Chapter 2
Elements of Cellular Mobile Radio System Design

SOURCE:

MOBILE CELLULAR TELECOMMUNICATIONS

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General Description of the Problem

- Aim – efficient spectrum utilization

- Elements of Cellular Mobile Radio System Design
- (1) the concept of frequency reuse channels
- (2) the co-channel interference reduction factor
- (3) the desired carrier-to-interference ratio
- (4) the handoff mechanism
- (5) cell splitting.

- Challenge - to serve the greatest number of customers with a specified system quality

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- 1. How many customers can we serve in a busy hour?
- 2. How many subscribers can we take into our system?
- 3. How many frequency channels do we need?

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Maximum Number of Calls Per Hour Per Cell

- The size of the cell
- The traffic conditions in the cell

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Maximum Number of Frequency Channels Per Cell

- Average calling time in the system
- Charging rate of the system
- The general income profile of the users

- **Offered load = A = Qi * T (hours) erlangs**
- average calling time - *T*
- maximum calls per hour per cell - Q_i

- Let the maximum calls per hour Q_i in one cell be 3000 and an average calling time T be 1.76 min. The blocking probability B is 2 percent.
- Find the offered load and number of channels.

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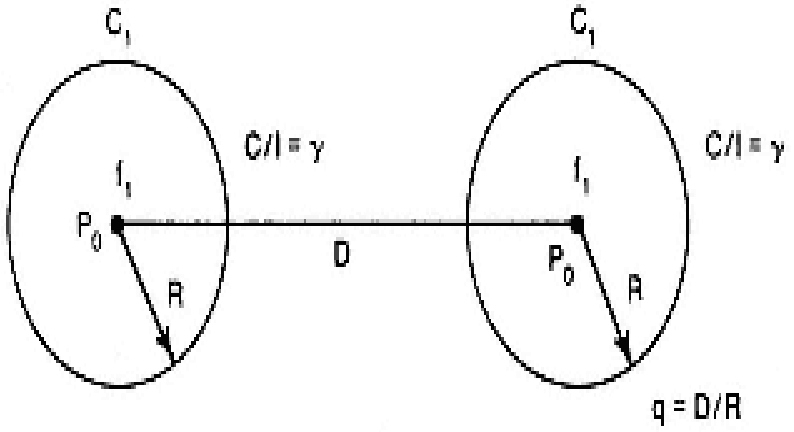
Concept of Frequency Reuse Channels

- In this frequency reuse system, users in different geographic locations (different cells) may simultaneously use the same frequency



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- increase the spectrum efficiency
- Interference due to the common use of the same channel is called *cochannel interference*

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Frequency Reuse Schemes

- Frequency reuse in the time domain results in the occupation of the same frequency in different time slots
- Frequency reuse in the space domain
  - 1. Same frequency assigned in two different geographic areas, such as AM or FM radio stations using the same frequency in different cities.
  - 2. Same frequency repeatedly used in a same general area in one system the scheme is used in cellular systems.

