SNS COLLEGE OF TECHNOLOGY

Coimbatore – 35

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

19ECT311 / Wireless Communication

III ECE/ VI SEMESTER

Unit I -**FUNDAMENTALS OF WIRELESS COMMUNICATION**

Topic 6 : Interference and system capacity

Interference and System Capacity

- It is a major limiting factor in the performance of cellular radio systems.

- Creates bottleneck in increasing capacity

- Interference in Voice Channels: Cross-Talk

- Interference in Control Channels: missed/blocked calls

- Urban areas usually have more interference,

because of:
    a) Greater RF Noise Floor,
    b) More Number of Mobiles

Interference and System Capacity

- Sources of interference
  - Another mobile in the same cell
  - A call in progress in the neighboring cell
  - Other base stations operating in the same frequency band
  - Noncellular system leaks energy into the cellular frequency band
- Two major cellular interference
  - Co-channel interference
  - Adjacent channel interference

Co-channel Interference and System Capacity

- Frequency reuse - there are several cells that use the same set of frequencies
- The cells that use the same set of frequencies are called co-channel cells
- The interference between signals from these cells is called Co-Channel Interference (CCI)
- Cannot be controlled by increasing RF power. Rather, this will increase CCI
- To reduce co-channel interference, co-channel cell must be separated by a minimum distance

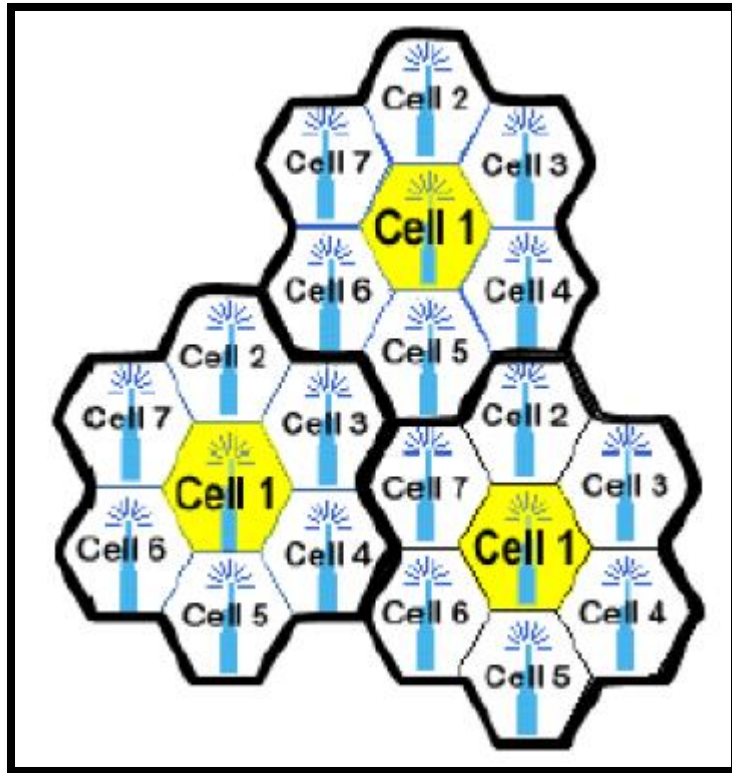# Co-channel Interference and System Capacity

- When the size of the cell is approximately the same
  - co-channel interference is independent of the transmitted power
  - co-channel interference is a function of
    - R: Radius of the cell
    - D: distance to the center of the nearest co-channel cell
- Increasing the ratio $Q=D/R$, the interference is reduced
- Q is called the co-channel reuse ratio

Co-channel Interference and System Capacity

❑ The yellow cells use the same set of frequency channels, and hence, interfere with each other

❑ In the cellular system there are 6 first-layer co-channels

Co-channel Interference and System Capacity

- For a hexagonal geometry

$$Q = \frac{D}{R} = \sqrt{3N}$$

- A small value of Q provides large capacity

- A large value of Q improves the transmission quality - smaller level of co-channel interference

- A tradeoff must be made between these two objectives

Co-channel Reuse Ratio for Some Values of N

	Cluster Size (N)	Co-channel Reuse Ratio(Q)
$i = 1, j = 1$	3	3
$i = 1, j = 2$	7	4.58
$i = 2, j = 2$	12	6
$i = 1, j = 3$	13	6.24

