Teletraffic Analysis of Overflowed Traffic with voice only in Multilayer 3G Wireless Mobile Networks

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Abstract - *Now a day's the structure of multilayer cell becomes the most important feature of 3G mobile cellular network to support overflow traffic of lower layered cells by upper ones. To enhance the Quality of service (QoS) of the wireless network in terms of resources utilization, blocking probability and dropping probability an well organized CAC scheme is required. In this paper, we deal with traffic model of three layered cells, i.e., micro cell, macro cell and satellite cell. Here we evaluate the performance of CAC for three layered cell of 3G mobile cellular networks. Blocking probability of data call, new voice call and handover failure of voice call, probability of utilization of micro cell channel, macro cell channel and satellite cell channel are evaluated against different traffic parameters.*

Key Words: **Multilayer, 3G Mobile Technology, microcell, macrocell, satellite cell, overflowed traffic, dropping probability, blocking probability and channel utilization.**

1. INTRODUCTION

As there is a rapid change in the area of telecommunications System. In the upcoming mobile networks will requires improved quality of services as the mobile cellular network moves towards 3G technology, the most challenging objectives is to use the single wireless system to support various services including voice, data and voice in various forms. The 3G mobile technology had combined both satellite and terrestrial networks together, and three- or four-layer cell structure (many micro cells are overlaid by a macro cell and again few macro cells are overlaid by a big satellite cell) is provided to combat network congestion. In multilayered cell, when a new call arrive then it will first search for a channel from micro cell and will route to macro cell in case of unavailability of the unused channel in a given micro cell. A call will only route to satellite cell if both micro and macro cells are found occupied. If any call proceed in macro or satellite cell finds the unused channel in micro cell, it will take-back to that micro cell; take-back may be take place even between satellite cell and macrocell. There are two key objectives in wireless network design. First, to maximize the spectrum efficiency, second, minimize the call dropping and call blocking probabilities to provide the high standard of service.

Many researchers proposed several techniques and methods to handle new calls and handoff calls traffic of the mobile users. K. Zhang et al.[1], proposed a single wireless system to support a different kinds of services including voice, data and voice in various forms. Yuguang Fang et al.[2] proposed a thinning scheme, for smooth reduction of traffic admission rates. They suggest that the thinning schemes can be frequently used to derive many known CAC schemes. Jabbari, and Fuhrmann [3] developed a simple analytical model for a flexible hierarchical system using overflow of new calls and handoff calls and a take-back mechanism. Paul Fitzpatrick et al. [4] proposed a blueprint for multilayered wireless mobile communications networks which provides a uniform treatment of overflow to account for intra- and interlayer overflow. Qian Huang et al. [5] presents an extended handoff control scheme which allows dynamic bandwidth sharing between different types of traffic for enhancing bandwidth utilization in multimedia mobile cellular networks. Bin Li et al. [6] propose a new call admission control scheme called dual threshold bandwidth reservation (DTBR) scheme. They proposed a complete sharing approach, in which the channels in each cell are shared among the different traffic types and multiple thresholds are used to meet the specific quality-of-service (QoS) requirements. Stemm, et al. [7] enforce a vertical handoff system that allows the users to move between cells in wireless networks .The main purpose is to present a user with the best feasible connectivity for as long as possible with a minimum of disruption during handoff. The co-channel interference problems of sharing frequencies between microcells and existing macrocells have been investigated by Coombs et al. [8]. Based on the assumptions made, it was found that an isolated microcell could operate under a macrocell layer of cluster size greater than Microcell clusters could not be introduced unless very large macrocell cluster sizes were used. In all cases, the microcell uplink was found to limit the placement of the microcell relative to the co-channel macrocells. Wenhao Shan et al.[9] proposed a call-overflow scheme functioning in two direction which was based on the speed of the mobile for making the calls. To verify whether the handoff calls are given higher priorities, they assumed guard channels to be allocated at both macrocells and microcells. Qi Liu et al [10] proposed a DLB scheme of hotspots for the enhancement in the transmission performance, for the underlying users. Mobility cognition and service arrival awareness was integrated in 3G/WLAN networks and were analyzed on user basis. Furthermore, they proposed a model for mobility which was based on velocity classification, which was valid for performance review in heterogeneous networks. Wu et al. [11] developed a model to study the performance of a one tier network having two types of users. This model is further used to analyze a multitier network with the queue in only one tier. An analytical model for the performance assessment of hierarchical cellular systems, which provides multiple routes for ongoing calls through overflow from one cell layer to another was presented by Yeo, and Jun [12].The model permits the case wherever both the decision time and the cell duration are usually distributed. Based on the characterization of the call time by a hyper- Erlang distribution, the laplace transform of channel Occupancy time distribution for every call type (new call, handoff call, and overflow call) was derived as a function of the laplace transform of cell residence time. The reverse link capacity of a spectrally overlaid macro/microcellular CDMA system supporting numerous styles of traffic was investigated by Kang, et al. [13] regarding the equivalent total throughput achievable in the system. Marsan et al. [14] presented a new technique to analyse the performance of mobile communication networks with hierarchical cellular architecture. Such technique allows considering general distributions for both call durations and dwell times; the call duration distribution is then approximated by a two-phase hyper-exponential distribution with the same first and second moments of the original general distribution, so as to limit the complexity in the description of the residual call duration after handovers. An analytical model and a performance analysis methods were developed by Tang and Li [15], for a two-layer HCN overflow and take-back strategies in bidirectional.

