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GUIDELINES FOR QUALITY OF SERVICE OF DATA SERVICES IN MOBILE NETWORKS

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# Introduction

The term Quality of Service (QoS) is extensively used today, not just in the telecommunication world in which it has its roots, but increasingly regarding broadband, wireless and multimedia services that are based on the IP protocol. Networks and systems are gradually being designed in consideration of the end-to-end performance required by user applications; however, the term QoS is usually not well-defined, is used loosely or, worst of all, misused. Therefore, guidance is needed on how to understand and apply the term QoS.

The term "Quality of Service" addresses technical as well as non-technical aspects affecting a service. Different concepts and guidance have been developed to cover various interests and viewpoints of all parties of telecommunications service market, i.e. users, service providers, network operators, manufacturers and regulators.

This guideline provides to EACO countries, guidance for: “*QoS parameters of the data services namely FTP and Web browsing from end-user perspective in mobile networks*”.

# Scope

This guideline covers the QoS of data services in Mobile Networks. This guideline covers only HTTP and FTP data services.

The document focuses on QoS parameters’ Definitions, Formulas and Trigger Points.

# References

[ITU-T E.800] Recommendation ITU-T E.800 (2008): *Definitions of terms related to quality of service*

 [ITU-T G.1000] Recommendation ITU-T G.1000 (2001): *Communications Quality of Service: A framework and definitions*

[ITU-T I.350] Recommendation ITU-T I.350 (1993): *General aspects of quality of service and network performance in digital networks, including ISDNs*

[ITU-T E.804] Recommendation ITU-T E.804 (2014):*QoS Aspects for Popular Services in Mobile Networks*

[ITU-T E.807] Recommendation ITU-T E.807 (2014): *Definitions, associated measurement methods and guidance targets of user-centric parameters for call handling in cellular mobile voice service*

[ETSI EG 202 057-2] ETSI EG 202 057-2, *User related QoS parameter definitions and measurements; Part 2: Voice telephony, Group 3 fax,modem data services and SMS*

# Abbreviations and Acronyms

DNS : Domain Name Server

EACO : East African Communication Organisation

HTTP : Hypertext Transfer Protocol

FTP : File Transfer Protocol

ICMP : Internet Control Message Protocol

IP : Internet Protocol

QoS : Quality of Service

PS : Packet Switched

PDP : Packed Data Protocol

TCP : Transmission Control Protocol

TE : Terminal Equipment

UE : User Equipment

# Definition of Terms

**End-to-End Quality** [ITU-T E.804]: Quality related to the performance of a communication system, including all terminal equipment. For voice services it is equivalent to mouth-to-ear quality.

**Network performance** [ITU-T E.800]: Is the ability of a network or network portion to provide the functions related to communications between users.

**Probing Attempt** [ITU-T E.804]: Trial to examine if the service under test works as expected

**Quality of Experience (QoE)** [ITU-T E.804]**:** The inclusion of the user himself or herself to the overall quality in telecommunications extends the rather objective Quality of Service to the highly subjective Quality of Experience.

**Quality of service** [ITU-T E.800]: Is the totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service.

# QoS parameter basics

## General overview

The following figure shows a model for quality of service parameters. This model has four layers as follows:

* The first layer is the "network availability", which defines QoS rather from the viewpoint of the service provider than the service user.
* The second layer is the "network access". From the service user's point of view this is the basic requirement for all the other QoS aspects and parameters.
* The third layer contains the other three QoS aspects "service access", "service integrity" and "service retainability".
* The different services are located in the fourth layer. Their outcomes are the QoS parameters.

|  |
| --- |
|  |

Figure 1: QoS aspects and the corresponding QoS parameters

## Issues about the FTP and HTTP services

Currently two main views about the best way to reflect the user's experience for these services are in place:

One preferring the payload throughput philosophy and the other preferring the transaction throughput philosophy:

* Method A defines trigger points which are as independent as possible from the service used, therefore representing a more generic view (payload throughput).
* Method B defines trigger points on application layer, therefore representing a more service oriented view (transaction throughput).

An example of the different trigger points defined for each set is illustrated in Annex 1 and Annex 2. The start trigger point for the "mean data rate" for web browsing is either the reception of the first packet containing data content (Method A) or the sending of the HTTP GET command (Method B).

A field test system compliant to this Recommendation shall measure both sets (Method A and B) of QoS indicators using commercial user equipments (UEs).

In addition, a set of technical QoS indicators is defined that covers the attach and packet data protocol (PDP) context activation procedure. Field test systems shall be able to measure these QoS indicators.

# Quality of Service Parameters

## Service independent QoS Parameters

### Attach failure ratio

1. **Definition:**

The attach failure ratio denotes the probability that a subscriber cannot attach to the PS network.

