The Simulation Study on the Effect of Outage Channels on Mobile Cellular Network

Hussein M. Aziz Basi * and M.B.Ramamurthy* *

Faculty of information science&Technology , ** Faculty of Engineering and Technology
Multimedia University, Jalan Ayer Keroh Lama, 75450 Melaka, Malaysia

Summary: A good channel allocation algorithm is the one that yields high spectral efficiency for specified grade of service (GOS). The system planning and design are still carried out with the tools of conventional traffic theory. The designers must evaluate the possible configurations of the system components and their characteristics in order to develop a system with greater efficiency. In this work the simulation study of the GOS degradation in presence of outage for mobile cellular network where the number of channel in outage can be used as an indicator of the traffic load. The performance parameters probability of delay, waiting time for priority and non-priority calls, and mean waiting time are estimated for two models namely the Fixed Outage Rate and Traffic Dependent Outage Rate model. The system is evaluated and compared under different conditions.

Key words:

Outage channels, delay probability, priority calls, mean waiting time.

1. Introduction

Mobile cellular traffic varies greatly from one period to another and not in any uniform manner, but according to the needs of the cellular users. The task of teletraffic theory is to specify methods to ensure that the actual GOS is fulfilling the requirements. To specify emergency actions when systems are overloaded or technical faults occur. GOS define the number of unsuccessful calls relative to the total number of attempted calls [1], [2] and [3]. Erlang C model is used in case where all users have access to all channels in the mobile network and where there are a large number of users using the available channels [1]. The number of required channels is used as a fraction of user traffic intensity and desired the GOS. The GOS in cellular system is affected not only by the system's traffic but also by co-channel interference. The cellular system presence of co-channel interference can cause the carrier-to-interference ratio (C/I) to drop below a specified threshold level [4 -8]. Such an event is known as outage. In some case outage can cause the loss of the communication system. When the C/I is below a certain quality threshold (ϑ) in a given channel, it becomes unusable, and it affects the GOS in the cell. While two subscribers are communicating in the cellular network the user could experiences an absence of the desired signal and some noise or crosstalk. Even if link outages are very short, they collectively degrade the system performance, although they may not be individually recognized. Generally only outages listing longer than tens of milliseconds are recognized and can cause the dropout of the communication [9]. In [5] they estimating the effect of outage it was taken that if there is no available channel the call is blocked or dropped. In this case they did not consider the aspect of buffering the dropped calls (outage calls) and the mean waiting time with priority calls. Another researcher has evaluated the performance of mobile systems with priority concept where no channel available the call is queued up till available channel been assign, the priority calls are placed in a queue before all non-priority calls but never interrupt a call in progress [10], however they did not consider the concept of outage. In this paper queuing the outage channel according to their priority are considered for two different models to evaluate the performance of outage channel on the cellular system.

This paper is organized as follow: In Section 2, the proposed models been discusses according to their outage behaviors. Section 3; present the detail simulation algorithm for the proposed model. While in Section 4, the results, discussions and the comparison with those in [10] are presented in this work. The conclusion of this work is given in section 5.

2. The Proposed System

The calls in the cellular network are made by individual customers according to their habit, needs etc. and the overall pattern of calls will be varying throughout the day. The telephony network equipment should be sufficient in quantity to cope satisfactorily for the period of maximum demand in the busy hour, depending on availability of free

Manuscript received , March 20, 2006
Manuscript revised, April 15, 2006.

channel. In order to determine the optimal channel loading it is necessary to relate the GOS to traffic characteristics; two models are considered for this work to evaluate the effect of outage channels in the cellular network. The fixed outage rate model (Model 1). Assuming a large cellular system in which the users are uniformly distributed among the cells and calls are also uniformly and independently generated, the outage arrival rate can be expected to be independent of the state while the outage recovery rate can be expected to increase with the number of channels in outage.

At any instant of time new calls arrive at rate λ and channel outage occurs at rate γ. Buffer queues up the incoming calls as well as the outage calls and the effective of the arrival rate is $\lambda_e=\lambda+\gamma$. Thus the effective rate at which channels are becoming available will be $\mu_e=(\mu+\alpha)$. The effective traffic intensity is taken to be $Ae = (\lambda_e / \mu_e)$.

While in a traffic dependent outage rate model (Model 2) the assumption that both the outage arrival rate and the outage recovery rate are state dependent is taken. A system with these parameters can be represented by a system which at a given time has low traffic (few users), but then suddenly begin to rise (for example, at the beginning of the busy hour) this will apparently cause higher interference for a higher number of channels in outage. Therefore, it can be assumed that both the outage arrival rate and the outage recovery rate are state dependent. The effective rate at which channels are becoming available will be $\mu_e=(\mu+\alpha)$. The effective traffic intensity $Ae = (\lambda_e / \mu_e)$. While the number of channel been assign for each cell is N and the outage channel is k, their for the available channels will be N-k.

