Wireless World Research Forum

(WWRF)

Working Group:
WG3: Co-operative and Ad-Hoc Networks

Addressed Objectives:
(a) Contributing towards the development of reference models for the Wireless World.
(b) Identifying important new research areas for wireless communication systems beyond the third generation.

Title of the research item:

End-to-End QoS Architecture for Multi-Domain and Wireless Heterogeneous Access Networks: the EVEREST approach

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Subject Area:
CRRM and E2E Qos for Heterogeneous Access Networks

Abstract:
This document provides the End-to-end QoS Architecture approach envisaged under the IST-EVEREST project. The architecture is aligned with the QoS framework introduced within 3GPP Release 5/6 and it is flexible enough to incorporate different Common Radio Resource Management (CRRM) scenarios for heterogeneous access networks (UTRAN, GERAN, WLAN) which are intended to be analysed within the project.

1 PROJECT MAIN GOALS

The objective of the EVEREST project is to devise and assess **a set of specific strategies and algorithms** for access and core networks, leading to an **optimised utilisation of scarcely available radio resources** for the support of mixed services with end-to-end QoS mechanisms within **heterogeneous networks beyond 3G.**

The provision of beyond 3G heterogeneous network topologies is conceptually a very attractive notion; however, it is a challenge to accomplish an efficient network design. In this context, Radio Resource Management (RRM) strategies are responsible for an utmost efficient utilisation of the air interface resources in the available Radio Access Networks (RANs). EVEREST will provide tangible contributions towards a heterogeneous realisation of 2G/2.5/3G (e.g. GERAN, UTRAN) and 3.5G networks with the inclusion of newly emerging RANs (e.g. WLAN for indoor coverage extensions and capacity enhancements). The potential inclusion of location information in RRM design, as well as some forms of RAN sharing, will be considered as additional examples of the medium and long term research focus of EVEREST.

In order to accomplish these objectives, the project evolves around two main activities:

- Algorithmic development and simulation by means of advanced simulation tools
- Demonstration of the technology by means of implementing real-time testbeds for proof of concepts

It is a further purpose of the project to contribute actively to the different standardisation fora. In that sense, the proposed solutions will be compliant with and aligned with standardisation activities carried out in the field, e.g. 3GPP, IETF, IEEE. Moreover, the results obtained in EVEREST are expected to be of significant momentum, the beneficiaries to which are service-providers, operators, manufacturers and end-users.

2 KEY ISSUES

The research challenges, to be tackled by EVERST project, can thus be summarised as follows:

- To identify, propose, simulate, assess and validate advanced RRM algorithms for GERAN and UMTS as well as novel radio concepts beyond 3G.
- For heterogeneous networks, to develop Common RRM (CRRM) algorithms between access technologies focused on UTRA and GERAN. The Iur-g interface between GERAN BSC and UTRAN RNC is discussed in 3GPP Rel-5 to be used in signalling to transfer information between BSC or BSC/RNC. The Iur-g is an interface containing a control plane and no user plane. Both for tight and very tight coupling will be considered.

- To consider other technologies that can be a complement to GPRS/UMTS, such as:
  - WLAN for indoor hotspots
  - Different types of repeaters, acting as coverage extensions

- To support end-to-end QoS in a heterogeneous wired and wireless mobile environment. To this end, the investigation about the relationship between the core network Band-width Broker (BB) and the RRM & CRRM entities for a plethora of RANs (UMTS, GERAN and WLAN) becomes of prime importance.

- To demonstrate the benefits of the developed RRM and CRRM algorithms by means of multimedia IP based applications over a real time testbed.

3 TECHNICAL APPROACH

The project will be carried out in the following three main stages:

1. Determination of interest and relevant target scenarios. This takes into account:
   - Communications environment, i.e. macrocell, microcell, indoor, etc., and user mobility
   - Technologies deployed (GSM, GPRS, EDGE, UMTS, WLAN), their corresponding capabilities and functionalities, as well as their corresponding network architectures and entities
   - Service mix and service load (conversational, interactive, streaming, etc.)

