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Performance Analysis of Channel Allocation Scheme for A System Model Based On Urban Structure

Suyash Kumar[1*], P.V. Suresh[2]

[1,2]SOCIS, IGNOU, New Delhi, India

[*]*Corresponding Author: suyashgarg@gmail.com*

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Abstract- Frequency channels are scarce resource and available in a limit. Due to this limitation user may experience call termination and call blocking as the traffic increases. We can limit call termination and call blocking by allocating permanent channel to home (apartment) and office user due to very limited movement. They are almost fixed if they communicate with each other frequently and this is the normal scenario in urban areas. By using this strategy these users will not feel any disconnection due to inaccessibility of frequency channel in cell. To achieve this we have proposed a scheme based on fixed channel and analyze the performance for both normal channel allocation and preserved channel allocation for home and office users. We have performed and compared the results of call blocking probability, handover failure probability, call termination due to successful handover probability and probability for not completed calls.

Keywords- Channel allocation, handover, call blocking, call termination

I. Introduction

Unlike wired communications which benefits from isolation provided by cables, wireless users within close proximity can cause considerable interference to one another [1,2,3]. Hence to overcome such factors, the concept of cellular wireless mobile network was introduced where each cell is allocated a portion of the total frequency spectrum [4,5,6,7]. For efficient utilization of the radio spectrum, frequency reuse schemes that are consistent with the objectives of increasing capacity and minimizing interferences are required. Frequency reuse is a technique of reusing frequencies and channels within a communication system to improve capacity and efficiency [8, 9, 10, 11, 12].

In this paper we propose a scheme based on fixed channel and analyze the performance for both normal channel allocation and preserved channel allocation for home and office users to which a part of channels are allocated permanently.

II. Model

We consider that we allocate a channel to user from set of channel $("s")$ if that channel is not in use. For total channels $("s+1")$, total numbers of states are $("s+1")$ as per the Markov process, when the handover call and new call being treated same. The rate of arrival is same throughout the $("s+1")$ states for our model [13.14]. The graphical representation is as follows:

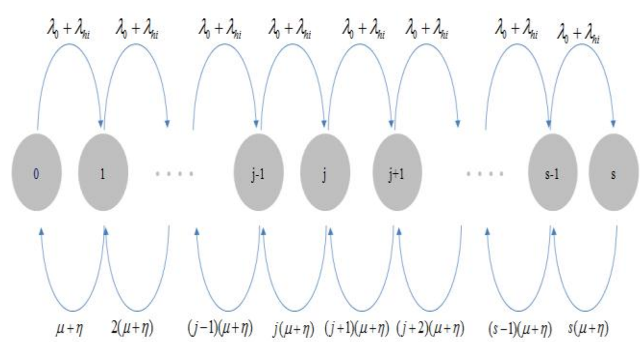

Fig 1(a): State diagram

From the above figure, the probability P_j of the states for $0 \le j < s$ in terms of the probability of zero state P_0 is given by:

$$P_j = \frac{\left(\frac{\lambda_0+\lambda_{hi}}{\mu+\eta}\right)^j}{j!} P_0 \qquad \text{------Eq (1)}$$

Where λ_0 is arrival rate of originating call,

λ_{hi} is arrival rate of handoff call,

$\mu+\eta$ is call service rate,

μ = rate of service for a job until its completion with handover $\eta =$ rate of service for a job until its completion within the cell without handover.

