Definition of Quality of Service parameters and their computation

3.4

10 August 2009

This is a non-binding permanent reference document of the GSM Association.

Security Classification Category (see next page)	
Unrestricted to	Industry

History

Version	Date	CR number	Brief Description
0.1.0	January 5th,2001		First draft of document for IREG QoS WP discussion
0.2.0	March 30th,2001		Second draft of document for IREG QoS WP e-mail discussion
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1.0.0	July 10th,2001		First stable Version for chapters Telephony, SMS
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3.2.1	February 10th, 2003		Editorial changes in chapters 2.5-2.7
3.3	April 16th, 2007		IREG doc 52_037 incorporated "Addition of the new QoS parameter definitions"
3.4	August 10th, 2009		Signal doc 43_009 incorporated "Changing computation method for speech quality from MOS to PESQ "

Table of Contents

1 Introduction

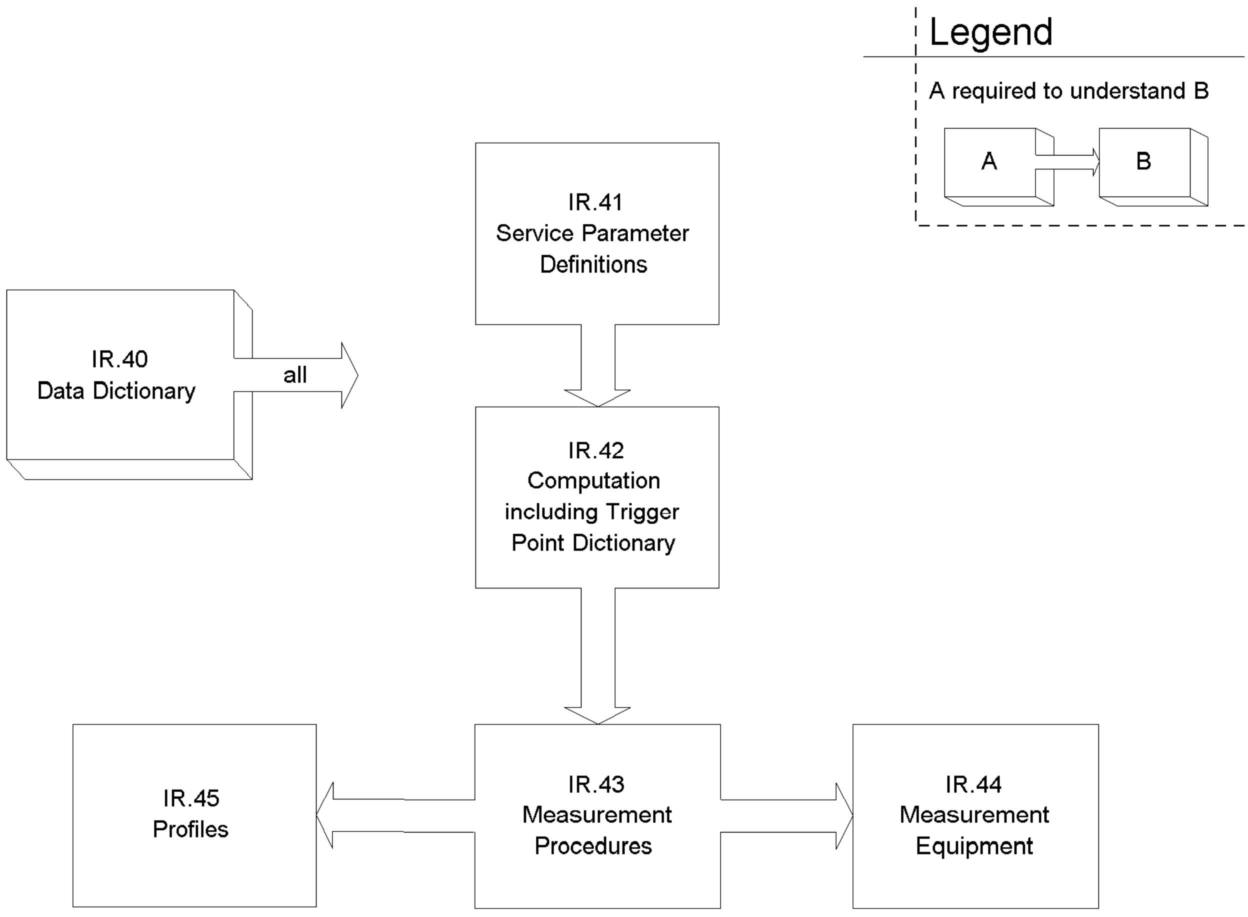
1.1 Scope of document

This document defines QoS parameters and their computation.

