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Speech and multimedia Transmission Quality (STQ);
Quality of Service aspects of voice communication
in an LTE environment

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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Speech and multimedia Transmission Quality (STQ).

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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Introduction

LTE networks are a reality in many markets. CS voice interworking is one of the most crucial points in many networks in Europe. Voice services used on LTE enabled handsets in an LTE environment bring along new QoS aspects which are not yet covered in [i.1], e.g.:

- CSFB, a procedure where the UE operating in LTE mode issues a special service request and the network signals the device to move (fall back) to 2G/3G to accept incoming calls or to place outgoing calls;
- VoLTE, Voice over IP in LTE networks using a dedicated packet bearer and SIP signalling. It is based on the IP Multimedia Subsystem (IMS) network with specific profiles for control and media planes. This approach results in the voice service being delivered as data flow within the LTE data bearer.

The two scenarios mentioned above, very frequently encountered in European networks and worldwide, present specific QoS issues that need to be addressed in detail.

Alternative approaches exist to carry voice calls in LTE networks such as SVLTE (Simultaneous Voice and LTE Data) and VoLGA (Voice Over LTE via Generic Access). However, these are not addressed in the present document as they have only limited industrial support at the time of publication of the present document.

1 Scope

The aim of the present document is to identify and describe important aspects, related QoS parameters, their trigger points and calculation methods in the context of voice communication taking place in an LTE environment.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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

Not applicable.

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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 TS 102 250-2 (V2.2.1): "Speech and multimedia Transmission Quality (STQ); QoS aspects for popular services in mobile networks; Part 2: Definition of Quality of Service parameters and their computation".

[i.2] ETSI TS 123 272 (V11.6.0): "Digital cellular telecommunications system (Phase 2+);Universal Mobile Telecommunications System (UMTS); LTE; Circuit Switched (CS) fallback in Evolved Packet System (EPS); Stage 2 (3GPP TS 23.272 version 11.6.0 Release 11)".

[i.3] ETSI TS 123 216 (V8.7.0): "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Single Radio Voice Call Continuity (SRVCC); Stage 2 (3GPP TS 23.216 version 8.7.0 Release 8)".

[i.4] ETSI TS 123 237 (V10.7.0): "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; IP Multimedia Subsystem (IMS) Service Continuity; Stage 2 (3GPP TS 23.237 version 10.7.0 Release 10)".

[i.5] ETSI TS 123 216 (V11.11.0): "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Single Radio Voice Call Continuity (SRVCC); Stage 2 (3GPP TS 23.216 version 11.11.0 Release 11)".

[i.6] ETSI TS 124 228 (V5.14.0): "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); Signalling flows for the IP multimedia call control based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP); Stage 3 (3GPP TS 24.228 version 5.14.0 Release 5)".

3 Abbreviations

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

2G	2nd Generation (mobile networks)
3G	3rd Generation (mobile networks)
3GPP	3rd Generation Partnership Project
4G	4th Generation (mobile networks)
CC	Call Control
CM	Connection Management
CS	Circuit Switched
CSFB	Circuit Switched Fall-Back
DL	DownLink
DTM	Dual Transfer Mode
EMM	EPS Mobility Management
eNodeB	Evolved Node B
EPS	Evolved Packet System
E-UTRAN	evolved UMTS Terrestrial Radio Access Network
GERAN	GSM EDGE Radio Access Network
GSM	Global System for Mobile communications
HO	HandOver
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IP-CAN	IP Connectivity Access Network
IRAT	Inter-Radio Access Technology
LTE	Long-Term Evolution
MME	Mobility Management Entity
NAS	Non-Access Stratum
P-CSCF	Proxy-Call Session Control Function
PS	Packet Switched
QoS	Quality of Service
RRC	Radio Resource Control
S-CSCF	Serving-Call Server Control Function
SIB	System Information Block
SIP	Session Initiation Protocol
SRVCC	Single Radio Voice Call Continuity
STQ	Speech and multimedia Transmission Quality
SVLTE	Simultaneous Voice and LTE Data
UE	User Equipment
UL	UpLink
UMTS	Universal Mobile Telecommunications System
UTRAN	UMTS Terrestrial Radio Access Network
VoLGA	Voice over LTE Generic Access
VoLTE	Voice over LTE

4 Circuit-Switched Fall Back

4.1 General overview of CSFB

Initially, operators are introducing LTE for packed data services only. For stationary fixed line substitution scenarios this was possible without special regards to existing circuit switched voice services. As LTE is now available on more and more Smartphones and VoLTE is only starting to be commercially deployed, many operators have integrated the circuit-switched fall back option to offer voice services to LTE-enabled handsets.

