	HOMEWORK #1	DUE: IN CLASS

1. Consider a cellular system that uses a 7-cell reuse cluster with hexagonal" cells.

   a) Show graphically the worst case co-channel interference for the reverse channel.

   b) Assuming the simple power-law path loss model, calculate the worst case Signal-to-Interference ratio in terms of propagation exponent n. Figure 2.9 will be useful for this problem.

   c) Calculate the values of S/I for $n=2,3,4$.

2. Consider the one dimensional array of base stations in Figures 2.3 and 2.4, and only one tier of co-channel interference as was considered for eq. 2.3 and 2.5. Further consider the user moving to the right from point p in Figures 2.3 and 2.4.

   a) For $n=3$ and $M=2$, how far would the user move before the downlink failed, if the downlink fails at S/I of 10dB

   b) Assume that the user is back at p and that the cochannel users are in the close user positions of Figure 2.4. Now assume that the closest cochannel interferer (the one to the right of p) moves left towards base station II. Under these conditions, how far to the left does the closest cochannel user move before the $\frac{S}{I}$ of the user at p decreases to 10dB.

3. Derive the number of channel sets (C_s) and the reuse interval (M) formulas for the 2-dimensional hexagonal grid base stations:

$$C_s = k^2 + l^2 + kl$$

$$M = \sqrt{k^2 + l^2 + kl}$$

4. Suppose that we decided to use more realistic model than Erlang C, in which we have still N channels but queue size is not infinite but a finite value M. An arrival which occurs when queue is full is blocked, leaves the system and does not return. Besides, each customer in the queue, after waiting for some random time interval, cancels his call, leaves the system and does not return. Waiting times are assumed to be iid and distributed according to negative exponential distribution with parameter ω. Find the blocking and wait probabilities for this model.

5. Exercises in trunking (queueing) theory:

a) What is the maximum system capacity (total and per channel) in Erlangs when providing 2% blocking probability with 4 channels, with 20 channels, with 40 channels. Use enclosed Erlang B chart as necessary.

b) How many users can be supported with 40 channels at 2% blocking? Assume $\frac{1}{\mu} = 105\,s$, $\lambda = 1$ call/hour

