GSM
Global System for Mobile Communication

Hany El-Ghaish

HISTORY OF COMMUNICATION

- CONTENT
  - -communication systems overview
  - - Introduction to Cellular Fundamentals
  - - Network Architecture
  - - GSM Air Interface
  - - Digital Mobile Elements
  - - GSM Network Protocols

HISTORY OF COMMUNICATION

- **Communication systems**

  - Deliver as much information as possible from the source to the destination (**capacity issues**).
  - Deliver information in shortest time (**delay issues**).
  - Reduce errors in delivery of information (**error detection/correction issues**).

HISTORY OF COMMUNICATION

Basic Communications System Elements

- Source
- Destination
- Transmission Medium

HISTORY OF COMMUNICATION

- Transmission Medium

HISTORY OF COMMUNICATION

Long Distance Communications

Telecommunication is the process of long distance communications.

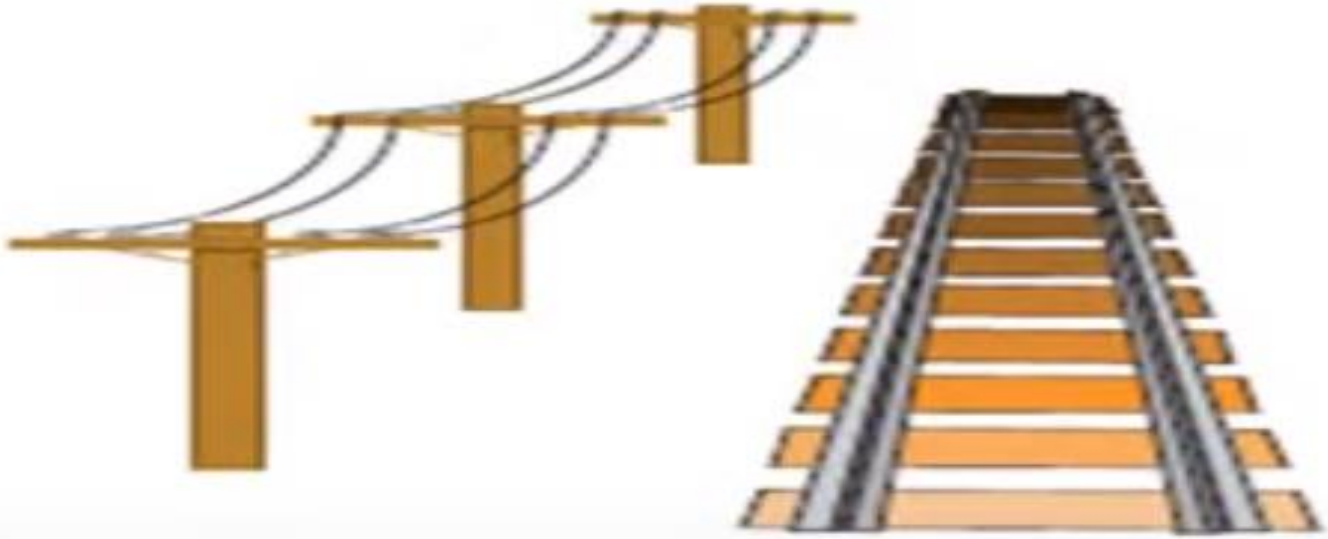
Early telecommunications involved smoke, flags, drums, and other such methods

to relay messages and information.

HISTORY OF COMMUNICATION

Telegraph

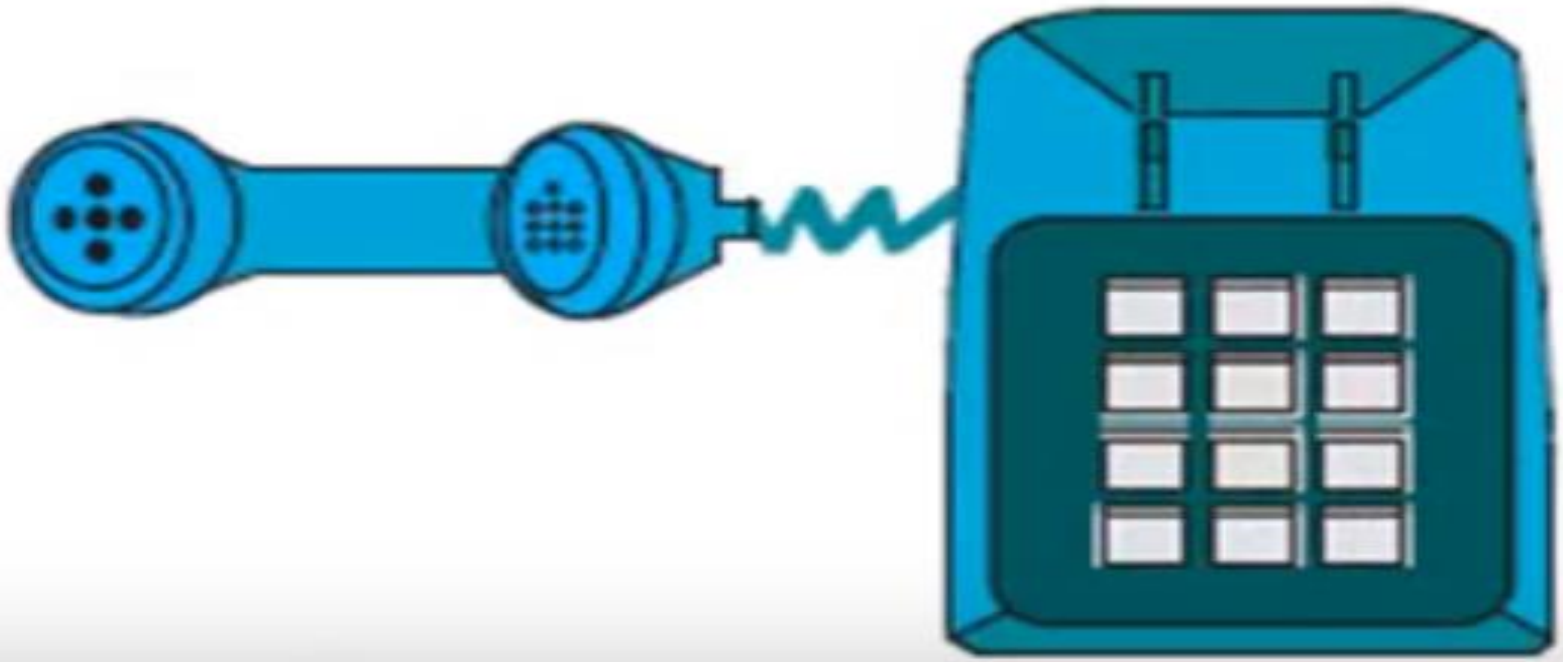
The first wire line communications was the telegraph. Invented in the mid 19th
century, it opened a new era in long-distance telecommunication.



HISTORY OF COMMUNICATION

Telephone

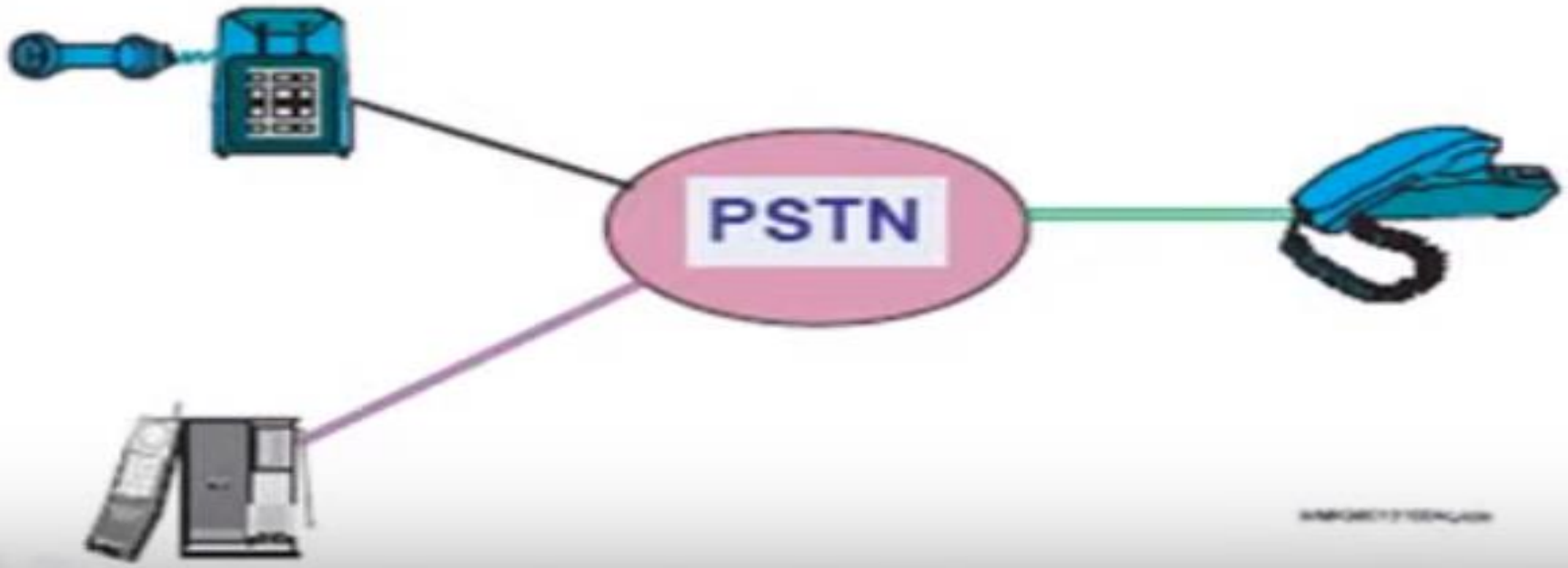
When we talk over the telephone, our voice is converted to a electronic signal by
the microphone in the handset. This signal is then transmitted over telephone wires.



HISTORY OF COMMUNICATION

Telephone Networks Early Switching Devices
Switches are devices that cause a connection between two transmitting/receiving devices.

Modern Switching Devices
Today many different types of automated switches are used which make it possible for fast placement of calls.



HISTORY OF COMMUNICATION

Wired VS Wireless

- Losses
- Mobility
- Security
- Bandwidth
- Cost

Wireless Telecommunications

FUNDAMENTAL OF CELLULAR SYSTEM

Transition from analog to digital

- Capacity

  Compression in digital gives more channels

- compatibility with other systems

  As ISDN (Integrated service Digital Network)

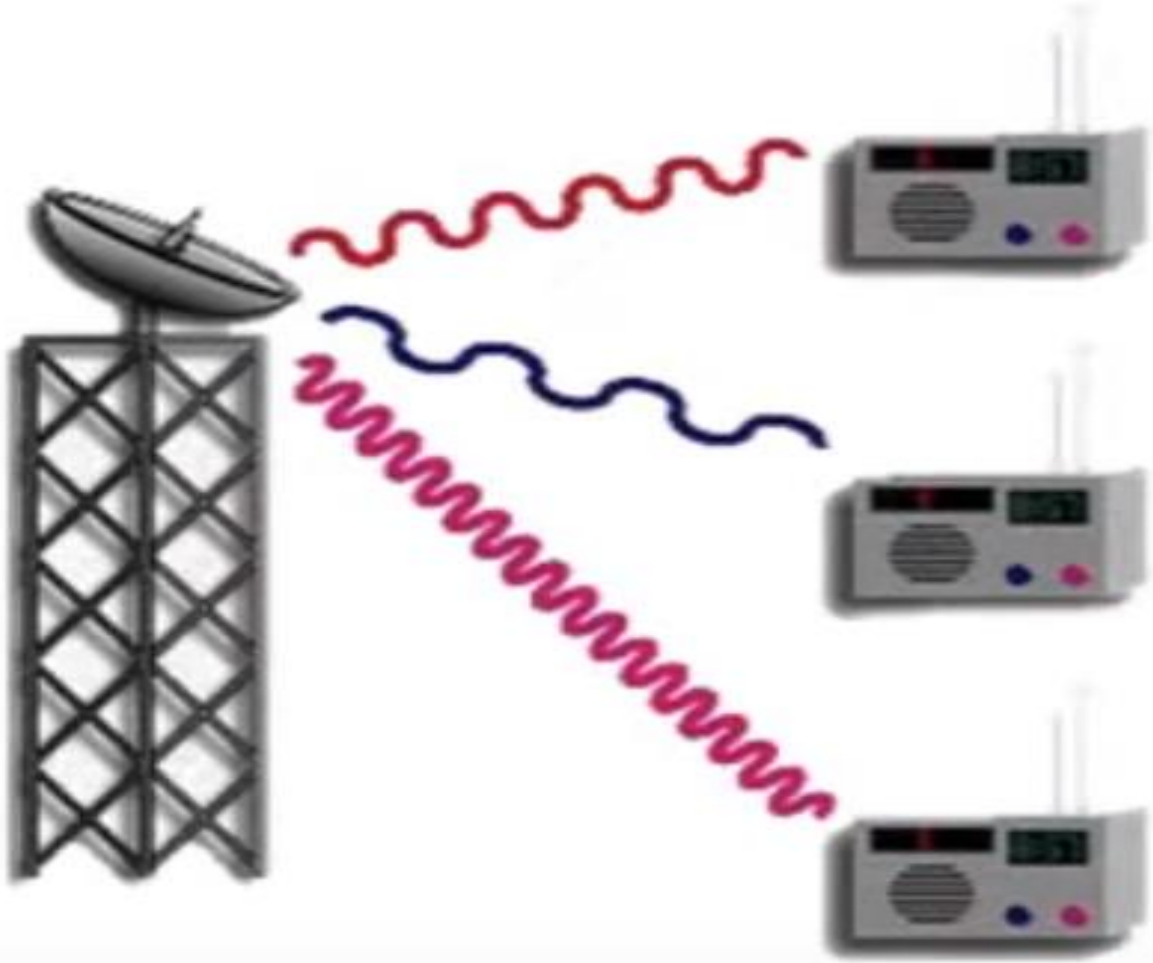
- Cost
- Quality
- Security

Cellular FUNDEMENTALS

- Some techniques used in wireless communication:
  - FDM
  - TDM
  - FDMA
  - TDMA