1. **Equation:**

$$Attach Failure Ratio\left[\%\right]=\frac{Unsuccessful Attach Attempts}{All Attach Attemps}×100\%$$

1. **Trigger Points:**

#### **Table 1:** Trigger Points for attach failure ratio

|  |  |  |
| --- | --- | --- |
| Event from equation | Trigger point from user's point of view | Technical description/protocol part |
| Attach attempt | Start: User turns the User Equipment on. | Start: Layer 3 (GMM): The "ATTACH REQUEST" message is sent by the User Equipment.AT: "AT+CGATT=1" is sent by the TE. |
| Successful attach attempt | Stop: Attach logo appears in the display of the UE. | Stop: Layer 3 (GMM): The "ATTACH ACCEPT" message is received by the UE.AT: "OK" is received by the TE. |
| Unsuccessful attach attempt | Stop trigger point not reached. |

### Attach Setup time

1. **Definition:**

The attach setup time describes the time period needed to attach to the PS network.

1. **Equation:**

$$AttachSetupTime[s]=(T\_{attachcomplete}-T\_{attachrequest})[s]$$

1. **Trigger Points:**

**Table 2:** Trigger Points for attach setup time

|  |  |  |
| --- | --- | --- |
| Event from equation | Trigger point from user's point of view | Technical description/protocol part |
| tattach request: Time of attach request | Start: User turns the UE on. | Start: Layer 3 (GMM): The "ATTACH REQUEST" message is sent by the UE.AT: "AT+CGATT=1" is sent by the TE. |
| tattach complete: Time when attach complete | Stop: Attach logo appears in the display of the UE. | Stop: Layer 3 (GMM): The "ATTACH ACCEPT" message is received by the UE.AT: "OK" is received by the TE. |

### PDP Context Activation Failure Ratio

1. **Definition:**

The PDP context activation failure ratio denotes the probability that the PDP context cannot be activated. It is the proportion of unsuccessful PDP context activation attempts and the total number of PDP context activation attempts.

1. **Equation:**

$$PDPContextActivationFailureRatio\left[\%\right]=\frac{Unsuccessful PDP context activation attempts}{All PDP context activation attempts}×100\%$$

1. **Trigger Points:**

#### **Table 3:** Trigger Points for PDP context activation failure ratio

|  |  |  |
| --- | --- | --- |
| Event from equation | Trigger point from user's point of view | Technical description/protocol part |
| PDP context activation attempt | Start: User initiates the service access. | Start: Layer 3 (SM): The first "ACTIVATE PDP CONTEXT REQUEST" message is sent by the UE. |
| PDP context activation attempt | Stop: PDP context logo appears in the display of the UE | Stop: Layer 3 (GMM): The "ATTACH ACCEPT" message is received by the UE.AT: "OK" is received by the TE. |
| Unsuccessful attempt | Stop trigger point not reached |

### PDP Context Activation Time

1. **Definition:**

The PDP context activation time describes the time period needed for activating the PDP context.

1. **Equation:**

$$PDPContextActivationTime[s]=(T\_{PDPcontextactivationaccept}-T\_{PDPcontextactivationrequest})[s]$$

**Note 1:**

While determining the average PDP context activation time only successful activation attempts are included in the calculations

1. **Trigger Points:**

#### **Table 4:** Trigger Points for PDP context activation time

|  |  |  |
| --- | --- | --- |
| Event from equation | Trigger point from user's point of view | Technical description/protocol part |
| tPDP context activation request : Time of PDP context activation request | Start: User initiates the service access. | Start: Layer 3 (SM): The first "ACTIVATE PDP CONTEXT REQUEST" message is sent by the UE.AT: "AT+CGACT=1,1" is sent by the TE. |
| t PDP context activation accept : Time when PDP context activation complete | Stop: PDP context logo appears in the display of the UE. | Stop: Point of time when the UE receives the "Activate PDP context Accept" message (Layer 3). |

### PDP Context Cut-off Ratio

1. **Definition:**

The PDP context cut-off ratio denotes the probability that a PDP context is deactivated without being initiated by the user.

1. **Equation:**

$$PDPContextCut-offRatio\left[\%\right]=\frac{PDP context losses not initiated by the user}{AllsuccessfullyactivatedPDPcontexts}×100\%$$

**Note 2:**

Precondition for measuring this parameter is that a PDP context was successfully established first.