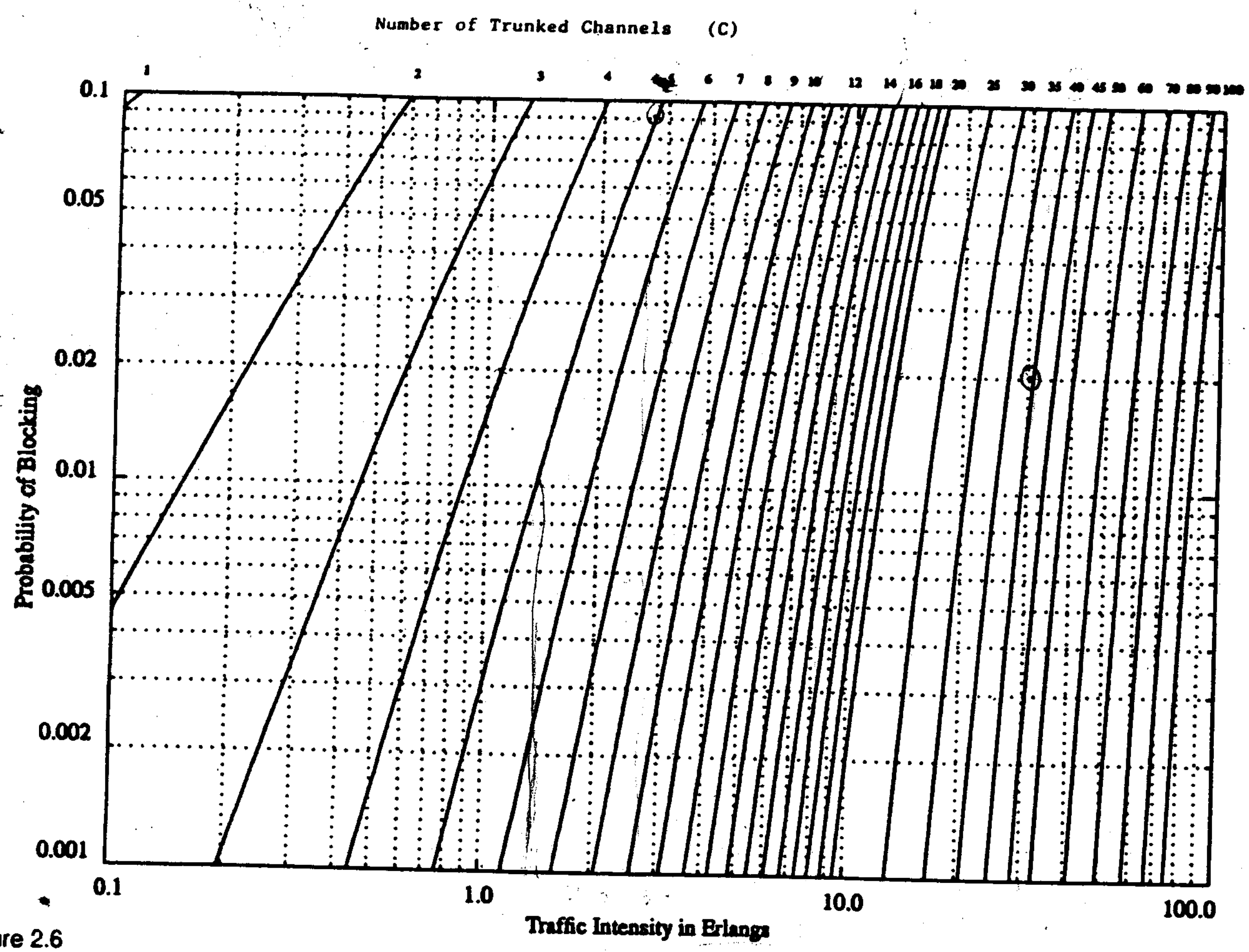


Figure 2.6
The Erlang B chart showing the probability of blocking as functions of the number of channels and traffic intensity in Erlangs.

Source : Rappaport

6. 5 years ago, there was a single company offering wireless communications service to a certain city. There were 15 channels per base station throughout the coverage area. Due to a recent court case result against undesirable monopolies, we now have 3 companies to provide personal communications service in the same area and not changing the density of channels per area, with the argument that it is the same total 15 channels. However, you note that the customers of one company will not be able to access the channels of the others. Therefore, the channel access group has been reduced by a factor of 1/3.

Assume that the offered traffic is also divided equally among the three companies, and that each company can now provide 15/3 = 5 channels per base station. Also, assume access to only one base station and that you want to use the same base station placement as would have been used for the 15 channel per base station system.

Summary : base station placement is the same, and the same number of channels are available in each base station. The difference is that customers are only allowed access to 5 channels per base station (depending on which company they are subscribing to).

Assume a specified blocking probability of 0.01 for the cases before and after the split.

a) What is the Erlang B blocking probability of a 1/3 capacity (5 channels) base station when offered 1/3 of the 8.11 Erlangs of traffic?

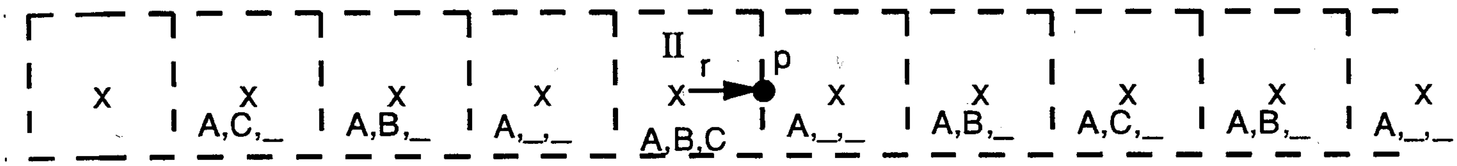
b) What is the Erlang B blocking probability if the traffic offered to the 5 channels is reduced to 1.36 Erlangs?

c) What is the ratio of the traffic offered capacity in Erlangs when used undivided (15 channels/base station) to the traffic offered in Erlangs when divided among 3 equal sets of users (5 channels/base station). Assume base station density is the same in both cases and that the required blocking probability is the same at 0.01.

d) What could you do to decrease the blocking probability of the 1/3 size system (5 channels/base station?)

