Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 4 Issue 6, June - 2017

Call Admission Control Using Constraint Optimization And Probability Techniques Based On Higher Order Markov Model

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***Abstract*—The next generation wireless network (NGWN) will be heterogeneous which will have different Radio Access Technologies (RATs) operating together. The radio resource management (RRM) is one of the key challenges in (NGWN). The call admission control (CAC) mechanism is one of the radio resource management technique which plays an instrumental role in ensuring the desired QOS to the users, working on different applications, which are having the diversified nature of QOS requirement to be fulfilled by the wireless networks. One of the major challenges to be addressed in the prevailing circumstance is the distribution of the available channel capacity amongst the multiple traffic with different bandwidth requirement so as to guarantee QOS requirements of the traffic. The call blocking probability is one such QOS parameter for the wireless network and for better quality of service QOS, it is desirable to reduce the call blocking probability. In this customer scenario it is highly advantageous to bring about an analytic performance model. In this paper we proposed a call admission control framework base on higher order Markov chains to effectively handle the call blocking probability in NGWN and to provide optimal QOS for the mobile users. In the proposed algorithm we have considered three classes of traffic having different QOS requirements. The result obtained from the performance model are encouraging and optimistic and indicates the need of an intelligent decision making system for CAC.**

Keywords—Radio, Resource, management, call admission, algorithm, QOS, wireless, network.

INTRODUCTION

The recent advances in wireless networks and mobile devices are inclined towards emerging of ubiquitous computing, where the users and applications running in the mobile terminal (MT), can enjoy seamless roaming [1, 2]. It is well known that the basic problem in the wireless network is the scarce of radio frequency spectrum. Therefore, the efficient radio resource management is of critical importance. The call admission control is one of the resource management technique which plays a dominant role in effectively managing the resources. The admission control in the wireless networks will reduce the call blocking probability in the wireless network by optimizing the utilization of the available radio resources. The mobile communication environment is dominated by moving terminals with different quality of service QOS demands and in this current scenario the need for guaranteed QOS is more of foremost imperative.[2, 3, 4]

The future users of mobile communication look for always, to best connected (ABC) networks at anywhere and anytime among the complementary access. Technologies like wireless local area network (WLAN) and worldwide interoperability for microwave access (Wi-Max), global system for mobile communication (GSM), general packet radio service (GPRS), universal mobile telecommunication systems (UMTS) etc.,
are of prime consideration in this paper. The mobile communication networks are evolving into adaptable internet protocol based network that can handle multimedia applications.[1, 3, 4] When the multimedia 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 amongst the multiple traffic that are with different bandwidth requirements: The existing admission control strategies can handle the resource management in homogeneous wireless networks but are unable to effectively handle the issues in heterogeneous wireless environment. The mobility of the terminals in the mobile community environment makes the resource allocation a challenging task when the resources are always in scarce. The efficient call admission control policy should be in place which can take care of this contradicting environment to optimize the resource utilization. The design of a call admission control algorithm must take into consideration packet level quality of service parameters like minimum delay, jitter as well as session level QOS parameters, like call blocking probability (CBP) and call dropping probability (CDP) [2,3,5]. 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 network resources. In order words the network is exhausted with the available resources and consequently drops the handover calls. In mobile network the admission control traffic management mechanism is needed to keep the call blocking probability at a minimal level and another RRM strategy with a vertical handover plays a crucial role in reducing the call dropping probability in an heterogeneous wireless network[5].

MATERIALS AND METHODS

1. **Related Work**

At present, dissimilar wireless access network including 2,5G, 3G, Bluetooth, WLAN and Wi-Max 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 are constant improvements in the existing technologies offering better performance at lesser cost. This is beneficial in both the end users and service providers perspective. The idea of benefitting from integration of the different technologies has lead to the concept of beyond international mobile telephony (IMT-2000) wireless network known as the next generation wireless network (NGWN).[4,6,7]. In this 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 (internet provider) networks as the backbone which makes the mobile computing environment to grow leaps and bounds and can effectively address the issue with regards to converge limitations concern. In this multifaceted wireless radio environment the radio resource management plays a major role. The effective utilization of the limited available resources in the challenge. The admission control is one such challenge a network service provider face to achieve better system utilization. The higher order Markov model is one of the mechanism in handling this complex scenario to provide the best QOS to the users of the network[6,7].

