QoS guaranteeing concepts in VIRTUOUS and FUTURE IST projects

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Abstract

In the scope of this paper, experiments for QoS provision strategy for packet oriented S-UMTS services researched in the IST VIRTUOUS and the IST FUTURE projects are introduced where different QoS guaranteeing mechanisms are presented by setting focus on mechanisms for the mobile terminal, access and core network in a system integrated with terrestrial and satellite UMTS. This paper deals with approaches for meaningful QoS architectures for packet oriented S-UMTS service in an integrated system by adapting the already investigated QoS guaranteeing algorithms for terrestrial UMTS like Connection Admission Control, Scheduling, Active Set Handling and Measurement Control.

1. Introduction

The integration of a satellite UMTS network with a terrestrial UMTS one represents one of the most attractive proposals to overcome the coverage limitations of the future 3G cellular mobile networks, together with the possibility of exploiting the intrinsic satellite transmission capabilities. An aim of the IST Virtuous project is to study and define suitable QoS management concept for an integration scenario with two 3rd generation systems, i.e. T-UMTS and S-UMTS where the investigation in the scope of the VIRTUOUS project focuses on the scheduling algorithm on mobile terminal side to support many kinds of sources (Voice, FTP, Web,…).

The IST FUTURE project is the logical continuation of the IST VIRTUOUS project on extension of VIRTUOUS QoS management concept towards access and core network level to complete end-to-end QoS provision for the target UMTS. Thereby FUTURE aims at the integration of multimedia services and at the development of enhanced Quality of Service (QoS) strategies for a packet based UMTS to fulfil the requirements of the integrated services.

For the satellite segment the general consensus of the industry is towards a GEO (Geo Stationary Earth Orbit) based solution for S-UMTS, which means that the system has to deal with high delays and Bit Error Rates (BERs).

The topic of this paper is the VIRTUOUS and the FUTURE QoS concepts which have to deal with the satellite channel and to be in compliance with the UMTS specifications at the same time. Thus first the basis of the both concepts will be described by means of introduction of both QoS architectures. After the description of the overall algorithms, each implemented QoS supporting functions are introduced. After above QoS aspects of the access network a short investigation of the Core Network (CN) within an integrated T-S-UMTS environment in order to give an end-to-end QoS approach.

2.VIRTUOUS/FUTURE QoS Architectures

The following demonstrator respects the architecture of a classical mobile network, separating the elements into domains: user equipment, radio access network and core network, plus the external ISP domain. This demonstrator is extended by FUTURE by means of addition of UMS (User Mobility Server), CSCF (Call and Session Control Function) and Feature Server where the S-UMTS part is amplified with FUTURE development in QoS issues.

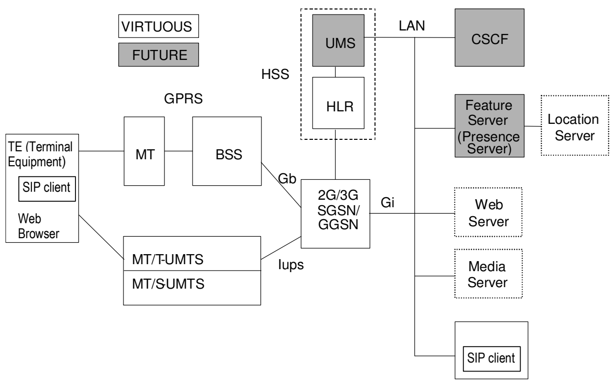

Figure 1 VIRTUOUS/FUTURE Demonstrator

I. VIRTUOUS QoS Implementation

In the scope of VIRTUOUS project, a general target QoS management system architecture is proposed and its implementation focuses onto the Radio Access Stratum (RAS) on the terminal side (see Figure 1).

