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An Adaptive Call Admission Control Scheme for Overflowed Traffic with Buffering of Data/New Voice Calls in Multilayer 3G Wireless Mobile Networks

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Abstract: In the current scenario, the multilayer cell structure is widely accepted for designing the wireless mobile networks. Such type of networks can support high capacity and larger coverage area and in order to provide better Quality of Service (QoS) requires an efficient call admission control scheme. In this paper, we consider that system is accessed by three types of traffic viz. data calls, voice calls (new/handoff) and handoff voice calls. We propose a call admission control scheme to handle overflowed traffic in a three layered cell architecture i.e. microcell, macrocell and satellite cell of 3G wireless mobile networks with queueing of blocked data calls and new voice calls at microcell and macrocell layers respectively. Guard channel policy is applied at microcell and macrocell level to give priority to voice (new/handoff) calls and handoff voice traffic respectively. The performance of proposed call admission control scheme is analyzed in terms of dropping probability, blocking probability and channel utilization.

Keyword: 3G Wireless Mobile Network, micro cells, macro cells, Guard Channel, Buffer

I. INTRODUCTION

Recently the demand for wireless mobile communication network has grown tremendously. Future wireless mobile networks will require improved quality of service, higher capacity and a larger coverage area than existing networks. In the designing of a wireless network two key objectives are considered, first, to maximize the spectrum efficiency, second, minimize the call dropping and call blocking probabilities to provide high quality of service. The 3G wireless mobile networks integrate different types of traffic such as voice, data, videos and compressed images. These service required large bandwidth to provide the Quality of Service (QoS) similar to these of wired networks. Multilayer cell architecture can support high capacity and larger coverage area in the design of 3G wireless mobile networks. The layered cellular architecture shown in figure-1.1 has two benefits, first, if a bigger cell covers an area, it is not necessary that a smaller cell also covers that area e.g. in rural areas with low overall demand and scattered high demand points, this means that fewer resources need to be spent for providing optimal Quality of Service.

Instead of covering whole area with microcells, a macrocell can be used in combination with microcells used to covered high demand points. Second, the bigger cell, with high coverage and capacity, can be used to serve high speed users to reduce the handoff probability. As the handoff probability is reduced, the risk of dropping of calls due to shortage of channels is also reduced.

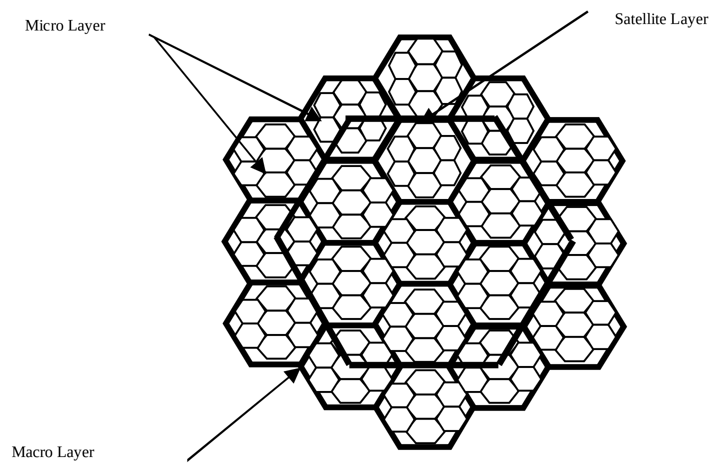

Fig -1.1 Layered Cellular Architecture

Many Researchers proposed several techniques and methods to handle new calls and handoff calls traffic of the mobile users. Chang, et al. [50] analyzed a hierarchical cellular system with finite queues for new and handoff calls. Both the effect of the reneging of waiting new calls because of the callers' impatience and the effect of the dropping of queued handoff calls as the callers move out of the handoff area are considered, besides the effect of guard channel scheme. Wie, et al. [107] proposed a hierarchical cellular system with an underflow scheme and analyzed the performance of the system. Performance characteristics for users with different mobility's are evaluated. The proposed underflow scheme reduces the blocking probability for high mobility users and the forced termination probability for high mobility users. It also reduces the forced termination probability for low mobility users. However, this scheme slightly increases the total carried traffic of the system. Gupta and Kumar [108] analyzed the capacity of wireless networks by scale space and suppose that n nodes are located in a region of area 1m2. Each node can transmit at W bits per second over a common wireless channel. They will describe in the sequel under what conditions a wireless transmission over a sub channel is received successfully by its intended recipient. Wu et al. [94] developed an analytical model to study the performance of a single tier network with two types of users. This model is further used to analyze a multitier network with the queue in only one tier. Ekici and Ersoy [109] introduced a Simulated Annealing (SA) based method to determine the design parameters of a multi-tier cellular network, for which the implementation cost is minimized. The cellular system employs guard channels and allows calls to overflow to upper tiers. Diederich and Zitterbart [30] introduced the basic functions of handoff prioritization schemes and described one proposal for a classification of these schemes. Based on this classification, they finally present a survey of available Schemes. Tang and Li [100] modeled various cell residence times by general distributions to adapt to more flexible mobility environments. The channel occupancy times were derived in terms of the Laplace transforms of various cell residence times. The handoff rates, overflow rates and take-back rates of each layer were also derived in terms of the new call arrival rates and related probabilities. Zhu et al. [110] proposed a dynamic load balancing algorithm based on sojourn time for heterogeneous multitier wireless networks consisting of macrocell cellular network and microcell cellular network. The sojourn time is calculated by the velocity, direction of motion and position of mobile station. Pandey, et al. [111] investigated a call-admission and handoff-control framework for multi-tier cellular networks. They propose and compare Call-Admission Control (CAC) algorithms based on the cell-dwelling time, by studying their impact on the handoff-call dropping and new-call blocking probabilities and the channel partitioning between the two tiers.