1. **Triggers:**

**Table 5:** Trigger point for PDP context cut-off ratio

|  |  |  |
| --- | --- | --- |
| Event from equation | Trigger point from user's point of view | Technical description/protocol part |
| PDP context successfully activated (pre-condition) | Start: PDP context logo appears in the display of the UE. | Start:Layer 3 (SM): The "ACTIVATE PDP CONTEXT ACCEPT" message is received by the UE. |
| PDP context deactivation initiated by the user | Stop: PDP context logo disappears from the display of the UE. | Stop:Layer 3 (SM): The "DEACTIVATE PDP CONTEXT REQUEST" message is sent by the UE upon desired initiation. |
| PDP context deactivation initiated by network when user is Idle for T seconds | Stop: PDP context logo disappears from the display of the UE. | Stop:Layer 3 (SM): The "DEACTIVATE PDP CONTEXT" message is received by the UE after Idle time. |
| PDP context loss not initiated by the user | Different trigger points for a PDP context deactivation not initiated intentionally by the user are possible: 1. SGSN failure or GGSN failure on which the PDP context will be deactivated by the SGSN or GGSN
2. No deactivation message received by the UE, but PDP context exhibits loss of connectivity.
 |

### DNS Host Name Resolution Failure Ratio

###

1. **Definition:**

The DNS host name resolution failure ratio is the probability that a host name to host address translation of a DNS resolver was not successful.

1. **Equation:**



1. **Trigger Points:**

**Table 5:** Trigger point from user's point of view for DNS host name resolution failure ratio

|  |  |  |
| --- | --- | --- |
| **Event from equation** | **Trigger point from user's point of view** | **Technical description/protocol part** |
| Host name resolution request | Start: Request to resolve a host name. | Start: Protocol: DNS.Data packet containing DNS type A (host address) "Standard query" message for the desired host name. |
| Successful host name resolution request | Stop: Host address resolved successfully. | Stop: Protocol: DNS.Data packet received containing a type A (host address) "Standard query response, No error" response, the respective type A "Standard query" query and an answer including the desired host name to host address translation. |
| Unsuccessful host name resolution request | Stop: Host address not resolved. | Stop trigger point not reached. |

### DNS Host Name Resolution Time

1. **Definition:**

The DNS host name resolution time is the time it takes to perform a host name to host address translation.

1. **Equation:**



1. **Trigger Points:**

**Table 6:** Trigger point from user's point of view of the DNS host name resolution time

|  |  |  |
| --- | --- | --- |
| **Event from equation** | **Trigger point from user's point of view** | **Technical description/protocol part** |
| tStandard Query: Host name resolution request | Start: Request to resolve a host address from DNS server. | Start: Protocol: DNS.Data packet containing DNS type A (host address) "Standard query" query for the desired host name. |
| tStandardQueryResponse: Host name resolution request answered | Stop: Host address received from DNS server. | Stop: Protocol: DNS.Data packet received containing a type A (host address) "Standard query response, No error" response, the respective type A "Standard query" query and an answer including the desired host name to host address translation. |

## Direct QoS Parameters

### File Transfer (FTP) service:

#### FTP {Download|Upload} Session Failure Ratio

###

1. **Definition**

The session failure ratio is the proportion of uncompleted sessions and sessions that were started successfully.

1. **Equation**

 

1. **Trigger points:**

**Download:**

**Table 7: Trigger points for session failure ratio (download)**

|  |  |  |
| --- | --- | --- |
| Event from abstract equation | Trigger point from user's point of view | Technical description/protocol part |
| Successfully started session | Start: User initiates file download. | Start: First [SYN] sent on the control socket. |
| Completed session | Stop: File download is successfully completed. | Stop: Reception of the last data packet containing content. |
| Uncompleted session | Stop trigger point not reached. |

Upload:

**Table 8: Trigger points for session failure ratio (Upload)**

|  |  |  |
| --- | --- | --- |
| Event from abstract equation | Trigger point from user's point of view | Technical description/protocol part |
| Successfully started session | Start: User initiates file upload. | Start: First [SYN] sent on the control socket. |
| Completed session | Stop: File upload is successfully completed. | Stop: Reception of the [FIN, ACK] for the last data packet containing content. |
| Uncompleted session | Stop trigger point not reached. |

**Note 3:** The PS bearer has to be active in the cell used by a subscriber and the mobile station has to be attached as well as the respective PDP context has to be activated.

#### FTP {Download|Upload} Mean Data Rate [kbit/s]

###

1. **Definition**

The mean data rate is the average data transfer rate measured throughout the entire connect time (i.e., after a data link has been successfully established) to the service. The data transfer shall be successfully terminated. The prerequisite for this parameter is network and service access.

1. **Equation**

 

1. **Trigger points**

The average throughput is measured from opening the data connection to the end of the successful transfer of the content (file).