Therefore, a CS-capable Device registered to LTE needs to fall back to UMTS or even GSM before originating or terminating a voice call. This can have influence on the perceived service quality in terms of:

- longer service access time for the voice service;
- higher risk of failing service access, in particular for mobile-terminated calls;
- interruption of the data service during the CSFB and continuation in slower UMTS network (or interruption of the data service for the whole duration of the voice call in case of CSFB to GSM, if DTM is not available in the network).

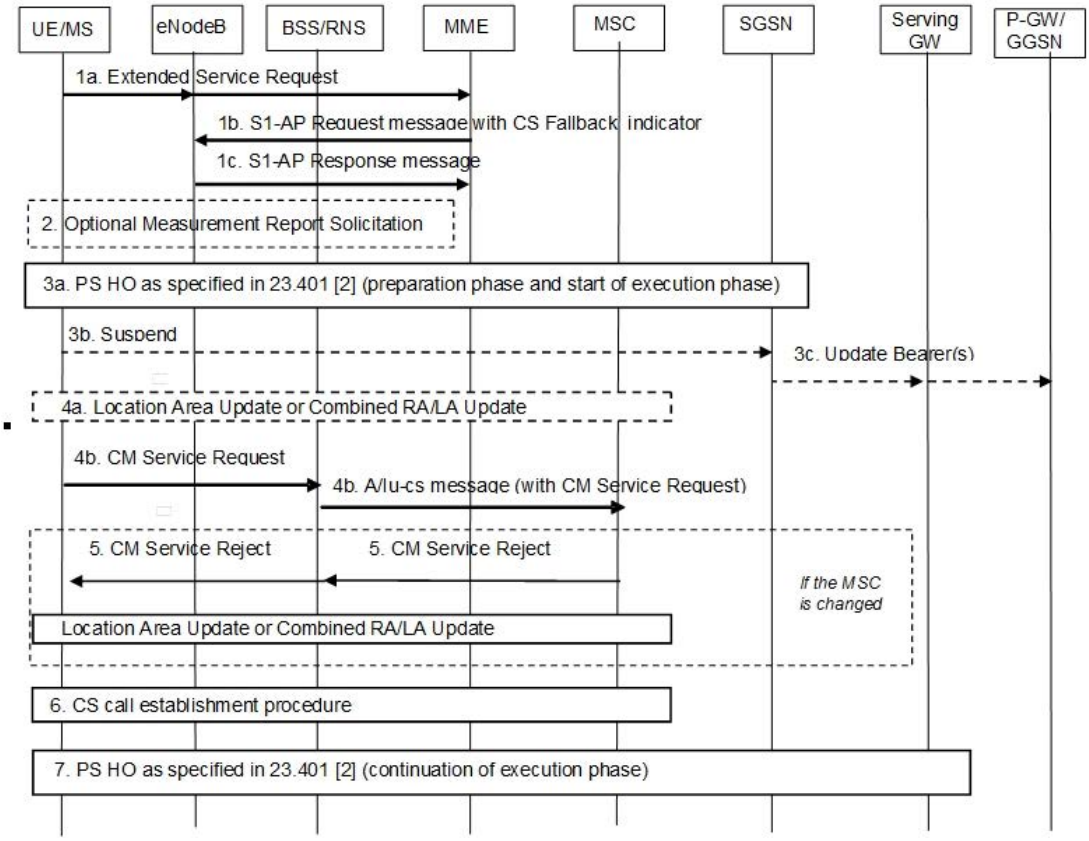

Figure 1: Mobile Originating call in Active Mode - PS HO supported (figure taken from ETSI TS 123 272 [i.2])

4.2 Amendments to existing QoS parameters

4.2.1 CSFB Call Setup Failure Ratio [%]

4.2.1.1 Preconditions

For a valid calculation the following preconditions need to be met:

- LTE coverage should be present.
- The UE should be registered to the LTE network.
- CSFB feature should be enabled in the network and supported by the UE.

4.2.1.2 Abstract definition

This parameter is the probability that the CSFB terminal cannot setup a call.