Zreikat et al. [112] presented a performance evaluation and resource management of hierarchical MACRO/MICRO cellular networks using the new Modeling and Evaluation Language (MOSEL-2). MOSEL-2 with new constructs has the ability to find the performance and reliability modeling and evaluation of systems with exponential and non-exponential distributions. Gowrishankar, et al. [113] evaluated the system performance under ideal condition by ignoring failures and recovery in the system. The availability models were conservative models and would assess the availability/ reliability of the system. The performability models were combined models of performance and reliability. The performability models were more realistic models of the system due to the simultaneous consideration of performance and reliability. Here the VHO process of a next generation wireless system was modeled and evaluated by an analytic performability model and performance of decision system is evaluated through the sensitivity analysis of VHO decision parameter.

Bhilare, and Sambare [114] presented the survey of various existing system and the need to provide best service in the (NGWS). Also the current state of mobility management in NGWS is presented and NGWS architecture for mobility management is introduced, and related open research issues are discussed in detail. Mangrulkar and Deshmukh [37] proposed two power reservation schemes for inter-cell handoff calls and intra-cell handoff calls, respectively. Correspondingly, two reservation factors are introduced, the values of which are determined by optimizing the metric of Grade of Service (GoS). Bouchti et al. [54] presented problem of queuing theoretic performance modeling and analysis of Orthogonal Frequency Division Multiple Access (OFDMA) under broad-band wireless networks. Sharma et al. [115] proposed a new Markov model with increasing the number of channels and queue size for a two-tier cellular network having a FIFO queue in the Microcell tier.

The rest of the paper is organised as follows, The system model of the proposed call admission control scheme is described with the help of state transition diagram in Section1.2. In Section-1.3, we describe the proposed call admission control with the help of algorithm and flowchart of the system presented in subsection 1.3.1. The performance metrics like utilization of cells, blocking probability and dropping probability are calculated in subsection 1.4 with the help of analytical model of the system. Section-1.5 consists of numerical calculation and discussion on results obtained. In Section-1.6, we conclude the paper with some discussion about the future work.

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II. SYSTEM MODEL

In this paper, we have consider a multilayer 3G wireless mobile network which is divided into three layers viz. microcell, macrocell and satellite cell. It is assumed that all the layers consist of uniform and homogeneous cells. We consider that a satellite cell overlays *N* macrocells and each macrocell overlays *n* microcells. Fig. shows the System model of the call admission control scheme. It is considered that every C_m microcells are overlaid by a macrocell, and every C_M macrocells are in turn overlaid by a C_s Satellite cell. Independent statistical behaviour between neighbouring cells is assumed. We therefore, can focus on only one cell in each layer.

III. CALL ADMISSION CONTROL SCHEME

Here we present call admission control scheme emphasizes on both voice and data services. The required modifications were made in order to accommodate the data services as well as the voice service in the call admission control scheme. Here we consider a multilayer 3G wireless mobile network with C channels, where, C_m channels are allocated to each microcell, C_M channels are allocated to each macrocell and C_S channels are allocated to each satellite cell. The guard channel policy is applied at microcell layer to give priority to voice (new/handoff) calls over data calls, and at macrocell layer to give priority to handoff voice calls over new voice calls. At microcell layer a first in first out buffer B_f of capacity P_1 is used to store the blocked data calls and at macrocell layer another first in first out buffer B_v of capacity P_2 is used to store blocked new voice calls. The calls stored in the buffer will be only be in processed when there will be any free channel available within the region specified for that type of call.