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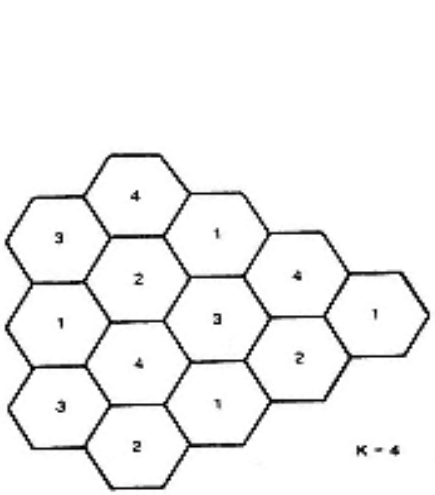
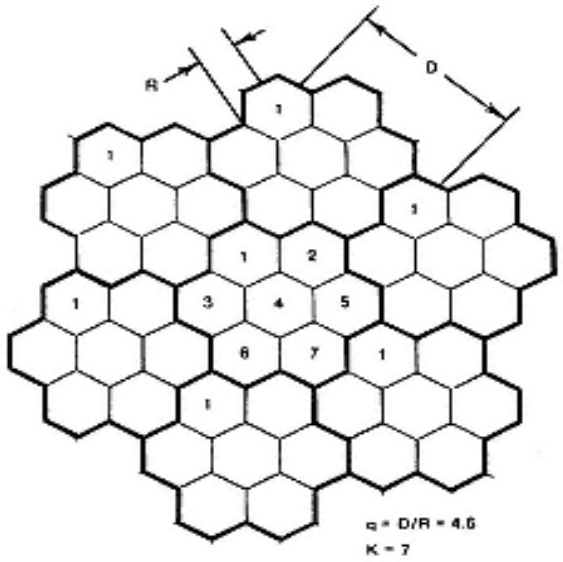
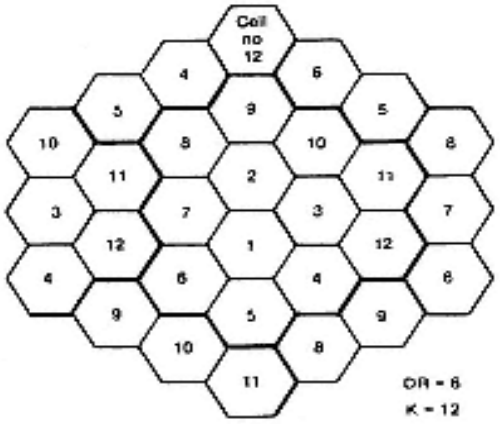
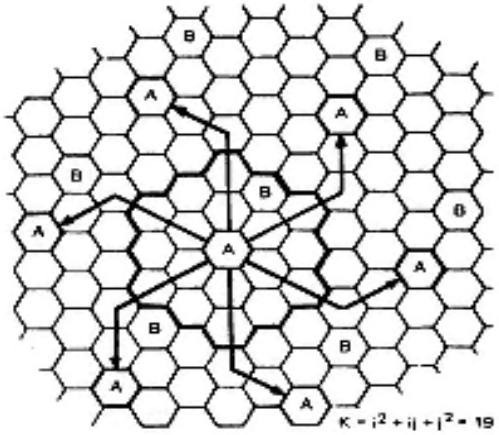




12 Cell reuse pattern to start-up configuration



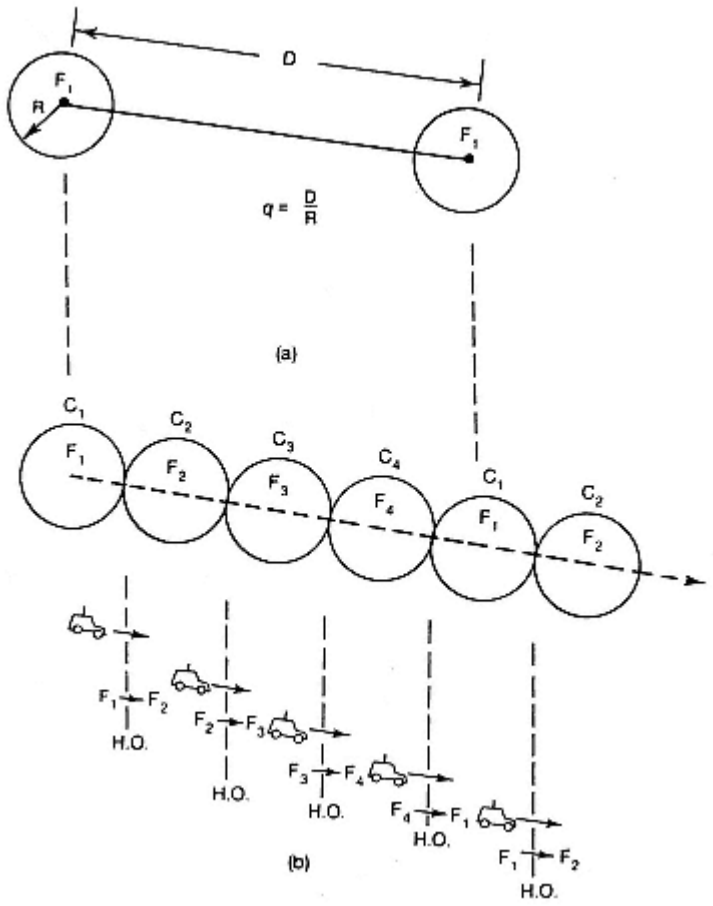


Shift parameters i = 3, j = 2

$$D = \sqrt{3K}\, R \qquad (2.2\text{-}1)$$

$$D = \begin{cases} 3.46R & K = 4 \\ 4.6R & K = 7 \\ 6R & K = 12 \\ 7.55R & K = 19 \end{cases}$$