Co-channel Interference

- Let i_0 be the number of co-channel interfering cells.
- The signal-to-interference ratio (SIR) for a mobile receiver can be expressed as

$$\frac{S}{I} = \frac{S}{\sum_{i=1}^{i_0} I_i}$$

S : the desired signal power

I_i : interference power caused by the ith interfering co-channel cell base station

- n is the path loss exponent which ranges between 2 and 4
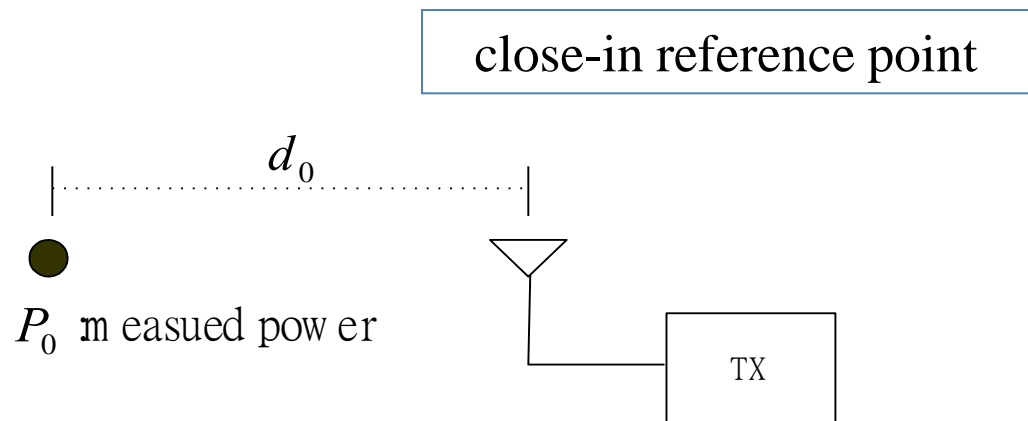
Co-channel Interference

- The average received power at a distance d from the transmitting antenna is approximated by

$$P_r = P_0 \left(\frac{d}{d_0} \right)^{-n}$$

or

$$P_r(\text{dBm}) = P_0(\text{dBm}) - 10n \log \left(\frac{d}{d_0} \right)$$

close-in reference point

d_0

P_0 measured power

TX

SIR

- When the transmission power of each base station is equal, SIR for a mobile can be approximated as

$$\frac{S}{I} = \frac{R^{-n}}{\sum_{i=1}^{i_0}(D_i)^{-n}}$$
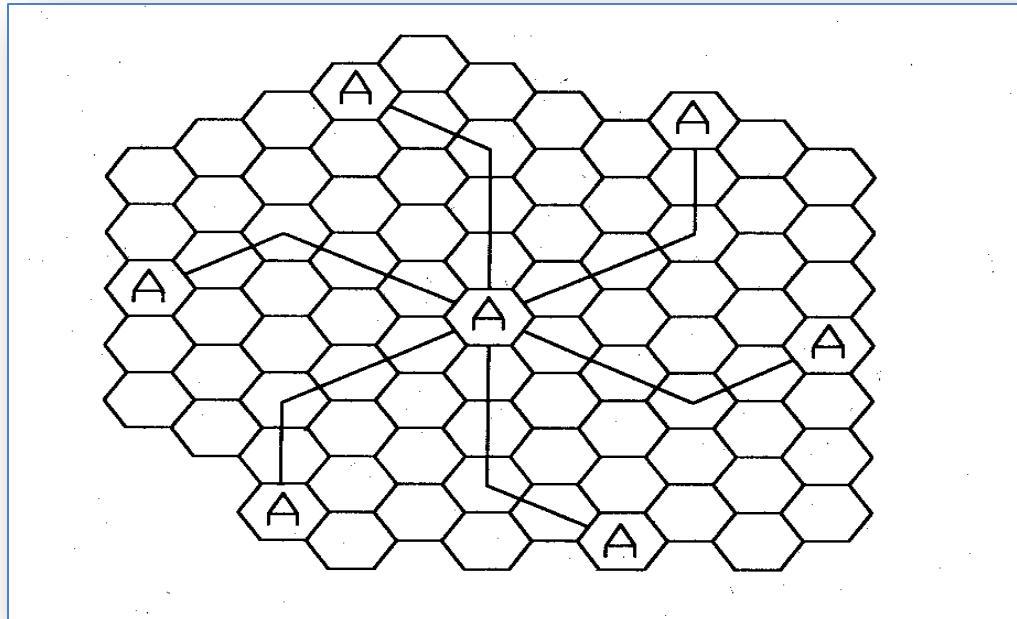
- Consider only the first layer of interfering cells

$$\frac{S}{I} = \frac{(D/R)^n}{i_0} = \frac{\left(\sqrt{3N}\right)^n}{i_0}$$

SIR

- Example: AMPS requires that SIR be greater than 18dB

  - *N* should be at least 6.49 for *n=4*.