4.2.1.3 Abstract equation

$$\text{CSFB Call Setup Failure Ratio}[\%] = \frac{\text{unsuccessful CSFB Call setup attempt}}{\text{all CSFB Call setup attempt}} \times 100$$

4.2.1.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
CSFB Call Setup attempt	Start: User initiates call by pushing the call button.	Start: "RRC Connection Request" with cause "mo_Data", if present. Otherwise: "EMM Extended Service request (CS fallback indicator)" message is sent by calling party.
Successful CSFB Call Setup attempt	Stop: Alerting tone heard by calling party and called party rings.	Stop: The "ALERTING" message is received by calling party.
Unsuccessful CSFB Call Setup attempt	Stop: Calling party receives a notification that the call set-up is cancelled or does not receive any notification at all within a pre-determined time.	Stop: Successful end trigger not reached within a pre-determined time.

4.2.2 CSFB Call Setup Time [s]

4.2.2.1 Preconditions

For a valid calculation the following preconditions need to be met:

- LTE coverage should be present.
- The UE should be registered to the LTE network.
- CSFB feature should be enabled in the network and supported by the UE.

4.2.2.2 Abstract definition

This parameter is the time period between initiation and establishment of a CSFB call.

4.2.2.3 Abstract equation

$$\text{CSFB Call Setup Time}[\text{s}] = \left(t_{\text{calling party receives Alerting tone}} - t_{\text{user press call button}}\right)[\text{s}]$$

4.2.2.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
$t_{\text{user press call button}}$ Time of user presses call button	Start: User initiates call by pushing the call button.	Start: "RRC Connection Request" with cause "mo_Data", if present. Otherwise: "EMM Extended Service request (CS fallback indicator)" message is sent by calling party.
$t_{\text{A-party receives Alerting tone}}$ Time of calling party receives Alerting tone	Stop: Alerting tone heard by calling party and called party rings.	Stop: The "ALERTING" message is received by calling party.
NOTE: In case of networks employing "early-alerting" features the "CONNECT" message should replace the "ALERTING" one, under the assumption that called party measurement system picks up the call after a constant time interval after ringing and that the latter is subtracted by the gross call setup time.		

For other CSFB call parameters such as CSFB Call Speech Quality on Call Basis and CSFB Call Speech Quality on Sample Basis, which are the same as in regular telephony case, please refer to [i.1], clause 6.6.

4.3 Proposed new QoS parameters in the context of CSFB

4.3.1 Overview

Service access procedure in the presence of CSFB can be broken down in order to better highlight the added delay and increased failure risk due to the CSFB phase itself. To this end we define CSFB Failure/Success Ratio [%] to denote whether the CSFB procedure ends successfully in such a way that the mobile can continue with the actual call setup signalling. In analogy, CSFB Time [s] indicates the duration of the CSFB procedure until the actual call setup signalling can be initiated. Finally, right after the call is completed the network is expected to move the UE back to 4G network to re-establish the desired data service experience for the users. Therefore, we denote as Return to LTE Failure Ratio [%] / Time [s] the probability that the UE is handed back to LTE after the CSFB call and the time interval since the call release until LTE data service is restored, respectively.

A relevant use case for the introduction of Return to LTE metrics is the situation where a user is running a data session (e.g. listening to digital radio, downloading an App, etc.) and receives an incoming call on its single-radio terminal. In this case, CSFB procedure starts, the call is established and the data session is transferred to e.g. UMTS technology - with potential detriment of user perceived performance. When the call is terminated, user data session should be handed back to LTE if network coverage is adequate, so that the user can benefit again from higher data rates. However, this reselection to LTE may be delayed to different extents depending on network implementation and configuration.

4.3.2 CSFB Failure Ratio [%] - Calling party

4.3.2.1 Preconditions

For a valid calculation the following preconditions need to be met:

- LTE coverage should be present.
- The UE should be registered to the LTE network.
- CSFB feature should be enabled in the network and supported by the UE.

4.3.2.2 Abstract definition

This parameter measures the probability that the CSFB procedure is not executed successfully by the calling party.

4.3.2.3 Abstract equation

$$\text{CSFB Failure Ratio}_{(\text{calling party})}\,[\%] = \frac{\text{unsuccessful CSFB attempts}_{(\text{calling party})}}{\text{all CSFB attempts}_{(\text{calling party})}} \times 100$$

4.3.2.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
CSFB attempt (calling party)	Start: User presses the dial button.	Start: "RRC Connection Request" with cause "mo_Data", if present. Otherwise: "EMM Extended Service request (CS fallback indicator)" message is sent by calling party.
Successful CSFB attempt (calling party)	Stop: Network type indicator on the UE's display switches to the new network type.	Stop: "CM Service Request" message is sent by calling party.
unsuccessful CSFB attempt (calling party)	Stop: Network type indicator on the UE's display does NOT switch to the new network type within a pre-determined time.	Stop: Successful end trigger is not reached within a pre-determined time.

