Tetcos Engineering

Global System for Mobile Communication (GSM)

White Paper

Revision History

Work	Author	Date
Created	Shashi Kant Suman	21st Sep 2010
Review	Pranav & Shashi kant	28th Sep 2010
Update	Shashi kant suman	29th Sep 2010
Review	Pranav & Shashi kant	30th Sep 2010
Update	Shashi Kant Suman	5th Oct 2010

Table of contents

Abstract:

Call blocking probability is a key performance metric for any telecommunication protocol. In this paper, we have compared the Call blocking probability obtained by the simulation of a GSM network in NetSim with theoretical value calculated using a Markovian model.

Introduction to GSM:

GSM stands for **G**lobal **S**ystem for **M**obile Communication. And, GSM differs from its predecessors in that both signaling and speech channels are digital, and thus is considered a second-generation (2G) mobile phone system.

GSM is based on **Time Division Multiple Access (TDMA)** and follows random behavior signal propagation.

Each base station is equipped with a certain number of frequency/time channels. Two frequency bands are used by the GSM system. These are 890-915 MHz for the direction mobile to base station, and 935-960 MHz for the direction base station to mobile terminal. These bands are divided into 124 pairs of carriers spaced by 200 kHz, starting with the pair 890.2 MHz. Each carrier has 8-time slot channel of length 577 micro sec. (as shown in figure 1)

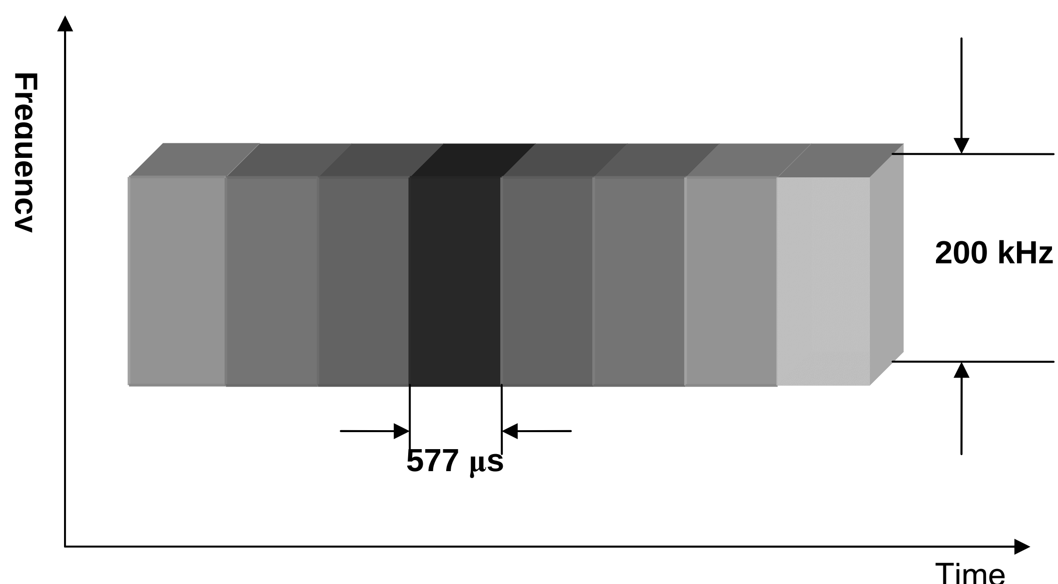


Figure 1

Why does blocking occur?

Each base station has certain fixed number of channel available to carry data traffic. If any new call arrives to base station, it will first check for the availability of a free channel. If a free channel is available, then this free channel is allocated for the call. If there is no free channel available then the call is blocked.

In this paper, we are try to interpret the behavior of a GSM system by increasing the load/traffic, and comparing the call blocking probability result obtained through NetSim simulation with theoretical generated formula using Markovian model.