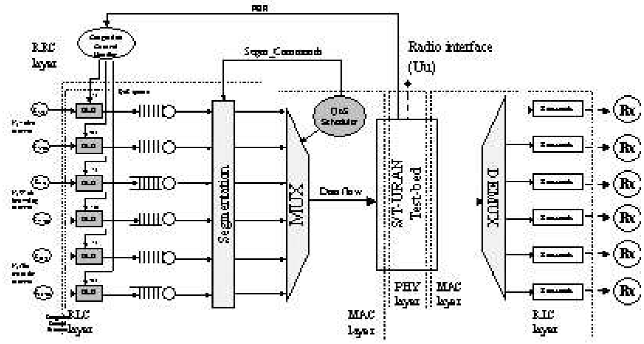

Figure 2 VIRTUOUS QoS Implementation

Figure 2 shows all the RAS protocols enhanced through the design of appropriate QoS modules/ devices [QoS2] [VD0302].

RRC: According to 3GPP standard, the RRC layer provides the group of functionalities but only a subset of them are implemented in VIRTOUS for the general management of the already admitted connections. VIRTUOUS implementation on RRC is focused on the dynamic resource management and therefore an algorithm for setting the best way to manage connections.

RLC: The RLC layer inserts the data packets belonging to different flows into the relevant queues, also performing the usual traffic shaping/ policing through a set DLB (Dual Leaky Buckets). Basing on the inputs derived form the MAC scheduling algorithm implemented in VIRTUOUS, the RLLC is in charge of performing the segmentation of the IP data-grams in order to adapt their format to the MAC PDU length.

MAC: The MAC scheduling algorithm selects both the most suitable transport format for transmission (this decision is taken during each TTI (Time Transmission Interval), i.e. each 10 msec in VIRTUOUS, and the packet to be actually transmitted among those stored in the RLC queues. This combined selection is performed through an innovative VIRTUOUS-specific algorithm, which allows to obtain dramatic improvements respect to the 32GPP proposed one.

II. FUTURE QoS Implementation

By FUTURE, the QoS guaranteeing algorithm is amplified/completed to the VIRTUOUS one where its implementation is more focused on the RAS of the RAN (Radio Access Network).

As shown in Figure 3, in FUTURE the RRC and MAC layers are extended out of the state of VIRTUOUS by means of Connection Admission Control (CAC), Measurement Control (MC), Active Set Handling (ASH) and additional Scheduling algorithm to VIRTUOUS one [QoS1] [FD0301].

CAC: Apparently, no admission request could be satisfied if the electromagnetic coverage conditions, at the point the requesting MN resides, are not adequate. In FUTURE three algorithms for CAC are investigated, namely the Wideband Power Based Admission Control Strategy, the Throughput Based Admission Control Strategy and CAC based on the signal-to-noise-plus-interference ratio either of which can be adopted in order for the CAC process to be realized at the Radio Bearer layer.

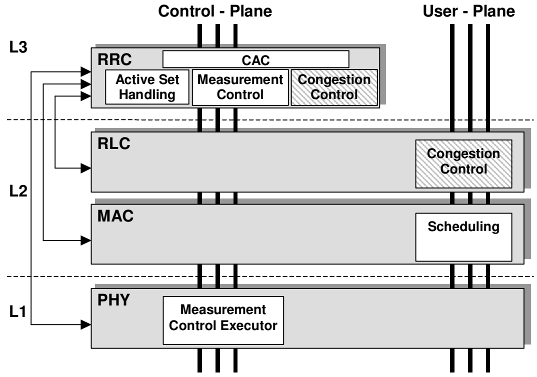

Figure 3 FUTURE QoS Implementation

Measurement Control : To support the provision of QoS the status of the system resources shall be suitably monitored and tracked. The provision of QoS entails the correct working of different functionalities. In particular three different mechanisms shall cooperate for successful QoS provision:

- Call Admission Control (CAC)
- Scheduling
- Congestion Control

Where different sets of parameters/measurements might be relevant for the three functionalities.

