IST FUTURE Project – Extended Service Capabilities in a Multi-Segment Environment

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The FUTURE (Functional UMTS Real Emulator) project belongs to the IST project group funded by the European Commission. Its goals are to demonstrate the applicability of multimedia services in an integrated terrestrial and satellite UMTS (T-S-UMTS) environment by developing and implementing a multimedia subsystem and the required QoS provisioning functions into an already existing T-S-UMTS demonstrator allowing to invent and demonstrate new innovative services.

I. Introduction

The project was motivated by the idea to reuse the demonstrator provided by the IST project VIRTUOUS as a cost effective base for new contributions to the development of T-UMTS and S-UMTS within a migration from the mobile communication systems of the present 2nd generation towards the systems of the 3rd generation (3G).
Therefore the FUTURE project aims at adopting the recent advances of the Internet scene in UMTS by exploring the applicability of native Internet protocols in 3G. Thereby the project gives vistas of a ubiquitous Internet by including the satellite based S-UMTS segment, which is furthermore leveraged by the integration of satellite inherent services.

To approach this idea the project has to achieve the following main objectives:

1. A SIP (Session Initiation Protocol) based UMTS multimedia subsystem will be designed and integrated into a cellular network operator's/service provider's network infrastructure in order to complement the UMTS packet domain by the capability to offer real-time multimedia services. Therefore a SIP Client and an enhanced SIP proxy meeting the requirements of a UMTS environment have to be designed, developed and integrated in order to give perspectives for new innovative applications and services offering yet unknown added values to end users. This can be expected from the innumerable combinations of SIP based real-time multimedia communication services and Web/WAP based non real-time information services. These vistas are also enhanced by the special emphasis given to the leverage of the satellite inherent capabilities of S-UMTS like wide area coverage, broadcasting or location determination.

2. The integration of real time services in a packet based mobile communication system has as consequence the need of good Quality of Service (QoS) strategies. Therefore FUTURE aims at demonstrating the achievement of end-to-end QoS for the following services: Voice over IP (VoIP), web browsing and file transfer via ftp.
   This means to establish a certain contract specifying the kind of traffic supported and the expected QoS performance. In order to meet the above-mentioned challenging goal, two sub-goals must be achieved, namely to respect the two QoS subcontracts both in the UMTS Radio Access Network (URAN) and in the UMTS Core Network. Thus, as a matter of fact, the end-to-end QoS contract has to be split in two subcontracts first, which is a challenging issue in itself. To meet the QoS subcontract in the URAN, QoS guaranteeing functions will be demonstrated. These are in particular a Connection Admission Control function deciding whether a connection set-up takes place or not, a scheduling mechanism to assign the available CDMA codes to the active connections, an active set handling function aiming at an efficient management of macro-diversity and handover and a measurement control mechanism in order to control the various measurements needed for effective QoS provisioning.

3. In order to demonstrate these QoS solutions certain enhancements on the demonstrator have to be performed. This means the efficiency of physical and MAC layer access mechanisms will be evaluated in regard to packet services. In particular packet access, as defined in the ESA SW-CDMA, will be further investigated because no definitive solution for the S-UMTS packet mode has yet been devised. Approaches for both the forward- and the reverse-link will be investigated, starting from the 3GPP solutions for T-UMTS and the VIRTUOUS results. Augmentation of the VIRTUOUS demonstrator to include the support for efficient packet operation on forward link is foreseen. The enhanced demonstrator will support two active users, thus allowing to also validate QoS solutions.

II. FUTURE S-UMTS Physical Layer Emulator Test Bed

Within FUTURE, the overall integrated VIRTUOUS demonstrator will be enhanced to permit the validation of QoS concepts as well as of an efficient packet-based access for the forward link of the satellite component. To achieve this, additions and modifications will be required for the S-UMTS section of the VIRTUOUS physical layer Test Bed and to the lower functionality of the MAC integrated within the Test Bed itself [Ref. 1].

The FUTURE Test Bed is designed to emulate scenarios with two Mobile Terminals (MT) linked to a land earth station acting as a Gateway (GW) of the UMTS Satellite Radio Access Network (USRAN) via up to two transparent satellites (linear transponder). Most of the physical layer modifications for adapting the VIRTUOUS Test Bed to the FUTURE program goal will concern the forward link, which typically represents the capacity bottleneck for satellite systems. The FUTURE S-UMTS physical layer Test Bed will allow to emulate two complete forward links between a Gateway Emulator and two Mobile Terminal Emulators in a virtually realistic satellite environment as far as the transmission channel is concerned.

