- Traffic intensity is expressed in Erlangs. It is given by the product of the number of calls/hour and the duration of the call (hours). For example, if a person makes an average of four calls/hour and the average duration of the call is 3 minutes, the traffic intensity generated is $4(3/60) = 0.2$ Erl.
- If the number of channels or trunks available is C, the blocking probability, $p(B)$, can be expressed as

$$p(B) = \frac{\left[\frac{A^C}{C!}\right]}{\sum_{k=0}^{C} A^k/k!},$$

where A is the offered traffic in Erl.

- The carried traffic A_c is given by $A[1 - p(B)]$ Erl.
- Even though co-channel interference is reduced through the use of sector antennae, the trunking efficiency is also reduced.
- Additional interference may arise from adjacent channels. ACI must be taken into account to calculate the overall interference.

PROBLEMS

1. In a cellular communication system, the signal power received is −100 dBm. The structure is a seven-cell pattern. If the noise power is −119 dBm and each of the interfering signals is −121 dBm, calculate the overall signal-to-noise ratio. Also calculate the signal-to-CCI ratio.

2. In a cellular communication system, the signal power received is −97 dBm. The structure is a seven-cell pattern. The noise power is −117 dBm and each of the interfering signals is −120 dBm.
(a) Calculate the overall signal-to-noise ratio.
(b) Calculate the signal-to-CCI ratio.
(c) If a 20 dB signal-to-CCI ratio is required, what should be the power of the signal from each of the interfering cells?

3. If the received power at a distance of 2 km is equal to 2 μW, find the received powers at 3 km, 6 km, and 15 km for a path loss exponent ν of 3.8.

4. If a mobile unit is 4 km away from the base station and 10 km away from the CCI site, find the signal-to-CCI ratio. Assume the path loss exponent ν to be 4.0.

5. If a signal-to-CCI ratio has to be 20 dB and the mobile unit is 8 km away from its own base station, how far away should the CCI site be located? Assume the path loss exponent ν to be 3.2.

6. A mobile unit receives a power of −105 dBm. If the predicted loss is 115 dB, what was the transmitted power?

7. For acceptable performance, the signal-to-CCI ratio must be at least 20 dB. What must be the value of D/R? Assume ν to be equal to 3.0.

8. Consider the case of a Rayleigh-faded signal received by a mobile unit (MU). The threshold SNR for acceptable performance is 15 dB. Assume that the average power being received is −96 dBm. The noise power is −115 dBm. Calculate the outage probability. If the acceptable outage is only 2%, what must the noise power be to maintain acceptable performance?

9. Explain the term *Erlang*.

10. If a provider is planning to have 20 voice channels per cell for a grade of service (GOS) of 2%, calculate the offered traffic and carried traffic. If the provider has 10 cells, what is the total carried traffic in Erlangs?

11. A provider has 75 channels in a cell. If the blocking probability is 2%, what is the offered traffic? What is the carried traffic? If each customer uses (holding time) 2 minutes and makes an average of two calls/hour, how many customers can be served?

12. Two service providers, A and B, provide cellular service in an area. Provider A has 100 cells with 20 channels/cell, and B has 35 cells with 54 channels/cell. Find the number of users that can be supported by each provider at 2% blocking if each user averages two calls/hour at an average call duration of 3 minutes.

13. A provider expects to provide coverage for about 700 users/cell. The acceptable GOS is 2%. If the user has an average holding time of 3 minutes/call and makes an average of three calls/hour, how many channels are required?

14. For the case of lognormal fading, given in eq 2.67, use MATLAB to calculate the outage. Assume that the average power being received is −100 dBm. Standard deviation of fading = 6 dB. Threshold power = −105 dBm. Repeat the calculations for standard deviations of 8, 10, and 12 dB. Generate either lognormal or normal random numbers (at least 5000) to compute the outage probability.

15. Instead of using the random number generator from MATLAB, use the analytical approach to calculate outage probability. Compare your results to the values calculated in Problem 14.

16. Use MATLAB to generate 1000 Rayleigh-distributed random variables such that the average signal power is 0 dBm. If the threshold is −3 dBm, compute the outage probability. Repeat the simulation for a threshold of −5 dBm.

17. Use the analytical approach to calculate the outage for the cases in Problem 16, and compare your results.

18. The transmit power of a base station is 2 W. If the coverage is to be split so that minicells (one-third size) can be created to accommodate additional users in the geographical region, what must be the transmit power (of the minicell) to keep CCI at the same level as that of the unsplit cell? Assume that $\nu = 3.0$.

19. To keep an acceptable level of performance, a service provider is planning to maintain an outage probability of 3%. What should be the threshold power? The standard deviation of fading (lognormal) has been found to be 8 dB. The average received power is −95 dBm.

20. Based on the Hata model for power loss, it has been determined that there is approximately 0.7 dB/km loss in the range of 10–18 km from the transmitter. The long-term fading margin is 6 dB and the short-term fading margin is 4 dB. Calculate the reduction in transmission distance when

(a) Only the long-term fading margin is factored in.
(b) Only the short-term fading margin is factored in.
(c) Both fading margins are taken into account.

21. Use MATLAB to plot the outage probability at the edge of a cell as a function of the power margin.

22. Use MATLAB to plot the area outage probability as a function of the power margin. Comment on the relative variation of the outage probabilities (for this problem and Problem 21) for the two power margin values 6 dB and 10 dB.

23. Use MATLAB to calculate the maximum distance using your calculations from Problem 21 for two outage probabilities, 0.1 and 0.05. Assume that the standard deviation of fading (lognormal) is 6 dB. The path loss exponent is 3.5. The received power at a distance of 4 km from the base station is −50 dBm. The threshold level for performance is −91 dBm.

24. Consider a seven-cell pattern that uses an omnidirectional antenna with 54 channels/sector. Calculate the trunking efficiency if

(a) A 60° sector antenna is used.
(b) A 120° sector antenna is used.

25. Explain the term *adjacent channel interference*. If the signal power received is −90 dBm, the CCI power/channel is −120 dBm, and the ACI is −110 dBm, calculate the overall signal-to-noise ratio. Note that thermal noise has been neglected.

26. Outage probabilities have been calculated for Rayleigh channels assuming that the co-channel power is constant. However, the co-channel signal also undergoes Rayleigh fading, and this must be taken into account. If our requirement for acceptable co-channel interference is that the ratio of the signal power to the co-channel signal power be α dB, derive an expression for the outage probability arising from co-channel interference.

27. Use MATLAB to obtain a plot of outage probability for various values of the "protection ratio" α.

28. Repeat Problem 26 if the desired signal and the CCI are subject to lognormal fading. Assume that the standard deviations of fading are same for both the desired and CCI signals.

29. Use MATLAB to obtain plots of the outage probability as a function of the "protection ratio" α for different values of the standard deviation of fading.

30. Using a random number generator, repeat Problem 26.

31. Repeat Problem 28 using a random number generator.