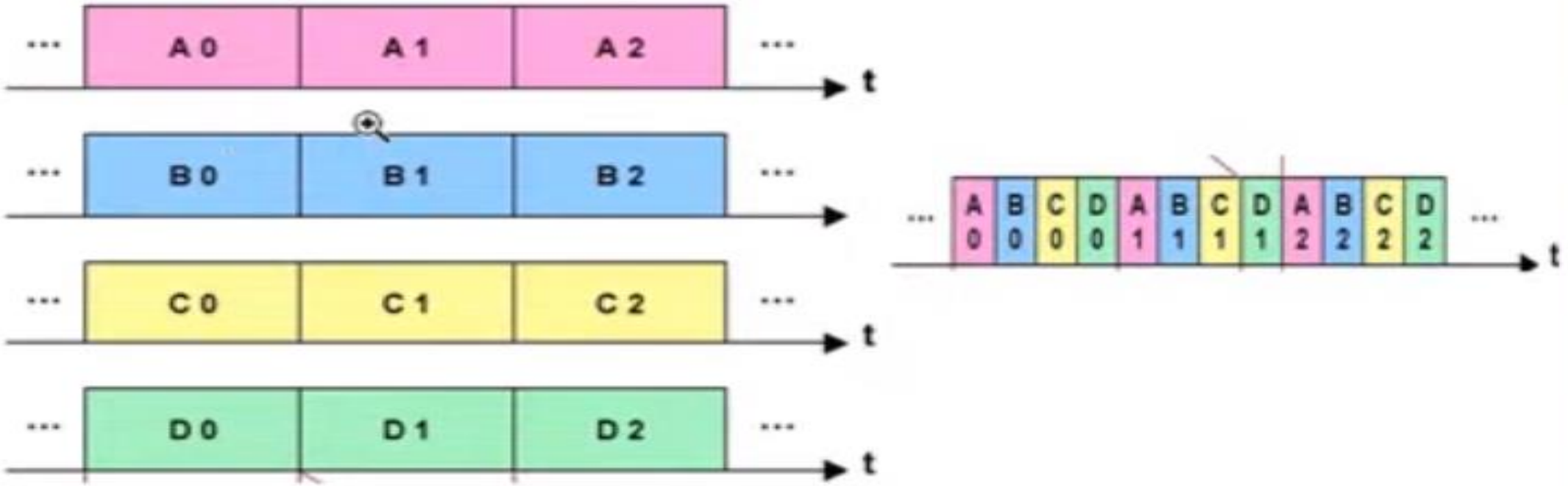
Cellular FUNDEMENTALS

- FDM



Cellular FUNDEMENTALS

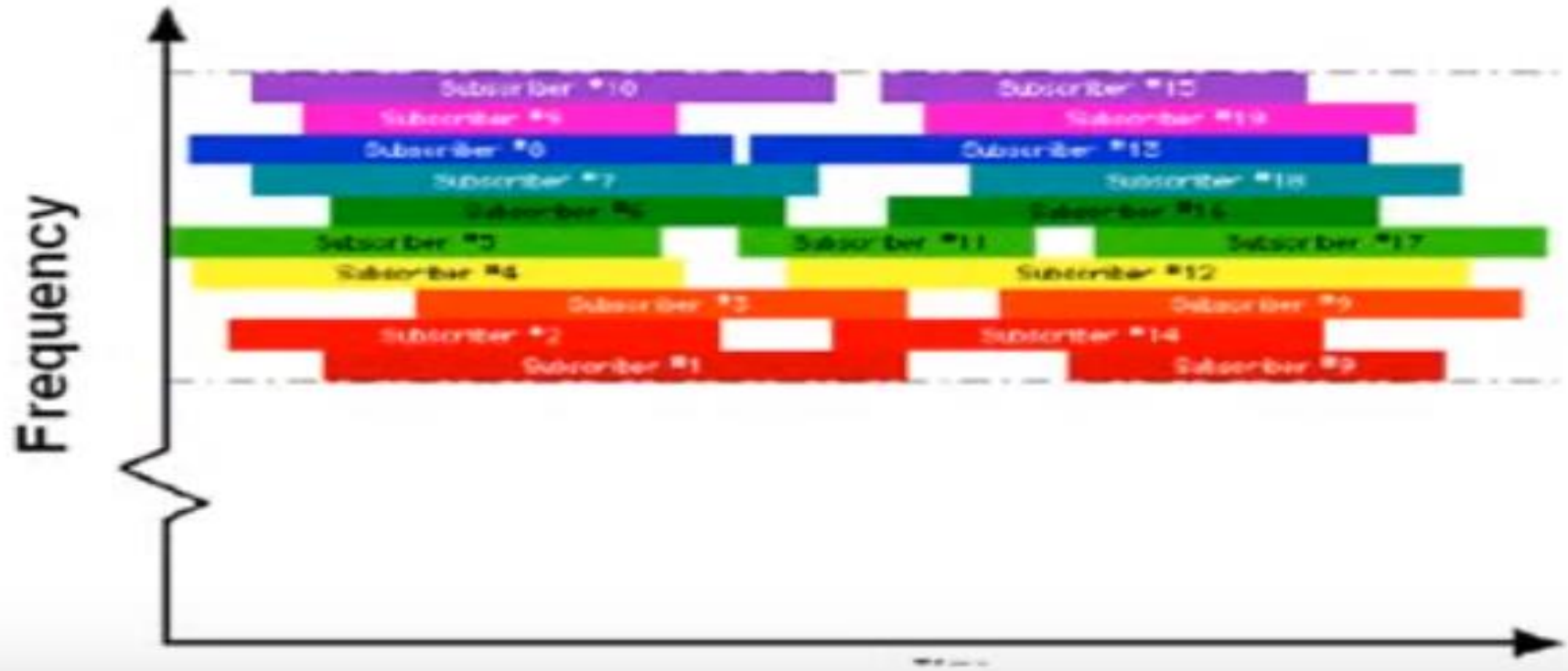
TDM



Cellular FUNDEMENTALS

- FDMA

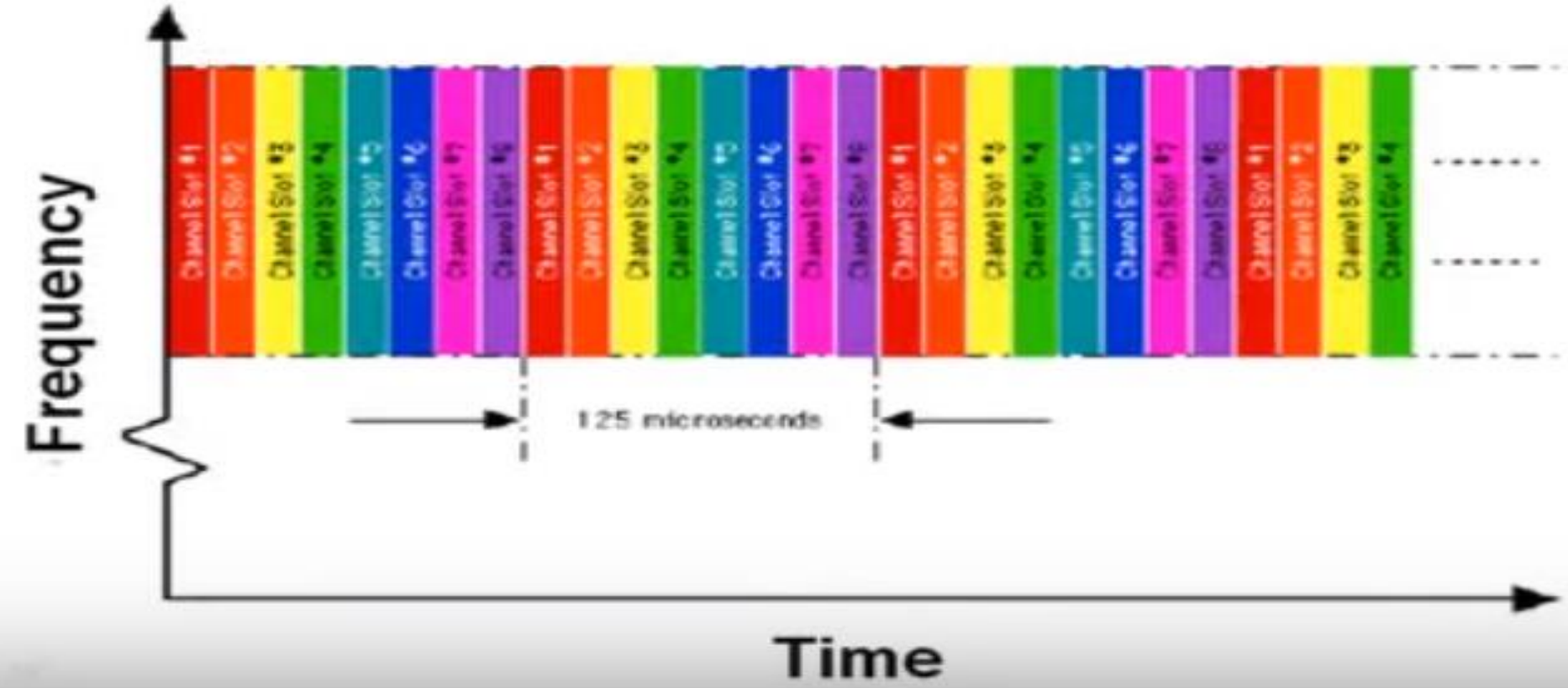
- FDMA is the division of each bandwidth (RX,TX) into many frequency bands (channels)



Cellular FUNDEMENTALS

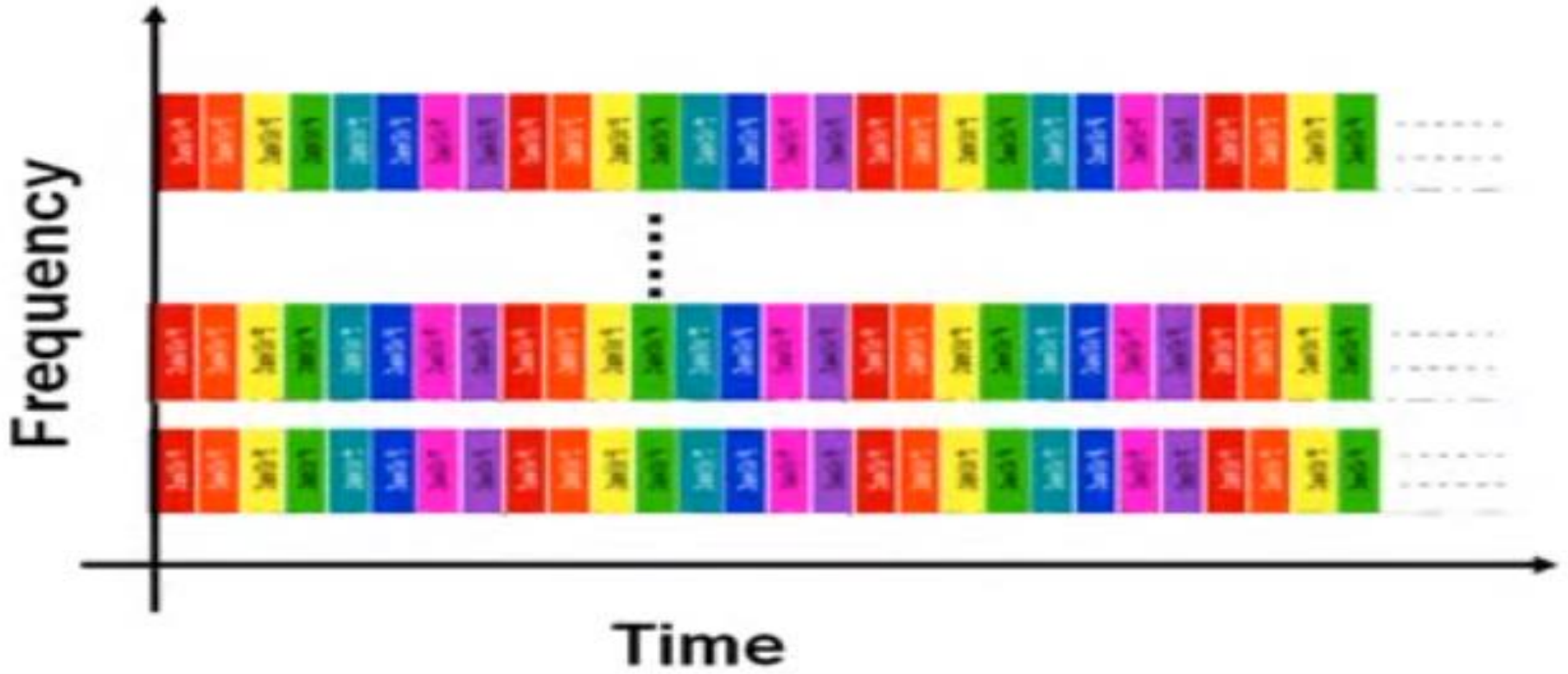
TDMA

- It allows several users to share the same radio frequency (RF) by dividing it into different timeslots



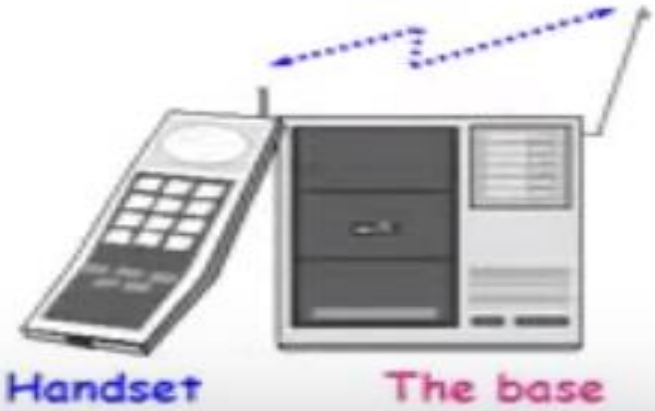
Cellular FUNDEMENTALS

TDMA/FDMA



Cellular FUNDEMENTALS

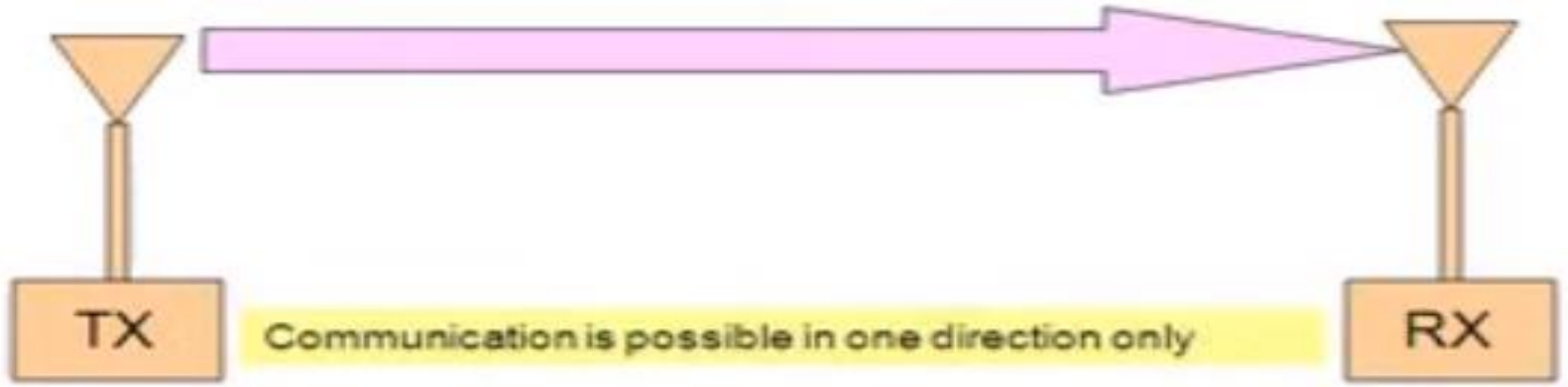
- Types of telephones
  - Fixed (PSTN) telephones
  - Cordless Telephones
  - Mobile Telephones



Cellular FUNDEMENTALS

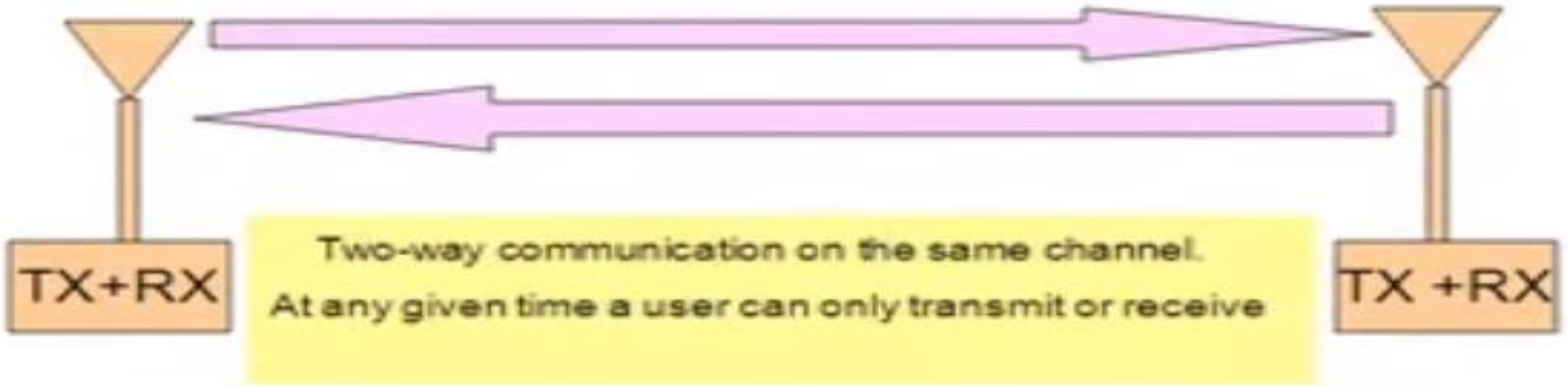
Modes OF Transmission in wireless

- Simplex communication system
  - Example:
    - Television , radio



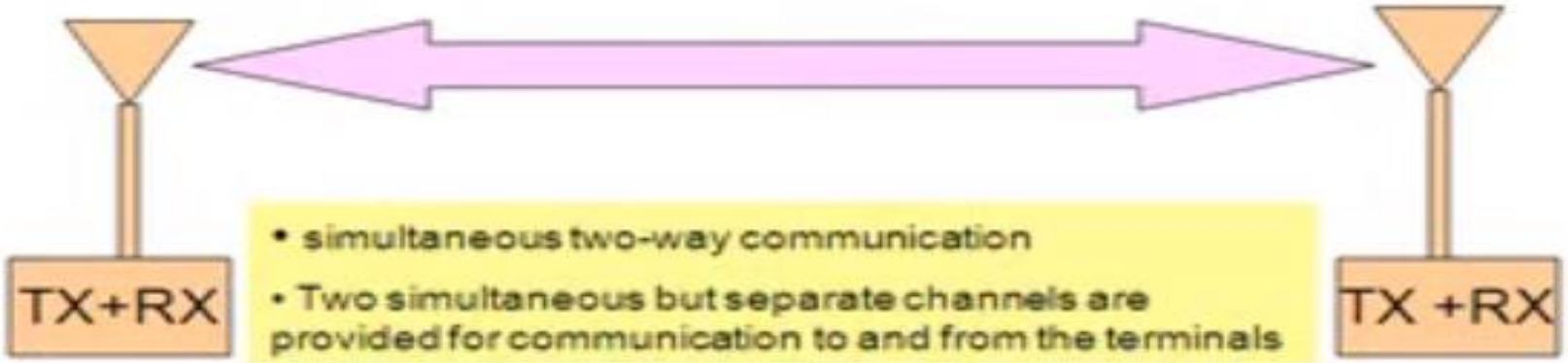
Cellular FUNDEMENTALS

- **Half - Duplex communication system**
  - Example :
    - **Police radio**



Cellular FUNDEMENTALS

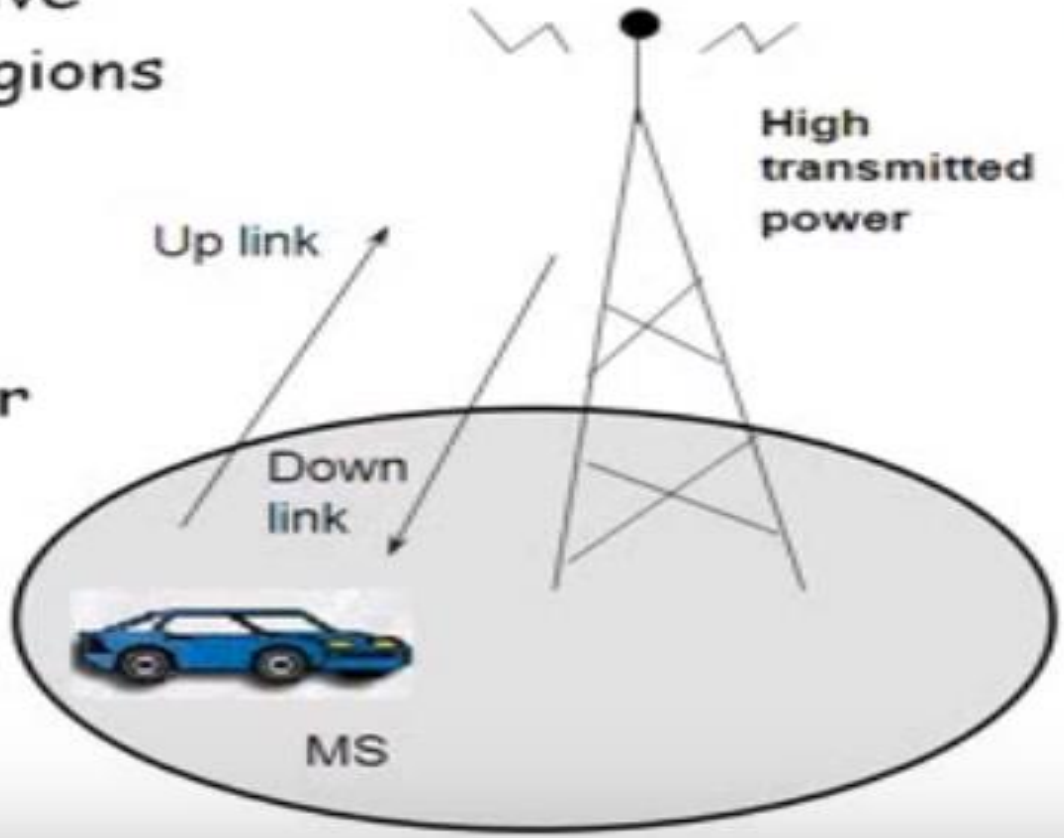
- **Full - Duplex communication system**
  - Example :
    - **GSM mobile radio**



Cellular FUNDEMENTALS

- **Simple growth was the single transmitting/receiving station**

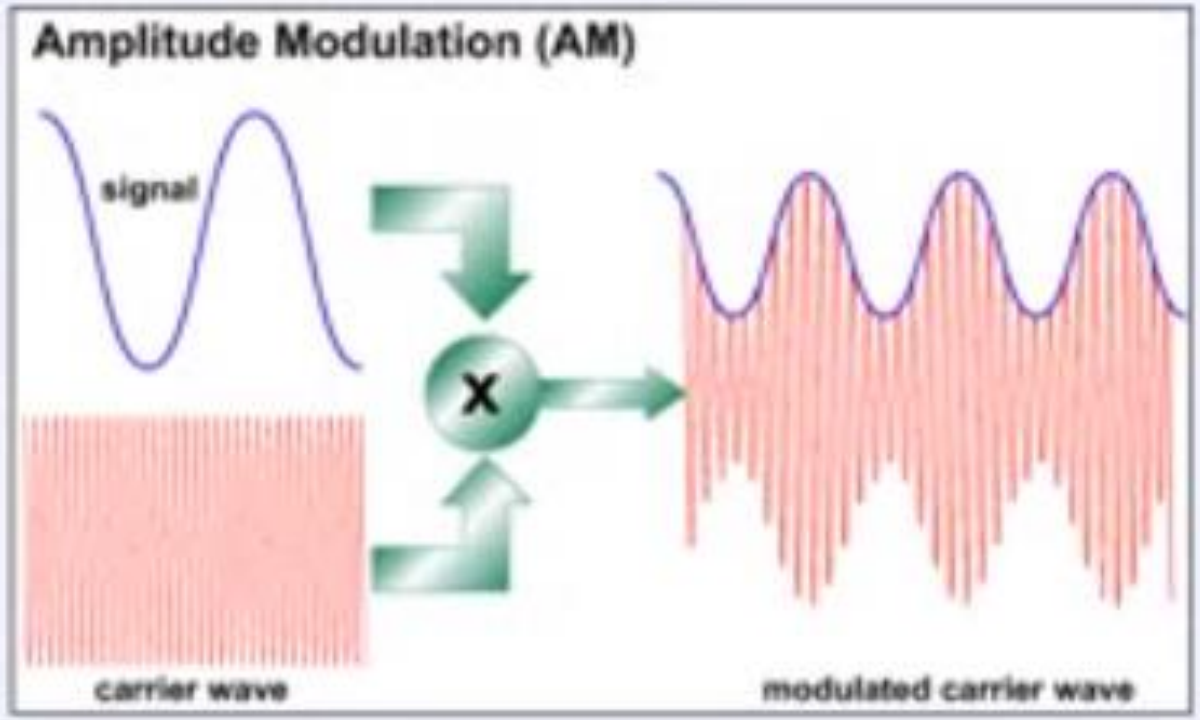
  - heavy, bulky and expensive
  - no switching between regions
  - low quality
  - limited capacity
  - rapid market saturation
  - power hungry transceiver
  - power level was not safe