Call admission control schemes can be divided into two categories, local and collaborative schemes. Local schemes use local information alone (e.g. local cell load) when taking the admission decision. Examples of these schemes are (T. Zhang, E.V.D. Berg, J. Chennikara, P. Agrawal, J.C. Chen, T. Kodama 2001) (C.W. Ahn, R.S. Ramakrishna, 2004). Collaborative schemes involves more than one cell in the admission process. The cells exchange information about these ongoing session and about their capabilities to support these sessions[4]. The fundamental idea behind all collaborative admission control scheme is to consider not only local information but also information from other cells in the network. The local cell, where the new call has be requested, communicates with a set of cells that will participate in the admission process. This set of cell is usually referred to as cluster. In general the scheme differs from each other according to how the cluster is constructed, the type of information exchanged and how this information is used,say for example, the cluster is defined as the set of direct neighbours. The main idea is to make decision of admission control in a decentralized manner.

There are good amount of work reported for homogeneous wireless networks and the single service wireless networks and few works in the heterogeneous wireless networks. The call admission control in heterogeneous wireless network is a real challenge. The varied QOS requirement of multimedia applications and the coexistence of different RATs, facade major challenges in designing CAC algorithms for next generation heterogeneous wireless networks. The challenges are heterogeneous networking, multiple service classes, flexibility in bandwidth allocation and cross layer issues based design[6,9].

2. **Heterogeneous Network**

4G network will have different types of RATs different from each other by our interface technology, cell size, services, price, access method, coverage, so CAC schemes must be able to handle new type of handoff called(vertical handoff) [8,9].

3. **Multiple Service Classes**

The B3G networks should be able to accommodate the applications and user with different QOS requirement, so the CAC algorithm should be designed to handle different classes of service to meet the QOS needs of all types of applications.

4. **Flexible in Bandwidth Allocation**

The diversity is in multimedia application and mobile users QOS requirement in NGWN. The resource utilization and QOS performance can be improved by adaptive bandwidth allocation. This clearly indicates that the CAC should be designed taking into consideration the flexible bandwidth allocation, where more resources can be allocated when the traffic is low, and the allocated bandwidth can be revoked when there is congestion.

MULTI-CRITERIA DECISION MAKING

One important solution for the decision making of call admission control is by multi criteria decision making (MCDM). This is an optimization technique used to analyse the contradicting decision making parameters. These decision making systems are generally used in the field of reliability, financial analysis, social and political related analysis and environmental impact analysis etc [1,6,8]. The NGWN has different RATs coexisting with different capability,which should cater for the varied QOS requirements of multimedia applications. Admission control with single criteria may be too trivial and so, the admission control decision should be based on multi criteria such that the optimization user satisfaction and selection of optimal RAT is achieved. There are several algorithm proposed on handling the admission control decision using MCDM in heterogeneous wireless networks.

The multiple criteria based admission control algorithm are categorized as utility-function based CAC and computation intelligent CAC. In the utility-function based CAC the incoming calls are admitted based on some utility or cost function, based on multiple criteria. These algorithm are very optimal and in most are complex in nature and pose high computation over head [10,11].

The computational-intelligence-based CAC use evolutionary approach like Genetic Algorithm (GA), Fuzzy Logic and Artificial Neutral Network (ANN) [5,7]. Most of the computational-intelligence-based CAC Algorithm incorporate Fuzzy Logic [8], Fuzzy neural and Fuzzy MCDM methods. There are very few works reported on the usage of artificial neutral networks in CAC.

SYSTEM MODEL

In this paper, we propose a novel analytical model for admission control for the call blocking probability, thereby 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 requirement. The applications considered for the study involves conversation traffic, interactive traffic, and background traffic. The representative application could be voice calls, web browsing and file transfer application respectively [10,11,12].

Let us consider a heterogeneous network which comprises a set of RATs, Rn with co-located cells in which radio resources are jointly managed. Cellular network 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. If the set of heterogeneous wireless networks coexisting is given as H = (RAT_I, RAT_Z, RAT_K) where K is the total number of RATs in the heterogeneous wireless network, this network supports n-channel of calls. And each RAT in set H is optimized to support certain class of calls.

The analytical model for call admission control mechanism in heterogeneous wireless networks is modelled using higher order Markov chain as in Fig. 1. The study considers that, whenever a new user enters the network, the user will originate the network request at the rate λ_1 and is assumed to follow a poison process. The service time of the different calls of traffic and types of calls is μ_1. The mean service of all types of users were assumed to follow negative exponential distribution with the mean rate $1/\mu$. Since voice traffic is Erlang distributed, and the condition that is considered for simulation is negative exponential distribution, the total number of virtual channels in the system are N. When the numbers of available channels are below the specified threshold the system will block/drop the calls. The threshold limit is determined by three positive integers A_1, A_2, and A_3. When the number of available channels falls below the threshold A_3 the proposed system will accept only the voice calls and web browsing. When the number of channels fall below the threshold A_2 the proposed system will accept the voice calls only, and when the available number of channels fall below the threshold A_1, the proposed system will not accept any calls as it reaches the stage where there will be no channels available to allocate to the incoming calls and leads to system blocking. The $P_{(o)}$ is probability that there are no allocated channels in the designated system [13,14,15].