4.3.3 CSFB Time [s] - Calling party

4.3.3.1 Preconditions

For a valid calculation the following preconditions need to be met:

- LTE coverage should be present.
- The UE should be registered to the LTE network.
- CSFB feature should be enabled in the network and supported by the UE.
- CSFB procedure needs to be successful.

4.3.3.2 Abstract definition

This parameter measures the duration of a CSFB procedure successfully executed on the calling party.

4.3.3.3 Abstract equation

$$\text{CSFB Time}\,[\text{s}]_{(\text{calling party})} = \left(t_{\text{calling party initiates CS call setup}} - t_{\text{user presses the dial button}}\right)[\text{s}]$$

4.3.3.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
$t_{\text{user presses the dial button}}$ Time when the user presses the dial button.	Start: User triggers CSFB procedure by pressing the dial button.	Start: "RRC Connection Request" with cause "mo_Data", if present. Otherwise: "EMM Extended Service request (CS fallback indicator)" message is sent by calling party.
$t_{\text{A-party initiates CS call setup}}$ Time when calling party initiates call setup procedure in the CS network.	Stop: Network type indicator on the UE's display switches to the new network type.	Stop: "CM Service Request" message is sent by calling party.

4.3.4 CSFB Failure Ratio [%] - Called party

4.3.4.1 Preconditions

For a valid calculation the following preconditions need to be met:

- LTE coverage should be present.
- The UE should be registered to the LTE network.
- CSFB feature should be enabled in the network and supported by the UE.

4.3.4.2 Abstract definition

This parameter measures the probability that the CSFB procedure is not executed successfully on the terminating side.

4.3.4.3 Abstract equation

$$\text{CSFB Failure Ratio}_{\text{(called party)}}\,[\%] = \frac{\text{unsuccessful CSFB attempts}_{\text{(called party)}}}{\text{all CSFB attempts}_{\text{(called party)}}} \times 100$$

4.3.4.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
CSFB attempt (called party)	Start: N/A	Start: "RRC Connection Request" with cause "mt_Access", if present. Otherwise: "EMM Extended Service request (CS fallback indicator)" message is sent by called party.
Successful CSFB attempt (called party)	Stop: Network type indicator on the UE's display switches to the new network type.	Stop: "Setup" Message is received from network.
unsuccessful CSFB attempt (called party)	Stop: Network type indicator on the UE's display does NOT switch to the new network type.	Stop: Successful end trigger not reached within a pre-determined time.

4.3.5 CSFB Time [s] - Called party

4.3.5.1 Preconditions

For a valid calculation the following preconditions need to be met:

- LTE coverage should be present.
- The UE should be registered to the LTE network.
- CSFB feature should be enabled in the network and supported by the UE.
- CSFB procedure needs to be successful.

4.3.5.2 Abstract definition

This parameter measures the duration of a CSFB procedure successfully executed on the terminating side.

4.3.5.3 Abstract equation

$$\text{CSFB Time [s]}_{\text{(called party)}} = \left(t_{\text{called party initiates CS call setup}} - t_{\text{called party requests fallback}}\right)\text{[s]}$$

4.3.5.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
$t_{\text{B-party requests fallback}}$ Time when the called party starts CSFB procedure after being paged.	Start: N/A	Start: "RRC Connection Request" with cause "mt_Access", if present. Otherwise: "EMM Extended Service request (CS fallback indicator)" message is sent by called party.
$t_{\text{B-party initiates CS call setup}}$ Time when the called party initiates call setup procedure in CS network.	Stop: Network type indicator on the UE's display switches to the new network type.	Stop: "Setup" message is received from network.

4.3.6 CSFB Return to LTE Failure Ratio [%]

4.3.6.1 Preconditions

For a valid calculation the following preconditions need to be met:

- LTE coverage should be present at the end of the CSFB call.
- CSFB feature should be enabled in the network and supported by the UE.
- A call should be successfully established (w/ or w/o CSFB).
- The call should be regularly disconnected (i.e. no drop).

4.3.6.2 Abstract definition

This parameter measures the probability that the UE does not re-join the LTE network after a CSFB call within a pre-determined time interval.