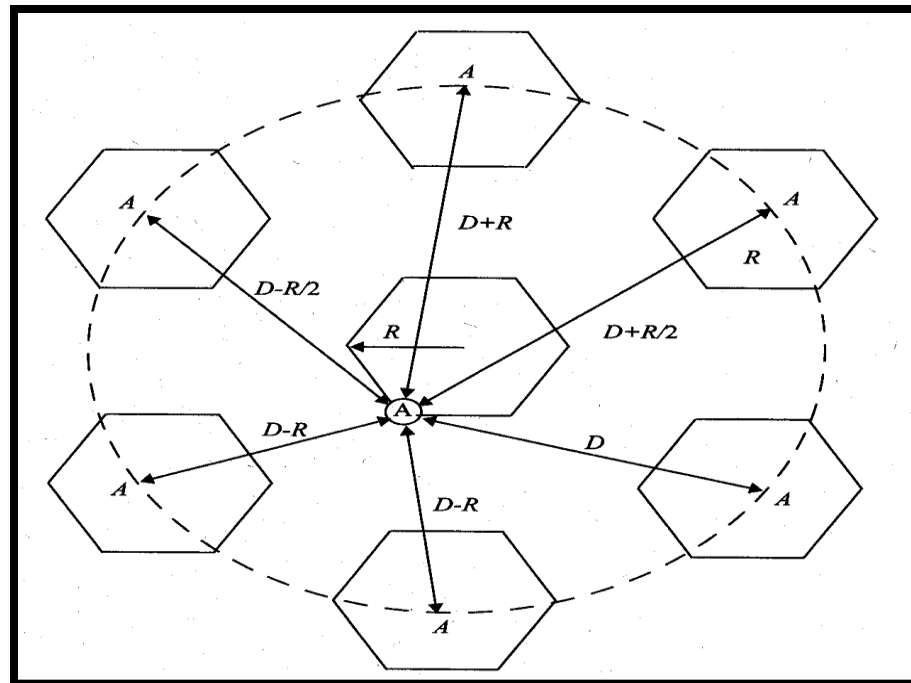 - Minimum cluster size is 7

Co-channel Interference-Example

- For hexagonal geometry with 7-cell cluster, with the mobile unit being at the cell boundary, the signal-to-interference ratio for the worst case can be approximated as

$$\frac{S}{I} = \frac{R^{-4}}{2(D-R)^{-4} + (D-R/2)^{-4} + (D+R/2)^{-4} + (D+R)^{-4} + D^{-4}}$$

Activity

Activity : Tangram Puzzle
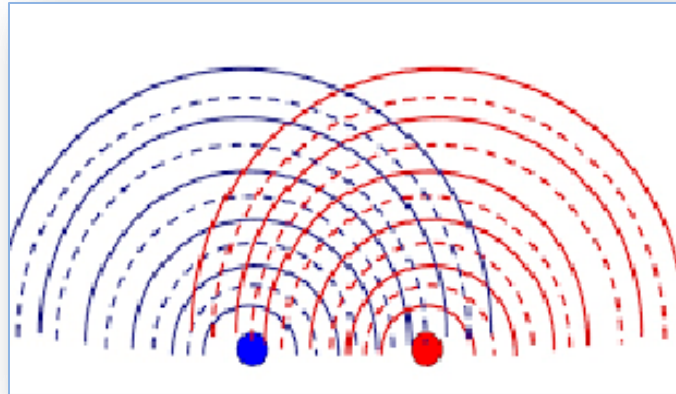
Adjacent Channel Interference

- Adjacent channel interference: Interference from adjacent in frequency to the desired signal.