The remaining paper is organized as follows, The system model of the proposed CAC is described with the help of diagram in Section 2. we describe the proposed CAC with the help of algorithm and flowchart of the system presented in section 3. The performance metrics like utilization of cells, blocking probability and dropping probability are calculated in section 4 with the help of analytical model of the system. Section 5 consists of numerical calculation and discussion on results obtained. In Section 6, we conclude this paper with some discussion about the future work.

2. 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* macro cells and each macrocell overlays *n* microcells. Fig. shows the encountered model layers. It is considered that every C_m microcells are overlaid by a macrocell, and every C_M macro cells 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.

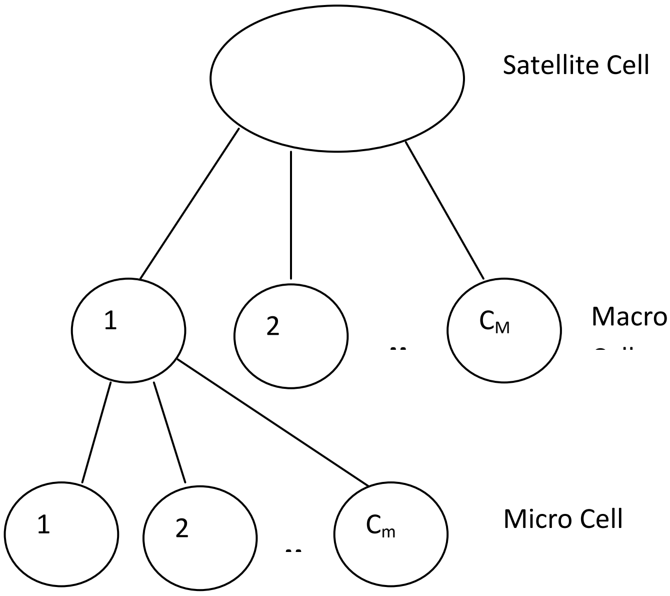

Figure 1.1 Hierarchical multilayer architecture.