In the scope of FUTURE, the measurement control functionality supports the management of the above functionalities for the S-UMTS case on the air interface (Uu interface). Moreover, they may depend on the considered satellite constellation. This happens not only because of the impact on propagation delay of different satellite constellations but also because of the very different hand-off rate which may result for example for a LEO and for a GEO constellation. So, this functionality will be implemented by taking the link specific condition under certain satellite constellation into account, i.e. the down-link (forward link) direction and then the up-link (reverse link) direction for GEO and LEO, respectively

Active Set Handling: The Active Set Handling for the satellite segment (S-UMTS), is based on the satellite diversity concept where its procedure for QoS provision is clearly depending on the considered satellite constellation (LEO,GEO systems).

Unlike T-UMTS, S-UMTS has own different characteristics through non-selective satellite fading channel, which preserves multiplex orthogonality and minimizes intra-beam interference. On the other hand, likewise the T-UMTS case, the signal replies sent by the Gateway to different non co-located satellite, introduce inter-beam interference, producing, in its turn, a capacity loss. This loss could be taken into account and kept with acceptable boundaries.

The difference between the proposed S-UMTS active set handling algorithm and the T-UMTS one lies in the time scale considered for incoming measures and/or in threshold introduced for different monitored beams. On the other hand, the actions taken into account by these algorithms are the same.

MAC Scheduling: In the scope of FUTURE, scenarios are investigated in which different services and/or applications can simultaneously be provided to two mobile users by a unique physical channel (Downlink Shared Channel, DSCH) per satellite beam.

FUTURE MAC scheduler has the main function of scheduling users, connections and packets. Besides, this module has to provide to CAC module the information about the available bandwidth in order to allow to accept/reject a new connection and to ASH-Power Control the information about the TE on which the data packets has to adresses. In this way, it will be indicated how the radio resources utillisation can be optimized, in particular, maximising the amount of accepted requests and the data flow throughtput, as well as satisfying QoS parameters. In order to respect the Radio Access QoS sub-contract, the MAC scheduling function assigns W-CDMA codes and radio farames to data packets to meet contracted QoS parameter.

3. Physical Architecture of QoS Test-Beds

I. VIRTUOUS QoS Test Bed

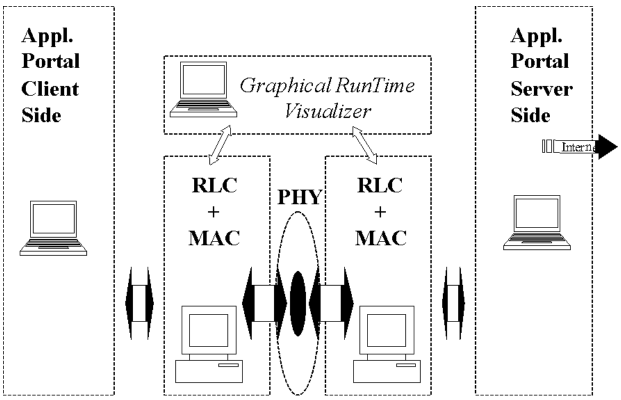

Figure 4 System Architecture of VIRTUOUS QoS Test Bed

Figure 4 shows the system architecture with which the QoS experiment is performed in the scope of VIRTUOUS.

The system architecture is made up of 5+1 blocks, 5 Linux based PCs and 1 other device [QoS2] [VD0302]:

The **PHY device** is a black box in this context and it represents the physical layer emulator that introduces channel noise, delays, several satellite constellation, user mobility utilization and so on. In fact, in the framework of the VIRTUOUS/FUTURE project, the radio link is represented by a suitable module, named ROBMOD, that targets at emulating the main features of the radio access section of a real T-S-UMTS integrated network.

