An Analytical framework for Call Admission Control in Heterogeneous Wireless Networks

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Abstract
It is envisaged that the Next generation wireless network (NGWN) will be heterogeneous where different radio access technologies (RATs) operate together .The mobile terminals operating in this heterogeneous environment will have different quality of service requirements to be handled by the system. The radio resource management is one of the key challenge in NGWN.Call admission control is one of the radio resource management technique plays instrumental role in ensure the desired quality of service (QoS) to the users working on different applications which have diversified nature of QoS requirements from the wireless networks . In wireless network the Bandwidth is one of the important resources of the network. In the wireless networks this resource is alienated into channels and is used by the network users which include the existing users and new users. One of the key challenges to be addressed in this prevailing scenario is the distribution of the available channel capacity among the multiple traffic with different bandwidth requirements so as to guarantee then QoS requirements of the traffic .The call blocking probability is one such QoS parameter for the wireless network. For better QoS it is desirable to reduce the call blocking probability. In this customary scenario it is highly desirable to obtain analytic Performance model. The Stochastic Petri Net (SPN) based Performance model has been developed to verify the efficiency and accuracy of analytic Performance model. In this paper we propose an optimal call admission control algorithm to reduce call blocking probability in NGWN and provides optimal QoS to the mobile users. In the proposed algorithm we have considered three classes of traffic having different QoS requirements. . The results obtained from both the Performance models are optimistic

Key words :
Radio resource management, call admission control, call blocking probability, QoS.

1. Introduction

The recent advances in the wireless networks and mobile devices are inclined towards emerging of ubiquitous computing where the user and application running in the mobile terminal (MT) can enjoy seamless roaming. It is well known that the basic problem in the wireless networks is the scarce of the radio resources. The efficient radio resource management is very essential. The admission control is one of the radio resource management technique which plays dominant role in effectively managing the resources. The admission control in the wireless networks will reduce the call blocking probability in the wireless networks by optimizing the utilization of the available radio resources. The mobile communication environment is featured by moving terminals with different QoS requirements in this current scenario the need of guaranteed QoS.

The future users of mobile communication look for always best connected (ABC) anywhere and anytime to the complementary access technologies like wireless local area networks (WLAN), and world wide inter operability for microwave access (WiMAX), global systems for mobile communications(GSM), general packet radio service(GPRS), Universal mobile telecommunication systems(UMTS) etc.

The mobile communication networks are evolving into adaptable Internet protocol based networks that can handle multi medial applications. When the multi medial data is supported by wireless networks, the networks should meet the quality of service requirements. One of the key challenges to be addressed in this prevailing scenario is the distribution of the available channel capacity among the multiple traffic with different bandwidth requirements so as to guarantee the QoS requirements of the traffic.

The existing admission control strategies can handle the resource management in homogeneous wireless networks but are unable to handle the issue in heterogeneous wireless environment. The mobility of the terminals in the mobile communication environment makes the resource allocation a challenging task when the resources are always in scarce. The efficient call admission control policies should be in place which can take care of this contradicting environment to optimize the resource utilization.

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The design of call admission control algorithm must take into consideration packet level QoS parameters like minimum delay, jitter as well as session level QoS parameters like call blocking probability (CBP) and call dropping probability (CDP). The CBP is the probability of denial of accepting the new call and CDP the likelihood of dropping the call by a new access network due to decline of the network resources to an unacceptable level in other words the networks is exhausted with the available resources at which it drops the handover calls. In mobile networks the

admission control traffic management mechanism is needed to keep the call blocking probability at a minimal level and another RRM strategy vertical handovers plays crucial role in reducing the and call dropping probability in an heterogeneous wireless networks.

In further sections of the paper is organized as follows. The section II discusses on the motivation and related work. Section III focuses on the proposed system model for the call admission control based on multi dimensional markov chains.The section IV represents the simulation results and conclusion and future work is indicated in section V.

2. Motivation and related work

At present, dissimilar wireless access networks including 2.5G,3G,Bluetooth, WLAN and WiMAX coexist in the mobile computing environment, where each of these Radio access technologies offer complementary characteristics and features in terms of its coverage area, data rate, resource utilization , power consumption …etc.. With all these there is constant improvements in the existing technologies offering better performance at lesser cost. This is beneficial in both the end users and service provider's perspective.