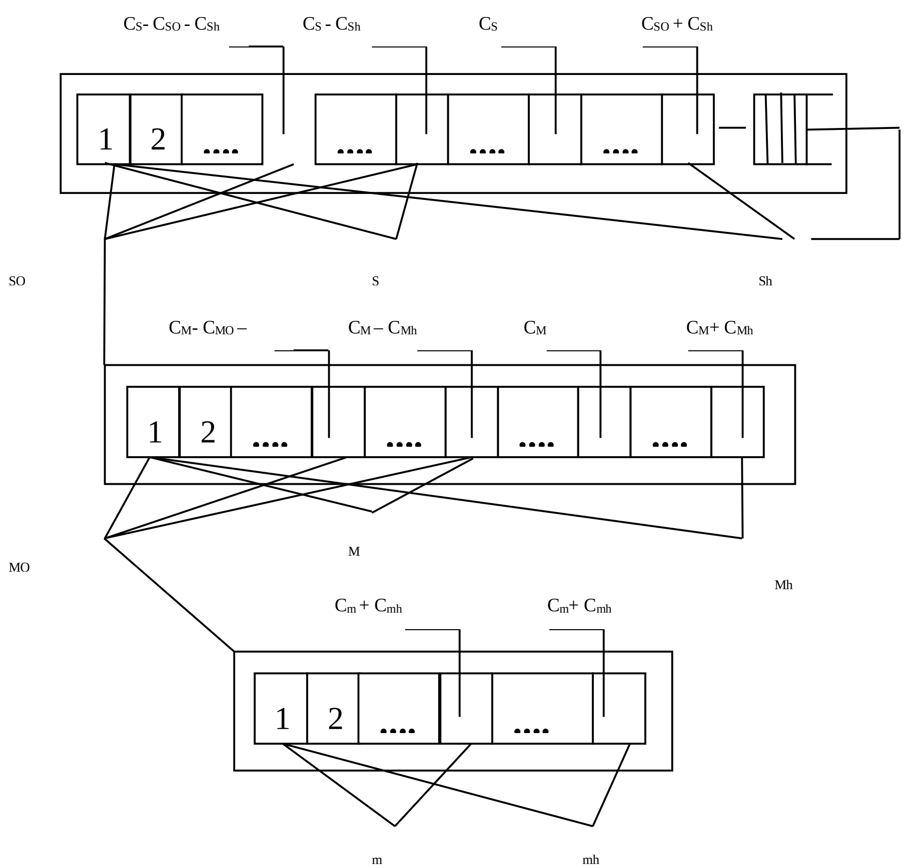


Fig. 1.2 System Model for the Proposed CAC

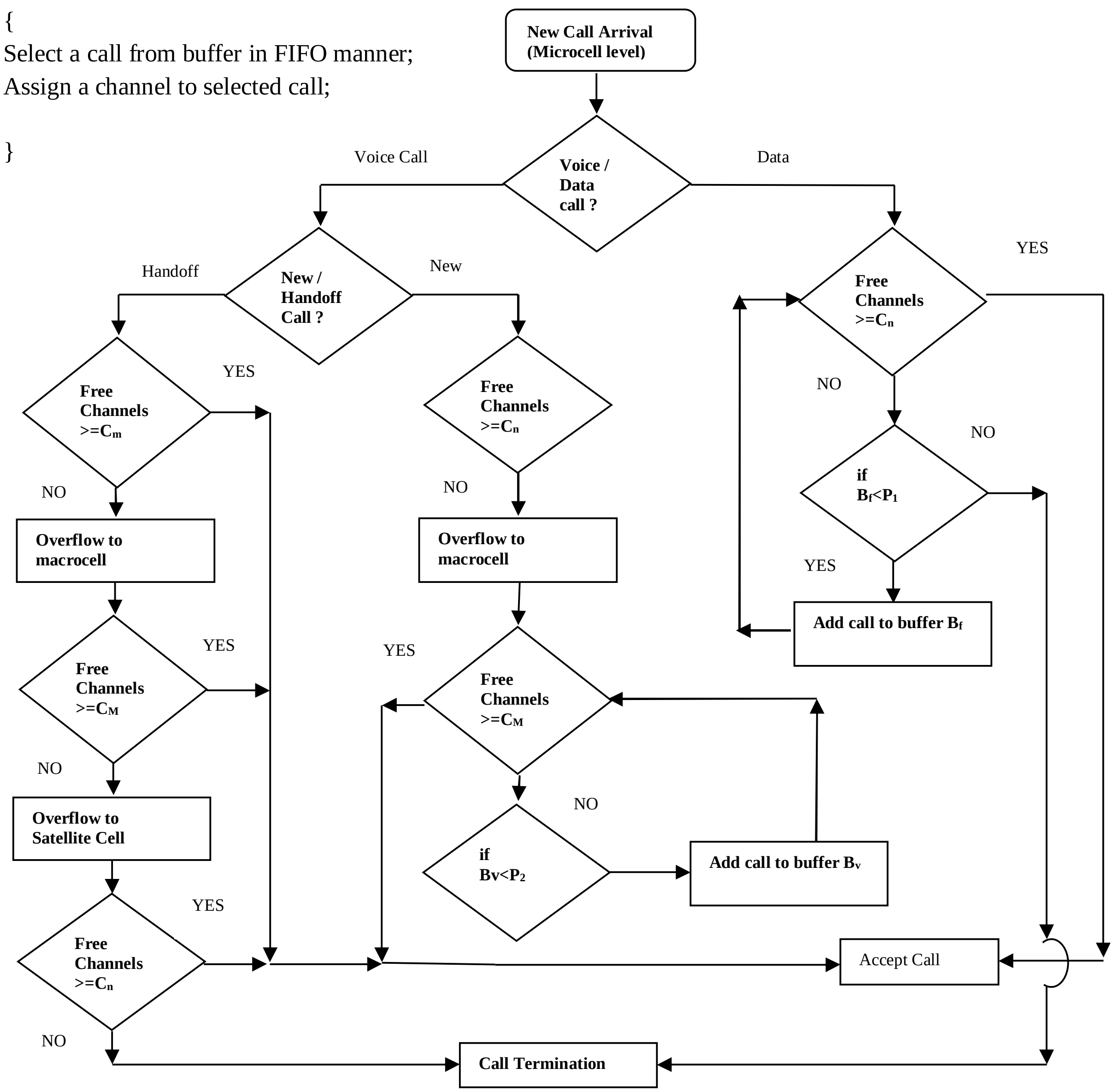
IV. ALGORITHM AND FLOWCHART OF PROPOSED CAC

The algorithm of the proposed call admission control scheme is given below:

```
if (INCALL = Voice_Call)
{
        If ( INCALL = New_Voice_Call)
```

```
        {
        if (number of free channels in microcell >= C_m)
{
admit INCALL;
}
Else If (number of free channels in macrocell >= C_M)
{
admit INCALL;
}
Else if (number of calls in buffer>=P_1)
{
drop INCALL;
}
                Else
{
                admit call to buffer;
while (! Empty P_1)
                if ( number of channels in macrocell >C_V)
                {
                Drop INCALL;
                }
                Else
                {
                Select a call from buffer in FIFO manner;
                Assign a channel to selected call;
                }
}
        }
Else If (INCALL= Handoff_Call)
        {
                if (number of free channels in microcell >= C_m)
{
admit INCALL;
}
Else If (number of free channels in macrocell >= C_M)
{
admit INCALL;
}
Else If (number of free channels in Satellite cell >= C_M)
{
admit INCALL;
}
Else
        {
                drop INCALL;
        }
}
}
Else if (INCALL= Data_Call)
{
```

If (number of free channels in microcell >= C_m)
{
admit INCALL;
}
Else if (number of calls in buffer>=P_1)
{
drop INCALL;
}
Else
{
admit call to buffer;
while (! Empty P_1)
if (number of channels in macrocell >C_V)
{
Drop INCALL;
}
Else
{
Select a call from buffer in FIFO manner;
Assign a channel to selected call;
} }