The realism of the emulation can be achieved through the dynamic simulation of a true satellite constellation and its payload configurations. Effects of time varying beam gains, free space loss, multi-path fading, and shadowing (blockage) will be thus realistically taken into account. Moreover, beam and satellite hand-offs can be reproduced as well as multiple satellite and beam diversity operation. The possibility to vary the system loading will be also provided through suitably emulated multi-user interference. Being the functionality of the FUTURE Test Bed the same as the VIRTUOUS one for what concerns handoff procedures, constellation simulation and channel propagation models we refer to [Ref. 1] for more details.

Differently from the forward link, only one complete return link will be emulated in the FUTURE Test Bed, the second path being simply simulated by means of an arrangement which emulates a direct connection between the second mobile terminal and the gateway.

The S-UMTS Test Bed to be implemented in FUTURE is shown in Figure 1and is composed of:

- A Gateway Modem Assembly (GWMA) implementing all the required physical layer functions and also some of the lower MAC functions needed to generate the modulated spread spectrum forward link transmit signals and to acquire, track, demodulate, decode and de-multiplex the satellite return link signals.
- A satellite Channel Simulator Assembly (CSA) implementing all required functions and models to simulate the satellite channels with all its impairments due to signal propagation and receiver noise in a realistic manner in both link directions and for both users.
- A Mobile Terminal Modem assembly (MTMA) implementing all the required physical layer and also some of the lower MAC functions needed to generate the modulated spread spectrum return link transmit signal and to acquire, track, demodulate, decode and de-multiplex the satellite forward link signals.

The upper part of Figure 1 represents (seen from left to right) the forward links, while the lower part (seen from right to left) the return links. The Test Bed functionality is controlled by means of a Test Bed Controller Element (TBCE) composed of a Man Machine Interface, a Processing and Interface Unit (PIU), and a Dynamic Satellite Assembly (DSA) for satellite constellation simulation. In Figure 1 only the PIU element of the TBCE is shown.

The presence of two simultaneous users in the FUTURE Test Bed will allow to more realistically test the contention for channel resources which is typical of packet access in a mobile environment and hence permitting to support the main FUTURE objective, i.e. the demonstration of the performance of QoS strategies.