Since the summation of all probabilities is one so:

$\sum_{j=0}^{s} P_j = 1$, which upon substituting in eq.(1) gives

$$P_0 = \frac{1}{\sum_{k=0}^{s} \frac{\left(\frac{\lambda_0 + \lambda_{hi}}{\mu + \eta}\right)^k}{k!}} \quad \text{-------Eq (2)}$$

And hence, P_j is obtained as:

$$P_j = \frac{\frac{\left(\frac{\lambda_0 + \lambda_{hi}}{\mu + \eta}\right)^j}{j!}}{\sum_{k=0}^{s} \frac{\left(\frac{\lambda_0 + \lambda_{hi}}{\mu + \eta}\right)^k}{k!}} \quad \text{-------Eq (3)}$$

With the above expression we obtained blocking probability by substituting $j = s$ (same arrival rate):

$$P_b = P_s = \frac{\frac{\left(\frac{\lambda_0 + \lambda_{hi}}{\mu + \eta}\right)^s}{s!}}{\sum_{k=0}^{s} \frac{\left(\frac{\lambda_0 + \lambda_{hi}}{\mu + \eta}\right)^k}{k!}} \quad \text{-------Eq (4)}$$

The above section explains the basic modeling used in mobile communication system. In this paper, we propose a model in which we preserve some channels for purpose of handover, some channels for the special users (who works in offices building for a long time so that they are almost fixed) and remaining channels can be used for any newly generated calls.

As per required with our model, we keep handover calls on priority. We assume that we have preserved ch channels for handover and k channels are for the special users out of total s channels. So numbers of channel available in the cell for remaining jobs are as follows:

$$n = [s - (ch + k)] \quad \text{----Eq (5)}$$

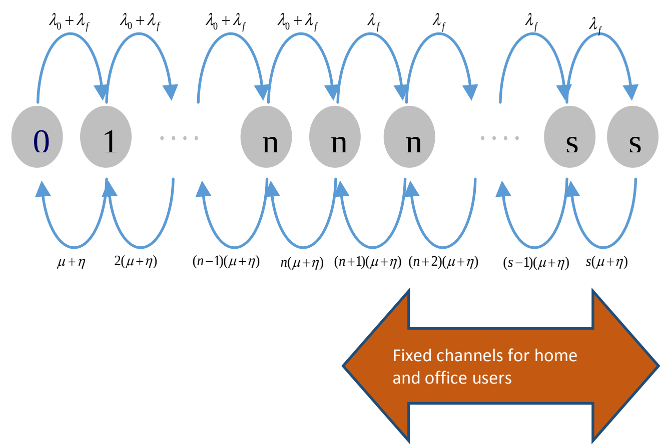

Fig. 1(b) State diagram for preserved channel for handover

By adding rate of handover arrival λ_{hi}, rate of arrival of new job λ_o and rate of arrival for special job λ_f, we obtain rate of arrival for n channels in the cell i.e.

$$\lambda = \lambda_o + \lambda_{hi} + \lambda_f$$

As in previous case, again number of states is defined by Markov Process and it gives number of states s+1.

The priority assignment to handover is shown in figure below. The advantage of doing this is that if all assigned channels (n) are busy then arrival of a handover job in the cell will be taken care by preserved channels ch for handover purpose and the call will not be dropped.

The state diagram clearly shows that both rate of arrival for preserved channels for handover and special channels move till the last state s and both are independent of each other. Total probability P_0 can be calculated by summing up three probabilities for $0 \le j < n$, for $n \le j < k$ and for $n \le j < k$. These are given by:

$$P_j = \frac{\left(\frac{\lambda_o + \lambda_{hi} + \lambda_f}{\mu + \eta}\right)^j}{j!} P_o \quad \text{for } 0 \le j < n \quad \text{--Eq (6)}$$

$$P_j = \frac{(\lambda_{hi})^{j-n} (\lambda_o + \lambda_{hi} + \lambda_f)^n}{j! (\mu + \eta)^j} P_o \quad \text{for } n \le j < s \quad \text{---Eq(7)}$$

$$P_j = \frac{(\lambda_f)^{j-n} (\lambda_o + \lambda_{hi} + \lambda_f)^n}{j! (\mu + \eta)^j} P_o \quad \text{for } n \le j < s \quad \text{---Eq (8)}$$