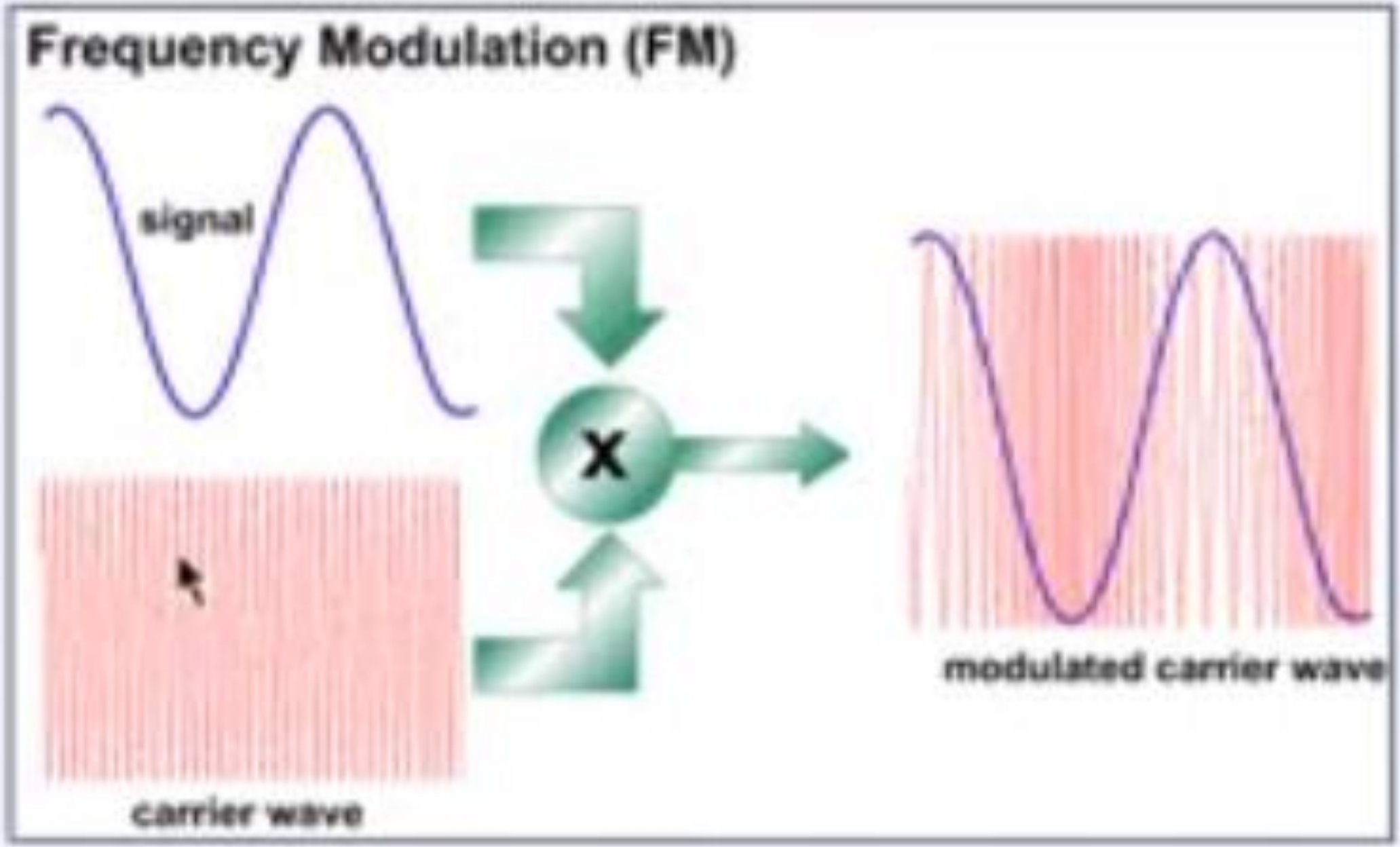


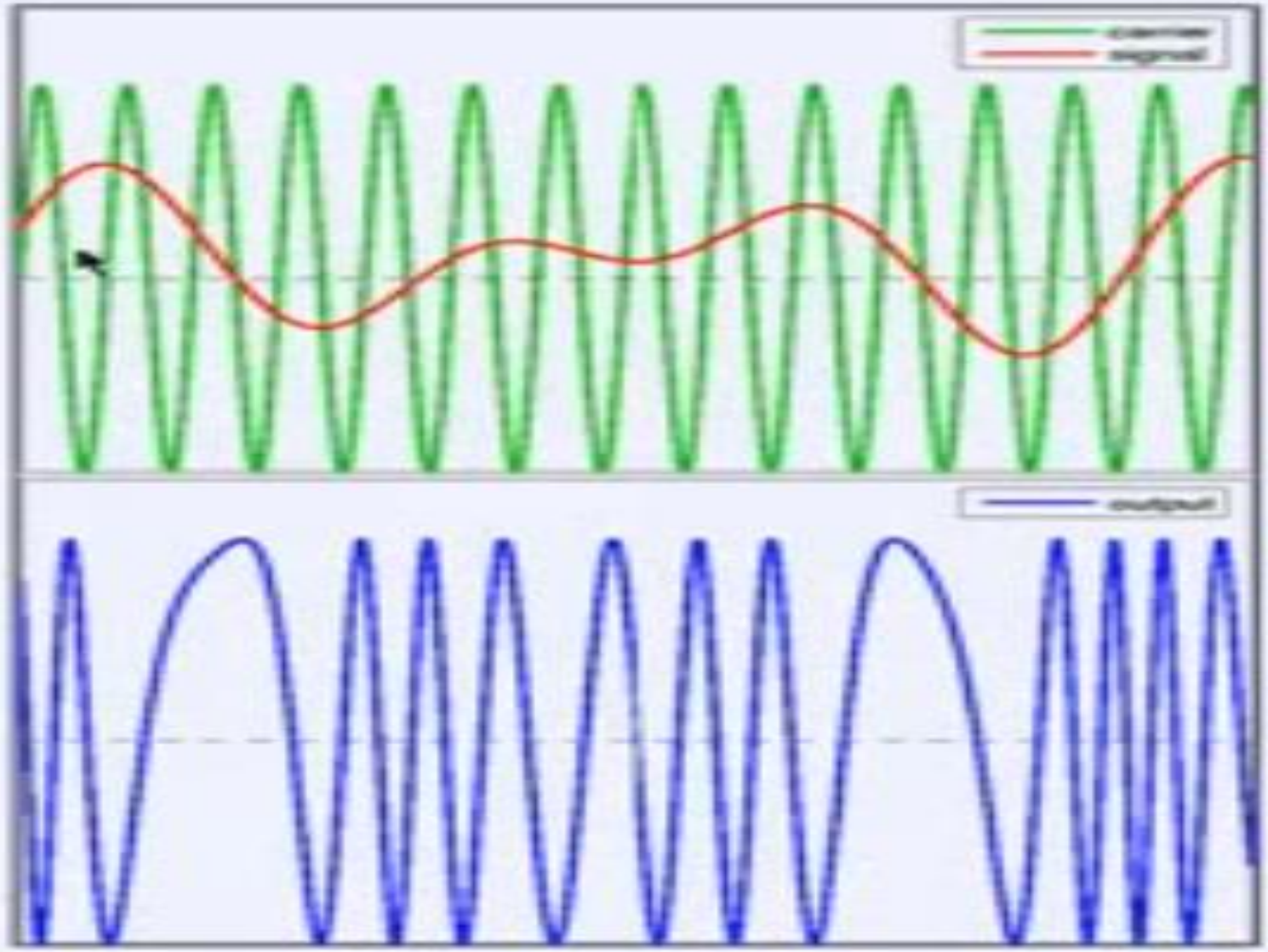
Cellular FUNDEMENTALS

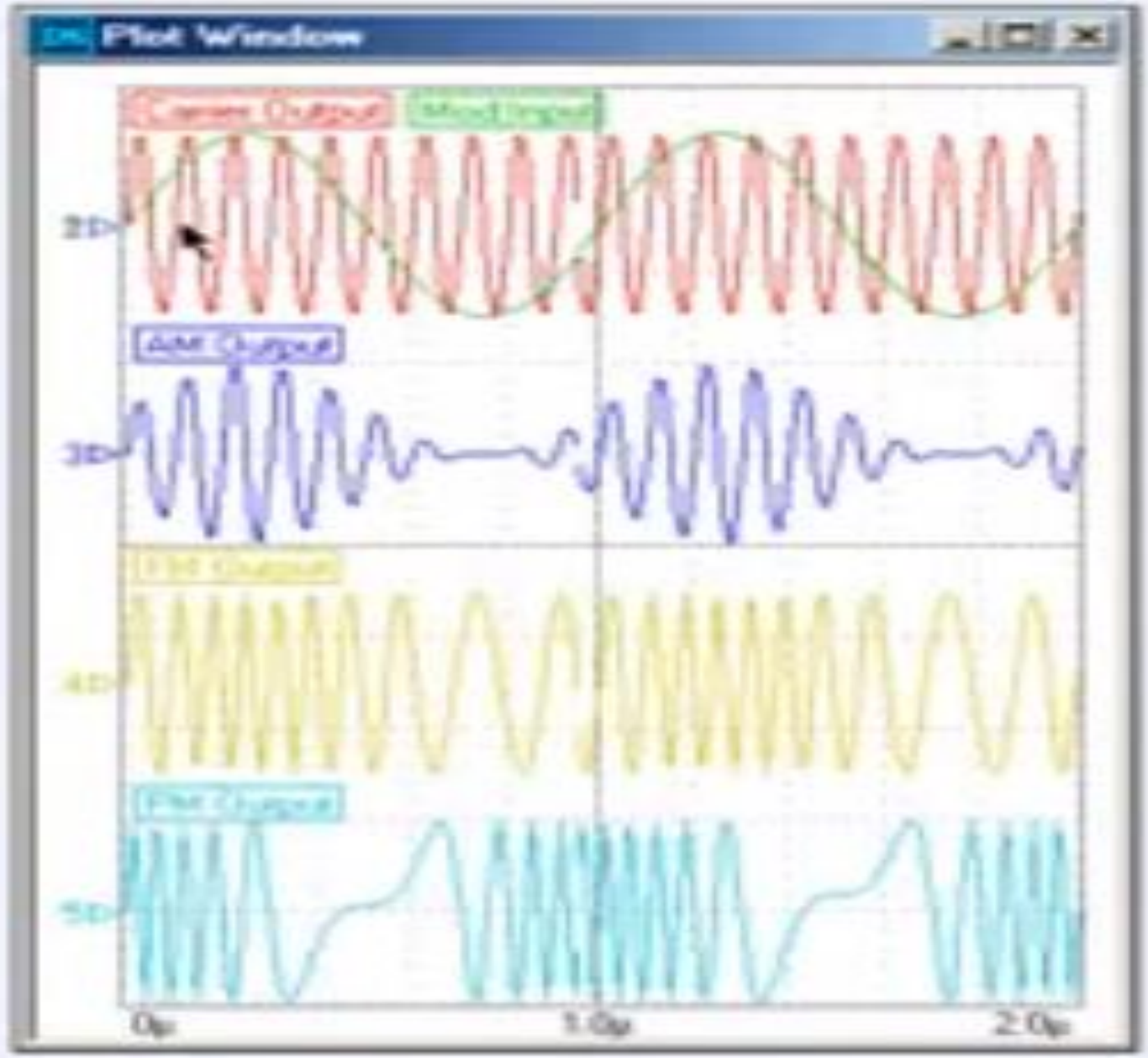
Cellular FUNDEMENTALS

- First generation cellular system
  - Introduction of analog cellular systems in the late 1970s and 1980s
  - analog system
  - incompatible systems
  - limited to voice service
  - no encryption
  - FM modulation
  - FDMA transmission technology
  - suffer from capacity saturation



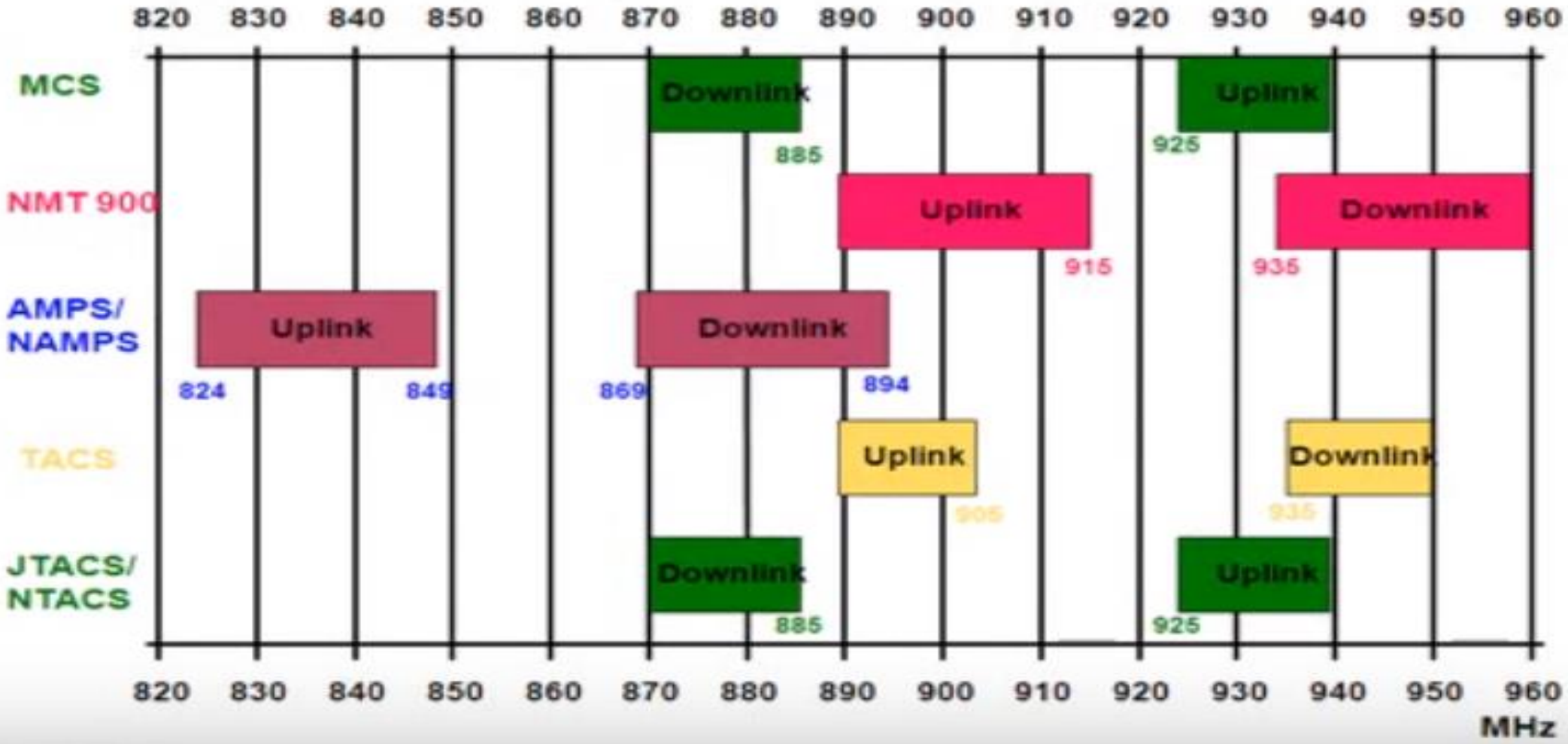

Frequency Modulation (FM)
signal
X
carrier wave
modulated carrier wave




Plot Window
0p
1.0p
2.0p

Cellular FUNDEMENTALS

- 1G Frequency Bands



Cellular FUNDEMENTALS

- Systems of first generation

System	Year of Introduction	Region	Access Mode/ Modulation
MCS-L2	1988 (1979)	Japan	FDMA/PM
NMT 450	1981	Scandinavia	FDMA/FM
NMT 900	1986	Scandinavia	FDMA/FM
AMPS	1983	North America	FDMA/FM
NAMPS	1991	North America	FDMA/FM
TACS	1985	United Kingdom	FDMA/FM
ETACS	1988	United Kingdom	FDMA/FM
JTACS	1989	Japan	FDMA/FM
NTACS	1991	Japan	FDMA/FM
C450	1985	Germany	FDMA/FM
RadioCom	1985	France	FDMA/FM

Cellular FUNDEMENTALS

- Second Generation cellular system
  - Introduction of digital cellular systems (90's)
  - development of unified international standard for mobile communications
  - pan-national roaming
  - digital encryption
  - enhanced range of services (data + voice)
  - low power consumption
  - light weight, compact and pocket size terminals
  - TDMA transmission technology
  - huge capacity

