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Resource Management of Mobile Communication System

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Abstract— *To ensure good traffic handling, channel allocation is one of the important mobile communication resources for quality of service. Usually, three types of channel allocations are widely used: fixed channel allocation, borrowing radio channels from surrounding calls and dynamic channel allocations. In this paper instead conventional channel allocation schemes, we used call admission control (CAC) scheme to combat forced termination (FT). The analytical model of traffic handling in mobile cellular network is implemented by Markov chain; hence the profile of call blocking probability of newly originating call and FT is shown against the call arrival rate and the number of channels. Finally the impact of fading parameters of wireless channel on FT is also analyzed under Rayleigh fading case.*

Keywords*— *Mobile communication resources, Blocking probability, forced termination (FT), call admission control (CAC), Markov chain, reserved channel.

I. INTRODUCTION

For quality of mobile communication services, it is essential to put emphasis on the management of channel allocation, channel bandwidth, channel loss, multipath fading and battery power, etc. Three different types of channel allocation techniques are prevalent: i) fixed channel allocation (FCA); where each cells of a mobile cellular network is provided fixed amount of channels, which is done using graph coloring algorithm, ii) channel borrowing scheme; where channels are borrowed from surrounding cells (adjacent cell) when all the channels of a cell is occupied and iii) dynamic channel allocation (DCA); where the channels are allocated from central pool according to demand vector of users. . All the channel allocation schemes can be applied for both circuit and packet switching network. First and second generation mobile cellular systems were designed mainly for voice services under circuit switch but the 3G integrates circuit and packet switches [1]-[2]. A new traffic model of 'Delay of Voice End- User' (DOVE) using one dimensional Markovian chain is proposed in [3] where the call blocking probability is reduced. In this case, the last user is delayed for few seconds so that few occupied users have the chance of releasing the channels within this duration. This resource allocation (channel or bandwidth) of mobile cellular network is done by call admission control scheme found in [4-6]. The main objective of such schemes is to reduce call blocking probability and forced termination (FT). In a mobile cellular network an initiation of call will be successful if both the idle channel is available and the SNR at receiving end is above a threshold value. The impact of Rayleigh fading on probability of symbol error is shown in detail in [7-8] and similar analysis is found [9] for Rician fading. The goal of this paper is to analyze in details the call admission control (CAC) scheme using Markov chain. In addition, the fading effect is also presented.

The rest of the paper is organized as: section II deals with the statistical model of mobile cellular network traffic based on Markov chain and modeling fading channel, section III provides the analytical results based on analysis of section II and section IV concludes entire analysis.

II. TRAFFIC AND FADING CHANNEL MODEL

In this section traffic of mobile cellular network is modeled using call admission scheme. Each cell of the network has $m+k$ traffic channels; where m channels are shared by both newly originating and handover calls and the remaining k channels are reserved for handover traffic. The traffic parameters are:

$\lambda_n \rightarrow$ call arrival rate of newly originating calls

$\lambda_h \rightarrow$ handover call arrival rate

$\mu \rightarrow$ call termination rate

The call admission scheme is shown in fig.1 and the corresponding Markov chain is modeled like fig.2.

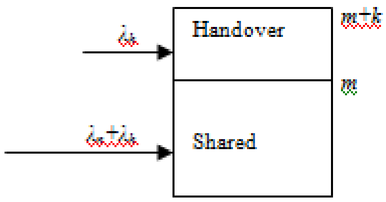

Fig.1: Call Admission Control Scheme

Any probability state P_i indicates the probability of occupancy of a cell with i calls. Applying cut equation between P_0 and P_1 like [10-11],

$$P_0\left(\lambda_n+\lambda_h\right)=P_1\mu$$

$$P_1=P_0\frac{\lambda_n+\lambda_h}{\mu}$$

Between node P_1 and P_2,

$$P_1\left(\lambda_n+\lambda_h\right)=P_2\mu$$

$$P_2=\frac{P_1\left(\lambda_n+\lambda_h\right)}{2\mu}=\frac{P_0\left(\lambda_n+\lambda_h\right)^2}{2\mu^2}$$

Between node P_2 and P_3,

$$P_2\left(\lambda_n+\lambda_h\right)=P_3 3\mu$$

$$P_3=\frac{P_2\left(\lambda_n+\lambda_h\right)}{3\mu}=\frac{P_0\left(\lambda_n+\lambda_h\right)^3}{\mu\cdot 2\mu\cdot 3\mu}$$

$$=\frac{P_0\left(\lambda_n+\lambda_h\right)^3}{3!\mu^3}=P_0\left(\frac{\lambda_n+\lambda_h}{\mu}\right)^3\cdot\frac{1}{3!}$$

