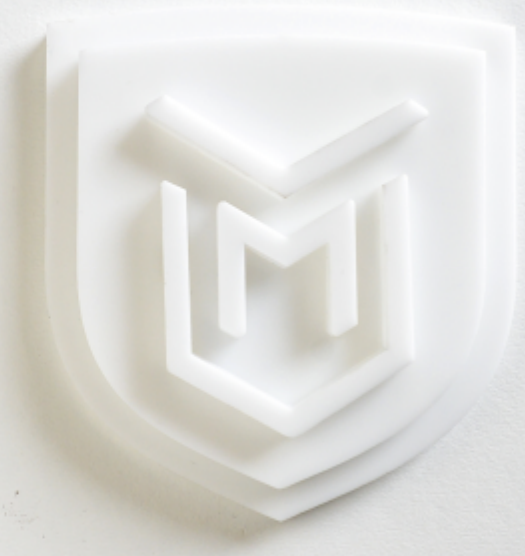

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01CE0701 – Mobile Computing

Unit - 2
The Cellular Concept

Computer Engineering Department

Outline

- Cellular System
- Hexagonal Geometry cell
- Concept of frequency reuse
- Channel Assignment Strategies
- Distance to frequency reuse ratio

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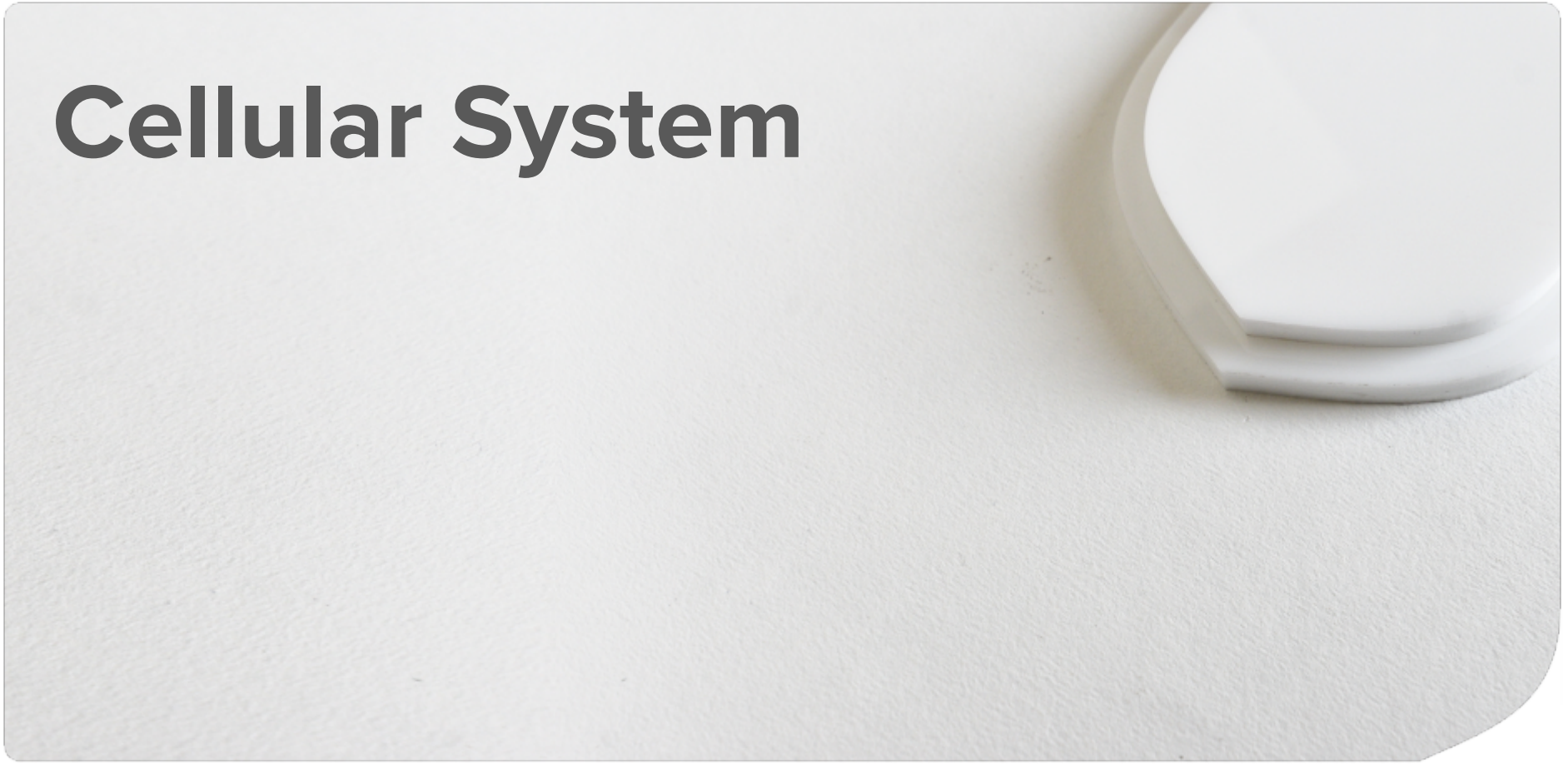
Cellular System



Cellular System-Introduction

•A cellular network is a radio network(mobile network) spread out over land in the form of cells, each of which has a base station permanently installed. Together, these cells offer broader geographic radio coverage.

• Therefore, even when the **user equipment** (UE), like a mobile phone, is moving through cells during transmission, communication is still possible.

• In comparison to previous options, cellular networks provide subscribers with improved advantages like increased capacity, low battery consumption, a wider geographic coverage area, and less signal interference.

The Global System for Mobile Communication, general packet radio service, 3GSM and code division multiple access are all common cellular technologies.

Cellular Network Towers

Cellular System in detail

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•A communication network that uses a wireless connection to connect end nodes is known as a cellular network or mobile network.

•The network is spread out over "cells" of land, which are each served by at least one fixed-location transceiver (A device that can both transmit and receive communications, in particular, a combined radio transmitter and receiver).

• These base stations give the cell network coverage, allowing it to transmit speech, data, and other kinds of information.

• To prevent interference and assure service quality within each cell, a cell normally employs a separate set of frequencies from its neighbours.

Cellular System in detail

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- These cells can be connected to offer radio coverage across a big geographic area.

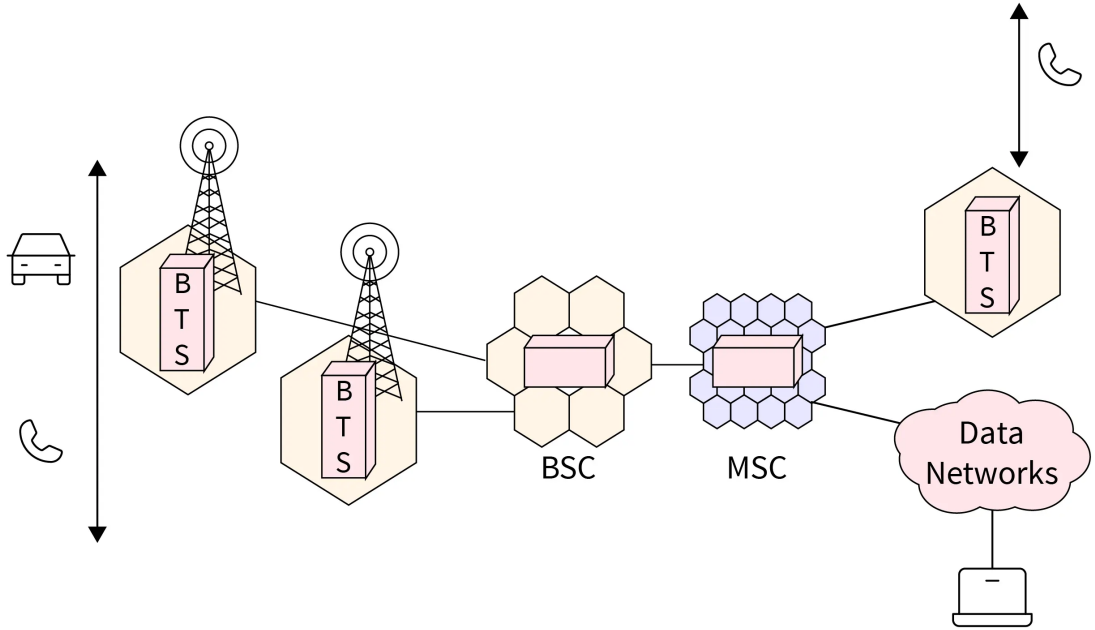
- This makes it possible for a large number of portable transceivers (such as mobile phones, tablets, laptops, pagers, etc.) to communicate with each other as well as fixed transceivers and telephones throughout the network via base stations, even if some of the transceivers are moving through multiple cells at once while transmitting.