Cellular FUNDEMENTALS

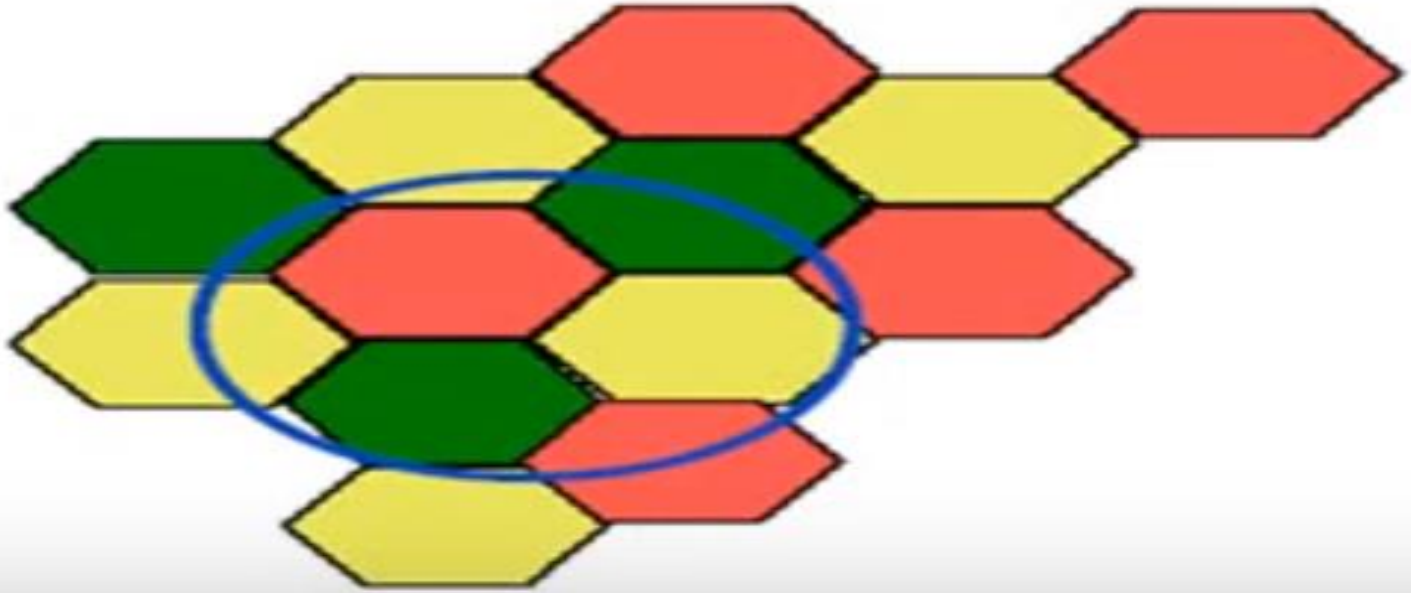
- WORLDWIDE GSM NETWORKS IN SERVICE

Cellular FUNDEMENTALS

- Third generation cellular system
  - Multimedia services
  - W-CDMA transmission technology
  - Large BW
  - Higher Bit Rate
  - More Services

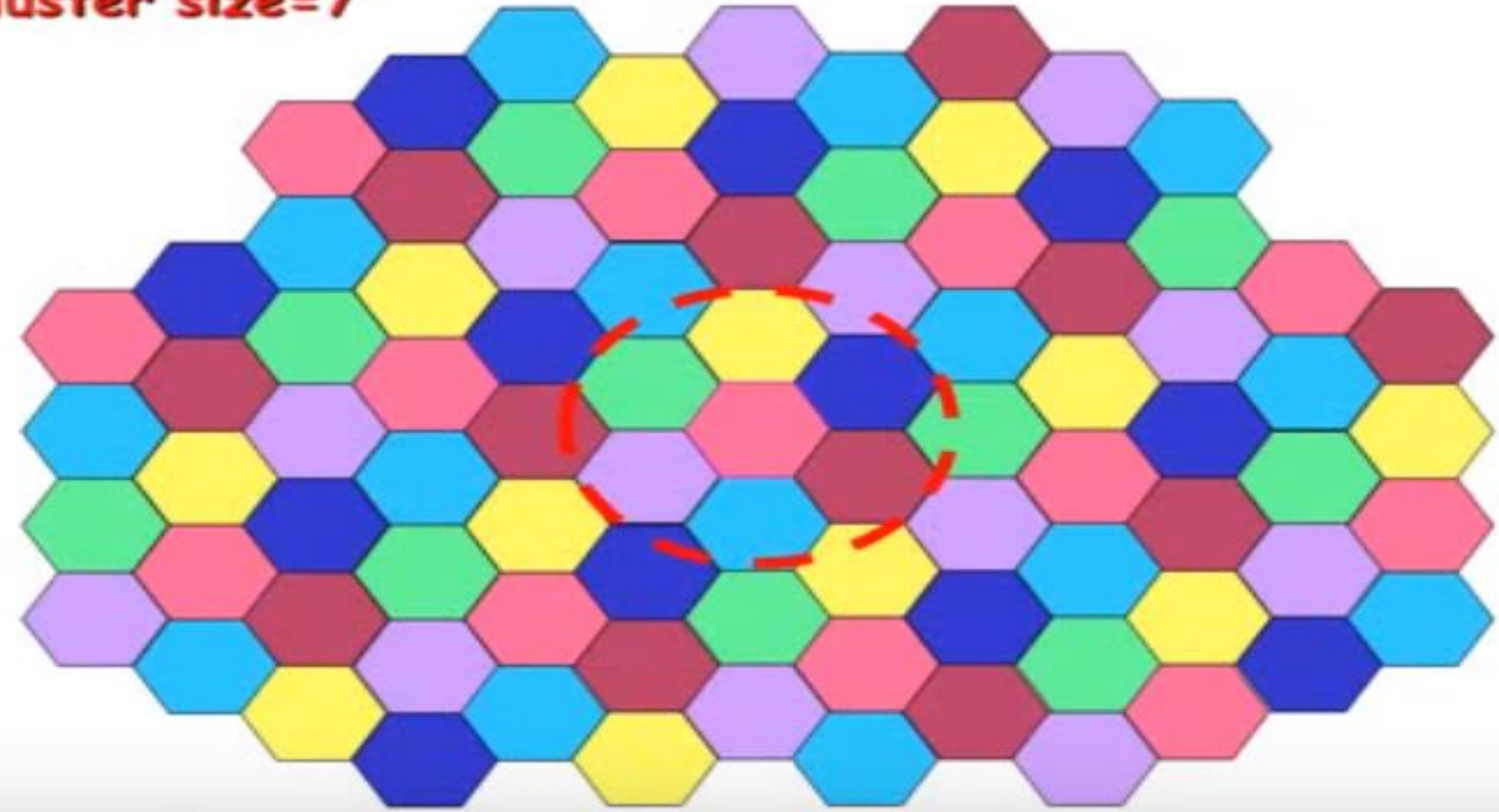
FUNDAMENTAL OF CELLULAR SYSTEM

- **The cellular structure**
  - area divided into small zones (cells)
  - cells grouped into clusters
  - this gives less power usage
  - enable frequency reuse