4.3.6.3 Abstract equation

$$\text{Return to LTE Failure Ratio [\%]} = \frac{\text{unsuccessful Return to LTE attempts}}{\text{all Return to LTE attempts}} \times 100$$

4.3.6.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
Return to LTE attempt.	Start: User hangs up the call.	Start: NAS DL/UL Disconnect (Normal clearing).
Successful Return to LTE attempt.	Stop: Network type indicator on the UE's display switches to LTE.	Stop: First SIB message decoded in LTE.
Unsuccessful Return to LTE attempt.	Stop: Network type indicator on the UE's display does NOT switch to LTE within a predetermined time.	Stop: Successful end trigger not reached within a pre-determined time.

NOTE: In a measurement system with automatic call dialling this parameter is influenced by the call interval. In particular the call interval will implicitly set the timeout for Return to LTE calculation.

4.3.7 CSFB Return to LTE Time [s]

4.3.7.1 Preconditions

For a valid calculation the following preconditions need to be met:

- LTE coverage should be present.
- CSFB feature should be enabled in the network and supported by the UE.
- A call should be successfully established w/ CSFB.
- The call should be regularly disconnected (i.e. no drop).
- Return to LTE procedure needs to be successful.

4.3.7.2 Abstract definition

This parameter measures the time needed by the UE to re-join the LTE network after a CSFB call.

4.3.7.3 Abstract equation

$$\text{Return to LTE Time}\,[\text{s}] = \left(t_{\text{first SIB message in LTE received}} - t_{\text{call disconnected}}\right)[\text{s}]$$

4.3.7.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
$t_{\text{call disconnected}}$ Time when the call is disconnected.	Start: User hangs up the call.	Start: NAS DL/UL disconnect (normal clearing).
$t_{\text{first SIB message in LTE received}}$ Time when the first SIB message in LTE is received.	Stop: Network type indicator on the UE's display switches to LTE.	Stop: First SIB message decoded in LTE.

NOTE: In a measurement system with automatic call dialling this parameter is influenced by the call interval. In particular the call interval will implicitly set the timeout for Return to LTE calculation.

5 VoLTE (IMS based)

5.1 Overview

The foreseen amendments for voice QoS parameters in the context of VoLTE are essentially due to the introduction of SIP protocol, with consequent revision of start/end triggers.

Besides SIP protocol triggers, special attention should be paid to Single Radio Voice Call Continuity (SRVCC) cases. In SRVCC (firstly introduced in Release 8), when LTE coverage is not sufficient, a handover of a packet-based VoIP call to a circuit-based voice call is performed. Among the different SRVCC scenarios it is worth mentioning:

- SRVCC for voice calls that are anchored in the IMS core [i.3].
- aSRVCC, i.e. SRVCC in alerting phase [i.4].
- rSRVCC, i.e. SRVCC from UTRAN/GERAN to E-UTRAN/HSPA [i.5].

In the present document the focus is restricted to the first type of SRVCC and considers UTRAN only as target network for the handover.

From the perspective of measurement methodology this implies that in the same call, triggers based on SIP protocol as well on CC protocol (as in case of UMTS/GSM) can be expected.