The idea of benefiting from integrating the different technologies has lead to the concept of beyond International mobile telephony 2000(IMT-2000) wireless networks known as the next generation wireless networks (NGWN). In this heterogeneous environment, the end user is expected to be able to connect to any of the different available access networks. The end user will also be able to roam seamlessly within these access networks through vertical handover mechanisms. The global roaming is supplemented by the existence of IP networks as the backbone which makes the mobile computing environment to grow leaps and bounds and can effectively address the issue with regard to converge limitations is concerned. In this multifaceted wireless radio environment the radio resource management plays major role. The effective utilization of the limited available resources is the challenge.

The admission control is one such challenge a network service provider face to achieve better system utilization face in handling this complex scenario to provide the best QoS to the users of the network.

Call admission control schemes can be divided into two Categories, local and collaborative schemes [1]. Local schemes use local information alone (e.g. local cell load) when taking the admission decision. Examples of these schemes are [1–2, 3]. Collaborative schemes involve more than one cell in the admission process. The cells exchange information about the ongoing sessions and about their capabilities to support these sessions. Examples of these Schemes are [4–5].

The fundamental idea behind all collaborative admission control schemes is to consider not only local information but also information from other cells in the network. The local cell, where the new call has been requested, communicates with a set of cells that will participate in the admission process. This set of cells is usually referred to as a cluster.

In general, the schemes differ from each other according to how the cluster is constructed, the type of information exchanged and how this information is used. In [6] for example, the cluster is defined as the set of direct neighbors. The main idea is to make the decision of admission control in a decentralized manner.

There are good amount of work reported for homogenous wireless networks and single service wireless networks. There are few works in the heterogeneous wireless networks.

3. Network Model

The heterogeneous networks considered in this paper include the overlay networks consisting of GSM, UMTS, WLAN WI MAX 802.11 –wireless LAN, 802.16 Wi-Max. This simple scenario is rich enough to illustrate the complexity of the problem, and describe the essence of our approach in a heterogeneous network environment. Our results can be generalized to more general heterogeneous RAT based networks. By using the results of the three RATS based network scenario as the baseline. Further investigation of such generalization in a heterogeneous Network environment which involves more diversified featured networks is a subject of on-going work and will be presented in a separate paper.

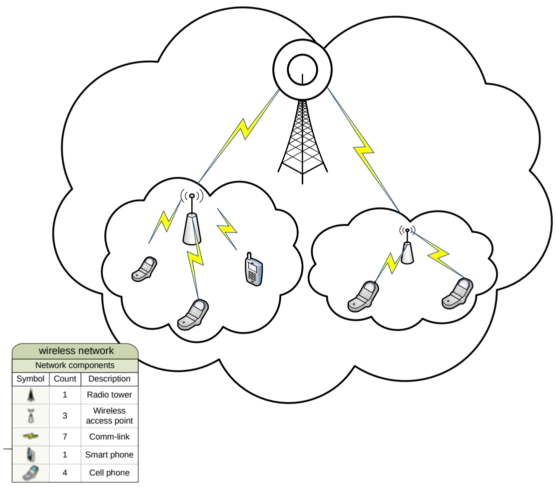
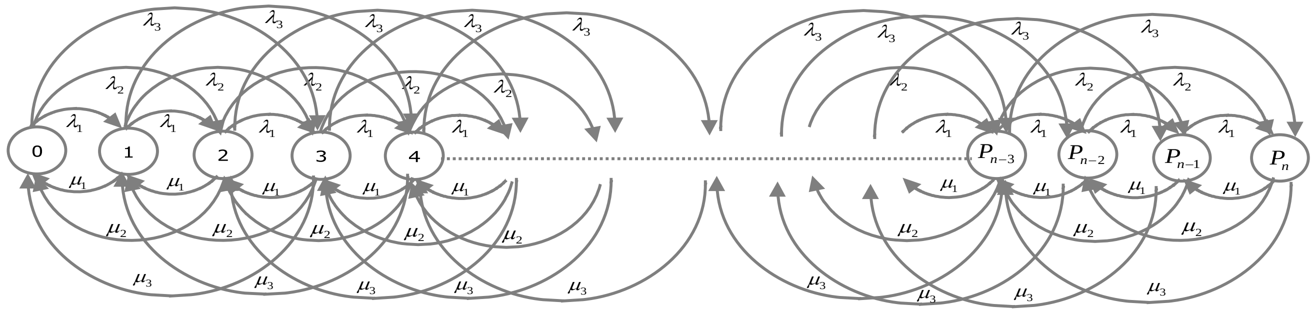