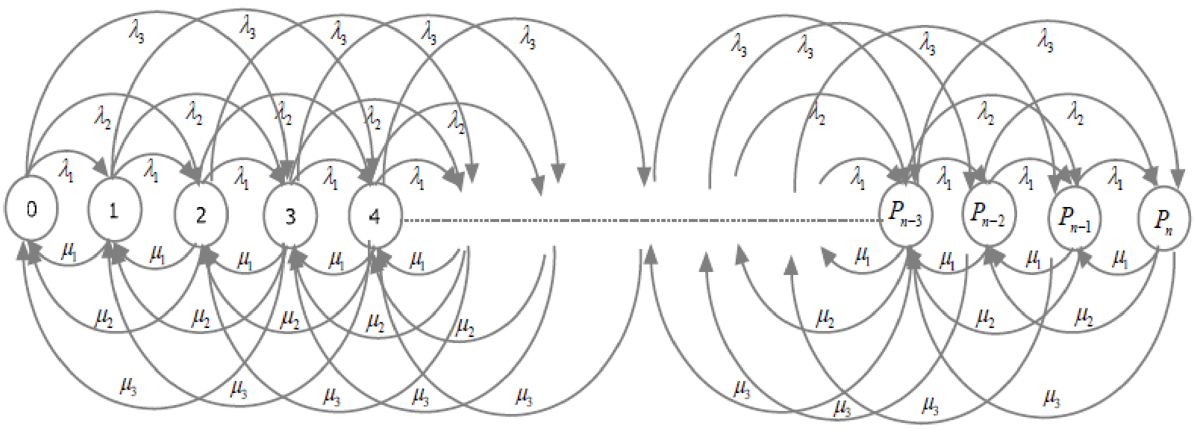

Fig. 1. System Model for Call Admission Control [13, 14, 15]

For the system model shown in fig. 1 the system state can be defined for the lower and upper boundaries as in equation (1) - (3) and (4) – (6) respectively.

The equations (1) – (3) are lower boundary equations and represents the systems states P_0,P_1, P_2 as:

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

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

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

The equations (4) – (6) are upper boundary equations for the system states P_n, P_{n-1}, P_{n-2} and are expressed:

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

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

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

The repeated states are those which are in-between these upper and lower boundary states based on fig.1. The repeated states of the system are represented in generic for 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 that can be presumed as the general equation for call blocking probability for traffic type 1 is:

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

Assuming that the arrival time of all the types of traffic are equal i.e. $\lambda_1 = \lambda_2 = \lambda_3 = \lambda$ and the service time for the types of traffic are equal i.e $\mu_1 = \mu_2 = \mu_3 = \mu$. the call blocking probability for type1 traffic could be expressed as:

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

Where a = Λ/μ is called the utilization rate which should be generally less than one for the system stability. Similarly, the call blocking probability for type 2 traffic P_{n-1} is

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

And the call blocking probability for type 3 traffic P_{n-2} is represented as:

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

The call blocking probability for the overall system traffic P_{nb} can be expressed as:

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

SIMULATION RESULT

Here, we present the numerical results and compare the call blocking probabilities of the different types of traffic, and MATLAB was used for the simulation. The proposed performance model for call admission control mechanism is analysed for the call blocking probability, by making the variation in the number of channels. The study set up is conducted by varying the traffic intensity of type 1. The experiment is repeated for the type 2 and type 3 traffic and the result of the dropping probabilities versus the traffic intensity are plotted as shown in fig. 2. 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 [13,14].

The performance model parameters are number of virtual channels (N), users arrival rate (Λ), arrival rate of type 1 call (Λ_1), arrival rate of type 2 call (Λ_2) and arrival rate of type 3 call (Λ_3). If we take the service time of the user as (μ), then the service time of the call of type 1 (μ_1), service time of the call type 2 (μ_2), service time of the call type 3 (μ_3). The simulation results shows that the call blocking probability of the different type of traffic will increase with the increase in intensity of type 1 traffic. The simulation results with increase in the intensity of the type 2 traffic and that of type 3 showed similar kind of result as plotted in fig. 2

