Hand Off Problem Analysis In Personal Communication System Using Splitted-Rating Channel Technique

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Abstract: In this paper, we study the hand-off performance in personal communication system using splitted rating channel technique. As the number of mobile users in cellular systems increases, the user mobility becomes the dominating factor for guaranteeing quality of service. In order to support quality of service for mobile users, The rapid increase in mobile users, handoff become a major issue in mobile network. Handoff is an action of switching a call in progress in order to maintain continuity and the required quality of service of the cell when a mobile user moves from one cell coverage to another cell coverage. Here the arrival of calls in personal communication services network are modeled according to a Markov Arrival Process (MAP). Each cell of the network consists of a finite number of channels and a buffer with finite size of handoff calls. Channel exist in each cell can be used by splitting the original rate if necessary into two channels with different rates when a handoff call arrives and find all the channels busy. We construct three tractable models (1) loss model (2) finite capacity model (3) finite population model with integrated traffic using fixed channel assignment scheme. The purpose of our study is to improve the performance of the cellular mobile system by using directed retry scheme with splitted-rating channel technique & cut-off priority scheme. The balking and reneging behaviors of the calls have also been taken into consideration. The expression for various performance indices viz. blocking probabilities for different traffic, overall blocking probability, offered carried load etc. are determined.

Keywords: Balking, Cut-off priority scheme, Handoff, Integrated Traffic, Markov Arrival Process, Reneging, Splitted-Rating Channel Technique.

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1 Introduction

In present era of telecommunication technology, cellular technology plays a vital role in development of cellular communication services. Cellular technology provides wide range of services like e-mail, teleconferencing, image processing etc. Development of ISDN (Integrated Service Digital Network) play important role in communication services. In personal communication services network four types of calls arrive in general:

- (i) New voice calls
- (ii) New data calls
- (iii) Handoff voice calls
- (iv) Handoff data calls

The new calls are those ones, which are just starting, and handoffs calls are those calls are already ongoing but have moved onto a new cell and need to connect to a new base station. When a new call is originated and attempt in a cell, one of the channels assigned to the base station of the cell if any channel is available for the new call. If all the channels assigned to the base station are in use, the new call attempt is blocked and cleared from the system. When a new call gets a channel, it keeps the channel until it is completed in the cell or the mobile moves out of the cell. When a call is completed in the cell, the channel is released and becomes available to serve another call. When the mobile user crosses a cell boundary and entered into an adjacent cell while the call is in progress, the call requires a new channel in the new base station in order to continue. If no channel is available in the new cell into which the mobile moves, the handoff call is temporarily queued in a buffer with finite size. Here we have given to priority to handoff voice calls, so Splitted rating channels technique is applied only in the case of handoff voice calls. In splitted rating channel technique, among C channels one channel split into two channels of different rates in case a handoff voice call arrives and find all C channels busy. Between these two splitted channels one allocate to already servicing call and second one for new arrive handoff voice call. After splitting all C channels the directed retry scheme is applied to get service. In overlapping area which is developed by adjoining cells, a caller has the ability to contact any of the base stations provided that they have free channel. In case, a call is blocked due to unavailability of channels in target cell, the caller may try in neighboring cells and also retry in target cell after some time to get access if free channel is available. The traffic model and performance measures of cellular radio system have attracted several researchers working in the area of applied probability theory. The first contribution on cellular radio system is due to Cox and Reudnik [1972]. F. M. Neuts [1981] provided Matrix-Geometric solutions in stochastic models. D. Hong and S. S. Rappaport [1986] gave traffic model and performance analysis for cellular mobile radio telephone systems with prioritized and non-prioritized handoff procedures. W. C. Y. Lie [1989] analyzed Mobile Cellular Telecommunications Systems and provide procedure for handoff. Lucantoni et al. [1990] described a single server queue with server vacations and a class of non-renewal arrival processes. Lucantoni [1991] provided new results on the single server queue with a batch Markovian Arrival Process (MAP). This result consists of three key characteristics: 1) the arrival of calls i.e. new and handoff calls in the network are modeled by a continuous MAP. 2) There exist some channels among each cell, which can be used by splitting the original rate into two channels