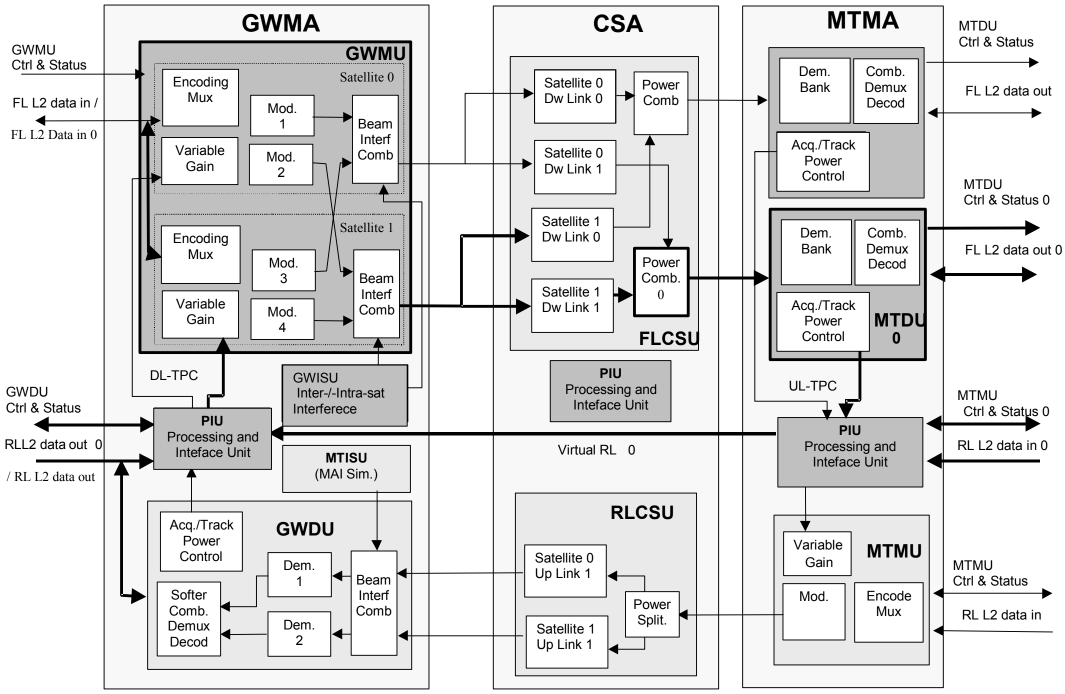

Figure 1: S-UMTS Physical Layer Emulator Test Bed for FUTURE

Independent fading channels will be provided for the two users, each of which can simultaneously operate over two satellites (for QoS validation it was considered sufficient the simulation of dual diversity or single diversity plus hand-over).

Finally new operating modes shall be developed, which are specifically optimised for an efficient use of the limited resources of mobile channels in a packet-oriented environment. In particular in the forward link a Down link Shared CHannel (DSCH) operating mode will be implemented which is particularly suited to avoid the rapid depletion of the code-book in the down link when a high number of packet sessions is active. In this operating mode a sub-tree of the Orthogonal Variable Spreading Factor (OVSF) code tree is selected for use by the down link shared channel.

This channel can be fast reconfigured (i.e. at each physical layer frame) to transmit at the maximum possible bit rate towards a single user (using the top node of the OVSF sub-tree code) or to transmit multiple channels each at lower bit rate (using multiple different OVSF code at a lower level in the code sub-tree) towards a multiplicity of users. A fast assignment mechanism is being devised to support this operating mode. The preliminary idea is to use a shared control channel, instead of a dedicated channel as in UTRA 3GPP specs, carrying the signalling information to the User Terminal (UT) for informing about the presence of data (and their characteristics) on the DSCH. To avoid the need for a UT to continuously demodulate the shared control channel (thus reducing power consumption) and still allowing power control, an additional channel is introduced: the SICH (Signalling Indication CHannel). Multiple users may be assigned different slots (in time division) of the same SICH. Anyway the number of users served by a single SICH is limited and multiple SICHs will be present simultaneously each serving a separate group of UTs with packet sessions open. Notwithstanding the multiple SICH channels needed, this approach appears better than assigning a Dedicated CHannel (DCH) to each user.

III. The Multimedia Subsystem

The multimedia subsystem is introduced to offer innovative multimedia services including S-UMTS aspects as well as multimedia aspects. These innovative services are provided by the FUTURE demonstrator and are carried out in the FUTURE IP multimedia (IM) subsystem which is based on the IM subsystem proposed by 3GPP for UMTS Release 5. It comprises a User Mobility Server (UMS), a Call State Control Function (CSCF) and a Feature Server as shown in Figure 2.

The main goal according to the FUTURE IM subsystem is to define and describe such services and to identify the S-UMTS issues as well as the multimedia aspects. With respect to the functionality of the defined services the FUTURE IM subsystem will be realised. Although traditional Internet services like web browsing, file transfer and more recent ones like VoIP will be supported, the system focuses on the provision of real-time multimedia services to the end-user based on broadcast and/or location determination capabilities of the satellite segment. The integration of the SIP protocol at the signalling and control part of the multimedia subsystem enables the exploitation of its capabilities such as the user mobility (application level) and the initiation/termination of sessions among many participants. Furthermore, the system incorporates mechanisms for rapid service creation and execution in order to meet the requirements of the supported applications and services the user has subscribed for.