  – Imperfect receiver filters allow nearby frequencies to leak into the passband

  – Performance degrade seriously due to *near-far* effect.

receiving filter
response

signal on adjacent channel

desired signal

signal on adjacent channel

FILTER

interference

desired signal
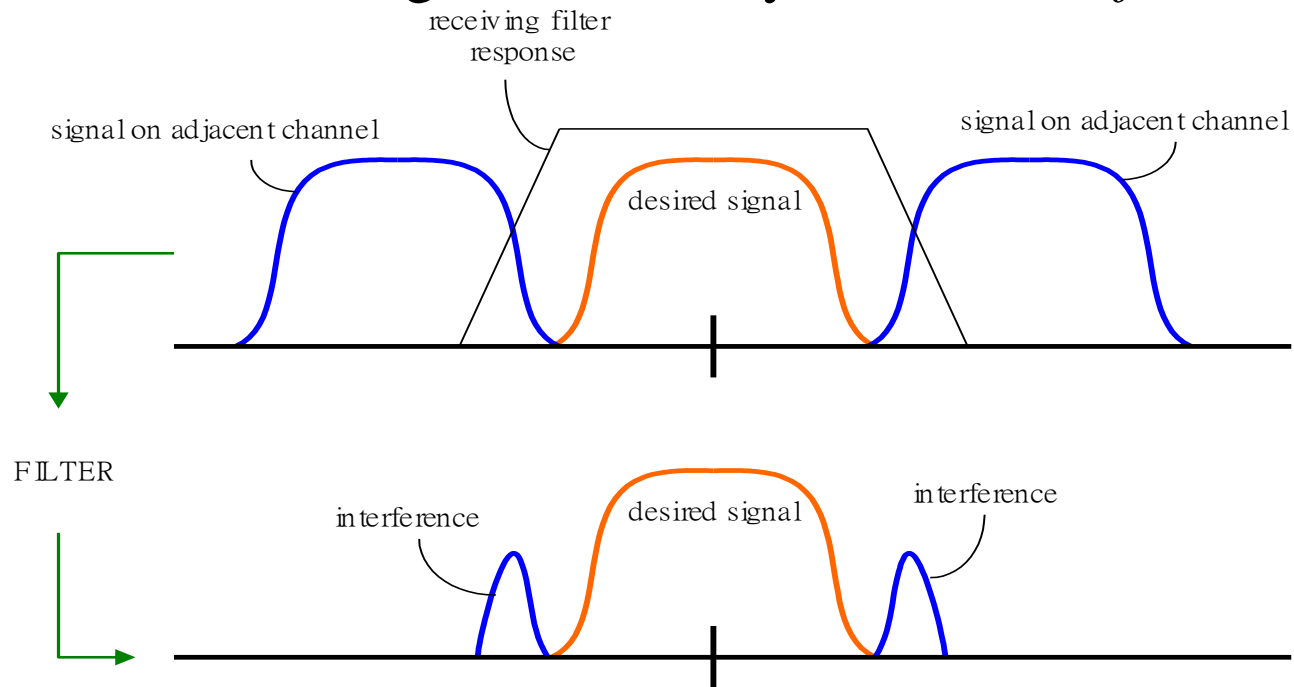
interference

Adjacent Channel Interference

- Adjacent channel interference can be minimized through careful filtering and *channel assignment*

- Keep the frequency separation between each channel in a given cell as large as possible

- A channel separation greater than six is needed to bring the adjacent channel interference to an acceptable level

Adjacent Channel Interference

- Problem is severer if the user of adjacent channel is in close proximity ➔ **Near-Far Effect**

- The other transmitter captures the receiver of the subscriber

- Also, when a Mobile Station close to the Base Station transmits on a channel, close to the one being used by a weaker mobile