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with different rates when a handoff call arrives and finds all the channels busy. 3) The queueing of handoff calls. Rappaport [1991] analyzed the multiple call handoff problems in high-capacity cellular communications systems. Here the system is assumed to be homogeneous. M. Mouly and Pautet [1992] provided a GSM (Global System for Mobile) system for mobile communications and also provide protocol for splitted rate channels. Tekinary and Jabbari [1992] proposed a measurement based prioritization scheme for handovers in cellular and micro cellular networks. Yoon and Un [1993] analyzed performance of personal portable radiotelephone systems with and without guard channels. Lin et al. [1994] provided queueing priority channel assignment strategies for PCS handoff and initial access. Massey and Whitt [1994] proposed a stochastic model to capture space and time dynamics in wireless communication system. Ruiz et al. [1998] provided teletraffic analysis and simulation for non-geostationary mobile satellite systems. He and Neuts [1998] proposed Markov chains with marked transitions stochastic process and their applications. Li and Alfa [1999] analyzed a PCS network with correlated arrival process using splitted-ratting channels technique. C.C. Shen, C. Srisathapornphat and C. Jaikaeo[2001] have been developed sensor network. G. Cao [2003] proposed much dynamic channel allocation mechanism. H.Wu and C. Qiao [2005] analyzed the Hand-off performance of the integrated cellular and Ad Hoc laying system. We have developed an analytical tractable model using directed retry scheme with splitted-rating channels technique. In this model, we provide priority to handoff voice calls. Some interesting result can be obtained by using directed retry scheme and splitted-rating channels technique. The balking and reneging behaviors of handoff data packets calls have also studied. To provide protection to handoff calls, guard channels have also been provided. Various system performance measures viz. blocking probabilities for each type of traffic and for overall system, average queue size and carried load have been computed by using iterative procedure. The interpretation of the results and conclusion has been drawn with the help of numerical results and graphs using simulation.

2 The traffic model

In this paper, three queueing models (1) Loss model (2) Finite Capacity Model 3) Finite Population Model dealing with cutoff priority for a cellular radio system with mixed traffic using directed retry scheme with splitted rating channels are developed. The assumptions and notations involved in this model are as follows: The two types of traffic voice and data are served in First In first Out (FIFO) order based on cut-off priority rule. In each cell four types of calls (i) new voice (ii) new data (iii) handoff voice (iv) handoff data arrive in Poisson fashion with mean rates λ_{nv}, λ_{np}, λ_{vh}, and λ_{ph} respectively. There are C channels associated with each cell. In order to protect handoff calls, C_h channels among C are reserved for handoff calls. When a new call is arrived, it can be served successfully if the number of ideal channels is greater than C_h. The call holding time i.e. patience (dwell) time is denoted by μ_d and assumed to be exponentially distributed with mean $1/\mu_d$. The service rate for voice and data packet calls is denoted by μ_v and μ_p respectively. If all channels are busy, the voice calls may balk with probability β. Due to lack of patience a call can be reneged from queue with rate ν. In each cell, voice calls also arrive from its neighbouring cells due to directed retry with rate σ_{nv} and σ_{vh} for new voice calls and for voice handoff callls respectively. It is assumed that random subscriber has a constant probability of hearing one extra transmitter. This probability is influenced by percentage of overlapped area in a cell. Coinsider the cellular structure of four cells with a fraction (f_i) of overlapping area for a cell i and the set of neighbouring cells S_i.

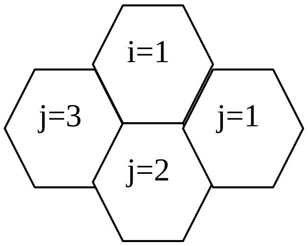
$|S_i|$ = The number of neighbouring cells of a cell i

$$1/\mu = 1/\mu_p + 1/\mu_v$$

$$\lambda = \lambda_h + \lambda_n$$

Where $\lambda_n = \lambda_{np} + \lambda_{nv} + \sigma_{nv}$

And $\lambda_h = \lambda_{ph} + \lambda_{vh} + \sigma_{vh}$



(Cluster of four cell)

Let P_k be the steady state probability that there are k attempts in the system.