In generalized form,

$$P_x=P_0\left(\frac{\lambda_n+\lambda_h}{\mu}\right)^x\cdot\frac{1}{x!} \quad (1)$$

;where $0\leq x\leq m$

Therefore the blocking probability of newly originating call will be,

$$P_m=P_0\left(\frac{\lambda_n+\lambda_h}{\mu}\right)^m\cdot\frac{1}{m!} \quad (2)$$

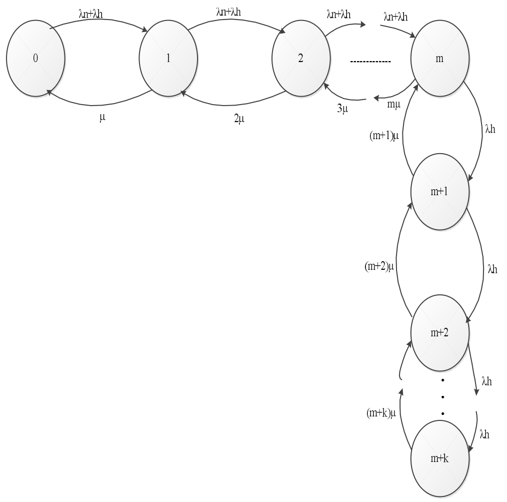

Fig.2: State transition chain of fig.1

Applying cut equation between P_m and P_{m+1}

$$P_m\lambda_h=P_{m+1}\left(m+1\right)\mu$$

$$\Rightarrow P_{m+1}=P_m\cdot\frac{\lambda_h}{\mu\left(m+1\right)}$$

Between node P_{m+1} and P_{m+2},

$$P_{m+1}\lambda_h=P_{m+2}\left(m+2\right)\mu$$

$$\Rightarrow P_{m+2}\left(m+2\right)\mu=P_{m+1}\lambda_h$$

$$\Rightarrow P_{m+2}=\frac{P_{m+1}\lambda_h}{\left(m+2\right)\mu}=P_{m+1}\cdot\frac{\lambda_h}{\mu\left(m+2\right)}=P_m\cdot\frac{\lambda_h}{\mu\left(m+1\right)}\cdot\frac{\lambda_h}{\mu\left(m+2\right)}$$

$$=P_m\cdot\left(\frac{\lambda_h}{\mu}\right)^2\cdot\frac{1}{\prod_{i=1}^{k}\left(m+i\right)}$$

In generalized form,

$$\therefore P_{m+k}=P_m\cdot\left(\frac{\lambda_h}{\mu}\right)^m\frac{1}{\prod_{i=1}^{k}\left(m+i\right)}$$

$$=P_0\left(\frac{\lambda_n+\lambda_h}{\mu}\right)^m\cdot\frac{1}{m!}\cdot\left(\frac{\lambda_h}{\mu}\right)^m\frac{1}{\prod_{i=1}^{k}\left(m+i\right)} \quad (3)$$

Therefore, for entire space,

$$\left(P_0+P_1+\ldots+P_m\right)+\left(P_{m+1}+P_{m+2}+\ldots+P_{m+k}\right)=1$$

$$P_0\sum_{j=0}^{m}\left(\frac{\lambda_n+\lambda_h}{\mu}\right)^j\cdot\frac{1}{j!}+P_0\sum_{r=1}^{k}\left(\frac{\lambda_n+\lambda_h}{\mu}\right)^m\cdot\frac{1}{m!}\cdot\left(\frac{\lambda_h}{\mu}\right)^m\frac{1}{\prod_{i=1}^{r}\left(m+i\right)}=1$$

$$P_0=\frac{1}{\sum_{j=0}^{m}\left(\frac{\lambda_n+\lambda_h}{\mu}\right)^j\cdot\frac{1}{j!}+\left(\frac{\lambda_n+\lambda_h}{\mu}\right)^m\cdot\frac{1}{m!}\cdot\left(\frac{\lambda_h}{\mu}\right)^m\cdot\sum_{r=1}^{k}\frac{1}{\prod_{i=1}^{r}\left(m+i\right)}} \quad (4)$$

Now, Probability of blocking of newly originated call,

$$P_m=\frac{\left(\frac{\lambda_n+\lambda_h}{\mu}\right)^m\cdot\frac{1}{m!}}{\sum_{j=0}^{m}\left(\frac{\lambda_n+\lambda_h}{\mu}\right)^j\cdot\frac{1}{j!}+\left(\frac{\lambda_n+\lambda_h}{\mu}\right)^m\cdot\frac{1}{m!}\cdot\left(\frac{\lambda_h}{\mu}\right)^m\cdot\sum_{r=1}^{k}\frac{1}{\prod_{i=1}^{r}\left(m+i\right)}} \quad (5)$$

