QoS Sensitive Roaming Principles

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1 Executive Summary

The 3GPP has from R99 onwards specified a QoS concept and QoS architecture. The concept includes the QoS profile, consisting of QoS parameters. It is up to the operator to configure the values for these parameters. Taking this as the starting point, the roaming situation naturally becomes challenging. Therefore, there has to be an agreement on a set of values for roaming between operators. Considering dual-mode networks (i.e. (E)GPRS and UMTS), also the relation between R97 and R99 QoS parameters has to be taken into account.

This document will include the relevant roaming issues considering the 3GPP QoS profile. The approach is based on the four traffic classes. The current version of the document considers the background and interactive classes, but later on also the streaming and conversational classes will be included.

2 Scope

The purpose of this document is to provide principles for QoS roaming. The basic need is to agree on a QoS profile that enables roaming in any operator's network. In plain text, it means that the QoS profile should work in multi-vendor and multi-operator environment. The first version of the document concentrates on background and interactive classes only. Coming versions of the document will also consider streaming and conversational traffic classes.

The document gives a short description of the parameters and what kind of effect they have on the network. Then a suitable value to use is discussed and a recommendation is given.

The current document considers only background and interactive classes. They have been specified by the 3GPP in order to offer bearers for non-real-time services. Streaming and conversational class bearers are specified for real-time services.

This document should not be mixed with IR.34 and the specification of the QoS requirements for the inter-operator backbone network. The values proposed in this document only affect the 3GPP specified network elements, like SGSN, GGSN, RNC and BSC (i.e. not the inter-operator backbone network).

2.1 Definition of Terms

Term	Description
3GPP	3rd Generation Partnership Project
APN	Access Point Name
ARP	Allocation/Retention Priority
BER	Bit Error Ratio
BSC	Base Station Controller
BSS	Base Station Subsystem
CN	Core Network
DL	Downlink
EGPRS	Enhanced General Radio Packet Service
FFS	For Further Studies
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
GTP	GPRS Tunnelling Protocol

Term	Description
HLR	Home Location Register
HPLMN	Home Public Land Mobile Network
IP	Internet Protocol
LLC	Logical Link Control
PDP	Packet Data Protocol
PDU	Protocol Data Unit
PFC	Packet Flow Context
PLMN	Public Land Mobile Network
PPP	Point-to-Point Protocol
QoS	Quality of Service
R97	3GPP release 97
R99	3GPP release 99
RAB	Radio Access Bearer
RAN	Radio Access Network
RB	Radio Bearer
RLC	Radio Link Control
RNC	Radio Network Controller
SDU	Service Data Unit
SGSN	Serving GPRS Support Node
THP	Traffic Handling Priority
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System
VPLMN	Visited Public Land Mobile Network

2.2 References

Ref	Doc Number	Title
[1]	RFC 2119	“Key words for use in RFCs to Indicate Requirement Levels”, S. Bradner, March 1997. Available at http://www.ietf.org/rfc/rfc2119.txt
[2]	TS 03.60	General Packet Switched Service (GPRS); Service description; Stage 2
[3]	TS 23.107	Quality of Service (QoS) concept and architecture
[4]	TS 34.108	Common test environments for User Equipment (UE) conformance testing

3 Background

The 3GPP has specified a QoS concept and a QoS architecture [TS23.107]. The QoS parameters have a central role in the QoS concept. Perhaps the most important QoS parameter is the traffic class. The traffic class divides the traffic into four distinct traffic classes according to how delay sensitive typical services representing the particular traffic class are.

The QoS parameters together form a QoS profile. One QoS profile is associated with each PDP context, thereby defining the characteristics of the connection through the mobile network. The QoS parameters, for example, affect the parameters in the radio network and policing and shaping functions in the core network.

The QoS profile resides in the home PLMN HLR. Therefore, it also determines the QoS profile to be used in the visited PLMN. **The QoS parameter values must work in a multi-operator environment.** The QoS profile is defined per end-user and per APN, i.e. a single end-user may have a separate QoS profile for each APN.

It is important to remember that 3GPP has only specified a model for the traffic classes and the other QoS parameters. However, the detailed implementation is not described in the specifications. The actual implementations will therefore vary from vendor to vendor. **The QoS parameters also have to work in a multi-vendor environment.**

The QoS profile defined in the HLR should work in both (E)GPRS and UMTS networks, i.e. there is only one profile defined for both access networks. The main difference is the air interface technology used in (E)GPRS and UMTS. The effect of the QoS parameters can vary somewhat depending on the access network used. The effect of each parameter should therefore be taken into account for both (E)GPRS and UMTS.