We define the following blocking probabilities:

b_{nvi} = Probability that a new voice call is blocked in cell i

b_{np} = Probability that a new packet attempt is blocked

b_{ph} = Probability that a packet handoff is blocked

b_{vhi} = Probability that a voice handoff call is blocked in cell i

B= Over all blocking probability that any type of call blocked

CL = offered carried load

3 The Mathematical Analysis

We are considering three cases to model cellular radio system. The steady state probability for these cases are obtained as follows:

3.1 M\M\C Loss Model

Using birth-death process as shown in figure (1), the steady state probabilities for this model are given by

$$P_k = \begin{cases} \frac{1}{!k}\left(\frac{\lambda}{\mu}\right)^k P_0, 0 \le k \le C - C_h \\ \frac{(\lambda)^{C-C_h}(\lambda_h)^{k-(C-C_h)}}{k!\mu^k} P_0, C - C_h \le k \le C \\ \frac{\lambda^{C-C_h}(\lambda_h)^{C_h}(\lambda_{hv})^{k-C}}{k!\mu^k} P_0, C + 1 \le k \le 2C \end{cases} \quad \dots (1)$$

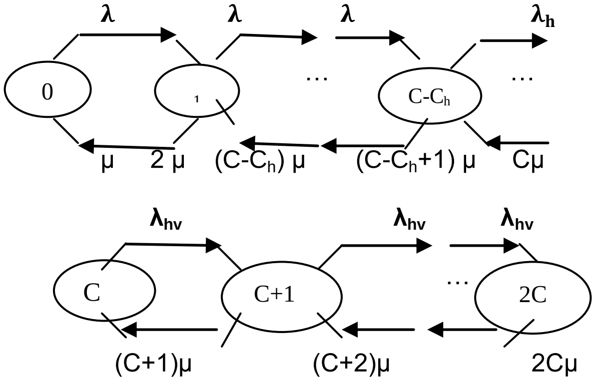
Where P_0 can be obtained by using normalizing condition

$$\sum_{k=0}^{2C} P_k = 1 \quad ..(2)$$

$$b_{np} = b_{nvi} = \sum_{k=C-C_h}^{2C} P_k \quad ...(3)$$

$$b_{ph} = \sum_{k=C}^{2C} P_k \quad ...(4)$$

$$b_{hv} = P_{2C} \quad ...(5)$$



(Figure 1: Transition rate diagram for loss model)

3.2 M\M\C\K Model with Finite Capacity

Using birth-death process as shown in figure (2), the steady state probabilities for this model are given by

$$P_k = \begin{cases} \frac{1}{!k}\left(\frac{\lambda}{\mu}\right)^k P_0, 0 \le k \le C - C_h \\ \frac{(\lambda)^{C-C_h}(\lambda_h)^{k-(C-C_h)}}{k!\mu^k} P_0, C - C_h \le k \le C \\ \frac{\lambda^{C-C_h}(\lambda_h)^{C_h}(\lambda_{hv})^{k-C}}{k!\mu^k} P_0, C + 1 \le k \le 2C \\ \frac{\lambda^{C-C_h}\left((\lambda_h)^{C_h}\lambda_{hv}\right)^{k-C}}{2C!(\mu)^{2C}\prod_{j=1}^{k-2C}[2C\mu+j(\mu_d+\nu)]} P_0, 2C + 1 \le k \le K \end{cases} \quad ...(6)$$

