SWE 425: Telecommunication Engineering

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Cellular Communications

Worldwide Wireless:

- **Wireless devices**
  - Mobile phones, cordless phones, remote controls, PDA, pager, laptop, iPAD PMP, MID, PND, UMPC
- **Wireless applications**
  - Wireless internet, inventory management, games, credit card verification, e-mail, navigation, entertainment, payments …
- **Wireless technologies**
  - GSM, WLAN, UMTS (3G), LTE, LTE/A. Bluetooth, Zigbee, WiMAX, microwave and many more

Why wireless?

- **No more cables**
  - No cost for installing or rewiring – terminals anywhere
  - Communications can reach where wiring is not feasible or is too costly, e.g.. rural areas, old buildings…
  - Satellite communications has global coverage
- **Mobility and convenience**
  - Allows users to access services whiling moving: walking, in vehicles, ships, planes…

Why wireless?

- **Flexibility**
  - Roaming allows the flexibility to connect and stay connected anywhere and any time
- **Scalability**
  - Much easier to expand network coverage compared to wired networks
- **Many other reasons**
  - Ad hoc, emergency, battlefield……

Challenges of wireless communication:

- Limited resources: finite radio spectrum
- Supporting mobility
  - Location management, handoff between cells/networks
- Maintaining Quality of Service (QoS) over unreliable wireless links
  - Radio path loss, shadowing, multipath fading, interference

Challenges of wireless communication:

- **Security**
  - Wireless channels are open to interception & jamming
  - Certification, authentication, DRM
- **Mobile terminal battery life**
  - Still an important constraint on equipment & services

Cellular Telephony:

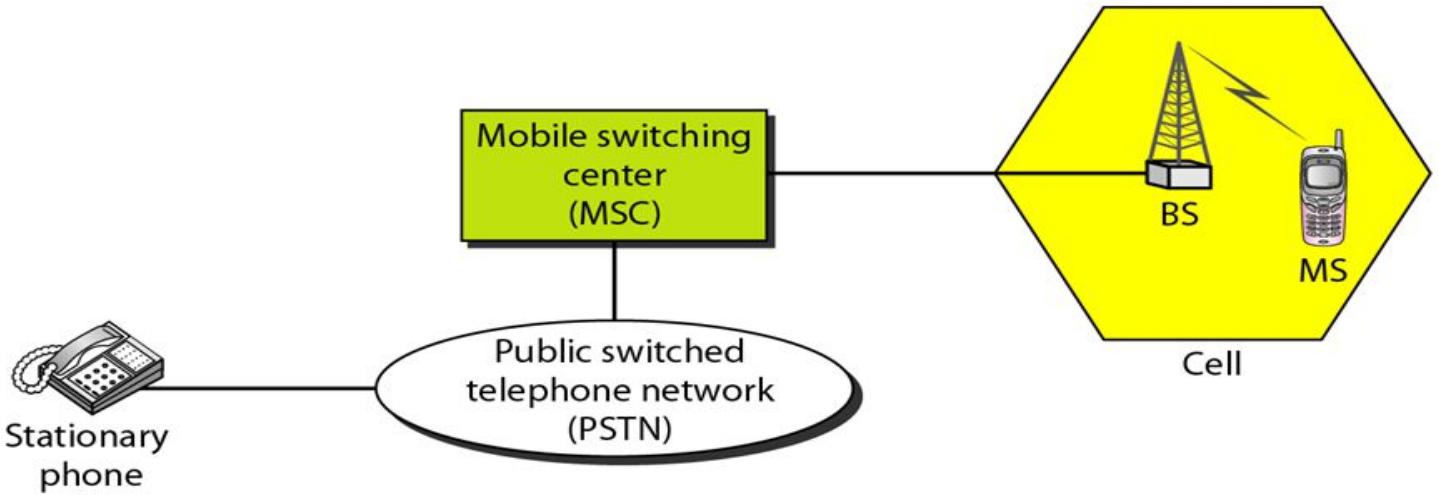
- Cellular telephony is designed to provide communications between two moving units called **Mobile Stations (MSs).**
- It also provide communication between one mobile unit and one stationary unit, often called a land unit.
- A service provider must be able to locate and track a caller, assign a channel to the call.