   This activity is carried out in WP2

2. Development of RRM and QoS management algorithms, with evaluation through simulation. Focus will be placed on finding commonalities among the different scenarios considered, rather than trying to optimise algorithms and algorithmic parameters for a specific scenario. Thus, the goals of EVEREST extend the mere analysis of different scenarios and will target the definition of generic RRM criteria, facilitating their applicability in scenarios differing from those studied in detail within the project.
   This activity is carried out in WP3

3. Validation and demonstration of the proposed algorithms for the defined scenarios by means of a real time testbed supporting IP-based mobile multimedia applications with end-to-end QoS capabilities. To support this latter service, the IP CN has to be configured in the following way: a mobility management has to be installed, and the QoS framework based on Diffserv, including its control plane, has to be configured. Then, the interactions of the BB with the radio resource entities will be considered.
   This activity is carried out in WP4

These main research topics in EVEREST will be addressed within a proposed end-to-end QoS management framework aligned as much as possible with the QoS architecture envisaged in 3GPP Release 5 and 6 and other relevant IETF proposals. In this sense, it is assumed within the project that any E2E QoS architecture for converged 3G mobile – wired IP networks should be compliant with 3GPP UMTS QoS general framework [1].

The main concepts arisen from the 3GPP UMTS QoS general framework are illustrated in Figure 1. A policy-based framework is introduced in Release 5 to manage QoS for multimedia services supported within the IMS Domain. This policy framework is intended to enable the coordination between events in the application/service layer and resource management in the IP bearer layer and it can be used to provide a policy-based admission control in charge of authorising specific QoS resources for the a set of IP flows within a user session. In this way, the service provider (i.e. the mobile operator) could decide which level of QoS is offered taking into consideration the characteristics of the service being requested but also any other consideration related to business models and management (premium users, etc.).

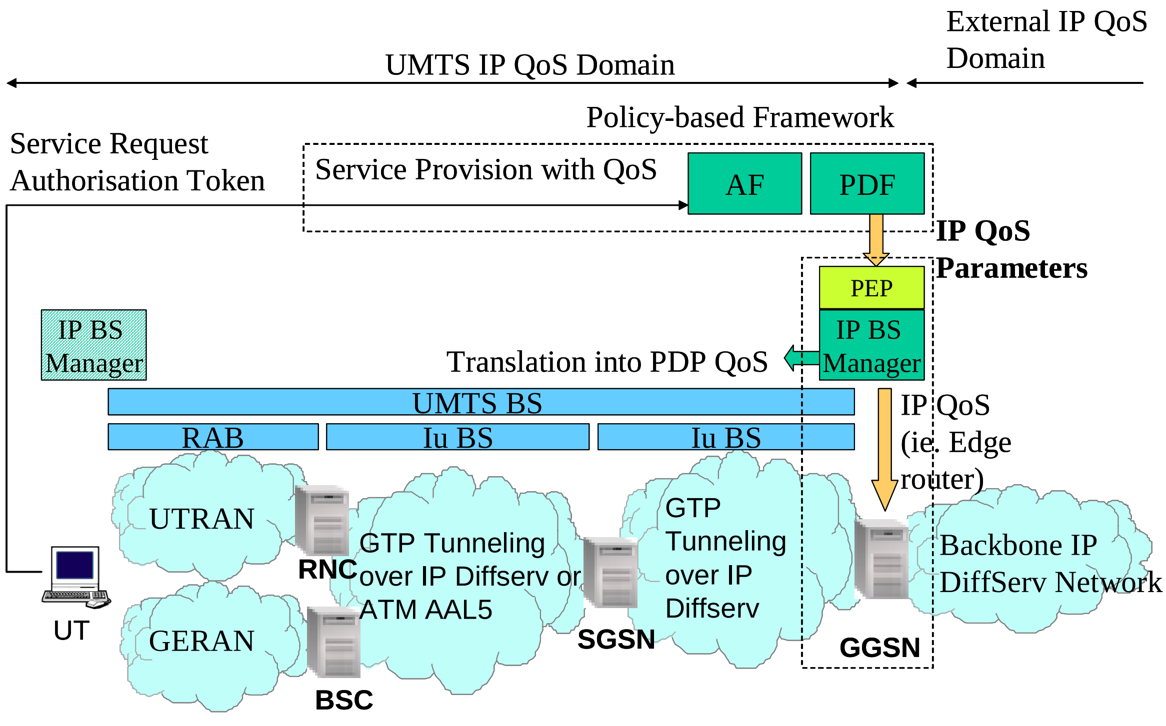

Figure 1. 3GPP UMTS End-to-End QoS Framework.