Cellular System -Architecture

• The fundamental structure and infrastructure of the cellular network have not altered much.

•It consists of a set of areas that are split into cells and services and are linked to one another by a network of transceivers, controllers, switches, routers, and registers. The following list includes some of the important parts and how they function:

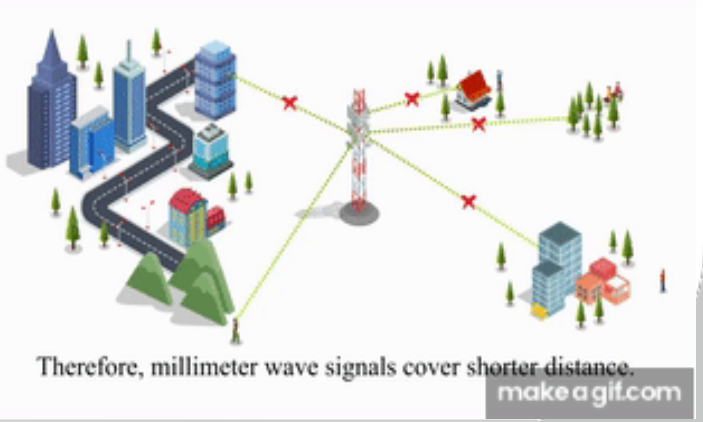
Cellular System in detail



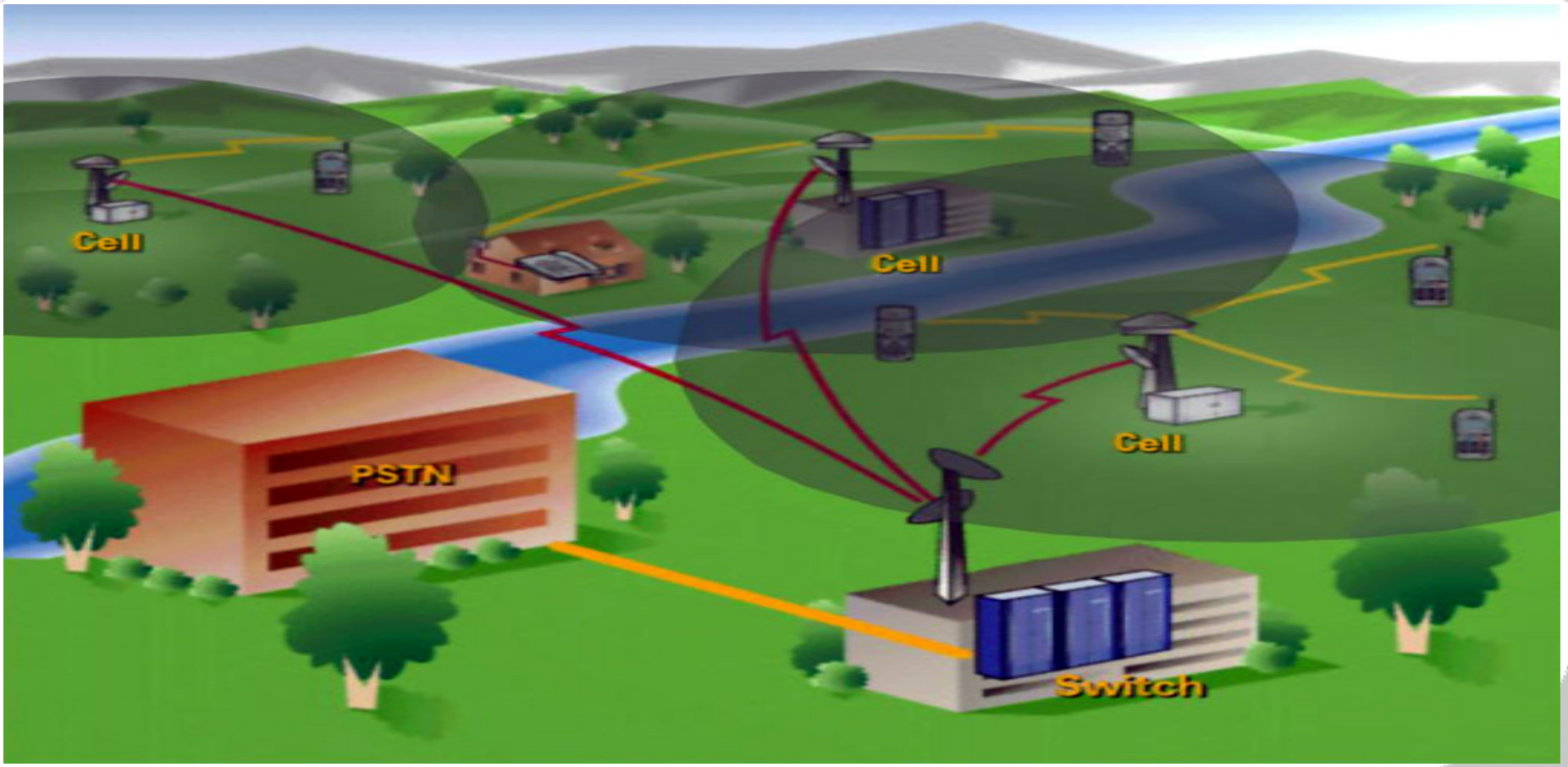
BSC : Base station controller **BTS :** Base transreceiver station **OSS :** Operation and support subsystem

Cellular System-Features

- A *cellular network* or *mobile network* is a communication network where the last link is wireless.
- **Cellular technology** is the foundation of Mobile Wireless Communications.
- It support the users in location that are not easily served by wired networks.
- Cellular network is an underlying technology for mobile phones, personal communication systems, wireless networking etc.
- The technology is developed for mobile radio telephone to replace high power transmitter/receiver systems with low power transmitter/receiver.
- Cellular networks use low power, shorter range and more transmitters for data transmission.

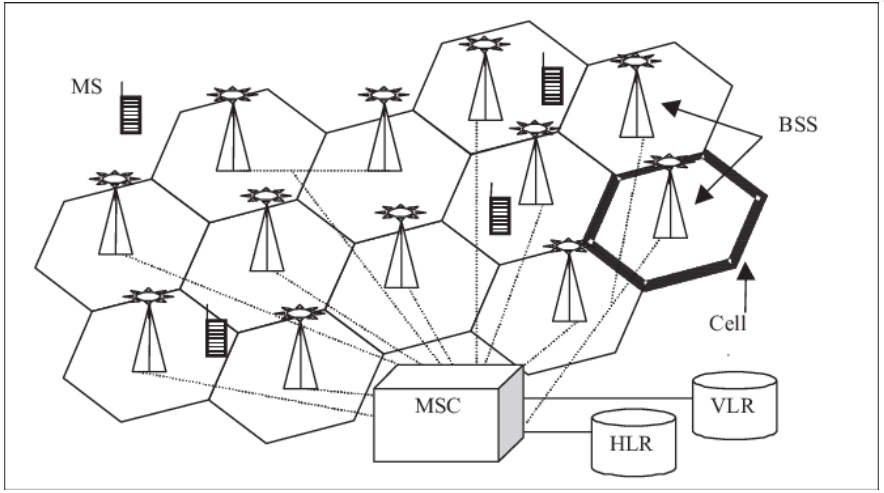


Cellular System



Cellular System

- Multiple low power transmitters
  - 100w or less
- Area divided into cells
  - Each with own antenna
  - Each with own range of frequencies
  - Served by Base Station (BS)
    - Transmitter, receiver, control unit
  - Adjacent cells on different frequencies to avoid crosstalk