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V. ANALYTICAL MODEL

We consider a multilayer 3G wireless mobile network with C channels, where, C_m channels are allocated to each microcell, C_M channels are allocated to each macrocell and C_S channels are allocated to each satellite cell. In this scheme we have considered three types of traffic data calls, voice calls and Handoff voice calls. Both data and voice shares the channels of a micro cell where call arrival rate is simply ruled by Poisson's distribution. In the i^{th} microcell region the data, new voice and handoff voice calls will arrive with homogeneous arrival rate λ, where $\lambda = \lambda_d + \lambda_{nv} + \lambda_h$ until the number of free channels is equal to a certain threshold value C_{di}, where $0 \leq i \leq n$, otherwise data call will be added to the buffer B_r if the number of calls in the buffer is less than the value P_1, otherwise the data call will be rejected. Only new voice calls and handoff voice calls will be accepted with arrival rate λ_v, where $\lambda v = \lambda_{nv} + \lambda_h$ until the number of free channels in i^{th} microcell region equal to C_{mi}, where $0 \leq i \leq n$. Otherwise, new voice calls and handoff voice calls will be overflowed to the overlaid macrocell. In the j^{th} macrocell region, only overflowed new voice calls and handoff voice calls will be accepted with arrival rate λ_v, where $\lambda v = \lambda_{nv} + \lambda_h$, until the number of free channels in j^{th} macrocell region equal to C_{Mj}, where $0 \leq i \leq N$, Otherwise the new voice call will be added to the buffer B_v if the number of calls in the buffer is less than the value P_2, otherwise the new voice call will be rejected. Only overflowed handoff voice calls will be accepted with arrival rate λ_h, until the number of free channels in j^{th} macrocell region equal to C_M, where $0 \leq j \leq N$. Otherwise, handoff voice calls will again be overflowed to the overlaid satellite cell. The satellite cell region can be accessed by only overflowed handoff voice calls with arrival rate λ_h, until the number of free channels in satellite cell region is equal to C_S. Otherwise, handoff voice calls will be rejected. The call holding time and traffic intensity for the combination of data, new voice and handoff voice calls is given by $1/\mu$ and ρ respectively, where $\mu = \mu_d + \mu_{nv} + \mu_h$, and $\rho = \lambda/\mu$ and call holding time and traffic intensity for the combination of new voice and handoff voice calls is given by $1/\mu_v$ and ρ_v, where $\mu_v = \mu_{nv} + \mu_{hv}$, and $\rho = \lambda_v/\mu_v$. It is assumed that, the probabilities of the thinning scheme for microcell are given by $\alpha_1 >$ $\alpha_2 > \alpha_3 > \alpha_4$ and $\beta_1 > \beta_2 > \beta_3 > \beta_4$ are the probabilities of the thinning scheme for macrocell.

Probability of utilization of micro cell channel taking equal termination rate, is derived like:

$$U_{(micro\ cell)} = \frac{\sum_{i=0}^{C_d}\frac{(\rho)^i}{i!}+\frac{\rho^{C_d}}{C_d!}\sum_{j=C_d}^{C_m}\frac{(\rho+\rho_v)^j}{\prod_{s=1}^{j}(C_d+s)}}{\left[\begin{array}{l}\sum_{i=0}^{C_d}\frac{(\rho)^i}{i!}+\frac{\rho^{C_d}}{C_d!}\sum_{j=C_d}^{C_m}\frac{(\rho+\rho_v)^j}{\prod_{s=1}^{j}(C_d+s)}+\frac{(\rho+\rho_v)^{C_m}}{C_d!\prod_{i=1}^{C_m}(C_d+i)}\sum_{j=1}^{C_v}\frac{(\rho+\rho_v)^j}{\prod_{r=1}^{j}(C_d+C_m+r)}+\frac{(\rho+\rho_v)^{C_m+C_v}}{C_d!\prod_{i=1}^{C_v}(C_d+C_m+i)}\\ \sum_{j=C_v}^{C_M}\frac{(\rho+\rho_v+\rho_h)^j}{\prod_{t=1}^{j}(C_m+(C_d+C_m)+r)}+\frac{(\rho+\rho_v+\rho_h)^{C_m+C_M}}{C_d!\prod_{i=1}^{C_M}(C_m+(C_d+C_m)+i)}+\sum_{j=1}^{C_s}\frac{(\rho+\rho_v+\rho_h)^j}{\prod_{t=1}^{j}(C_M+C_m+(C_d+C_m)+t)}\end{array}\right]}$$

....(1)

Probability of utilization of macro cell channel is defined as

$$U_{(macro\ cell)} = \frac{\frac{(\rho+\rho_v)^{C_m}}{C_d!\prod_{i=1}^{C_d}(C_d+i)}\sum_{j=1}^{C_v}\frac{(\rho+\rho_v)^j}{\prod_{r=1}^{j}(C_d+C_m+r)}+\frac{(\rho+\rho_v)^{C_m+C_v}}{C_d!\prod_{i=1}^{C_v}(C_d+C_m+i)}\sum_{j=C_v}^{C_M}\frac{(\rho+\rho_v+\rho_h)^j}{\prod_{t=1}^{j}(C_m+(C_d+C_m)+t)}}{\left[\begin{array}{l}\sum_{i=0}^{C_d}\frac{(\rho)^i}{i!}+\frac{\rho^{C_d}}{C_d!}\sum_{j=C_d}^{C_m}\frac{(\rho+\rho_v)^j}{\prod_{s=1}^{j}(C_d+s)}+\frac{(\rho+\rho_v)^{C_m}}{C_d!\prod_{i=1}^{C_m}(C_d+i)}\sum_{j=1}^{C_v}\frac{(\rho+\rho_v)^j}{\prod_{r=1}^{j}(C_d+C_m+r)}+\frac{(\rho+\rho_v)^{C_m+C_v}}{C_d!\prod_{i=1}^{C_v}(C_d+C_m+i)}\\ \sum_{j=C_v}^{C_M}\frac{(\rho+\rho_v+\rho_h)^j}{\prod_{t=1}^{j}(C_m+(C_d+C_m)+r)}+\frac{(\rho+\rho_v+\rho_h)^{C_m+C_M}}{C_d!\prod_{i=1}^{C_M}(C_m+(C_d+C_m)+i)}+\sum_{j=1}^{C_s}\frac{(\rho+\rho_v+\rho_h)^j}{\prod_{t=1}^{j}(C_M+C_m+(C_d+C_m)+t)}\end{array}\right]}$$

