RESOURCE MANAGEMENT IN INTEGRATED S-T-UMTS NETWORKS

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ABSTRACT

This paper proposes a framework for an optimal resource management in Satellite UMTS systems based on the work undertaken by the IST project FUTURE (Functional UMTS Emulator).

We will discuss some Resource Management aspects for the S-UMTS access network (USRAN) and for the UMTS Core Network, which will be likely shared amongst the terrestrial and satellite segments. As for the USRAN, maximum commonality with terrestrial solutions is pursued looking for an effective integration of both segments, avoiding extra and unnecessary efforts.

1. INTRODUCTION

S-UMTS poses as a valuable complement to T-UMTS networks. However, for the time being, it is not yet decided at which level the terrestrial and satellite systems would interoperate and, as a consequence, the concrete benefits that the cooperation could yield. The alternatives vary from the highest-level approach, considering S-UMTS an independent network, up to the lowest level one, where a satellite radio interface is embedded in the terrestrial infrastructure, reusing it as much as possible. The challenge to be faced is how to combine and complement the terrestrial and satellite technologies taking into account their strengths and weaknesses so as to give significant service enhancements as a result of their synergy. Such cooperation is expected to yield an improvement on the efficiency of existing services through better utilization of spectrum and network resources in general.

Several TDMA and CDMA radio access technologies have been proposed for the satellite component of IMT2000. This paper assumes a CDMA environment in the USRAN aiming to attain maximum synergy with the UTRAN W-CDMA technology.

The multiplicity of services, the diverse QoS guarantees, and the need for a very efficient utilization of resources demand efficient transportation means in 3G networks, i.e. packet switched. Although some packet-based resource management schemes have emerged in the IP world, the task trends to be more complicated in 3G radio networks than in fixed networks because of, between others, factors such as the unpredicted conditions of the radio environment, the soft capacity of CDMA systems and the inherent dynamic nature of mobile networks.

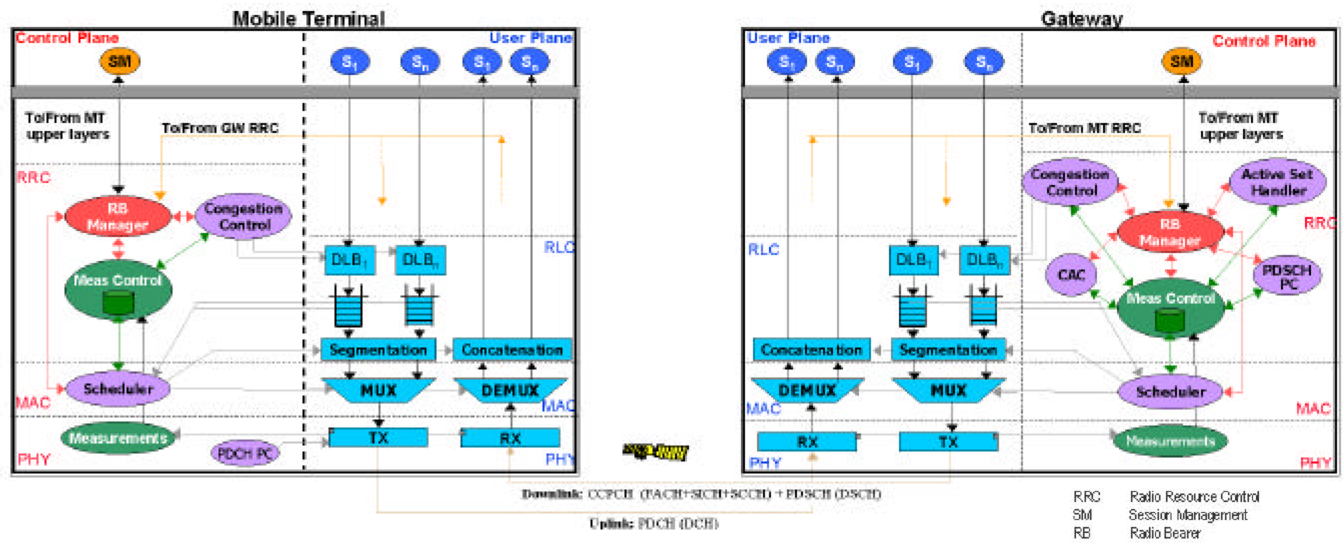
An efficient resource management deals with the guarantee of the QoS (Quality of Service) condition and the maximization of the system capacity. In the scope of the IST project FUTURE a multimedia service platform is investigated taking these both aspects into account, i.e., guaranteeing the QoS conditions contracted between the network and the user by means of an appropriate resource allocation, and that of maximizing the system capacity by making an efficient usage of the available resources. This paper will give discussion for some resource management aspects for the S-UMTS access network and for the UMTS core network which will be likely shared among the terrestrial and satellite radio segments.

