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

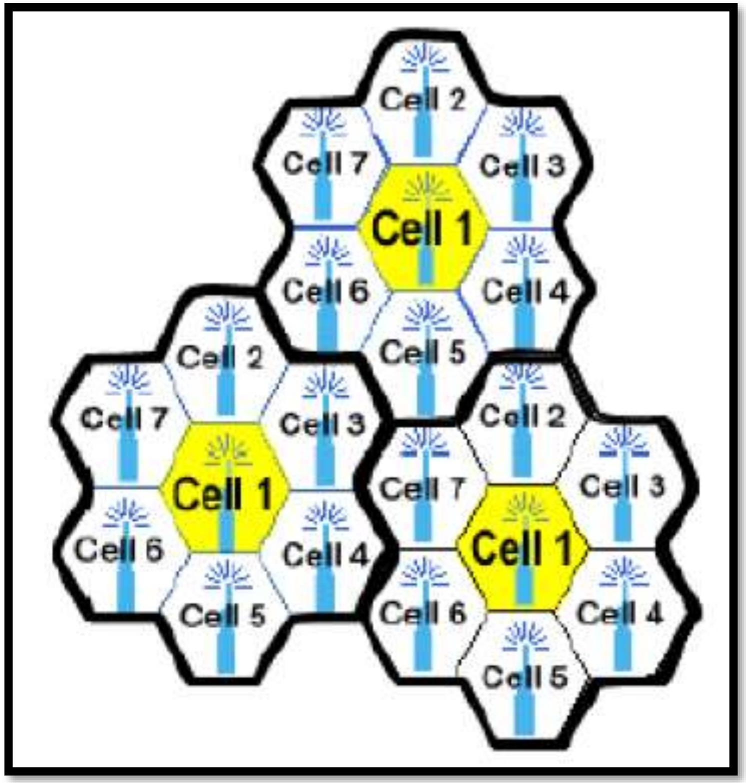
Co-channel Interference and System Capacity