3. Simulation Model

Simulating the Erlang C formula with the effect of outage channel for the proposed models to find the probability of delay is used to evaluate the waiting times as well. The total duration *(d)* of call is known as call duration add the recovery rate time, using this concept to find the mean waiting time of priority and non-priority calls from the relations of Barceló & Paradells [10], thus d is taking as $d_r + \alpha$, ; d_r is duration time and α is outage recovery. ρ is overall system load and p is the priority proportion. The load due to priority calls will be $\rho \times p$. The evaluation conditions of channel system are heavy traffic (high ρ) and low priority propagation (low p) to maintain the effectiveness of the priority system as statues.

The simulation system is been design to evaluate the proposed models, where the coming calls as well as the outage channels are queued with the following assumption:

1. all the channels are fully available for servicing calls until all channels are occupied,
2. the offered traffic is uniformly distributed in the cell,
3. the number of subscribers is assumed infinite,
4. the call is initiation is a Poisson process with a mean call arrival of λ calls/ hour,
5. the call holding time is exponentially distributed with a mean of 120 s,
6. threshold level for new calls >19dB and for dropped calls <17.3 dB,
7. the interference channel (outage channels) should be limited,
8. the outage recover rate is 0.00664
9. the buffer is assumed to be infinite, and
10. sort the calls according to their priority without interrupting a call in progress.

The flowchart of the simulation models is shown in Fig. 1.

4. Results and Discussions

The results obtained for the two models are presented in this section. The models are developed for large cellular system and the results are analyzed for different scenarios, using the Erlang distribution for a high number of users in the cellular cell.

In Fig. 2 the number of channels are used is 40 channels where the traffic load is 360 calls/hour and the outage recovery rateμ=0.2, for the results is found that the probability of delay for both models are increased with the increase of the number of channel in outage. It can see that probability of delay is much lower in the fist model than the second model under different values where the outage channels are changed. It means that the two models have a similar behavior but model two gives high probability of delay.

While in Table 1, the comparison for the both models with Erlang C model to evaluate the effect of outage on the system and the value of outage channel is taken is 1 to see clearly the difference effect of outage channels on cellular system and it found that model one and two is given higher delay than Erlang C model.

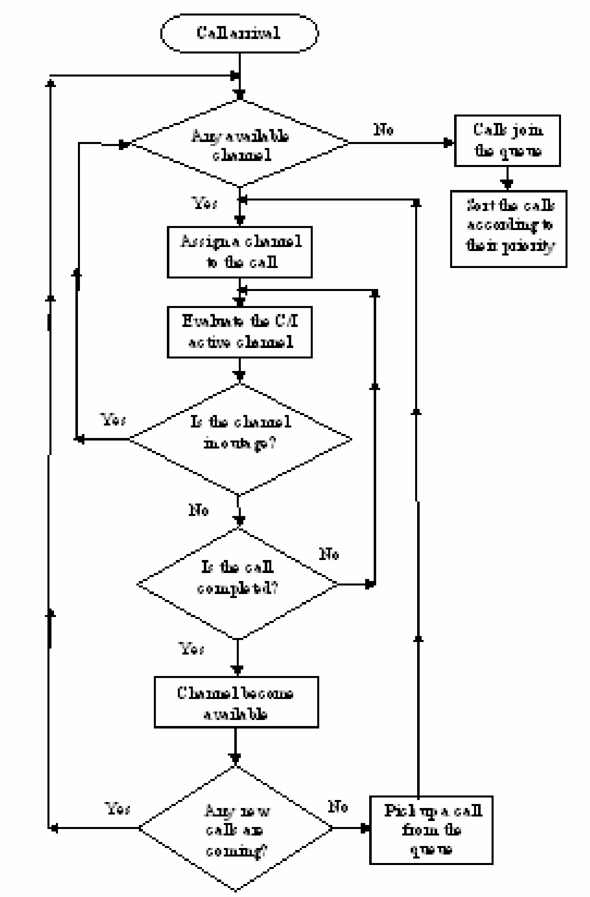

Fig. 1: Flowchart of the simulation model.

In Fig. 3 & 4, the waiting time for priority calls and non-priority calls for the first model is less than the time that the call is waiting in the second models under different outage channel load.

In Table 2, the waiting times for priority calls is less than that of non-priority calls and their variation is in line with those reported in [10], for different priority calls percentage, it's found that model one and two is giving higher waiting time for heavy load and low for priority call percentage than in [10], this is the situation of interest in a mobile channel system with priority concept.