The FUTURE Resource Management concept is split from a functional perspective in two different blocks: a first one which deals with procedures related to the set-up phase of user data connections; and a second one dealing with the ongoing phase of the data connections. In the former phase, the connection request from an user is checked by the Admission Control based on the demanded QoS constraints such as traffic class, bit rate, error rate, delay or priority; and on the current status of the radio interface, which is measured periodically. After acceptance of a request, the network tries to maximise the radio capacity through packet scheduling, power control and diversity procedures, while at the same time maintaining the contracted quality during the on-going connections.

The present paper is organized in four clauses: following an introduction, the description of radio resource management in the access network is given in the second clause. Core network issues are dealt with in the third clause, and our conclusions are presented in the last section.

2. ACCESS NETWORK

The S-UMTS access network is discussed in the next subsection from the physical layer perspective, followed by an analysis on some key RRM modules in a satellite context, such as admission control in the service setup-phase and diversity control and traffic scheduling for the run-phase. Far from being isolated modules, strong dependencies exist between them; sometimes assisting each other to enhance their working and sometimes agreeing compromise solutions given that different modules may target contrasting goals. To finalise this section, the radio access bearer manager will be presented as the responsible in coordinating, combing and linking the different pieces so as to make up a framework providing QoS enabled Radio Bearers. For illustrative purposes, the general architecture of the FUTURE RRM framework is shown in Fig. 1



RRC Radio Resource Control
SM Session Management
RB Radio Bearer
DLB Dual Leaky Bucket
PDSCH Physical Downlink Shared Channel
PDCH Physical Dedicated Channel
PC Power Control
CAC Connection Admission Control

Fig. 1. FUTURE RRM system

2.1 Physical layers trade offs for S-UMTS packet mode support

Forward Link Packet Access

According to Terrestrial Radio Access Network (UTRAN) approach, the forward link packet access for S-UMTS will be mainly based on the DSCH (Down-link Shared CHannel). Forward Access Channels (FACH) and Dedicated Channels (DCH) are also available for packet access, but the DSCH is considered the most efficient and flexible mechanism for supporting such kind of access although the FACH channel is also essential for transition of Mobile Terminals (MT) to the connected mode. In Release99 UTRA specs, each user of the DSCH also needs a down-link DCH carrying the signalling for implementing closed-loop power control and DSCH resource allocation.

Further, DSCH operation is typically associated also with an up-link DCH required for the down-link power control feedback signalling. From the physical layer perspective, the most important optimisation to consider for the DSCH in S-UMTS is the possible decoupling of such channel from the associated DCH to avoid the overhead (both in power and in code usage) in maintaining such DCH.

Two alternatives are possible [1]. The first one envisages the utilisation of rate adaptation or open-loop power control strategies. This is justified by the fact that power control is less important in S-UMTS than in T-UMTS due to the reduced signal dynamic expected and therefore an open-loop strategy can be sufficient. A Shared Control Channel (SCCH) can be then utilised in order to support DSCH related signalling and therefore no DCHs are strictly required. The GW adjusts its transmission power according to the reported SNIR, which is periodically measured by MT, and the target SNIR. The target SNIR can be adjusted to achieve the desired FER with a strategy similar to the outer loop of the closed loop power control. In particular, the target SNIR is increased by the amount e for each unsuccessfully packet transmission (no ACK received) for a certain period or decreased by *eP (P* being the target frame error rate) for each successful packet.