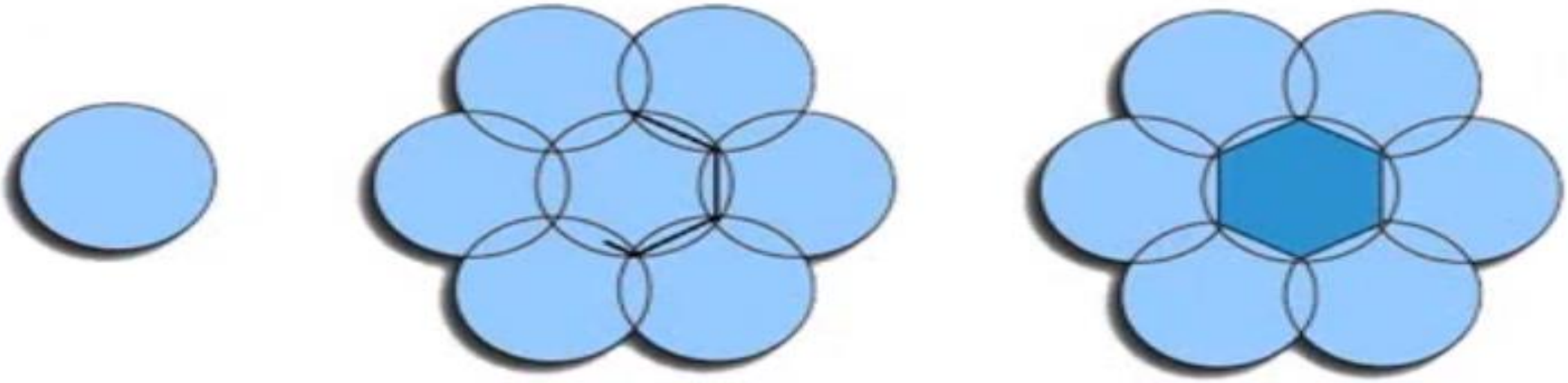
FUNDAMENTAL OF CELLULAR SYSTEM

Cluster size=7

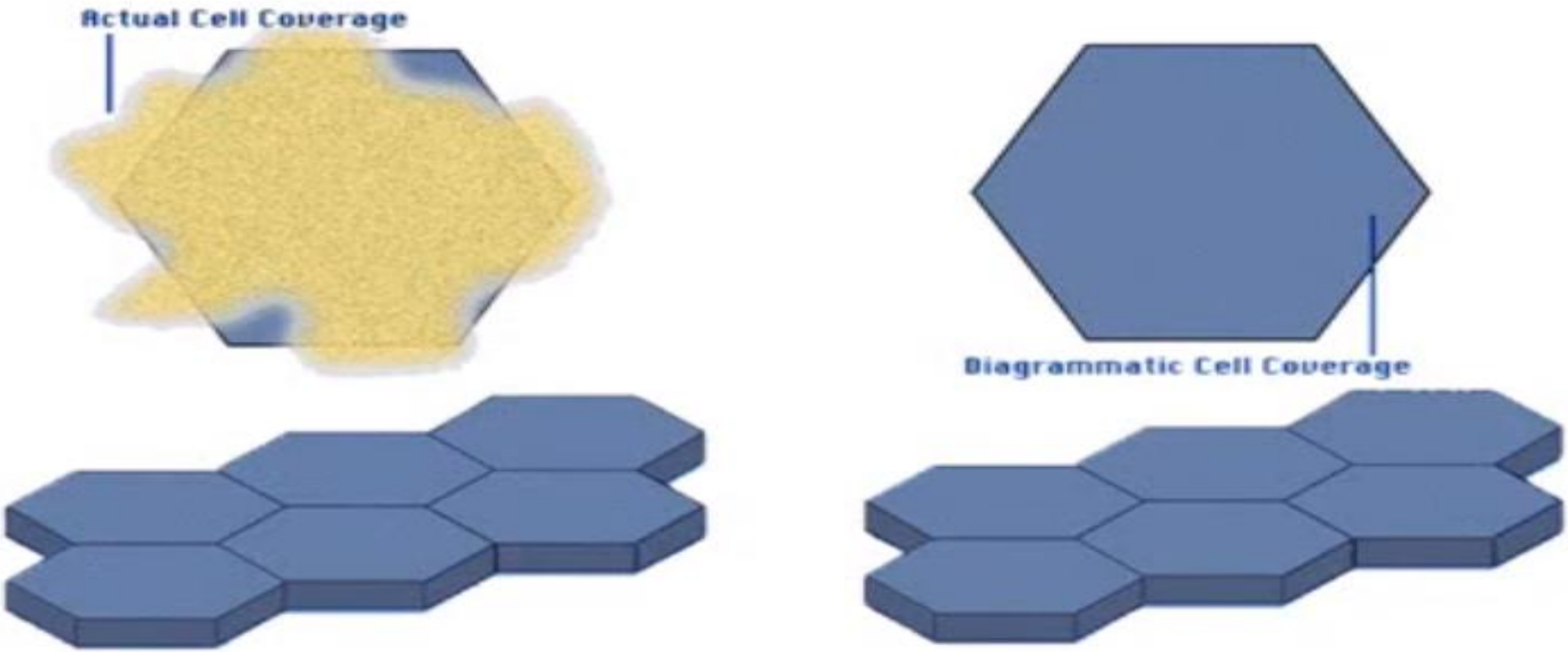


FUNDAMENTAL OF CELLULAR SYSTEM

- Cell shape

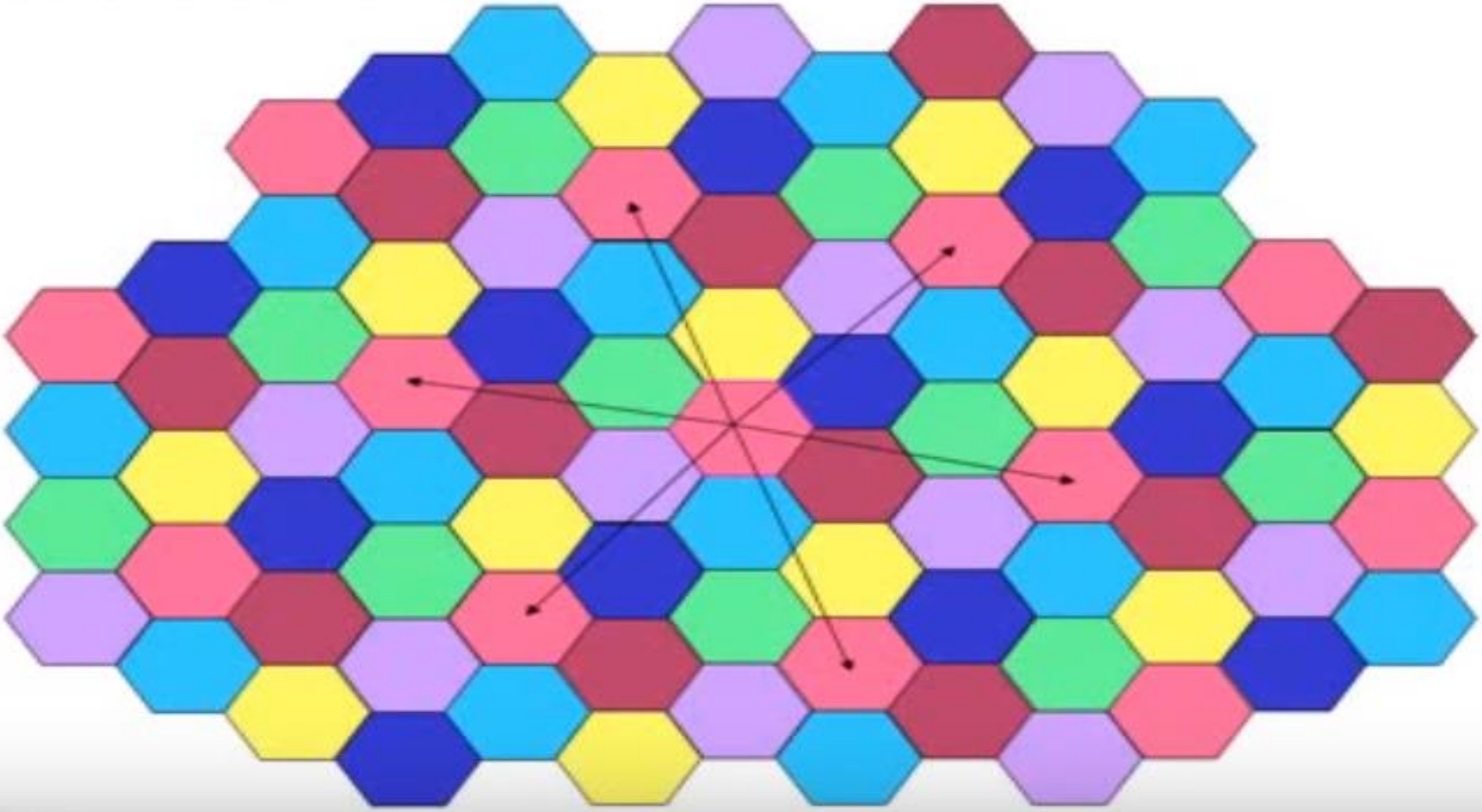


FUNDAMENTAL OF CELLULAR SYSTEM



FUNDAMENTAL OF CELLULAR SYSTEM

- cell sectorization



FUNDAMENTAL OF CELLULAR SYSTEM

60° cells

6 Cell Site
Transmit/Receive
Antenna

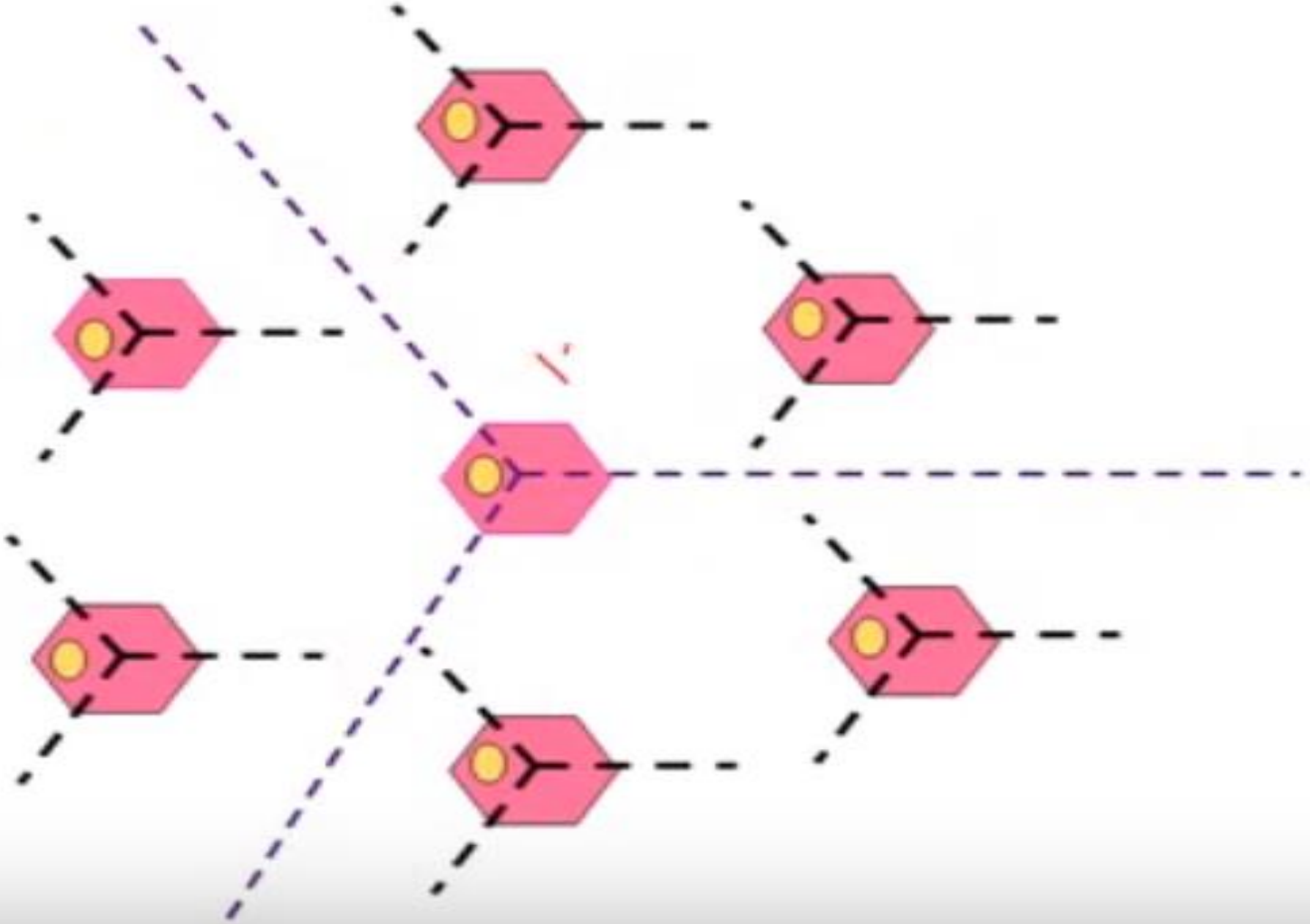
120° cells

3 Cell Site
Transmit/Receive
Antenna

Omni (360°) cell site

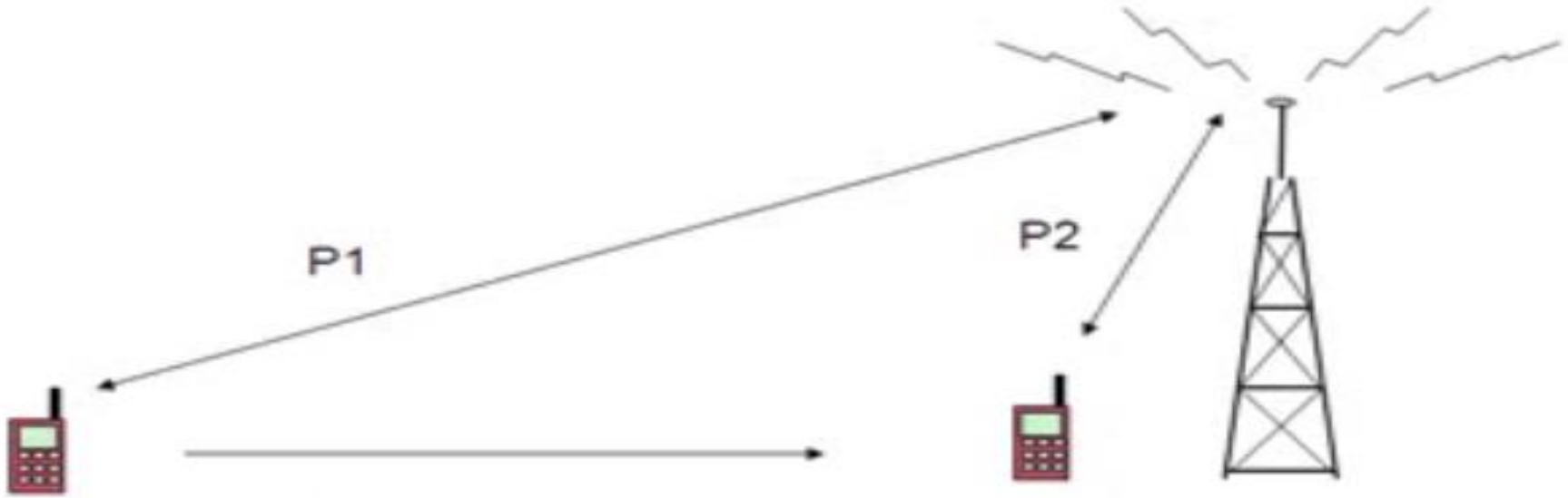
FUNDAMENTAL OF CELLULAR SYSTEM

- cell sectorization

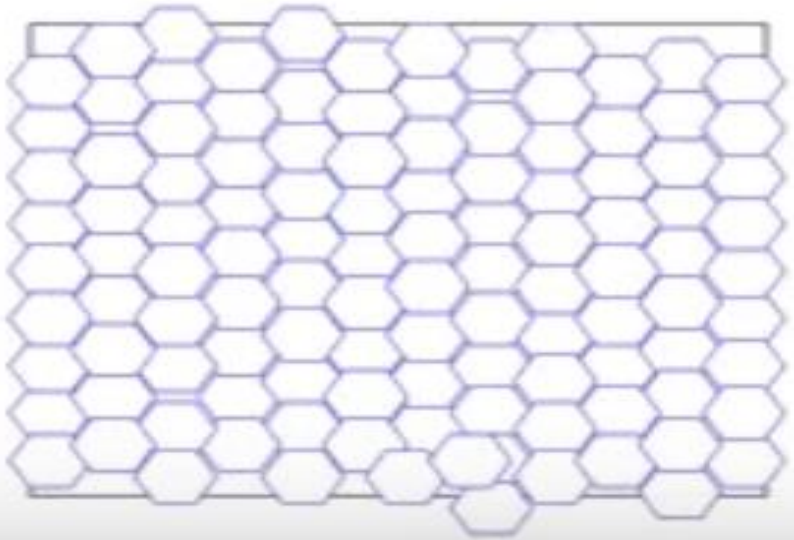


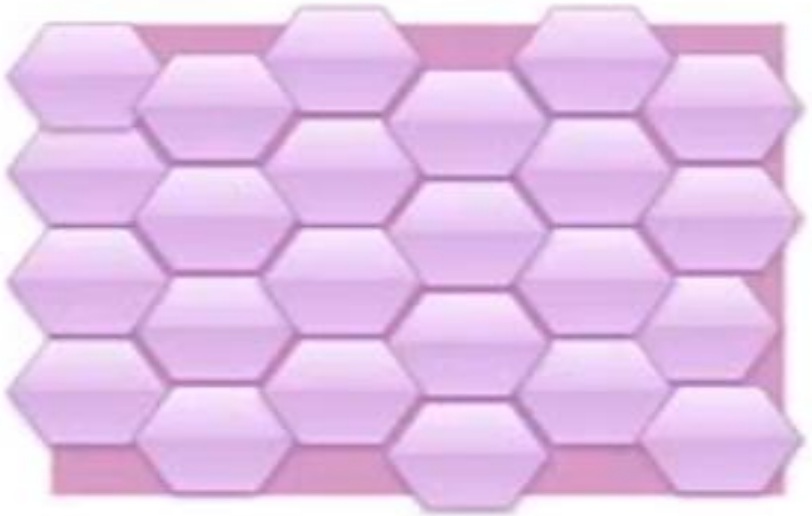
FUNDAMENTAL OF CELLULAR SYSTEM

- **adaptive power control**
  - as cellular mobile moves power seen at Bs changed
  - so we use adaptive power control to maintain it



FUNDAMENTAL OF CELLULAR SYSTEM

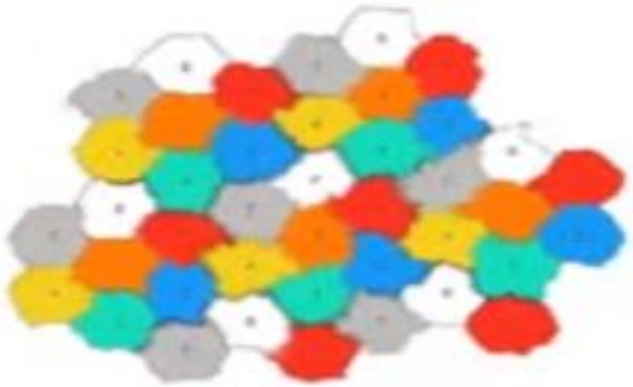




FUNDAMENTAL OF CELLULAR SYSTEM

- cell types
  - macrocell
  - microcell
  - picocell

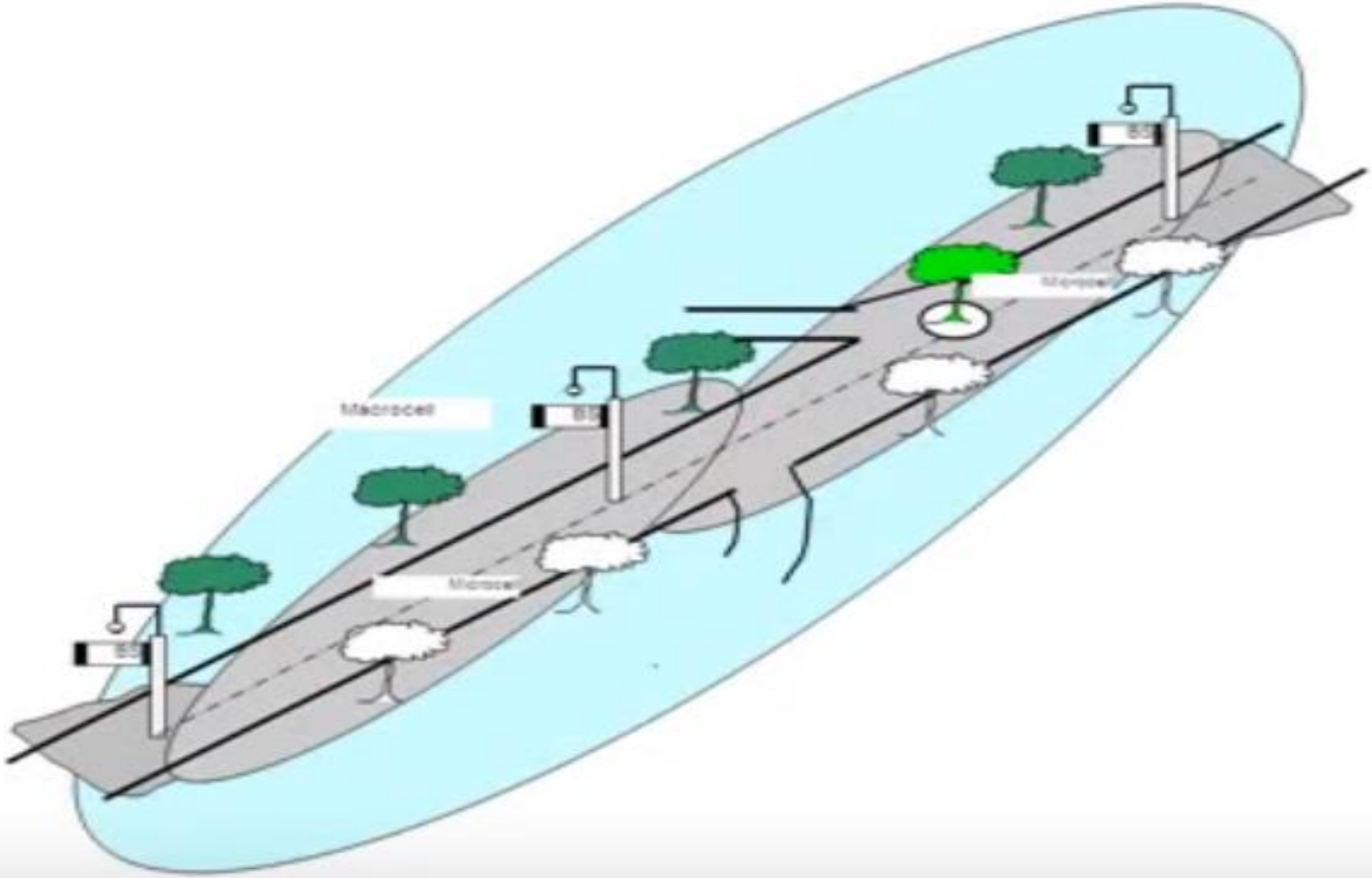
Large Cells



Very small cells

Small Cells

FUNDAMENTAL OF CELLULAR SYSTEM



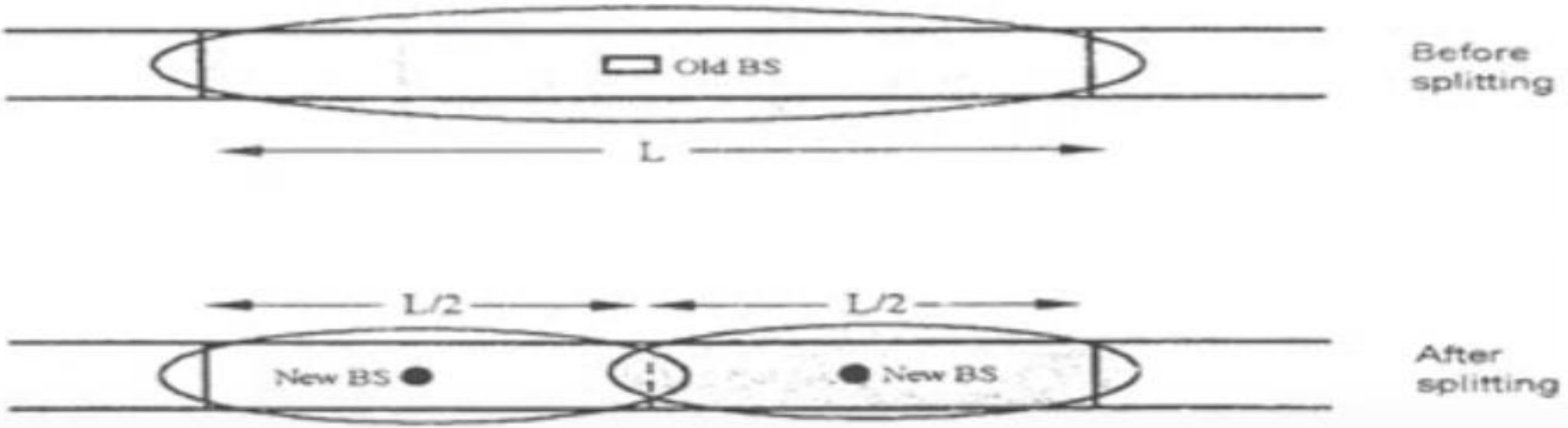
FUNDAMENTAL OF CELLULAR SYSTEM

Pico Cell

FUNDAMENTAL OF CELLULAR SYSTEM

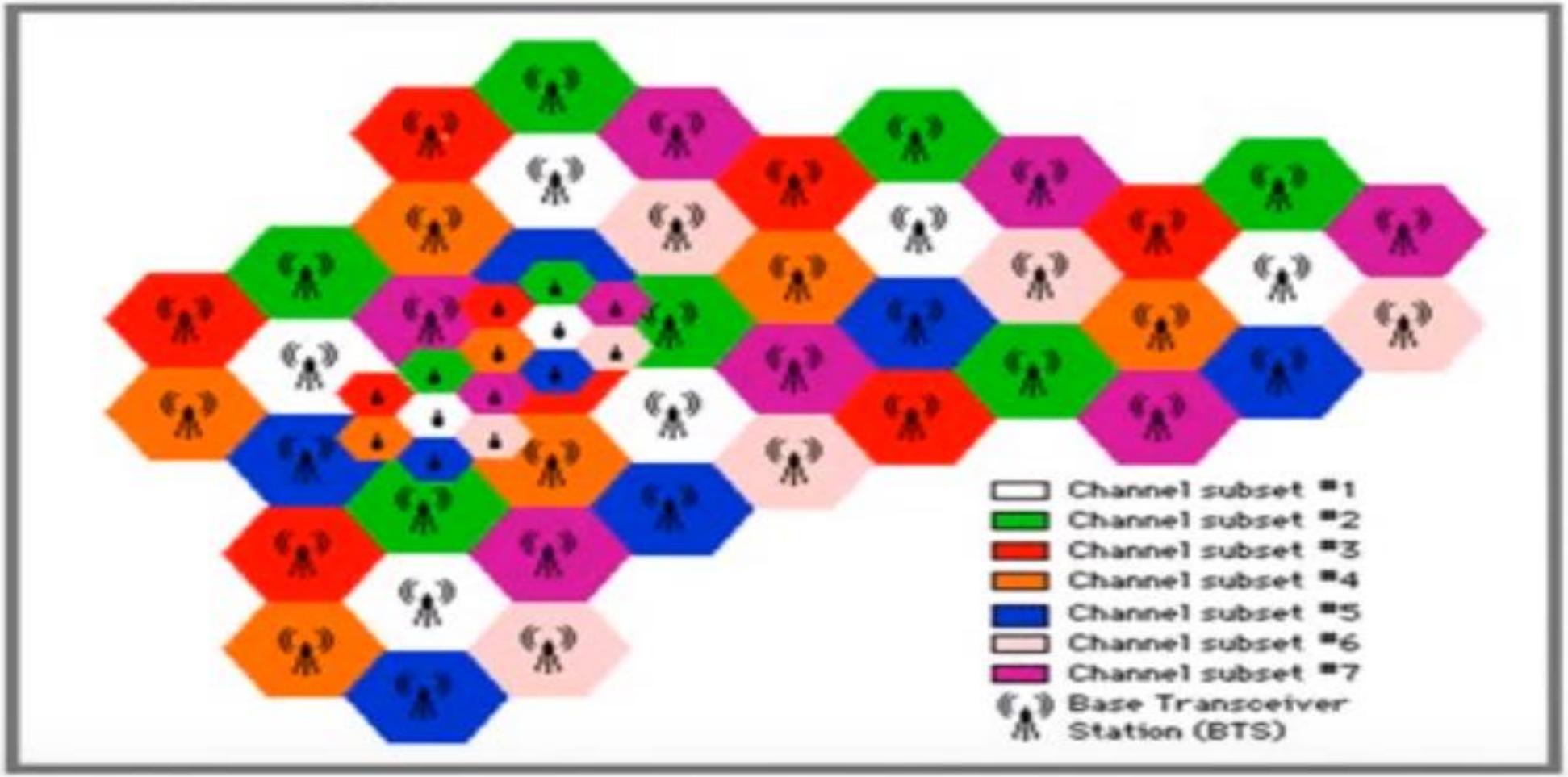
FUNDAMENTAL OF CELLULAR SYSTEM

- **cell splitting**
  - as traffic load increases in a cell
  - to increase channels designer tend to split cell into smaller cells
  - R decrease Dc decrease so more capacity



FUNDAMENTAL OF CELLULAR SYSTEM

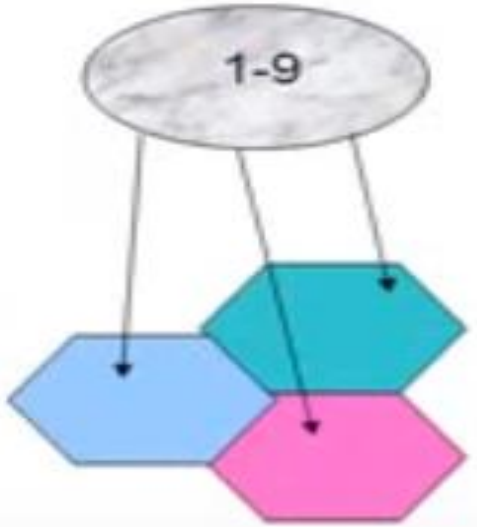
- cell splitting



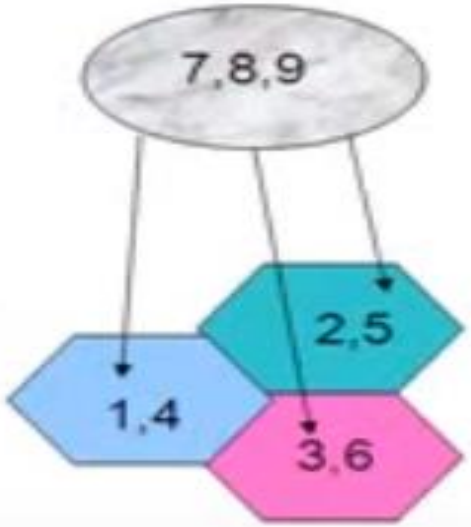
FUNDAMENTAL OF CELLULAR SYSTEM

- channel allocation techniques
  - Fixed channel assignment technique (less Ts)
  - dynamic channel assignment technique (largest Ts)
  - hybrid channel assignment technique (Improved)

