UMTS Quality of Service Concept and Architecture

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1. Introduction

The 3rd Generation Cellular Networks (UMTS) introduce new IP-based services for mobile users. Some of the new services (e.g. video streaming) need a guaranteed level of Quality of Service (QoS) from the network in order to work properly.

In the existing IP world QoS is handled by widening the pipe. Obviously, this approach does not fit into mobile communications, where the radio resources are limited. With a QoS solution based on different QoS classes (traffic classes) the use of the mobile network resources can be optimized.

The users of the new networks services are only interested in end-to-end QoS. End-to-end services typically involve communication through external networks, which make it obligatory to be able to map UMTS QoS parameters to external network QoS parameters and vice versa.

3GPP (3rd Generation Partnership Project) has released Technical Specification 23.107 version 3.0.0 concerning UMTS QoS Concept and Architecture. This paper is a brief overview of TS 23.107.

2. Requirements for QoS

3GPP has specified high level requirements for UMTS QoS. These requirements are divided into three categories – end user, general and technical requirements. Following chapters lists some of them.

2.1 End User Requirements for QoS

- Only the QoS perceived by end-user matter.
- The number of user defined / controlled parameters has to be as small as possible.
- Derivation / definition of QoS attributes from the application requirements has to be simple.
- QoS attributes must be able to support all applications that are used, a certain number of applications have the characteristic of asymmetric nature between two directions, uplink / downlink.
- QoS has to be provided end-to-end.

2.2 General Requirements for QoS

- QoS parameters (or mapping of them) should not be restricted to one or few external QoS control mechanisms but the QoS concept should be capable of providing different levels of QoS by using UMTS specific control mechanisms (not related to QoS mechanisms in the external networks).
- QoS mechanism have to allow efficient use of radio capacity.
- Allow independent evolution of Core and Access networks

2.3 Technical Requirements for QoS

- The UMTS QoS mechanisms shall provide a mapping between application requirements and UMTS services.
- The UMTS QoS control mechanisms shall be able to efficiently interwork with current QoS schemes.
- QoS shall support efficient resource utilisation.
- The QoS parameters are needed to support asymmetric bearers.
- QoS behaviour should be dynamic , i.e., it shall be possible to modify QoS parameters during an active session.

3. UMTS QoS Architecture

3.1 Overview of Different Levels of QoS

Network Services are considered end-to-end, this means from a Terminal Equipment (TE) to another TE. An End-to-End Service may have a certain Quality of Service (QoS) which is provided for the user of a network service. It is the user that decides whether he is satisfied with the provided QoS or not.

To realise a certain network QoS a Bearer Service with clearly defined characteristics and functionality is to be set up from the source to the destination of a service. A bearer service includes all aspects to enable the provision of a contracted QoS. These aspects are among others the control signalling, user plane transport and QoS management functionality. A UMTS bearer service layered architecture is depicted in Figure 1, each bearer service on a specific layer offers it's individual services using services provided by the layers below.

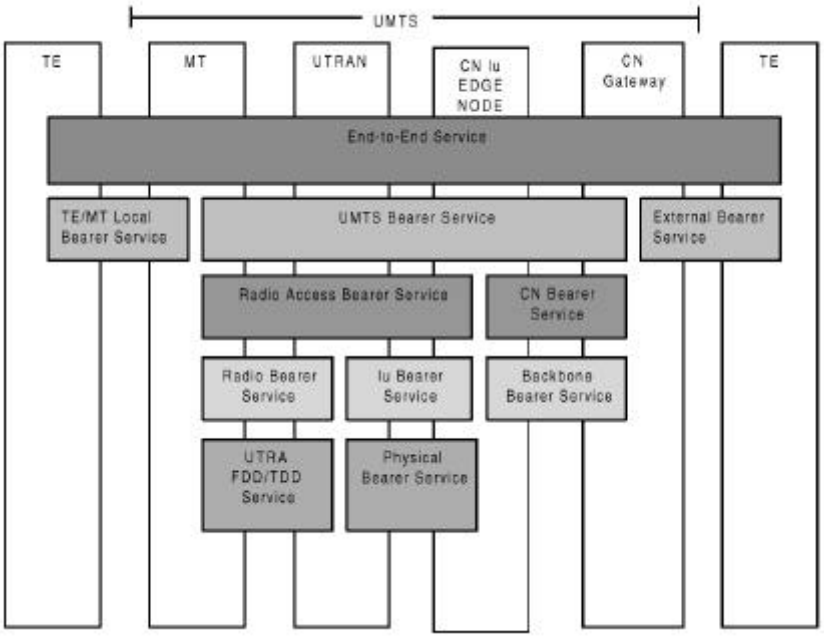

Figure 1: UMTS QoS Architecture

3.2 The End-to-End Service and UMTS Bearer Service

On its way from the TE to another TE the traffic has to pass different bearer services of the network(s). A TE is connected to the UMTS network by use of a Mobile Termination (MT). The *End-to-End Service* on the application level uses the bearer services of the underlying network(s).