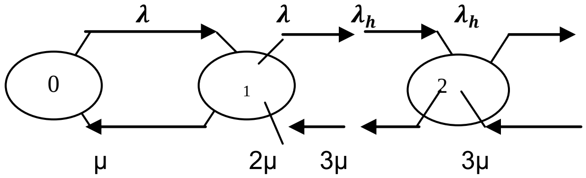
Where P_0 can be obtained by using normalizing condition

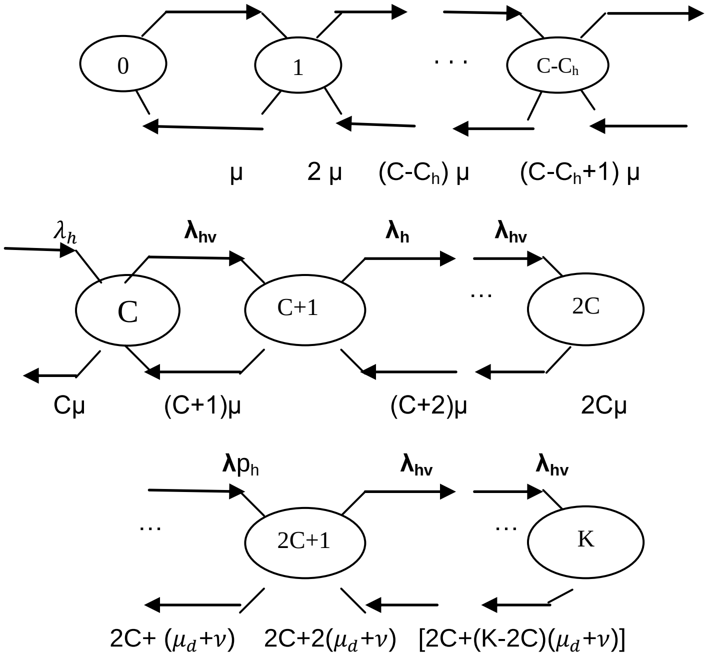
$$\sum_{k=0}^{K} P_k = 1 \quad ..(7)$$

$$b_{np} = b_{nvi} = \sum_{k=C-C_h}^{K} P_k \quad ...(8)$$

$$b_{hvi} = \sum_{k=2C}^{K} P_k \quad ...(9)$$

$$b_{ph} = P_K \quad ...(10)$$





(Figure 2: Transition rate diagram for finite capacity model)

3.3 M\M\C\K\M Finite Population Model

Using birth-death process as shown in figure (3), the steady state probabilities for this model are given by

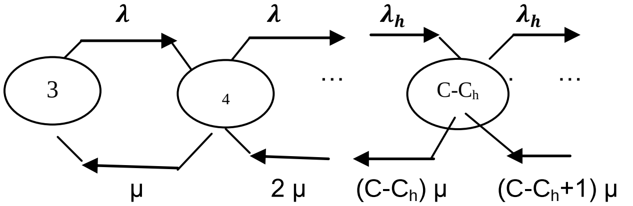
$$P_k = \begin{cases} \left(\frac{!M}{!k!M-k}\right)\left(\frac{\lambda}{\mu}\right)^k P_0, 0 \le k < C - C_h \\ \left(\frac{!M}{!k!M-k}\right)\frac{(\lambda)^{C-C_h}(\lambda_h)^{k-(C-C_h)}}{\mu^k} P_0, C - C_h \le k < C \\ \left(\frac{!M}{!k!M-k}\right)\frac{\lambda^{C-C_h}(\lambda_h)^{C_h}(\lambda_{hv})^{k-C}}{k!\mu^k} P_0, C \le k < 2C \\ \left(\frac{!M}{!M-C!2C}\right)\frac{\lambda^{C-C_h}\left((\lambda_h)^{C_h}\lambda_{hv}\right)^{k-C}}{(\mu)^{2C}\prod_{j=1}^{k-2C}[2C\mu+j(\mu_d+\nu)]} P_0, 2C + 1 \le k \le M \end{cases} \quad ...(11)$$

