Performance Improvement in High capacity mobile Network using Call Admission Control Scheme

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ABSTRACT

Call admission control (CAC) is one of the key elements to provide quality of service (QoS) guarantee in wireless mobile networks. The main focus of this paper is to put forth a call admission scheme suitable for high capacity networks. The basic idea is to admit / reject a new call based on the load conditions of all neighbouring cells (where the mobile unit will possibly visit), in addition to the current cell, where the new call request is made. This is possible by allowing the base station to periodically exchange their load status without the involvement of the network processor. A similar algorithm exists in the literature under the name of distributed call admission Control. However, there are some shortcomings in the original scheme, which leads to performance degradation. An attempt is taken to eliminate the limitations of distributed CAC, by incorporating the nature of the mobile user movement. This has resulted in enabling the admission controller to make a clear sighted admission decision leading to improved performance in terms of resource efficiency and low blocking probabilities. Performance analysis is carried out for varying load and number of channels assigned. Simulation results reveal that the proposed scheme outperforms the conventional one. It is also important to note that; the CAC algorithm is computationally simple enough, allowing it to be more suitable for micro cellular networks supporting real time services.

Key words: CAC scheme, blocking probabilities, QoS guarantees

1. INTRODUCTION

Due to limitations on radio spectrum, future mobile networks will require micro-cellular architectures in order to provide higher capacities. Such networks encounter frequent hand-offs, which introduces a new paradigm in the area of network congestion and admission control. A good call admission control (CAC) algorithm should efficiently support hand-offs and maintain a high utilization of the radio resource, while it should also be simple for implementation. It is generally accepted that a hand-off user is given more preference as compared with new call users. Most of the earlier CAC schemes are based on trunk reservation policies [1, 2], where fixed amount of resources are reserved for hand-off users blindly. Most of the time, these reserved resources are left unutilized. This greatly affects the resource utilization rate and hence blocks large number of new calls leading to poor system capacity.

Among them, the distributed call admission control seems to be simpler with fewer assumptions and more efficient with regard to the above said requirements. However, the call admission process of distributed algorithm needs to be Poisson to calculate call admission threshold. This assumption seems to be impractical for implementation and conflicts with the pre-calculated call admission threshold. In addition to this, it makes resource reservation for newly admitted calls in both local and adjacent cell without considering the users mobility considerations. To emphasis the significance of the nature of user movement, consider an example, where a mobile user resting in the parent cell may not need the intercell handoff support during communication while the hand-off support is indispensable for a taxi passenger using a mobile phone. Obviously, for requests from “resting user” resource allocation in local cell is enough to guarantee QoS without extra resource allocation in neighbouring cells. Hence in this work, suitable modifications are incorporated into the original distributed scheme to improve the performance.

The rest of this paper is organized as follows: Section 2 deals with an introduction to the original distributed CAC (D-CAC). Section 3 describes the modifications carried out in the original scheme. Simulation results and discussions are detailed in section 4. Finally, in section 5 conclusions are summarized.

2. AN INTRODUCTION TO DISTRIBUTED CAC

Consider a 2-D cellular array with each cell capable of supporting N number of calls, as shown in the Fig.2. The network strictly uses a fixed channel allocation (FCA) scheme. Let λ_n and λ_h denote the arrival rate for new and hand-off call to any radio cell, μ and h denote the call departure rate and hand-off rate respectively. Considering a test mobile in radio cell C_0, let the test mobile remains in the same cell with probability P_s and that it hand-off to any neighbouring cell C_i where $i=1,2………6$, with equal probability $P_m/6$ during the T, where T is referred as CAC period. In addition to this, the call duration $(1/\mu)$ and the time a call spends in a radio cell $(1/h)$ prior to handing off to another cell is considered to be exponentially distributed.