- 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

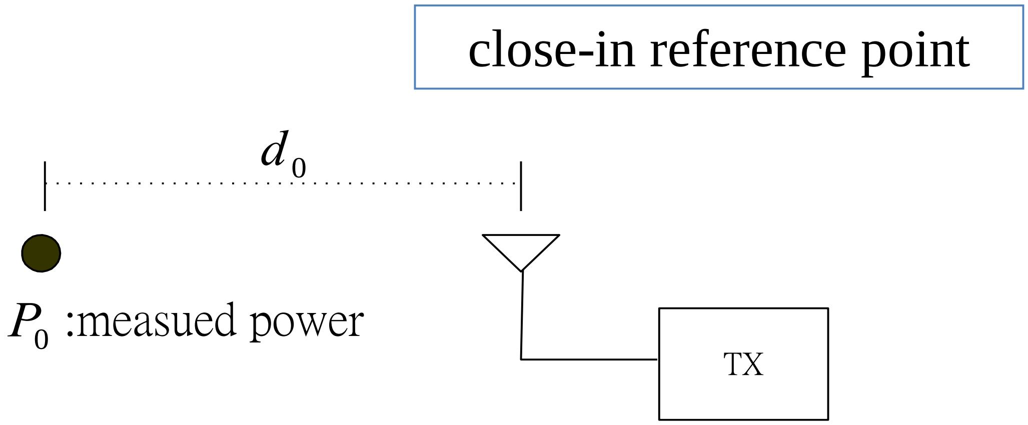
Co-channel Interference

- 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

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



SIR

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

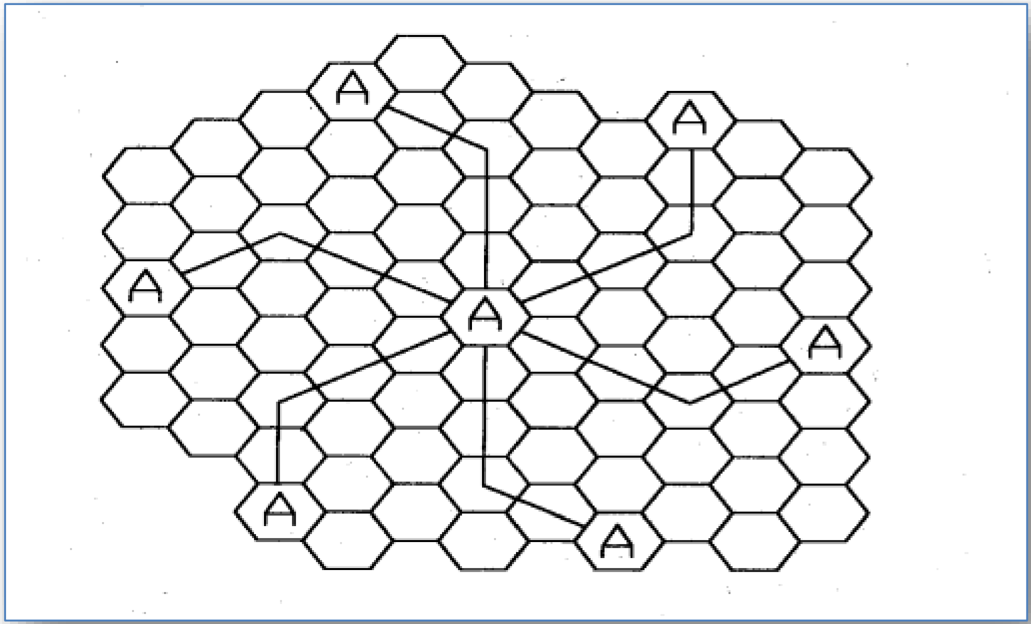
$$\frac{S}{I} = \frac{R^{-n}}{\sum_{i=1}^{i_0} (D_i)^{-n}}$$

- 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

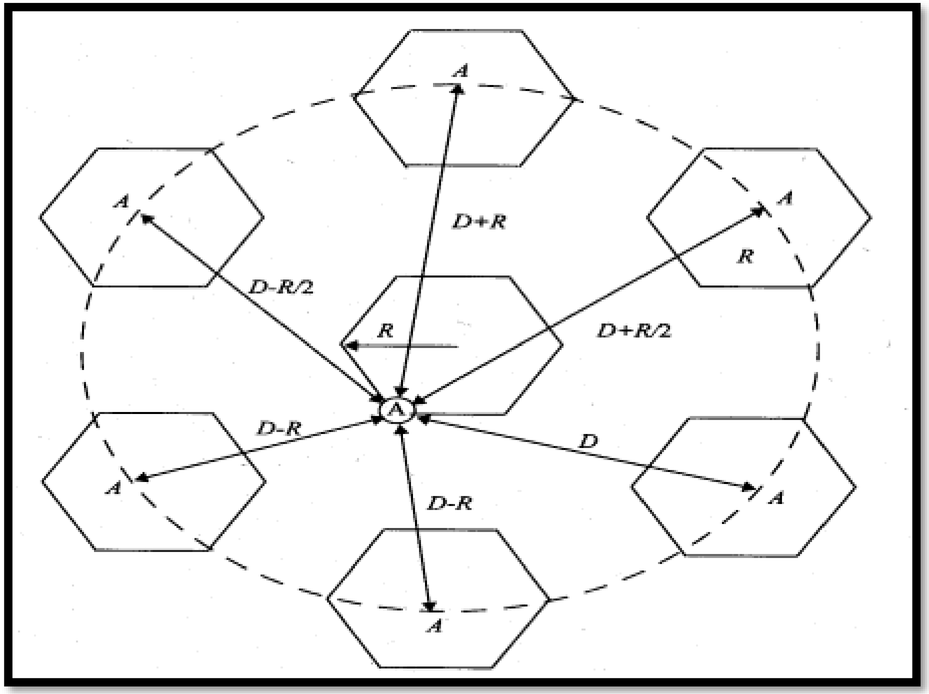
- Example: AMPS requires that SIR be greater than 18dB
  - *N* should be at least 6.49 for *n=4*.
  - Minimum cluster size is 7



