Priority Based Hard Handoff Management Scheme for Minimizing Congestion Control in Single Traffic Wireless Mobile Networks

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Abstract

Handoffs in a mobile cellular communications environment have become an increasingly important issue accommodating an increasingly large demand for services with simultaneous reduced cell sizes. In this paper, a new Prioritized Hard Handoff (PH2) ordering scheme is proposed which can be used to provide rapid handovers with a smaller percentage of dropped calls than other methods. The performance metrics namely Call Blocking Rate and Call Dropping Rate are in addition analyzed by simulating this proposed model to focus the nature of mobility of the users. An overlook on the comparison study between nonpriority scheme and this model makes the model more fruitful to the mobile users.

Keywords: Base Station, Mobile Caller, Mobile Station, Hard Handoff, BMC, CBR.

1. Introduction

At the present time, request and demand for mobile communication facilities are greater than ever exponentially. With ever-increasing number of subscribers, on the other hand, quality of connectivity, and bandwidth limitations have become a major dilemma towards imparting efficient services. Because, in today's wireless networks different users (mobile caller) may need different bandwidth requirements with heterogeneous quality of service (QoS) requirements. And in parallel these are competing for the network bandwidth. Network designers are in continuous proposing suitable channel allocation schemes [3,5,6,11,12] for appropriate distribution of resources and effective scheduling policies for handling users' call so that network congestion can be avoided successfully [1]. Again, Handoffs [7] in a mobile cellular communications environment also become progressively more important issue as cell sizes shrink to accommodate an increasingly large demand for services [13].The paper

introduces a new prioritized model PH2 for Hard Handoff [7] providing rapid handovers with a smaller percentage of dropped calls. We organize this paper in the following manner. Next session conveys some preliminary ideas about previous works subsequently presenting our suggested model. Afterward, experimental results followed by an overlook on comparison study have been covered.

2. Related Work

Mobile Networks have gained an impulsion in the past few years in rapacious dimensions. Due to massive use of mobile phones, maintenance of both congestion control and Quality of Service (QoS) could not be ascertained at the same time. The concept of dynamic pricing has evolved to make an advancement of this general policy. A novel dynamic pricing scheme PTG model [3] and its extension PQSHI model [2][1] for mobile networks has been already proposed. The cellular structures for both the models including our suggested model PH2 is shown in Fig. 1 [1].
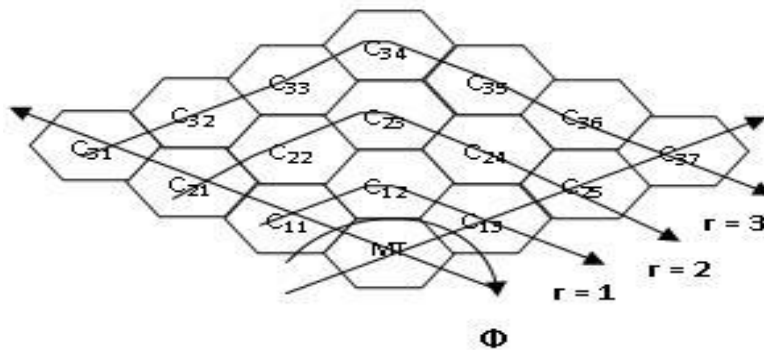

Fig. 1: Cellular structure for r = 3

In PQSHI model with the introduction of handoff management scheme two major functionalities were performed.

2.1 Call Scheduling

The incoming calls w.r.t BS are scheduled with the generation of a unique priority queue. This queue [1] has been further implemented by employing heap [8] structure. The call requests are realized with priority number to reduce the time and the scheduling has served as the basic platform to analyze the handoff behavior of incoming calls.

2.2 Handoff Implementation

The handoff behavior of various calls has been established as well as formulated on the basis of generated priority queue [1]. Some approaches have been evolved with respect to a caller movement in a cell considering the adjacent cells. These are noted in Table 1 [2] and here, 'Y' denotes Yes and 'N' denotes No.