This 3GPP UMTS policy framework is aligned with the policy framework defined within IETF. Under the IETF vision, one way to think of a policy-controlled network is to first model the network as a state machine and then use policy to control which state a policy-controlled device should be in or is allowed to be in at any given time. Given this approach, policy is applied using a set of policy rules. Each policy rule consists of a set of conditions and a set of actions. IETF has defined a policy framework [RFC2753] within which sets of policy rules described in the form of policy models [RFC3060] are transformed into network device configurations in an administrative domain. The policy rules are stored in the *policy repository* from which the policy decision point (PDP) retrieves the appropriate policy rules in response to policy events that are triggered by the contracted IP QoS services, such as the reception of a RSVP message by the policy enforcement point (PEP) in the outsourcing model, or in the provisioning model where the policy events and configuration of the PEPs are asynchronous.

According to this IETF framework, the UMTS Framework introduces the Policy Decision Function (PDF) entity, that is equivalent to the PDP in the IETF model, and the PEP is located in the GGSN (See Figure 1). The interface between the PDF and GGSN, named Go interface, supports the transfer of information and policy decisions between the policy decision point and the IP BS Manager in the GGSN. The authorized resources provide an upper bound on the resources that can be reserved or allocated for the set of IP flows. The authorized resources are expressed as a maximum authorised bandwidth and QoS class. The PDF generates a maximum authorized QoS class for the set of IP flows and this information is mapped by the **Translation/mapping function** in the GGSN to give the authorized resources for UMTS bearer admission control. An additional entity named Application function (AF) is used to offer services that require the control of IP bearer resources (e.g SIP Proxy). The AF maps QoS-related application level parameters (e.g. SDP) into policy set-up information, and sends this information to the PDF in order to obtain the authorisation of the QoS settings for the requested service. And important consideration here is that 3GPP is extending the policy-based QoS control architecture for IMS to other services [2].

As also illustrated in Figure 1, end-to-end QoS support in UMTS mandates the existence of an IP BS Manager function in charge of managing IP bearer services using standard IP mechanisms. According to 3GGP TS 23.207, interaction between UMTS bearer services and IP bearer services shall only occur at the *translation* function in the GGSN or in the UE. While the existence if the IP BS Manager in the GGSN is mandatory, in the UE is left to be optional. If an IP BS Manager exists both in the UE and the Gateway node, it is possible that these IP BS Managers communicate directly with each other by using relevant signalling protocols (e.g. RSVP). So, IP QoS parameters available at the IP BS Manager are enforced at the Gateway SGN and a translation of these parameters into the QoS parameters considered in the Packet Data Protocol (PDP) context is done. Then, it is the UMTS Bearer Service (BS) manager which will apply such a QoS requirement in the different segments within UMTS.

A key goal of the QoS architecture taken as a reference within EVEREST should be the support of end-to-end paths in IP multi-network over various access technologies. It is expected that end-to-end scenarios in future wireless systems can encompass several L2 hops and multiple IP networks. End-to-end QoS guarantees need to be spread along all domains involved in the communication path. QoS handling in each domain can follow different QoS models as the ones outlined for DiffServ domains and UMTS networks. This concept has been addressed from different perspectives and different approaches exist, although no one offers a complete solution according to EVEREST's goals.

A first approach of this multi-domain scenario is proposed in [3]. Within the Always Best Connected (ABC) vision, and end-to-end path is established though several different IP-based domains according to the following key issues:

- QoS requirements are user-driven and are instantiated by means of wireless hints (Information Elements that are QoS-mechanism-agnostic and access-technology-agnostic). Wireless hints are envisaged to be qualitative rather than quantitative. This

Wireless hints could be derived after session negotiation between end users according to the requirements of the information to be transmitted.

- Each involved domain contains an IP QoS aware element, named IP QoS Controller in the proposal, with is equivalent to the IP BS Manager element introduced in UMTS. In this sense, a UMTS network could be seen as simple as one of multiple domains that a connection might traverse.
- There is a need for some QoS information distribution mechanism among the QoS Controllers in each domain. This mandates the existence of some IP-level QoS signalling to support the end-to-end QoS (work in IETF Next Steps in Signalling WG is pointed as possible solution)
- Each network domain makes a local decision to translate distributed QoS parameters into specific domain QoS provision.