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

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

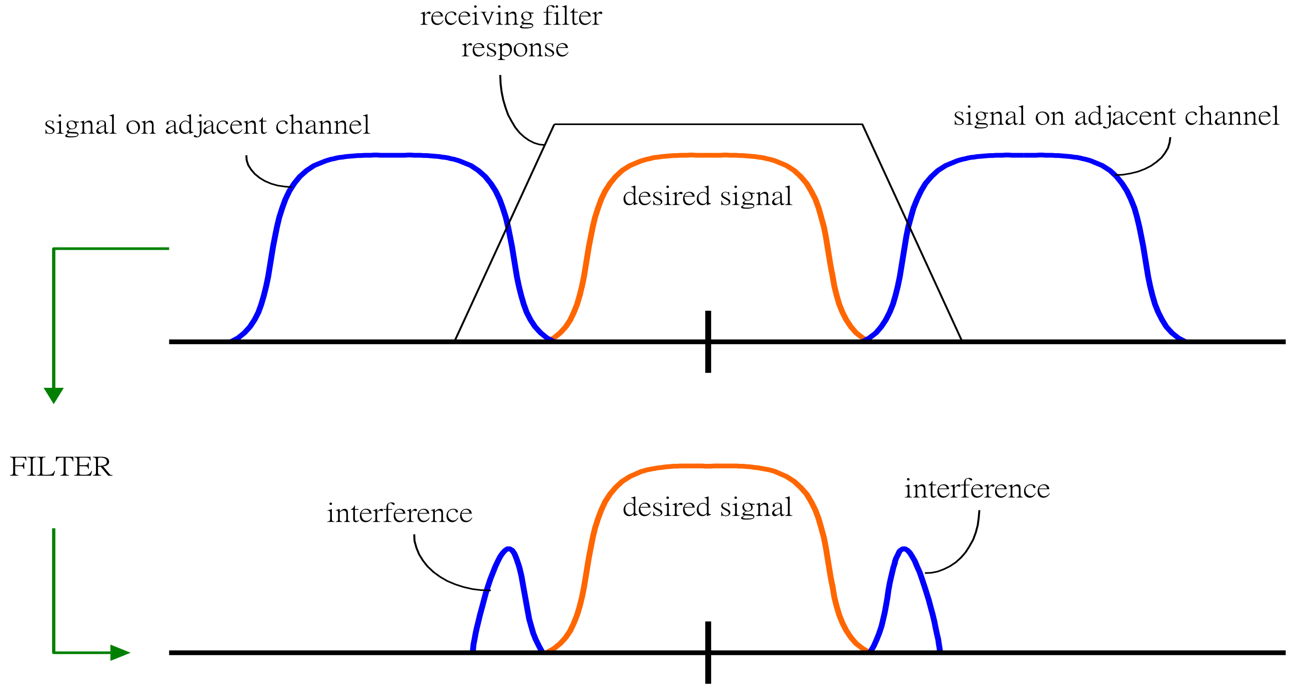


Activity

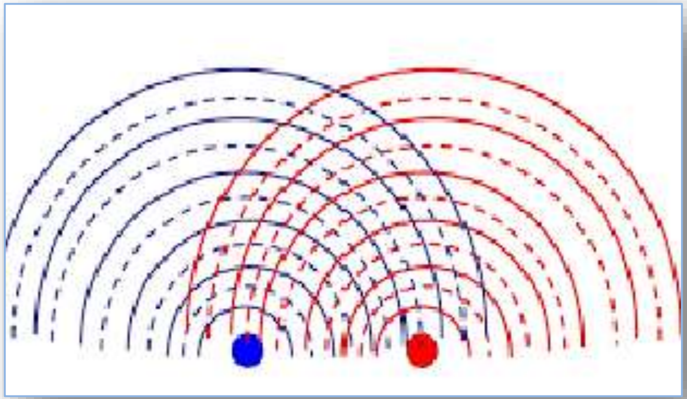
Activity : Tangram Puzzle

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.