While in Fig. 5, the mean waiting time for model one is less than in model two for different outage channels, Its means that, the time for the call is waiting for requests in first model is less than the second models and also it can seen that the difference in the both model with those in [10] for a different load calls with outage load consideration in the cellular network as been shown in Table 3.

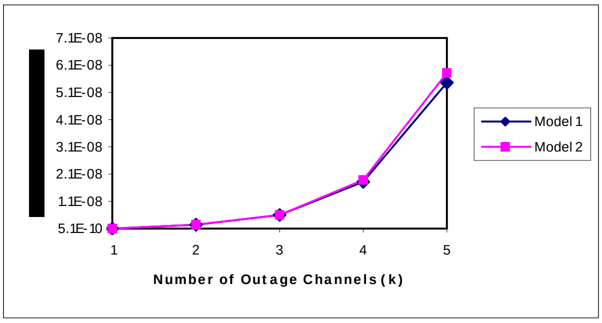

Fig. 2: The probability of delay versus the outage channels (k), where the number of calls are 360 calls/hour, and μ=0.2.

Table 1: The number of calls versus the probability of delay. Where N=40, k=1 and μ=0.2.

Calls/hour	Erlang C	Model 1	Model 2
360	1.5812E-10	5.3453E-10	5.3615E-10
400	2.9608E-09	9.0211E-09	9.0447E-09
450	6.6330E-08	1.8004E-07	1.8043E-07
500	1.7769E-06	4.2349E-06	4.2423E-06
600	5.5551E-05	1.1418E-04	1.1433E-04
720	1.8690E-03	3.2422E-03	3.2452E-03
900	5.5248E-02	7.9358E-02	7.9400E-02

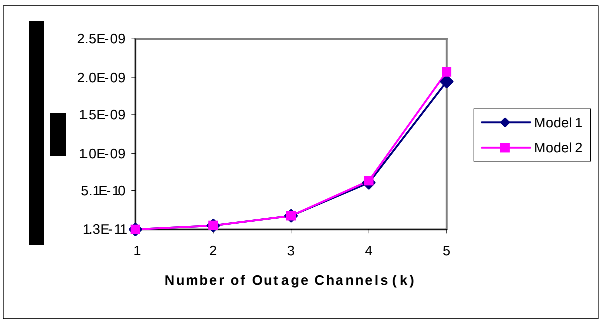

Fig 3: Waiting time for priority calls versus the number of

channels in outage (k), where the number of calls are 360 calls/hour, μ=0.2 and the priority percentage is 3%.

Fig 5: Main waiting time versus the number of channels in outage (k), where the number of calls are 360 calls/hour and μ=0.2.

Table 2: Waiting time for priority and non-priority calls versus different priority percentage.

	Waiting time for Priority			Waiting time for Priority		
Priority %	Barceló Model	Model 1	Model 2	Barceló Model	Model 1	Model 2
0.1	4.8011E-12	1.6675E-11	1.6725E-11	5.4558E-12	1.8949E-11	1.9007E-11
0.2	4.8601E-12	1.6880E-11	1.6931E-11	5.5228E-12	1.9182E-11	1.9240E-11
0.3	4.9206E-12	1.7090E-11	1.7142E-11	5.5916E-12	1.9420E-11	1.9480E-11
0.4	4.9826E-12	1.7305E-11	1.7358E-11	5.6621E-12	1.9665E-11	1.9725E-11
0.5	5.0462E-12	1.7526E-11	1.7579E-11	5.7343E-12	1.9916E-11	1.9977E-11

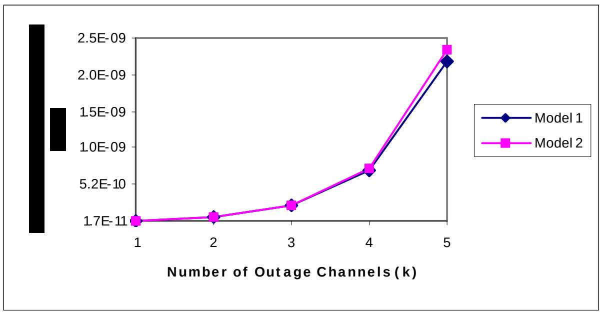

Fig 4: Waiting time for regular calls versus the number of channels in outage (k), where the number of calls are 360 calls/hour and μ=0.2.

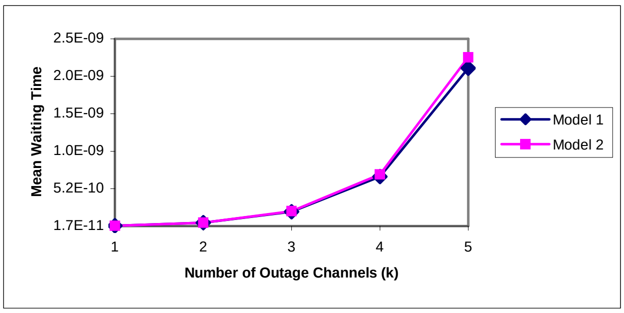

Table 3: The main waiting versus the probability of delay. Where N=40, k=1 and μ=0.2.