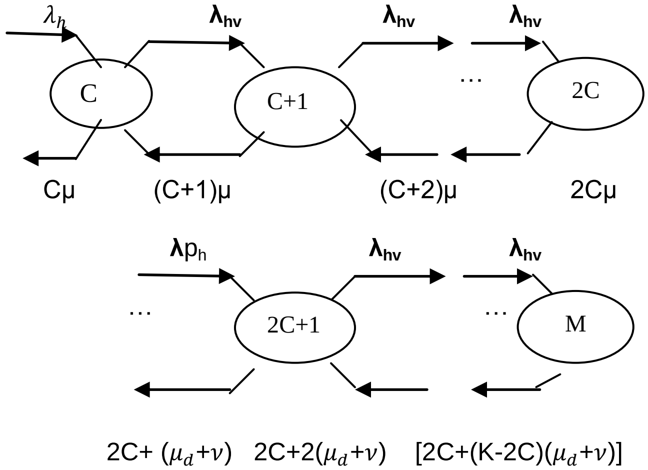
$$\sum_{k=0}^{M} P_k = 1 \quad ..(12)$$

$$b_{np} = b_{nvi} = \sum_{k=C-C_h}^{M} P_k \quad ...(13)$$

$$b_{vhi} = \sum_{k=2C}^{M} P_k \quad ...(14)$$

$$b_{hp} = P_M \quad ...(15)$$





(Figure 3: Transition rate diagram for finite population model)

3.4 Overall blocking probability and carried load

The overall blocking probability in a cell can be obtained by taking into consideration the cell where the call is originated. We consider the cluster of four hexagonally shaped cells to compute the overlap covering area of the central cell i with the adjacent cells j. The analysis is done for individual cell i where the call is assumed to arrive. Let f_i denotes the fraction of total area of cell i which is obtained by overlapping with nearly cells. The overall blocking probability for voice handoff calls is

$$B_{vh}=(1-f_i)b_{vhi} + f_i b_{vhi} \textstyle\sum_j b_{vhj} \qquad \text{. . . (16)}$$

The overall blocking probability for new voice calls is

$$B_{nv}=(1-f_i)b_{nvi} + f_i b_{nvi} \textstyle\sum_j b_{vnj} \qquad \text{. . . (17)}$$

The overall blocking probability that all types of calls are blocked is

$$B = \frac{\lambda_{nv}B_{nv}+\lambda_{np}b_{np}+\lambda_{vh}B_{vh}+ (1-\beta)\lambda_{ph}b_{ph}}{\lambda} \qquad \text{... (18)}$$

The carried load is given by

$$CL = \frac{\lambda_{nv}(1-B_{nv})+\lambda_{np}(1-b_{np})+\lambda_{vh}(1-B_{vh})+(1-\beta)\lambda_{ph}(1-b_{ph})}{\lambda} \qquad \text{...(19)}$$

3.5 Calculation of directed retry traffic

Here we provide a technique to compute arrival rates due to directed retry. The retry is allowed only for handoff voice calls in the case when these cannot get a free channel in the cell to which it is going to enter. Since overlapping area f_i is not too large so that there are little retry. For convenience, we can assume that blocking probabilities in cell i and j are independent to each other. The traffic due to directed retry is as follows:

σ_{nvi}= $\sum_j \lambda_{nvi}$Prob.(Cell j is blocked &cell I is not blocked for new voice traffic). Prob.(a new voice call is directed to cell i/cell j is blocked and cell I is not blocked for new voice calls)

$$\sigma_{nvi} = \textstyle\sum_j \lambda_{nvi} b_{nvj}(1-b_{nvi})\frac{f_i}{|S_j|}, \quad j\epsilon S_j \qquad \text{… (20)}$$

Similarly,

$$\sigma_{vhi} = \textstyle\sum_j \lambda_{vhi} b_{vhj}(1-b_{vhi})\frac{f_i}{|S_j|}, \quad j\epsilon S_j \qquad \text{… (21)}$$

Using above results, we compute blocking probabilities including arrival rates due to directed retry. We provide an iterative procedure to compute performance characteristics as follows:

Step 1: $\sigma_{nvi} \longleftarrow 0$, $\sigma_{vhi} \longleftarrow 0$, $\delta \longleftarrow 1$

Step 2: If | δ|< є(say .00001), go to step 5, otherwise go to step 3.