Model:

Number of Mobile Stations (MS) = n
Number of channels = m
Call arrival rate at each MS = λ
Call completion rate at each MS = μ

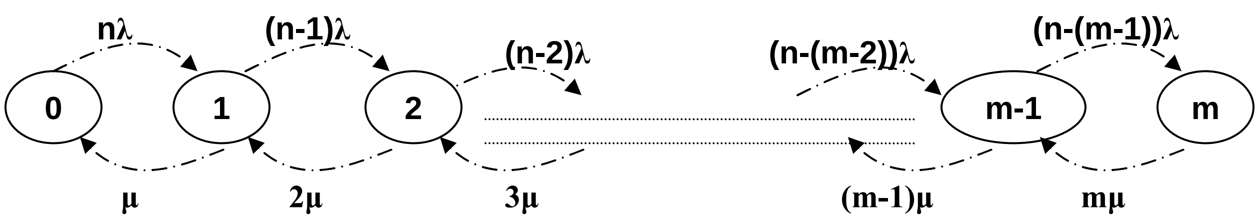


Figure 2

Figure 2 shown above explains the above model in terms of a Markov Model. The states 0, 1, 2 …. M represent the number of channels those are busy.

For example: In the beginning there is no busy channel. The total arrival rate of calls is Number of MS * Call arrival rate in each MS (n* λ). This moves the system to state 1; where 1 channel is busy. From this state the system can move to state 2 or to state 0. It moves to state 2 if an additional call arrives; and this arrival rate is (Number of MS – 1) * Call arrival rate at each MS ((n-1)* λ). The system moves to state 0 if the one call is complete. This would happen at the call completion rate, which is μ.

Extending logically, if a system is in k state, then

Rate at which system jumps to k+1 state = (n-k) λ
Rate at which system jumps to k-1 state = k μ

A MS cannot generate any call, when a call is already in progress. If any call is blocked, then a new call will generate after exponential λ, so, the call model for single MS looks like figure 3,

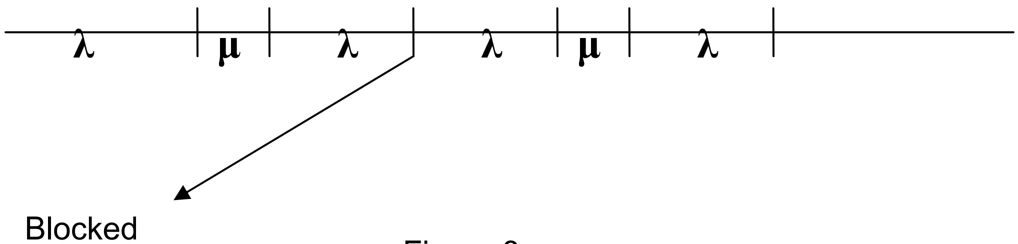


Figure 3

Theoretical blocking probability calculation

At state k, Erlang load = $(n - k)\frac{\lambda}{\mu}$ Where, k is the number of MS busy

$$\rho = \frac{\lambda}{\mu}$$

π_0 = Probability to remain in state 0.
π_1 = Probability to remain in state 1.
π_2 = Probability to remain in state 2.
.
.
.
π_k = Probability to remain in state k.
.
.
π_m = Probability to remain in state m.

So,

$$n\lambda\pi_0 = \mu\pi_1 \Rightarrow \pi_1 = \frac{n\lambda}{\mu}\pi_0 = n\rho\pi_0$$

$$(n-1)\lambda\pi_1 = 2\mu\pi_2 \Rightarrow \pi_2 = \frac{n-1}{2}\rho\pi_1$$

.

.

$$\pi_m = (n-(m-1))\rho\pi_{m-1}$$

Therefore, $\pi_k = \left[\rho k \frac{n(n-1)....(n-(k-1))}{k(k-1)(k-2)....1}\right]\pi 0$

Now, $\sum_{k=0}^{m} \pi_k = 1$

$$\Rightarrow \pi_0\left[1 + n + \frac{n(n-1)}{2} + ... + \frac{n(n-1)..(n-(m-1))}{m\,|}\right] = 1 \quad .... \text{(1)}$$

By solving the equation 1, we can get the value of π_0, hence π_1, $\pi_2 \ldots \pi_m$.

$$P_{blocking} = \frac{\pi_m(n-m)\lambda}{\sum_{k=0}^{m} \pi_k(n-k)\lambda} = \frac{\pi_m(n-m)}{\sum_{k=0}^{m} \pi_k(n-k)}$$