Table 1: Generated Handoff Approaches

Approach	Movement direction with respect to MT		Position of Adjacent Level		Position of Cells Column	
	Towards	Away from	Upper	Lower	Same column	Not in Same column
I	N	Y	Y	N	Y	N
	Y	N	N	Y	Y	N
II	N	Y	Y	N	Y	N
	Y	N	N	Y	N	Y
III	N	Y	Y	N	N	Y
	Y	N	N	Y	Y	N
IV	N	Y	Y	N	N	Y
	Y	N	N	Y	N	Y

This handoff behaviour has been established using Xie and Kuek's Traffic single traffic model [7] with the movements of the Mobile Station (MS) or Mobile Caller (MC) towards or away from Mobile Terminal (MT) also known as Base Station (BS) as shown in Fig. 2 [1].
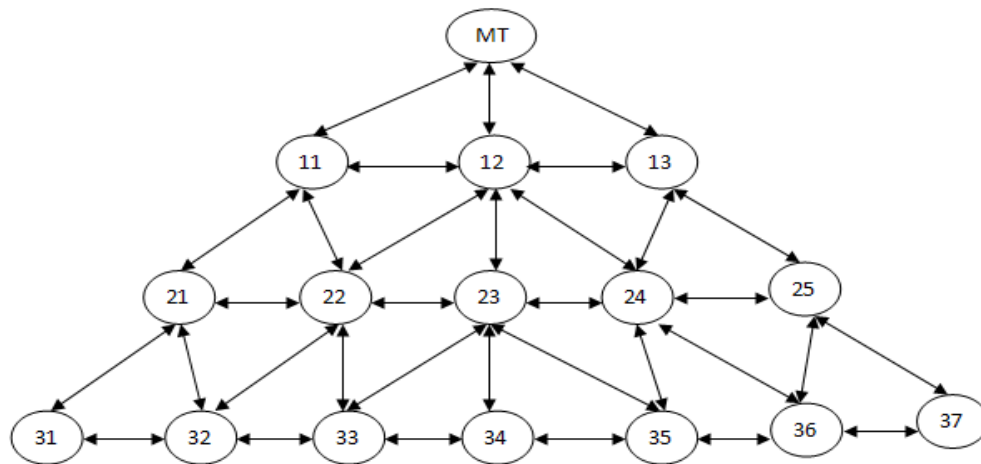

Fig. 2: Movements of the Mobile Stations

3.   PH2 MODEL

Every cell in cellular network architecture is served by a BS. BSs are connected together by using a wireless network. Users are moving in the coverage area and when moving from a cell to another cell, handoff occurs [9]. In this section, we describe several existing traffic terminology and the proposed PH2 model with the essence of mathematical interpretation.

3.1 Selection of Traffic Model

In cellular system, establishment of a traffic model is more imperative before analyzing the performance of the system. Several traffic models [7] have been established on basis of making different assumptions about user mobility. For our purpose *Xie and Kuek's Traffic Model* [7][1][2] has been chosen as implementation model for single traffic.

3.2 Basic Traffic Parameters

We also assume that our system has many cells, with each having S channels. The channel holding time in terms of departure rate or service time has an exponential distribution with mean rate μ. Generated originating and handoff calls in a cell both are according to Poisson processes [10], with mean rates λ_O and λ_H respectively. Cells in the proposed model are assumed to be homogeneous. We focus our attention on a single cell with single user in it.

3.3. Priority Traffic Scheme [7][14]

Newly generated calls in a cell are labeled as originating calls (new calls). A handoff request is generated in the cell when a MS approaches the cell from a neighboring cell with significant signal strength. Priority is set to handoff requests by assigning S_R channels exclusively for handoff calls out of S channels in a cell. Both originating calls and handoff requests share the remaining S_C (= $S - S_R$) channels. Obviously, an originating call is blocked when in a cell available channels number is $\leq S_R$. A handoff request is failed if no channel is available in the target cell. The system model is shown in Fig. 3.