The technical QoS indicators, listed in document PRD IR.41, are the basis for the parameter set chosen. The parameter definition is split into two parts: the abstract definition and the generic description of the measurement method with the respective trigger points. Only measurement methods not dependent on any infrastructure provided are described in this document.[1]

The harmonised definitions given in this document are considered as the prerequisites for comparison of QoS measurements and measurement results.

1.2 Structure of PRD QoS Documents



1.3 Abbreviations

All abbreviations are given in the PRD IR.40 document.

[1] Computation of certain parameters may depend in the vary cellular system, i.e. GSM or 3GPP specified 3G system. In this case respective notification is provided.

1.4 General considerations

All the defined quality of service parameters and their computations are based on field measurements. That indicates that the measurements were made from customers point of view (full End-to-End perspective, taking into account the needs of testing).

It is assumed that the end customer can handle his mobile and the services he wants to use (operability is not evaluated at this time). For the purpose of measurement it is assumed

- that the service is available and not barred for any reason
- routing is defined correctly without errors and
- the target subscriber equipment is ready to answer the call.

Voice quality values measured should only be employed by calls ended successfully for statistical analysis.

However, measured values from calls ended unsuccessfully (e.g. dropped) should be available for additional evaluations and therefore, must be stored.

Further preconditions may apply when reasonable.

2 QoS Parameter

2.1 Overview

The following Figure 1 shows a model for quality of service parameters. This model has three layers.

The first layer is the Network Access, the basic requirement for all the other QoS aspects and QoS parameters. The outcome of this layer is the QoS parameter Network Accessibility

The second layer contains the other three QoS aspects Service Access, Service Integrity and Service Retainability.

The different services are located in the third layer. Their outcome are the QoS parameters.