Fixed



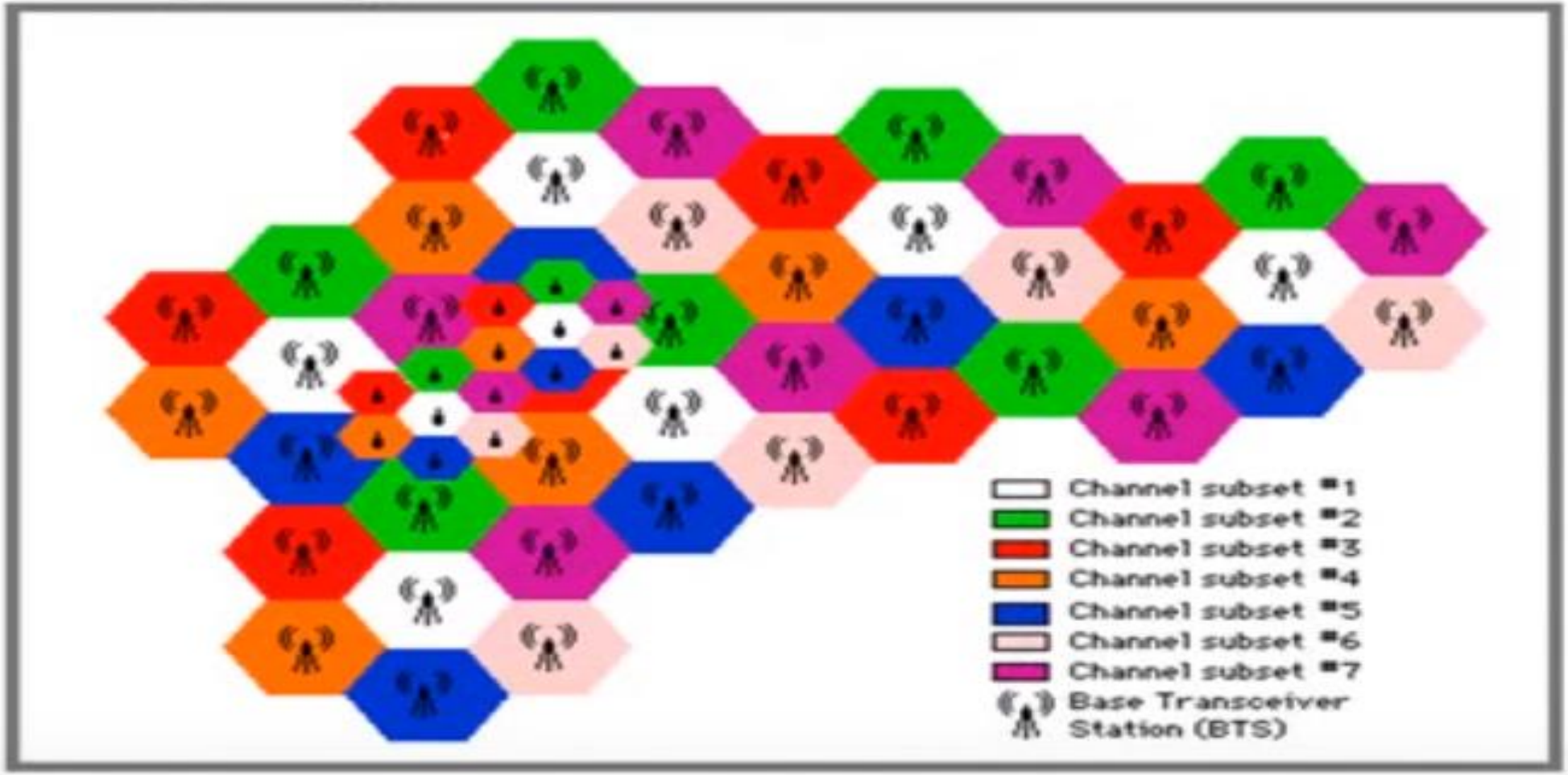
Dynamic



Hybrid

FUNDAMENTAL OF CELLULAR SYSTEM

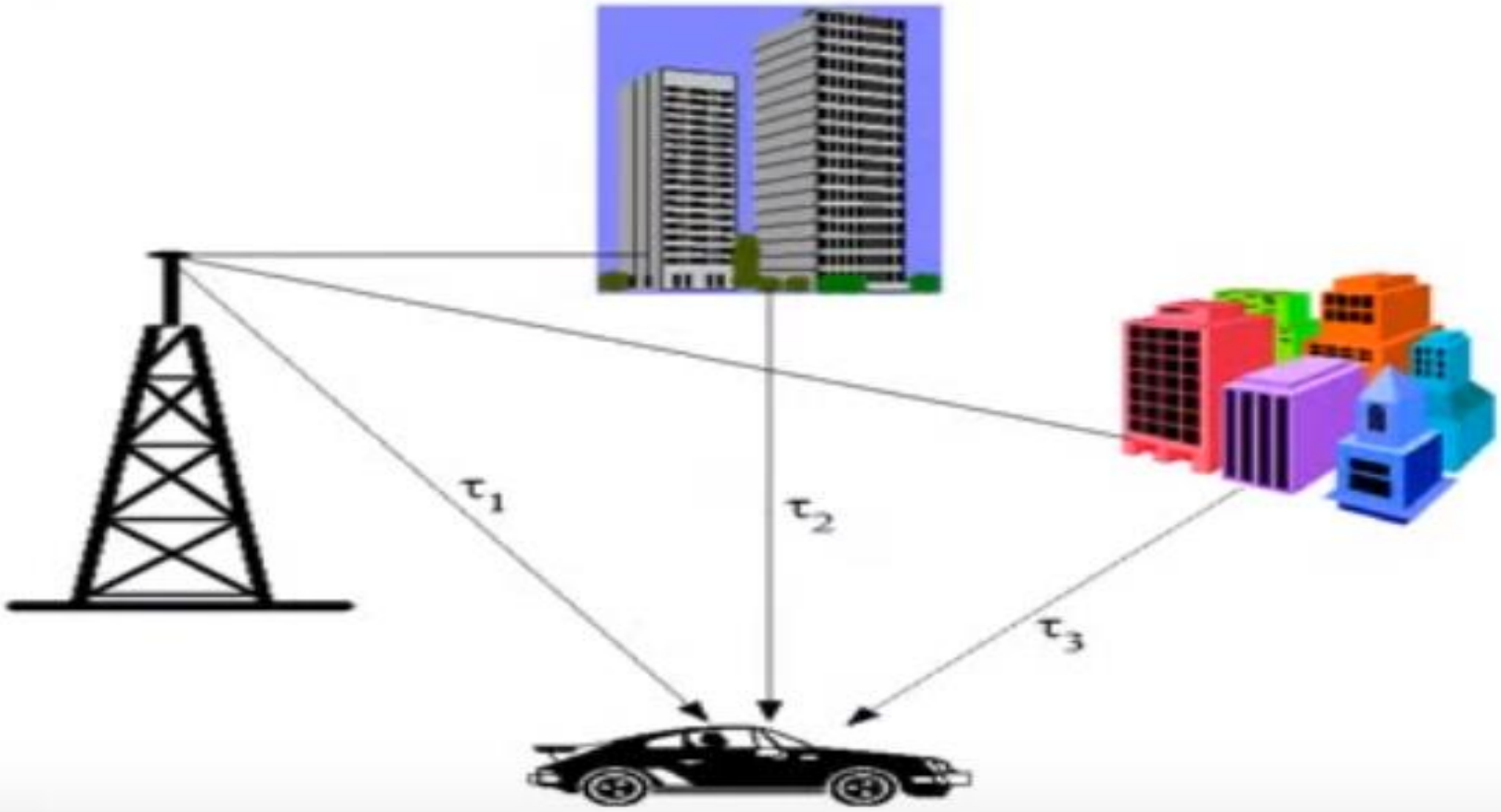
- cell splitting



Lecture 3 : Chapter1

FUNDAMENTAL OF CELLULAR SYSTEM

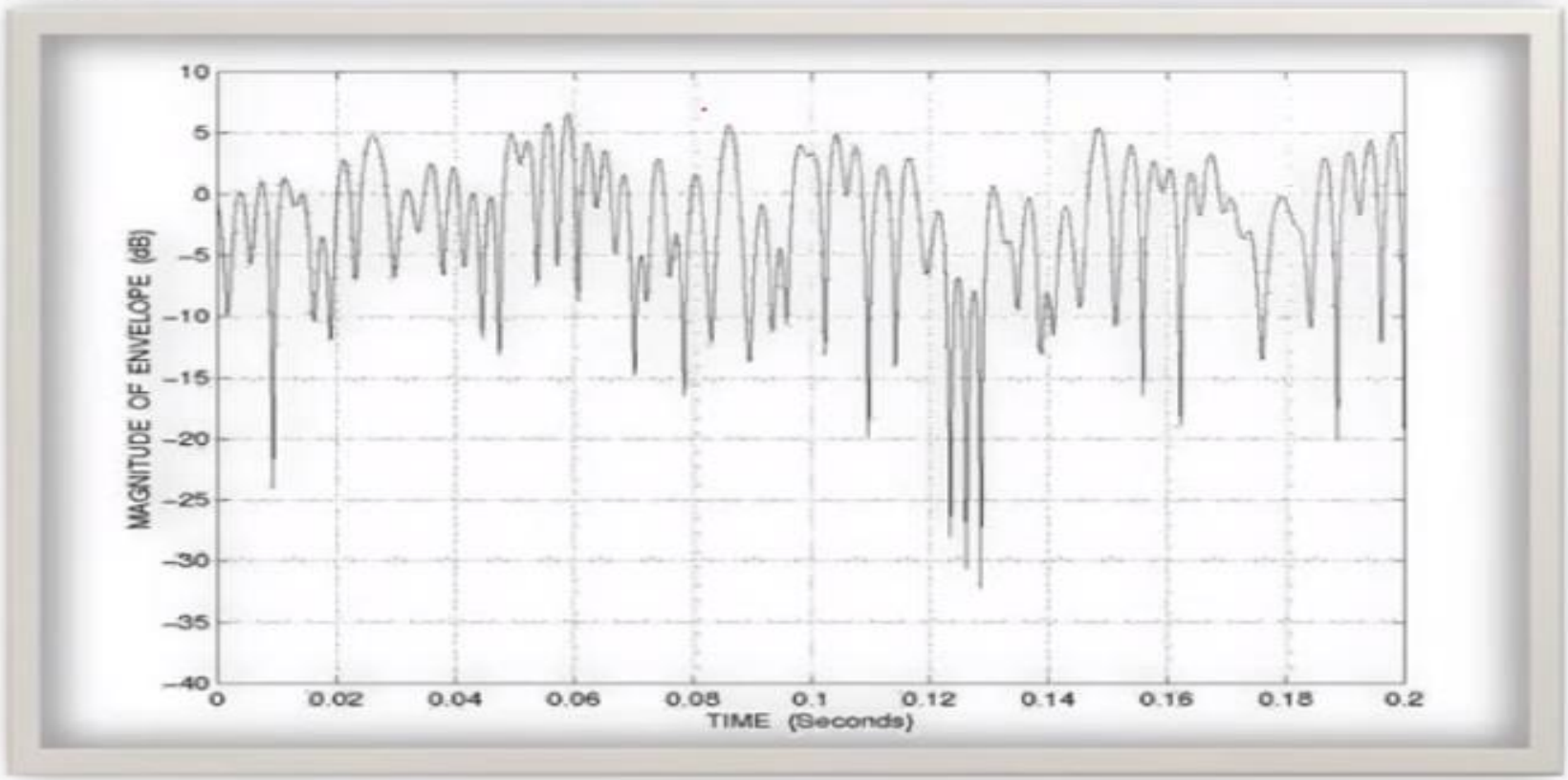
- channel characteristics
  - Multipath fading



FUNDAMENTAL OF CELLULAR SYSTEM

-It gives a Rayleigh fading distribution

- Rayleigh fading is frequency selective



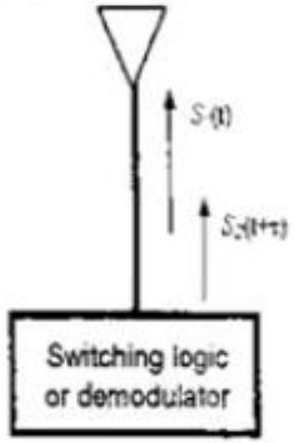
FUNDAMENTAL OF CELLULAR SYSTEM

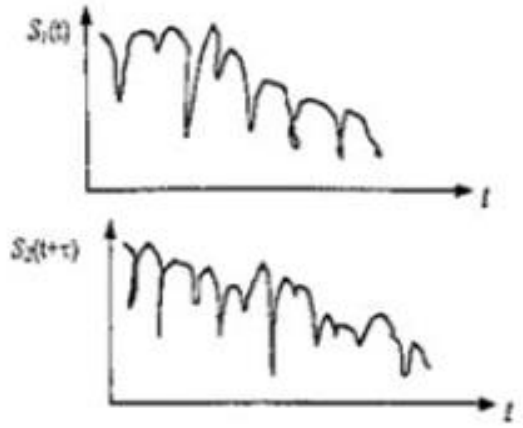
- **To overcome multipath fading we use :**
  - Microscopic diversity and combining techniques
  - Frequency hopping
  - Error correction
  - Interleaving technique
  - adaptive power control

FUNDAMENTAL OF CELLULAR SYSTEM

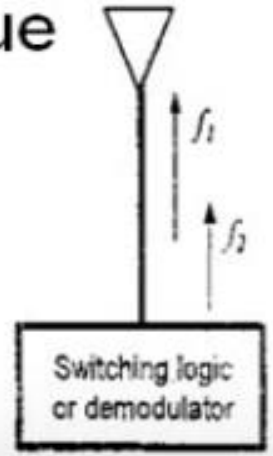
-Microscopic diversity techniques :