- MS – Mobile Station
- MSC – Mobile Switching Centre
- HLR – Home location register
- VLR – Visitor location register

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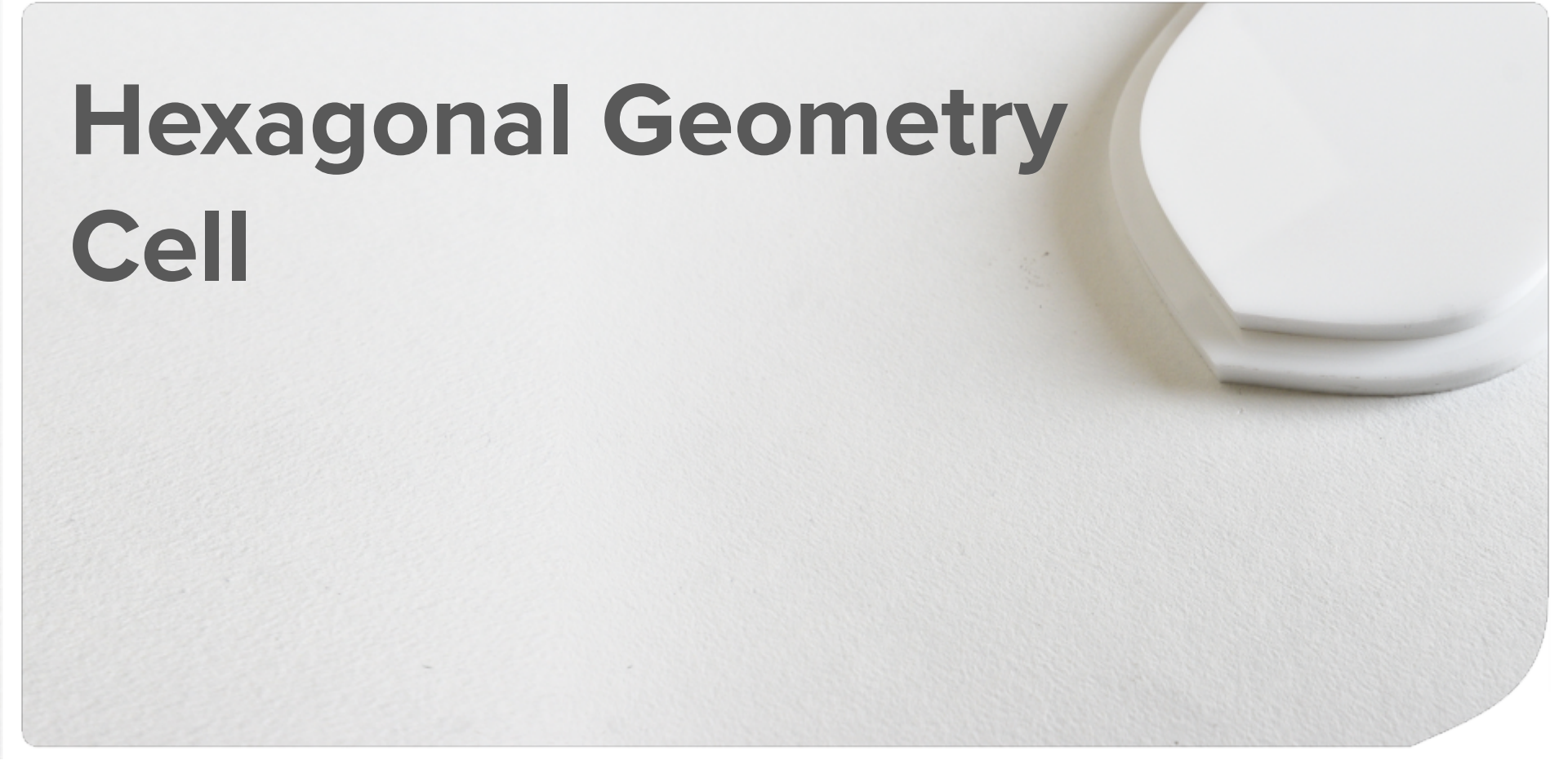
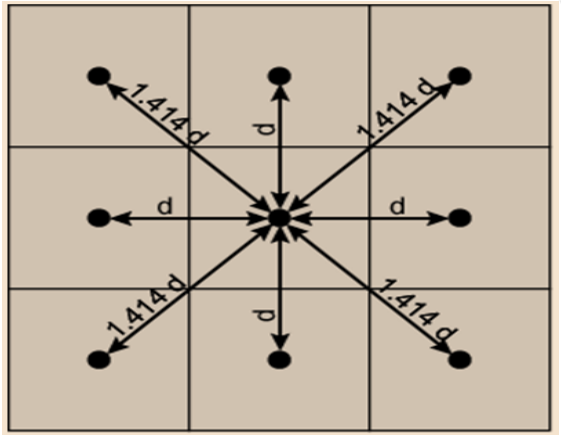
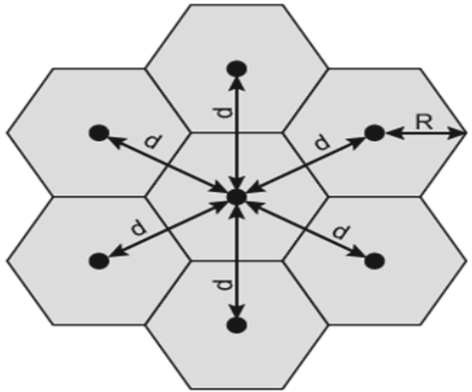
Hexagonal Geometry Cell



Hexagonal Geometry Cell

- **Square**
  - Width *d* cell has four neighbours at distance *d* and four at distance *1.414 d*
  - However, this geometry is not ideal
  - Better if all adjacent antennas equidistant
    - Simplifies choosing and switching to new antenna
- **Hexagon**
  - Provides equidistant antennas
  - Radius defined as radius of circum-circle
    - Distance from centre to vertex equals length of side
  - Distance between centres of cells radius *R* is *R*
  - Not always precise hexagons
    - Topographical limitations
    - Local signal propagation conditions
    - Location of antennas





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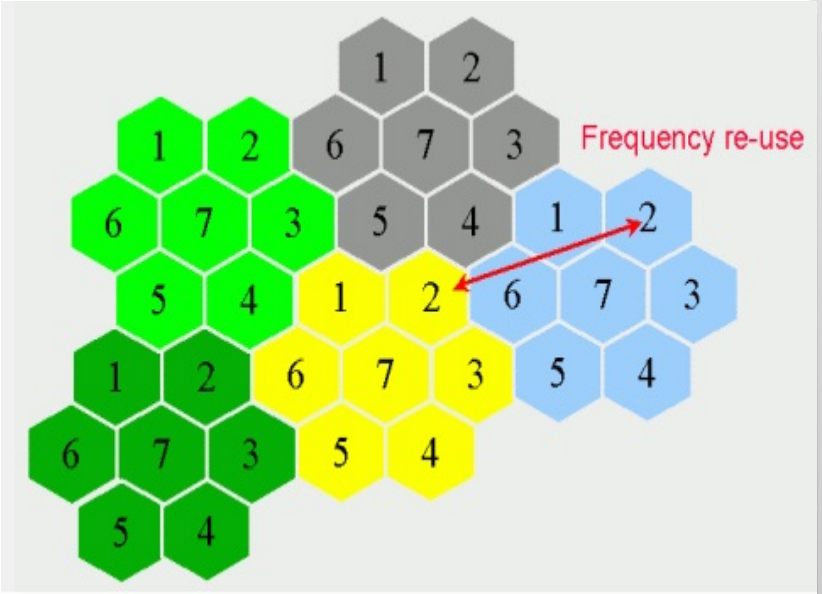
Concept of Frequency Reuse