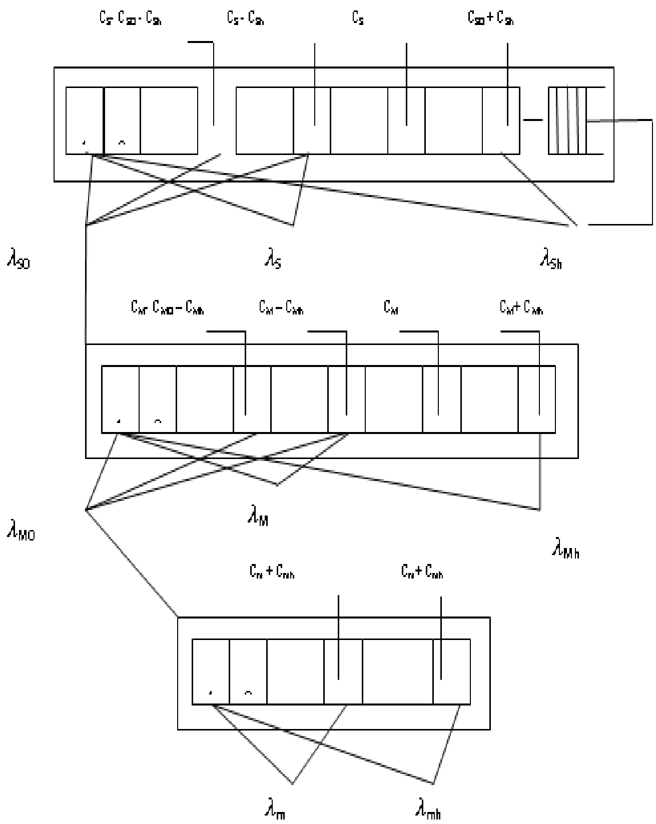

Figure 1.2 System Model for the Proposed CAC2.

3.CALL ADMISSION CONTROL SCHEME

Call Admission Control Scheme Here we present call admission control scheme emphasizes on giving priority to voice traffic mainly to handoff voice calls as these calls are more sensitive to access delay than data calls. We consider a multilayer 3G wireless mobile network with C channels, where, Cm 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 proposed call admission control scheme follows the following procedure to admit various types of calls in the system.

1) Three categories of users are existing in the system. These are terrestrial-only users with access to terrestrial sub network, satellite-only users with access to the space segment only and dual-mode users with access to both terrestrial and space segments.

2) A call attempt in terrestrial network is directed first to the lowest layer, i.e., the microcell. The call is served if the number of channels in use is less than C_m - C_{mh}, or overflowed to the umbrella macrocell and gets service there if the number of channels in use is less than C_M - C_{Mo} - C_{Mh}. Otherwise, the call is directed to the overlaid highest layer (satellite cell) and served there if the number of channels in use in the satellite cell is less than C_s - C_{so} - C_{sh}.

3) Handoff requests are privileged with more reserved channels. A handoff request is served in the microcell if the number of channels in use is less than C_m and in the macrocell if the numbers of channels in use are less than C_M - C_{Mh}, and in satellite cell if the numbers of channels in use are less than C_s - C_{sh}. A similar approach is adopted for new and handoff calls initiated firstly in macrocells. we also applied channel sub-rating scheme in addition with reserved channel scheme. For those calls first initiated in the satellite cell we, furthermore, implement a queuing priority scheme in this layer. The next subsection presents the algorithm and flowchart of the proposed call admission control scheme

ALGORITHM AND FLOW CHART OF PROPOSED CALL ADMISSION CONTROL

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

```
if (INCALL = New_Voice_Call)
{
if (number of free channels in microcell >= Cm)
        {
        admit INCALL;
        if (INCALL = Handoff_Voice_Call)
        {
If (number of free channels in microcell >= Cm)
        {
        admit INCALL;
        }
        }
Else (number of free channels in macrocell >= CM)
        {
        admit INCALL;
if (INCALL = Handoff_Voice_Call)
        {
If (number of free channels in macrocell >= CM)
        {
        admit INCALL;
        }
        }
Else (number of free channels in satellite cell >= CS)
        {
        admit INCALL;
if (INCALL = Handoff_Voice_Call)
        {
If (number of free channels in satellite cell >= CS)
        {
        admit INCALL;
        }
        }
Else
        {
        wait INCALL for the Time Tq;
if (number of free channel in satellite cell >=CS and <=Tq)
        {
         admit INCALL;
        }
        }
Else
        {
        drop INCALL;
        }
        }
Else
    {
        drop INCALL;

    }
    }
```

4. 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 only voice data. Both data and voice shares the channels of a micro cell where call arrival rate λ is simply ruled by Poisson's distribution. If any data arrives beyond the capacity of a microcell then it will be blocked but the overflowed voice call will be supported by overlaid macrocell. Satellite cell will only support the handover part further. Channels of macro and satellite cells resemble the guard channel of handover call, hence probability of forced termination/handover failure will be reduced to minimum. State transition diagram for three layer cell structure of is shown in Fig. 1.3. Here overlaid cell carries overflow traffic from underlain cell. At the same time take-back alleviates overloading of any upper layer cell in order to reduce blocking probability. As channels of macro and satellite cells are shared among several micro cells, the probability of getting free channel of macro and satellite cells will be gradually decreased, 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.