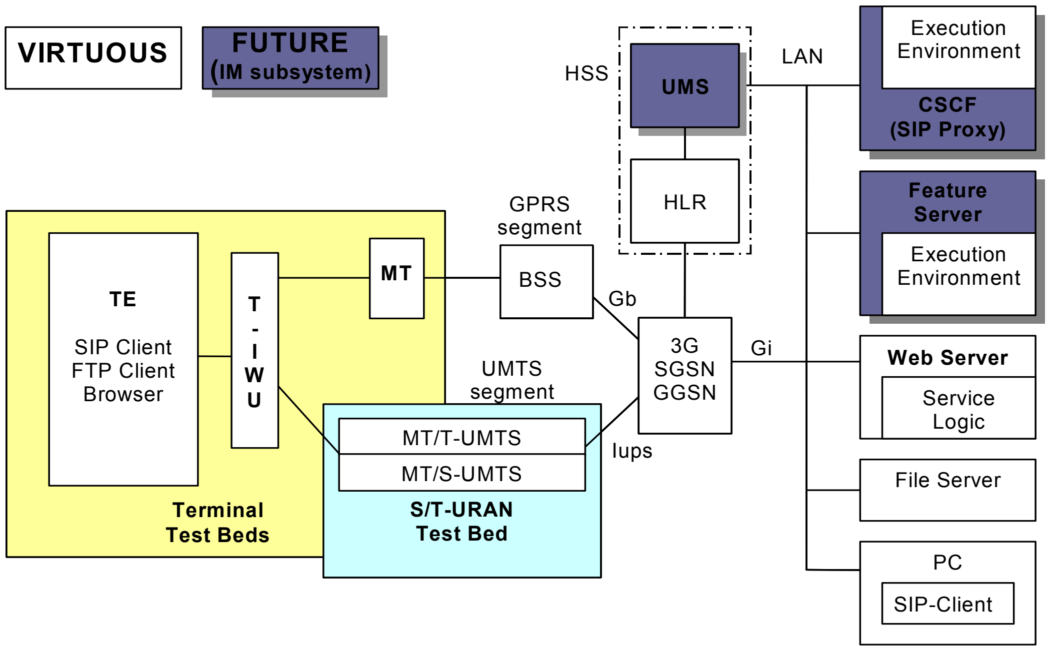

Figure 2: FUTURE demonstrator architecture

The service provisioning within the multimedia subsystem is based on a service execution element which is called execution environment and a service logic which is the real implementation of a service. The execution environment is a logical part and is either located in the CSCF or in the Feature Server. The location depends on the services which will be specified in the FUTURE project. In principle it is possible to carry out the services on the CSCF as well as on the Feature Server. For the service logic several IETF mechanisms like Call Processing Language (CPL), Common Gateway Interface (CGI) and SIP Servlets are analysed and finally used to implement the defined services.

The three parts of the Multimedia subsystem are described bellow:

User Mobility Server (UMS):
The UMS is a database that contains an identifier for the system where a mobile station is currently registered (or the last known system where the mobile station was registered). The UMS is part of the Home Subscriber Server (HSS).
It stores related information for the users such as User Service Profile and User Mobility information. UMS might also generate, store and/or manage security data and policies (e.g. IETF features). Moreover, it should provide logical name to transport address translation in order to provide answer to DNS queries. It basically interacts with the CSCF providing the latter with all the appropriate information for the location of the user and for his service profile.

CSCF (SIP Proxy):
The CSCF is basically a stateful SIP Proxy. It can work in different functions as proxy CSCF (P-CSCF), as interrogating CSCF (I-CSCF) or as serving CSCF (S-CSCF). Thus it acts as gateway between the IM subsystem and the access network (S-UMTS, T-UMTS, GPRS), as entry point of a

home network and also as SIP registrar. In FUTURE the main emphasis lays on the S-CSCF functionalities which comprise the service execution of some services and the service control of all executed services within the IM subsystem. The CSCF interrogates the HSS (the UMS part) in order to download the user profile.

Feature Server

The Feature Server is better known as application server in the 3GPP specifications. Its main task is to execute services and applications in order to relieve the CSCF. During the project it will be investigated which services will be executed on the CSCF and which on the Feature Server. The service execution will be performed by scripts (CPL, CGI) or servlets either on the Feature Server or on the CSCF.

IV. QoS Guaranteeing Functions

The main goal of FUTURE is to demonstrate the achievement of end-to-end QoS. This can only be granted when all parts of the system provide appropriate mechanisms to fulfil the required demands.

As a matter of fact the end-to-end contract will be established at connection set-up between the service provider and the user. Within the contract the adherence of limits for QoS specific parameters like delay, jitter, packet loss and latency will be agreed for the whole connection. The range of the parameter values depends on the service which is going to be established. Therefore the different QoS classes have been introduced in the 3GPP specifications [Ref. 2]. Due to the introduction of the S-UMTS component for packet based services within the FUTURE project, it will be investigated whether there is a need of new QoS parameters and new QoS classes complementing the existing UMTS specification towards a T-S-UMTS.