NetSim Simulation Results

Plot of call blocking probability vs. Number of MS

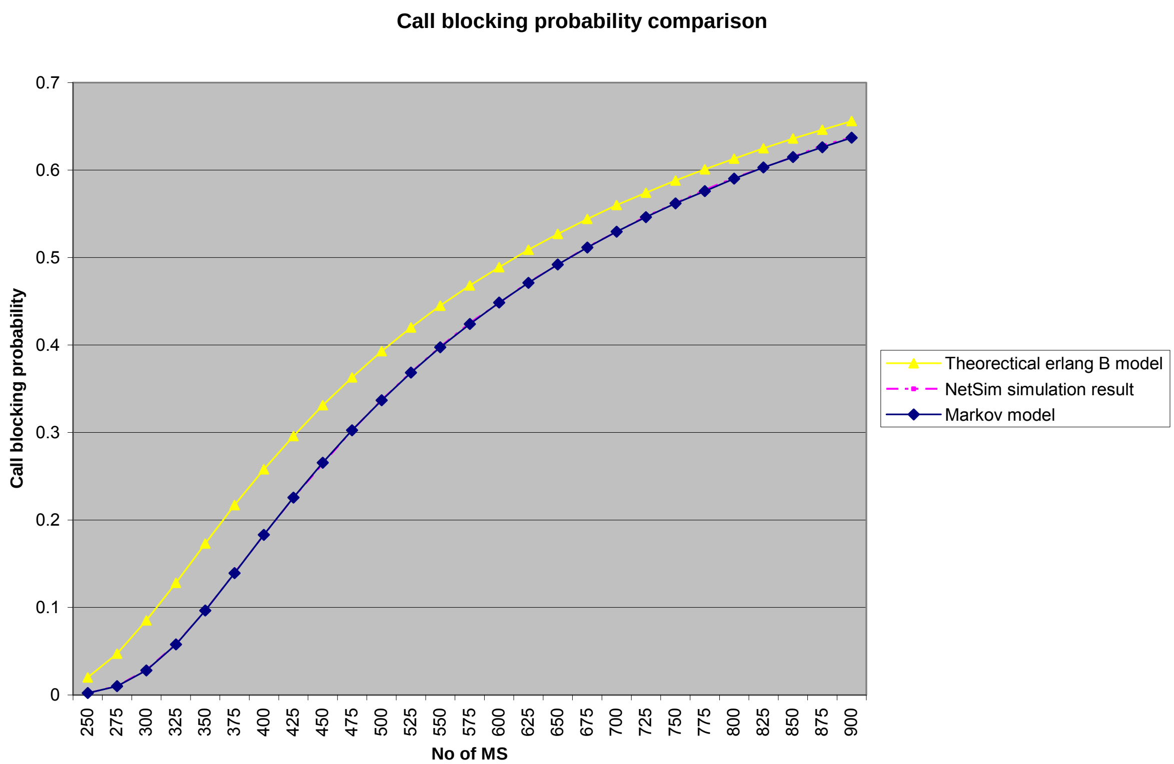


Figure 4

Note: In the above graph, the Erlang B model is shown for comparison purposes.

The erlang B distribution is used for dimensioning trunk route. It is based on following assumptions

- There are infinite number of sources
- Call arrives at random
- Call are served in order of arrival
- Blocked call are lost
- Holding times are exponentially distributed.