4 QOS Parameter Description

In this chapter a general description will be given for each of the QoS parameters. The description includes the definition of the parameter and the effect(s) of the parameter. Possibly different effects in (E)GPRS and UMTS networks are also discussed. Parameters that should assign the same value for all traffic classes are also given a recommended value.

4.1 Traffic class

The traffic class is also a QoS parameter. The idea behind the traffic class parameter is to map different services onto different bearers so that the service requirements can be met. The division into traffic classes are made according to how delay sensitive typical services representing a traffic class are. The conversational class is the most delay sensitive traffic class and the background class the least sensitive.

4.2 Delivery order

The delivery order parameter indicates whether the bearer should provide in-sequence delivery of SDUs or not. The specifications indicate a coupling to the reliability of the bearer; “Whether out-of-sequence SDUs are dropped or re-ordered depends on the specified reliability”.

(E)GPRS: Delivery order has no corresponding parameter amongst the R97 QoS parameters. Delivery order is mapped to PDP context information “reordering required” in SGSN and GGSN.

UMTS: The delivery order affects the operation of the RNC.

Using the delivery order value “yes” is comparable to guaranteeing the packet order in IP networks. IP networks, in general, do not reorder packets or guarantee in-sequence delivery of packets. Therefore IP based applications do not assume that the underlying network does provide in-sequence delivery of the packets. It is also quite clear, that reordering of packets in any element does not lower the end-to-end delay, i.e. improve the performance.

The reordering of packets in the RNC will also probably decrease the performance. Packets arriving late to the RNC will also delay other packets (i.e. they cannot be sent before the late packet is sent). This will most probably also trigger unnecessary RLC retransmissions (i.e. if RLC acknowledged mode is in use). **The recommendation is therefore to use the delivery order value "no".**

4.3 Delivery of erroneous SDUs

This parameter indicates whether SDUs detected as erroneous should be delivered or discarded.

- No – N – means that error detection is used and erroneous SDUs are discarded.
- Yes – Y – means that error detection is used and erroneous SDUs are delivered with error indication.
- No Detect – ND – means that error detection is not in use and all SDUs are delivered.

The mapping between R97 and R99 parameters is the limiting factor considering the value to use for delivery of erroneous SDUs. The reliability class used in (E)GPRS determines the protocol modes to be used for GTP, LLC, and RLC. In practice, reliability class = 3 has been found to be the only working value. The reliability class maps to delivery of erroneous SDUs, residual BER and SDU error ratio in R99 parameters. **The suitable value to use for delivery of erroneous SDUs is therefore "no".**

4.4 Maximum SDU size

Describes the maximum allowed SDU size. The specifications state that it should be used for admission control and policing.

The maximum allowed value to use is 1500 B (for PDP type = PPP 1502 is allowed). For background and interactive classes there is no reason to use a value lower than the maximum value. A smaller value only increases the overhead, which in turn decreases the throughput for user data. **The recommended value for maximum SDU size is, in the case of PDP type = IP, 1500 B.**

4.5 Maximum bit rate (DL/UL)

Specifies the maximum allowed bit rate. There is a separate parameter for DL and UL.

In practice, the maximum bit rate parameter defines the maximum bit rate for the mobile core network (CN). The maximum value that can be used is limited by the bit rate the network supports, although the maximum bit rate parameter is assigned a higher value. The SGNs can use shaping and policing functions to conform the traffic to the defined maximum bit rate.

UMTS: Defines the maximum bit rate of the RAB and the RB to be used.

It would be feasible to recommend only a short list of different values to use. Since, the maximum bit rate maps to a RAB in the RAN the values should conform to the reference RABs defined by 3GPP [TS34.108 R99]. It ensures that different vendors support RABs with the particular bit rate. Moreover, testing is made easier when there are fewer values to be tested.

The following combinations of RABs are recommended for background and interactive classes (specified in TS34.108 R99):

UL (kbps)	DL (kbps)
8	8
16	16
32	32
32	64
64	64
64	128
64	384
128	128
128	384

Table 1: Radio Access Bearer Table

The recommended maximum bit rate is 384 kbps for DL and 128 for UL. Any combination below these figures is also allowed.

4.6 Residual BER

Indicates the undetected bit error ratio in the delivered SDUs. If no error detection is requested, residual bit error ratio indicates the bit error ratio in the delivered SDUs. According to this, the meaning of the Residual BER parameter depends on the Delivery of Erroneous SDUs parameter. Generally speaking, the Residual BER parameter is used to configure radio interface protocols, algorithms and error detection coding.