Connecting the mobile network to the Internet the end-to-end QoS contract can be split in various subcontracts whereby each subcontract has to meet the agreed QoS parameter values. Within the FUTURE project the contract is only divided in two subcontracts, one for the CN and one for the URAN, whereby the QoS strategies applied for the CN are only analysed by performing both theoretical and functional analysis.

Concerning the QoS strategies for the URAN, VIRTUOUS has already performed first steps towards QoS guaranteeing functions. Thus FUTURE will complement these process by upgrading the VIRTUOUS demonstrator with more QoS functionalities concerning the URAN as shown in the table below.

QoS guaranteeing function	**VIRTUOUS demonstrator**	**FUTURE demonstrator**	**Target UMTS**
Congestion control	Yes	Yes	No
Connection Admission Control	No	Yes	Yes
Scheduling	No	Yes	Yes
ARQ	No	No	Yes
Snoop	No	No	Yes
Inter-segment roaming	Yes	Yes	Yes
Inter-segment handover	No	No	Yes
Macrodiversity Intra-segment roaming/handover	Yes	Yes	Yes
Active Set handling	No	Yes	Yes
Measurement Control	No	Yes	Yes

Table 1: Foreseen QoS guaranteeing functions for VIRTUOUS, FUTURE and the target UMTS

Also shown in the table, FUTURE focuses on four different QoS guaranteeing functions, which will be implemented in the resulting demonstrator. A more detailed description of the functions is given below.

Connection Admission Control (CAC)

The implementation of this function requires an upgrade of the Non-Access Stratum (NAS) functions by some session management procedures allowing connection set-up and release. The CAC procedure then controls the acceptance or rejection of connections and establishes the QoS contract.

Scheduling
To demonstrate this QoS guaranteeing function, the demonstrator will be enhanced introducing a second user and a second satellite. For the investigation of the scheduling algorithm the specific characteristics of multimedia traffic will be taken into account as well as the satellite specific characteristics. In any case, except the conversational like VoIP, we have an asynchronous traffic model. Thus a dynamic code-to-user assignment of the CDMA codes will be performed in order to allow the demonstration of the downlink shared channel capability.

Active Set Handling
With this QoS guaranteeing function, an efficient handling of the adding/removing of satellites/beams from the Active Set will be performed by trading-off contrasting requirements such as consumption of CDMA codes and the enhancement of the received signal quality. The Active Set handling algorithm will be tested in presence of the realistic channel simulator of the available hardware physical layer emulator.

Measurement Control
A more sophisticated measurement control than in VIRTUOUS will be implemented as many of the new procedures make references to the measurement stored in the Management Information Base (MIB).

V. Expected trials and results

The FUTURE project aims at performing trials for an overall assessment of the proposed architecture. In particular, various scenarios taking into consideration the physical layer test-bed configuration together with suitable demonstrator of AS and NAS, the deployment and schedule of services will be employed and measurements will be evaluated in order to prove the advances in three main directions:

- The enhanced UMTS multimedia subsystem based on the SIP-related modules introduced into the cellular network operator's/service provider's network infrastructure in parallel with the exploitation of broadcasting and multicasting capabilities of S-UMTS. Market or research SIP-based applications will be considered and will be customized for FUTURE needs.
- The assurance of guaranteed end-to-end Quality of Service (URAN and CN) in conjunction with an efficient usage of the available bandwidth. Services such as voice over IP, web browsing and file transfer will be tested in order to demonstrate the achievement of this goal.
- The efficiency of packet access at the physical/MAC layer for S-UMTS.

VI. Conclusion

The FUTURE project is expected to provide valuable contributions for the development of a T-S-UMTS. The achievement of many end-user services will be investigated and demonstrated. In particular a basis for services based on inherent satellite functionalities will be provided by the implementation of a multimedia subsystem in the FUTURE demonstrator. The capability of providing multimedia services will also be supported by the demonstration of QoS functionalities which is one of the main emphasis of the project.
Thus, with the development of a multimedia subsystem in combination with the QoS demonstrating functions, a basis for the development of new innovative services running over UMTS networks will be provided.

References

[Ref. 1] Campa C., Eglin P., Gallinaro G., Widmer H.P., Giralda A., "A Real-Time Satellite & Terrestrial UMTS Physical Layer Testbed for the VIRTUOUS Project"

[Ref. 2] 3GPP TS 23.107 v4.0.0 (Release 4), "QoS Concept and Architecture"