Figure 2.3

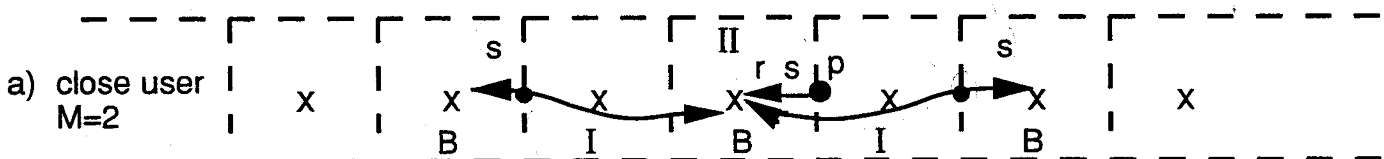
Downlink Interference Representation



One Dimensional Array of Base Stations

Figure 2.4

Uplink Interference Representation



Uplink Interference Representation

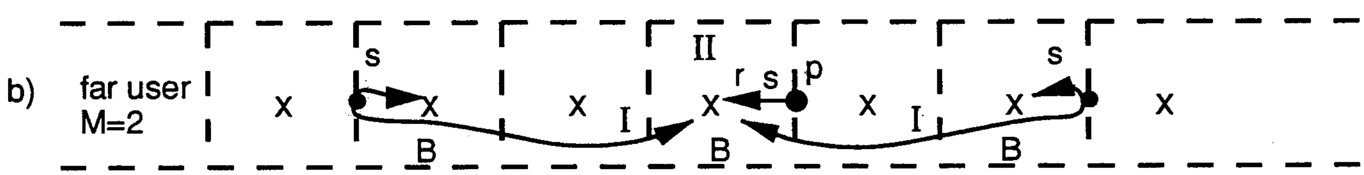
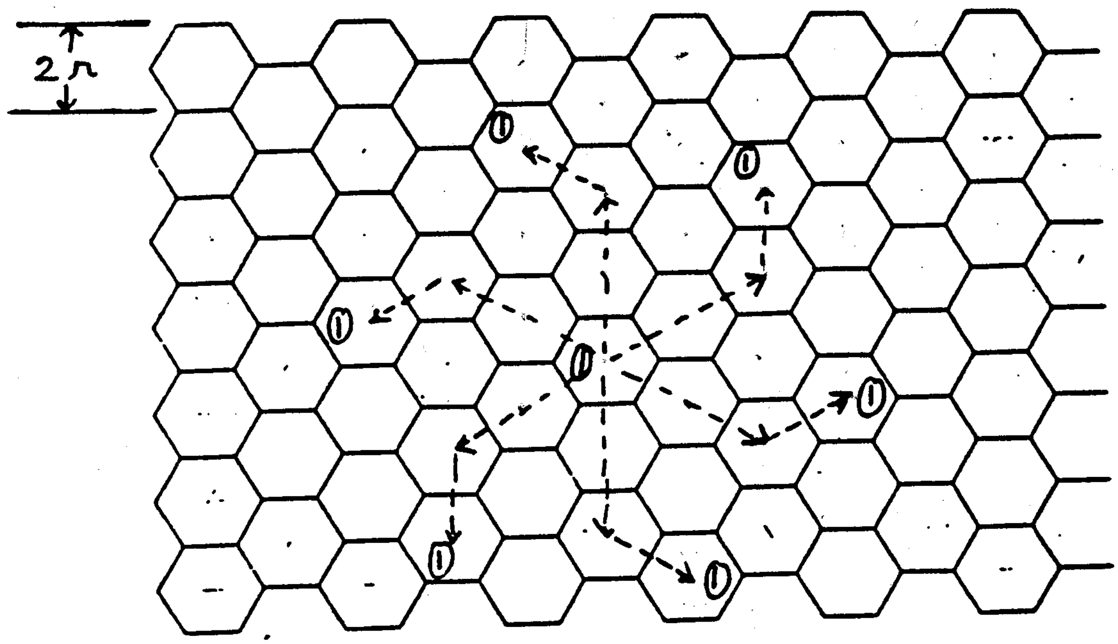
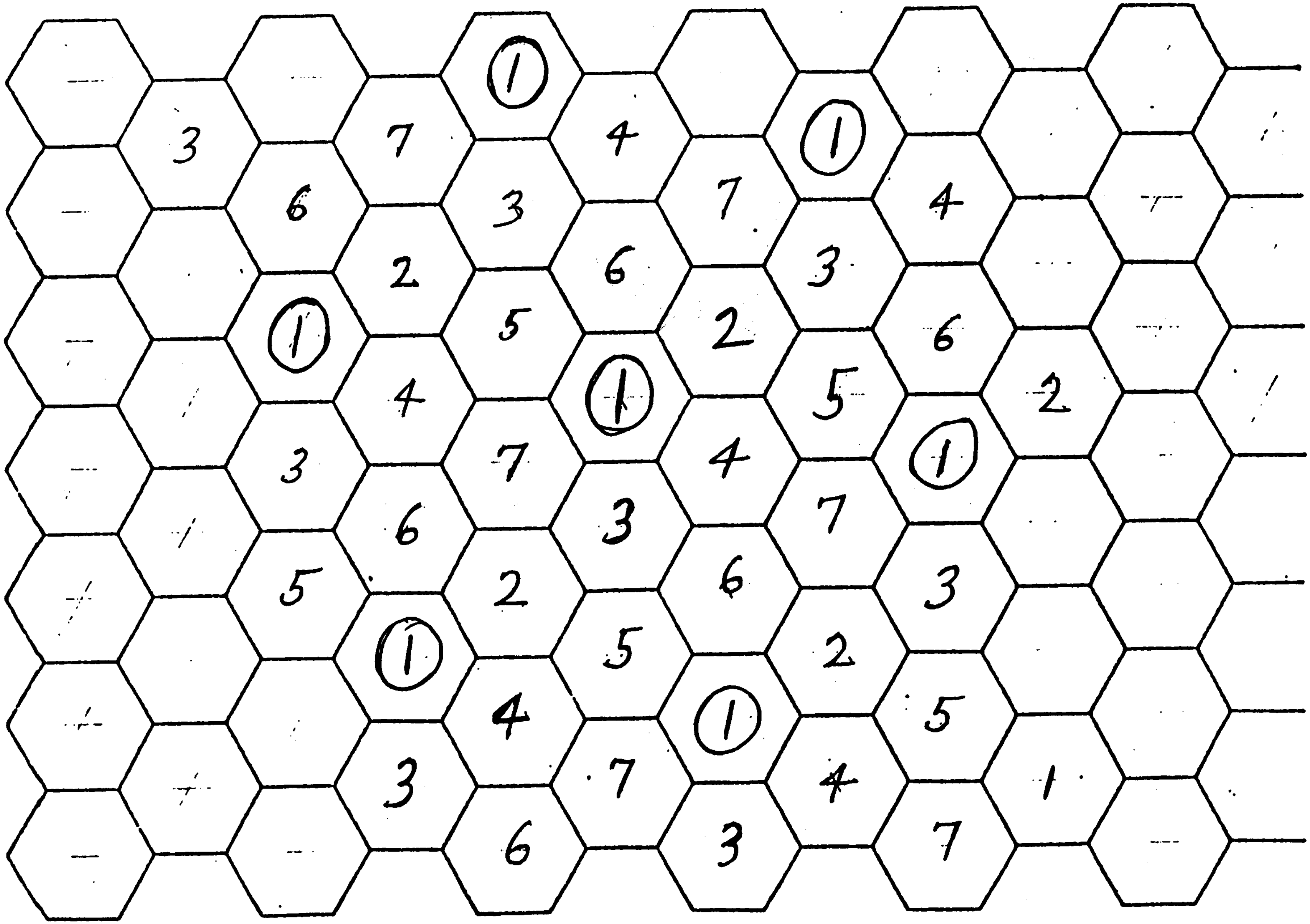


Figure 2.8

Hexagonal Cells:

k=2 and *l*=*1*





$C_s = 7$ Set Reuse Pattern

Figure 2.9

HOMEWORK #2 :

1. Consider a user of wireless personal communications set moving slowly in a residential area having many random paths arriving at many random angles so the envelope variations of the small scale multipath variation is well approximated by a Rayleigh distribution. Over the distance interval of motion there is no large scale (shadow) signal variation, i.e. the mean of the small scale variation does not change over the interval. Also, assume that from subjective listening tests it has been determined that users judge the radio link to be acceptable under these conditions if only 2% of the time the signal level falls below the minimum usable signal level threshold.