Cellular Telephony:

- To make this tracking possible, each cellular service area is divided into small regions called **Cells.**
- Each cell contains an antenna and is controlled by a network station, called the **Base Station (BS).**
- Each base station, in turn, is controlled by a switching office, called a **Mobile Switching Center (MSC).**
- It is a computerized center that is responsible for connecting calls, recording call information,

Cellular Telephony :

Figure 16.1 *Cellular system*



Cellular Communication Impairments:

- **Path loss**

  ⇒ received power falls with distance

- **Shadowing (slow fading)**

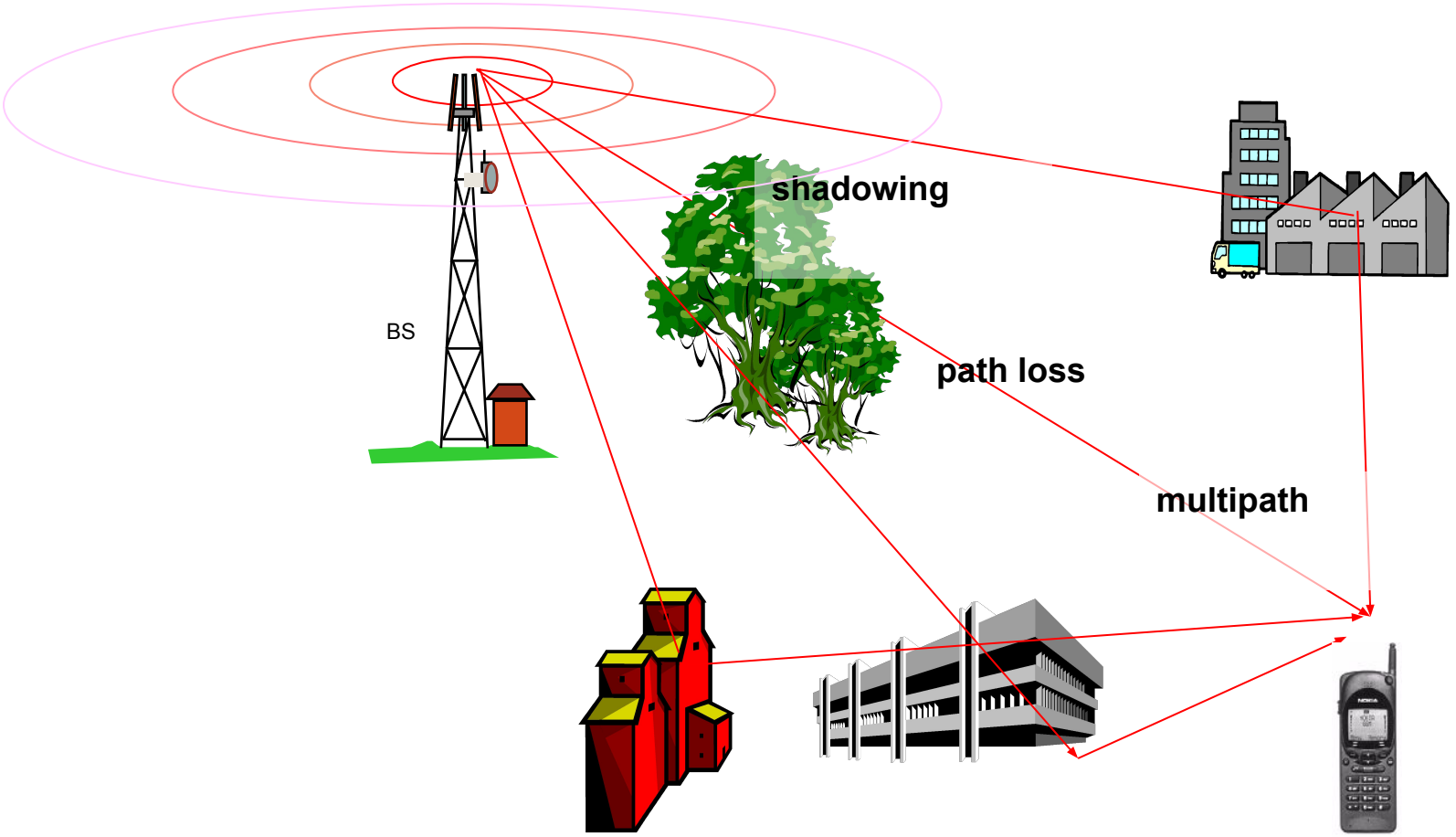
  ⇒ caused by obstruction of buildings, hills, trees and foliage.

- **Multipath fading (fast fading)**

  ⇒ caused by multipath reflection of a transmitted wave by objects.