Step 3: Compute B_{nv} and B_{vh}.

Step 4: Compute new σ_{nvi} and σ_{vhi}. Calculate δ, which is the difference between the old and new σ_{vhi}. Go to step 2.

Step 5: Compute b_{np}, b_{ph}. Also compute B_{vh}, B_{nv}, B and CL.

4 Simulation Analyses

To evaluate handoff performance i.e. call dropping probability under more realistic assumption, we have developed simulation model using c language. In this section, we have studied the effect of different parameters on blocking probabilities. For voice and data packet users, blocking probabilities of originating calls and forced termination probability of handoff voice call are important performance criteria. Blocking have calculated by taking different values of different parameters like population, fixed channels for handoff calls, reneging probability, walking probability, different service rates and different arrival rates etc. As shown in graph1, the blocking probability of new voice calls increases by increasing the mean arrival rate of new voice calls and decreases with as the no. channels increase. Graph 2 displays the blocking probability for handoff voice calls vs. mean arrival rate of new voice calls. It is found that the blocking probability of handoff voice calls increases with the increase of mean arrival rate of new voice calls and decreases by increasing no. channels increase in service faculty. Graph 3 depicts the blocking probability of new voice calls vs. mean arrival rate of new packet calls. It is observed from the graph that the blocking probability of new voice calls increases by increasing the mean arrival rate of new voice calls and decreases with as the no. channels increase. Graph 4 displays the blocking probability of handoff voice calls vs. mean arrival rate of handoff packet calls. The graph shows that the blocking probability of handoff voice calls increases as mean arrival rate of handoff packet calls increases. Graph 5 displays the blocking probability of handoff data packet calls vs. balking probability. The graph shows that the blocking probability increases as the balking probability increases. Graph 6 displays the blocking probability of handoff voice calls vs. mean arrival rate of handoff packet calls. The graph shows that the blocking probability of handoff voice calls increases as the arrival rate of handoff packet calls increases but decreases with increase of number of channels.

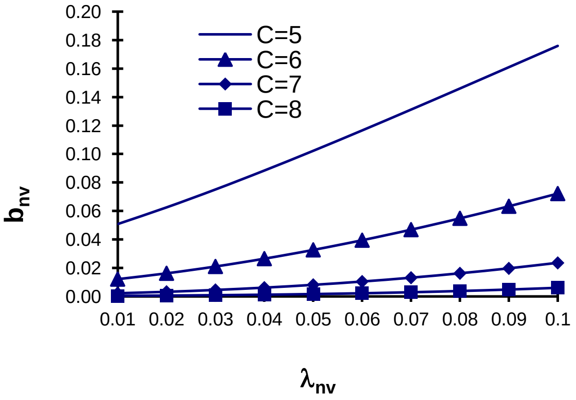


Fig. 1 : Blocking Probability of New voice calls vs. mean arrival rate of new voice calls

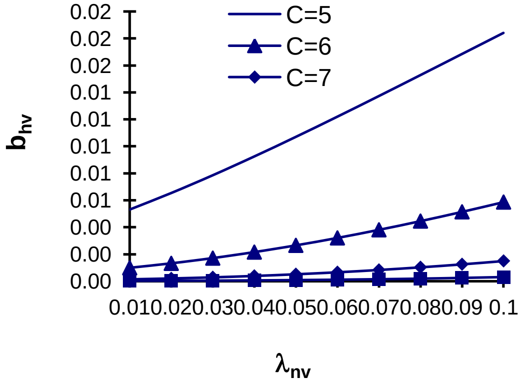


Fig. 2 : Blocking Probability of Handoff voice calls vs. mean arrival rate of new voice calls