....(2)

Probability of utilization of satellite cell channel is defined as

$$U_{(satellite\ cell)} = \frac{\frac{(\rho+\rho_v+\rho_h)^{C_m+C_M}}{C_d!\prod_{i=1}^{C_M}(C_m+(C_d+C_m)+i)}+\sum_{j=1}^{C_s}\frac{(\rho+\rho_v+\rho_h)^j}{\prod_{t=1}^{j}(C_M+C_m+(C_d+C_m)+t)}}{\left[\begin{array}{l}\sum_{i=0}^{C_d}\frac{(\rho)^i}{i!}+\frac{\rho^{C_d}}{C_d!}\sum_{j=C_d}^{C_m}\frac{(\rho+\rho_v)^j}{\prod_{s=1}^{j}(C_d+s)}+\frac{(\rho+\rho_v)^{C_m}}{C_d!\prod_{i=1}^{C_m}(C_d+i)}\sum_{j=1}^{C_v}\frac{(\rho+\rho_v)^j}{\prod_{r=1}^{j}(C_d+C_m+r)}+\frac{(\rho+\rho_v)^{C_m+C_v}}{C_d!\prod_{i=1}^{C_v}(C_d+C_m+i)}\\ \sum_{j=C_v}^{C_M}\frac{(\rho+\rho_v+\rho_h)^j}{\prod_{t=1}^{j}(C_m+(C_d+C_m)+r)}+\frac{(\rho+\rho_v+\rho_h)^{C_m+C_M}}{C_d!\prod_{i=1}^{C_M}(C_m+(C_d+C_m)+i)}+\sum_{j=1}^{C_s}\frac{(\rho+\rho_v+\rho_h)^j}{\prod_{t=1}^{j}(C_M+C_m+(C_d+C_m)+t)}\end{array}\right]}$$

....(3)

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Blocking probability of data call is defined as

$$\mathbf{P_{data\ call}\ (C_m\ C_M\ C_s)} = \frac{\sum_{i=0}^{C_d+P_1}\frac{(\rho)^i}{i!}}{\left[\begin{array}{c}\sum_{i=0}^{C_d+P_1}\frac{(\rho)^i}{i!}+\frac{\rho^{C_d+P_1}}{(C_d+P_1)!}\sum_{j=C_d}^{C_m}\frac{\lambda_v^j}{\prod_{s=1}^{j}(c_d\mu(c_d+s)\mu_v)}+\frac{\rho^{C_d+P_1}}{(C_d+P_1)!}\frac{\lambda_v^{C_m}}{\prod_{s=1}^{C_m}(c_d\mu(c_d+s)\mu_v)}\sum_{j=1}^{C_v+P_1}\frac{\lambda_v^{C_m}\sum_{j=1}^{i}\alpha_j}{\prod_{r=1}^{j}(c_d\mu(c_m+t)\mu_v)}\\ +\frac{\rho^{C_d+P_1}}{(C_d+P_1)!}\frac{\lambda_v^{C_v}\sum_{j=1}^{C_v}\alpha_j}{\prod_{s=1}^{C_v}(c_d\mu(c_m+s)\mu_v)}\sum_{i=c_v}^{C_M}\frac{\lambda_h^i\sum_{j=c_v}^{i}\alpha_j}{\prod_{t=1}^{j}(c_d\mu(c_m+c_v)\mu_v+(c_v+t)\mu_h)}\\ +\frac{\rho^{C_d+P_1}}{(C_d+P_1)!}\frac{\lambda_h^{C_M}\sum_{j=c_v}^{C_M}\alpha_j}{\prod_{s=1}^{C_M}(c_d\mu(c_m+c_v)\mu_v+(c_v+s)\mu_h)}\sum_{i=1}^{C_s}\frac{\lambda_h^i\sum_{j=1}^{i}\beta_j}{\prod_{t=1}^{j}(c_d\mu(c_m+c_v)\mu_v+(c_v+c_m)\mu_h+(c_M+t)\mu_h)}\end{array}\right]} \quad ....(4)$$