A second solution can still provide the possibility to MTs to continuously measure the SNIR for closed loop power control or rate adaptation purposes. A possible scheme at this regard is to share a DCH between multiple users. This actually means that in addition to the SCCH, also a new type of channel (referred here as Signalling Indication Channel, SICH) has to be defined to support power control and signalling indication to multiple terminals. Each user having an active packet session has resources assigned on a SICH channel for both power control and signalling indication purposes. A possible approach for SICH is that of dedicating a whole slot each frame to a single user for SNIR measurement during the whole packet session, transporting of TPC commands related to up-link transmission and for signalling indication. It is worth to point out that the use of the closed loop power control scheme still requires a DCH on the reverse link for transmission of PC commands. The first solution is anyway the most attractive one and is further considered inthis paper.

Satellite Diversity has been shown to be an effective mechanism to minimize the outage probability due to satellite shadowing and also to improve the system power efficiency. For satellite DSCH operation, it may be worth to support both the conventional satellite diversity and a FCS-like (Fast Cell Selection mechanism proposed for HSDPA operation in 3GPP) operating mode (hereafter referred to as Fast Satellite Selection or FSS). Whilst in FCS it is the user which explicitly selects the best Node B for transmission, here we will assume that the GW autonomously selects the best path without explicit feedback (i.e. only using measurement report and/or measurement of user up-link signal quality). To minimize data transmission, a new measurement report is only transmitted whether a new best satellite is available.

While conventional diversity operation of the SCCH is not applicable due to the different signalling content of the SCCH frames transported on different satellite paths, conventional diversity operation with maximal ratio combining of the DSCH is instead possible even though it make scheduling somewhat more difficult due to the constraint that the same data packet shall be simultaneously transmitted with the same characteristics (in terms of spreading factor) on multiple satellite paths. In

an FSS based strategy the network will maintain an *Active Set* list of satellite paths (to be signalled to the user) and select the *best path* within such list which will be used for both SCCH and DSCH transmission. The user shall receive the SCCH on all the satellite paths in its *Active Se*t. (more detailed about AS handling is described later.)

Return Link access

As far as the Return Link is concerned, a hybrid scheme with access based on Spread Aloha or on a Capacity Reservation Scheme is attractive. In fact, whilst a Spread Aloha approach seems the more suitable one for RL access at low rates and comparatively low packet volumes [2], a capacity reservation approach could address the traffic with medium to larger number of packets user data. In this approach, through communication among MT and GW, the GW is able to allocate to the MTs the appropriate resources both in terms of data rate and allocation time in order to satisfy their needs, and to coordinate the up-link aggregated traffic taking interference level into account.

The combination of these two approaches seems to be the most suitable solution for what concerns packet access in the RL maximizing channel usage and minimizing channel delay. A strategy based on traffic volume could be implemented at the MTs in order to decide which of the two mechanisms to select for RL channel access. In this way, basing on the current MT queue length, the Spread-Aloha or reservation access scheme is selected. At higher loading anyway the system could revert to the reservation scheme only. The discriminating threshold to decide which mechanism to use for the access can be decided at network level and broadcast by the GW to all MTs basing on the current system load.

Broadcast/Multicast Support

Broadcast/Multicast applications have already become a key feature of the emerging multimedia services. Satellite in particular is best placed to offer multicast because of its inherent broadcast capability. In general, if the broadcast data flow is continuous and with constant (or almost constant) bit rate, it is certainly not worth to allocate resource for such broadcast channel on the DSCH but an ad-hoc carrier can be envisaged for such a purpose (e.g. Secondary CCPCH used for FACH transmission). If the broadcast channel is very bursty in nature on the other hand the DSCH can be a suitable model even if the Secondary CCPCH may still be used efficiently, because variable data rate are well supported. In case of DSCH/SCCH option, the presence of broadcast/multicast data will be indicated within the SCCH through the utilisation of IDs identifying group of users accessing the same service.