Here:

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

$U_{(micro\ cell)}$ =

$$\frac{\sum_{i=0}^{C_m}\frac{(\rho)^i}{i!}}{\sum_{i=0}^{C_m}\frac{(\rho)^i}{i!}+\frac{(\rho)^{C_m}}{C_m!}\sum_{j=1}^{C_M}\frac{(\rho)^j}{\prod_{s=1}^{j}(C_m+s)}+\frac{(\rho)^{C_m+C_M}}{C_m!\prod_{i=0}^{C_M}(C_m+i)}\sum_{t=1}^{C_S}\frac{(\rho)^t}{\prod_{z=1}^{t}(C_m+C_M+z)}} \quad \text{........ (1)}$$

(ii) Probability of utilization of macro cell channel is defined as

$U_{(macro\ cell)}$=

$$\frac{\frac{(\rho)^{C_m}}{C_m!}\sum_{j=1}^{C_M}\frac{(\rho)^j}{\prod_{s=1}^{j}(C_m+s)}}{\sum_{i=0}^{C_m}\frac{(\rho)^i}{i!}+\frac{(\rho)^{C_m}}{C_m!}\sum_{j=1}^{C_M}\frac{(\rho)^j}{\prod_{s=1}^{j}(C_m+s)}+\frac{(\rho)^{C_m+C_M}}{C_m!\prod_{i=0}^{C_M}(C_m+i)}\sum_{t=1}^{C_S}\frac{(\rho)^t}{\prod_{z=1}^{t}(C_m+C_M+z)}} \quad \text{........ (2)}$$

(iii) Probability of utilization of satellite cell channel is defined as

$U_{(satellite\ cell)}$ =

$$\frac{\frac{(\rho)^{C_m+C_M}}{C_m!\prod_{i=0}^{C_M}(C_m+i)}\sum_{t=1}^{C_S}\frac{(\rho)^t}{\prod_{z=1}^{t}(C_m+C_M+z)}}{\sum_{i=0}^{C_m}\frac{(\rho)^i}{i!}+\frac{(\rho)^{C_m}}{C_m!}\sum_{j=1}^{C_M}\frac{(\rho)^j}{\prod_{s=1}^{j}(C_m+s)}+\frac{(\rho)^{C_m+C_M}}{C_m!\prod_{i=0}^{C_M}(C_m+i)}\sum_{t=1}^{C_S}\frac{(\rho)^t}{\prod_{z=1}^{t}(C_m+C_M+z)}} \quad \text{........ (3)}$$

(iv) Blocking probability of data call is defined as

$P_{data\ call}$ (C_m C_M C_s)=

$$\frac{\sum_{i=C_m}^{C_m}\frac{(\rho)_t^i}{i!}}{\sum_{i=0}^{C_m}\frac{(\rho)_t^i}{i!}+\frac{(\rho)_t^{C_m}}{C_m!}\sum_{s=1}^{C_M}\frac{\lambda_v^s\prod_{j=0}^{s}\alpha_j}{\prod_{j=1}^{s}(C_m\mu_t+j\mu_v)}+\frac{\lambda_v^{C_M}\prod_{j=0}^{C_M}\alpha_j}{\prod_{j=1}^{C_M}(C_m\mu_t+j\mu_v)}+\frac{(\rho)_t^{C_m}}{C_m!}\sum_{r=1}^{C_s}\frac{\lambda_h^r\prod_{j=0}^{r}\beta_j}{\prod_{j=1}^{r}(C_m\mu_t+C_M\mu_{t+}i\mu_{vh})}} \quad \text{........ (4)}$$