The *End-to-End-Service* used by the TE will be realised using a *TE/MT Local Bearer Service*, a *UMTS Bearer Service*, and an *External Bearer Service*.

The UMTS operator offers services provided by *UMTS Bearer Service*. Thus, UMTS Bearer Service provides the UMTS QoS.

3.3 Lower Level Bearer Services

3.3.1 The Radio Access Bearer Service and the Core Network Bearer Service

The UMTS Bearer Service consists of two parts, the Radio Access Bearer Service and the Core Network Bearer Service. Both services reflects the optimised way to realise the UMTS Bearer Service over the respective cellular network topology taking into account such aspects as e.g. mobility and mobile subscriber profiles.

The Radio Access Bearer Service provides confidential transport of signalling and user data between MT and CN Iu Edge Node with the QoS adequate to the negotiated UMTS Bearer Service or with the default QoS for signalling. This service is based on the characteristics of the radio interface and is maintained for a moving MT.

The Core Network Bearer Service of the UMTS core network connects the UMTS CN Iu Edge Node with the CN Gateway to the external network. The role of this service is to efficiently control and utilise the backbone network in order to provide the contracted UMTS bearer service. The UMTS packet core network shall support different backbone bearer services for variety of QoS.

3.3.2 The Radio Bearer Service and the Iu Bearer Service

The Radio Access Bearer Service is realised by a Radio Bearer Service and an Iu-Bearer Service.

The role of the Radio Bearer Service is to cover all the aspects of the radio interface transport. This bearer service uses the UTRA FDD / TDD.

The Iu-Bearer Service together with the Physical Bearer Service provides the transport between UTRAN and CN. Iu bearer services for packet traffic shall provide different bearer services for variety of QoS.

3.3.3 The Backbone Network Service

The Core Network Bearer Service uses a generic Backbone Network Service.
The Backbone Network Service covers the layer 1 / Layer2 functionality and is selected according to operator's choice in order to fulfil the QoS requirements of the Core Network Bearer Service. The Backbone Network Service is not specific to UMTS but may reuse an existing standard.

3.2 QoS Management Functions in the Network

The QoS management functions provide the functionality needed to establish, modify and maintain a UMTS Bearer Service with a specific QoS. The QoS management functions need not necessarily all to be standardised. Their allocation to the UMTS entities shall indicate the requirement for the specific entity to enforce the QoS commitments negotiated for the UMTS bearer service. The specific realisation of these functions is implementation dependent and has only to maintain the specified QoS characteristics.

The QoS management functions of all UMTS entities together shall ensure the provision of the negotiated service between the access points of the UMTS bearer service. The end-to-end service is provided by translation / mapping with UMTS external services.

The QoS management functions are illustrated in figures 2 (control plane) and 3 (user plane).