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

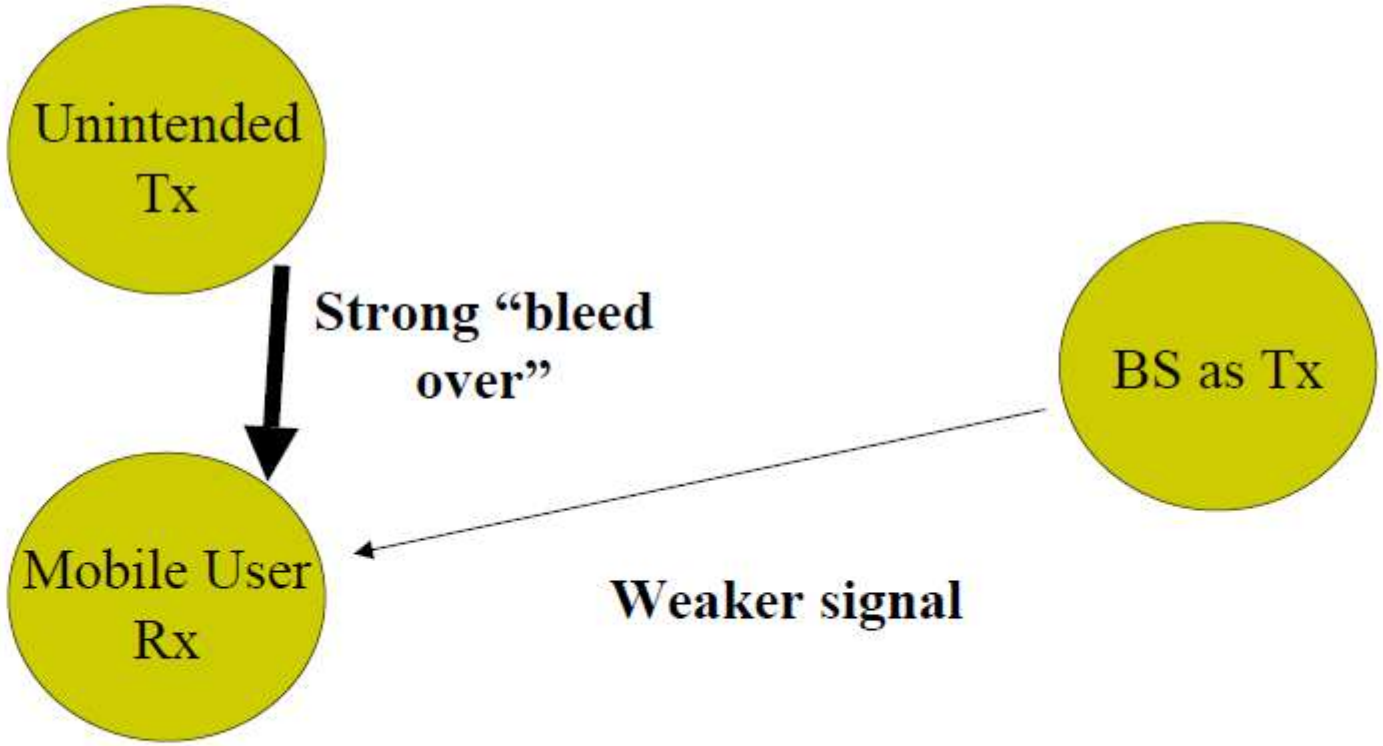
- Problem is severer if the user of adjacent channel is in close proximity → **Near-Far Effect**