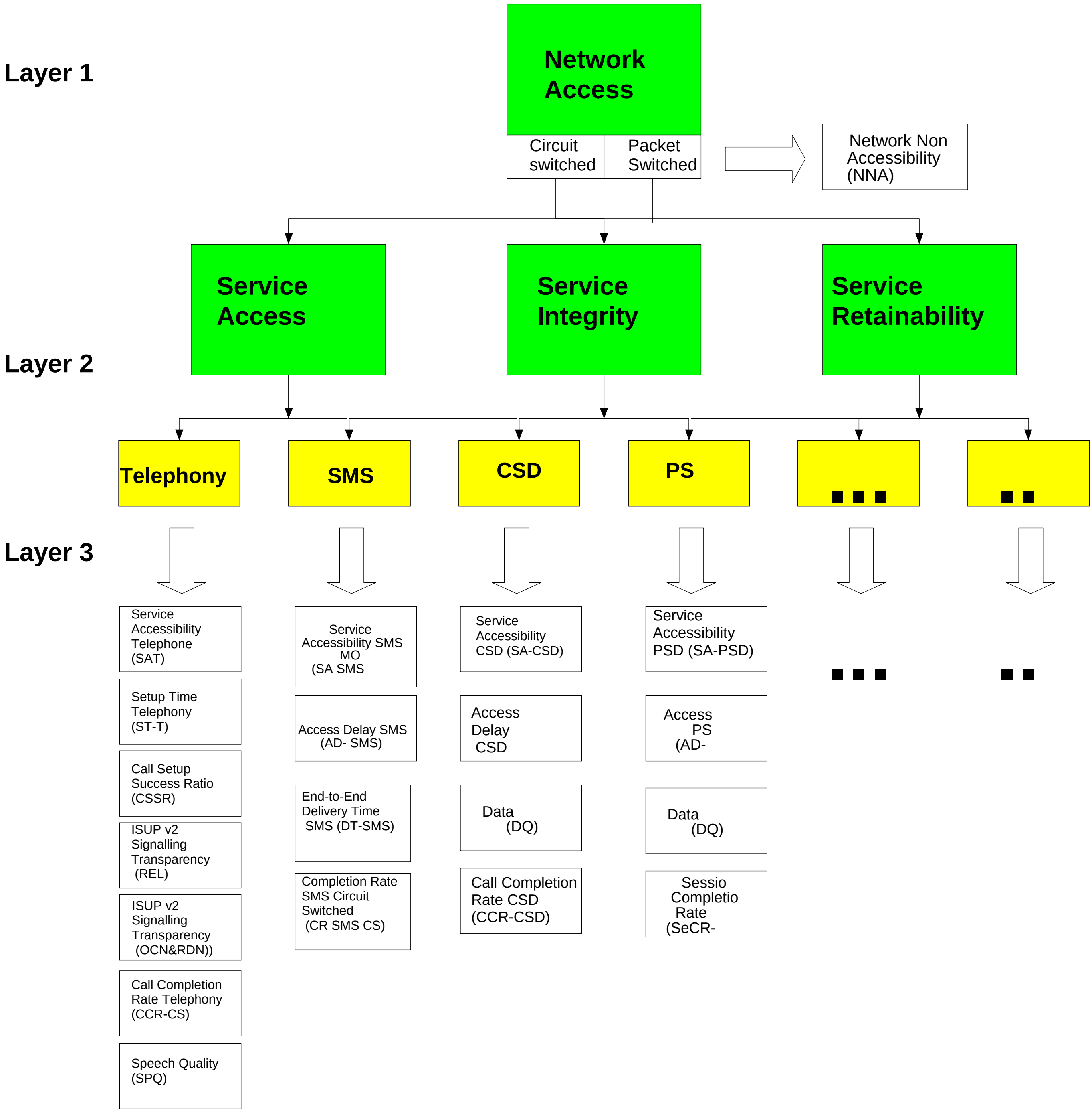


Figure 1: QoS aspects and the corresponding QoS parameters

2.2 Service independent

2.2.1 Network Accessibility Circuit Switched (NA – CS)

2.2.1.1 Abstract definition

Probability that the Mobile Services are offered to an end-customer by the target network indicators on the Mobile Equipment in idle mode.

2.2.1.2 Computation

Trigger points:

GSM: C1-Criteria > 0. Any emergency camping on any other than the target networks is considered as no network.

The target networks could constitute more than one network, e.g. to cover national or international roaming.

Abstract formula:

$$\text{NA-CS}_{gsm}[\%] = \frac{\text{Number of measurement samples with } C1 > 0}{\text{Number of all measurement samples}} \cdot 100\%$$

The sampling rate should be the same or a multiple of the Service Accessibility sampling rate. In order to compare the Network Accessibility with the Service Accessibility the sampling rate must be the same.

2.2.2 Network Accessibility Packet Switched (NA – PS)

2.2.2.1 Abstract definition

Probability that the Mobile Services are offered to an end-customer by the target network indicators on the Mobile Equipment in Standby mode.

2.2.2.2 Computation

Trigger points:

GSM: C1-Criteria > 0. And GPRS available in cell as designated in System Information Type 4 message or System Information Type 7 & 8 messages .The target networks could constitute more than one network, e.g. to cover national or international roaming.

Abstract formula:

$$\text{NA-PS}[\%] = \frac{\text{Number of measurement samples with } C1 > 0 \text{ and GPRS enabled for Cell}}{\text{Number of all measurement samples}} \cdot 100\%$$

The sampling rate should be the same or a multiple of the Service Accessibility sampling rate. In order to compare the Network Accessibility with the Service Accessibility the sampling rate must be the same.

2.3 Telephony

2.3.1 Service Accessibility Telephony (SA-T)

2.3.1.1 Abstract definition

Probability that the end-customer can access the Mobile Telephony Service when requested if it is offered by display of the network indicator on the Mobile Equipment.

