Optimization of Handover in Wireless Cellular Networks Utilizing Neyman-Pearson Criterion

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Abstract: The forced termination probability with respect to handoff call is very critical as it's less desirable to subscribers than the blocking probability of new call. This paper proposes analytic and simulation models to optimize the performance of hand-off calls using Neyman-Pearson criterion (NP). It is observed that using the NP criterion gives high priority to hand-off attempts over initial access attempts without degrading the initial access seeks.

Keywords: Nayman-Pearson Criterion, Force Termination, Blocking Probability.

I.   INTRODUCTION

In anticipation of the 5G cellular communication networks, the Pico and Nano cells would be used enormously. This will bring about frequent transfer of calls from one base station (BS) to another. Mobility of subscribers thus becomes a very vital problem to be considered and it has been well researched on both theoretically and practically. Usually, continuous service is achieved by supporting handoff from one cell to another which is often initiated either by crossing a cell boundary, by deterioration in quality of the signal in the current channel and as a means of balancing load [1, 2, 4].The blocking of originating calls and termination of hand-off requests forcefully in view of traffic considerations are the main performance metrics that determine the Quality of Service (QoS). This paper with the assumption that the arrival rate of the Originating Calls (OC) is Poissonian, and the Handoff Calls assumed to be arriving at an exponential distribution rate, seeks to develop a theoretical framework that embraces the competing objectives of both calls whilst optimizing the probability of detection of HC [3]. The FIFO queuing system is primarily considered as the focus of this study.

II.   SYSTEM MODEL

We consider communication system with a non-prioritized scheme where channel is allocated based on the FIFO system. According to [5], with respect to the non-prioritized call handling scheme, we are motivated by the definition in [5] and we say the probability of forced termination equals the probability of call blocking, which is given by the long-familiar Erlang B formula for the M / M / c / c queue .

$$P_c = P_F = \frac{\dfrac{(cp)^c}{c!}}{\displaystyle\sum_{i=1}^{c} \dfrac{(cp)^i}{i!}} \tag{1}$$

$$\rho = \frac{\lambda}{c\mu} \tag{1a}$$

The call holding time is assumed, $1/\mu =1$ minute; hence, the traffic intensity is numerically equal to the sum of the arrival rates of originating calls and handover requests. The FIFO queuing scheme closed together by using an **M / M / c** queue with the arrival rates of OC and HC being Poissonian and exponential respectively. Until all the channels are engaged, the arrival rate is that of the sum of originating calls and handovers, whereas once the number in the system equals the number of channels, only handovers are considered for the next available channel. The blocking probability

of originating calls is simply given by the probability of the number in the system being equal to or more than the number of channels, and thus,

$$P_c = \sum_{n=c}^{\infty} p_n \qquad (2)$$

and when $n \geq c$,

$$P_n = \frac{(\lambda_c + \lambda_H^c)\lambda_H^{n-c}}{c^{n-c}c!\mu^n} p_o \qquad (3)$$ Where, λ_c and λ_H represents the arrival rates of

originating call and handover, call respectively. Substituting $\sum_0^{\infty} p_n = 1$, into equation (3) yields,

$$p_o = \left[\sum_{n=0}^{c-1} \frac{1}{n}\left(\frac{\lambda_c + \lambda_H}{\mu}\right)^n + \frac{1}{n}\left(\frac{\lambda_c + \lambda_H}{\mu}\right)^c \left(\frac{c\mu}{c\mu - \lambda_H}\right) \right]^{-1} \qquad (4)$$

Substituting, P_n and P_o the probability of call blocking for the FIFO scheme P_c, is found to be

$$P_c = \frac{1}{c!}\left(\frac{\lambda_c + \lambda_H}{\mu}\right)^c \frac{c}{c - \lambda_{H/\mu}} \qquad (5)$$ The average queue size is given by

$$Q_x = \sum_{n=c}^{\infty} (n-c) p_n \qquad (6)$$ Substituting the expression p_n into equation (6),

$$Q_x = p_o \left(\frac{\lambda_c + \lambda_H}{\mu}\right)^c \frac{1}{c!} \frac{\rho}{(1-\rho)^2}, \qquad (7)$$

$$\rho = \frac{\lambda_H}{c\mu}$$

from [3], the probability of forced termination

is quoted as,

$$P_F = 1 = \int_0^{\infty} w_q(t) f\tau_d(t) dt \qquad (8)$$

$w_q(t)$ represents the cumulative queue waiting time distribution and τ_d stands for the normally distributed degradation interval.

III. THE FIFO QUEUING SYSTEM

The FIFO queuing scheme primarily allocates channels based on first in first out manner. But, the goal of this paper is to determine a scheme to encumber the probability of detecting the OC and make optimal the detecting probability of HC. Here, we make use of the NP criterion as it the best for such purpose.