Data

Number of MS	Mean call inter-arrival time (s)	Mean call holding time(s)	Number of channels	Erlang blocking probability (Pr)	Call Blocking Probability Run 1	Run2	Run3	Run4	Run5	Average (Run 1 through 5)	Markov Call Blocking
250.000	100.000	15.000	47.000	0.020	0.001	0.002	0.003	0.002	0.002	0.002	0.002
275.000	100.000	15.000	47.000	0.047	0.009	0.010	0.010	0.011	0.012	0.010	0.010
300.000	100.000	15.000	47.000	0.085	0.029	0.030	0.028	0.028	0.029	0.029	0.028
325.000	100.000	15.000	47.000	0.128	0.055	0.062	0.056	0.059	0.058	0.058	0.058
350.000	100.000	15.000	47.000	0.173	0.095	0.096	0.093	0.099	0.097	0.096	0.096
375.000	100.000	15.000	47.000	0.217	0.138	0.138	0.140	0.138	0.145	0.140	0.139
400.000	100.000	15.000	47.000	0.258	0.178	0.179	0.182	0.188	0.188	0.183	0.183
425.000	100.000	15.000	47.000	0.296	0.222	0.224	0.227	0.226	0.227	0.225	0.226
450.000	100.000	15.000	47.000	0.331	0.261	0.263	0.263	0.265	0.266	0.264	0.265
475.000	100.000	15.000	47.000	0.363	0.301	0.300	0.302	0.304	0.305	0.302	0.303
500.000	100.000	15.000	47.000	0.393	0.335	0.335	0.335	0.338	0.343	0.337	0.337
525.000	100.000	15.000	47.000	0.420	0.367	0.370	0.369	0.369	0.370	0.369	0.368
550.000	100.000	15.000	47.000	0.445	0.395	0.397	0.398	0.402	0.399	0.398	0.397
575.000	100.000	15.000	47.000	0.468	0.422	0.425	0.426	0.425	0.428	0.425	0.424
600.000	100.000	15.000	47.000	0.489	0.445	0.444	0.452	0.449	0.449	0.448	0.449
625.000	100.000	15.000	47.000	0.509	0.470	0.472	0.473	0.472	0.472	0.472	0.471
650.000	100.000	15.000	47.000	0.527	0.488	0.492	0.493	0.492	0.494	0.492	0.492
675.000	100.000	15.000	47.000	0.544	0.511	0.512	0.513	0.513	0.512	0.512	0.511
700.000	100.000	15.000	47.000	0.560	0.530	0.528	0.530	0.528	0.530	0.529	0.530
725.000	100.000	15.000	47.000	0.574	0.546	0.547	0.546	0.550	0.546	0.547	0.546
750.000	100.000	15.000	47.000	0.588	0.560	0.562	0.564	0.564	0.562	0.562	0.562
775.000	100.000	15.000	47.000	0.601	0.575	0.579	0.574	0.583	0.576	0.577	0.576
800.000	100.000	15.000	47.000	0.613	0.589	0.589	0.591	0.595	0.590	0.591	0.590
825.000	100.000	15.000	47.000	0.625	0.604	0.600	0.603	0.606	0.602	0.603	0.603
850.000	100.000	15.000	47.000	0.636	0.613	0.615	0.615	0.619	0.612	0.615	0.615
875.000	100.000	15.000	47.000	0.646	0.625	0.628	0.627	0.634	0.629	0.628	0.626
900.000	100.000	15.000	47.000	0.656	0.637	0.635	0.637	0.640	0.638	0.637	0.637

Figure 5

Inference

As we see in the above graph, NetSim result matches exactly with the theoretical value. However one needs to note that call blocking probability will always be less than erlang blocking probability. The reasoning is given below