Therefore, probability of forced termination,

$$P_{m+k} = \frac{\left(\frac{\lambda_n+\lambda_h}{\mu}\right)^m \cdot \frac{1}{m!} \cdot \left(\frac{\lambda_h}{\mu}\right)^m \cdot \sum_{r=1}^{k} \frac{1}{\prod_{i=k}^{k}(m+i)}}{\sum_{j=0}^{m}\left(\frac{\lambda_n+\lambda_h}{\mu}\right)^j \cdot \frac{1}{j!} + \left(\frac{\lambda_n+\lambda_h}{\mu}\right)^m \cdot \frac{1}{m!} \cdot \left(\frac{\lambda_h}{\mu}\right)^m \cdot \sum_{r=1}^{k} \frac{1}{\prod_{i=1}^{r}(m+i)}} \quad (6)$$

For the next part of this section we will deal with fading channel model of mobile cellular network then will be integrated with traffic model. A mobile cellular network in a dense urban area experiences huge small scale fading (rapid fluctuation of signal with small variation in time and distance). In this paper we consider the Rayleigh fading environment i.e. there is no line of sight (LOS) between base station and mobile user. The probability density function of SNR of Rayleigh is expressed as [12-13],

$$f_\Gamma(\gamma) = \frac{1}{\gamma_{av}} e^{-\frac{\gamma}{\gamma_{av}}} \quad (7)$$

;where γ is the instantaneous SNR and γ_{av} is the average SNR.

The outage probability of the fading channel will be,

$$P_{out}(\tau) = \int_0^\tau f_\Gamma(\gamma) d\lambda \quad (8)$$

;where τ is the threshold SNR to maintain the desired QoS (quality of service) of a wireless link.

Finally the probability of FT including the fading parameters will be,

$$P_{FT} = 1-(1-P_{m+k}(\lambda_n, \lambda_h, \mu))(1-P_{out}(\tau)) \quad (9)$$

Next section will deal with the profile of above traffic parameters taking typical values of call arrival, termination rate and average SNR.

III. RESULTS

This section provides results based on theoretical analysis of section 2. Fig.3 shows the variation of call blocking probability against arrival rate of newly originating calls (in calls/min) taking termination rate as a parameter. Here we consider λ_h =1.2 calls/min, n = 8 and k = 4. The increases with increase in arrival rate but decreases with increase in termination rate. Again the probability of forced termination is plotted against the arrival rate of newly originating calls taking the termination rate as a parameter in fig.4. The profile of curves is found like fig.3. Similarly the variation of blocking probability and FT is plotted against the number of channels in fig.5 and 6 where the number of reserved channel is taken as a parameter. Here we consider λ_n = 2.8 calls/min, λ_h = 2.2 calls/min and μ = 1.5 calls/min. Both the traffic parameter decreases with increase in the number of channels and reserved channel as well.

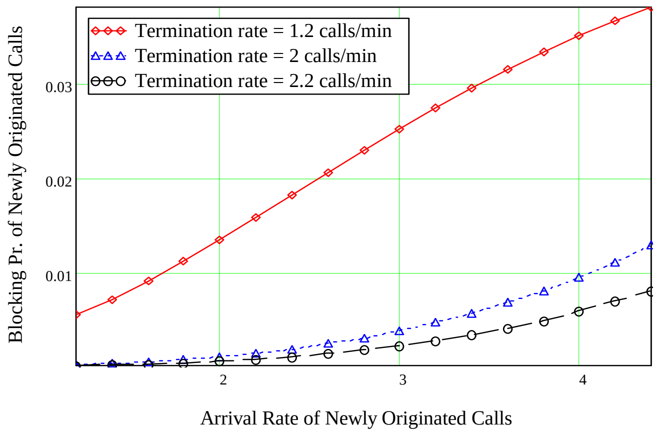

Fig. 3: Variation of blocking probability of against arrival rate of newly originated calls

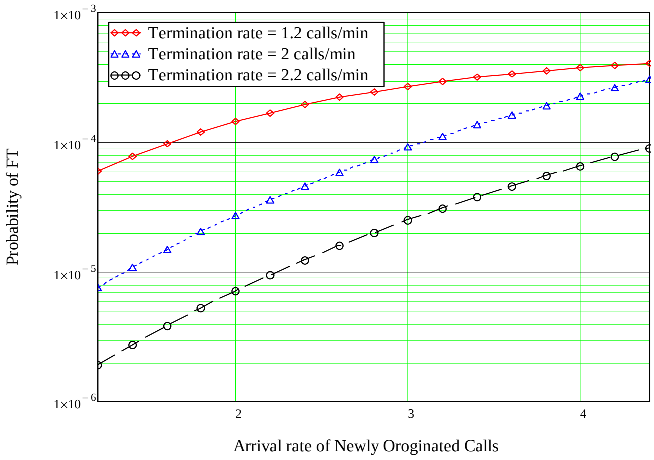

*Fig. 4: Variation of FT against arrival rate of newly originated calls taking termination rate as a **p**arameter*