A. Employing Neyman-Pearson Criterion

A system of subjecting both the OC and HC to a binary hypothesis is employed. Let, H_o represent the hypothesis that

OC is not present in the scheme and H_1 represent the hypothesis **OC** is present in the scheme; and $P_x|H_k, k = 0,1$

represent the calls arrival rate under all hypotheses.
The fundamental goal of this criterion is to increase Probability of Detection (PD) and decreases the Probability of False Alarm (PFA). Again, prompted by this definition in [3], we employ the NP criterion which suggests choosing

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$\phi(\bullet)$ to maximise Lagrangian objective function. The hypothesis OC is always last or not present is denoted by H_0 and H_1 represents the hypothesis that the HC is always first in the FIFO scheme.

$$\mathbf{Z}_{NP} = PD + \eta.\left(\bar{\alpha} - PFA\right)$$

$$= \int \phi(x)\, px|H_1 dx + \eta\left(\bar{\alpha} - \int \phi(x) px|H_0 dx\right)$$

$$= \eta\,\bar{\alpha} + \int \phi(x)\left(px|H_1 - \eta.px|H_0\right)dx \qquad (9)$$

By inspection, the optimal NP decision rule is seen to be:

$$\phi_{NP}(x,\eta) = \begin{cases} 1 & px|H_1 > \eta.px|H_0 \\ 0, & px|H_1 < \eta.px|H_0 \end{cases} \quad (10)$$

When arrival rate is exponential and $px \mid H_0$ non-zero, then decision rule in (10) can be summarized as the following statistical test compared to threshold η

$$p_{\,x|H_k} = \int p_s.p_{x|s,H_k}\,ds,\, k = 0,1\,;$$

$$t_{LRT(x)} \triangleq \frac{px \mid H_1}{px \mid H_0} \underset{\underset{H_0}{<}}{\overset{\overset{H_1}{>}}{}} \eta \qquad (11)$$

that is known as the Likelihood Ratio Test (LRT)

B.   Bridging Data Models

In non-prioritized call traffic handling schemes, handover requests are treated in the same manner as originating calls. Both the OC and the HC compete for available channels to complete it communication operation, we say the probability of handover failure equals the probability of call blocking.

Following the procedure in [3], we let the prior probabilities for OC being absence and HC being presence be P_0 and P_1 respectively. It follows that

$$p_{x|s} = P_{0.}p_{x|s,H_0} + P_{1.}p_{x|s,H_1} \qquad (12)$$

and consequently,

$$p_x = \int p_s p_{x|s,}\,ds$$

$$= \int p_s\left(P_{0.}p_{x|s,H_0} + P_1.p_{x|s,H_1}\right)ds \qquad (13)$$

also, probability theory informs that

$$p_{\,x|H_k} = \int p_s.p_{x|s,H_k}\,ds,\, k = 0,1 \qquad (14)$$

IV.   NUMERICAL RESULTS

For purposes of validation, we analyzed the performance of the FIFO queuing scheme linked with the NP criterion. The number of the available channel is 70 and the mean holding time is 21.57s. The results are as depicted below.
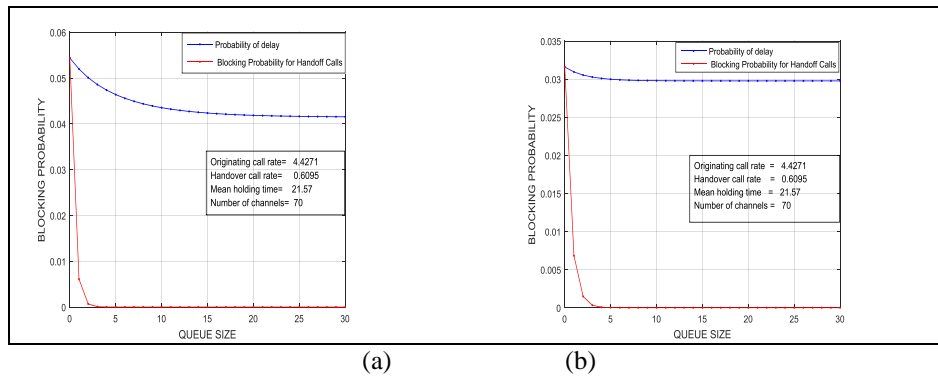
(a)   (b)

FIGURE 1. Probability and blocking probability graphs showing blocking probability for handoff, with N=70, it is observe the NP criterion yields a better blocking probabilities for the HC.
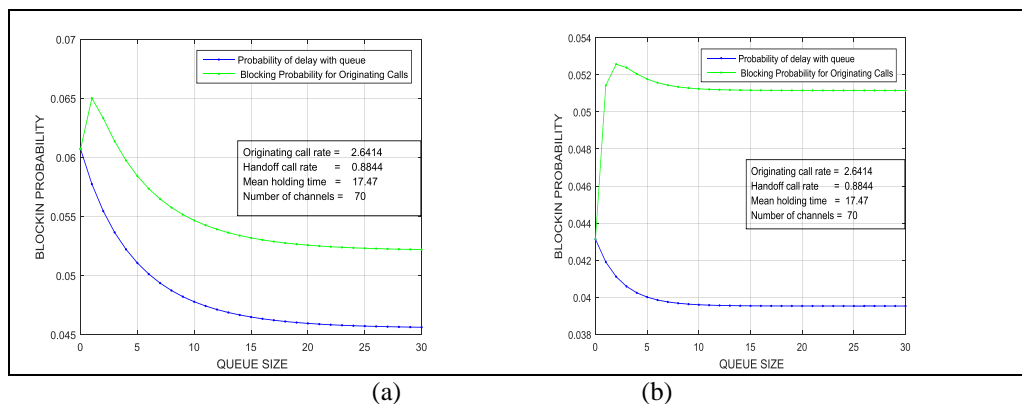

(a)   (b)

FIGURE 2. Probability of delay and blocking probability graphs, exhibiting the performance of OC when the NP criterion is utilized.

V.   CONCLUSION

We analyzed using the NP criterion the blocking rates of OC and HC. The fundamental idea is to increase the selection of OC when the FIFO queuing scheme is used. The results from the simulation make affirm our novelty of employing the NP criterion. The result distinctly indicates the advantage that the proposed system offers in terms of probability of delay and blocking probability.

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