Figure 2 illustrates the ABC approach: and end-to-end IP Bearer is established through multiple heterogeneous domains. Figure also clearly depicts the three different steps involved in the path establishment: session layer negotiation, distribution and reservation for end-to-end QoS and IP QoS bearer set-up.

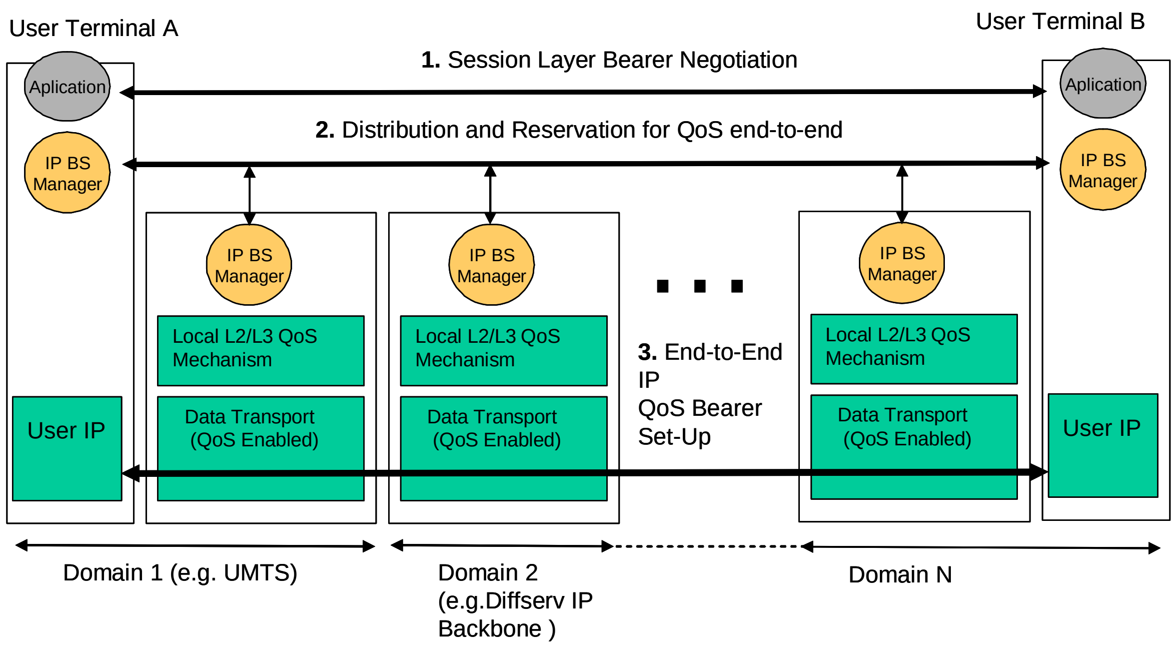

Figure 2. End-to-End QoS IP architecture (ABC in [Fodor]).

However, the ABC proposal has some open issues that are considered relevant within EVEREST and should be taken into account. Among these open issues we can remark:

- How partitioning of QoS is carried out among the involved domains.
- How other aspects than those related to resource management can be considered in QoS Management decisions.

Another E2E approach more focused on solving these latter issues can be found in [4]. This work proposes a policy-based QoS management architecture that may be applied to a multi-domain scenario. QoS Management in each domain is done according to a set of policy rules that are negotiated and maintained in a consistent way by all the involved domains that can be traversed when establishing a user session. Among the keys aspects of such framework we can remark:

- Policy rules describe the amount of network resources required to realize QoS services without going into the details of how to configure the network devices.
- The PDP translates the acquired policy rules into a set of QoS mechanism configuration actions based on the capabilities of the PEP and the current network conditions.
- A hierarchical policy architecture can be employed within a single operator's multi-domain network and a peering architecture should be used to interconnect multiple operators' networks.
- Network-level policies when interconnecting peer domains are determined by SLSs that could contain static and dynamic service requirements. Static service requirements can be directly translated to enforceable network-level policies while dynamic service requirements are dependent on the state of the network (i.e. Load) and so a negotiation should take place before being able to enforce such policies (SLS negotiation) This negotiation may not be initiated on a per-session basis. Instead, SLS negotiation is usually initiated when there is a change in the state of the network that makes existing policies to be no longer enforceable).