- **Delay spread, angular spread, Doppler spread, interference**

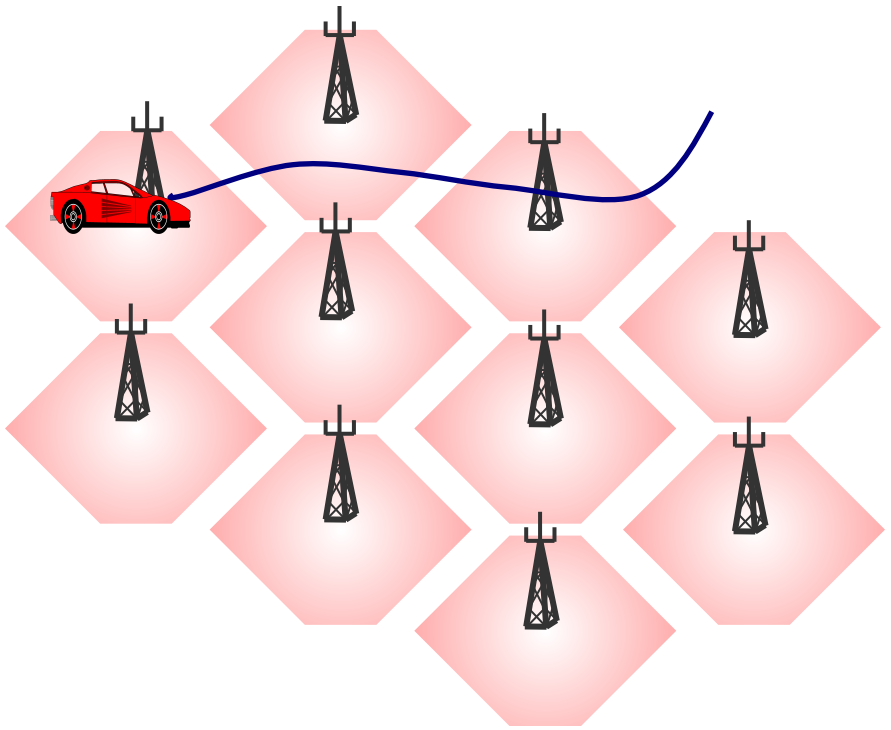
Impairments:



Handoff (Handover):

- During a conversation, the mobile station moves from one cell to another. When it does, the signal may become weak.
- To solve this problem, the MSC monitors the level of the signal every few seconds.
- If the strength of the signal diminishes, the MSC seeks a new cell that can better accommodate the communication.
- This is called Handoff (Handover).

- Guarantees the continuity of wireless services when the mobile user moves across the cell boundaries. Thus it handles user mobility
- Maintains required QoS
- Minimises interference level in the whole system by keeping the mobile linked to the



Types of Handoff

- **Hard Handoff :**Early systems used a hard handoff. In a hard handoff, a mobile station only communicates with one base station. When the MS moves from one cell to another, communication must first be broken with the previous base station before communication can be established with the new one. This may create a rough transition.
- **Soft Handoff :** New systems use a soft handoff. In this case, a mobile station can communicate with two base stations at the same time. This means that, during handoff, a mobile station may continue with the new base station before breaking off from the old one.

Reasons for Handoff

- The signal between the current base station and the mobile may have deteriorated to such an extent that the call is in danger of being dropped,
- A cell may have become overloaded, handling a large number of calls. This congestion may be alleviated by handing off mobiles to less congested nearby cells.