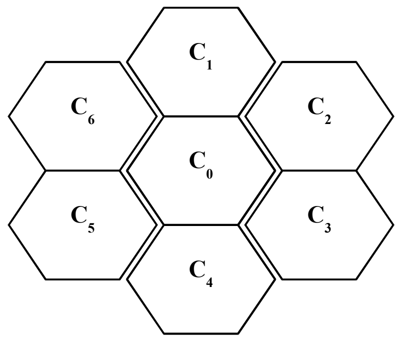

Fig 2. 2-D Network model

The call admission is based on the state of both the current cell C_0, (where a new call seeks admission) and its surrounding cells. Let the number of calls in C_0 and the i-th neighbouring cell C_i be n_o and n_i respectively. Let P_{QoS} be the highest tolerable handoff dropping probability or call dropping probability (CDP) i.e., target CDP in the mobile system considered. It is expected that all calls of the same type require the same P_{QoS} throughout their connection, which is considered to be 1% in our analysis. In order to admit a new call to C_o at time t_o, the following admission conditions need to be satisfied:

i) At time to+T, the overload probability of the cell C_0 affected by handoffs from $C_1,\ldots C_6$ to C_0 and including handoffs from C_0 to any cell, must be smaller than P_{QoS}..

ii) At time to+T, the overload probability of the cell C_1 affected by handoffs from cells $C_0, C_2,\ldots,C_6$ and including handoffs from C_1 to any other cell, in addition to new calls admitted to cell C_1 during T, must be smaller than P_{QoS}..

Similarly, the admission condition for the remaining neighbouring cells $C_2,\ldots,C_6$ can be also stated. Hence, the admission thresholds for cells can be computed periodically for every CAC period and accordingly the call attempts can be accepted or rejected.

3. MODIFIED DISTRIBUTED CAC

D-CAC [3] determines the admission threshold for a radio cell to admit new calls during a CAC period T by considering the number of active calls in both the local and the adjacent cells. This is possible by mutual exchange of load information among the base stations. This CAC operation is performed every T, and T is assumed be short enough so that the probability that a call hands offs more than once during T is negligible. D-CAC needs no assumption on handoffs and new call arrival processes while the admission process is supposed to be Poisson to calculate the call admission threshold for a CAC period T. This assumption seems to be impractical for implementation and conflicts with the pre-calculated admission threshold. Since, if the arrival process tends to be non-poisson in nature, then it cannot satisfy the poisson admission criteria. One solution to the above said problem is to keep the interarrival time obey the exponential distribution. Suppose a new call is admitted at time t_1. At the same time, there are empty channels and a non-zero admission threshold that is valid until t' in the cell. The next admission should occur at $t_2 = t_1 + \Delta$, where Δ is generated according to the exponential distribution. Consider $t_2 < t'$, a new call may arrive i) before t_2, ii) at t_2 or iii) after t_2. Case 'ii' is ideal but rare. In case `i', the new call can be queued until t2 for admission with compliance to the Poisson-assumption. This will cause resource wastage. However, it is complex to deal with case 'iii'. The best solution is to determine *T* necessarily, since the T setting heavily affects the accuracy of the calculation for call admission threshold and will further affect QoS guarantee.

3.1 MEASUREMENT FOR T, P_M AND P_S

An important issue is how to determine *T* to guarantee hand off dropping while to keep resource utilization high. It is difficult to calculate *T* mathematically without other assumptions. A practical way to estimate T is to devise an algorithm to adjust *T* automatically according to the measured CDP and new call blocking or call blocking probability (CBP). In this case, *T* should be decreased until another *T* setting gives a CDP smaller than but close to the target CDP, and also gives a smaller CBP.

The values of p_m and p_s are estimated using a measurement method instead of the mathematical calculation used in [3] since the calculation requires assumptions on distributions for call lifetime and channel holding time. The measurement can be operated periodically and the final result is the weighted accumulation of all the previous results. It is easy for a cell to observe the events of handoffs and termination of calls. Therefore, a cell can count the calls that handoffs to other cells (K_{ho}), the calls that terminate in the local cell (K_{te}) and total calls present in the local cell (K) during a measurement period T_m (measured CAC period). The probabilities that a call handoffs to other cells (P^m_{Tm}) or terminates (P^t_{Tm}) during a measurement period can be approximated by $P^m_{Tm} = (K_{ho} / K)$ and $P^t_{Tm} = (K_{te}/K)$.The probability that a call remains in the local cell during a measurement period, P^s_{Tm}, is given by,

$$P^s_{Tm} = (1 - P^m_{Tm} - P^t_{Tm}) \qquad (1)$$

The weighted accumulation of P^m_{Tm} and P^t_{Tm} from 0 to $t+T_m$ can be generally represented by

$$M_{t+Tm} = \alpha M_t + (1-\alpha) M_{Tm} \qquad (2)$$

where M_t is the weighted accumulation from 0 to t, M_{Tm} is the measured result at t + Tm, and α is a weight less than 1.