Handoff mechanism



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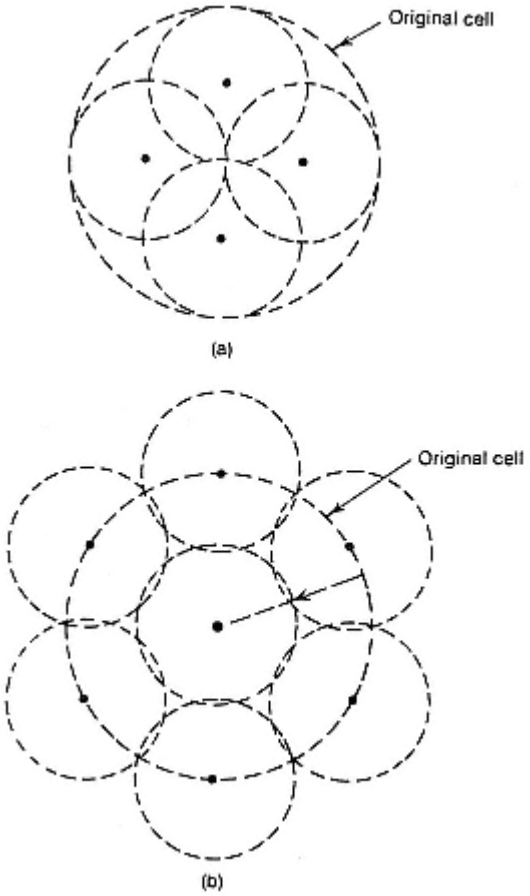
Cell splitting



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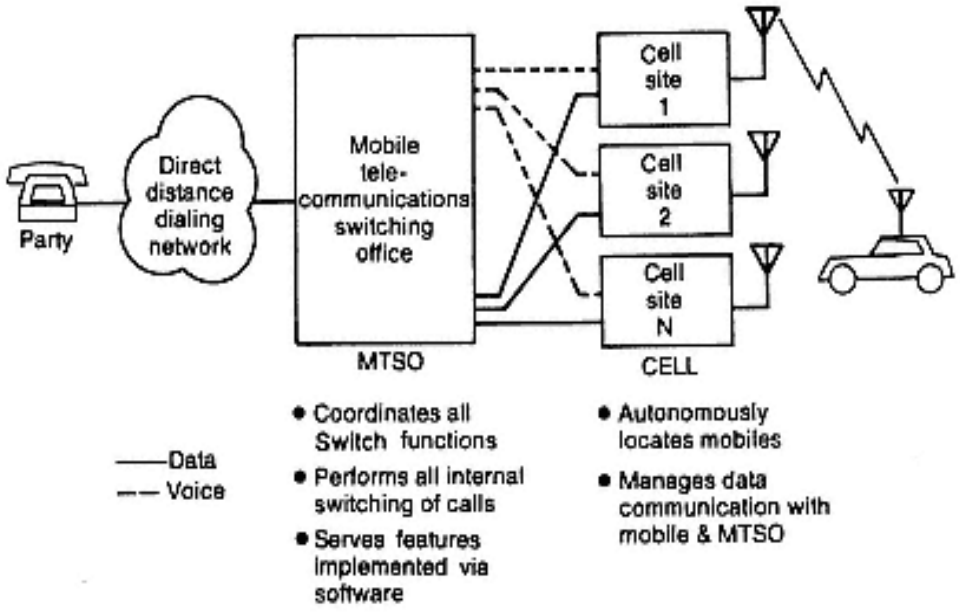
Consideration of the Components of Cellular Systems



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Cochannel Interference Reduction Factor

