.

Trigger points:

Start OTT message service attempt:	Initiate sending an OTT message from the subscriber located in the VPMLN via the real user equipment (smartphone)
Successful OTT message delivery:	Receiving OTT message at the real user equipment (smartphone) located in the VPMN

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Feedback

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