By considering the difference on mobility support for low and high mobility calls together with the estimated parameters the performance can be enhanced to a greater extent , which is clearly shown in the simulated results. Let λ_1 and λ_2 denote the mean call arrival rates for low and high mobility calls present in a given cell, respectively. And let $\lambda' = \lambda_1 + \lambda_2$, where λ' indicates the total mean new arrival rate. Suppose the entire capacity of a cell, N, is divided into N_l and N_h for low and high mobility calls respectively, with $N_l / N_h = \lambda_1 / \lambda_2$ and $N = N^l + N^h$. Then,

$$N^l = (\lambda_1 / (\lambda_1+\lambda_2))\, N \quad \text{and} \quad N^h = (\lambda_2 / (\lambda_1+\lambda_2))\, N \qquad (3)$$

For low mobility call requests, resource allocation is needed only in the local cell where the user submits the request. The admission threshold for low mobility calls is N^l, which, however, can be shared by handoffs. N^h channels are shared by high mobility calls and handoffs generated by the admitted high mobility calls.

4. SIMULATION RESULTS

The simulation model used here is the same as the one used in [3].The system capacity is set to 20 and 50 channels in each cell and the target CDP is fixed as 0.01 for both cases. The new call arrival process is Poisson with mean arrival rate of 0.4calls/s. Both the call lifetime and channel holding time are set to be exponentially distributed. According to the *T*-assumption, the shorter *T,* the more accurate the calculation is for the call admission threshold. This will be reflected by the approach between the target CDP and the measured CDP. Therefore, set the initial *T* small, and then increase T until the measured CDP is close to but not larger than the target CDP. However, a very long T setting can also give a small CDP that meets the target CDP since a long *T* cannot increase the admission threshold in a cell immediately if there are many calls have left the cell. This will give a low CDP but a high CBP as shown in figs.3 and 4.

This phenomenon can be observed by the system because there will be a lot of unused empty channels while new call requests are still dropped.

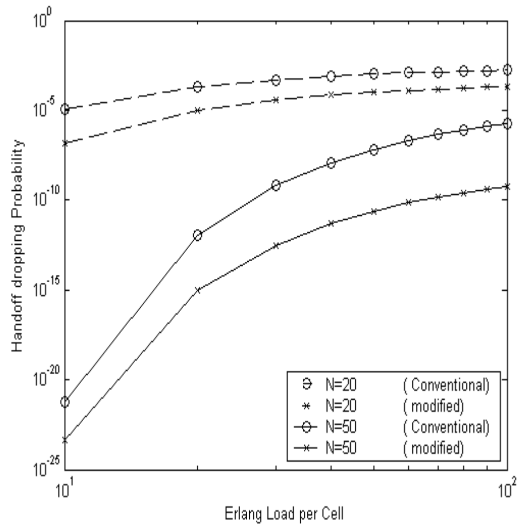

Fig.3 Effect of varying loads on handoff dropping Probability

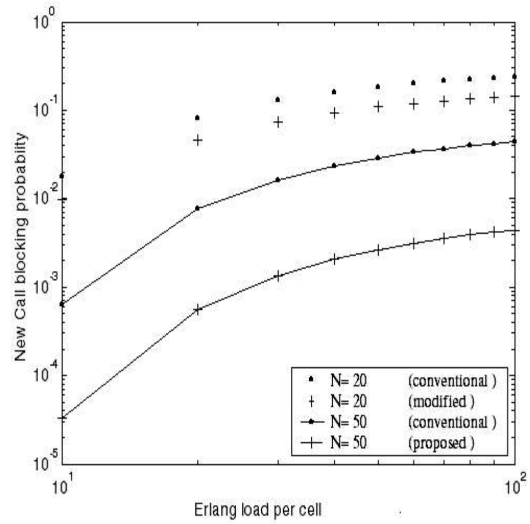

Fig.4 Effect of varying loads on Call blocking probability

4. CONCLUSIONS

In this paper, the shortcoming of distributed CAC is eliminated by incorporating the nature of the mobile user movement and based on the measured blocking probabilities; the estimated *'T'* is adjusted automatically. This has resulted in enabling the admission controller to make a clear sighted admission decision leading to improved performance in terms of resource efficiency and low blocking probabilities. Algorithms to find the value T and measure p_m and p_s have been proposed. Therefore, this modified distributive approach CAC can be used in general environments. Further research will extend the enhanced scheme for multimedia environments, where applications will require different amounts of bandwidth with different QoS requirements

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