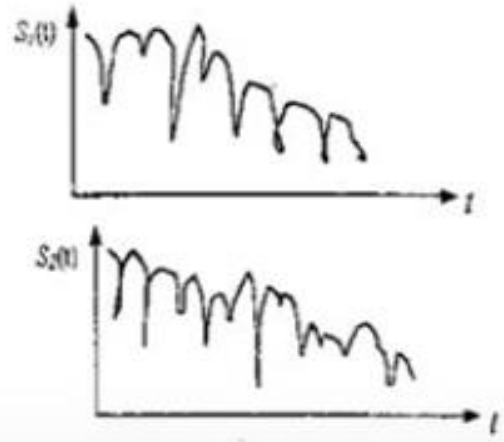
1-Time diversity technique





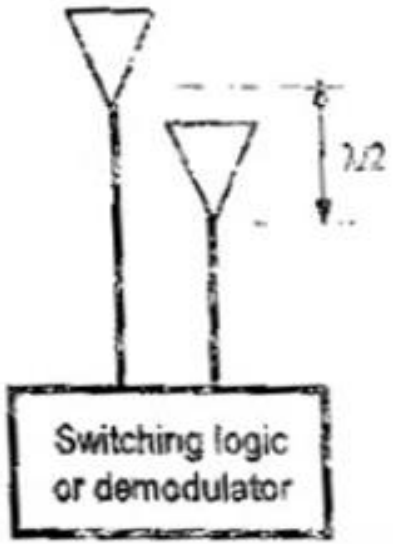
2-Frequency diversity technique

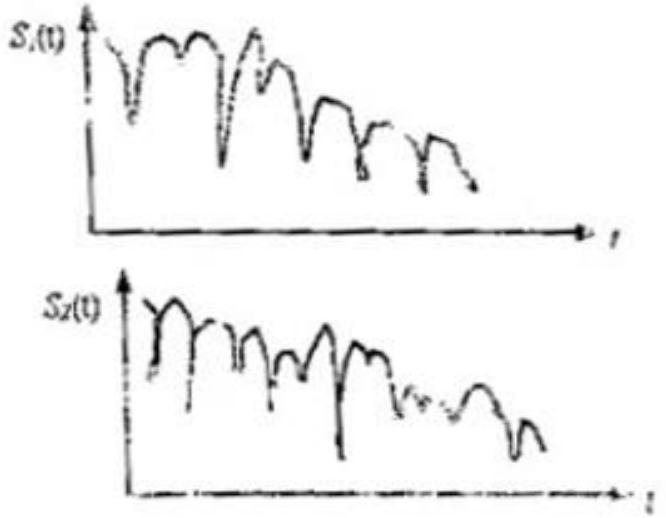




FUNDAMENTAL OF CELLULAR SYSTEM

3-Space diversity technique



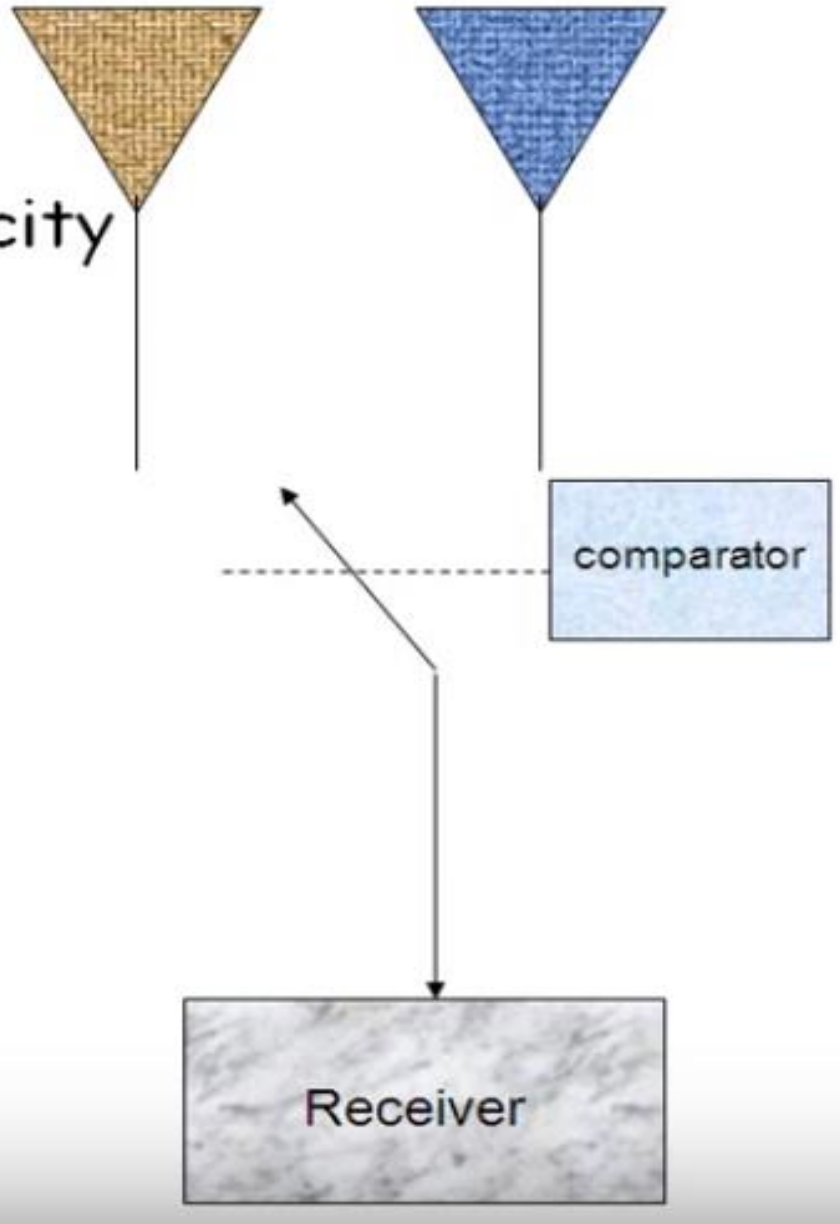


FUNDAMENTAL OF CELLULAR SYSTEM

-Space diversity technique

FUNDAMENTAL OF CELLULAR SYSTEM

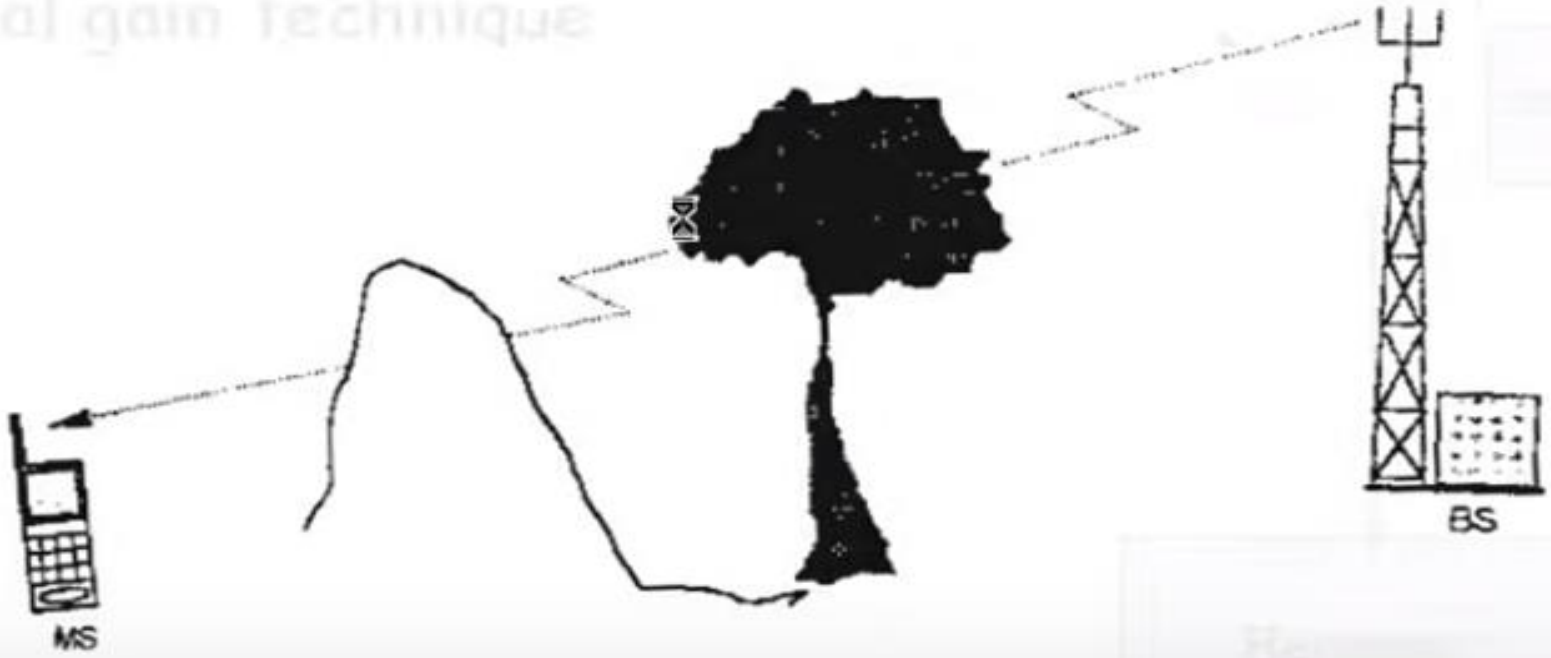
- Combining techniques :
  - 1-Selective technique
    - used in mobile due to simplicity
  - 2-Maximal ratio technique
    - Best fading reduction
  - 3-Equal gain technique



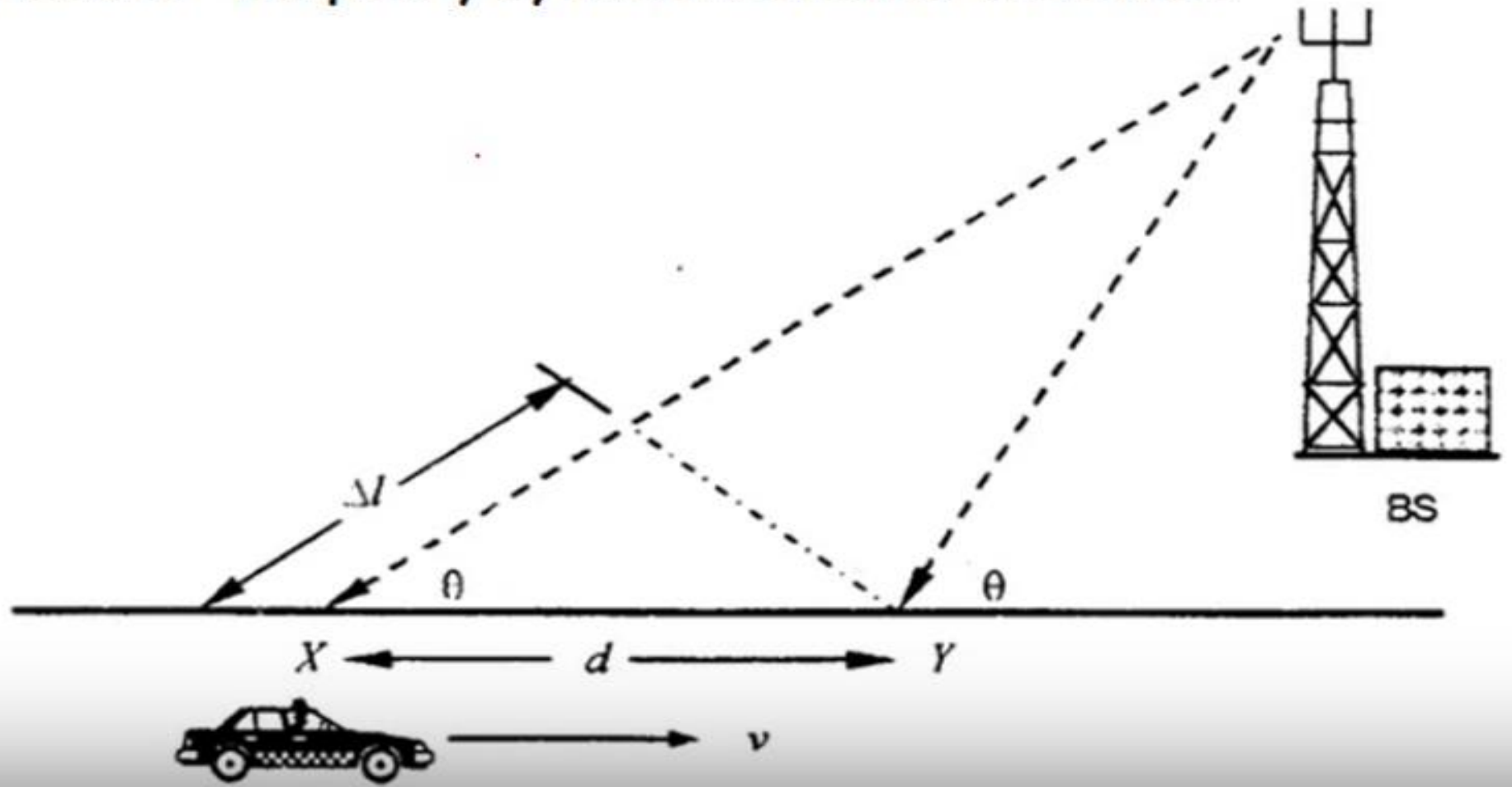
FUNDAMENTAL OF CELLULAR SYSTEM

- **Shadow fading**

-The Solution of this problem by using Macroscopic Diversity By selecting a BS which is not shadowed when others are.

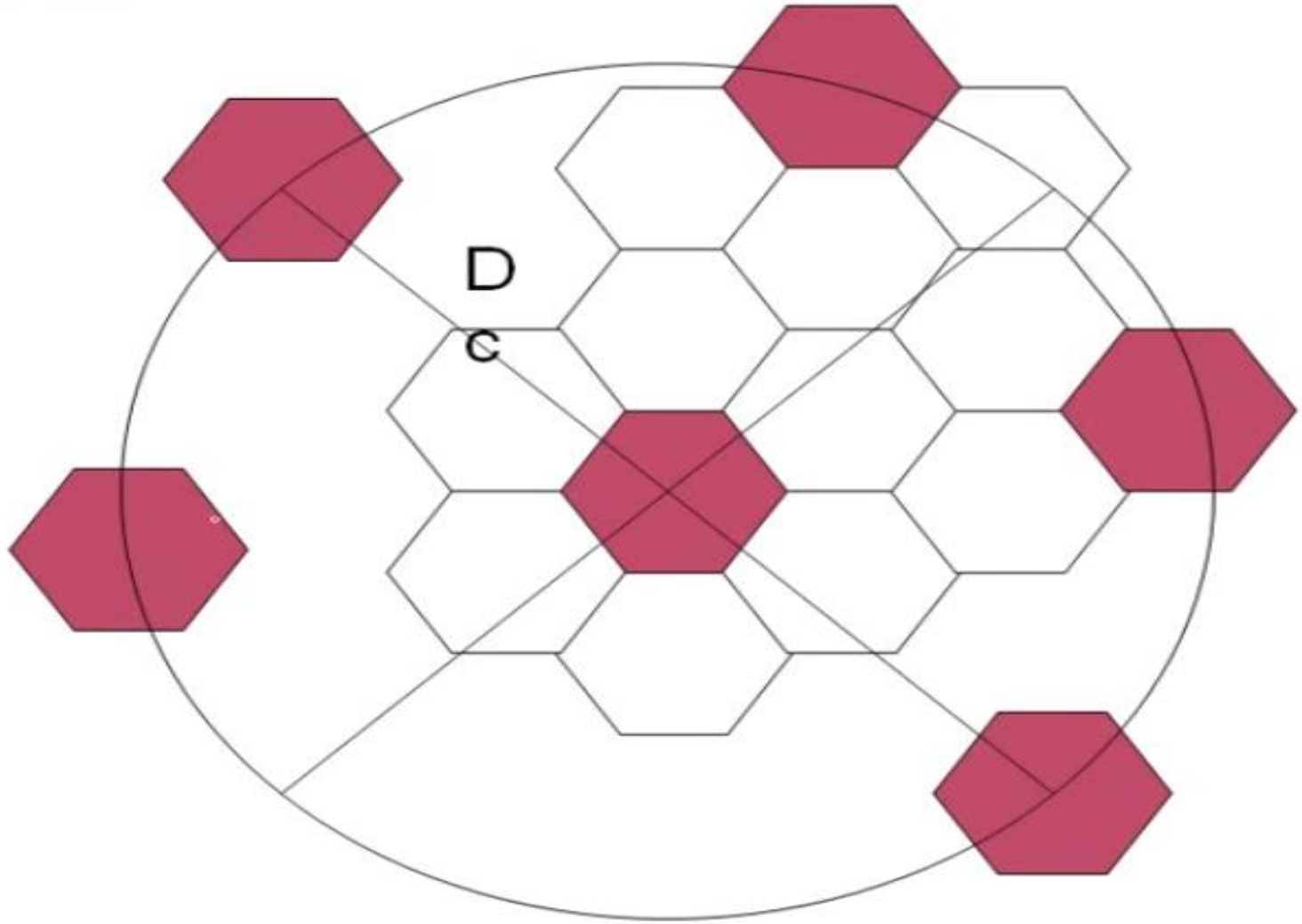


- Doppler shift
  - +ve if the mobile moves toward the BS
  - -ve if the mobile moves away from the BS
  - The Doppler frequency shift should be compensated so that a correct frequency synchronization is achieved .