According to both approaches, in EVEREST, it is proposed to extend the ABC end-to-end architecture in order to support a service-based policy management as depicted in the following figure.

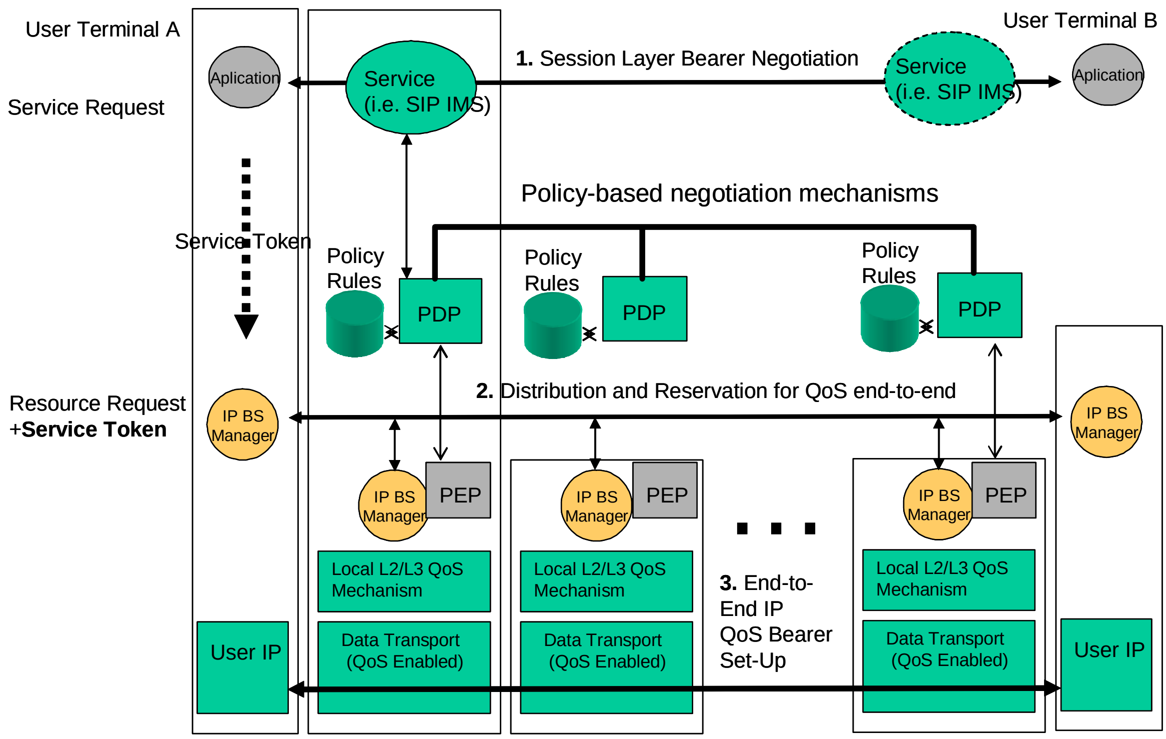

Figure 3. Extension of the ABC approach with policy-based QoS Management

According to previous end-to-end and to the UMTS QoS architectures, Figure 4 shows a proposed architecture for QoS handling in a Heterogeneous Radio Access Network with CRRM capabilities. As shown in the Figure, different RANs are envisaged to offer access to the same Core Network (tight coupling approach) and CRRM functions are used to manage radio resources optimally. The proposed architecture is more aligned with the vision of UMTS Release 6 and envisages the possibility of using a Diffserv-enabled IP network as Core Network. Among the key aspects of the proposed architecture we can remark:

- SGSN control functions are separated from its routing functions. This approach is intended to introduce native IP transport down to the RNC and its equivalents.
- UMTS core network is a diffserv network and mobility management solutions other than GTP are used. QoS management in CN might be addressed according to the bandwidth broker concepts introduced in [6] [6].
- Functions associated to the so-called Wireless QoS Broker in the Figure include the ones envisaged in the Radio Access Bearer Manager considered in UMTS (see Figure) plus all the additional functions derived from the handling of different RAN simultaneously (CRRM co-operation).
- Policy-based framework mechanism to manage end-to-end QoS policies. Besides, within the heterogeneous access networks this framework may be extended up to RNCs and its equivalents.
- As detailed below, the proposed architecture is flexible enough to cope with different approaches about common RRM that are going to be addressed within the project.