The Erlang model is

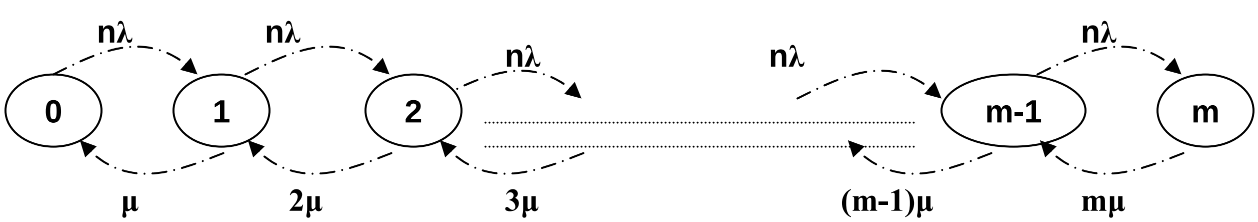


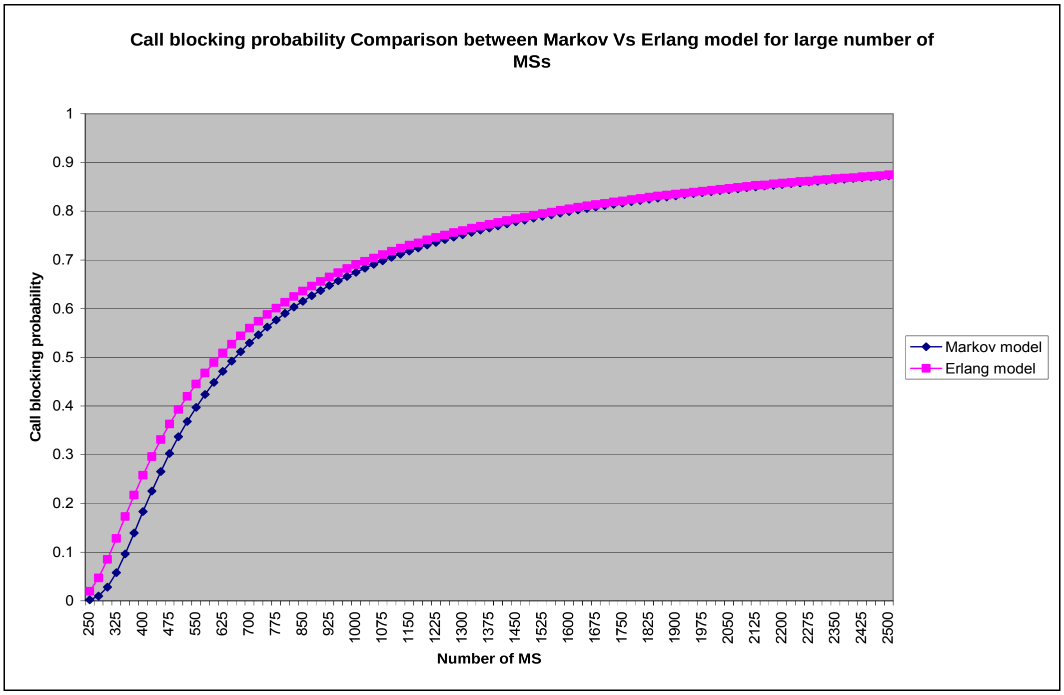
Figure 6

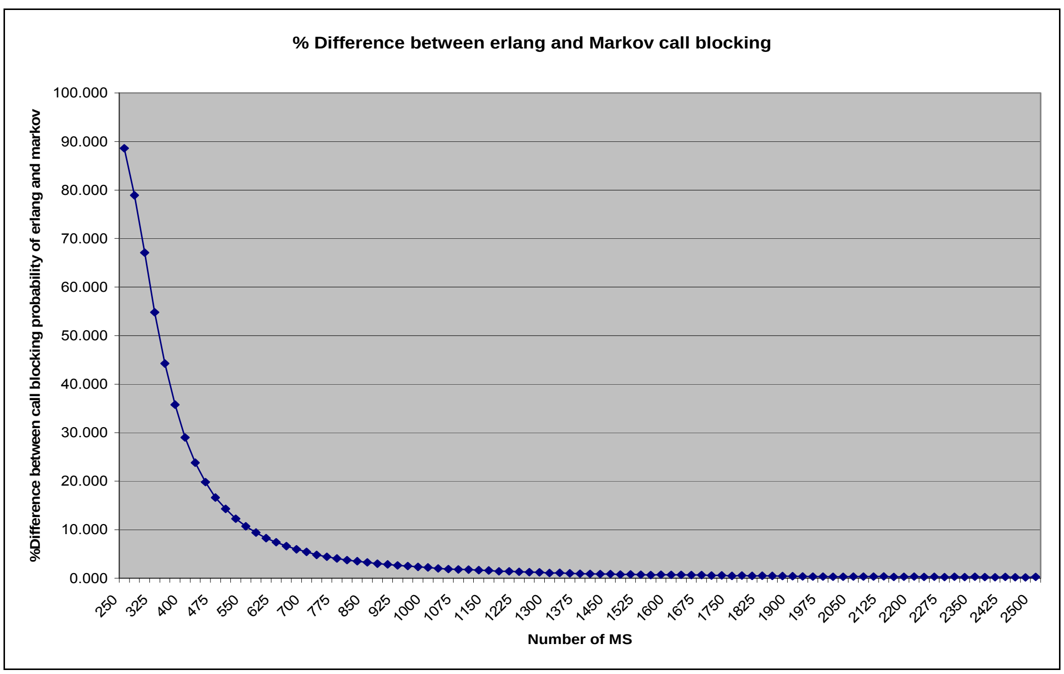
The arrival rate for all states is nλ, against an arrival rate of (n-(m-1)λ for the markov model. Therefore the call blocking probability of the markov model is always less than that of the erlang model.

Figure 5

If n >>> m, then Erlang and Markov model will converge as shown in figure 7 and 8.

Plot





As we see in the figure 7, when the number of transmitting MS increase, the Erlang blocking probability and the Markov blocking probability converge. This is also clear from figure 8, where the % difference between erlang and Markov is shown. The difference in call blocking probability between the two models decreases exponentially as number of MS increase.