We define the state i ($i = 0, 1, \cdots, S$) of a cell as the number of calls in progress for the BS of that cell. Let $P(i)$ represent the steady-state probability that the BS is in state i. The probabilities $P(i)$ can be determined in the usual way for birth–death processes. The pertinent state transition diagram is shown in Fig. 4.
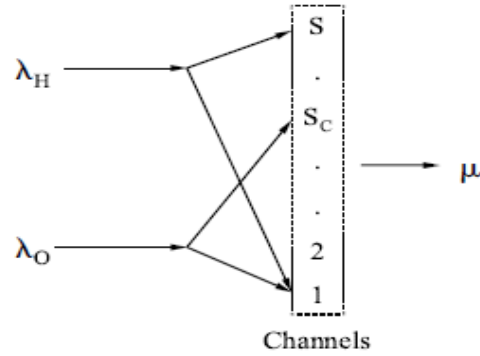
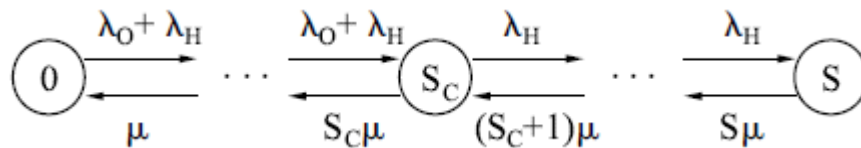Fig. 3: System Model with Priority for Handoff Call.

Fig. 4: State Transition Diagram for Fig. 3

From Fig. 4, the state balance equations are

$$\begin{cases} i\mu P(i) = (\lambda_O + \lambda_H)\, P(i-1) & 0 \le i \le S_C \\ i\mu P(i) = \lambda_H\, P(i-1) & S_C < i \le S \end{cases} \quad\quad \text{.................. (1)}$$

Now,
$$\sum_{i=0}^{S} P(i) = 1 \quad\quad\quad \text{.................. (2)}$$

Thus, the steady-state probability $P(i)$ is easily found as follows:

$$P(i) = \begin{cases} \dfrac{(\lambda_O + \lambda_H)^i}{i!\,\mu^i}\, P(0) & 0 \le i \le S_C \\[3mm] \dfrac{(\lambda_O + \lambda_H)^{S_C} \lambda_H^{i-S_C}}{i!\,\mu^i}\, P(0) & S_C \le i \le S \end{cases} \quad\quad \text{.................. (3)}$$

From Fig. 4, it is observed that, steady state probability that the system is in state '0'.

$$P(0) = \left[\sum_{i=0}^{S_C} \frac{(\lambda_O + \lambda_H)^i}{i!\,\mu^i} + \sum_{i=S_C+1}^{S} \frac{(\lambda_O + \lambda_H)^{S_C} \lambda_H^{i-S_C}}{i!\,\mu^i} \right] \quad\quad \text{.................. (4)}$$

The blocking probability B_O for an originating call is given by

$$B_O = \sum_{i=S_C}^{S} P(i)$$ .... (5)

The blocking probability B_H of a handoff request is

$$B_H = P(S) = \frac{(\lambda_O + \lambda_H)^{S_C} \lambda_H^{S-S_C}}{S! \mu^S} P(0)$$ .... (6)

A blocked handoff request call can still maintain the communication via either the current BS until or the conversation is completed before the received signal strength goes below the receiver threshold.

3.4 Mathematical Interpretation

Several parameters such as arrival rate of handoff calls λ_H, arrival rate of originating calls λ_O, service rate μ, blocked mobile callers, etc are primarily responsible in computing Call Blocking Rate (CBR) as well as blocking probability of the handoff request B_H.

(a) Determination of λ_H

For each cell we are considering the adjacent cells in just upper & lower levels for calculating the arrival rate of handoff calls. Handoff calls for different radius levels r can be determined as:

At radial distance r = 1,
$\lambda_H = [(2+1) + (3+1) + (2+1)] / 3 = 10/3$

At radial distance r = 2,
$\lambda_H = [(2+1) +(2+2) + (3+1) + (2+2)+(2+1)] / 3 = 18/5$

At radial distance r = 3,
$\lambda_H = [(2+1) +(2+2) + (2+2) +(3+1) +(2+2) + (2+2)+(2+1)] / 7 = 26/7$

At radial distance r = 4,
$\lambda_H = [(2+1) +(2+2) + (2+2) +(2+2) +(3+1) +(2+2) +(2+2) + (2+2)+(2+1)] / 9 = 34/9$

Thus, the generalized formula for the arrival rate of handoff calls,

$\lambda_H = (8r + 2) / (2r+1)$ ………….. (7)

(b) Determination of μ

Usually one caller at a time gets serviced while the cell is changing from state from (i) to (i-1). Thus it is preferable to set the service rate μ = 1.

(c) Determination of λ_O

We assume that there is at least one mobile caller resides in every cell at any r. So, the arrival rate of originating calls $\lambda_O = 1$.