- q= D/R
- D = f(KI, C/I)
- where K_I is the number of cochannel interfering cells in the first tier and
- *C/I* is the received carrier-to-interference ratio at the desired mobile receiver

$$\frac{C}{I} = \frac{C}{\sum_{k=1}^{K_I} I_k} \qquad (2.3\text{-}3)$$

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$$\frac{C}{I} = \frac{R^{-\gamma}}{\sum_{k=1}^{K_I} D_k^{-\gamma}} \qquad (2.3\text{-}4)$$

$$\frac{C}{I} = \frac{1}{\sum_{k=1}^{K_I} \left(\frac{D_k}{R}\right)^{-\gamma}} = \frac{1}{\sum_{k=1}^{K_I} (q_k)^{-\gamma}} \qquad (2.3\text{-}5)$$

$$q_k = \frac{D_k}{R} \qquad (2.3\text{-}6)$$

where q_k is the cochannel interference reduction factor with kth cochannel interfering cell

$$\frac{C}{I} = \frac{R^{-\gamma}}{6D^{-\gamma}} = \frac{q^{\gamma}}{6} \qquad (2.4\text{-}1)$$

Thus

$$q^{\gamma} = 6\frac{C}{I} \qquad (2.4\text{-}2)$$

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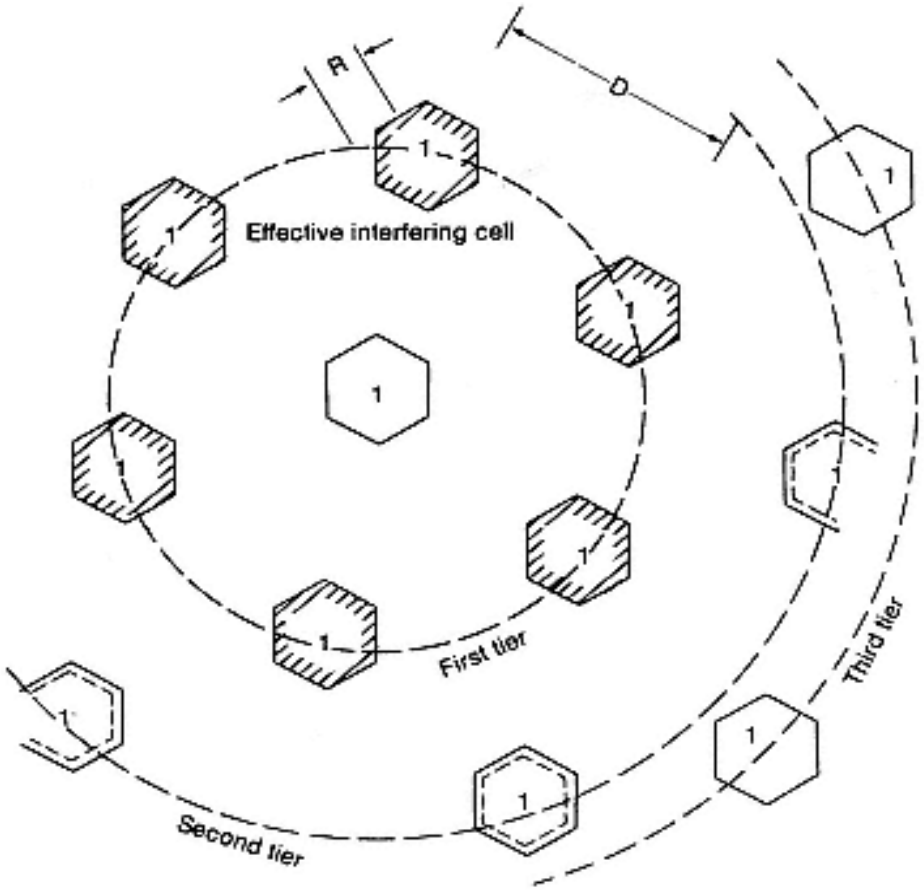
- The propagation path loss is 40dB/dec
- Hence,
- q = (6* C/I) ^1/r
- = (6 * 63.1) ^ 1/6 = 4.41
- C/I = 18dB is measured by the acceptance of voice quality from the present receivers.

The maximum number of K_I in the first tier can be shown as six (i.e., 2piD/D » 6).



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