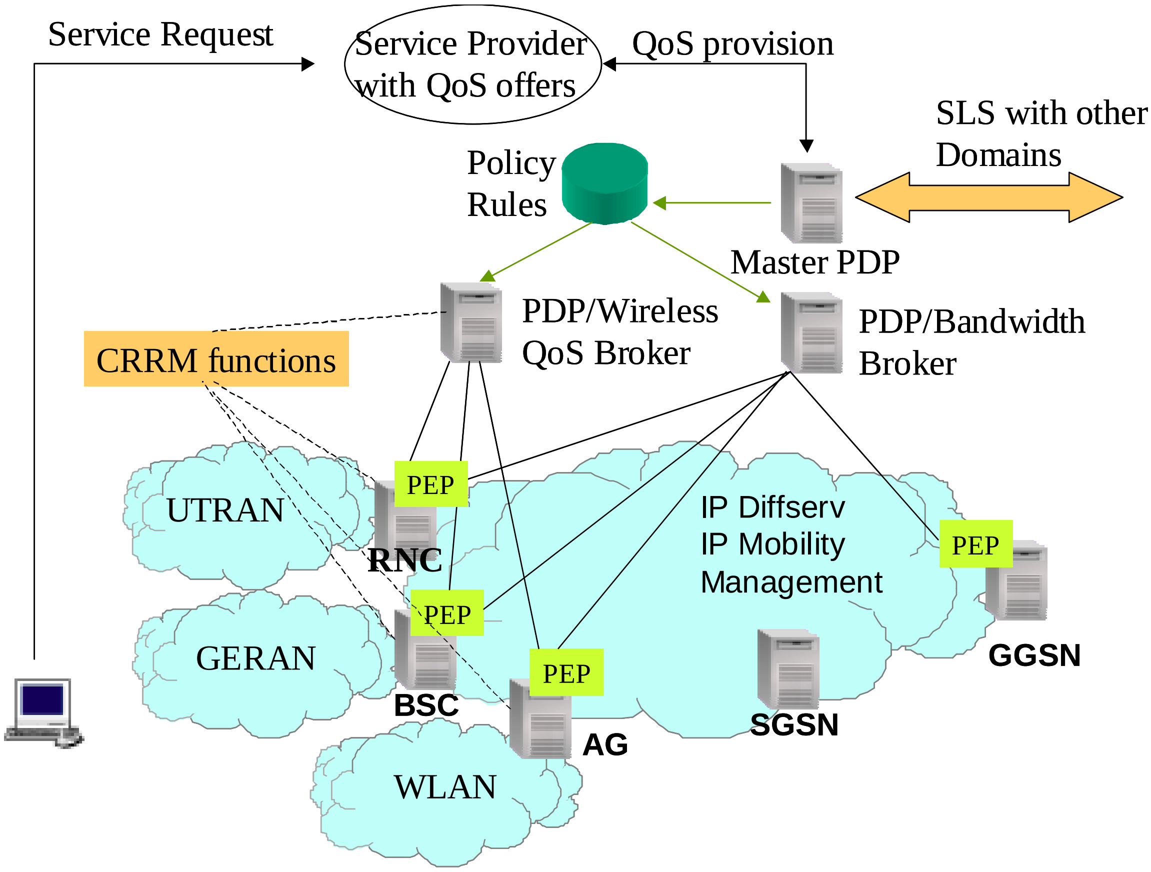

Figure 4. EVEREST proposal for QoS Architecture in a heterogeneous radio access network

Focusing on CRRM issues, two main approaches are envisaged to support CRRM in UTRAN and GERAN: integrated CRRM and loose RRM [TR 25.881, TR 25.891].