Term NER (Network Effectiveness Ratio defined in ITU-E 425) can be understood as Service Accessibility Telephony.

2.3.1.2 Computation

There are two possibilities for a successful call attempt:

- The customer hears the alerting
- B-party is busy

It is assumed that the routing to the destination is successful (without any failures).

Abstract formula:

$$\text{Service Accessibility Telephony [\%]} = \frac{\text{Number of successful call attempts}}{\text{Number of call attempts}} * 100\%$$

Trigger points:

Beginning of the call attempt:	successful pressing send button (it is important to check, if coverage has been given when send button is pressed, otherwise this Call Attempt counts to Network Non Accessibility (NNA)).
Successful call attempt:	connect measurement (e.g. alerting or busy heard by A- party).

2.3.2 Setup Time Telephony (ST-T)

2.3.2.1 Abstract definition

Time between sending of complete address information and receipt of call set-up notification.

ITU-E 431 PDD (Post Dialling Delay) can be understood as ST-T.

2.3.2.2 Computation

Abstract formula:

$$\text{Setup Time Telephony [s]} = t_2 - t_1$$

t_2: point of time where connect is established (e.g. alerting[2] or subscriber busy is detected by test equipment))

t_1: point of time where the customer presses the send button on mobile equipment

<u>Trigger points:</u>

Beginning of the Setup Time measurement:	successful pressing send button (it is important to check, if coverage has been given, otherwise this Call Attempt counts to Network Non Accessibility (NNA))
Successful connection:	connect measurement (e.g. alerting or busy heard by A- party)

2.3.3 CSSR (Call Setup Success Ratio)

2.3.3.1 Abstract definition

CSSR expresses the relationship between the number of seizures and the sum of the number of seizures resulting in a successful established call.

2.3.3.2 Computation

Abstract formula:

$$CSSR[\%] = \frac{\text{Number of successful call establishments}}{\text{Number of call attempts}} * 100\%$$

Trigger points:

Beginning of the call attempt: successful pressing send button (it is important to check, if coverage has been given when send button is pressed, otherwise this Call Attempt counts to Network Non Accessibility (NNA)).

Successful call establishment: open connection between A-party and B-party, where both parties can hear each other.

2.3.4 REL (ISUPv2 signalling transparency)

2.3.4.1 Abstract definition

Effective uncorrupted transmission by the VPMN of the Cause Value in the Release (REL) ISUP messages, as defined in ITU-T Q850

2.3.4.2 Computation

Testing protocol :

[2] [If you don’t establish an end to end connection afterwards you must ignore this measurement.] It is assumed that early traffic channel assignment is used.

- the HPMN sends to the VPMN a REL ISUP message with a valid populated 'Cause Value' field
- the VPMN must send back to the HPMN the REL ISUP message with the same 'Cause Value'
- the HPMN uses SS7 monitoring tool to measure the KPI

Abstract formula:

$$REL-CV[\%]=\frac{\text{Number of uncorrupted Cause Value in REL ISUP messages}}{\text{Number of sent REL ISUP messages with populated Cause Value}}\cdot 100\%$$

2.3.5 OCN & RDN (ISUPv2 signalling transparency)

2.3.5.1 Abstract definition

Effective uncorrupted transmission by the VPMN of Original Called Number and Redirecting Number, as defined in ITU-T Q.732.2.

2.3.5.2 Computation

Using a testing tool:

- A, B and C all belong to the HPMN
- A is roaming on the VPMN network while B and C are located in the HPMN
- A is not reachable, thus the call will be diverted to the voicemail.

Abstract formula:

$$OCN\&RDN[\%]=\frac{\text{Number of successful voice-mail deliveries}}{\text{Number of CAll Divert tests}}\cdot 100\%$$

Trigger points:

OCN & RDN are correctly transmitted in case the voice-mail can be deposited

2.3.6 Call Completion Rate Circuit Switched Telephony (CCR-CS-T)

2.3.6.1 Abstract definition

Probability that a successful call attempt is maintained for a predetermined time until it is released intentionally by A- or B-party.