The important observations from the performance model are: increase in traffic of type 1 call and reduction in traffic of type 2 and type 3 call, will reduce the call blocking probability of type 1 call. The result shows a reduction in call blocking probability of type 2 call, when there is a reduction type 1 and type 2 traffic in the system, similarly when we reduce the type 1 and type 2 traffic, the call blocking probability of type 3 traffic is minimal. In next generation wireless system, it is desirable to uphold guaranteed QOS to all the types of users and optimize the utilization of system resources needed. In order to provide superior QOS to the user/application, it is required to maintain the cell blocking probability. But this is only possible when we have non varying traffic for all the types traffic model. Note that there is a possibility of wastage of the bandwidth if one of the three traffic intensity is lower than the bandwidth of the channels allocation. It is predicted that the next generation network is heterogeneous and obviously will have the time varying traffic as iterated in the traffic model discussed above [15].

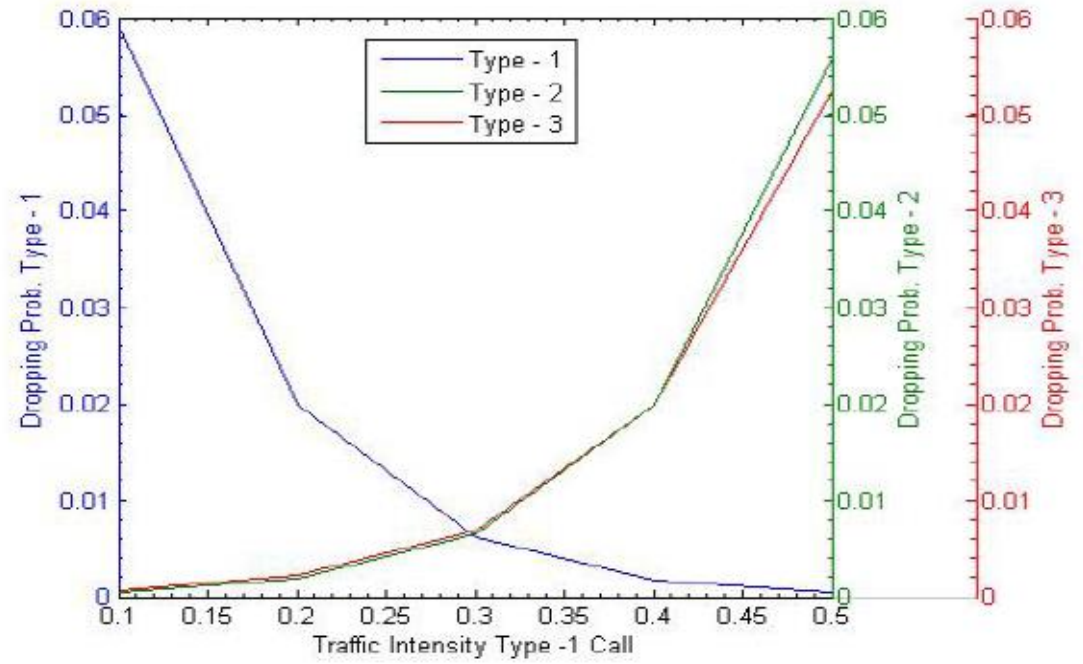

Fig 2. Call Blocking Probability for varying traffic [5, 13, 14]

In this prevailing circumstance, it is very difficult and tricky situation to satisfy the needs of different types of traffic. Hence it is enviable to use a multi constraint optimization technique in achieving better trade off between set of system performance metrics. The performance parameters such as BER, ABW and network traffic are the input to the optimization technique for achieving better trade off between set of performance metrics.

Some of the well known techniques in solving multi constraints optimization problem are Game theory Markov Decision Process (MDP), Genetic Algorithm (GA), Goal programming and multi attribute making (MADM) technique. Among these set of techniques MADM is most widely used [6, 7, 9].

CONCLUSION

In this paper, we have proposed a performance model for call admission control mechanism, in the heterogeneous RATs, and by analyzing the call blocking probability, we are able to keep the variation in the number of channels. In order to measure the call blocking probability of the analytical model, the simulation study was made and following observations were made. In the experiment setup, all the types of traffic was varied and we observed that: increase in the number of type 1 traffic, will increase the call blocking probability of type 2 and type 3 calls and vice versa. Secondly, increase in the traffic density of one type of traffic will increase the system blocking probability [16].

The concept of minimizing the call blocking probability is an optimization technique to provide fair QOS to the set of user in the wireless network. Also there is the need of intelligent call admission control strategy, in the admission control mechanism to make the decision of accepting or rejecting a call, while keeping the blocking probability minimal, in heterogeneous RATs based network working under dynamic condition. The future work of this research is pitched upon using intelligence for decision making in the call admission control process [3,15,16].

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