The reliability of Multicast data delivery is nowadays a major issue. In S-UMTS multicast applications it will be common not to have a feed-back channel, either because a receiver only MT is used or because the number of users is so large that the required RL capacity for supporting ARQ would be excessive. In general a FEC-only approach can fulfil the vast majority of the multicast applications and can be therefore considered the most cost-effective solution to be implemented for S-UMTS. Alternative scenarios where the number of users is not excessively great could exploit a combination of FEC and ARQ in order to reach full reliability.

Another important point concerning Multicast/Broadcast applications is related to Power Control [3]. Broadcast data for instance are received by definition by all users and no feedback for power control purposes (either closed or open loop) can be in general expected. The same applies for Multicast applications where a large number of users is involved (Excessive processing required at the GW on the RL). Open loop power control solutions without MTs feed-back could be in such a case envisaged basing on the exploiting of users position information (if known) or on the setting up of permanent measurement field devices in order to get a continuous flow of measurements to be used to set up the Tx power level. A further and different solution could be based on the feedback power control reports coming from a limited number of designed users (each representing a particular region of interest).

2.2 Admission control

Connection Admission Control (CAC) is considered to be a major issue in 3G cellular systems because it is strictly related to the Quality of Service that is being promised by these systems. The mission of the CAC module is to monitor the available system resources in order to accommodate new service requests in the network according to its quality demands while at the same time respecting the QoS of existing connections. Thus, the CAC turns out to be a crucial function for the network operator in order to guarantee the stability of the network and to achieve high network capacity. In the very complex CAC task in 3G cellular systems, due to the soft capacity of CDMA systems, the system may be mainly interference limited since the acceptance of a new call aims at achieving a target signal-to-interference ratio (SIR) while respecting at the same time the target SIRs of the already active calls.

The target pursed by the admission control function can be faced by applying different schemes adapted to capabilities of the system. A couple of examples are *power-based and throughput-based algorithms* described in [4]. On the other hand, the FUTURE approach (see [1]) is an *interactive SIR-based* algorithm that aims at finding out whether a power equilibrium point can be reached respecting satellite and terminal power budgets, so that all target SIRs are met after accepting the call. Given that the acquisition of instantaneous measurements on power levels, interference levels or propagation conditions may lead to erroneous CAC decisions due to the varying nature of the WCDMA radio interface and of the packet services, instantaneous measurements are properly processed over time windows to regard the time variations of the measured values.

Besides power and interference effects caused by the new connection, the FUTURE CAC also checks that capacity of the network to support the required bandwidth and delay by means of a capacity planning function provided by the DSCH Scheduler. A mid-term simulation of the averaged traffic presently cursed is performed in order to estimate the resources left for the new connection.

The FUTURE CAC regards the interference from the nearby cells on the cell where the admission request is issued (target cell). In general, the effect of the possible admission on those nearby cells need to be considered as well, so that the interference generated by the new connection in every neighbouring cell must not exceed its current resource margin. Another factor that requires coordination between cells is the fact that a connection request can be originated either from a new connection or from a handoff. In satellite systems, handoffs are expected to be not so frequent as in terrestrial systems. Another factor, the downlink power allocation, becomes essential in this case. If it is possible the distribution of the total satellite available power between beams, suitable algorithms should be designed to optimise power utilization for the whole population of users covered by a satellite.

The CAC developed in FUTURE is applied to the admission of bi-directional, high demanding services which could commit the stability of the network. In the satellite environment with a potentially large number of users, non-interactive and simpler power based or throughput based CAC schemes are worth to be explored as well, specially considering that reduced or no feedback information from the terminals may be available at the gateway. This could well be the case of multicast communications, whose characteristics make them specially suited for a satellite network.

2.3 Active set handling

With reference to Soft Handover, the “Active Set” (AS) is defined as the set of satellite beams which the MT is simultaneously connected to. All other candidate beams are defined as “Monitored Set”. Based on the measurement of beams monitored, the Soft Handover function evaluates if any beam should be added to (Radio Link Addition), removed from (Radio Link Removal), replaced in (Combined Radio Link Removal and Addition) the Active Set, performing than what is known as “Active Set Update” (ASU) procedure.