Blocking probability of new voice call is defined as

$$\mathbf{P_{voice\ call}}\ (C_m\ C_M\ C_s) = \frac{\frac{\rho^{C_d+P_1}}{(C_d+P_1)!}\sum_{j=C_d}^{C_m}\frac{\lambda_v^j}{\prod_{s=1}^{j}(c_d\mu(c_d+s)\mu_v)}+\frac{\rho^{C_d+P_1}}{(C_d+P_1)!}\frac{\lambda_v^{C_m}}{\prod_{s=1}^{C_m}(c_d\mu(c_d+s)\mu_v)}\sum_{j=1}^{C_v+P_2}\frac{\lambda_v^{C_m}\sum_{j=1}^{i}c_j}{\prod_{r=1}^{j}(c_d\mu(c_m+t)\mu_v)}}{\left[\begin{array}{c}\sum_{i=0}^{C_d+P_1}\frac{(\rho)^i}{i!}+\frac{\rho^{C_d}}{C_d!}\sum_{j=C_d}^{C_m}\frac{\lambda_v^j}{\prod_{s=1}^{j}(c_d\mu(c_d+s)\mu_v)}+\frac{\rho^{C_d+P_1}}{(C_d+P_1)!}\frac{\lambda_v^{C_m}}{\prod_{s=1}^{C_m}(c_d\mu(c_d+s)\mu_v)}\sum_{j=1}^{C_v+P_2}\frac{\lambda_v^{C_m}\sum_{j=1}^{i}\alpha_j}{\prod_{r=1}^{j}(c_d\mu(c_m+t)\mu_v)}\\ +\frac{\rho^{C_d+P_1}}{(C_d+P_1)!}\frac{\lambda_v^{C_v}\sum_{j=1}^{C_v}\alpha_j}{\prod_{s=1}^{C_v}(c_d\mu(c_m+s)\mu_v)}\sum_{i=c_v}^{C_M}\frac{\lambda_h^i\sum_{j=c_v}^{i}\alpha_j}{\prod_{t=1}^{j}(c_d\mu(c_m+c_v)\mu_v+(c_v+t)\mu_h)}\\ +\frac{\rho^{C_d+P_1}}{(C_d+P_1)!}\frac{\lambda_h^{C_M}\sum_{j=c_v}^{C_M}\alpha_j}{\prod_{s=1}^{C_M}(c_d\mu(c_m+c_v)\mu_v+(c_v+s)\mu_h)}\sum_{i=1}^{C_s}\frac{\lambda_h^i\sum_{j=1}^{i}\beta_j}{\prod_{t=1}^{j}(c_d\mu(c_m+c_v)\mu_v-(c_v+c_m)\mu_h+(c_M+t)\mu_h)}\end{array}\right]} \quad ....(5)$$

Probability of handover failure of voice call is defined as

$$\mathbf{P_{HANDOFF\ FAILURE}\ (C_M\ C_M\ C_S)} = \frac{\left[\begin{array}{c}\frac{\rho^{C_d+P_1}}{(C_d+P_1)!}\frac{\lambda_v^{C_v+P_2}\sum_{j=1}^{C_v}\alpha_j}{\prod_{s=1}^{C_v+P_2}(c_d\mu(c_m+s)\mu_v)}\sum_{i=c_v}^{C_M}\frac{\lambda_h^i\sum_{j=c_v}^{i}\alpha_j}{\prod_{t=1}^{j}(c_d\mu(c_m+c_v)\mu_v+(c_v+t)\mu_h)}\\ +\frac{\rho^{C_d+P_1}}{(C_d+P_1)!}\frac{\lambda_h^{C_M}\sum_{j=c_v}^{C_M}\alpha_j}{\prod_{s=1}^{C_M}(c_d\mu(c_m+c_v)\mu_v+(c_v+s)\mu_h)}\sum_{i=1}^{C_s}\frac{\lambda_h^i\sum_{j=1}^{i}\beta_j}{\prod_{t=1}^{j}(c_d\mu(c_m+c_v)\mu_v+(c_v+c_m)\mu_h+(c_M+t)\mu_h)}\end{array}\right]}{\left[\begin{array}{c}\sum_{i=0}^{C_d+P_1}\frac{(\rho)^i}{i!}+\frac{\rho^{C_d}}{C_d!}\sum_{j=C_d}^{C_m}\frac{\lambda_v^j}{\prod_{s=1}^{j}(c_d\mu(c_d+s)\mu_v)}+\frac{\rho^{C_d+P_1}}{(C_d+P_1)!}\frac{\lambda_v^{C_m}}{\prod_{s=1}^{C_m}(c_d\mu(c_d+s)\mu_v)}\sum_{j=1}^{C_v+P_2}\frac{\lambda_v^{C_m}\sum_{j=1}^{i}\alpha_j}{\prod_{r=1}^{j}(c_d\mu(c_m+t)\mu_v)}\\ +\frac{\rho^{C_d+P_1}}{(C_d+P_1)!}\frac{\lambda_v^{C_v}\sum_{j=1}^{C_v}\alpha_j}{\prod_{s=1}^{C_v}(c_d\mu(c_m+s)\mu_v)}\sum_{i=c_v}^{C_M}\frac{\lambda_h^i\sum_{j=c_v}^{i}\alpha_j}{\prod_{t=1}^{j}(c_d\mu(c_m+c_v)\mu_v+(c_v+t)\mu_h)}\\ +\frac{\rho^{C_d+P_1}}{(C_d+P_1)!}\frac{\lambda_h^{C_M}\sum_{j=c_v}^{C_M}\alpha_j}{\prod_{s=1}^{C_M}(c_d\mu(c_m+c_v)\mu_v+(c_v+s)\mu_h)}\sum_{i=1}^{C_s}\frac{\lambda_h^i\sum_{j=1}^{i}\beta_j}{\prod_{t=1}^{j}(c_d\mu(c_m+c_v)\mu_v+(c_v+c_m)\mu_h+(c_M+t)\mu_h)}\end{array}\right]} \quad ....(6)$$

VI. NUMERICAL RESULTS AND DISCUSSION

In this section, the performance of proposed call admission control scheme is demonstrated by evaluating various parameters such as probabilities of utilization of cells at various layers, probabilities of blocking probabilities of data and new voice calls and dropping probabilities of handoff voice calls for increasing values of the channels of cells at each layer. The blocking probabilities of data calls and new voice calls have been evaluated for different threshold values and for various buffer capacities. The accuracy of our analysis is checked using an event driven simulation. The performance parameters are calculated on the basis of the following assumptions, arrival rates of calls at various stages of the call admission control scheme are assumed to be λ= 20 calls/min, λ_v= 12 calls/min and λ_h= 2.4 calls/min and the call holding time are assumed to be $\frac{1}{\mu}$=0.25 min, $\frac{1}{\mu_v}$ = 0.33 min and $\frac{1}{\mu_h}$ =1.25 min. The probabilities of thinning scheme for microcell are α_1= 0.9, α_2= 0.8, α_3= 0.75 and α_4= 0.7 and that for macrocell are β_1= 0.9, β_2= 0.8, β_3= 0.75 and β_4 = 0.7. The value of C_d and C_v is assumed as the 50% to 70% of the total number of channels assigned for microcell and macrocell respectively. The buffer capacities of both the buffers are assumed to be constant during evaluation of various performance metrics of the call admission control scheme. Figures-1.3 and 1.4 show the graphs of the probabilities of the utilization of microcell, macrocell and satellite cell plotted against the increasing number of channels of various cells at each layer of the system respectively. The probability of the utilization of microcell (*Um*) increases while the probabilities of the utilization of macrocell (*UM*) and satellite cell (*US*) decreases with increase in the number of channels of microcells *Cm* and when the number of channels of macrocell *CM* and satellite cell *CS* remains fixed (figure-1.3).