Step by Step Handoff Procedure

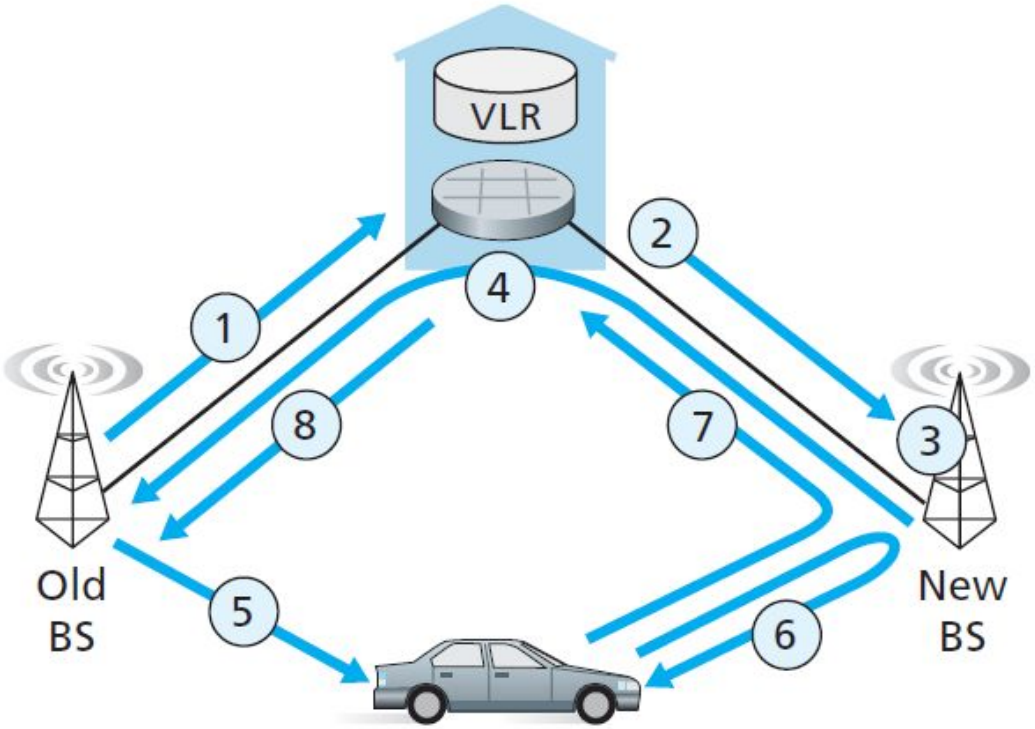


Figure 6.31 ♦ Steps in accomplishing a handoff between base stations with a common MSC