The purpose of the active set update procedure is to update the active set of the connection between the MT and the USRAN. The MT should keep on using the old radio links while allocating the new radio links. Also the MT should keep on using the transmitter during the reallocation process.

A possible solution for realizing the active set update procedure is the “Relative Threshold” algorithm; for the description of this algorithm the following parameters are needed:

- *As_Th*: Threshold for macro diversity (reporting range) [dBm];
- *As_Th_Hyst*: Hysteresis for the above threshold [dBm];
- *As_Rep_Hyst*: Replacement Hysteresis [dBm];
- *Dt*: Time to Trigger [sec];

Using the following definitions:

- *Best_Ss*: the best measured beam in the Active Set.
- *Worst_Old_Ss*: the worst measured beam in the Active Set.
- *Best_Cand_Ss*: the best measured beam in the Monitored Set.
- *Meas_Sign1*: the measured and filtered quantity of the worst beam in the Active Set.
- *Meas_Sign2*: the measured and filtered quantity of the best beam in the monitored set.

The main steps of the algorithms are:

1. If *Meas_Sign1* is below (*Best_Ss–As_Th–As_Th_Hyst*) for a period of *Dt*, then remove Worst beam in the Active Set.
2. If *Meas_Sign2* is grater than (*Best_Ss–As_Th*+As_Th_Hyst) for a period of *Dt* and the Active Set is not full, then add Best beam outside the Active Set in the Active Set.
3. If Active Set is full and *Best_Cand_Ss* is higher than (*Worst_Old_Ss+As_Rep_Hyst*) for a period of *Dt*, then add best beam outside Active Set and Remove Worst beam in the Active Set.

2.3 Packet scheduling

The FUTURE scheduling function [1] has the tasks of:

(i) selecting a transport format (TF) so as to maximise the data flow sent in the current transmission time interval (TTI).

(ii) allocating the available band of the shared channel (DSCH) in downlink to MTs so as to guarantee to both MTs the timely delivery of a sufficient data flow in a mid-term time horizon.

The functionality developed to cope with the latter task represents the most innovative aspect of the Scheduler, and is implemented by a module (capacity planner) in charge of allocating the band so as to guarantee the required QoS to *both* MTs in the mid range. This is done by a mid-term analysis of the content of the logical channels, which takes into account all the packets in the input queues and the relevant due-dates. To avoid MT starvation, we search for Pareto-optimal solutions maximising the utility of one MT provided that the utility of the other MT is greater than or equal to a given threshold. This is called a *competitive* approach. The utility function considered is the number of on-time data-packets of each MT, and is evaluated by previously partitioning the content of logical channels into blocks: each block is relevant to one MT only, and contains up to half the bytes that can be sent by the physical channel during one TTI. A solution is an assignment of block pairs to TTIs. One can then easily evaluate the utility of assigning each block to each TTI in terms of the (weighted) number of on-time packets. The evaluation is approximated since the amount of useful traffic data sent depends also on the TF chosen, and we do not know in advance the TF for each TTI (a solution to this drawback would be associating two TFs per TTI, one per MT, but this would not agree with 3GPP standards).

Once the evaluation is completed, we solve an optimisation problem *(competitive matching*) which is NP-hard. The feasibility of the approach in terms of computational resource has been successfully tested on a prototype pseudo-polynomial version of the algorithm based on the following recursion:

$$a(n,k,b) = \max\left\{a(n-1,k-1,b-b_{k,n}),\ a(n-1,k,b)+a_{n-k,n}\right\},$$

where $a_{it}(b_{it})$ is the utility of assigning the i-th block of MT#0 (MT#1) to the t-th TTI, and $a(n,k,b)$ denotes the maximum utility of MT#0 when the blocks are assigned to n TTIs, $k \le n$ $k < n$ TTIs are assigned to MT#1, and the utility threshold for MT#1 is b. The above formula holds under the stipulation that $a(n,k,b)$ is not defined if such a solution does not exist, and the initial conditions:

$$a(n,n,b) = 0$$

for all n and b such that $\sum_{j=1\dots n} b_{jj} \ge b$

2.4 Radio access bearer management

The support of QoS functionality in UMTS [5] has been based on a layered architecture constituted by bearer services provided over the reference points of the system's domains. The basic functional entities in this model are the service managers that perform QoS management functions in the nodes they reside and additionally control the signalling exchange among the network domains. In the case of radio access network, the Radio Access Bearer (RAB) Manager fulfils these tasks and is responsible for the establishment, maintenance and release of correspondent Radio Access Bearers between the MT and the CN. Responsibility of the RAB manager is also the co-ordination of the radio resource management procedure within the access network as it is the entity that collects connection-related information from user terminals and core network and triggers the local RRM procedures accordingly. The aforementioned RABs are constituted by lower layer flexible enough Radio and Iu Bearers able to support different traffic types, throughput rates, transfer delays and bit error rates according to the UMTS QoS concept. The management of these bearers is performed via RRC and RANAP signalling exchange among the RAB manager and its MT and CN entities respectively.

The CN-located UMTS Bearer Service manager handling the interaction with user (with the NAS signalling), instructs the RAB Manager to check whether the establishment or modification of a RAB with the specific characteristics is feasible. The RAB Manager consults the admission control module whether it is possible to establish the new connection or to modify an existing one without exhausting the radio resources. The affirmative response results in the establishment of the Radio Bearers (logical channels), featuring the mapped traffic characteristics of the RAB that triggered the procedure towards the user side and the correspondent Iu bearers towards the CN side. At this point, in FUTURE, the RAB manager also communicates to the active set handler and power control modules the updated information regarding the user's connection status, informs the MAC scheduler about it and stores all required information to a local database.

3. CORE NETWORK

The elaboration of the UMTS's QoS concept and architecture has been based in two main principles. The first one refers to the grouping of the packet flows in specific traffic classes each of which features special properties, while the second one addresses the functionality needed to be supported in each domain of the UMTS for an end to end guaranteed service provision. As presented in [5] and [6], 3GPP proposes a functional architecture, regarding the packet switched domain, where bearer services are being established between various UMTS entities belonging to different layers, providing in this way the required QoS guarantees. Each bearer service performs operations concerning the control of signalling messages, the user traffic and the resource management of the particular domains it references. In the following an investigation of the impacts caused by the integration of the satellite access segment with the terrestrial one to the CN will be performed and the implications of the support of broadcast and multicast services in it will be depicted.

There is a significant number of issues presenting the interoperability distance between the positioning of S-UMTS with respect to T-UMTS. The service interoperability between the terrestrial and the satellite component can result from different architectures exhibiting different degrees of integration between the two components with a direct impact on the system cost. (Ideally this interoperability would expand down to the terminal level, in order to make the S-UMTS system more "attractive" to the end-user). Two possible scenarios are envisaged for the interoperation of the T- and S- UMTS concerning the CN, namely the single and the two domain case. In the two domain case it is proposed that there is a separate and independent CN for each segment. On the other hand, in the single domain case, followed in FUTURE, it is assumed that one CN exists interfacing both the UTRAN and USRAN via the Iu. The decision for the selection of one scenario against the other is operator dependent and therefore both cases are a feasible option for the final UMTS implementation.

One existing problem inherent in the single domain case, is the extension of the QoS procedures followed in the CN in order to adapt the properties of the propagation through the satellite channels. An implied requirement will be the extension of the supported mechanisms in the bearer service managers, so as to support the extra characteristics related to the greater delay or the greater error rate values experienced. A possible solution would be to set different configuration for the flows routed through the satellite segment or the installation of TCP proxies capable to handle the differentiation in the access, the core as well as the external networks.