2.3.6.2 Computation

Abstract formula:

$$\text{CCR - CS - T [\%]} = \frac{\text{Number of intentionally terminated telephony calls}}{\text{Number of successful telephony call attempts}} \cdot 100\%$$

Trigger points:

Successful call attempt: connect measurement (e.g. ‘alerting’ or ‘busy’ detected by A- party)

Terminated call: release of connection directly by A- or B-party

2.3.7 ALOC (Average Length of a Call)

2.3.7.1 Abstract Definition

As defined in ITU E-437 and in IN01: average duration of calls. The advice is to measure this for MOC and MTC separately, as there could be a significant natural difference between these 2 call types.

2.3.7.2 Computation

Using traffic report:

$$\text{ALOC MOC [seconds]} = \frac{\text{Total network usage of MOC seconds in a month}}{\text{Total number of MOC calls in a month}}$$

$$\text{ALOC MTC [seconds]} = \frac{\text{Total network usage of MTC seconds in a month}}{\text{Total number of MTC calls in a month}}$$

2.3.8 CLI Transparency

2.3.8.1 Abstract Definition

CLI needs to be delivered correctly and complete, in a way it can be used to dial back the original called party.

2.3.8.2 Computation

$$\text{CLI transparency [\%]} = \frac{\text{Number of complete and correct CLI's}}{\text{Number of calls}} * 100\%$$

2.3.9 Speech Quality (SpQ)

2.3.9.1 Abstract definition

Indicator representing the quantification of the end-to-end speech transmission quality of the Mobile Telephony Service.

2.3.9.2 Computation

The validation of the end-to-end quality is made using the PESQ score. This scale represents the distance between the original and degraded speech signal in a voice transmission and it's troubles (noise, robot voice, echo, dropouts etc). The speech quality measurement is taken per call.

Reference: ITU-T P.862E (PESQ Algorithm)

Abstract formula:

$$\text{SpQ(received A - side)} = \text{f(PESQ)}$$
$$\text{SpQ(received B - side)} = \text{f(PESQ)}$$

Optionally it might be useful to aggregate both speech quality values into one. In this case the worst of both shall be used. This aggregated speech quality value shall be called SpQ (min).

Trigger points:

Beginning of connection:	interchange speech samples between a-party and b-party
End of connection:	release of connection

Note: The acoustic behaviour of terminals is not part of this speech quality measurement.

2.4 Short Message Service

2.4.1 Service Accessibility SMS MO (SA SMS MO)

2.4.1.1 Abstract definition

Probability that the end-customer can access the Short Message Service when requested while it is offered by display of the network indicator on the Mobile Equipment. In this case the customer wants to send a Short Message.

2.4.1.2 Computation

Note: For the trigger point explained here, the connection over the air interface must be measured (e.g. Layer-3) and the answers of the SMSC must be counted statistically. The protocol for every connection shows the deviation from the successful service access.

Only the first try should be measured. If the Short Message is established with the second try this should not be counted.

Abstract formula:

$$\text{Service Accessibility SMS MO [\%]} = \frac{\text{Number of successful SMS service attempts}}{\text{Number of all SMS service attempts}}$$

Trigger points [e.g. Layer-3 messages]:

Start SMS service attempt:	Initiate sending a SMS
Successful SMS service attempt:	receiving acknowledgement of the SMSC

2.4.2 Access Delay SMS MO (AD SMS-MO)

2.4.2.1 Abstract definition

Time between sending a Short Message to a Short Message Centre and receiving the notification from the Short Message Centre.

2.4.2.2 Computation

Abstract formula:

$$\text{Access Delay SMS MO [s]} = t_{receive} - t_{send\ SMS}$$

$t_{receive}$: point of time the mobile equipment receives the confirmation from the SMS Centre

$t_{send\ SMS}$: point of time the customer sends his SMS to the SMS Centre

Trigger points [e.g. Layer-3 messages]:

Start SMS service attempt:	Initiate sending a SMS

Successful SMS service attempt: receiving acknowledgement of the SMSC

2.4.3 End-to-End Delivery Time SMS (DT SMS)

2.4.3.1 Abstract definition

Time between sending a Short Message to a Short Message Centre and receiving the very same Short Message on another mobile equipment.