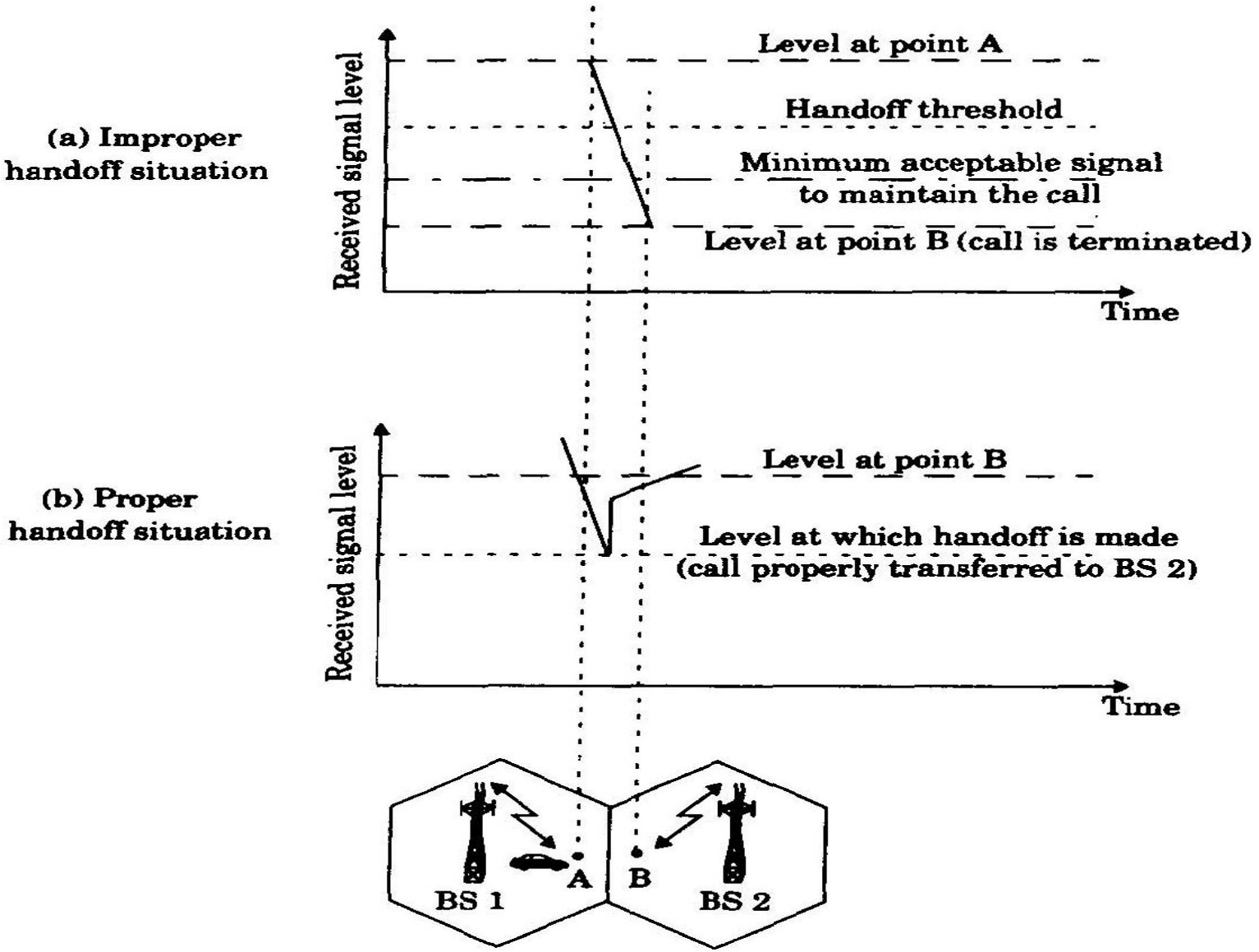
Step by Step Handoff Procedure

1. The old base station (BS) informs the visited MSC that a handoff is to be performed and the BS (or possible set of BSs) to which the mobile is to be handed off.
2. The visited MSC initiates path setup to the new BS, allocating the resources needed to carry the rerouted call, and signaling the new BS that a handoff is about to occur.
3. The new BS allocates and activates a radio channel for use by the mobile.
4. The new BS signals back to the visited MSC and the old BS that the visited-MSC-to-new-BS path has been established and that the mobile should be informed of the impending handoff. The new BS

Step by Step Handoff Procedure

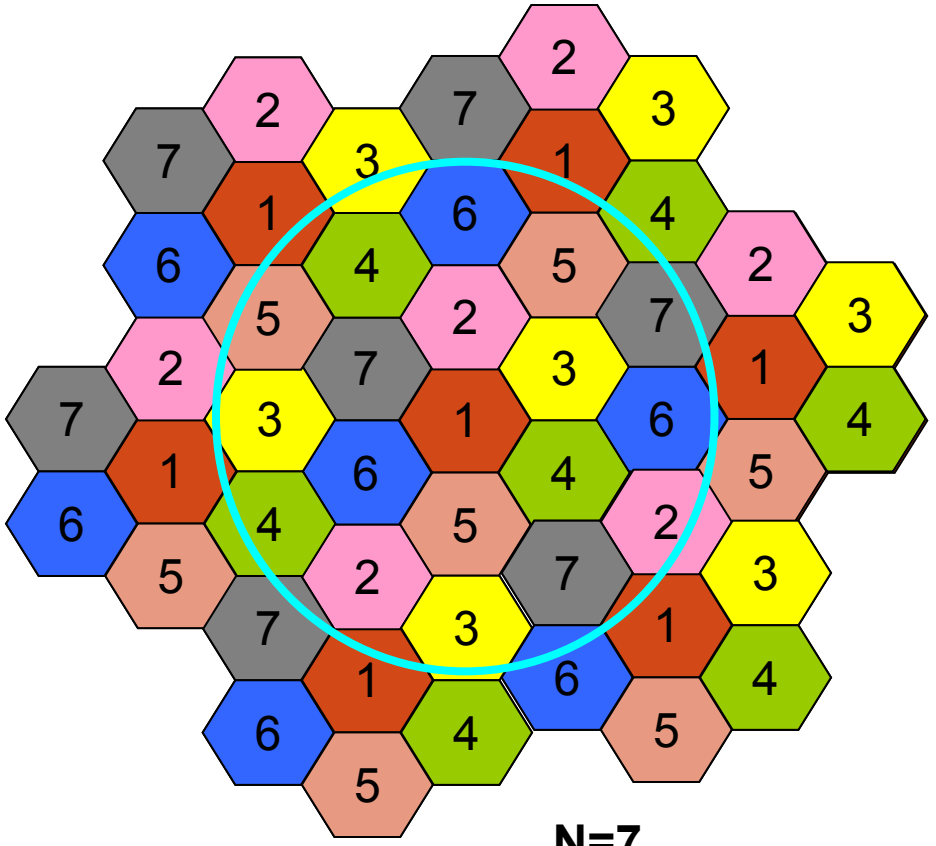
5. The mobile is informed that it should perform a handoff. Note that up until this point, the mobile has been blissfully unaware that the network has been laying the groundwork for a handoff.
6. The mobile and the new BS exchange one or more messages to fully activate the new channel in the new BS.
7. The mobile sends a handoff complete message to the new BS, which is forwarded up to the visited MSC. The visited MSC then reroutes the ongoing call to the mobile via the new BS.
8. The resources allocated along the path to the old BS are then released.