(v) Blocking probability of new voice call is defined as

$P_{voice\ call}\,(C_m\ C_M\ C_s)$=

$$\frac{\frac{(\rho)_t^{C_m}}{C_m}\sum_{s=C_M}^{C_M}\frac{\lambda_v^s\prod_{j=1}^{s}\alpha_j}{\prod_{j=1}^{s}(C_m\mu_t+j\mu_v)}}{\sum_{i=0}^{C_m}\frac{(\rho)_t^i}{i!}+\frac{(\rho)_t^{C_m}}{C_m!}\sum_{s=1}^{C_M}\frac{\lambda_v^s\prod_{j=0}^{s}\alpha_j}{\prod_{j=1}^{s}(C_m\mu_t+j\mu_v)}+\frac{\lambda_v^{C_M}\prod_{j=0}^{C_M}\alpha_j}{\prod_{j=1}^{C_M}(C_m\mu_t+j\mu_v)}+\frac{(\rho)_t^{C_m}}{C_m!}\sum_{r=1}^{C_s}\frac{\lambda_h^r\prod_{j=0}^{r}\beta_j}{\prod_{j=1}^{r}(C_m\mu_t+C_M\mu_{t+}i\mu_{vh})}} \quad \text{........ (5)}$$

(vi) Probability of handover failure of voice call is defined as

$P_{handoff\ failure}$ (C_m C_M C_s) =

$$\frac{\frac{\lambda_v^{C_M}\prod_{j=0}^{C_M}\alpha_j}{\prod_{j=1}^{C_M}(C_m\mu_t+j\mu_v)}+\frac{(\rho)_t^{C_m}}{C_m!}\sum_{r=1}^{C_s}\frac{\lambda_h^r\prod_{j=0}^{r}\beta_j}{\prod_{j=1}^{r}(C_m\mu_t+C_M\mu_{t+}i\mu_{vh})}}{\sum_{i=0}^{C_m}\frac{(\rho)_t^i}{i!}+\frac{(\rho)_t^{C_m}}{C_m!}\sum_{s=1}^{C_M}\frac{\lambda_v^s\prod_{j=0}^{s}\alpha_j}{\prod_{j=1}^{s}(C_m\mu_t+j\mu_v)}+\frac{\lambda_v^{C_M}\prod_{j=0}^{C_M}\alpha_j}{\prod_{j=1}^{C_M}(C_m\mu_t+j\mu_v)}+\frac{(\rho)_t^{C_m}}{C_m!}\sum_{r=1}^{C_s}\frac{\lambda_h^r\prod_{j=0}^{r}\beta_j}{\prod_{j=1}^{r}(C_m\mu_t+C_M\mu_{t+}i\mu_{vh})}} \quad \text{........ (6)}$$

5. NUMERICAL RESULTS AND DISCUSSION

Here, we demonstrate the performance of proposed call admission control scheme by 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. Graphs in figure 1.4 to 1.6 represents 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 graphs shows that probability of the utilization of microcell ($U_{micro\ cell}$) increases while the probabilities of the utilization of macrocell ($U_{macro\ cell}$) and satellite cell ($U_{Satellite\ cell}$) decreases with increase in the number of channels of microcells C_m and when the number of channels of macrocell C_M and satellite cell C_S remains fixed (figure 1.4).The probability of the utilization of macrocell ($U_{macro\ cell}$) increases while the probabilities of the utilization of satellite cell ($U_{Satellite\ cell}$) decreases and that of microcell ($U_{micro\ cell}$) remains approximately constant with number of channels of macrocells ($C_{macro\ cell}$) increases and when the number of channels of microcell (C_m) and satellite cell (C_S) remains fixed (figure1.5). The probability of the utilization of satellite cell U_S increases while the probabilities of the utilization of microcell ($U_{micro\ cell}$) and macrocell ($U_{macro\ cell}$) remains approximately constant with number of channels of macrocells (C_M) increases and when the number of channels of microcell (C_m) and satellite cell (C_S) remains fixed (figure-1.6).Graphs in figures to shows the data call blocking probabilities ($P_{data\ call}$), new voice call blocking probabilities ($P_{voice\ call}$) and handoff voice call dropping probabilities plotted against the variable number of channels of microcell, macrocell and satellite cell respectively. 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_t = 20 calls/min, λ_v= 12 calls/min and λ_h= 2.4 calls/min and the call duration time are assumed to be μ_t= 0.25 min, μ_v= 0.33 min and μ_{vh}= 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. According to the proposed call admission control scheme, at the microcell layer only data calls are blocked, hence as the number of channels of microcell increases, the data call blocking probability decreases sufficiently as more channels are available for providing service to incoming data calls. Furthermore, the blocking probability of the new voice calls and dropping probability of the handoff voice call are also decreases with the increase in microcell channels (figure-1.7). The macrocell layer is accessed only by new voice call and handoff voice calls and only new voice calls are blocked at this layer, therefore, with the increasing number of macrocell channels there is a significant decrease in the probability of blocking new voice call. Further the probability of dropping handoff voice calls is also decreases (figure 1.8). 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 1.9), while the probabilities of blocking data calls and new voice calls remains approximately constant.