The reliability class in (E)GPRS determines the protocol modes for GTP, LLC and RLC protocols. Currently the only working value is reliability class = 3. The reliability class maps to residual BER, delivery of erroneous SDUs and SDU error ratio in R99 QoS parameters. **The recommended value for residual BER is therefore 10^{-5} for background and interactive classes.**

4.7 SDU error ratio

Indicates the fraction of SDUs lost or detected as erroneous. SDU error ratio is defined only for conforming traffic. For example, traffic that exceeds the maximum bit rate and is hence dropped is not included in the SDU error ratio.

By reserving resources (i.e. conversational and streaming classes), SDU error ratio performance is independent of the loading conditions, whereas without reserved resources (i.e. interactive and background classes), SDU error ratio is used as target value.

Generally speaking, the SDU error ratio is used to configure the radio interface protocols, algorithms and error detection schemes.

The reliability class in (E)GPRS determines the protocol modes for GTP, LLC and RLC protocols. Currently the only working value is reliability class = 3. The reliability class maps to SDU error ratio, delivery of erroneous SDUs and residual BER in R99 QoS parameters. **The recommended value for SDU error ratio is therefore 10^{-4} for background and interactive classes.**

4.8 Transfer delay

The transfer delay parameter is only specified by 3GPP for streaming and conversational traffic classes. Is left out FFS.

4.9 Guaranteed bit rate

The guaranteed bit rate is only specified by 3GPP for streaming and conversational traffic classes. Is left out FFS.

4.10 Traffic handling priority (THP)

The THP parameter is only specified for the interactive class. The interactive class enables prioritisation between bearers, which in turn enables end-user or service prioritisation. THP specifies the relative importance for handling of traffic belonging to a RAB compared to traffic belonging to other RABs.

(E)GPRS: THP maps to delay class in R97 QoS parameters. In R97 BSS the delay class is not visible to the BSS. It means that air interface prioritisation is not possible with THP in R97 BSS. R99 brings the Packet Flow Contexts (PFC) to the BSS and the traffic class and THP parameters become visible to the BSS. That is, prioritisation is possible with interactive class and THP over the air interface. For this to work, it requires support in the terminal, the BSS and the SGSN. In R97 BSS air interface prioritisation is possible with the precedence class parameter. The precedence class parameter is mapped to/from allocation/retention priority (ARP) in R99 QoS parameters.

UMTS: THP affects the relative priority between RABs within the interactive class. Relative priority means that it affects the allocation of the bearers and the retention of the bearer. In other words, it affects the operation of the packet scheduler located in the RNC.

Consequently there are two different parameters that do the same prioritisation over the air interface, precedence class (i.e. ARP) in R97 networks and THP (requires interactive traffic class) in R99 networks. Since this is contradictory to some extent, the recommendation for priorities should be made in a consistent and logical way in dual-mode networks. Therefore, **it is recommended to use the same value for the THP and ARP parameters for interactive class.**

4.11 Allocation/Retention priority

Specifies the relative importance compared to other RABs for allocation and retention of the RAB. The ARP parameter is a subscription parameter, which is not negotiated from the mobile terminal.

The priority is used for differentiating between bearers when performing allocation and retention of a bearer. In situations where resources are scarce, the relevant network elements can use the ARP to prioritise bearers with a high ARP over bearers with a low ARP when performing admission control.

(E)GPRS: Maps to/from precedence class in R97 parameters. The precedence class allows prioritisation over the air interface. Notable is that prioritisation is possible also when background class is in use.

UMTS: Affects the allocation and retention of RABs/RBs.

It is recommended to use the same value for ARP as for THP for interactive class (see description of THP for more detailed motivation). The background class is specified in such a way that it has lower priority than the interactive class. In order to maintain the consistency of the priorities it is therefore **recommended to use ARP = 3 for background class**.

4.12 SDU format information

The SDU format information is only specified by 3GPP for streaming and conversational traffic classes. Is left out FFS.

Source statistics descriptor

The source statistics descriptor is only specified by 3GPP for streaming and conversational traffic classes. Is left out FFS.

5 Recommended Values for R99 QoS Traffic Classes

In this chapter the QoS parameters will be discussed per traffic class. A recommended value to use in roaming situations is given for each parameter. If a parameter is given a different value for different traffic classes an explanation is also included.