Handoff Strategies:



Frequency Reuse

- Adjacent cells are assigned different frequencies to avoid interference or crosstalk
- Cells sufficiently distant from each other can use the same frequency (frequency reuse)
- Reuse factor *N*: number of cells in a repeating pattern
- **The number of cells per cluster, *N*, *can only have values which satisfy:***
  - $N = i^2 + ij + j^2$

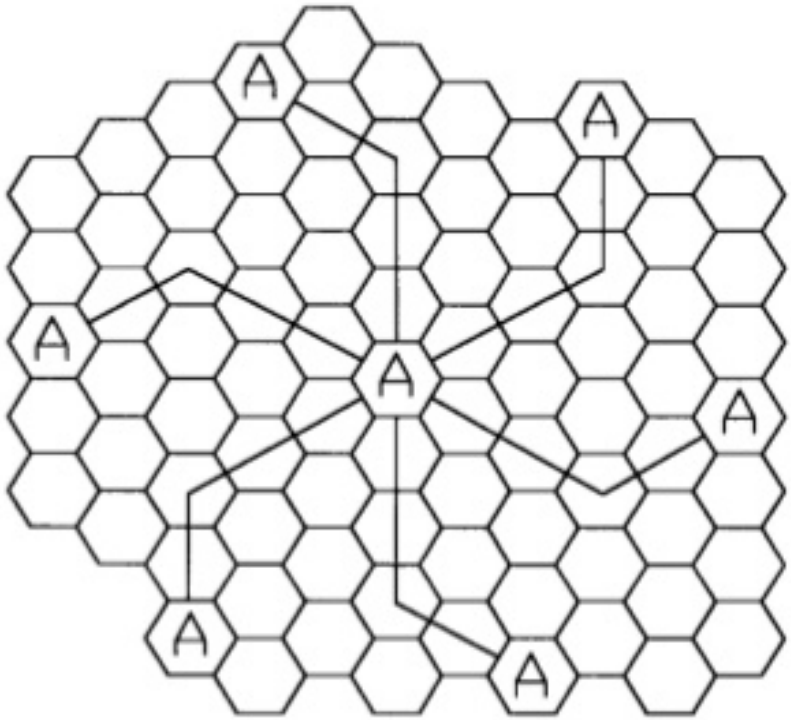


N=7

In practice each cell uses a set of frequencies and it is these that are repeated

19-cell reuse example (N=19)

- Figure shows method of locating co-channel cells in a cellular system. In this example, $N = 19$ (i.e., $i = 3$, $j = 2$).



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Frequency Reuse & System Capacity:

- S = Number of duplex channels in the cellular system
- K = Number of channels per cell
- N = Number of cells (4, 7 or 12)
- M = Number of times a cluster is repeatedly used

- **Available Channels per cell is:**

$$K = S/N$$

- **The system capacity (total number of channels) in the system is:**

$$C = M\,S = MNK$$

Calculate:

If a total of 33 MHz of bandwidth is allocated to a particular FDD cellular telephone system which uses two 25 kHz simplex channels to provide full duplex voice and control channels, compute the number of channels available per cell if a system uses (a) 4-cell reuse, (b) 7-cell reuse (c) 12-cell reuse. If 1 MHz of the

Solution:

Given:

Total bandwidth = 33 MHz

Channel bandwidth = 25 kHz × 2 simplex channels = 50 kHz/duplex channel

Total available channels = 33,000/50 = 660 channels

(a) For $N = 4$,

total number of channels available per cell = $660/4 \approx 165$ channels.

(b) For $N = 7$,

total number of channels available per cell = $660/7 \approx 95$ channels.

(c) For $N = 12$,

total number of channels available per cell = $660/12 \approx 55$ channels.

How we make a Call:

- To place a call from a mobile station, the caller enters a phone number and presses the send button.
- The mobile station then scans the band and sends the data (phone number) to the closest base station using that channel.
- The base station relays the data to the MSC.
- The MSC sends the data on to the telephone central office.
- If the called party is available, a connection is made

How we receive a Call:

- When a mobile phone is called, the telephone central office sends the number to the MSC.
- The MSC searches for the location of the mobile station by sending query signals to each cell in a process called *paging*.
- Once the mobile station is found, the MSC transmits a ringing signal.
- when the mobile station answers, assigns a voice channel to the call.
- allowing voice communication to begin.

Thank You !!!
Any Questions ???