In the two domain scenario the situation is complicated in the case where one mobile station changes its point of attachment and thus changes the serving Core Network. Apart from the signalling overhead caused in such situations, related to the mobility profile of each user and the provided service itself, inherent are the impacts caused by the fact that the used mechanism employed to support QoS in UMTS is DiffServ, and thus there are no offered guarantees that the CN domain of the segment at which the mobile terminal is attaching, will have sufficient resources for the manipulation of the extra traffic. A not optimal solution would be the a-priori reservation of an amount of the available resources (bandwidth, buffer space, processing power in GSNs etc.) resulting in a worse utilisation of the CN's resources.

The optimisation of the CN resources utilisation is also addressing the multicast/broadcast (MBMS, Multimedia Multicast Broadcast Service) transmission of traffic flows within it. The standardization procedure now being conducted on behalf of the sixth release of the UMTS, presents two alternatives for the CN's support of MBMS. These deal with the mechanisms used for the transport of the multimedia flows and the involved entities that enable the transport. The possible scenarios for the implementation of such procedures, described in [7], address the way the GTP traffic is transmitted. The first one supposes that in the Gateway GSN the traffic is forked towards the multiple SGSNs, which service users belonging to each multicast session, via unicast tunnels created for this reason. No other changes are required in the IP level. The other one proposes that the routers used for the transport for all kind of multicast traffic in the UMTS's CN, are multicast-enabled. The created GTP tunnels (multicast tunnels) between the GSNs are preserved. It is required from GGSN to establish multicast groups of local scope that will be used for the transport of MBMS traffic in the CN. A functional entity is introduced in order to handle the traffic and signalling for the multicast transport, namely the Broadcast Multicast Service Centre (BM-SC). This node will be responsible to interface multicast sources from public Packet Data Networks or other content providers and to determine the applicable QoS properties for the being established connections within the PLMN's boundaries.

The procedure followed to support multicast service delivery in the target UMTS is similar to the one employed in the case of unicast. The extension of the UMTS Bearer Service Manager is required in order to include the MBMS Bearer services used for the control and transport of the multicast flows in the CN.

The combined support of multicast and DiffServ technologies by the CN routers are considered to have rather incompatible operation within an IP-based core network, though. The former assumes that state information is being stored in the router tables, whereas the latter does not suppose any kind of state storage in the tables, as only the DSCP field is used for the packets' forwarding. The support of multicast transport in the DiffServ domain requires modifications of both technologies so as to the enable the integrated operation of them.

Furthermore, it is not recommended that the creation (or change of location of a user with removal of a branch and addition of a new one) of a branch of the MBMS distribution to impact the already established branches. Such an approach implies a heavy mechanism to adjust the QoS of all the already established MBMS branches. As a consequence, QoS negotiation may not be negotiable by the network nodes. One of the consequences is that some branches may not be established if QoS requirement cannot be accepted by the concerned network node.

Finally relative is the issue of the QoS profile that each multicast session will be featuring. It is required that each branch of the created distribution tree, will have the same QoS profile as the rest of the tree branches. Two possible scenarios on providing differentiation of the perceived QoS level would be the establishment of multiple sessions with different quality characteristics, or the creation of a more scalable solution by providing more than one enhancement layers in separate multicast sessions. It is for further study whether an MBMS service can be provided over multiple distribution trees with differing QoS profiles but in any case the GGSN should provide the mechanisms that will enable such a capability. The GGSN is capturing MBMS data coming from a multicast source and places it on one or more GTP tunnels opened as part of the service. Different media flows comprising a single MBMS from a user's point of view, may be provided over separate GTP tunnels, enabling QoS differentiation for each one. The different media components are either transmitted by using one IP multicast group but multiple ports or by using separate IP multicast groups.

4. CONCLUSIONS

In this paper we have proposed a template for a resource management framework in S-UMTS which takes the satellite specific condition into account and aims to reach the guarantee of the contracted QoS level and the maximization of the limited radio resource.

Moreover the UMTS CN aspect regarding the resource management has been handled in order to investigate the inter-operation between S-UMTS and UMTS CN in terms of resource management.

Currently we are in the final phase of implementing the FUTURE test bed which will demonstrate a framework for resource management in S-UMTS. As result, we will validate the performance of our concepts in a reality-near condition.

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