The probability of the utilization of macrocell (*UM*) increases while the probabilities of the utilization of satellite cell US decreases and that of microcell (*Um*) remains approximately constant with number of channels of macrocells (*CM*) increases and when the number of channels of microcell (*Cm*) and satellite cell (*CS*) remains fixed (figure-1.4). Graphs in figure-1.5 shows the data call blocking probabilities (*Pdb*) for different capacities of buffer *Qd*, plotted against variable number of channels of microcell. According to the proposed call admission control scheme, at the microcell layer only data calls are blocked, the probability of data calls blocking (*Pdb*) has been compared for the following conditions for buffer *Qd*, (i) no buffer (ii) buffer size P_1=10 (iii) buffer size P_1=15. Hence, under the first condition as the number of channels of microcell increases, the data call blocking probability decreases, as more channels are available for providing service to incoming data calls. Under the second and third conditions the data calls blocking probability decreases respectively, as we increase the buffer capacity as more data calls are added to the buffer instead of blocking. Graphs in figures-1.6, shows the new voice call blocking probabilities (*Pnvb*) for different capacities of buffer *Qv*, plotted against variable number of channels of macrocell. According to the proposed call admission control scheme, at the macrocell layer only new voice calls are blocked, the blocking probability of new voice calls (*Pdb*) has been compared under the following conditions for buffer *Qv*, (i) no buffer (ii) buffer size P_2=10 (iii) buffer size P_2=15. Hence, under the first condition when there is no buffer the new voice call blocking probability decreases as the number of channels of macrocell increases, because more channels are available for providing service to incoming data calls. Under the conditions second and third, as we increase the buffer size, we observe that the new voice call blocking probability decreases with the increasing number of channels at macrocell layer. Only handoff voice calls can access of satellite cell layer, therefore, when the number of channels of satellite cell increases the handoff call dropping probability decreases (figure-1.7). It has been also observed that the proper selection of buffer capacities and threshold values at microcell/macrocell layers, there is a significant decrease in handoff dropping probability.

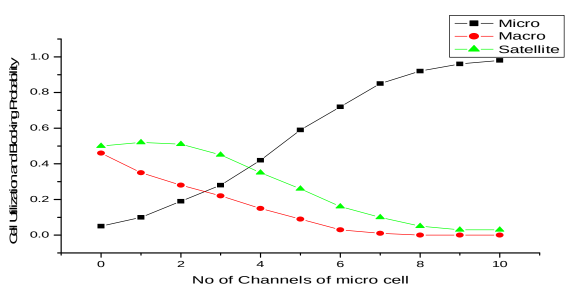

Fig. 1.3 Cell Utilization Probabilities with the increase in no. of channels of microcell

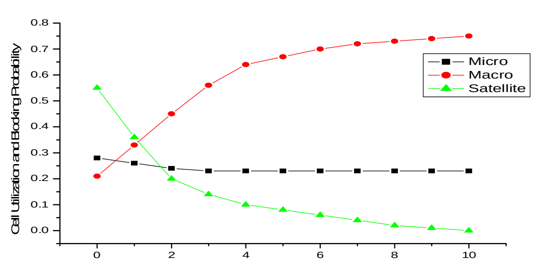

Fig. 1.4 Cell Utilization Probabilities with the increase in no. of channels of macrocell

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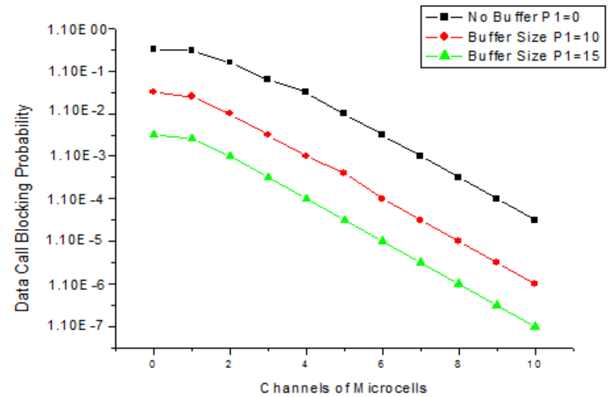

Fig. 1.5 Data Call Blocking Probabilities with the increase in no. Of channels of microcell for different buffer capacity P1.

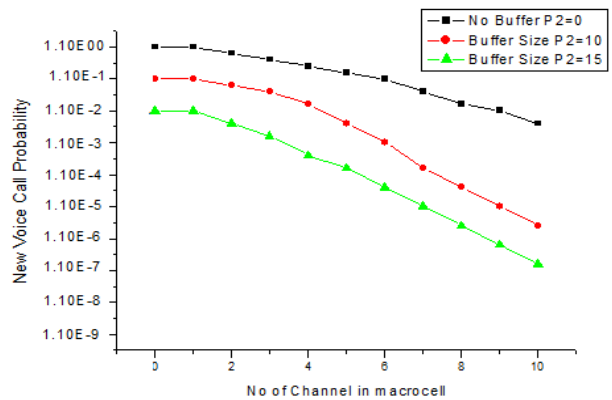

Fig. 1.6 Data Call Blocking Probabilities with the increase in no. Of channels of macrocell for different buffer capacity P2.