2.4.3.2 Computation

Abstract formula:

$$\text{End-to-End Delivery Time SMS}\,[s] = t_{\text{receive SMS}} - t_{\text{send SMS}}$$

$t_{\text{receive SMS}}$: point of time the mobile equipment 2 receives the Short Message from mobile equipment 1.

$t_{\text{send SMS}}$: point of time the customer sends his Short Message to the SMS Centre

Trigger points:

Start SMS service attempt: Initiate sending a SMS

Receiving SMS on Mobile Equipment 2:

2.4.4 Completion Rate SMS Circuit Switched (CR SMS CS)

2.4.4.1 Abstract definition

Ratio of received and send Test SMS from one mobile to another mobile part, excluding duplicate received and corrupted Test SMS.

A corrupted Test SMS is a SMS with at least one bit error.

For test and measurement purposes a message is considered valid if it is delivered successfully within a time window defined (see IR.43).

2.4.4.2 Computation

Abstract formula:

$$\text{CR SMS CS}\ [\%] = \frac{\text{successful received Test SMS - duplicate received Test SMS - corrupted Test SMS}}{\text{Number of all send Test SMS}}$$

Trigger points:

Successfully send and received SMS via SMSC.

Time window of measurements according to customer profile.

2.5 Circuit Switched Data Service

2.5.1 Service Accessibility , Circuit Switched Data(SA –CSD)

2.5.1.1 Abstract definition

Probability that the end-customer's DTE can access the Mobile Data Service when requested. This will be indicated by the DTE receiving the valid ‘connect message from the distant DTE.

Probability that the end-customer's DTE can access the Mobile Data Service when requested.

There are 2 layers of accessibility for CSD

- Access to the target network DCE.
- Access to the required data service provided by a data server.

To a customer, these 2 events would be seamless and therefore the calculation for the service access should be a composite of these 2 activities. The field test system therefore must automate and combine the two layers to provide a single SA-CSD metric.

To combine the 2 layers should involve calculation of the success of the following actions.

- ATDT command including target number.
- Receive Connect from target network DCE
- Send relevant command to target Data Server.
- Receive valid response from Data Server

The specific commands and responses from data servers will be detailed in ‘Typical procedures for quality of service measurements’.

2.5.1.2 Computation

A successful call attempt is when the A-party DTE receives valid response from test server. This can either be a dedicated data test server or a data server accessed when testing functionality via the public internet.

Abstract formula:

$$\text{Service Accessibility CSD} = \frac{\text{Number of successful call attempts}}{\text{Number of call attempts}}$$

Trigger points:

Beginning of the call attempt:	ATDT command with dialled number sent by A-party DTE.
Successful call attempt:	Valid response received from Data Server.

2.5.2 Set-up Time (ST – CSD)

2.5.2.1 Abstract definition

Time between sending of complete address information in ATDT command by A-Party and receipt of valid response from data server.

2.5.2.2 Computation

Abstract formula:

$$\text{Set-up Time Circuit Switched Data [s]} = t_2 - t_1$$

t_1: point of time where A-party DTE sends ATDT command

t_2: point of time where connect is established (valid response received by A-party from data server)

Trigger points:

Beginning of the Set-up time measurement:	Sending of ATDT command by A-party
Successful connection:	Valid response received from Data Server.

2.5.3 Data Quality (DQ-CSD)

For definitions of Data Quality Parameters refer to section 2.7.

2.5.4 Completion Rate Circuit Switched Data (CR-CSD)

2.5.4.1 Abstract definition

Probability that a successful call attempt is not released except when intended by any of the parties involved in the call.

2.5.4.2 Computation

Abstract formula:

$$\text{Call completion Ratio CSD} = \frac{\text{Number of calls terminated by end users}}{\text{Number of successful data call attempts}}$$

Trigger points:

Successful call attempt: Valid response received by A-party DTE.

Completed call: DTE 'ready' only when call ended by either party intentionally.