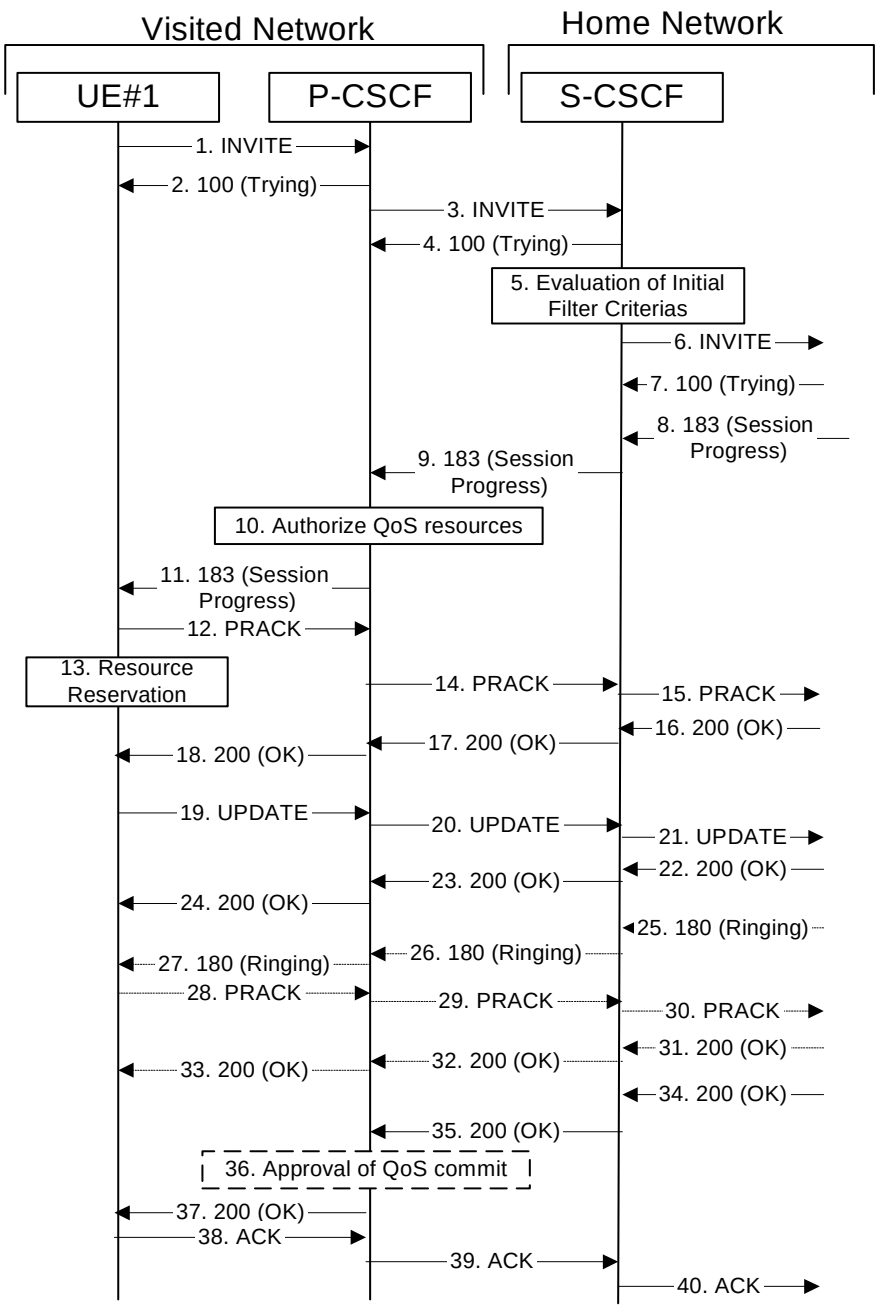

Figure 2: Mobile origination, roaming assumed, without I-CSCF providing configuration independence, see MO#1a in [i.6]

5.2 Amendments to existing QoS parameters

5.2.1 VoLTE Session Setup Failure Ratio [%]

5.2.1.1 Preconditions

For a valid calculation the following preconditions need to be met:

- EPS bearer should be established and the EPS ATTACH message should contain "IMS PS Voice" in the voice domain preference list.
- IMS should be present.
- LTE coverage should be present.
- IMS registration should be successfully accomplished.
- The call setup should start as IMS to IMS (although it may continue over legacy technologies after iRAT handover).

5.2.1.2 Abstract definition

This parameter is the probability that the VoLTE terminal cannot setup a session.

5.2.1.3 Abstract equation

$$\text{VoLTE Session Setup Failure Ratio}\,[\%] = \frac{\text{unsuccessful VoLTE session setup attempt}}{\text{all VoLTE session setup attempt}} \times 100$$

5.2.1.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
VoLTE Session Setup attempt.	Start: User initiates session by pushing the call button.	Start: Protocol SIP: first "INVITE" sent by calling party.
Successful VoLTE Session Setup attempt.	Stop: Alerting tone heard by calling party and called party rings.	Stop: Protocol SIP: "200OK (INVITE)" received by calling party.
Unsuccessful VoLTE Session Setup attempt.	Stop: Calling party receives a notification that the session set-up is cancelled or does not receive any notification at all within a pre-determined time.	Stop: Successful end trigger not reached within a pre-determined time.

5.2.2 VoLTE Session Setup Time [s]

5.2.2.1 Preconditions

For a valid calculation the following preconditions need to be met:

- EPS bearer should be established and the EPS ATTACH message should contain "IMS PS Voice" in the voice domain preference list.
- IMS should be present.
- LTE coverage should be present.
- IMS registration should be successfully accomplished.