Frequency Reuse

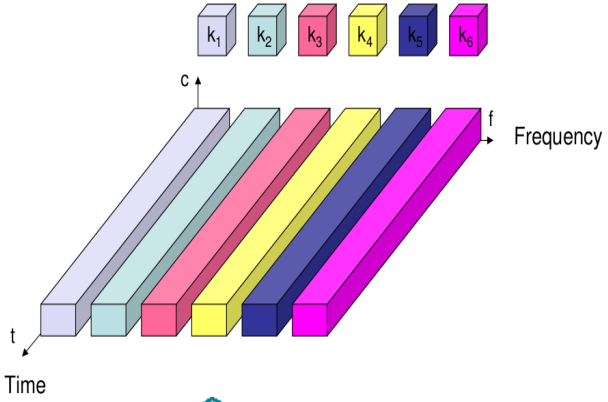
- The key characteristic of a cellular network is the ability to re-use frequencies to increase both coverage and capacity.
- Many techniques are available for Multiple Access for Users by Reusing or Dividing Frequencies among users
- Basic Ways of Multiple Access of Frequency:

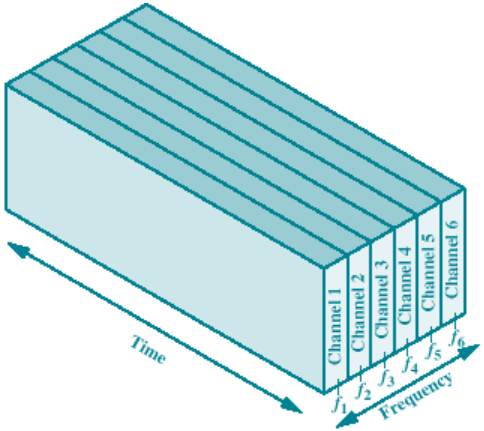
1. FDMA
2. TDMA
3. CDMA



Frequency Division Multiple Access (FDMA)

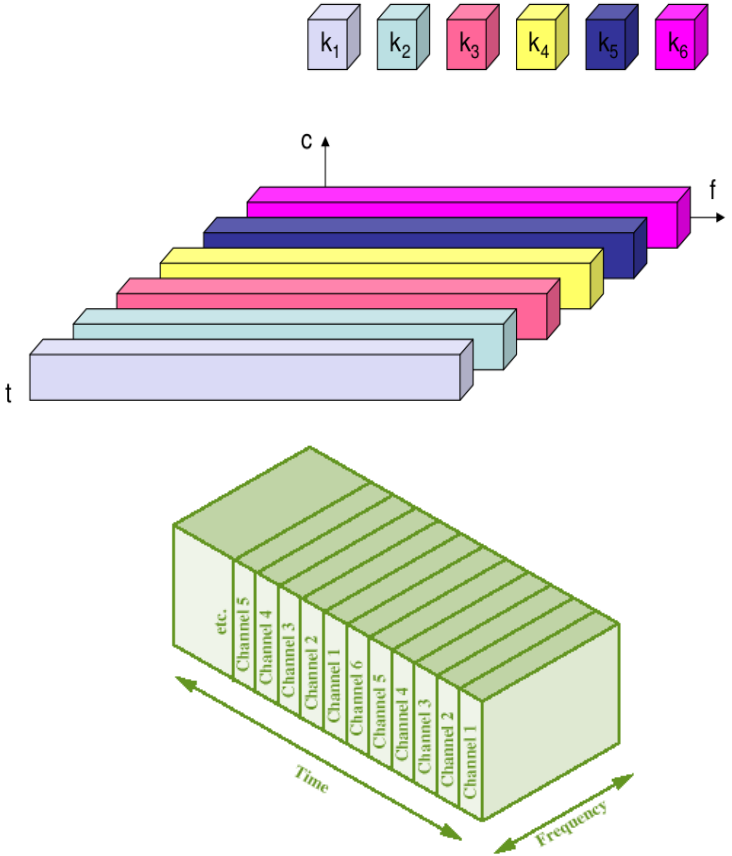
- Analog technique 
- **FDM** is a technique in which the available bandwidth of a single transmission medium is subdivided into several channels.
- In **FDM**, all signals operate at the same time with different frequency.
- **FDM** is mainly used in radio broadcasts and TV networks.
- Radio stations: Each radio station has its own frequency.
- Receiver: Tune in to the specific frequency.





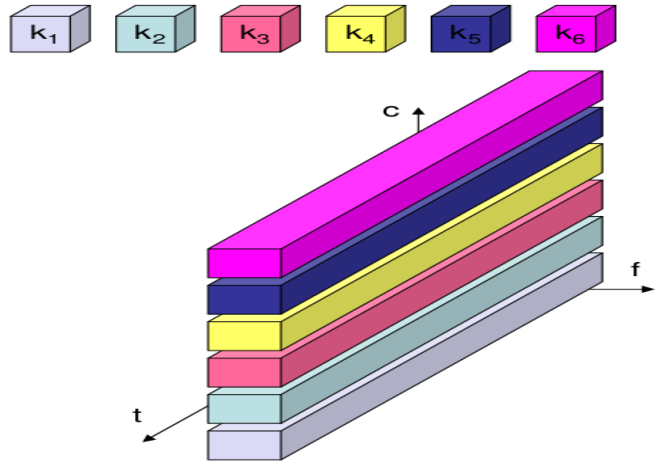
Time Division Multiple Access (TDMA)

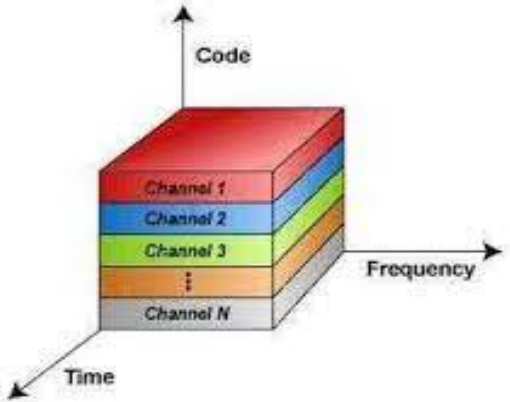
- Digital technique 
- In **TDM**, the total time available in the channel is distributed among different users. Therefore, each user is allocated with different time interval known as a Time slot at which data is to be transmitted by the sender.
- In **TDM**, all signals operate at the same frequency with different time.
- A user takes control of the channel for a fixed amount of time.
- In **TDM**, data is not transmitted simultaneously rather the data is transmitted one-by-one.
- **TDM** is mainly used in Telephone lines, ISDN (Integrated Services Digital Network) telephone lines.



Code Division Multiple Access (CDMA)

- Each channel has a unique code
- All channels use the same spectrum at the same time
- First used in military applications due to its inherent security features.
- Now used in many civil applications due to low processing power.
- Ex., people talk different languages in a party.
- If the listener doesn't know the language, the signals are received but useless.
- CDMA allows for greater development and use of broadband devices such as GPS units, PDA's, wireless laptop modems, Internet capable cell phones, and other innovative devices.