We have permanent channels in the cell if n is according to Eq (5). So by using Eq (2), P_0 is calculated by summing up all the probabilities from equations (6), (7) and (8).

$$P_o = \frac{1}{\sum_{j=0}^{n}\left(\frac{\left(\frac{\lambda_o+\lambda_{hi}+\lambda_f}{\mu+\eta}\right)^j}{j!}\right)+\sum_{j=n+1}^{s}\left(\frac{(\lambda_{hi})^{j-n}(\lambda_o+\lambda_{hi}+\lambda_f)^n}{j!(\mu+\eta)^j}\right)+\sum_{j=n+1}^{s}\left(\frac{(\lambda_f)^{j-n}(\lambda_o+\lambda_{hi}+\lambda_f)^n}{j!(\mu+\eta)^j}\right)}$$

-----Eq (9)

The above expression is clearly modified with taking into consideration of fixed channels [3].

The blocking probability P_b will be sum of all the probabilities from n to s (s is total number of channels).

$P_b = \sum_{j=n}^{s} P_j$ where n is given by equation (5) and depends upon the occurrence of fixed channels in the cell. The above equations incorporate the preserved channel allocation as well as handover in the model. This is to be noted that in preserved channel allocation n depends on values of both permanent channels (k) and special channels for handover (ch) channels.

In the next section(s) we present the numerical simulation results obtained. The model equations have been used to simulate certain practical situations as presented below.

III. Simulations and model parameters

In this section we explain various parameters required to perform the simulations based on above theoretical analysis of the model proposed. The corresponding results have been shown in section 4.

All the arrival intensities (mobile jobs, handover jobs and fixed jobs) depend on offered traffic load ρ by the cell. If there is no fixed channels in the cell then fixed job arrival intensity will be neglected. The value of ρ is taken equal to the total number of channels available in the cell for simulations. Clearly, handover arrival intensity depends on the mobile job arrival intensity because handover will occur due to mobile jobs. The dependence of λ_0 (mobile job arrival intensity) on traffic load ρ is given by:

$$\lambda_o = \rho\mu \qquad \text{----Eq (10)}$$

The mean service time $\bar{x}$ and is given by:

$$\bar{x} = 1/\,service \quad rate \qquad \text{----Eq (11)}$$

As shown in section 2, the two service rates are used, one for the jobs that complete within the parameter of the cell (η) and second for the jobs in service, that leave the parameter of the cell (μ). So we have two mean service times in the cell $\bar{x}_1 = 1/\eta$; $\bar{x}_1 = 1/\mu$

We have kept mean service time for both service intensities same to keep the traffic conditions uniform i.e. $\overline{x_1} = \overline{x_2}$ =180 seconds.

These parameters and values for mean services times are used to produce our simulation results for the four probabilities i.e. blocking probability P_b, handover failure probability P_h, forced termination probability P_{ft} and Probability of not completed calls P_{nc}

IV. Results and Discussion

The results as calculated for blocking probability P_b, handover failure probability P_h, forced termination probability P_{ft} and Probability of not completed calls P_{nc} varying as a function of time period is shown in Fig.2a we set up the simulation code for 125 busy channels for both NORMAL ALLOCATION and PSFH (Preserved channel for handover) and for PSFH &PC (Preserved channel for handover and permanent channels)

Permanent channels k=20, Preserved channels for handovers Ch=50 and total channels = 125 for NORMAL ALLOCATION.

Based on parameters available channels for mobile jobs in the cell are: PSFH without permanent channels, using $n = [s - ch]$ gives n=75 channels.

PSFH with permanent channels using $n = [s - (ch + k)]$ gives n=55 channels.

