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Two Layer Call Admission Control Analysis in Microcellular Wireless Networks

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Abstract: - Microcellular solutions in wireless networks increase the network traffic control as a result of frequent handover behavior. This paper proposes a two layer wireless call admission control to optimize the forced termination probability of frequent handovers.

Key-Words: -Wireless Networks, Handover, Call Admission Control Analysis

1 Introduction

Several handover algorithms in microcellular wireless networks have been proposed in international literature, aiming to guarantee transmission quality. In [4] a model for frequent handovers in microcellular networks is proposed. In this model, a mobile connection call setup procedure creates a *virtual connection tree* and covers a large geographical region. Moreover a Base Station (BS) group is adopted to ensure that a mobile subscriber can move rapidly between radio cells. All messages terminated to a mobile subscriber are multicasted to all the BSs of the group. However this approach consumes a large volume of network bandwidth to ensure that messages are not lost. In this paper, in order to prevent handover dropping, a fixed channel assignment [2], [3] in combination with a wireless call admission control scheme is proposed.

The network architecture, under consideration, is composed by large geographical areas created by a number of BS's and controlled by an BS controller [2]. A group of BS's creates a radio location area and we further assume that a mobile handset (MH) is served by a Base Station of this group. The surrounding cells are called adjacents [2]. During call setup a path from the BS controller to the serving BS is set up with a dedicated path and six more distinct paths, each one for the adjacent BS's, have been reserved for handover purposes. These six pre-established paths and the active path form a Virtual Connection Tree, (VCT), and the geographical area covered by these six adjacent BS's is the Virtual Connection Area, (VCA). During connection only the dedicated path is active and the reserved paths of VCT are used only for future handovers

2 Hierarchical Call Admission Control

Handover blocking probability and forced termination probability are two important QoS parameters for evaluating the performance of wireless networks [3]. Based on VCT a two layer wireless call admission control scheme is examined. The model of call admission control is an M/M/m queue with an arrival λ of new calls and h of handover calls (Poisson processes), exponential call duration of mean value $1/\mu$ and each BS has C radio channels available. A new call may be blocked first by the tree-based call admission control (when the total number of new and handover calls in the tree exceeds a predetermined threshold of N calls, then new calls are rejected and only handover calls are admitted) or later by the cell-based admission control (when the available channels in the serving cell are less than a predefined ratio of all channels, then new calls are rejected and only handover calls are admitted). We assume the probabilities of a new call blocked by the tree-based admission control as P_t and blocked by the cell-based admission control as P_c

3 Tree-Based Call Admission Control

We assume a homogeneous traffic over the VCA. Since a tree consists of seven cells (serving and six adjacents), the tree new call arrival rate is 7λ. The rate of handover calls is obtained by calculating the product of the 18 edges of the VCA [1] with the rate of h/6 handover calls per edge from each cell, that is

$$\lambda_{th} = 18h/6(1-P_{hb}) = 3h(1-P_{hb}) \quad (1)$$

where P_{hb} denotes the handover blocking probability to be calculated later. If the total number of calls in a tree exceeds the threshold N, then the admission control will deny new calls and allow only handover calls. The arrival rate λ_k of the queue model is

$$\lambda_k = \begin{cases} 7\lambda+\lambda_{th}, & 0 \le k < N \\ \lambda_{th}, & N \le k < 7C \end{cases}, \text{ k=1,2,3,…..7C} \quad (2)$$

A call in the tree is released with rate

$$\mu_k = k\mu_t = k\left(\mu + hP_{hb} + \frac{h}{7}(1-P_{hb})\right), \text{ k=1,2,3,…..7C} \quad (3)$$

In Figure 1 the state transition diagram of Markov process for new calls in a tree is presented.