- The call setup should start as IMS to IMS (although it can continue over legacy technologies after iRAT handover).
- The call should be successfully established.

5.2.2.2 Abstract definition

This parameter is the time needed to initialize a VoLTE session.

5.2.2.3 Abstract equation

$$\text{VoLTE Session Setup Time}\,[\text{s}] = \left(t_{\text{Calling party receives notification}} - t_{\text{Calling party initiates call session}}\right)[\text{s}]$$

5.2.2.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
$t_{\text{Calling party initiates call session}}$ Time when calling party initiates call session.	Start: User initiates session by pushing the call button.	Start: Protocol SIP: first "INVITE" sent by calling party.
$t_{\text{Calling party receives notification}}$ Time when calling party receives notification.	Stop: Alerting tone heard by calling party and called party rings.	Stop: Protocol SIP: "200 OK (INVITE)" received by calling party.

5.2.3 VoLTE Session Cut-off Ratio [%]

5.2.3.1 Preconditions

For a valid calculation the following preconditions need to be met:

- EPS bearer should be established and the EPS ATTACH message should contain "IMS PS Voice" in the voice domain preference list.
- IMS should be present.
- LTE coverage should be present.
- IMS registration should be successfully accomplished.
- The call setup should start as IMS to IMS (although it can continue over legacy technologies after iRAT handover).
- The call should be successfully established.

5.2.3.2 Abstract definition

This parameter is the probability that a successfully started call is ended by a cause other than intentional termination by Calling or Called party.

5.2.3.3 Abstract equation

$$\text{VoLTE Session Cut-off Ratio}\,[\%] = \frac{\text{unsuccessful completed VoLTE session}}{\text{all Successful started VoLTE sessions}} \times 100$$

5.2.3.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
Successfully Started VoLTE Session	Start: N/A	Start: Protocol SIP: "200 OK (INVITE)" received by calling party.
Successfully completed VoLTE Session.	Stop: The user is notified that the call has ended.	Stop: If (RRC: "MobilityFromEUTRACommand" with CS-fallback indicator set to false and TargetRATtype set to UTRA/GERAN is received) and (RRC "handovertoUTRANComplete" is received afterwards) then: CC: "DISCONNECT" message sent by calling or called party. Otherwise: protocol SIP "200 OK (Bye)" sent by calling or Called party.
Unsuccessfully completed VoLTE Session.	Stop: The call is unexpectedly released.	Stop: Successful end trigger not reached within a pre-determined time.

For other VoLTE call parameters such as VoLTE Call Speech Quality on Call Basis and VoLTE Call Speech Quality on Sample Basis, which are the same as in regular telephony case, please refer to [i.1], clause 6.6.

5.3 Proposed new QoS parameters in the context of VoLTE

5.3.1 Overview

User perception of QoS in the context of VoLTE calls in terms of accessibility, call retainability and speech quality is impacted by VoLTE-specific behaviours that are worth analysing in greater detail.

Concerning control-plane procedures, two typical procedures are considered in this clause:

- IMS Registration.
- SRVCC handover.

IMS registration is performed whenever the UE is turned on. However, there are several other cases when such a procedure may occur, for instance when the initial registration is unsuccessful or there is a change in the IP-CAN. Furthermore, re-registration should be performed after timer expiry or when arbitrarily decided by network (depending on different implementations). Therefore, the amount of registration attempts and their duration may determine a decrease in network availability which should be taken into account.

SRVCC procedure consists of an IRAT handover from LTE to UMTS/GSM (or vice versa in rSRVCC case, not considered here) during an active call. The expected user perception may vary from an unnoticeably brief speech interruption to a major interruption or decrease of speech quality or even call drop in worst cases.

5.3.2 IMS Registration Success Ratio [%]

5.3.2.1 Preconditions

For a valid calculation the following preconditions need to be met:

- EPS bearer should be established and the EPS ATTACH message should contain "IMS PS Voice" in the voice domain preference list.
- IMS should be present.

- LTE coverage should be present.
- UE knows the IP address of its proxy CSCF (P-CSCF).

5.3.2.2 Abstract definition

This parameter is the probability that UE successfully registers to IMS.