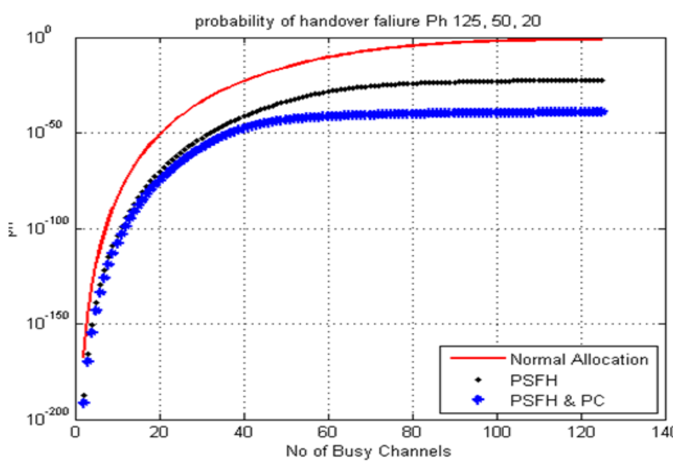

Fig.(2a): Handover probability (y-axis) Vs No. of busy channels.

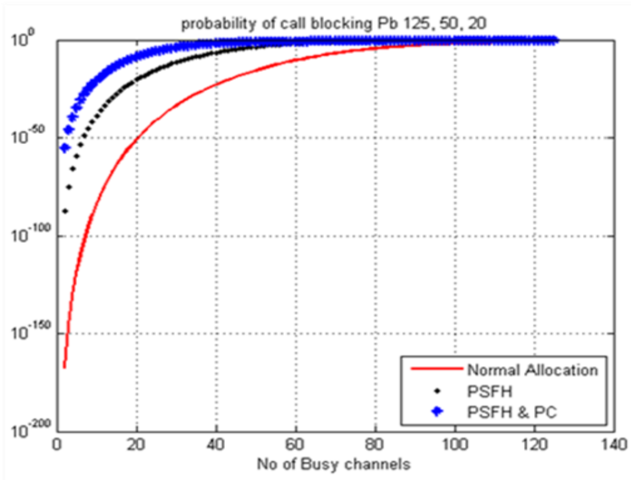

Fig.(2b): Call blocking probability (y-axis) Vs No. of busy channels.

Handover Probability: Fig. (2a) shows that handover failure probability P_h increases with increase in the number of busy channels for both Normal allocation and PSFH. Handover failure rate is higher in normal allocation as compared to other two schemes. This happens because all the channels in the cell are busy in Normal allocation and no channel available to serve a handover arrival job and that job will be terminated in the cell. In PSFH, arrival is taken care of by assigning a channel from set of preserved channel. Also P_h for PSFH & PC is lesser than PSFH. This is because in this case there are lesser number of remaining channels for mobile jobs, which use the handovers channels in the cell. So it implies that number of handovers performed will be less.