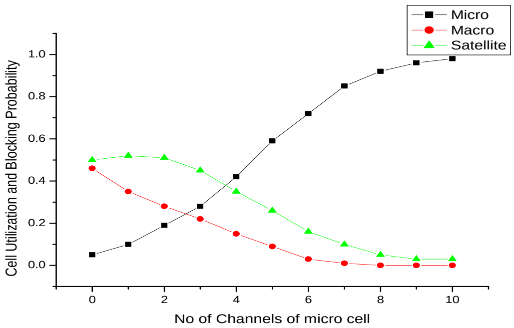

Figure 1.4 Cell Utilization Probabilities with the increase in no. of channels of microcell

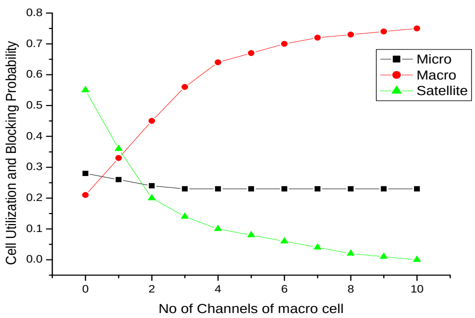

Figure 1.5 Cell Utilization Probabilities with the increase in no. of channels of macrocell

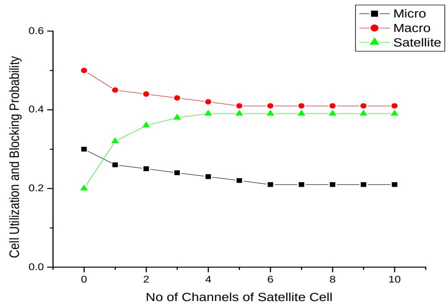

Figure 1.6 Cell Utilization Probabilities with the increase in no. of channels of Satellite Cell

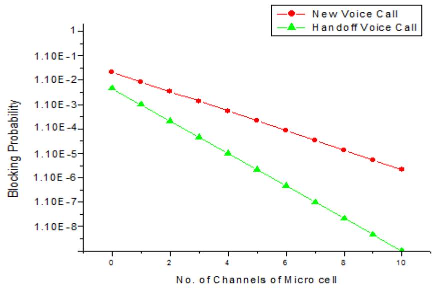

Figure 1.7 New Voice Call Blocking Probabilities and Handoff Voice Call Dropping Probabilities with the increase in no. of channels of microcell

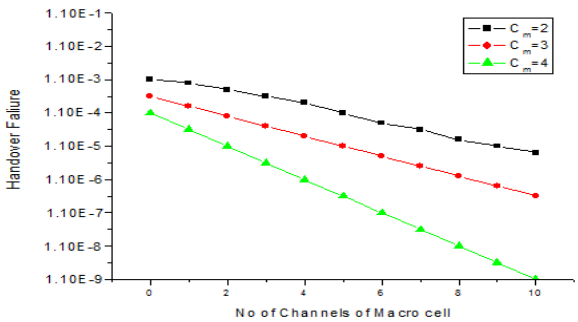

Figure 1.8 Macro cell channels on handover failure.

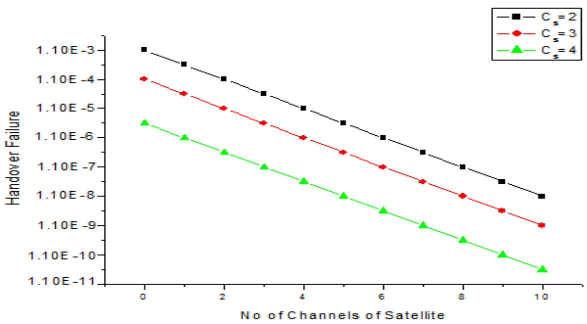

Figure 1.9 Satellite cell channels on handover failure.