2.6 Packet Switched Data Service (General Packet Radio Service)

For test purposes it will be necessary to have the mobile test equipment in a stable state before testing. For each test the mobile should begin by being powered on and attached but not PDP context activated. Specific details are to be found in 'Typical procedures for quality of service measurements'.

2.6.1 Service Accessibility Rate – Packet Switched Data(SA – PSD)

2.6.1.1 Abstract definition

Probability that the end-customer's DTE can access the Mobile Data Service when requested.

There are 2 layers of accessibility for GPRS

Access to the mobile network GPRS core infrastructure.

Access to the required data service provided by a data server.

To a customer, these 2 events would be seamless and therefore the calculation for the service access should be a composite of these 2 activities. The field test system therefore must automate and combine the two layers to provide a single SA-PSD metric.

To combine the 2 layers should involve calculation of the success of the following actions.

Sending of valid command (e.g. ATD*99# (with IP address of target sever)) from A party DTE to obtain IP connection.

Receive valid response from GGSN

Send valid command to target Data server.

Receive valid response from target Data server.

The specific commands and responses from data servers will be detailed in ‘Typical procedures for quality of service measurements’.

2.6.1.2 Computation

A session will be considered set-up successfully if a valid response is received from the target data server

Abstract formula:

$$\text{Service Accessibility PSD} = \frac{\text{Number of successful session attempts}}{\text{Number of session attempts}}$$

Trigger points:

Beginning of the session attempt:	Send valid command request (e.g. ATD*99# (with IP address of target sever))
Successful session attempt:	Valid response received from target data server

2.6.2 Set-up Time – Packet Switched Data (ST – PSD)

2.6.2.1 Abstract definition

Time between sending of valid command (e.g. ATD*99# (with IP address of target sever) message and receipt of valid response message from target data server.

2.6.2.2 Computation

A session will be considered set-up successfully if a valid response is received from the target data server

Abstract formula:

$$\text{Set-up Time Packet Switched Data [s]} = t_2 - t_1$$

t_1: point of time where A-party valid session request command

t_2: point of time where connect is established (valid response received by A-party from data server)

Trigger points:

Beginning of the session attempt: Send valid command request (e.g. ATD*99# (with IP address of target sever))

Successful session attempt: Valid response received from target data server

2.6.3 Data Quality (DQ-PSD)

Note for all data quality testing it is assumed that for each test, PDP Context is activated and at the end of the individual test PDP Context is de-activated.

For definitions of Data Quality Parameters refer to section 2.7.

2.6.4 Completed Session Ratio (CoSeR – PSD)

2.6.4.1 Abstract definition

Probability that a successful session attempt is not released for a reason other than intentional by any of the parties involved in the session.

2.6.4.2 Computation

Abstract formula:

$$\text{Completed Session Ratio PSD} = \frac{\text{Number of sessions not released other than by end user}}{\text{Number of successful data session attempts}}.$$

Trigger points:

Successful session attempt: Valid response received from target data server.

Completed session: Session released intentionally by either end-user.

2.7 Data Service Class Definitions and Measurements

The following definitions for data services and data quality **DQ** are relevant for both circuit switched and packet switched data as, the different classes of data service will be applied identically irrespective of the data bearer system.

Session /call duration for individual data service class definitions are specified in IR45

Note that data quality will be a result of an overall call or session. For test purposes it may be desirable to break this down into geographically distinct measurements but for QoS reporting should be kept to call or session lengths

Data classes are defined in 3rd Generation Partnership Project

Technical Specification Group Services and System Aspects

QoS Concept and Architecture (3G TR 23.907) see table 1

Traffic class	Conversational class conversational RT	Streaming class streaming RT	Interactive class Interactive best effort	Background Background best effort
Fundamental characteristics	• Preserve time relation (variation) between information entities of the stream • Conversational pattern (stringent and low delay)	• Preserve time relation (variation) between information entities of the stream	• Request response pattern • Preserve payload content	• Destination is not expecting the data within a certain time • Preserve payload content
Example of the application	- voice	- streaming video	- Web browsing	- background download of emails

Table 1: UMTS QoS classes

2.7.1 Conversational Class Data

2.7.1.1 Abstract definition

Indicator representing the end-to-end data transmission quality of the Conversational Class Data Service. This represents full duplex transfer of data in near real time.

