Experiment 3: Trunking and Grade of Service

1. **Aim**: To understand the concept of Trunking and perform calculations for probability of call blocking or call delay.

2. **Requirements:** Matlab/Scilab/Phyton and Erlang B chart

3. **Pre-Experiment Exercise**

3.1 Brief Theory

Cellular systems rely on trunking to accommodate a large number of users in a limited radio spectrum. Trunking is based on the concept of pool of available channels which are assigned to users on demand. This allows a large number of users to share the relatively small number of channels in a cell. In a trunked radio system, each user is allocated a channel on a per call basis and upon termination of the call, the previously occupied channel is immediately returned to the pool of available channels.

Grade of service (GOS) is a parameter used to measure the ability of a user to access a trunked system during the busiest hour. It is also defined as the likelihood that a call is blocked or the likelihood that a call is experiencing a delay greater than a certain queuing time. It is used to measure the performance of the trunking system.

Traffic IntensityA is defined as average channel occupancy and is measured in Erlangs. The traffic intensity offered by each user (A_u)is equal to the *Call request rate (λ)*multiplied by the *Holding time (H)* where *H* is defined as the average duration of a call.

$$A_u = \lambda * H$$

If a single user generates a traffic intensity A_u and if the no. of users in the system are given by *U*, then the total traffic intensity is given as follows.

$$A = U * A_u$$

If the total channels in a trunked radio system are assumed to be *C* and if the traffic is equally distributed among the channels, the traffic intensity per channel (A_c) is given as follows.

$$A_c = U * A_c/C$$

Trunked systems are categorized into two types: Erlang B and Erlang C

1) *Erlang B* system works on the concept that any user who requests access to the system is given immediate access if channels are available in the system. If all channels are occupied, the call is blocked and the requesting user is free to access the system again later. The GOS for Erlang B system is defined as the probability that a call is blocked without queuing.

$$\Pr[blocking] = \frac{\frac{A^C}{C!}}{\sum_{k=0}^{C} \frac{A^k}{k!}} = GOS$$

2) *Erlang C* system works on the concept that a call request from a user can be delayed till a channel is available. The call is held for a finite amount of time in the system if all channels are occupied. If no channels are available after the queuing time, the call is blocked. The GOS for Erlang C system is defined as the probability that a call is blocked after waiting a specific length of time in the queue.

$$\Pr[delay > 0] = \frac{A^C}{A^C + C! * \left(1 - \frac{A}{C}\right) * \sum_{k=0}^{C-1} \frac{A^k}{k!}}$$

$$\Pr[delay > t] = Pr[delay > 0] * \Pr[delay > t | delay > 0]$$

$$= \Pr[delay > 0] * \exp(-(C - A) * t/H)$$

4. Laboratory Exercise

Part 1:

1. What do you understand by the term Erlang
2. If 90 calls are made in one hour, each lasting 5 minutes. Find out the number of Erlangs

Part 2:

Write a simulation program to understand the concept of trunking and grade of service

A certain city has an area of 1,300 square miles and is covered by a cellular system using a seven-cell reuse pattern. Each cell has a radius of four miles and the city is allocated 40 MHz of spectrum with a full duplex channel band-width of 60 kHz. Assume a GOS of 2% for an Erlang B system is specified. If the offered traffic per user is 0.03 Erlangs, compute (a) the number of cells in the service area, (b) the number of channels per cell, (c) traffic intensity of each cell, (d) the maximum carried traffic, (e) the total number of users that can be served for 2% GOS, (f) the number of mobiles per unique channel (where it is understood that channels are reused), and (g) the theoretical maximum number of users that could be served at one time by the system.

5. Post-Experiment Exercise

5.1 Conclusion

5.2 Questions:

a) Define the following terms

- traffic intensity
- holding time
- request rate
- setup time
- GOS