Calls/hour	Barceló Model	Model 1	Model 2
360	5.3903E-12	1.8721E-11	1.8778E-11
400	1.0249E-10	3.2082E-10	3.2166E-10
450	2.3410E-09	6.5281E-09	6.5424E-09
500	6.4338E-08	1.5753E-07	1.5781E-07
600	2.0832E-06	4.3989E-06	4.4048E-06
720	7.3778E-05	1.3149E-04	1.3161E-04
900	2.3678E-03	3.4941E-03	3.4961E-03

5. Conclusion

Since the outage channels are queued along with normal arriving calls into the same buffer, as the number of outage is increase the parameters been considered are also increase exponentially with the increase of outage channel. The parameter probability that the requests will be queued and not blocked is dependent on the effective traffic intensity. The results show the higher value of outage channel increased the probability of delay is exponential increase with the effective of traffic intensity. The parameter mean waiting time and waiting time for priority and non-priority calls is linear and bounded for lower values of outage channel. However, for higher values of outage channels, the changes observed are exponential. The results of model-1 are better in performance than model-2. Model-2 shows greater sensitivity to outage channels than Model 1. Therefore, to have a better performance, the designers need to take care about the number of channel in outage and it should be limited at any time.

6. Reference

[1] Nathan B., Ran, G.and A. Freedman 2002. Unified Approach of GOS Optimization for Fixed Wireless Access, Vehicular Technology, IEEE Transactions, Vol 51, No. 1, pp: 200-2008.

[2] Zhao D., Shen X. and Mar, J. W.k 2002, Performance Analysis for Cellular System Supporting Heterogeneous Services. ICC 2002. IEEE International Conference on Volume 5, pp: 3351 – 3355.

[3] Hong, H. H., R. Malhamd and Gerald Chen, 1991. Traffic Engineering of Trunked Land Mobile Radio Dispatch System, Vehicular Technologuy confreance,' gateway to the future Technology in Motion', 41st IEEE; May 19-22, pp. 251-256.

[4] Annamalai A. C., Tellambura, V. K. Bhargava, 2001. Simple and Accurate Methods for outage Analysis in Cellular Mobile Radio System– A Unified Approach. IEEE Transactions in Communications, Vol. 49, No. 2, pp: 303-308.

[5] Aguirre A., D. Munoz, C. Molina, and K. Basu, 1998. Outage – GOS Relationship in cellular Systems, IEEE Communications Letters, Vol. 2, No. 1,pp: 5-7.

[6] Yang, L.; Alouini, M.-S.(2006), Performance Comparison of Different Selection Combining Algorithms in Presence of Co-Channel Interference, Vehicular Technology, IEEE Transactions,Vol. 55 , Issue: 2,pp. 559 – 571.

[7] Zhang, Q.T. (1996). Outage probability in cellular mobile radio due to Nakagami signal and interferers with arbitrary parameters, Vehicular Technology, IEEE Transactions. Vol 45, No. 2 pp. 364-372.

[8] Yang, L.; Alouini, M.-S. (2002), Outage probability of dual-branch dilversity system in Presence of Co-Channel Interference. IEEE Transactions wireless communication, Vol. 2 No. 2, pp. 310-319.

[9] Caini, C. G. Immovilli, M. L. Merani, Outage, 2002 Probability for Cellular Mobile Radio Systems: Simplified Analytical Evaluation and Simulation Results, Electronics Letters, Vol. 28 No. 7, pp: 669-671.

[10] Barcelo, F and J. Paradells, 2000. Performance Evaluation of Public Access Mobile Radio (PAMR) Systems with Priority calls. IEEE, pp. 979-983.

Hussein M. Aziz Basi completed his BSc degree in Computer Sciences in 1993 from MUC, Iraq. MSc. Degree in Computer Sciences from University Putra Malaysia (UPM) in 1999. Currently he is a PhD candidate at the Faculty of Information Science and Technology, Multimedia University, Melaka, Malaysia. His research interests are Mobile Cellular Networking and Mobile transaction managements.

M. B. R. Murthy completed his B E degree with Electrical Engineering major in 1972 from Andhra University Waltair (India), M Sc (Engg) Communication Systems in 1974 from R E C Rourkela (India) andPh D from Karnatak University Dharwad India. He has academic experience over 30 years teaching undergraduate and postgraduate courses. Currently Murthy is with Faculty of Engineering and Technology, Multimedia University, Melaka, Malaysia. His areas of research interest include communications, dielectric studies and biomedical instrumentation.