Directly connected to the PHY, there are the MAC+ RLC device and the application portal server device and to the MAC+RLC device an application portal client device is connected. The **application portal server** device is equipped with server software like ftp, web, real player etc, in order to test the implemented QoS algorithms with several QoS classes proposed in 3 GPP standard. Then the **application portal client** devices is equipped with the corresponding software for communication with servers. By the QoS experiment, a set of above mentioned applications will be triggered there simultaneously and all the traffic generated from these applications is captured from a module named "sniff ip" and separated into different connections to RLC+MAC device, which will be treated with the prefixed QoS parameters from the MAC module.

The **RLC+MAC** device is responsible of the packet scheduling selecting data from the parallel channels received by the Application Portal. In this phase all the captured data is transformed into a single stream to be sent through the physical emulator. The de-multiplexing task runs on the other side, and it is in charge of "de-coding" the single stream, reconstructing the different channels and sending everything to the Application Portal, where the IP packets are put again on the net. The backward path is almost the same.

As mentioned before, the attenuation of the VIRTUOUS QoS experiment is focused on the MAC layer where the scheduling algorithm is highlighted. So, the construction of the test bed is so principled that only the minimum requirement of this goal is implemented and furthermore the results of the demonstration are reliable in every testing condition. The scheduling algorithm contained in the MAC module is easily configurable. In particular it is also possible to change the scheduling algorithm in order to compare the performance of different QoS implementations. In fact, we have implemented three algorithm modules: the 3GPP proposed one, the "fixed length" and the innovative VIRTUOUS algorithm [TFS].

Comparative logs of the tests can be easily obtained from the fifth (optional) module: the **Graphical Visualizer**. This is an external module that can be connected to the MAC block in order to view the transmission performance in real time and to log every information sent from the MAC during the scheduling task. In this way it is possible to further elaborate the demonstration results.

II. FUTURE QoS Test Bed [FD0302]

With the aim of taking advantage of the work already done in the VIRTUOUS project, avoiding unnecessary effort, the VIRTUOUS QoS architecture is reused as much as possible, taking into account the FUTURE requirements. In particular, the FUTURE QoS experiment is extended from the VIRTUOUS one with following points:

1. Representation of more realistic scenario: two users (VIRTUOUS: only one user)
2. Implementation of Call Setup: consequently, CAC and required CN functionality are implemented (VIRTUOUS: Call Setup procedure is neglected in order to concentrate to investigate the MAC scheduling behaviour.)
3. Implementation of Active Set Handling: (VIRTUOUS: it is very simplified with pre-configuration before experiment)

In this respect, special attention is paid to the need to dynamically establish, modify and release PDP contexts; as well as to the access method to the PLSE emulator for both, data and measurements.

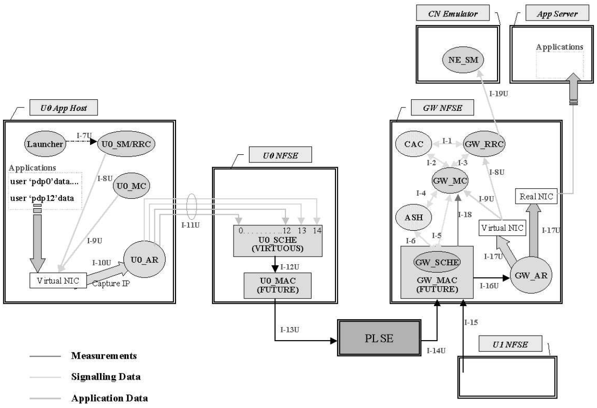

Figure 5 System Architecture of FUTURE QoS Test Bed (Uplink)

Figure 5 reflects the physical components of the QoS test bed for the Uplink case, the software modules inside each device and the interfaces between these modules for the user #0 of the demonstrator, where the same components exist for the Downlink and the user #1 of the demonstrator.