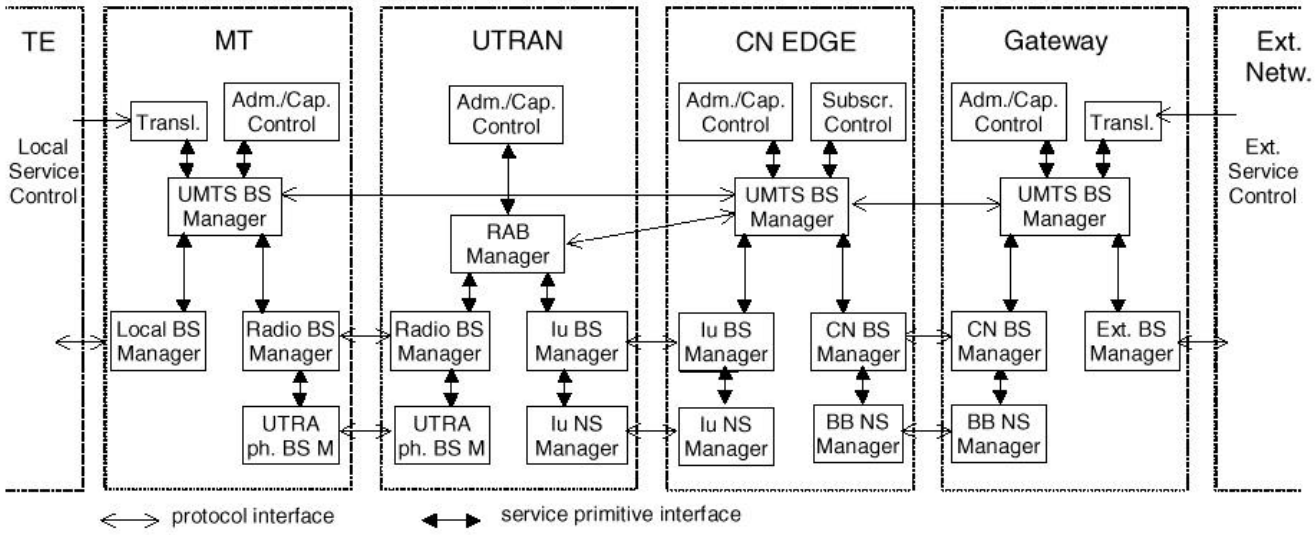

Figure 2: QoS management functions for UMTS bearer service in the control plane

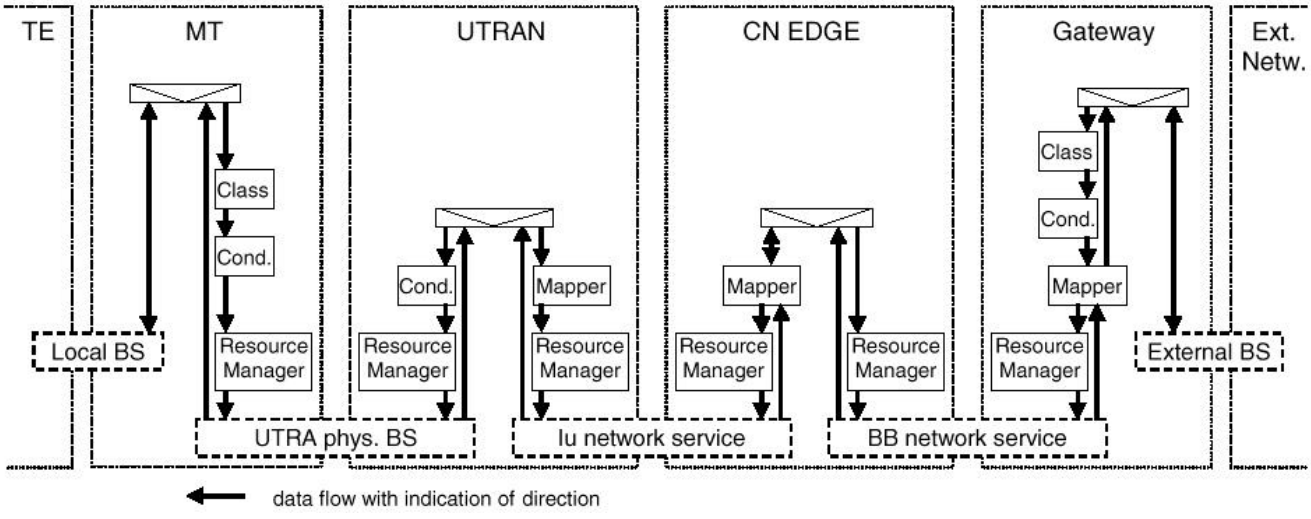

Figure 3: QoS management functions for the UMTS bearer service in the user plane

4. UMTS QoS Classes

When defining the UMTS QoS classes the restrictions and limitations of the air interface have to be taken into account. It is not reasonable to define complex mechanisms as have been in fixed networks due to different error characteristics of the air interface. The QoS mechanisms provided in the cellular network have to be robust and capable of providing reasonable QoS resolution. In the proposal there are four different QoS classes (or traffic classes): Conversational class, Streaming class, Interactive class and Background class.

The main distinguishing factor between these classes is how delay sensitive the traffic is: Conversational class is meant for traffic which is very delay sensitive while Background class is the most delay insensitive traffic class.

Conversational and Streaming classes are mainly intended to be used to carry real-time traffic flows. The main divider between them is how delay sensitive the traffic is. Conversational real-time services, like video telephony, are the most delay sensitive applications and those data streams should be carried in Conversational class. Streaming class is a one way transport (e.g. real time audio stream). Both Conversational and Streaming class preserves the time relation (variation) between information entities of the stream.

Interactive class and Background are mainly meant to be used by traditional Internet applications like WWW, Email, Telnet, FTP and News. Due to looser delay requirements, compared to conversational and streaming classes, both provide better error rate by means of channel coding and retransmission. The main difference between Interactive and Background class is that Interactive class is mainly used by interactive applications, e.g. interactive Email or interactive Web browsing, while Background class is meant for background traffic, e.g. background download of Emails or background file downloading. Responsiveness of the interactive applications is ensured by separating interactive and background applications. Traffic in the Interactive class has higher priority in scheduling than Background class traffic, so background applications use transmission resources only when interactive applications do not need them. This is very important in wireless environment where the bandwidth is low compared to fixed networks. Table 1 illustrates proposed QoS classes for UMTS.