(d) Channel Assignment

Both originating and handoff call requests may share the same common channel. Oppositely, handling handoff calls need an exclusive channel. Thus, minimum number of total channels S must be at least 2, one for both request calls and another for handoff calls. Thus, $S_R = S_C = 1$.

(e) Determination of Blocked Mobile Caller

Total Blocked Mobile Caller (BMC) can be determined in general in the proposed model level wise (at every radial distance) as:

$$BMC = \text{Avg. calls in a cell} * B_H * (2r+1) \qquad\qquad \text{……………. (8)}$$

(f) Determination of Total Blocked Caller

Percentage of Total Blocked Caller (TBC) level wise is given by as below.

$$TBC = \frac{\text{Total Blocked Customer}}{\text{Total Customer}} * 100\% \qquad\qquad \text{……………. (9)}$$

(g) Call Blocking Rate (CBR)

In the same fashion Call Blocking Rate (CBR_r) may be defined at a particular radial distance from the underlying BS as:

$$CBR_r = \frac{\text{Number of Cells in Non Column in just Higher Radius Level}}{\text{Number of Total Mobile Callers in that Radius Level}} * 100\% \qquad \text{…….. (10)}$$

(h) Call Dropping Rate (CDR)

In the proposed model PH2, CBR and CDR together result out the maximum performance i.e. 100%. Thus, CDR can be determined at radial distance r from MT by:

$$CDR_r = 100 - CBR_r \% \qquad\qquad \text{………….. (11)}$$

4.   Experimental Results

Our proposed model PH2 is simulated in Matlab version 7.6. The basic traffic factors with numerical values and their corresponding growths are symbolized in this section for the validation of the proposed model.

(a) Blocking Probability of Originating Call (Bo)

Using equation (5), the blocking probability Bo for an originating call can be shown in Table 2 as given below and its growth rate is shown in Fig. 5.

Table 2: Blocking Probability of Originating Call

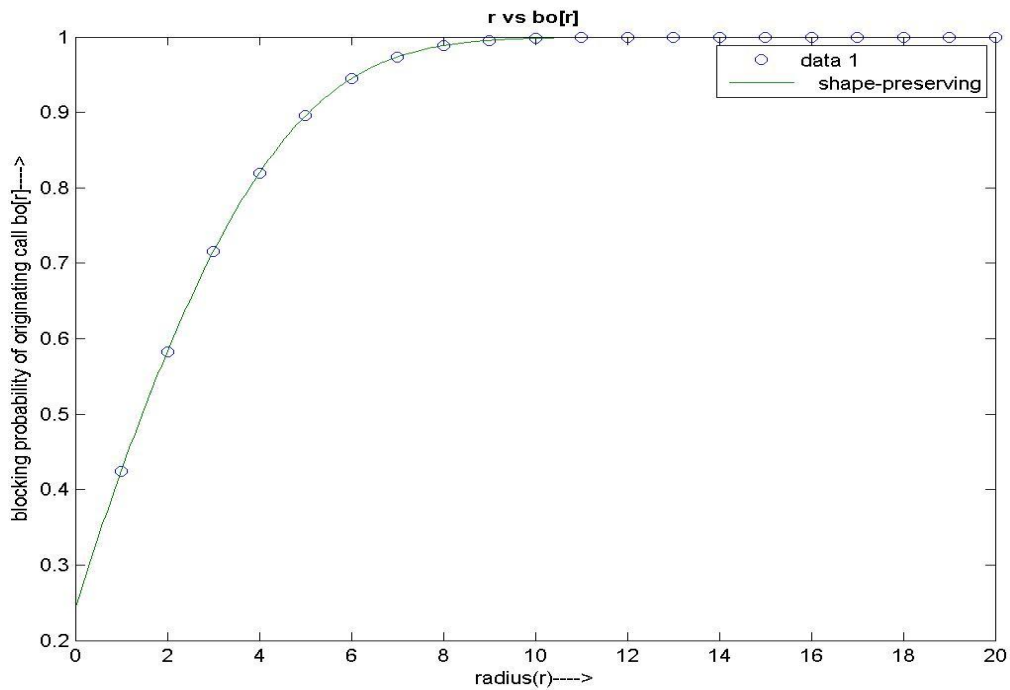| Radius (r)	r = 1	r = 2	r = 3	r = 4	r = 5
B_O	0.42478	0.5828	0.71546	0.81983	0.89529

Fig. 5: Growth Rate of Blocking Probability of Originating Call

(b) Blocking Probability of Handoff Request (B_H)

Using equation (6), the blocking probability for a handoff request call at different radial distances can be publicized in Table 3 as given below. And its growth rate is shown in Fig. 6.