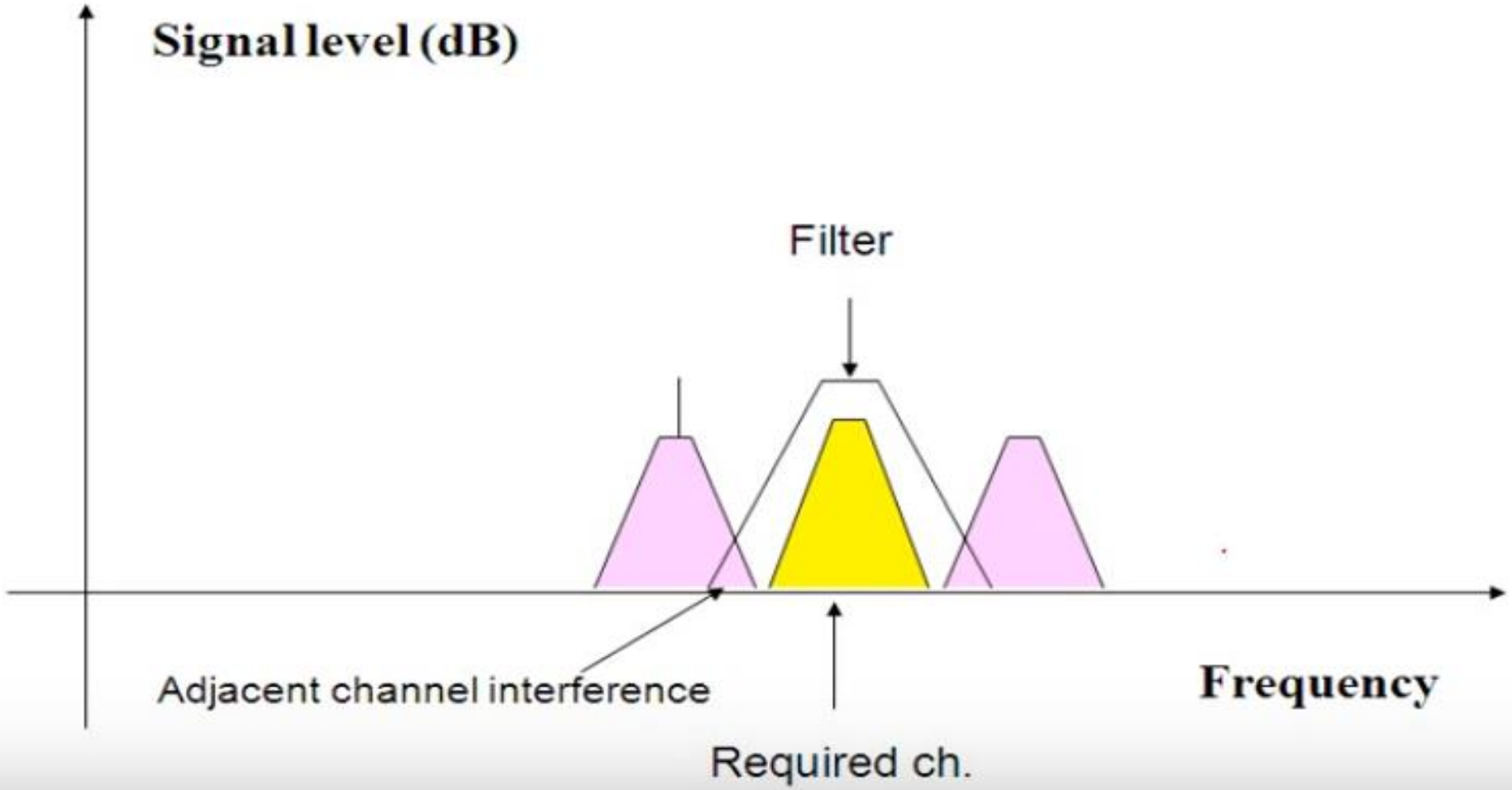
FUNDAMENTAL OF CELLULAR SYSTEM

- Co-channel interference



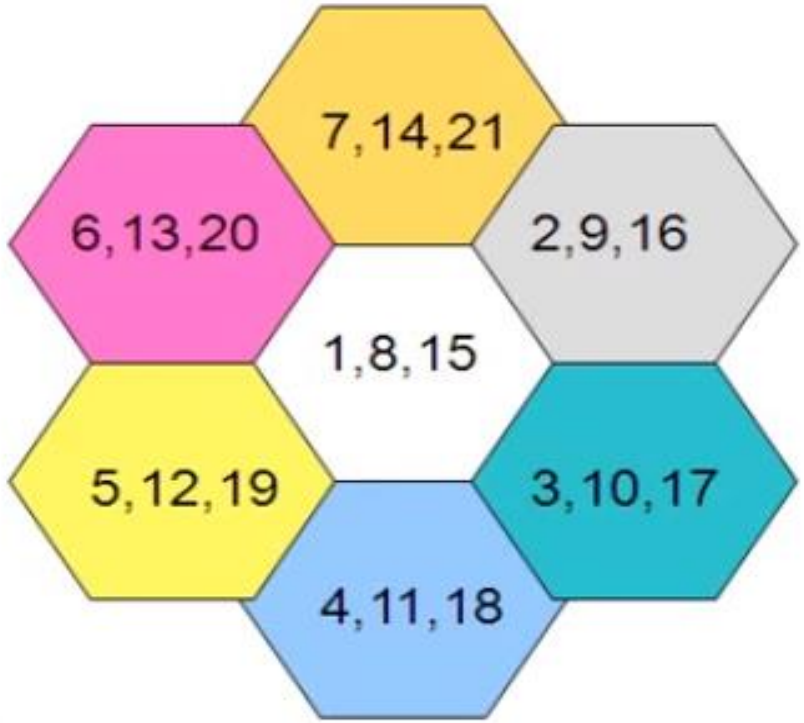
FUNDAMENTAL OF CELLULAR SYSTEM

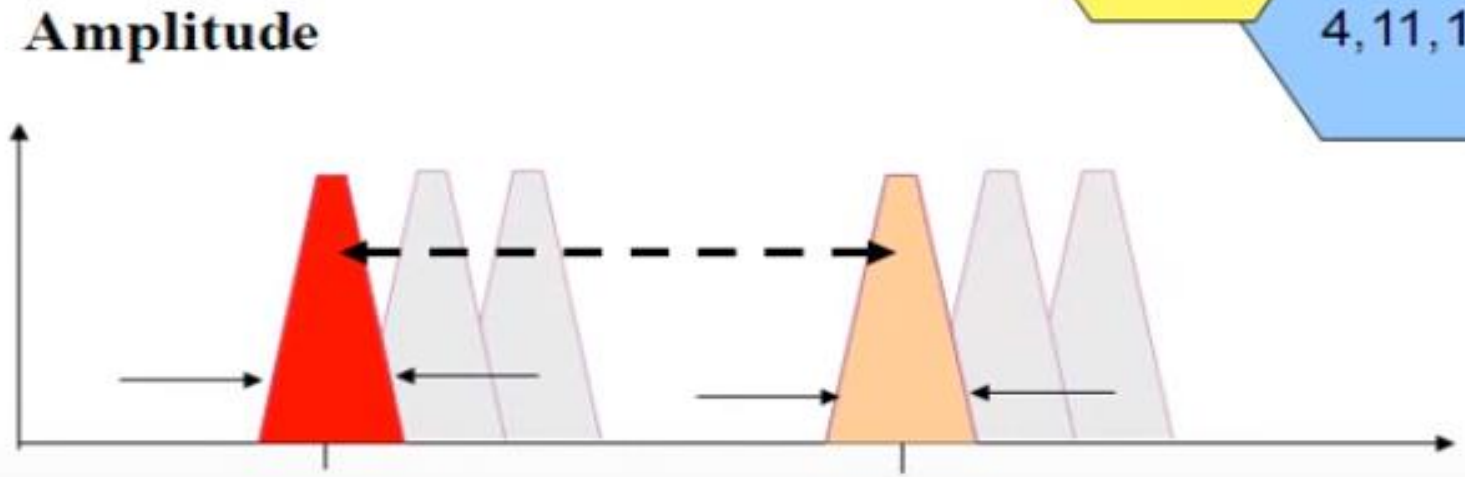
- Adjacent channel interference



FUNDAMENTAL OF CELLULAR SYSTEM

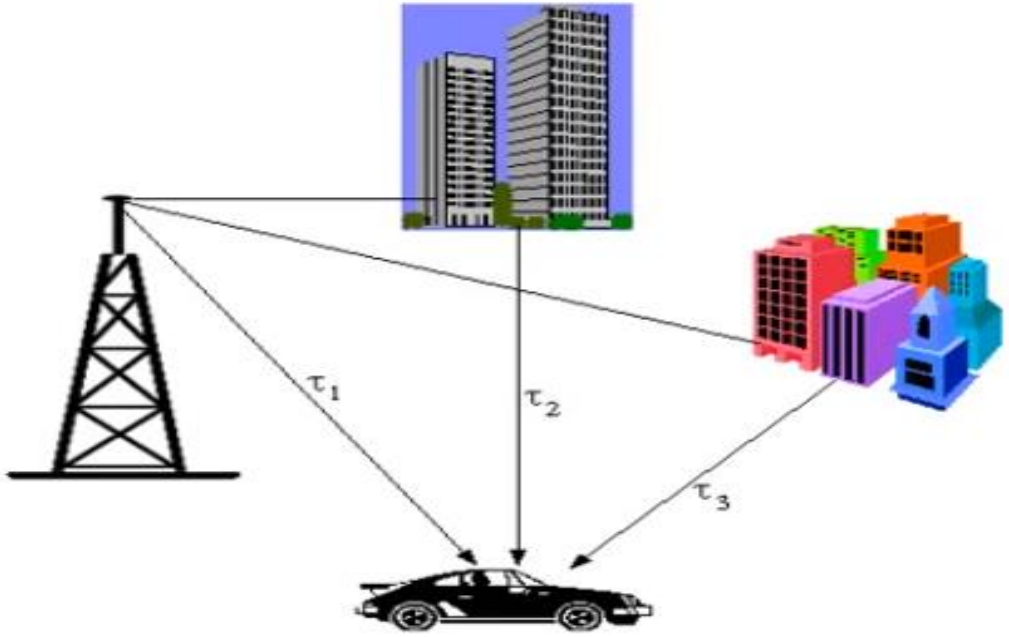
- Channel management

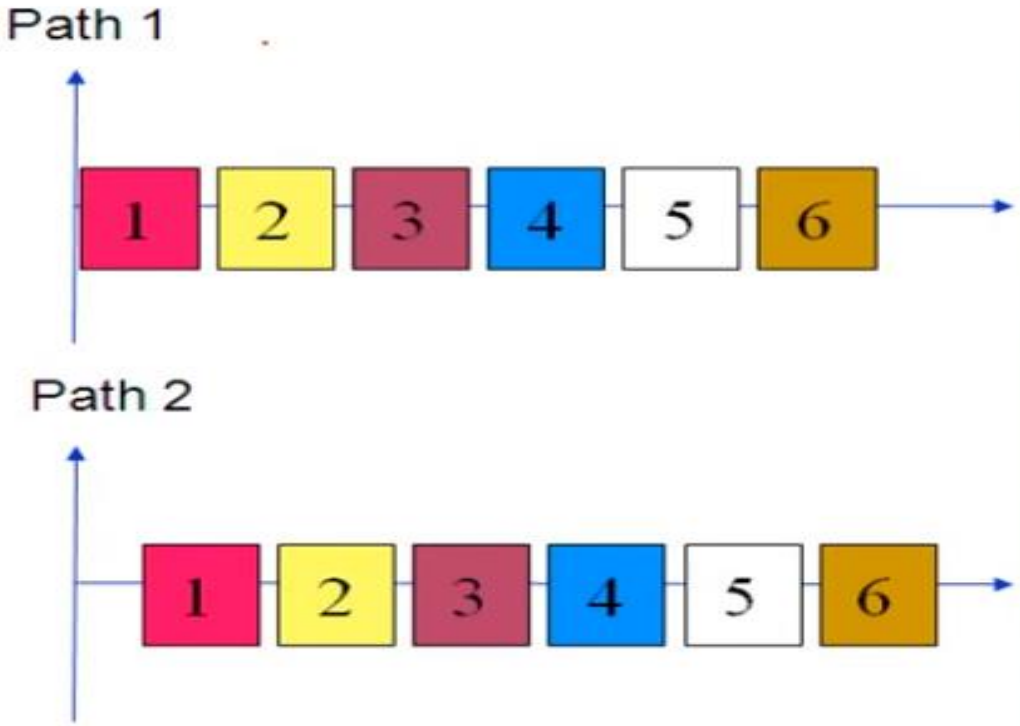




FUNDAMENTAL OF CELLULAR SYSTEM

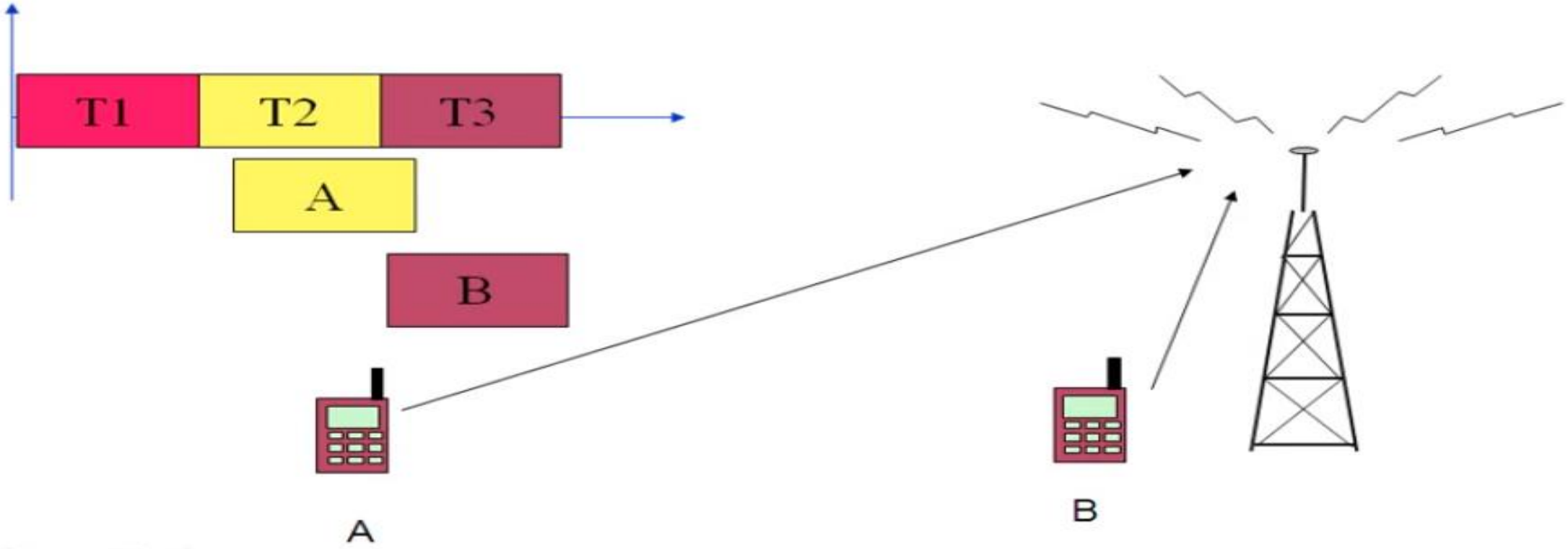
- **Delay Spread (Time dispersion)**
  - Due to multipath fading
  - To overcome this we use delay equalizer





FUNDAMENTAL OF CELLULAR SYSTEM

- **Distance between MS and BS**
  - This makes Time alignment Problem
  - To overcome this system should respond to this delay

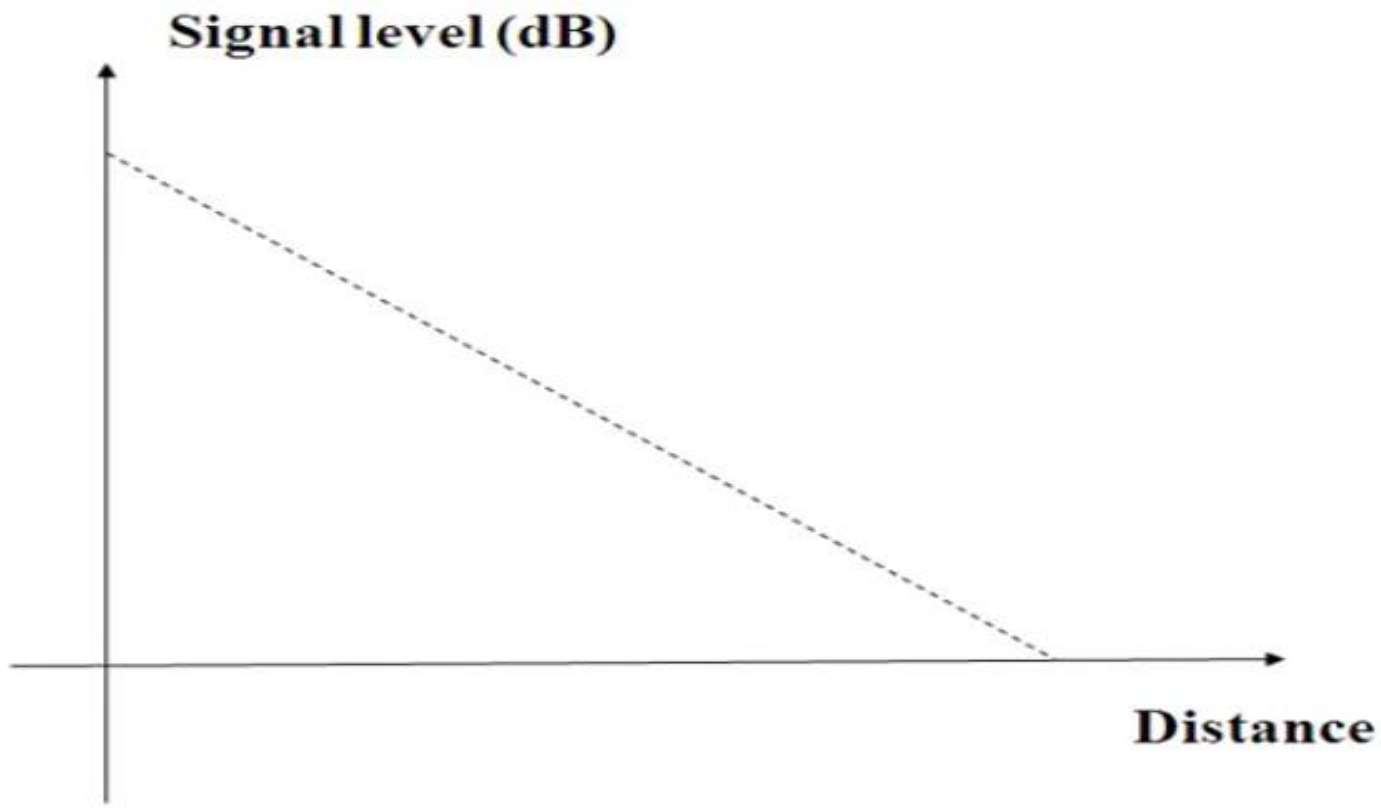


FUNDAMENTAL OF CELLULAR SYSTEM

- Path loss

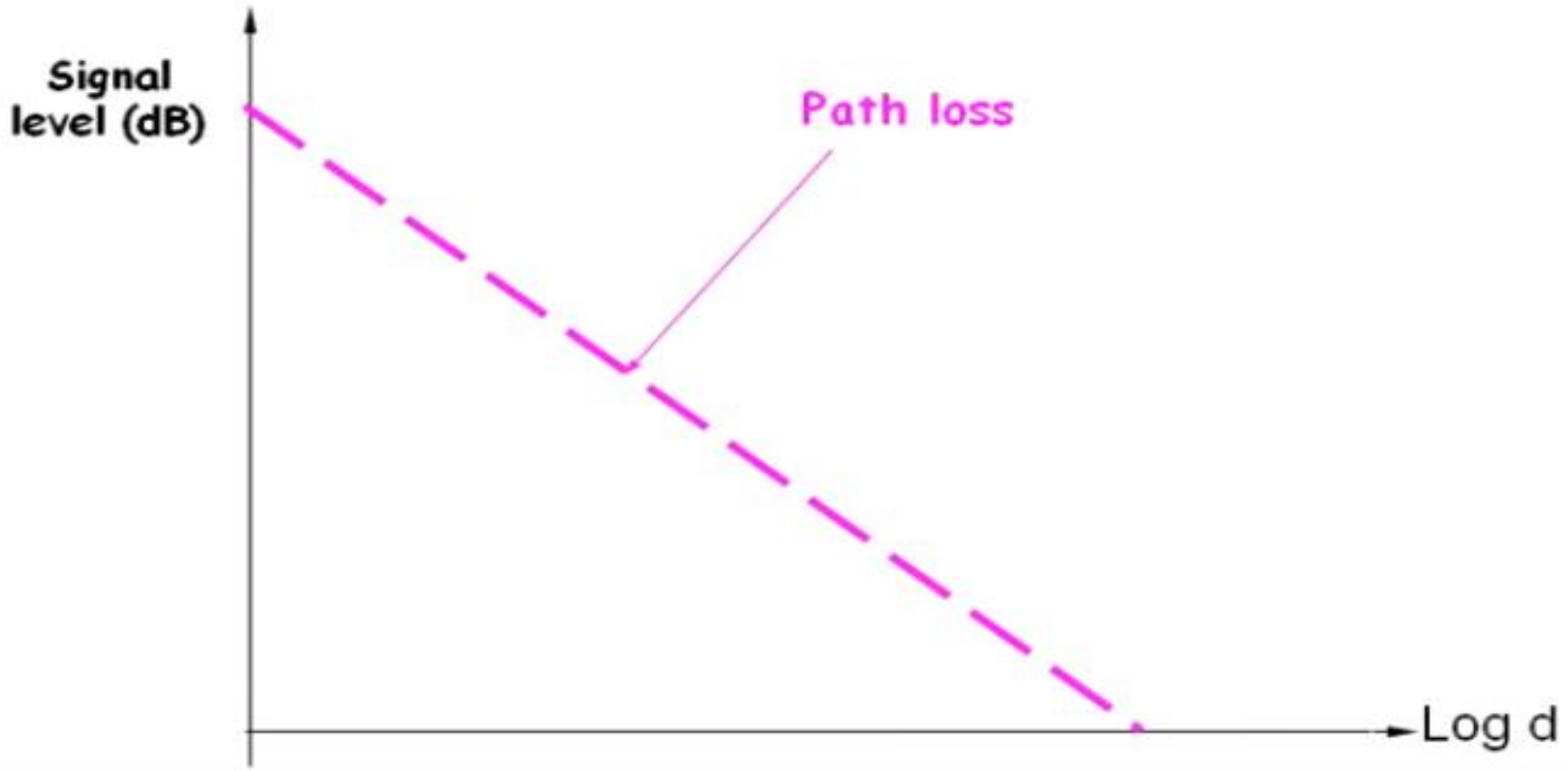
$$Pr \propto \frac{Pt}{R^{\beta}}$$

$$\beta = 3 \sim 4$$



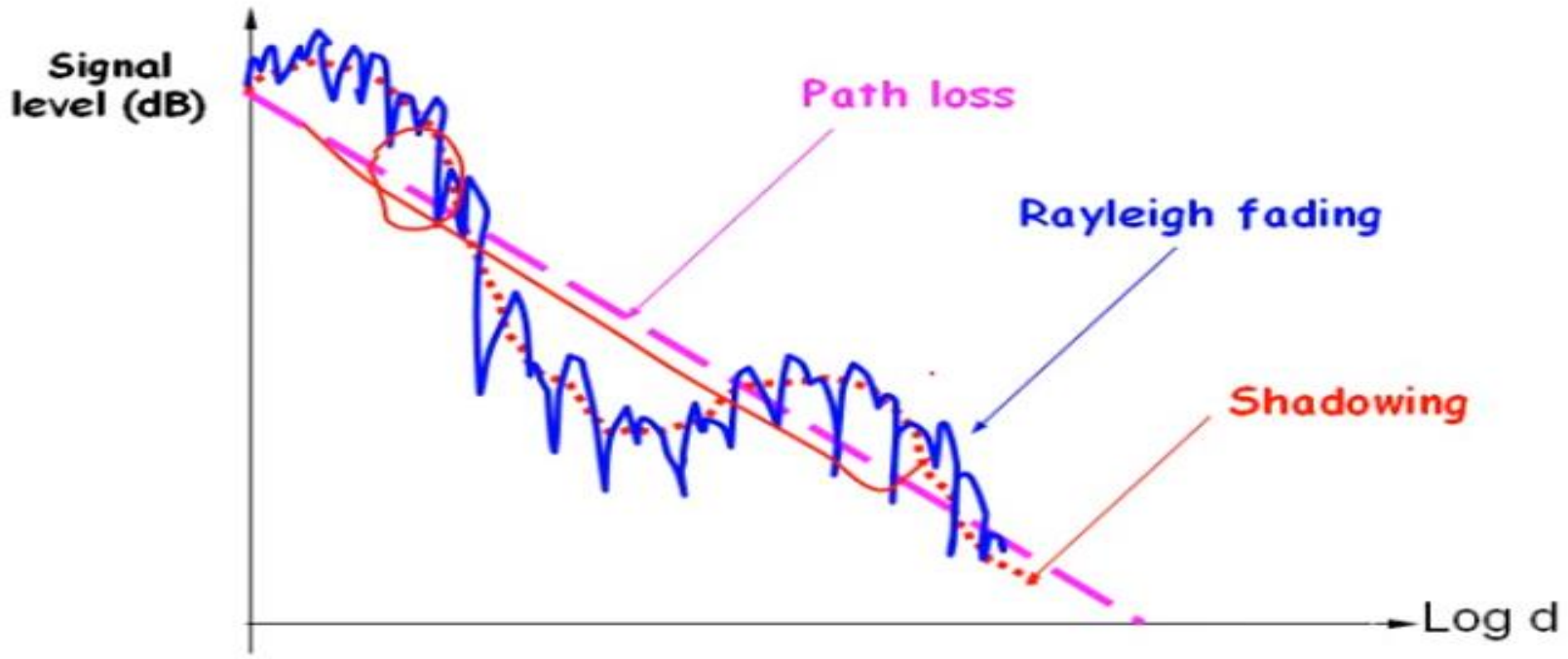
FUNDAMENTAL OF CELLULAR SYSTEM

- Combined signal loss



FUNDAMENTAL OF CELLULAR SYSTEM

- Combined signal loss



Thanks