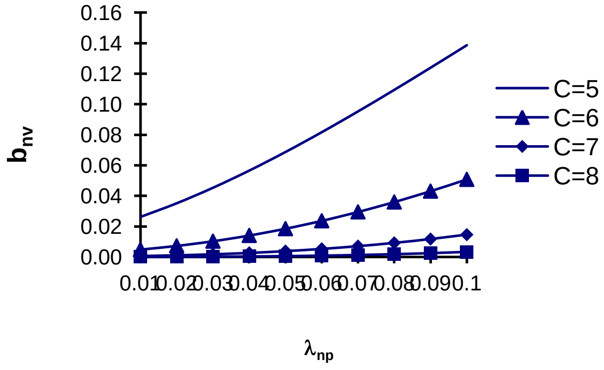


Fig. 3 : Blocking Probability of New voice calls vs. mean arrival rate of new data packet calls

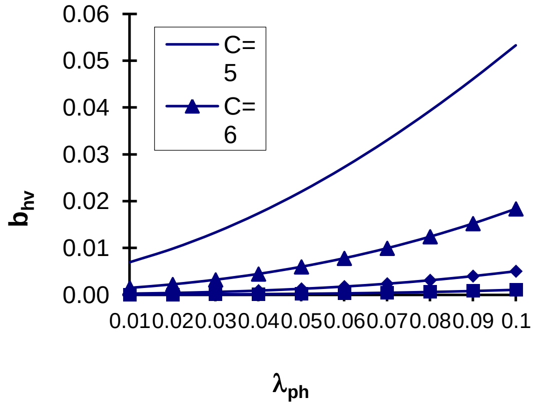


Fig. 4 : Blocking Probability of Handoff voice calls vs. mean arrival rate of handoff data packet calls

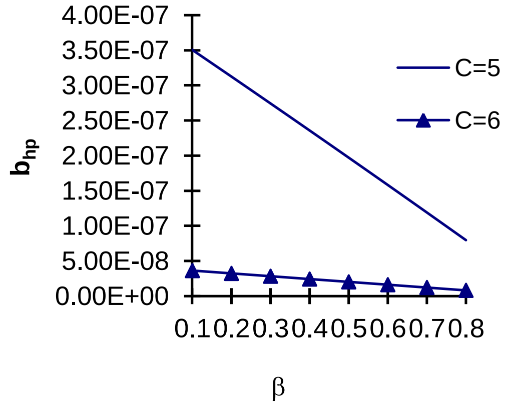


Fig. 5 : Blocking Probability of Handoff data packet calls vs. balking probability

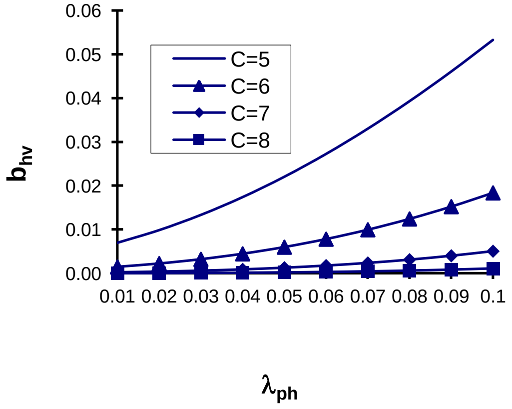


Fig. 6 : Blocking Probability of Handoff voice calls vs. mean arrival rate of handoff data packet calls

5. Conclusion

Mobile customers expect best quality of service from cellular network system. In order to reflect real world cellular network system, the availability and quality of service issues should be considered together to obtain more realistic performance measures. In this paper, wireless cellular system for handoff has been analyzed. Here three mathematical models have been developed with simulation to analyze the problem of handoffs in personal communication services network. Balking and reneging behaviors of queued handoff calls also has been Considered. Here integrated traffic of voice and data has been taken, which is demand of present communication system. Various performance measures have been evaluated. It is observed that from the simulation results that the blocking probability of handoff calls can be reduced by using splitted rating channel and directed retry schemes. Thus proposed schemes can improve the service of handoff calls.

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