Radio Resources Management and QoS Provisioning in Cellular Networks

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Abstract – **The advent of maturing and ever evolving communications technology and convergence of communications services (voice and data, telecoms and entertainment, fixed and mobile or the combination of all these as quadruple play) is advantageous to service providers in terms of expansion, multiple services delivery and hence revenue. This evolution from voice only networks into integrated, affordable and most importantly mobile multi-service networks with varying traffic classes poses a huge challenge in keeping up with the quality of service (QoS) and the scarcity or the shortage of the radio frequency spectrum. To provide these services with better QoS and as a matter of enhancing the performance of the wireless network, the management of the scarce radio resource is imperative. As a result, the development of these Radio Resources Management (RRM) schemes is able to exploit the flexibility of the air interface.**

This paper focuses mainly on the RRM and scheduling policies in multiservice mobile cellular networks that provides real time services (voice services) and data best effort services. The main objective of the research is mainly in call admission control (CAC) and scheduling policies that can provide a good tradeoff between the users QoS, depending on the service class and operators income and resource optimisation. This work will also investigate analytical techniques for the assessment of their performance metrics. In general, the admission criteria are based on network load (channels and buffer occupancies). Besides, the CAC considers services differentiation based on radio channels reservation and scheduling, in order to favour handoff and data packet traffics over new call connection requests.

Index Terms – **Call Admission Control, Call Dropping, Radio Resources Management, QoS.**

I. INTRODUCTION

Within the telecommunications world, the evolution of technology and the enhanced services that can be offered through synergies with Information Technology (IT) have been captured into the concept of the next generation networks (NGN). This concept does not mean a particular network but rather the process of evolution from present technology and services to new technologies, enabling new services and applications with both telecommunications and information technology (IT) characteristics [1]. These technologies represent an evolution of a heterogeneous mix of services and increased data speeds and support a wide range of applications with different QoS profiles.

Radio resources management (RRM) is a control mechanism or techniques that are used to manage radio resources in the air interface within a cellular network. RRM algorithms are responsible for efficient utilisation of the air interface resources and are also needed to guarantee the Quality of Service (QoS), to maintain the planned coverage area, and to offer high capacity [2]. Owing to the increased data rates, coverage and mobility in the integrated network, the scarcest resource in the system is radio resources and therefore it is essential to maximise the resource utilisation and also providing the best QoS in the wireless network. In this way we will be able to maximise the performance and spectral efficiency so much that the number of users will be maximised without the possibility of service degradation as the QoS will be preserved. The paper is organised in five sections; section II under Background explains the call admission control as one of the fundamental mechanisms of RRM in the quest for efficient radio resources allocation. Section III gives the related work in RRM while section IV discusses the motivation and objectives for the proposed study and the concluding remarks are given in section V.

II. BACKGROUND

There has been much discussion on issues related to CAC in multiservice networks specifically UMTS WCDMA 3G networks. According to [2], CAC is an algorithm that manages radio resources in order to adapt to traffic variations and is always performed when a mobile initiates communication in a new cell either through a new call or handoff. Furthermore, admission control is performed when a new service is added during an active call. Also in [2] it is mentioned that it is the CAC that makes a decision to accept or reject a new call according to the amount of available resources versus user QoS requirements, and the effect on the QoS of existing calls that may occur as a result of the new call.

The purpose of an admission control algorithm is to regulate admission of new users into the system, while controlling the signal quality of the already serviced users without leading to call dropping. The admission control algorithm will then balance between high capacity and interference. Another goal of admission control is to optimize the network revenue. This can, for example, be done by maximizing the instantaneous reward achievable when a new service request arrives. The reward associated with each QoS level is assumed to increase with the amount of resources required for the service [3].

In the pursuit of analysing and developing an understanding of the RRM algorithms in this work, a number of complex processes will be examined and thus a quite large number of considerations. Owing to these considerations, optimisation tools like game theory and mathematical programming will be

applied to analyse these interactive decision processes. It is anticipated that applying these tools to RRM issues with the proper models, many of the RRM problems addressed primarily through simulations will be easily understood and hence will be able to be solved within this framework.

III. RELATED WORK

The family of RRM algorithms can be divided amongst others the handover control, power control, admission control, load control and packet scheduling functionalities. The RRM algorithms can be based on the amount of hardware in the network or on the interference levels in the air interface [2]. The study will however be aimed at the admission control and packet scheduling which are mostly required to guarantee the QoS and to maximise the system throughput with a combination of different bit rates, services and quality requirements. Typical locations of the RRM algorithms in a WCDMA network are shown in Figure 1 below.

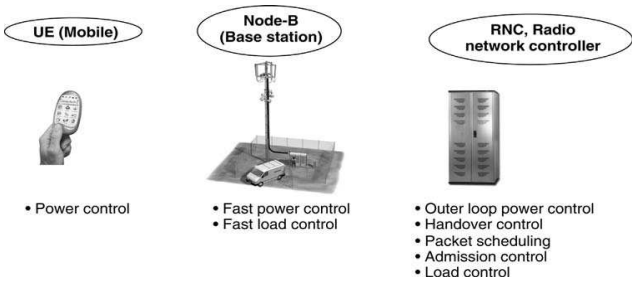

Figure 1. Typical locations of RRM algorithms in a WCDMA network.

In [3-5], the author introduces some ways of implementing CAC in WCDMA using fuzzy logic. They apply fuzzy logic for accepting a call while calculating the effective bandwidth and mobility information of the mobile station from the base station within a particular cell and its neighbouring cells in a network. Also in [6], a CAC scheme for CDMA systems supporting multiservice systems evaluating their performance using markov analysis is proposed. CAC for packet transmission in multiservice networks like in UMTS is evaluated by setting an effective capacity threshold for uniform and non-uniform traffic scenarios in cells [7].

Several research works have been published on this subject [5]. However, much emphasis is placed in this study to focus on the use of Game theory and mathematical programming for problem formulation and solving. Game theory is a set of mathematical tools used to analyse interactive decision makers. It is presumed that the proper application of game theory models and mathematical programming can be applied in the analysis of RRM processes. It is also believed that the task of problem solving currently addressed primarily through simulations will be translated into simpler and more robust solutions which are easily understood.

IV. MOTIVATIONS AND OBJECTIVES

The main objective of the research is mainly in call admission control (CAC) and scheduling policies that can provide a good tradeoff between the users QoS, depending on the service class and operators income and resource optimisation. This work will also investigate analytical techniques for the assessment of their performance metrics. In general, the admission criteria are based on network load (channels and buffer occupancies). Besides, the CAC considers services differentiation based on radio channels reservation and scheduling, in order to favour handoff and data packet traffics over new call connection requests.

V. CONCLUSIONS

Expectations are very high in multiservice mobile cellular networks with respect to the end user's point of view. The QoS provisioning in this networks therefore has to meet the end user's expectations while also ensuring a reasonable high utilization of the allocated radio spectrum. In these networks, QoS provisioning is a large challenge owing to the fact of the scarcity of radio resources such as the link bandwidth and now the mobility factor together with its associated interference factor. RRM is therefore responsible and needed to guarantee the much needed QoS.

This paper has outlined the basic background of the RRM and its basic radio resource allocation mechanism or scheme; call admission control. It has also shown that with the use of this scheme and its set of algorithms, a tradeoff can be found for the efficient allocation of radio resources.

VI. REFERENCES

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