Figure 1: WiMax–WLAN based Heterogeneous Network

4. System Model

In this paper we propose a novel admission control mechanism for reducing the call blocking probability there by increasing the resource utilization. This would achieve the Objective of guaranteeing the user QoS requirements. The proposed model is able to handle three types of applications which are complementary in nature with respect to their QoS requirements are considered.

The applications considered for the study involves conversation traffic, interactive traffic and background traffic. The representative applications could be voice calls, Web browsing and file transfer applications respectively



The CAC mechanism proposed is focused only on the system's ability to accommodate newly arriving users in terms of the total channel capacity which is needed for all terminals after the inclusion of the new user. In the case when the channel load with the admission of a new call, was precompiled (or computed online) to be higher than the capacity of the channel the new call is rejected, if not, the new call could be admitted. The decision of admitting or rejecting a new call in the network will be made only based on the capacity needed to accommodate the call.

We consider a heterogeneous network which comprises a set of RATs *Rn* with co-located cells in which radio resources are jointly managed. Cellular networks such as Wireless LAN and Wi- Max can have the same and fully overlapped coverage, which is technically feasible, and may also save installation cost [4]. H is given as $\boldsymbol{H = \{RAT\ 1, RAT\ 2, RAT\ k\}}$ where K is the total number of RATs in the heterogeneous cellular network. The heterogeneous cellular network supports n-classes of calls, and each RAT in set H is optimized to support certain classes of calls.

The Analytical model for Call admission control mechanism in heterogeneous wireless networks is modeled using higher order Markov chains. The system model for reducing the call blocking probability is developed based on Hierarchical Markov model. as shown in figure 2The study considers that, whenever a new user enters the network will originate the network request at the rate $\boldsymbol{\lambda_i}$ and is assumed to follow a Poisson process. The service time of the different class of traffic and types of calls is $\boldsymbol{\mu_i}$ .The mean service time of all types of users were assumed to follow negative exponential distribution with the mean rate 1/μ. The total number of virtual channel in the system are N. When the numbers of available channels are below the specified threshold the system will drop the calls. The threshold limit is determined by three positive integers A_1 A_2 and A_3. When the available number of channels falls below the threshold A_3 the proposed system will accept only the voice calls and web browsing. When the available number of channels falls below the threshold A_2 the proposed system will accept only the voice calls .The P(0) is probability that there is no allocated channels in the designated system. The probability that system has allocated i channels is expressed using the following set of Markov equations.

The equations (1) - (3) are lower boundary equations

$$\lambda_1 P_0 + \lambda_2 P_0 + \lambda_3 P_0 - \mu_2 P_2 - \mu_1 P_1 - \mu_3 P_3 = 0 \quad (1)$$

$$\lambda_1 P_1 + \lambda_2 P_1 + \lambda_3 P_1 - \mu_1 P_2 - \mu_2 P_3 - \mu_3 P_3 = 0 \quad (2)$$

$$\lambda_1 P_2 + \lambda_2 P_2 + \lambda_3 P_2 + \mu_1 P_2 + \mu_2 P_2 - \mu_1 P_3 - \mu_2 P_4 - \mu_3 P_5 = 0 \quad (3)$$

The equations (4) - (6) are upper boundary equations and are expressed as

$$P_{n-3}(\lambda_1+\lambda_2+\lambda_3+\mu_1+\mu_2+\mu_3)-\lambda_1 P_{n-4}-\lambda_2 P_{n-5}-\lambda_3 P_{n-6}-\mu_1 P_{n-2}-\mu_2 P_{n-1}-\mu_3 P_n=0 \quad (4)$$

$$P_{n-2}(\lambda_1+\lambda_2+\mu_1+\mu_2+\mu_3)-\lambda_1 P_{n-3}-\lambda_2 P_{n-4}-\lambda_3 P_{n-5}-\mu_1 P_{n-1}-\mu_2 P_n=0 \quad (5)$$

$$P_{n-1}(\lambda_1 + \mu_1 + \mu_2 + \mu_3) - \lambda_1 P_{n-2} - \lambda_2 P_{n-3} - \lambda_3 P_{n-4} - \mu_1 P_n = 0 \quad (6)$$