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

5. QoS Parameters

Note: The discussion of UMTS bearer service parameters as well as lower level bearers service parameters is still going on.

UMTS bearer service parameters describe the service provided by the UMTS network to the user of the UMTS bearer service. A set of QoS parameters (QoS profile) specifies this service. At UMTS bearer service establishment or modification different QoS profiles have to be taken into account:

- The UE capabilities form a QoS profile which may limit the UMTS bearer service which can be provided.
- The UE or the terminal equipment (TE) within the terminating network may request a QoS profile at UMTS bearer establishment or modification. The application using the UE may request the UE to provide a UMTS bearer service with a specific QoS profile. If the application requests no specific QoS the UE may use a QoS profile configured within the UE (e.g., by AT commands). How the TE derives a QoS profile is out of scope for UMTS.
- A QoS profile in the UMTS subscription describes the upper limits for the provided service if the service user requests includes specific values. Otherwise, this QoS profile may describe a default QoS service profile requested by the user.
- Default QoS profile(s) may be configured by the operator for the UMTS bearer services provided by the network.

- A Network specific QoS profile characterising for example the current resource availability or other network capabilities or limitations may limit the provided UMTS bearer service or initiate a modification of an established UMTS bearer service.

In Table 2, the defined UMTS bearer attributes and their relevancy for each bearer (QoS) class are summarised. The parameters related to throughput/bitrate should be separated for uplink/downlink in order to support asymmetric bearers.

Traffic class	Conversational class	Streaming class	Interactive class	Background class
Maximum bitrate	X	X	X	X
Delivery order	X	X	X	X
Maximum SDU size	X	X	X	X
SDU format information	X	X		
SDU error ratio	X	X	X	X
Residual bit error ratio	X	X	X	X
Delivery of erroneous SDUs	X	X	X	X
Transfer delay	X	X		
Guaranteed bit rate	X	X		
Traffic handling priority			X	
Allocation/Retention priority	X	X	X	X

Table 2. UMTS bearer attributes defined for each bearer (QoS) class.

6. QoS Parameter Mapping

The QoS parameter mapping between parameters from external networks and within UMTS network is an ongoing work with a lot details to be solved.

6.1 Within UMTS Network

Qos parameter mapping between different bearer services within UMTS network is needed. Following parameter mappings are discussed in TS23.107:

- From Application Parameters to UMTS Bearer Service Parameters
- From UMTS Bearer Service Parameters to Radio Access Bearer Service Parameters
- From UMTS Bearer Service Parameters to CN Bearer Service Parameters

6.2 Interworking with other networks

6.2.1 UMTS-GSM CS/GPRS

- UMTS-GSM CS:
  The mapping between UMTS-GSM CS is based on GSM CS mechanisms and CC parameters.
- UMTS-GPRS:
  The mapping between UMTS and GPRS phase 2 QoS parameters is still unspecified. TS23.107 gives some examples of mapping GPRS phase 1 QoS parameters to UMTS traffic classes.

6.2.2 UMTS-PSTN

PSTN does not have QoS mechanisms thus QoS parameter interworking/mapping is not needed. However, means for determining required bandwidth, delay and reliability has to be developed. It is simple in MO cases but in MT cases the mechanisms (or in worst case defaults) have to be developed.

6.2.3 UMTS-ISDN

ISDN does not have QoS mechanisms thus QoS parameter interworking/mapping is not needed. However, means for determining required bandwidth, delay and reliability has to be developed. It is simple in MO cases but in MT cases the mechanisms (or in worst case defaults) have to be developed.

6.2.4 UMTS-Internet

In the case of Internet applications, the selection of the class and appropriate traffic attribute values is made according to the Internet QoS parameters. Internet applications do not directly use the services of UMTS but they use Internet QoS definitions and attributes, which are mapped to UMTS QoS attributes at API. Currently there are two main Internet QoS concepts, namely Integrated Services and Differentiated Services.

IP based QoS models must be supported for PDP contexts, meaning both Integrated Services (IntServ) signalled by RSVP [RFC2205] and Differentiated Services (6-bit QoS parameter on each IP packet, DiffServ). Both mechanisms are controlled by applications residing in the

TE, allowing different application specific QoS levels for the same PDP context. Application level IP based QoS must be mapped to UMTS packet core QoS by a network element at the border of the network, such as the 3G gateway node. RSVP support would require flow establishment, and possibly aggregation of flows, within the UMTS packet core network. Differentiated services would require that there is either one QoS profile for each traffic type or alternatively the priority and traffic type information is included in the data packets.

7. Summary

The specification TS 23.107 v.3.0.0 released by 3GPP specifies the UMTS QoS concept and architecture. TS 23.107 includes still many details to be solved by 3GPP. Especially the parameter mapping between UMTS network and external networks needs more work.