Download:

**Table 9: Trigger points for mean data rate (download)**

|  |  |  |
| --- | --- | --- |
| Event from abstract equation | Trigger point from user'spoint of view | Technical description/protocol part |
| tdata transfer start: Time when successfully started the data transfer. | Start: File download starts. | Start method A: Reception of the first data packet containing the content.Start method B: Reception of the [ACK] from the [SYN, ACK] for active mode connections, sending of the [ACK] for the [SYN, ACK] for passive mode connections on the data socket. |
| tdata transfer complete: Time when data transfer is complete | Stop: File download is successfully completed. | Stop: Reception of the last data packet containing content. |

Upload:

**Table 10: Trigger points for mean data rate (upload)**

|  |  |  |
| --- | --- | --- |
| Event from abstract equation | Trigger point from user'spoint of view | Technical description/protocol part |
| tdata transfer start: Time when successfully started the data transfer | Start: File upload starts. | Start method A: Sending of the first data packet containing the content.Start method B: Reception of the [ACK] from the [SYN, ACK] for active mode connections; sending of the [ACK] for the [SYN, ACK] for passive mode connections on the data socket. |
| tdata transfer complete: Time when data transfer is complete | Stop: File upload is successfully completed. | Stop: Reception of the [FIN, ACK] for the last data packet containing the content. |

**Note 4:**

The mobile station is already attached, a PDP context is activated and a service was accessed successfully (see service non‑accessibility).

### Web Browsing Service (HTTP)

#### HTTP session failure ratio [%]

1. **Definition**

The HTTP session failure ratio is the proportion of uncompleted sessions and sessions that were started successfully.

1. **Equation**



1. **Trigger points**

**Table 11: Trigger points for HTTP session failure ratio**

|  |  |  |
| --- | --- | --- |
| Event from abstract equation | Trigger point from user'spoint of view | Technical description/protocol part |
| Successfully started session | Start: User enters the URL and hits "Return". | Start: First [SYN] sent. |
| Completed session | Stop: The complete web page appears in the browser window. | Stop: Reception of the last data packet containing content. |
| Uncompleted session | Stop trigger point not reached. |

**Note 5:**

The PS bearer has to be active in the cell used by a subscriber and the mobile station has to be attached as well as the respective PDP context has to be activated.

#### HTTP mean data rate [kbit/s]

1. **Definition**

After a data link has been successfully established, this parameter describes the average data transfer rate measured throughout the entire connect time to the service. The data transfer shall be successfully terminated. The prerequisite for this parameter is network and service access.

1. **Equation**

 

1. **Trigger points**

The average throughput is measured from opening the data connection to the end of the successful transfer of the content (web page).

**Table 12: Trigger points for average data transfer rate**

|  |  |  |
| --- | --- | --- |
| Event from abstract equation | Trigger point from user'spoint of view | Technical description/protocol part |
| tdata transfer start: Time of successfully started data transfer | Start: Web page download starts. | Start method A: Reception of the first data packet containing the content.Start method B: Sending of the first GET command. |
| tdata transfer complete: Time when data transfer is complete | Stop: Web page download successfully completed. | Stop: Reception of the last data packet containing the content. |

**Note 6:** The mobile station is already attached a PDP context is activated and a service was accessed successfully (see service non‑accessibility).

### Ping round trip time [ms]

1. **Definition:**

The ping round trip time is the time required for a packet to travel from a source to a destination and back. It is used to measure the delay on a network at a given time. For this measurement, the service must have already been established.

1. **Equation:**

 

1. **Trigger points:**

**Table 13: Trigger points for ping round trip time**

|  |  |  |
| --- | --- | --- |
| Event from abstract equation | Trigger point from user's point of view | Technical description/protocol part |
| tpacket sent: Time when the packet is sent | Start: User starts to ping the client. | Start: ICMP echo request sent. |
| tpacket received: Time when the packet is received | Stop: Echo reply is displayed. | Stop: ICMP echo reply received by the sender. |

**Note 7:**

As an alternative, the measurement of the round trip time can be done by considering the TCP handshake:

* Start: Point of time when the [SYN] is sent.
* Stop: Point of time when the [SYN, ACK] is received.

This applies to all services that are TCP based, such as file transfer (FTP), web browsing (HTTP) and so on.

# Harmonization

This section aims at proposing parameters and their thresholds where applicable. This is summarized in the table below.

**Table 14: Quality of Service Parameters**

|  |  |
| --- | --- |
| **Parameters** | **Targets** |
| Attach failure ratio | ≤ 2% |
| Attach Setup time | ≥98% of successful attach attempts should be completed within 1s |
| PDP Context Activation Failure Ratio | ≤ 3% |
| PDP Context Activation Time | ≥98% of successful attach attempts should be completed within 2seconds. |
| PDP Context Cut-off Ratio | ≤ 1% |

# ANNEX 1: QoS parameters version A (example: HTTP via GPRS)

|  |
| --- |
|  |

# ANNEX 2: QoS parameters version B (example: HTTP via GPRS)

|  |
| --- |
|  |