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Channel Assignment Strategies

Channel Assignment/Allocation Strategies

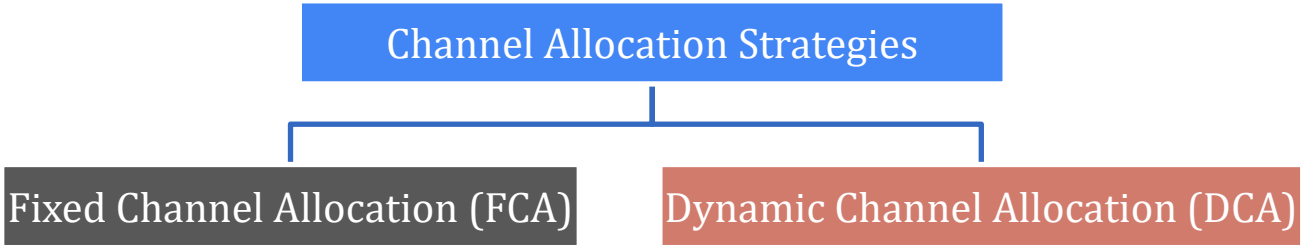
What is Channel Allocation?

- Channel Allocation means to allocate the *available channels* to the *cells* in a cellular system.

- When a user wants to make a *call request* then by using channel allocation strategies their requests are fulfilled.

Purpose

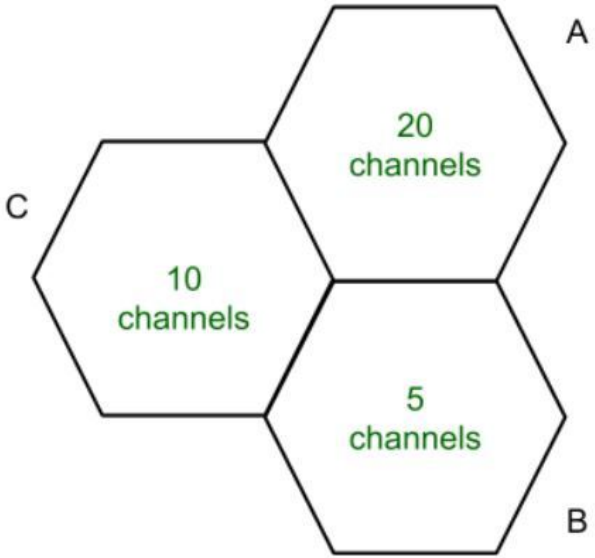
- Channel Allocation Strategies are designed in such a way that there is efficient use of *frequencies*, *time slots* and *bandwidth*.



Fixed Channel Allocation

❑ Fixed Channel Allocation

- Fixed Channel Allocation is a strategy in which *fixed number of channels* or *voice channels* are allocated to the *cells*.
- Once the channels are allocated to the *specific cells* then they *cannot be changed*.
- In FCA channels are allocated in a manner that *maximize Frequency reuse*.
- In cell A 20 Channels or Voice channels are allocated. If all channels are occupied and user make a call then the call is blocked.
- *Borrowing Channels* handles this type of problem. This cell borrow channels from other cells.



Dynamic Channel Allocation

❑ Dynamic Channel Allocation

- Dynamic Channel allocation is a strategy in which channels are not permanently allocated to the cells.
- Channels are assigned to the user as needed.
- In this strategy, blocking calls is *reduced*. As traffic increases more channels are *assigned* and vice-versa.
- The available channels are kept in a queue or a spool. The allocation of the channels is *temporary*.
- When a User makes a call request then Base Station (BS) send that request to the Mobile Station Center (MSC) for the allocation of channels or voice channels.
- Dynamic channel allocation schemes increases the computational as well as storage load on the system.

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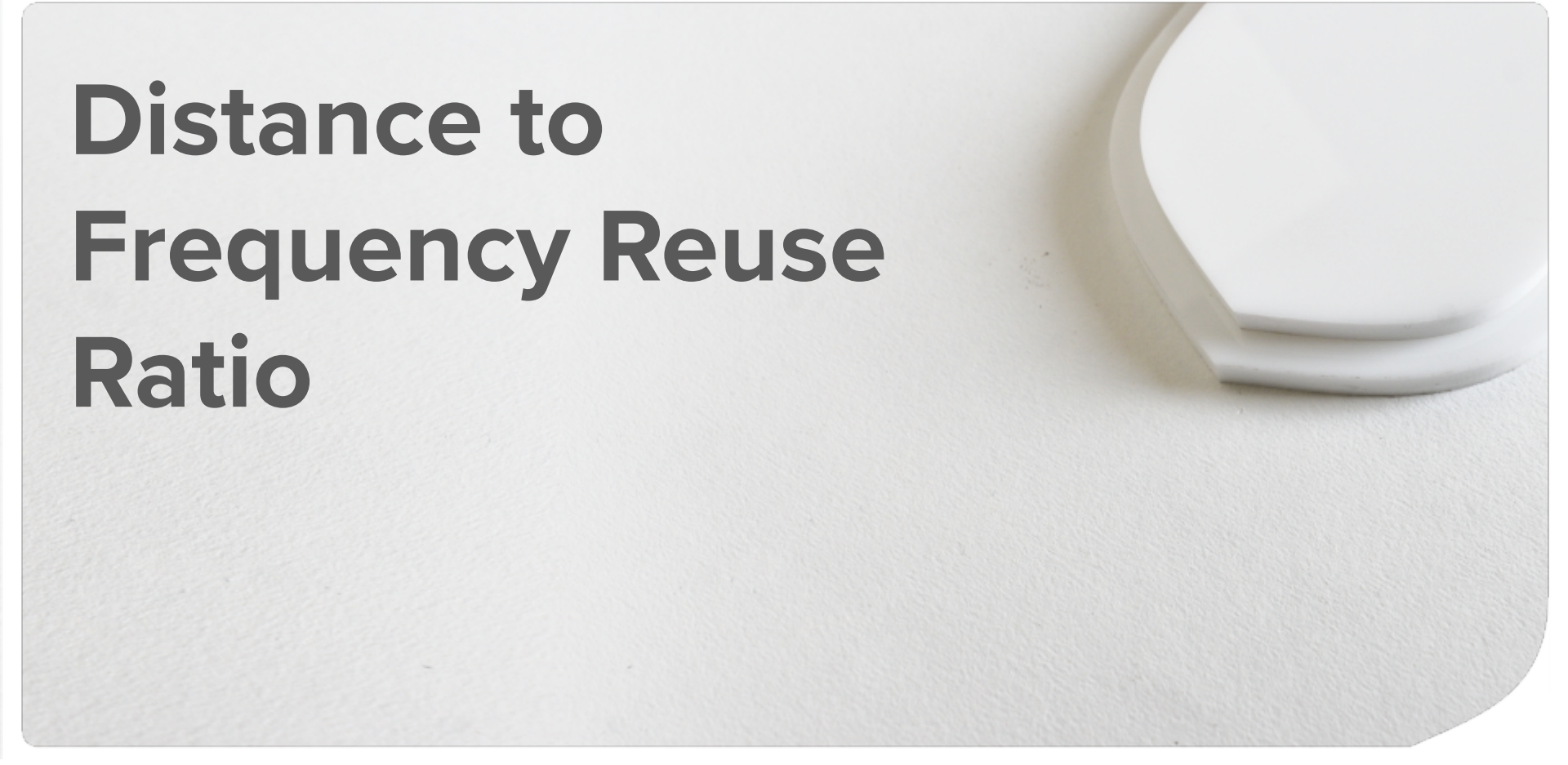
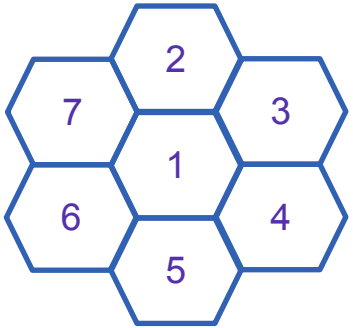
Distance to Frequency Reuse Ratio



Frequency Reuse

Example:

- N cells all using same number of frequencies
- K total number of frequencies used in systems
- Each cell has K/N frequencies