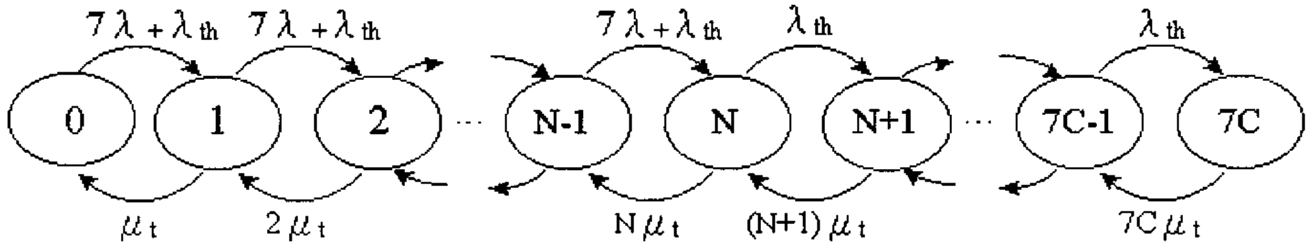

Figure 1: *State transition diagram for tree-based call admission control*

The probability P_i that calls have occupied the i state is

$$P_i = \begin{cases} P_0 \dfrac{(7\lambda+\lambda_{th})^i}{\mu_t^i \cdot i!}, & i \le N \\ P_0 \dfrac{(7\lambda+\lambda_{th})^N \cdot \lambda_{th}^{i-N}}{\mu_t^i \cdot i!}, & i > N \end{cases} \quad (4)$$

Where

$$P_0 = \left[\sum_{i=0}^{N} \frac{(7\lambda+\lambda_{th})^i}{\mu_t^i \cdot i!} + \sum_{i=N+1}^{7C} \frac{(7\lambda+\lambda_{th})^N \lambda_{th}^{i-N}}{\mu_t^i \cdot i!}\right]^{-1} \quad (5)$$

Finally

$$P_t = \sum_{i=N}^{7C} P_i \quad (6)$$

4 Cell-Based Wireless Call Admission Control

A fixed channel assignment scheme is proposed where a BS reserves a fraction γ of total C channels as guard channels for handover calls. If the total number k of new calls in a cell exceeds $m = (1-\gamma)\cdot C$ then BS will accept only handover calls. New calls, after the tree admission control acceptance, have an arrival rate of

$$\lambda_c = \lambda(1-P_t) \quad (7)$$

and the rate of handover calls into a cell is

$$\lambda_{ch} = h(1-P_{hb}) \quad (8)$$

The call arrival rate of the queue model is

$$\lambda_k = \begin{cases} \lambda_c+\lambda_{ch}, & 0 \le k < m \\ \lambda_{ch}, & m \le k < C \end{cases}, \text{ k=1,2,3…..C} \quad (9)$$

The release rate in queue model is given by

$$\mu_k = k \cdot (\mu + h), \text{ k=1,2,3,…..C} \quad (10)$$

Similar to figure 1, Q_i is the probability of occupied radio channels up to state i in the cell calculated as:

$$Q_i = \begin{cases} Q_0 \dfrac{(\lambda_c+\lambda_{ch})^i}{(\mu+h)^i \cdot i!}, & i \le m \\ Q_0 \dfrac{(\lambda_c+\lambda_{ch})^m \cdot \lambda_{ch}^{i-m}}{(\mu+h)^i \cdot i!}, & i > m \end{cases} \quad (11)$$

Where

$$Q_0 = \left[\sum_{i=0}^{m} \frac{(\lambda_c+\lambda_{ch})^i}{(\mu+h)^i \cdot i!} + \sum_{i=m+1}^{C} \frac{(\lambda_c+\lambda_{ch})^m \cdot \lambda_{ch}^{i-m}}{(\mu+h)^i \cdot i!} \right]^{-1} \quad (12)$$

Therefore, the new call blocking probability of cell admission control is

$$P_c = \sum_{i=m}^{C} Q_i \quad (13)$$

and the handover blocking probability in the cell is

$$P_{hb} = Q_i \big|_{i=C} = Q_0 \frac{(\lambda_c+\lambda_{ch})^m \cdot \lambda_{ch}^{C-m}}{(\mu+h)^C \cdot C!} \quad (14)$$

where the value of P_{hb} can be calculated by assigning an initial value to P_{hb} and using iterating method with equations (8), (12) and (14) until P_{hb} converges. Finally the forced termination probability is calculated to be:

$$P_{ft} = \frac{h \cdot P_{hb}}{\mu + h \cdot P_{hb}} \quad (15)$$

5. Simulation Results

We consider a homogeneous system with call duration 1/μ of 10 time units and dwelling time 1/h equal to 2 time units. For each BS the radio channels number is C = 10. In Figure 2 the hand over blocking probability versus cell traffic load is compared for two layer admission control and single layer admission control. It is obvious that as cell traffic load increases handover blocking probability increases. However the handover blocking probability can be reduced, optimizing the network performance, if the tree call admission control rejects more calls (P_t increases). Figure 3 shows the forced termination probability P_{ft} of a cell versus cell traffic load. P_{ft} increases as cell traffic load increases thus degrading the offered service. In order to keep quality of service requirements the forced termination probability should be kept below a certain threshold. As P_t increases P_{ft} is reduced, hence a feed back algorithm could be realised in the controller to guarantee quality of service requirements.

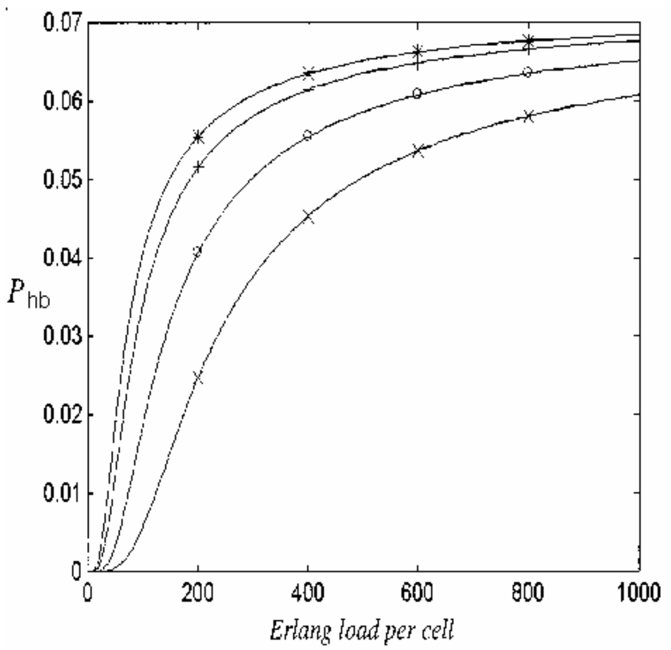

Figure 2: *Handover blocking probability versus cell traffic load*

*: non tree call admission control (P_t = 0)

+: tree call admission control (P_t = 0.2)

o: tree call admission control (P_t = 0.4)

x: tree call admission control (P_t = 0.6)

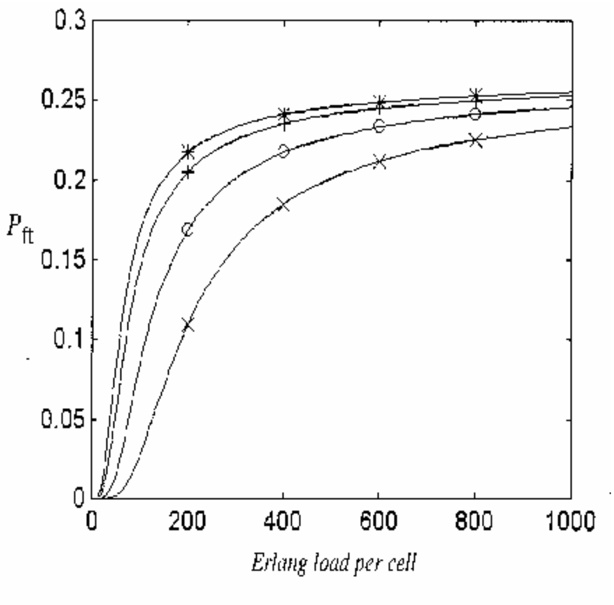

Figure 3: *forced termination probability versus cell traffic load*

*: non tree call admission control ($P_t = 0$)

+: tree call admission control ($P_t = 0.2$)

o: tree call admission control ($P_t = 0.4$)

x: tree call admission control ($P_t = 0.6$)

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