- The BS faces difficulty in discriminating the desired mobile user from the "bleed over" of the adjacent channel mobile.
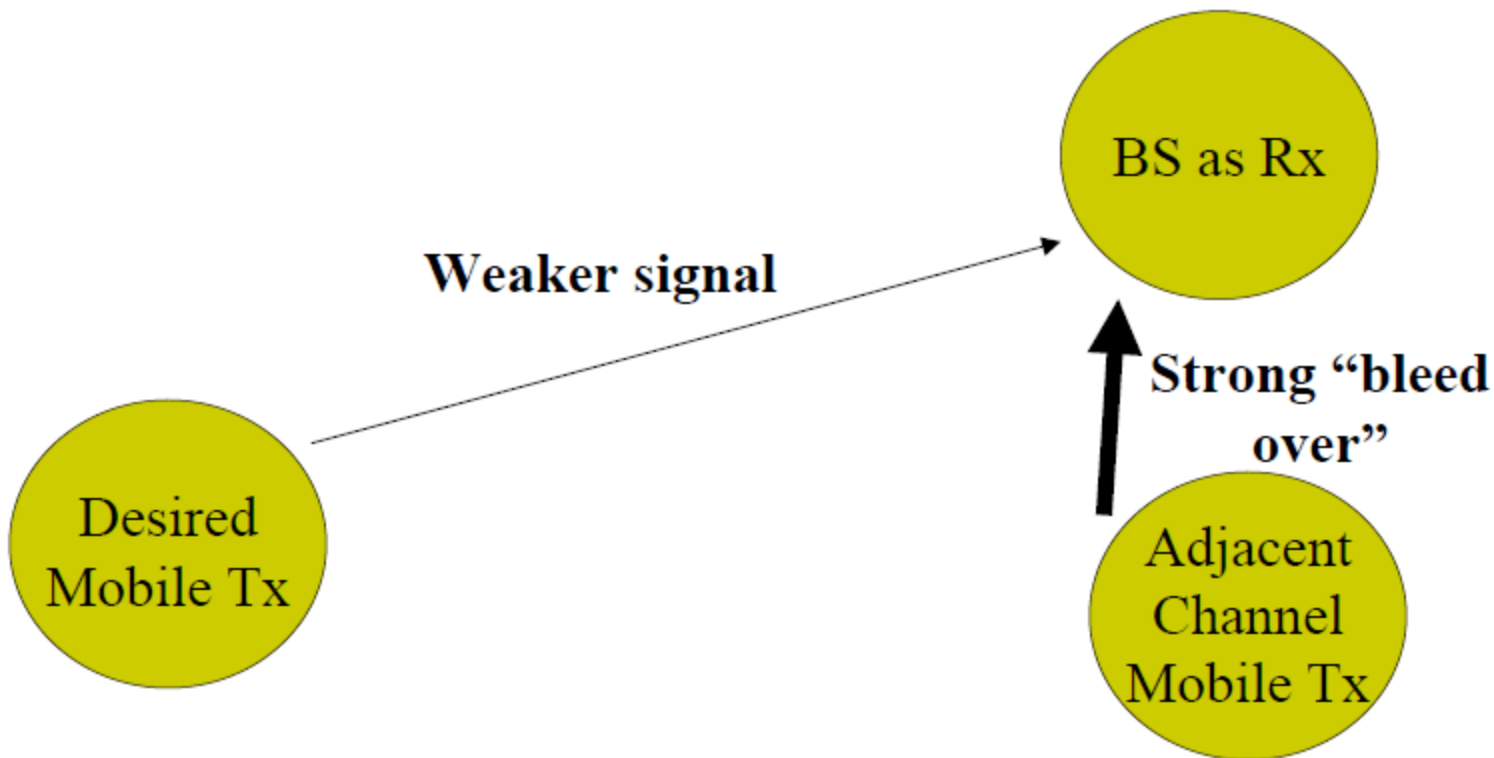
Unintended Tx

Strong "bleed over"