Given: N=7

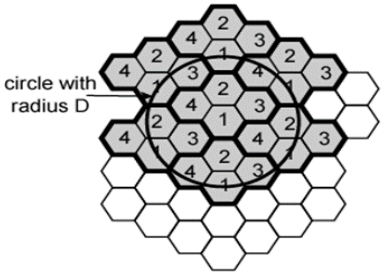
K=395 kHz

Find: Frequency of each cell

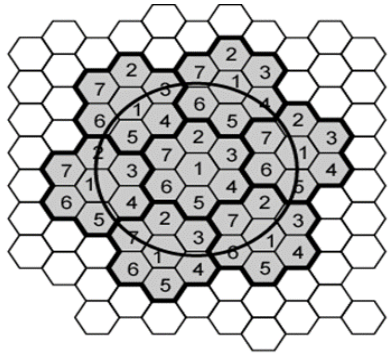
Solution: Frequency of each cell= $\frac{K}{N} = \frac{395}{7} \cong 57$ kHz

Cluster Size

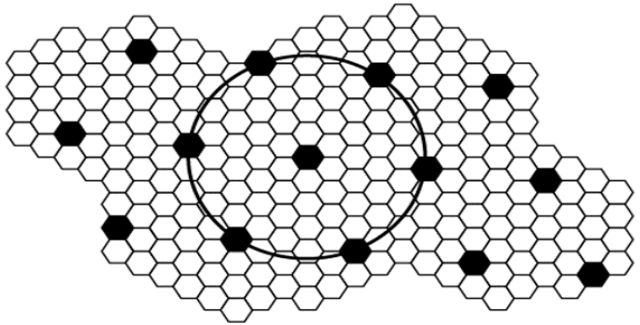
- How to find cluster size of cellular network?



(a) Frequency reuse pattern for N = 4



(b) Frequency reuse pattern for N = 7

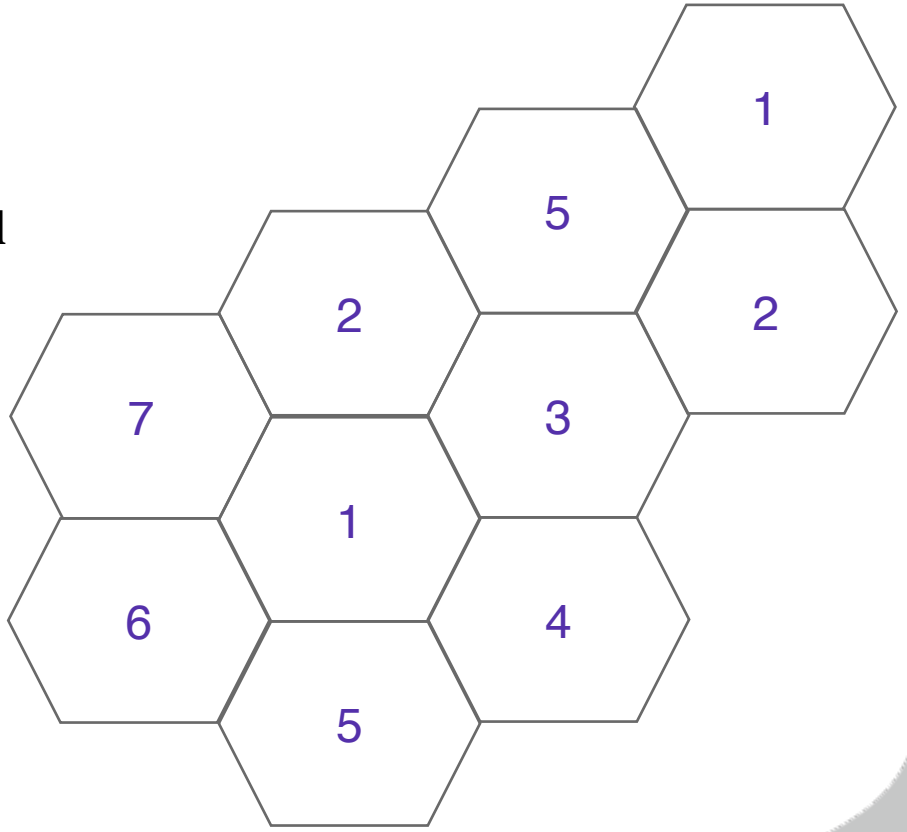


(c) Black cells indicate a frequency reuse for N = 19

Cluster Size

- How to find cluster size of cellular network?
- Formula: $N=I^2+J^2+(I * J)$

N: No. of cell with unique/non repeated frequency



Cluster Size

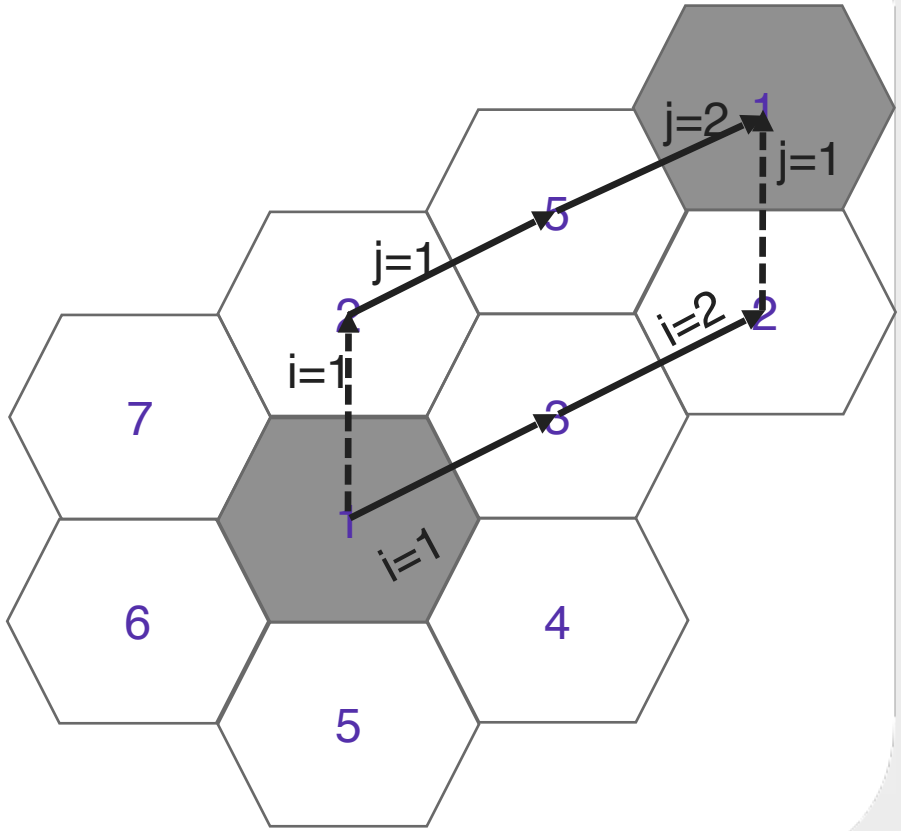
- How to find cluster size of cellular network?
- Formula: $N=I^2+J^2+(I * J)$

N: No. of cell with unique/non repeated frequency

I: No. of steps required to move in one direction in order to reach cell with same frequency

J: No. of steps required to move in other direction(i.e. 60° anticlockwise) in order to reach cell with same frequency.