5.1 Background Traffic Class

5.1.1 Traffic class

The traffic class parameter is in this case assigned the value *background class*. The background traffic class is the least delay sensitive of the four traffic classes and has the lowest priority of all traffic. Traffic belonging to the background traffic class is best-effort traffic.

(E)GPRS: The traffic class has no direct corresponding parameter in R97 parameter. The background class is mapped to delay class = 4.

The recommended QoS parameter values for background class are summarized in Table 1.

R99 QoS parameter	Recommended value
Traffic class	Background
Delivery order	N
Delivery of erroneous SDUs	N
Max SDU size	1500
Max bit rate DL	384

R99 QoS parameter	Recommended value
Max bit rate UL	128
Residual BER	10^{-5}
SDU error ratio	10^{-4}
Transfer delay	-
Guaranteed bit rate DL	-
Guaranteed bit rate UL	-
Traffic handling priority	-
Allocation retention priority	3

Table 2:Recommended R99 QoS parameters for background traffic class

5.2 Interactive traffic class

5.2.1 Traffic class

The traffic class parameter in this case assigns the value *interactive class*. The idea behind the interactive class is to enable prioritisation between end-users or services. Prioritisation does not offer any guarantees in form of bit rate or delay. Instead a higher priority offers a higher portion of the available resources in congestion situations. Noticeable is that also high-priority users run out of resources when there are enough end-users within the same cell.

(E)GPRS: R97 capable (in QoS sense) networks supports only background and interactive classes. The interactive class support is not obvious, since it is “hidden” behind the precedence class parameter. The precedence parameter allows the operator to prioritise services and/or end-users over the air interface. The idea behind interactive class is also prioritisation, so precedence class can be seen as a “pre-R99 interactive class”. In terms of R99 parameters, the ARP maps to precedence class in R97 parameters.

R99 (E)GPRS networks improves the QoS support of the BSS. The traffic class parameter is visible to the BSS, enabling prioritisation over the air interface with interactive class. R99 QoS support requires support in terminal, BSS and 2G-SGSN. If support is lacking from one of them, R97 QoS will be used. In both R97 and R99 the prioritisation is done in the BSC.

UMTS: Interactive class enables prioritisation over the air interface. The packet scheduler located in the RNC schedules the packets according to the given priority. The actual operation of the packet scheduler is implementation dependent.

The traffic handling priority (THP) parameter indicates the priority of the interactive class bearer. See the THP description for more information.

The recommended QoS parameter values for interactive class are summarized in Table 3**Error! Reference source not found.**.

R99 QoS parameter	Recommended value
Traffic class	Interactive
Delivery order	N
Delivery of erroneous SDUs	N
Max SDU size	1500
Max bit rate DL	384
Max bit rate UL	128

Residual BER	10^{-5}
R99 QoS parameter	**Recommended value**
SDU error ratio	10^{-4}
Transfer delay	-
Guaranteed bit rate DL	-
Guaranteed bit rate UL	-
Traffic handling priority	Same as for ARP
Allocation retention priority	Same as for THP

Table 3: Recommended R99 QoS parameters for interactive traffic class

5.3 Streaming traffic class

To be defined.

5.4 Conversational traffic class

To be defined.

5.5 The recommended QoS parameters mapped to R97 QoS parameters

Error! Reference source not found. Table 3 depicts the recommended QoS parameters for background traffic class mapped to R97 QoS parameters.

R97 QoS parameter	Value mapped from R99 profile in Table 1
Delay class	4
Reliability class	3
Peak throughput class	Same as max bit rate parameter
Precedence class	Same as ARP
Mean throughput class	31 (=best effort)

Table 4: R97 QoS parameters mapped from the recommended R99 background QoS parameters.

Error! Reference source not found. Table 4 depicts the recommended QoS parameters for interactive traffic class mapped to R97 QoS parameters.

R97 QoS parameter	Value mapped from R99 profile in Table 1
Delay class	1-3 (Depends on THP value in use)
Reliability class	3
Peak throughput class	Same as max bit rate parameter
Precedence class	Same as ARP
Mean throughput class	31 (=best effort)

Table 5: R97 QoS parameters mapped from the recommended R99 interactive QoS parameters

Annex A Document Management

A.1 Document History

Version	Date	Brief Description of Change	Approval Authority	Editor / Company
0.9	03 March 2005	IREG Doc 48_039 – approved as IR.68	Networks Group	
1.0	26 May 2005	Approved by General Assembly vote	Networks Group	Marko Onikki (TeliaSonera Finland Oyj)

A.2 Other Information

Type	Description
Document Owner	Network Group
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