Loose architectures are based in a CRRM server linked by open interfaces to the RNC (UMTS) and BSC (GERAN). CRRM Server establishes CRRM policies and each RAT executes RRM algorithms according the CRRM server policies (e.g. when a determined load is overcome). Within this approach, CRRM may contain updated and ordered information from the different RATs. Figure 5 illustrates the CRRM architecture.

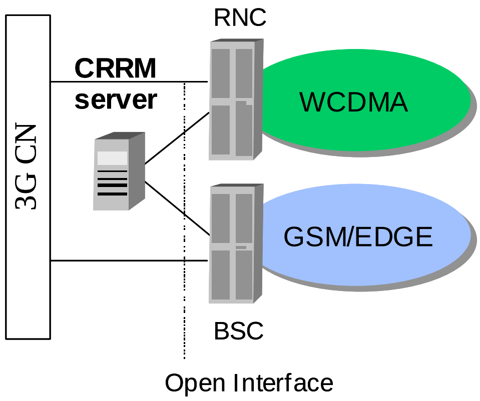

Figure 5. CRRM Server approach

On the other hand, integrated CRRM, also referred to as tight CRRM, incorporates CRRM functions into the existent UTRAN nodes. Hence, proprietary Interfaces are needed and non radio dependent messages get through indistinctly in each RAT air Interface. Figure 6 illustrates the integrated CRRM architecture.

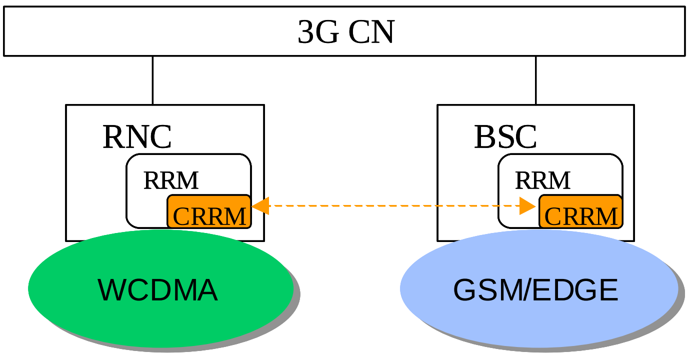

Figure 6. Integrated CRRM approach

The two different architectures should impact only the performances of CRRM algorithms without introduce any other considerable limitations.

WLAN access will be also taken into consideration within EVEREST since it is believed it will have and important part to play in the future of 3G evolution. Focusing on CRRM aspects, WLAN is not included at all in the initial proposed CRRM framework since there is still no standard entity devoted to manage RRM within a WLAN access network. However, pros and cons of the tight and loose coupling architectures will be addressed in EVEREST from the point of view of Common RRM. Besides, although loose coupling seems to be the preferred solution in both the WLAN and 3GPP communities (TS 23.234), integrated CRRM in tightly coupling architectures is also envisaged within EVEREST.

4 EXPECTED ACHIEVEMENTS/IMPACT

The expected research results from the EVERST project, can be summarised as follows:

- Further progress on the definition of advanced RRM mechanisms leading to an optimized usage of the different Radio Access technologies
- Acknowledge and contribute to the definition of useful Common RRM strategies, where a pool of resources belonging to different technologies are commonly considered and commonly optimized.
- Providing end-to-end QoS in an IP mobile access network. Define the interactions between a BB and the radio entities, in order to provide the adapted QoS to the service and to use in an optimal way the heterogeneity of the IP access network.

On the other hand, mobile communications will continue to be one of the most dynamic sector in nowadays and future economics. In such a competitive and standard-centric industrial environment, all issues related to implementation are of key importance because they constitute the differentiation elements among equipment manufacturers and, consequently, the door to successful product marketing. In that context, RRM/CRRM is one vital differentiation element in the framework of beyond 3G technologies, this being augmented by the inherent complexity to optimise the usage of a plethora of complementary systems.

Then, the commercial impact of the studies to be carried out within the project is expected to be viable in the years 2007-2010; from the much hoped-for commercial success of 3G networks until their full maturity. Until then, a major evolution is anticipated to happen in the way mobile networks will be jointly managed by operators and service providers. This process will be driven by the definite need to exploit end-to-end services at their full potential while minimising CAPEX and OPEX. The operator driven approach selected for the proposal is coherent with the aforementioned mid- and long term focus. It ensures that the project will provide its results at a suitable time.

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