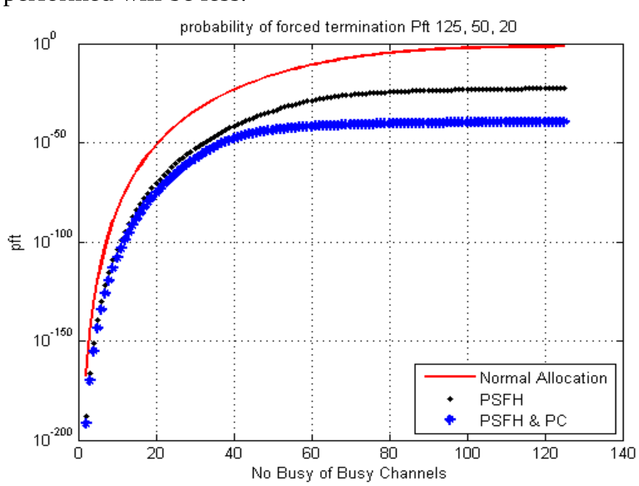

Fig.(2c) Force termination Probability(y-axis) Vs No. of busy channels

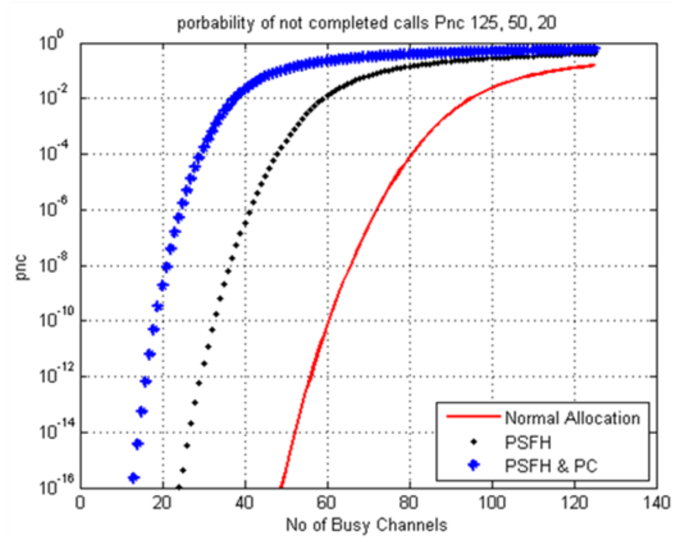

Fig.(2d): Probability of not completed calls (y-axis) Vs No. of busy channels.

Blocking Probability: Fig. (2b) shows that blocking probability P_b increases with increase in the number of busy channels for both N**ormal allocation** and PSFH. However, the order of P_b is: PSFH & PC > PSFH > Normal allocation. This happens because all channels are available for all kind of jobs (mobile, fixed or handover) in Normal allocation.
While in PSFH there are preserved channels for handover jobs, due to this for any new job initiated in the system, the remaining channels are less, hence P_b is higher than in normal allocation. Similarly in PSFH & PC there are permanent as well as preserved channels for handover jobs, so the available channels for a new job are less in comparison of other two schemes, so P_b is higher than the other two in PSFH & PC.

Probability of Forced Termination: Probability of forced termination P_{ft} increases with increase in the number of busy channels for both Normal allocation and PSFH as shown in Fig. (2c).
We see here that results are almost same as that for P_h. This is because P_{ft} depends on P_h due to mobile job arrival intensity. The only difference is that in P_{ft} handover failure occurs when a job moves to neighboring cell successfully and again enters in the cell of origination.

Probability of Not Completed Calls: The probability of all not completed mobile jobs because of blocking and handover failure represents probability of not completed calls. As shown in Fig (2d) P_{nc} increases with increase in the number of busy channels for all the three cases. The PSFH & PC scheme has maximum P_{nc} corresponding to smaller number of busy channels however as the busy channels increase in number the graph shows a competing trend for all the three schemes.

V. Conclusion

The analysis of the results presented in section **4** implies that PSFH & PC is excellent especially where permanent channels are required to be allocated. As permanent channels are allocated to those users for which disconnectivity is intolerable. We also conclude that in the case of handover failure PSFH & PC out performs normal allocation because PSFH has reserved channels for handover purpose which are never allocated to mobile users in the cell.

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Authors Profile

Mr. Suyash Kumar is a research scholar at SOCIS, IGNOU, India. He received a bachelor degree in Computer science and engineering from Gurukul Kangri University Haridwar and master’s degree in Information technology from Guru Gobind singh indraprastha University, India. His area of expertise is in mobile computing. Broadly, he is interested in computer networks and wireless networks.

Dr. P.V. Suresh is an Associate Professor at SOCIS, IGNOU, India. He is also a member in various boards of university. He was the Director of SOCIS for more than 3 years. He received BSc degree from PR Government College, Kakinada, Andhra Pradesh, India and master’s degree in Computer Science from PB Siddhartha College of Arts and Science, Vijayawada, Andhra Pradesh, India. He Completed his Ph.D in Computer Science and Engineering from Acharya Nagarjuna University, Andhra Pradesh, India. His area of expertise in GSM Networks. He is interested in Software Engineering and Wireless Networks.