- Now, if we want to find distance to reach from cell1 to another cell1 then,



Given: I=1, J=2

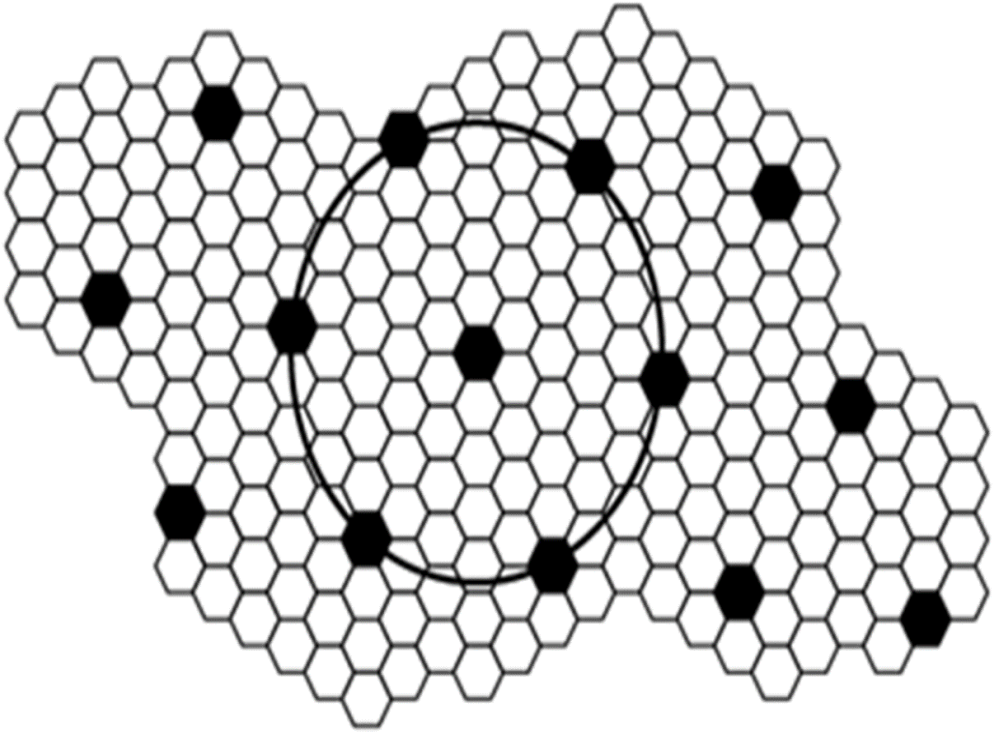
Solution: $N=1^2+2^2+(1*2)$

$=1+4+2$

$=7$

Cluster Size

- How to find cluster size of cellular network?
- Formula: $N=I^2+J^2+(I * J)$



- Now, if we want to find distance to reach from cell1 to another cell1 then,

Given: I=2, J=3

Solution: $N=2^2+3^2+(2*3)$

$=4 + 9 + 6$

$=19$

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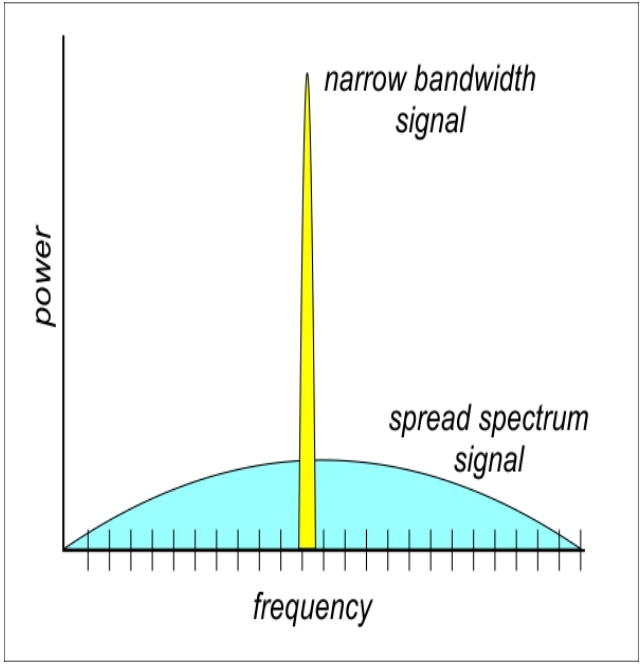
Concept of Spread Spectrum

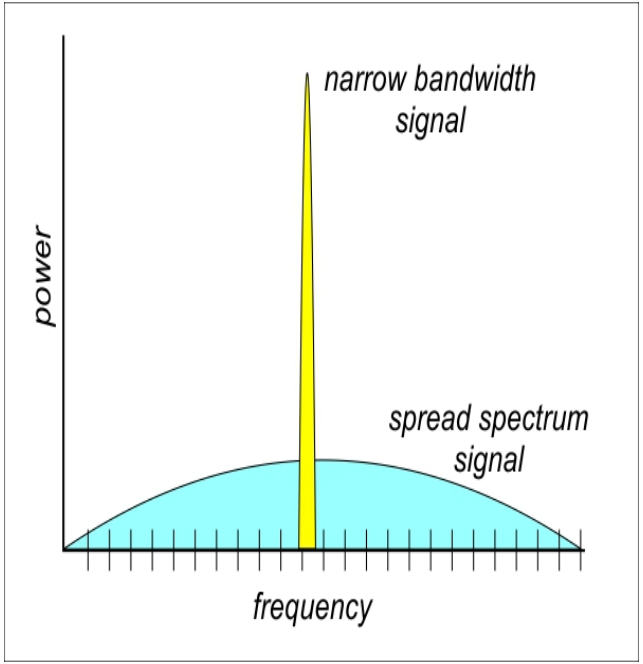
Concept of Spread Spectrum

- A collective class of signalling techniques are employed before transmitting a signal to provide a secure communication, known as the **Spread Spectrum Modulation**.
- The pivotal aim of spread spectrum communication technique is to prevent "interference" whether it is intentional or unintentional.'
- The spread spectrum signals are hard to interfere and can't be jammed.

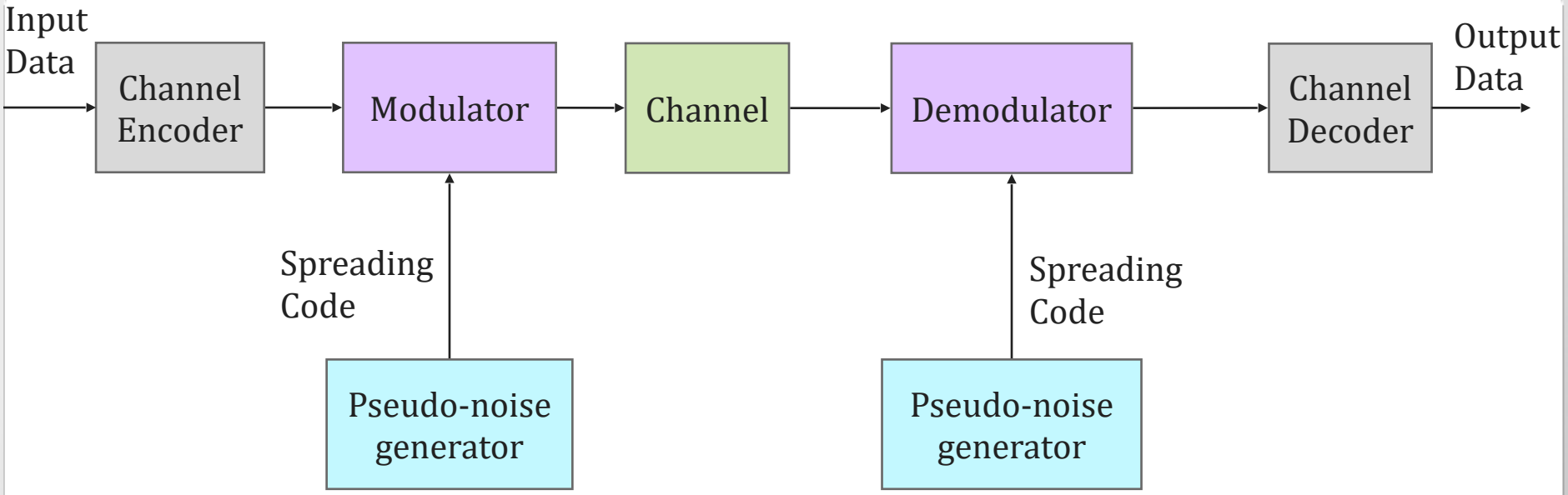


Concept of Spread Spectrum

- Narrow Band Signal features
  - Band of signals occupy a narrow range of frequencies
  - Power density is high
  - Spread of energy is low and concentrated
  - Signals are prone to interference
- Spread Spectrum Signal features
  - Band of signals occupy a wide range of frequencies
  - Power density is very low
  - Energy is wide spread
  - Highly resistant to interference or jamming