Table 3: Blocking Probability of Handoff Request

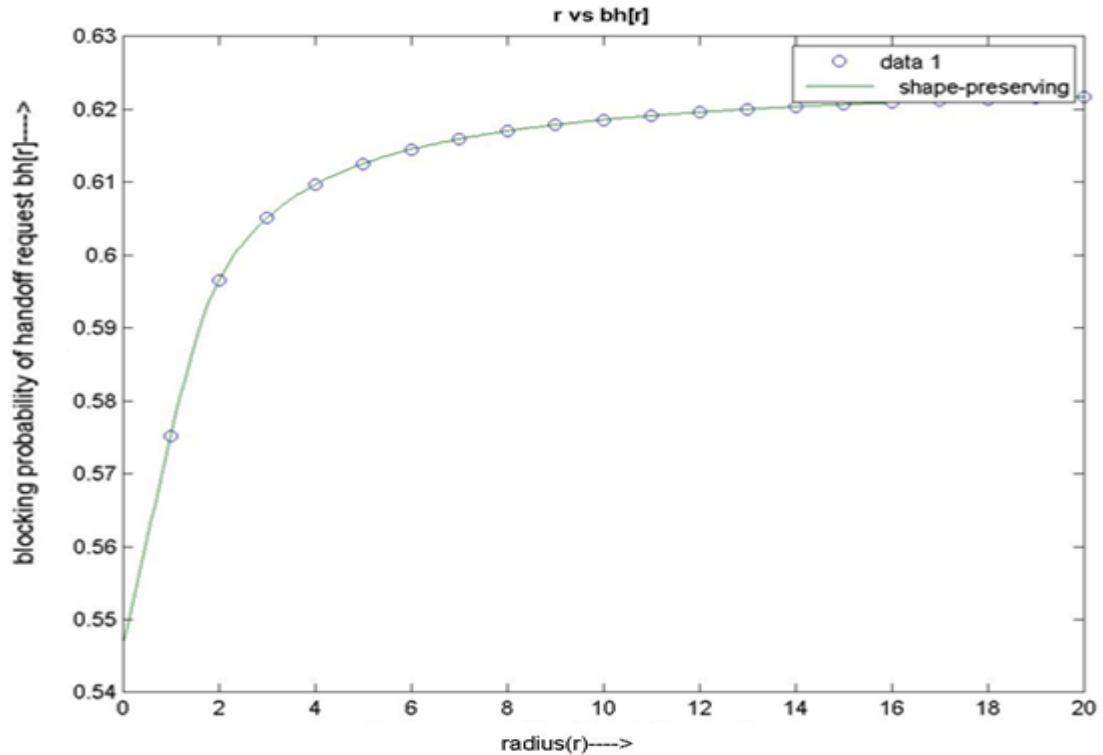| **Radius** (r)	r = 1	r = 2	r = 3	r = 4	r = 5
B_H	0.57522	0.59654	0.60508	0.60967	0.61255

Fig. 6: Growth Rate of Blocking Probability of Handoff Request

5.   Comparison Study

In IPBCS [1] model for non-prioritization scheme new calls and handoff calls are treated the same way .When the BS has an idle channel, it is assigned according to first come first serve basis regardless of whether the call is new or handoff .But, forced termination of an active call is less desirable by the cellular users in contrast to new call blocking. In order to provide lower forced termination probability, prioritization scheme assigns more channels to the handoff calls.

6.   Conclusions

Our model is only a base for handoff-mechanism considering mobility of users. The newness in the model is that we able to improve the performance in terms of performing experimental analysis on the preferred traffic model of priority scheme. Again handoff behavior especially hard handoff behavior is utilized carefully. Though, limited number of allocated channels has been considered for simplicity still the model shows satisfactory results in some extend. Further study on the users' mobility and presence of more callers in each cell with supplementary channels are in progress.

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