The repeated states are those which are in-between these states based on figure3. The repeated states are represented in a generic form as.

$$P_4 (\lambda_1+\lambda_2+\lambda_3+\mu_1+\mu_2+\mu_3) - \lambda_1 P_3 - \lambda_2 P_2 - \lambda_3 P_5 - \mu_1 P_6 - \mu_2 P_6 - \mu_3 P_7 = 0 \quad (7)$$

The equation can presumed as the general equation for call blocking probability for traffic type 1 is

$$Pn = \frac{\lambda_1 P_{n-1} + \lambda_2 P_{n-2} + \lambda_3 P_{n-3}}{(\mu_1 + \mu_2 + \mu_3)} \quad (8)$$

Assuming and **$\lambda_1 = \lambda_2 = \lambda_3 = \lambda$** and **$\mu_1 = \mu_2 = \mu_3 = \mu$** ,the call blocking probability for type 1 traffic could be expressed as

$$P_n = \frac{a}{3}(P_{n-1} + P_{n-2} + P_{n-3}) \quad (9)$$

Similarly The call blocking probability for type 2 traffic is

$$P_{n-1} = \frac{a}{3}(P_{n-2} + P_{n-3} + P_{n-4}) \quad (10)$$

And for Type 3 traffic is

$$P_{n-2} = \frac{a}{3}(P_{n-3} + P_{n-4} + P_{n-5}) \quad (11)$$

The call blocking probability for the overall system traffic

$$Pn = \frac{a}{3}(P_n + P_{n-1} + P_{n-2}) \quad (12)$$

5. Simulation Results and Discussion

In this section, we present the numerical results and compare the call blocking probabilities of the different types of traffic. The experiment setup is conducted considering the varying traffic intensity of Type1 traffic and blocking probability of the type 1, type 2, type3 traffic , and overall call blocking probability of the system is plotted. The experiment was conducted by assuming the system with the channel capacity with 40 channels. The Figure 3 shows call blocking probability for all three types of traffic when then intensity of the type 1 traffic is increased. The horizontal axis shows the number of users with type 1 traffic while the vertical axis shows the call blocking probability of all types of traffic.

The simulation results shows that the call blocking probability of the system and different types of traffic will increase with the increase in the intensity of type 1 traffic. The simulation results with increase the intensity of type 2 traffic and simulation results with increase the intensity of type 3 also showed the similar kind of results.

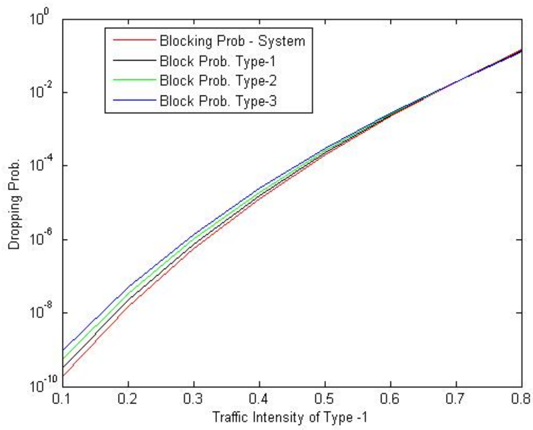


Figure 3 : Call blocking probability of the system and for Different types of traffic

6. Conclusion and Future work

In this paper, we have proposed a performance model for call admission control mechanism in the heterogeneous RATs. In order to measure the call blocking probability of the analytical model the simulation study was made and following observations were made. Firstly, increase in the number of type 1 users will increase the call blocking probability of type2 and type 3 calls and vice versa. Second, Increase in the traffic intensity of one type of traffic will increase the system blocking probability.

Our future work is focused on analyzing the call blocking probability keeping the variation in the number of channels.

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