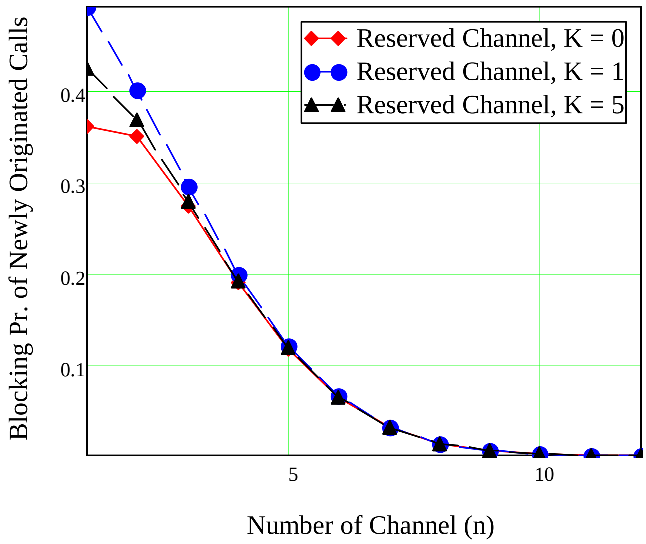

Fig. 5: Variation of blocking probability of newly originated calls against the number of channels

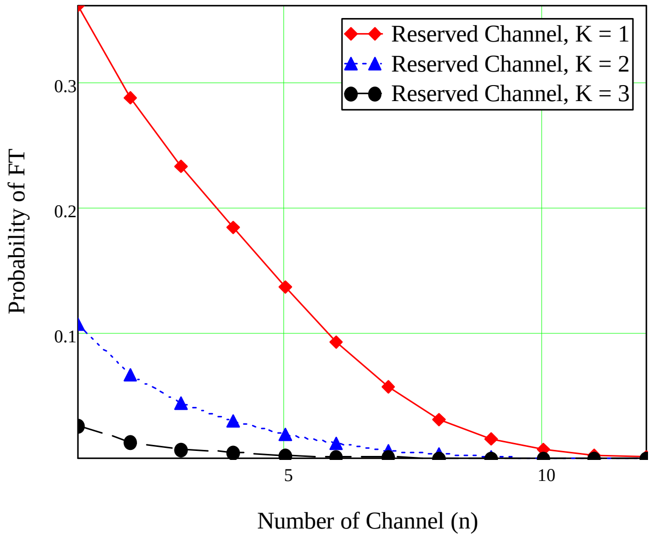

Fig. 6: Variation of FT against the number of channels of newly originated calls

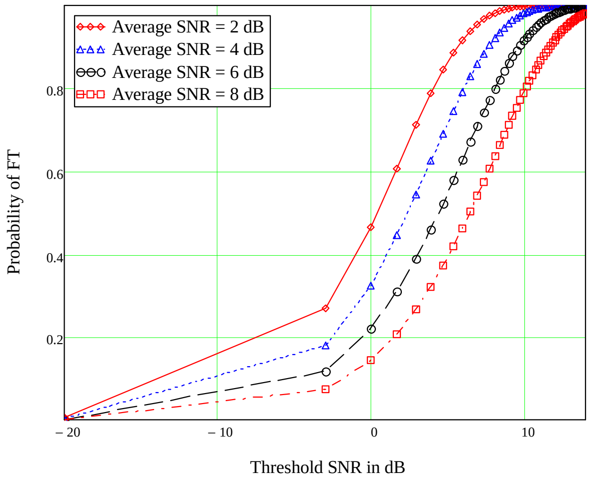

Fig. 7: Variation of PFT against threshold SNR

Finally taking λ_n = 2.8 calls/min, λ_h = 1.2 calls/min, μ = 1.2 calls/min, k = 4 and m = 8; we plot the probability of forced termination under Rayleigh fading (eq. (9)) condition shown in fig. 7. Here P_{FT} is plotted against threshold SNR (in dB) taking average SNR (in dB) as the parameter. It is visualized that P_{FT} decreases with increase in the threshold SNR (since hurdle of the wireless link in enhanced) and average SNR.

IV. CONCLUSIONS

The paper only shows the theoretical results based on state transition chain and fading channel model of wireless link of section 2. Still we have the scope to use SINR (signal to interference and noise ratio) instead of SNR to model the interference of mobile cellular network. In this case the probability density function of SINR will be ratio of two random variables. In future traffic simulation algorithm will be developed to verify the theoretical results of the paper.

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