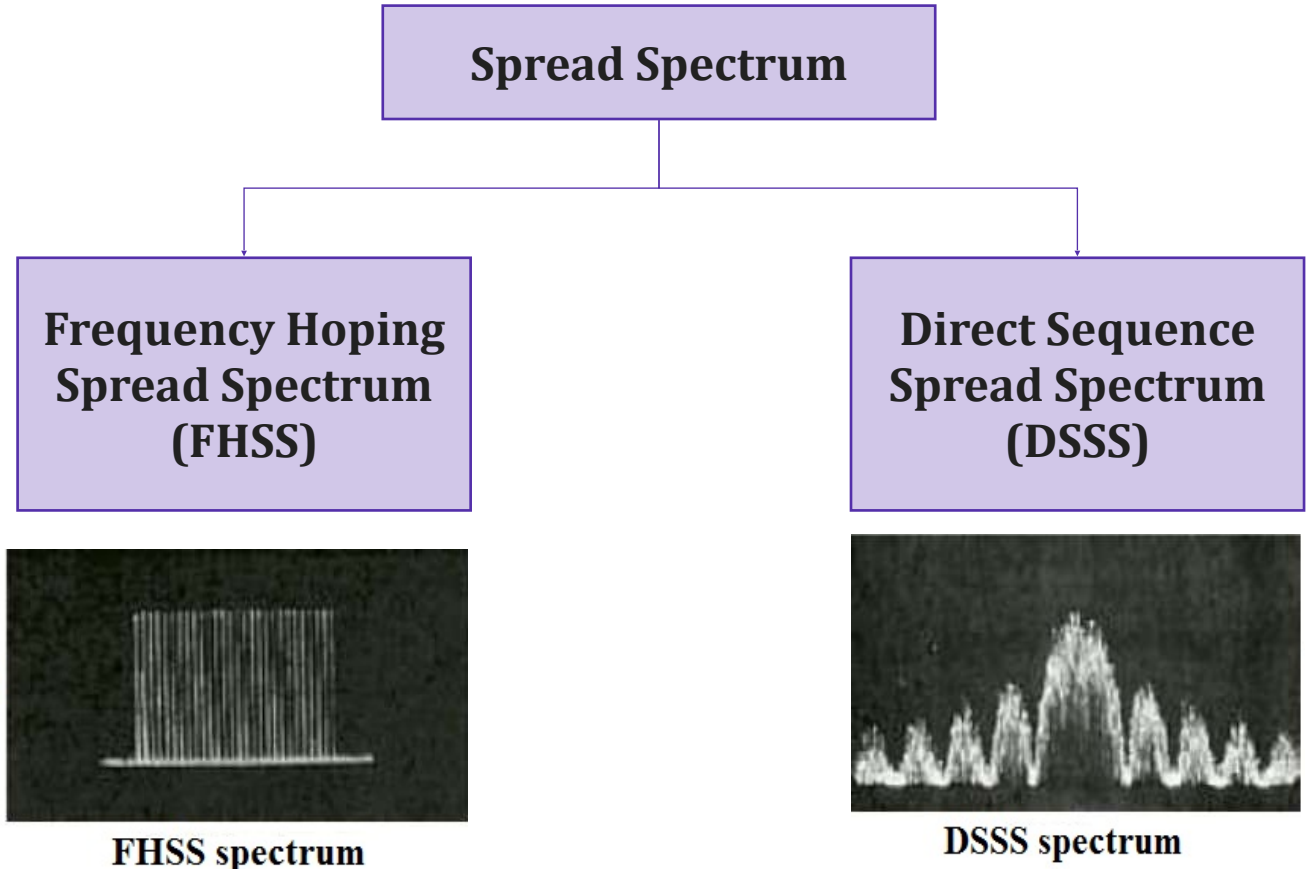


Concept of Spread Spectrum



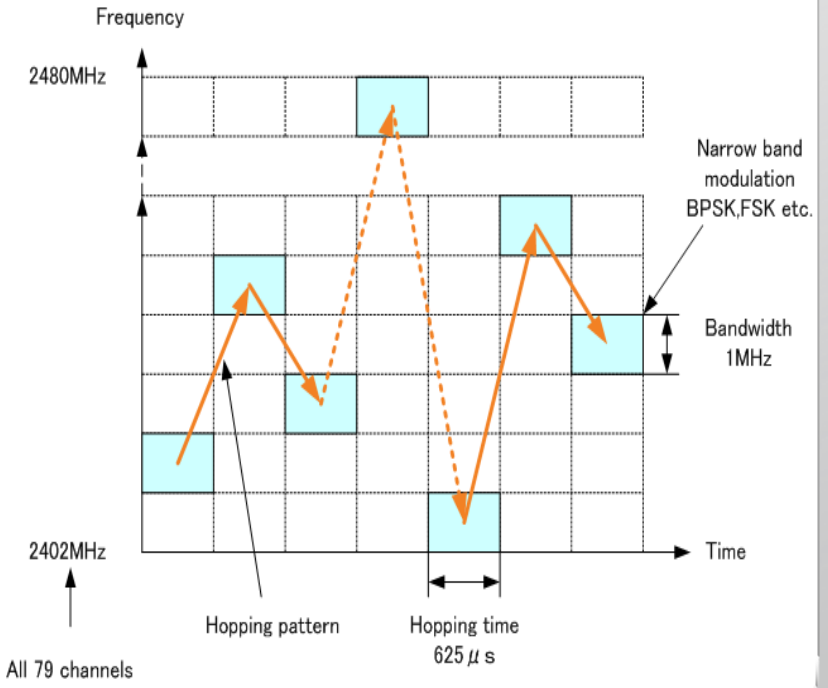
- **Applications**
  - Military communication
  - It can also be used for hiding and encrypting signals. Only a recipient who knows the spreading code can recover the encoded information.

Concept of Spread Spectrum



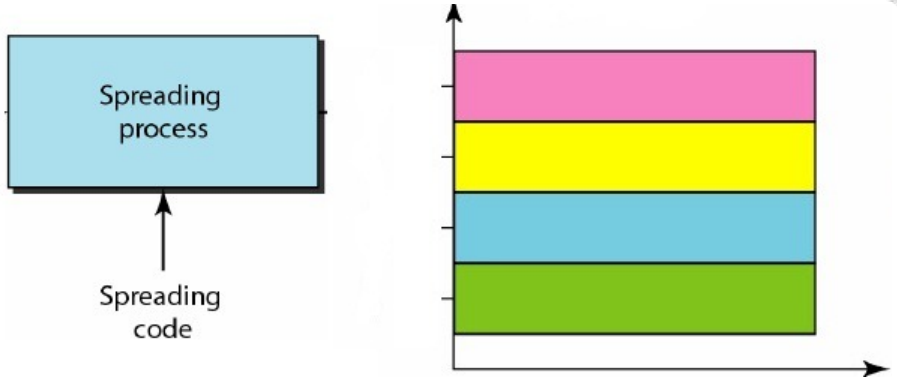
Frequency Hopping Spread Spectrum (FHSS)

- The first type of spread spectrum developed is known as frequency hopping.
- The sequence of channels used is indicated by a spreading code.
- Signal is broadcast over seemingly random series of radio frequencies
  - A number of channels allocated for the FH signal
  - Width of each channel corresponds to bandwidth of input signal
- Signal hops from frequency to frequency at fixed intervals
  - Transmitter operates in one channel at a time
  - Bits are transmitted using some encoding scheme
  - At each successive interval, a new carrier frequency is selected



Direct Sequence Spread Spectrum (DSSS)

- Each bit in original signal is represented by multiple bits in the transmitted signal
- Spreading code spreads signal across a wider frequency band
- One technique combines digital information stream with the spreading code bit stream using exclusive-OR.



Direct Sequence Spread Spectrum (DSSS)