BS as Tx

Mobile User Rx

Weaker signal
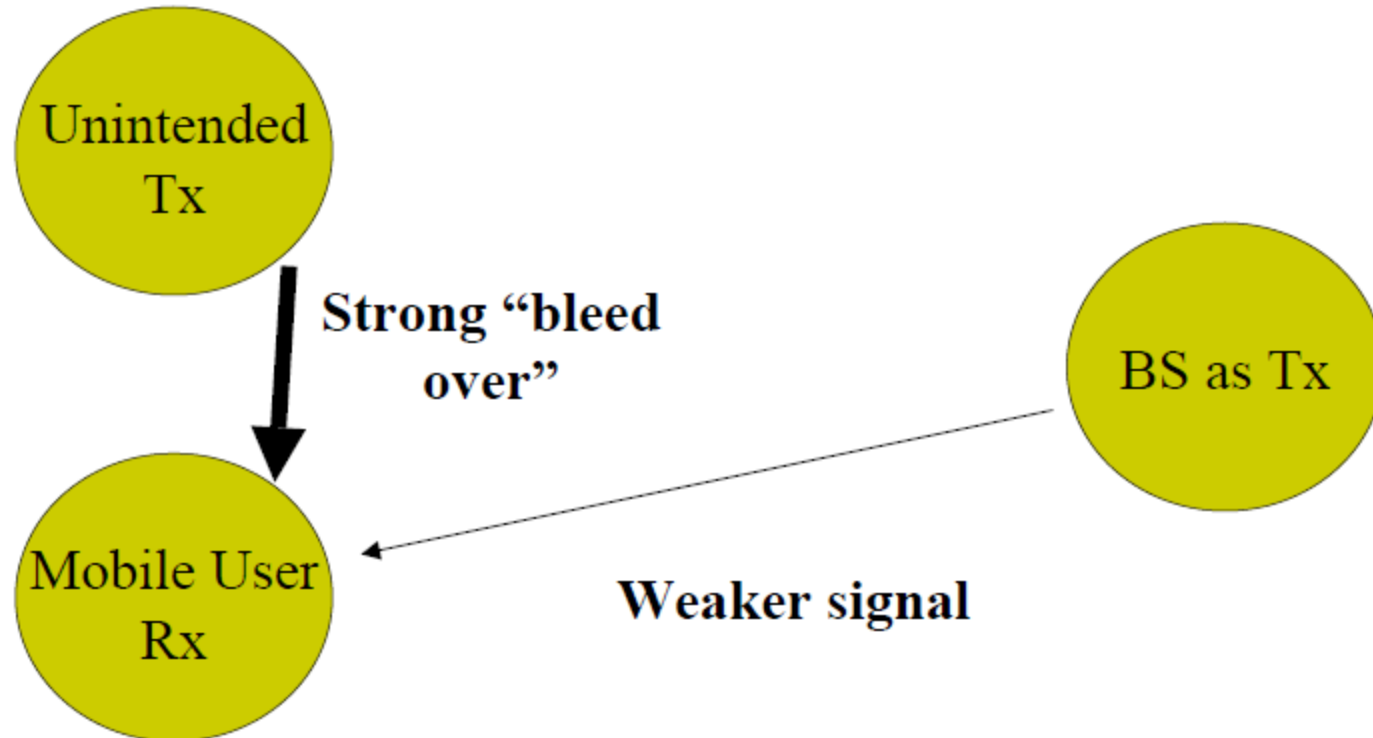
- The Mobile receiver is captured by the unintended, unknown transmitter, instead of the desired base station

Near-Far Effect: Case 2

- *The Base Station faces difficulty in recognizing the actual mobile user, when the adjacent channel bleed over is too high.*

Minimization of ACI

(1) Careful Filtering ---- min. leakage or sharp transition

(2) Better Channel Assignment Strategy

- Channels in a cell need not be adjacent: For channels within a cell, Keep frequency separation as large as possible.

- Sequentially assigning cells the successive frequency channels.

- Also, secondary level of interference can be reduced by not assigning adjacent channels to neighboring cells

- For tolerable ACI, we either need to increase the frequency separation or reduce the passband BW

Power Control for Reducing Interference

- Ensure each mobile transmits the smallest power necessary to maintain a good quality link on the reverse channel
  - long battery life
  - increase SIR
  - solve the near-far problem
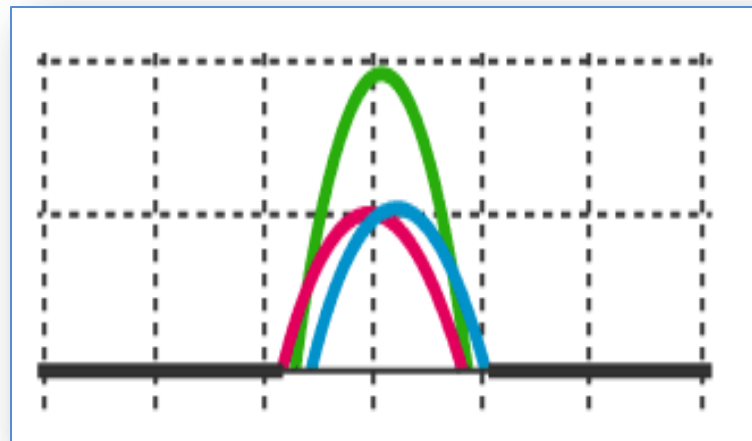
Assessment

1. If a signal to interference ratio of 15db is required for satisfactory forward channel performance of a cellular system, what is the frequency reuse factor and cluster size that should be used for maximum capacity if the path loss exponent is (a) n=4 (b) n=3? Assume that there are six co channel cells in the first tier, and all of them are at the same distance from mobile .Use suitable approximations.