How many dB must the median signal level exceed the minimum usable signal level threshold in order to insure that the signal does not fall below that threshold more than 2%. (i.e., how much signal margin must be allowed relative to the median to insure that only 2% of the distance moved through will have signal level below the minimum threshold.) Do the problem for no receiving diversity.

2. Large scale signal variation can be approximated by a log-normal distribution with a standard deviation, σ_s. Interference also can be approximated by a log-normal distribution with a different standard deviation, σ_i. Let signal power be represented by S and interference power by I, then, if we define

$s = 10 \log S$

$i = 10 \log I$

then s and i are normally distributed with means $\bar{s}$ and $\bar{i}$ and standard derivations σ_s and σ_i. Then the S/I ratio becomes s-i and a quantity of interest often is

$$P_1 = P\{s - i < \gamma\}$$

where γ is a signal-to-interference threshold for a system in decibels. Derive a relationship for P_1 in terms of $\bar{s}$, $\bar{i}$, σ_s, σ_i and γ.

[Hint: the final expression will contain a variable v-function of ($\bar{s}$, $\bar{i}$, σ_s, σ_i and γ)]

3. Consider a wireless system with the following parameters:

transmitter power of +20 dBm (20 dB greater than 1 milliwatt)

minimum usable received power of -100 dBm (100dB less than 1 milliwatt)

gain of transmitting antenna=10 dB

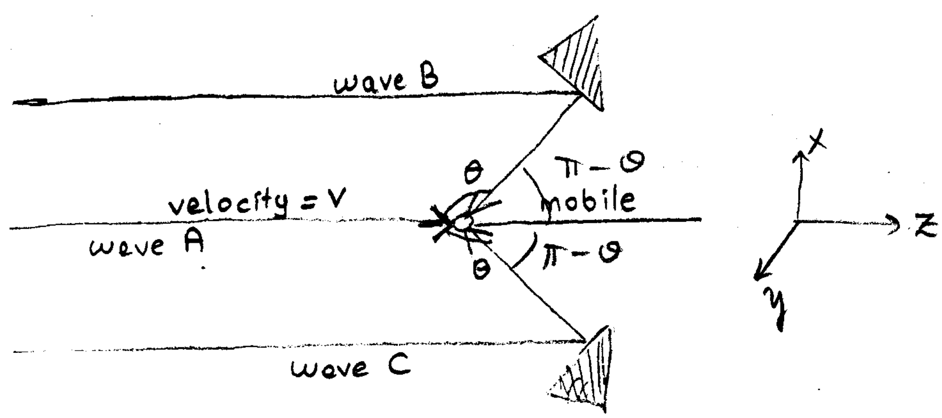
gain of receiving antenna=0 dB

frequency=2 GHz

a) What is the distance in free space over which the wireless system will work?

b) Assume propagation over a flat earth with ideal reflection coefficient of -1. For h_t=30 ft and h_r=5 ft, what is the distance over which the wireless systems will work? (h_t is height of transmitting antenna, h_r is height of receiving antenna). Compare this distance with the distance in free space in a.

4.



Consider the situation in Figure above where mobile station is moving in the vicinity of two local scatterers.

[redacted] each of which has [redacted] a reflection coefficient of 0.5. The reflecti coefficient is the ratio of the amplitudes of the reflected and incident electric fields.

a) Derive an expression for the resultant signal from paths A, B, and C ?

b) Plot the amplitude variation due to multipath fading and calculate the doppler frequency. (Assume $\tau_A = \tau_B = \tau_C$, i.e. time delays of all paths are same, $\theta = 30°$, $v = 30 km/hour$, $f_c = 900 MHz$)

5. Consider a zero-mean complex Gaussian random process $r(t)$ having the autocorrelation function $\phi_{rr}(\tau)$. Determine the correlation function of $z(t) = |r(t)|^2$. Write the expression for $\phi_z(\tau)$ when $r(t)$ is the signal received at isotropic scattering case for a mobile with constant speed v_z.