5.3.2.3 Abstract equation

$$\text{IMS Registration Success Ratio}\,[\%] = \frac{\text{successful IMS Registration attempts}}{\text{all IMS Registration attempts}} \times 100$$

5.3.2.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
IMS Registration attempt.	Start: N/A	Start: Protocol SIP: first "REGISTER" sent by UE.
Successful IMS Registration attempt.	Stop: N/A	Stop: Protocol SIP: "200 OK (REGISTER)" received by UE.
Unsuccessfully IMS Registration attempt.	Stop: N/A	Stop: Successful end trigger not reached within a pre-determined time.
NOTE: On first registration after UE switches on, the proxy CSCF will respond to the first SIP "REGISTER" message with SIP "401 UNAUTHORIZED" containing an authorization challenge. Then UE will issue a second SIP "REGISTER" containing the authentication response. In case of success, P-CSCF will acknowledge the authentication with a SIP "200 OK (REGISTER)". The above triggers remain valid for both registration types with or without authentication challenge.		

5.3.3 IMS Registration Time [s]

5.3.3.1 Preconditions

For a valid calculation the following preconditions need to be met:

- EPS bearer should be established and the EPS ATTACH message should contain "IMS PS Voice" in the voice domain preference list.
- IMS should be present.
- LTE coverage should be present.
- UE knows IP address of its proxy CSCF (P-CSCF).
- IMS registration needs to complete successfully.

5.3.3.2 Abstract definition

This parameter is the time needed for successful registration to IMS.

5.3.3.3 Abstract equation

$$\text{IMS Registration Time}\,[\text{s}] = \left(t_{\text{Network confirms IMS registration}} - t_{\text{UE requests IMS Registration}}\right)[\text{s}]$$

5.3.3.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
UE requests IMS Registration attempt.	Start: N/A	Start: Protocol SIP: first "REGISTER" sent by UE.
Network confirms IMS registration.	Stop: N/A	Stop: Protocol SIP: "200 OK (REGISTER)" received by UE.
NOTE: On first registration after UE switches on, the proxy CSCF will respond to the first SIP "REGISTER" message with SIP "401 UNAUTHORIZED" containing an authorization challenge. Then UE will issue a second SIP "REGISTER" containing the authentication response. In case of success, P-CSCF will acknowledge the authentication with a SIP "200 OK (REGISTER)". The above triggers remain valid for both registration types with or without authentication challenge.		

5.3.4 SRVCC Success Ratio [%]

5.3.4.1 Preconditions

For a valid calculation the following preconditions need to be met:

- EPS bearer should be established and the EPS ATTACH message should contain "IMS PS Voice" as well as "CS Voice" in the voice domain preference list.
- VoLTE (IMS) call should be successfully established.

5.3.4.2 Abstract definition

This parameter is the probability that UE successfully handover an IMS-anchored call to UMTS.

5.3.4.3 Abstract equation

$$\text{SRVCC Success Ratio}\,[\%] = \frac{\text{successful SRVCC handovers}}{\text{all SRVCC invocations}} \times 100$$

5.3.4.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
SRVCC invocation.	Start: N/A	Start: Layer3 RRC: "MobilityFromEUTRACommand" with CS-fallback indicator set to false and TargetRATtype set to UTRAN is received.
Successful SRVCC handover.	Stop: N/A	Stop: Layer3 RRC: "handovertoUTRANComplete" is received.
Unsuccessful SRVCC handover.	Stop: The call might be unexpectedly released, interrupted or disturbed.	Stop: Successful end trigger not reached within a pre-determined time.

5.3.5 SRVCC Time [s]

5.3.5.1 Preconditions

For a valid calculation the following preconditions need to be met:

- EPS bearer should be established and the EPS ATTACH message should contain "IMS PS Voice" as well as "CS Voice" in the voice domain preference list.
- VoLTE (IMS) call should be successfully established.
- SRVCC handover needs to be successfully performed.

5.3.5.2 Abstract definition

This parameter is the time taken to successfully handover an IMS-anchored call to UMTS.

5.3.5.3 Abstract equation

$$\text{SRVCC Time}\,[\text{s}] = \left(t_{\text{SRVCC handover successfully completed}} - t_{\text{SRVCC handover invoked}}\right)[\text{s}]$$

5.3.5.4 Trigger points

Event from abstract equation	Trigger point from user's point of view	Technical description/protocol part
SRVCC invocation.	Start: N/A	Start: Layer3 RRC: "MobilityFromEUTRACommand" with CS-fallback indicator set to false and TargetRATtype set to UTRAN is received.
Successful SRVCC handover.	Stop: N/A	Stop: Layer3 RRC: "handovertoUTRANComplete" is received.

History

Document history		
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