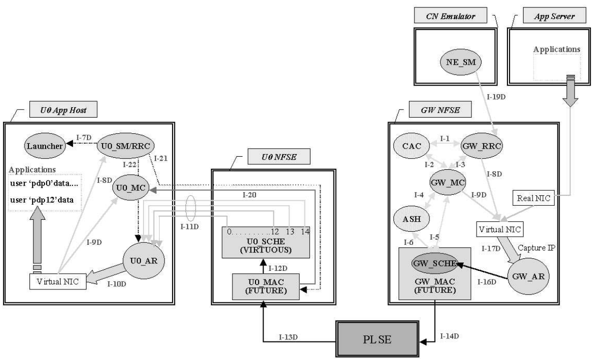

Figure 6 System Architecture of FUTURE QoS Test Bed (Downlink)

Three main parts can be distinguished in the test bed architecture: the **user part**, the **network part** and the **PLSE** (Physical Layer Simulation Element).

At the **user side**, the *U0 App Host* contains non access stratum (NAS) functionality, radio resource control (RRC) functionality as well as end user applications, whilst the *U0 NFSE* computer encloses modules with RLC and MAC functionality.

At the **network side**, the radio functionality (RRC, RLC and MAC) is located in a single PC, the *GW NFSE*, whereas the *CN Emulator* incorporates non access stratum functionality and the *App Server* contains the network side of the end user applications.

The **PLSE** acts as the link between the user side and the network side (note that this link is virtual in the uplink path of the user #1), implementing the physical layers of both, users and gateway.

It is worth to note that the term *NFSE* (Network Function Simulator Element) comes from the ROBMOD and VIRTUOUS projects, although the modules inserted in the FUTURE NFSE PCs are different to those inserted in the NFSE PCs of the previous projects. In fact, any computer with the required communication means (RS232 ports) to access to the PLSE can serve as a FUTURE NFSE PC.

All of the computers in the test bed run the Linux Operative System.

4. QoS experiments

Basically, both QoS experiments have the same goals which will be reached by investigating following three points:

1. ***Feasibility proof*****:** it must test the correctness of all the implemented functions and services
2. ***Performance measurement*****:** it must show if all the QoS constraints required by each established connection are respected. It is one of the way to verify if the system is optimally designed. To perform this task, many meaningful probes are collected such like ***Instantaneous bit-rate***, ***Transfer Delay, Jitter*** and ***Packet error ratio.***
3. ***Maximum System Capabilities*****:** aim of this test is to verify what are the limits of the demonstrator through activation of as many as possible number of connections.

In order to meet the above mentioned investigation points, by trials of both projects the following variations are combined and the performance of the implemented concepts are anlaysed:

VIRTUOUS trials [Trial]

1. Variation I: Trials with several Satellite Constellation → LEO, GEO
2. Variation II: Trials with several kinds of applications: → VoIP, Web, Sound and FTP
3. Variation III: Trials by comparing several MAC scheduling algorithms: → Fixed, 3GPP standard, VIRTUOUS scheduling algorithm

FUTURE trials

1. Variation I: Trials with several Satellite Constellation → LEO, GEO
2. Variation II: Trials with several kinds of applications: → VoIP, Web, Sound and FTP

3. Variation III: Trials by comparing several CAC algorithms: → Fixed, FUTURE CAC algorithm
4. Variation IV: Trials by comparing several MAC algorithms: → Only VIRTUOUS one, VIRTUOUS + FUTURE MAC algorithm

5. Conclusion

In the scope of this paper, the QoS provision strategies in the IST VIRTUOUS and IST FUTURE are summarised where these both projects are aiming to develop a laboratory test-bed that demonstrates performance of the investigated QoS provision concepts and furthermore to represent a meaningful QoS system architecture for the target UMTS.

The results of both projects will provide many essential aspects to the UMTS standards, particularly in the areas of interworking between 2G and 3G systems, the 2nd and the 3rd generation of telecommunication systems and the terrestrial and satellite systems.

6. Acknowledgment

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[FD0301] FUTURE Deliverable D03.01 "Description an Functional Design of the QoS Procedures for the FUTURE UMTS Demonstrator"

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