- 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

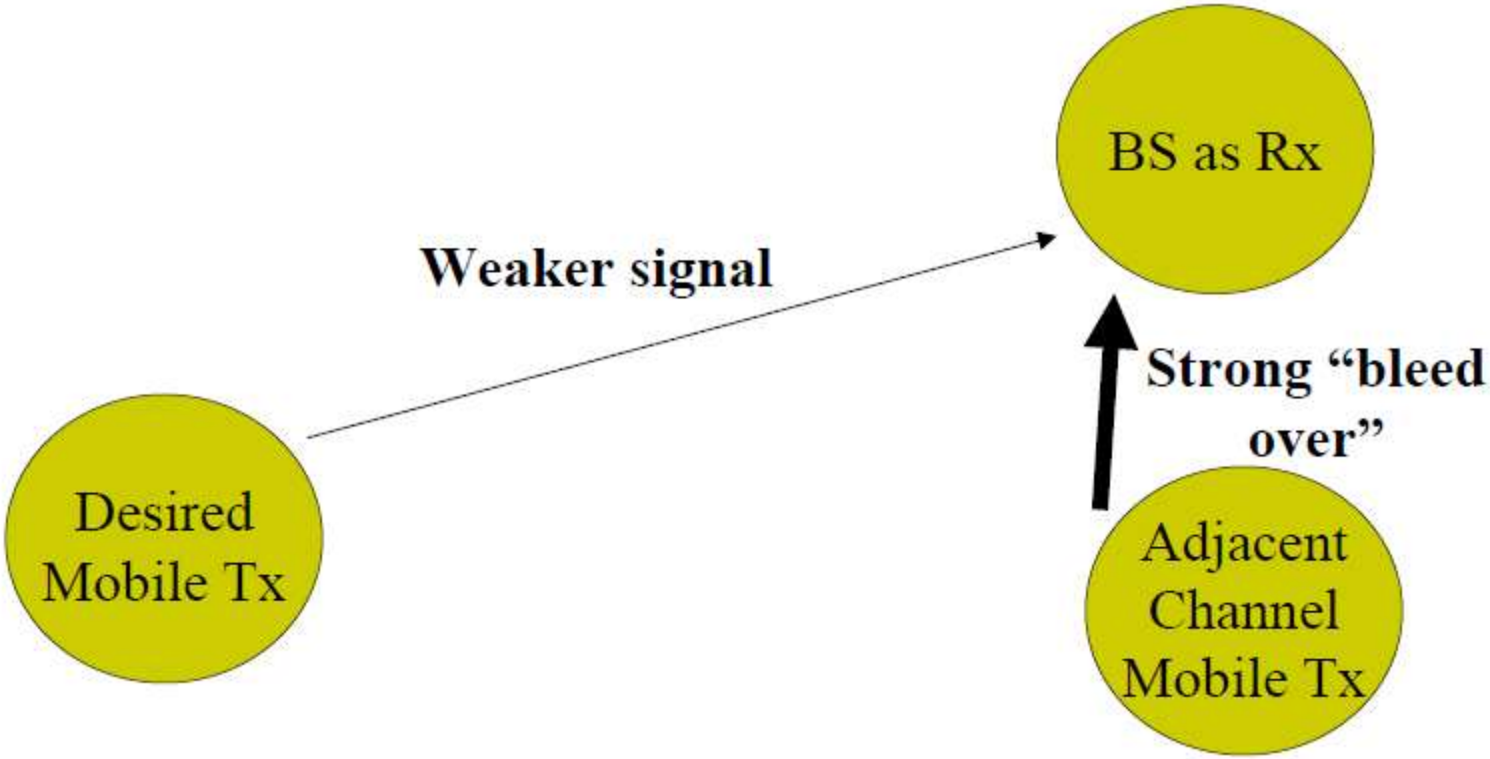
- The BS faces difficulty in discriminating the desired mobile user from the “bleed over” of the adjacent channel mobile.

Near-Far Effect: Case 1



- 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

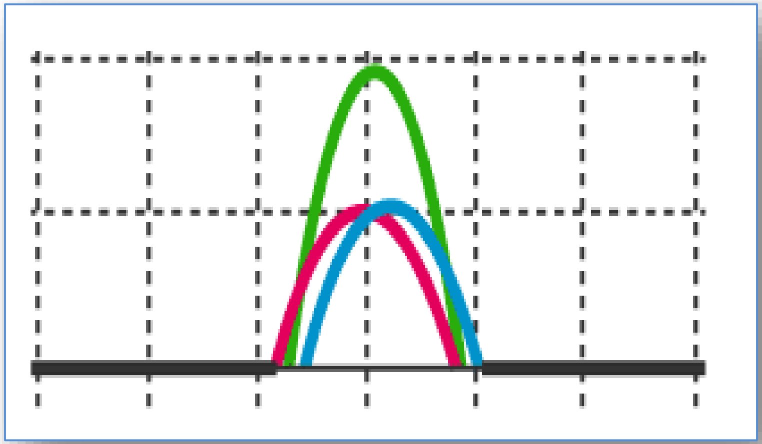
(1) Careful Filtering ---- min. leakage or sharp transition

(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.