6. CONCLUSIONS

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. In this model, handoff voice calls gets maximum opportunity of using trunk of overlaid cells to minimize the probability of handoff dropping. The performance of CAC scheme is analyzed by computing various performance metrics viz. cell utilization of all the layers, blocking probability of data or new voice calls and dropping probabilities of handoff voice calls. From the results obtained from the analysis, we observe that the proposed CAC scheme provide a better QoS for different traffic types, however, the approximately similar results was obtained by Islam et al. [16]. Hence, the proper selection of number of channels at different layers and threshold values at microcell and macrocell layers may optimize the performance of the system and obtain good Quality of Service (QoS) for different types of traffics.

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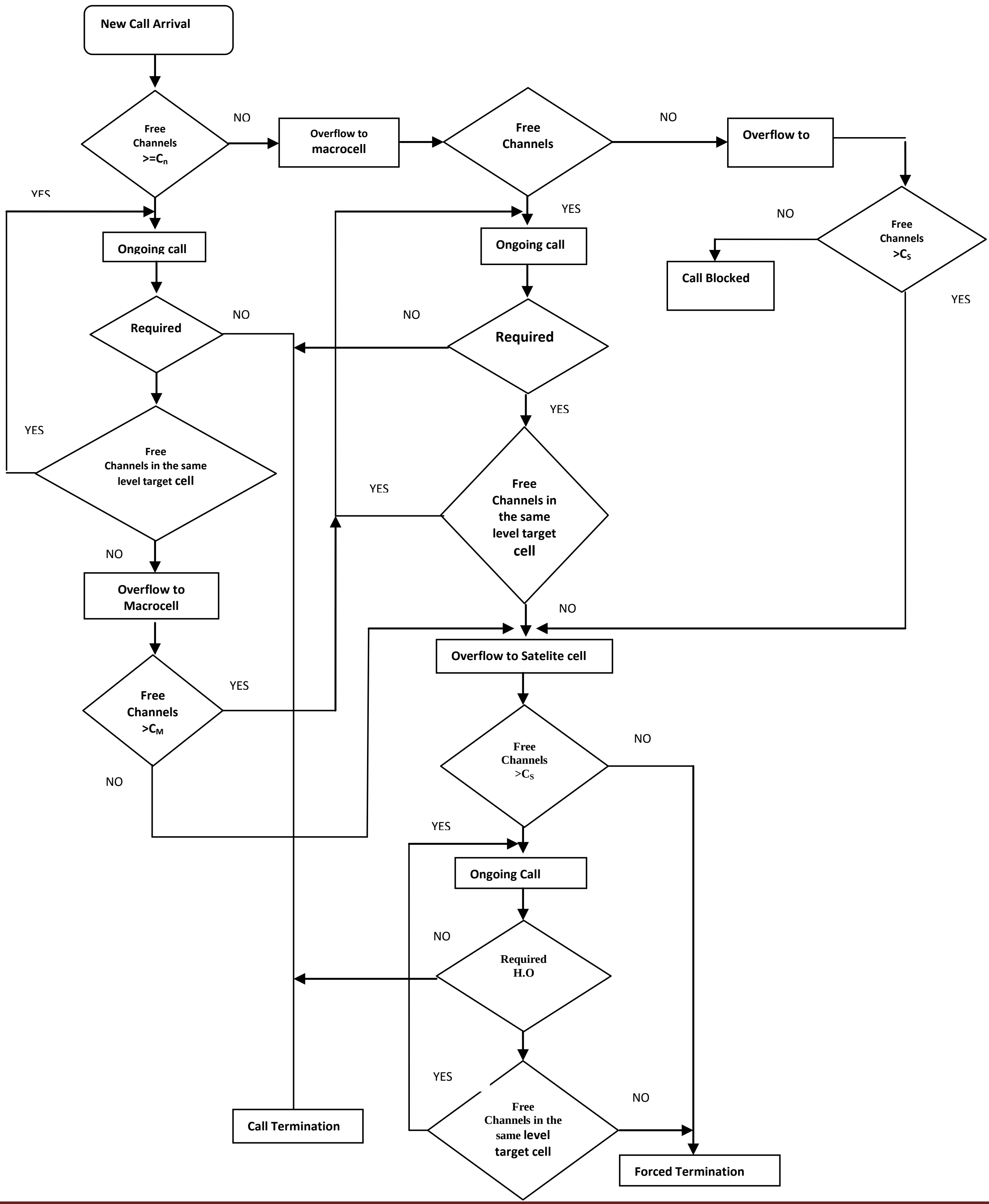
THE FLOW CHART:



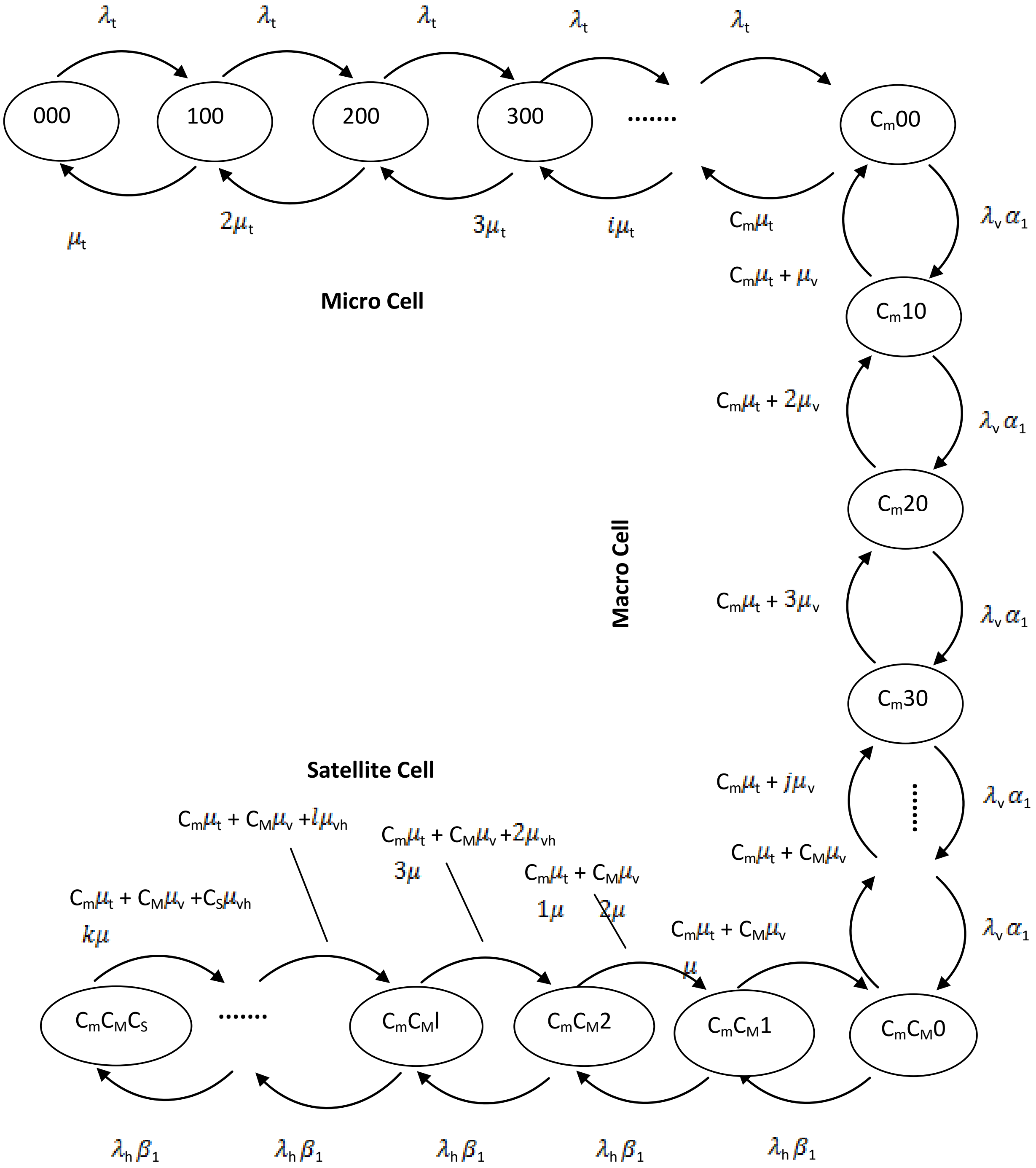


Figure 1.3 State Transition diagram of the call admission control scheme