2.7.1.2 Computation

The end-to-end data quality is validated by measuring the average data throughput in both up-link and down link direction on a best effort basis. The data throughput measurement will be computed and averaged over the duration of the session/call and reported in bits per second. Additionally the minimum throughput averaged over 10% of the overall call/session length , the maximum throughput over 10% of the overall call/session length and worst. The worst delay time for the call/session should also be reported

Abstract formula:

$$DQ(\text{received A-side}) = X \text{ bits/sec}$$
$$DQ(\text{received B-side}) = X \text{ bits/sec}$$

Trigger points:

Beginning of call/session data sample: interchange data frames of predefined data between A and B-party DTE

End of call/session data sample: Calculation of average data throughput for Call/session data sample

2.7.2 Streaming Class

2.7.2.1 Abstract definition

Indicator representing the end-to-end data transmission quality of the Mobile, Circuit Switched, Streaming Class Data Service. This measure represents a delivery of data in one direction (up-link or down-link) in near real time e.g. video broadcast.

Additionally the minimum throughput averaged over 10% of the call/session duration, the maximum throughput averaged over 10% of the call/session duration and the worst block error rate., The worst delay time for the call/session should also be reported

Note for streaming class service only the down link direction is considered, but if service applications are introduced for uplink streaming then this can be added for calculation for data received by B-Party

2.7.2.2 Computation

The end-to-end data quality is validated by measuring the data throughput in down link direction on a best effort basis. The data throughput measurement will be computed and averaged over the duration of the call/session and be reported in bits/sec.

Abstract formula:

$$DQ(\text{received A-side}) = X \text{ bits/sec}$$

Trigger points:

Beginning of Call/session data sample:	Transmission of data frames of indexed predefined data B-party to A-party
End of Call/session data sample:	Calculation of average data throughput for call/session data sample

2.7.3 Interactive Class

2.7.3.1 Abstract definition

Indicator representing the end-to-end data transmission quality of the Mobile Circuit Switched Interactive Class Data Service. This represents duplex transfer of data in non real-time.

2.7.3.2 Computation

The validation of the end-to-end data quality is made by the time taken to download specified files of fixed data size to the A-party DTE when, requested by the A-party sending a request to the data server.

Assumption: The A-party DTE has already been connected to the data server as part of the call set-up process.

Abstract formula:

$$\text{DQ download time [s]} = t_2 - t_1$$

t_1: point of time where A-party DTE sends data request.

t_2: point of time where A-party receives complete uncorrupted requested file/s

Trigger points:

Beginning of request for download: Data request sent by A-party DTE

Download of file/s complete: Uncorrupted file/s received by A-party DTE.

2.7.4 Background class

2.7.4.1 Abstract definition

Indicator representing the end-to-end data transmission quality of the Mobile Circuit Switched Background Class Data Service. This represents data transfer with no real-time dependency (although for QoS testing, data transfer time is measured).

2.7.4.2 Computation

The validation of the end-to-end data quality is made by the time taken to download a file/s of fixed data size to the A-party DTE when, requested by the A-party sending a request to the target server.

Assumption: The A-party DTE has already been connected to the data server as part of call set-up process.

Abstract formula:

$$\text{DQ File download time [s]} = t_2 - t_1$$

t_1: point of time where A-party DTE sends data transfer request

t_2: point of time where A-party receives complete uncorrupted file/s

Trigger points:

Beginning of request for download: Request sent by A-party DTE

Download of file/s complete: Uncorrupted file/s received by A-party DTE

Appendix A: Examples for measuring trigger points

SMS-Service:

Layer 3 Messages:

Start SMS Service Attempt:	generating random access (chan_request SDCCH) at mobile equipment
Successful SMS Service Attempt	receiving cp_data (rp_ack) at mobile equipment
Receiving SMS on Mobile Equipment 2:	receiving cp_data (rp_ack) at mobile equipment