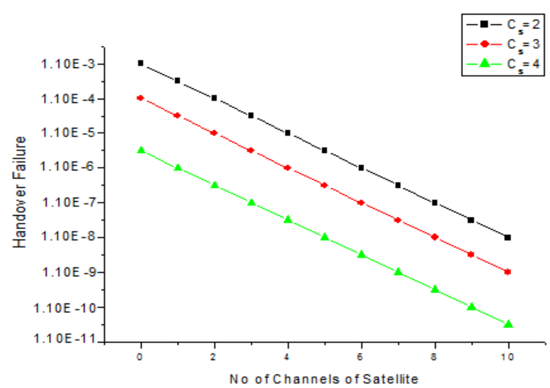

Fig. 1.7 Satellite cell channels on handover failure.

VII. CONCLUSION

In this chapter, we present a call admission control scheme for a multilayer wireless mobile communication networks that applies guard channel policy at microcell layer to prioritize voice calls (new/handoff) and at macrocell layer to prioritize handoff voice calls and two buffers are used one at microcell layer and another at macrocell layer to temporarily store the blocked data or new voice calls respectively. In this model, handoff voice calls gets maximum opportunity of using trunk of overlaid cells to minimize the probability of handoff dropping. In this scheme the buffering of blocked data and new voice calls decreases the blocking probability of these calls up to a great extent and provide a better quality of service to all types of traffic. The performance of CAC scheme is analyzed by computing various performance metrics such as blocking probability of data or new voice calls under varying buffer capacity, and dropping probabilities of handoff voice calls with different threshold values for blocking of data calls at microcell layer and new voice calls at macrocell layer. From the results obtained from the analysis, we observe that by proper selection of number of channels at different layers, threshold values and buffer capacity at microcell and macrocell layers, the proposed CAC scheme provide a better QoS for different traffic types and hence may optimize the performance of the system and obtain good Quality of Service (QoS) for different types of traffics.

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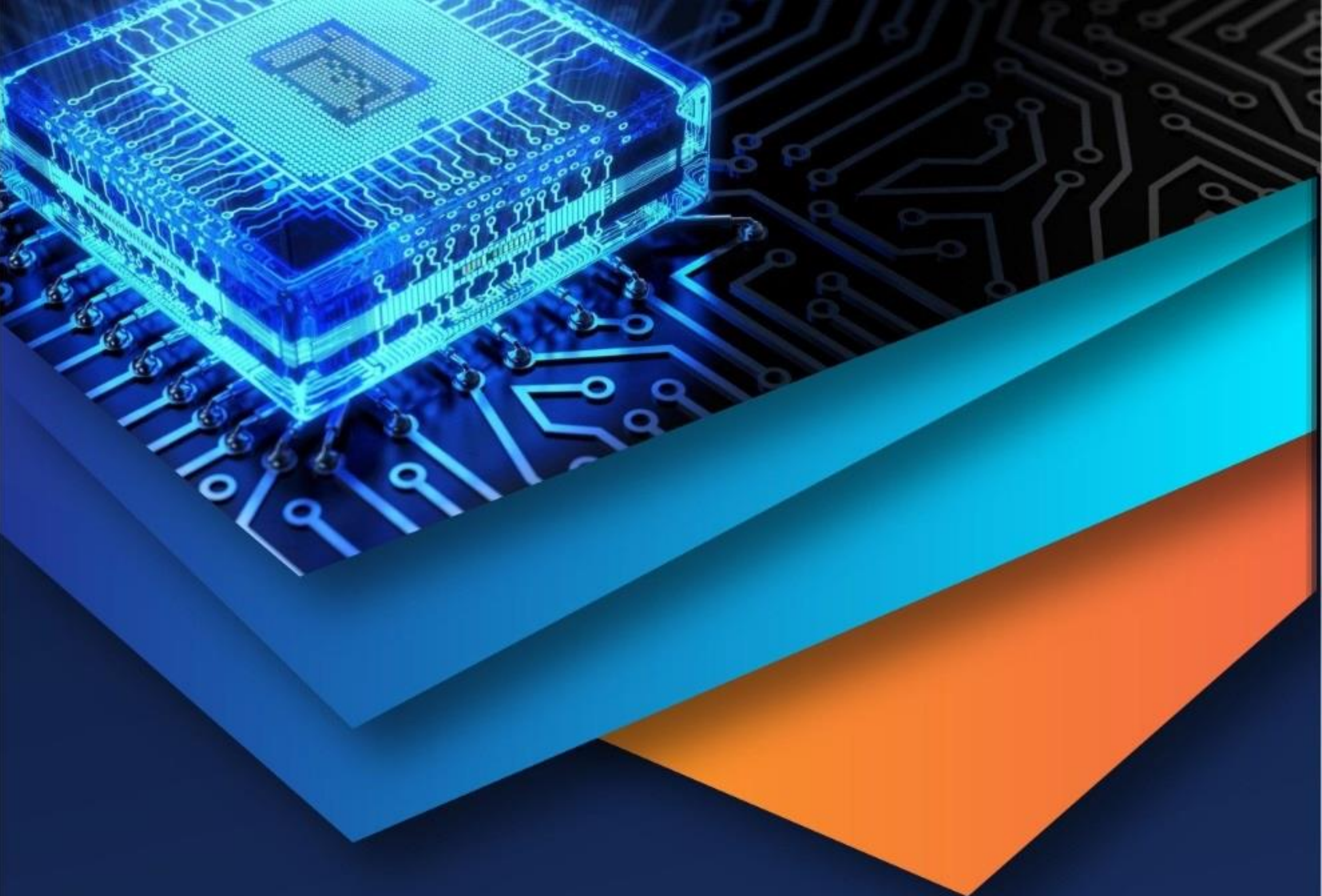

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