# Ubiquitous Computing (CS60055)

# Cellular Systems

**Prof. Sudip Misra**

**Department of Computer Science and Engineering**
**Indian Institute of Technology Kharagpur**
**Email: smisra@sit.iitkgp.ernet.in**
**Website: http://cse.iitkgp.ac.in/~smisra/**
**Research Lab: cse.iitkgp.ac.in/~smisra/swan/**

# Overview

❑ Cellular telephone systems are designed to provide two-way voice.

❑ Cellular systems were initially designed for mobile terminals inside vehicles with antennas mounted on the vehicle roof.

❑ The basic feature of the cellular system is frequency reuse.

❑ In a cellular system, the signal from a mobile unit (cell phone) to a base station is transmitted by radio waves through the air, instead of through metallic wires, However, the signal from the base station is sent to a mobile switching center and possibly to a telephone central office through electrical wires.

# Cont…

- In a cellular radio system, a land area to be supplied with radio service is divided into regular shaped <span style="color:red">cells</span>, which can be <span style="color:red">hexagonal, square, circular</span> or some other regular shapes. Each of these cells is assigned multiple <span style="color:red">frequencies</span> which have corresponding radio base stations. The group of frequencies can be <span style="color:red">reused</span> in other cells Cellular Concept to increase both coverage and capacity.



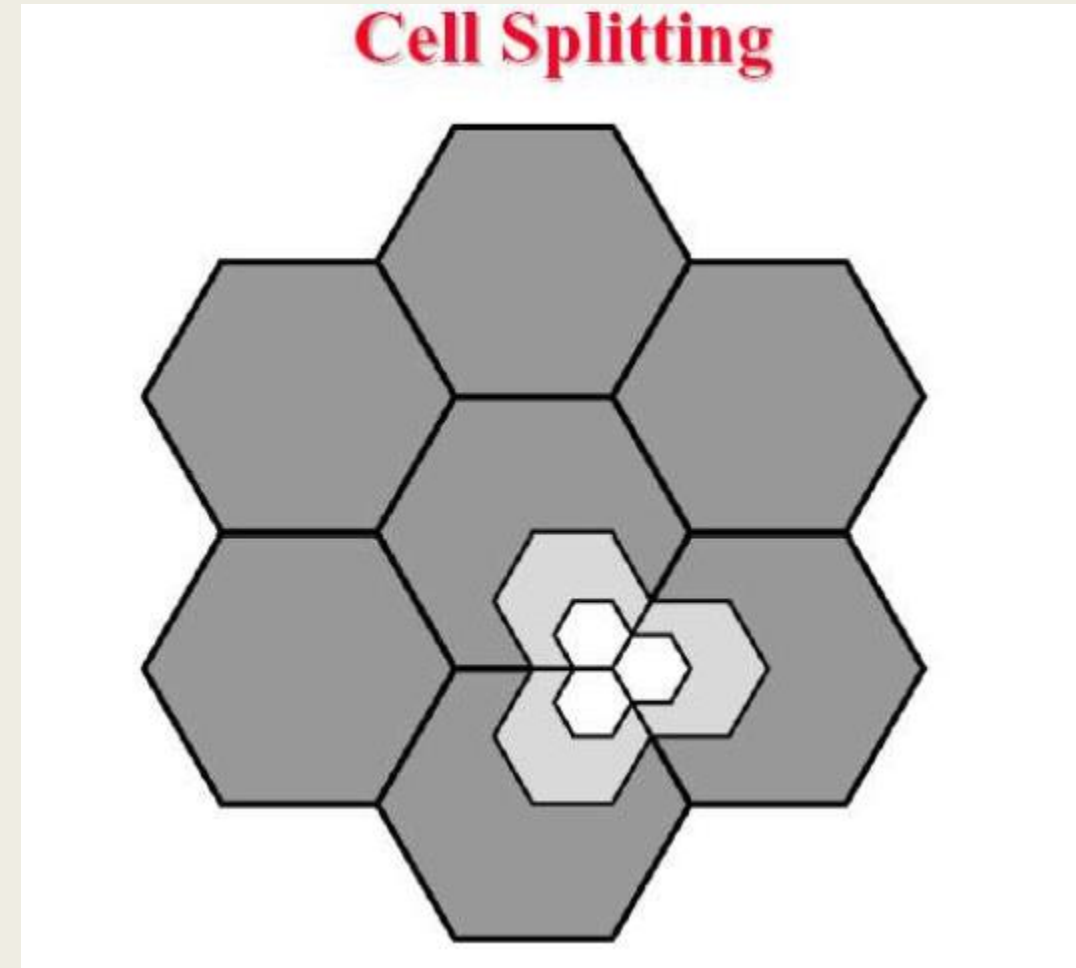https://www.javatpoint.com/cellular-system-infrastructure
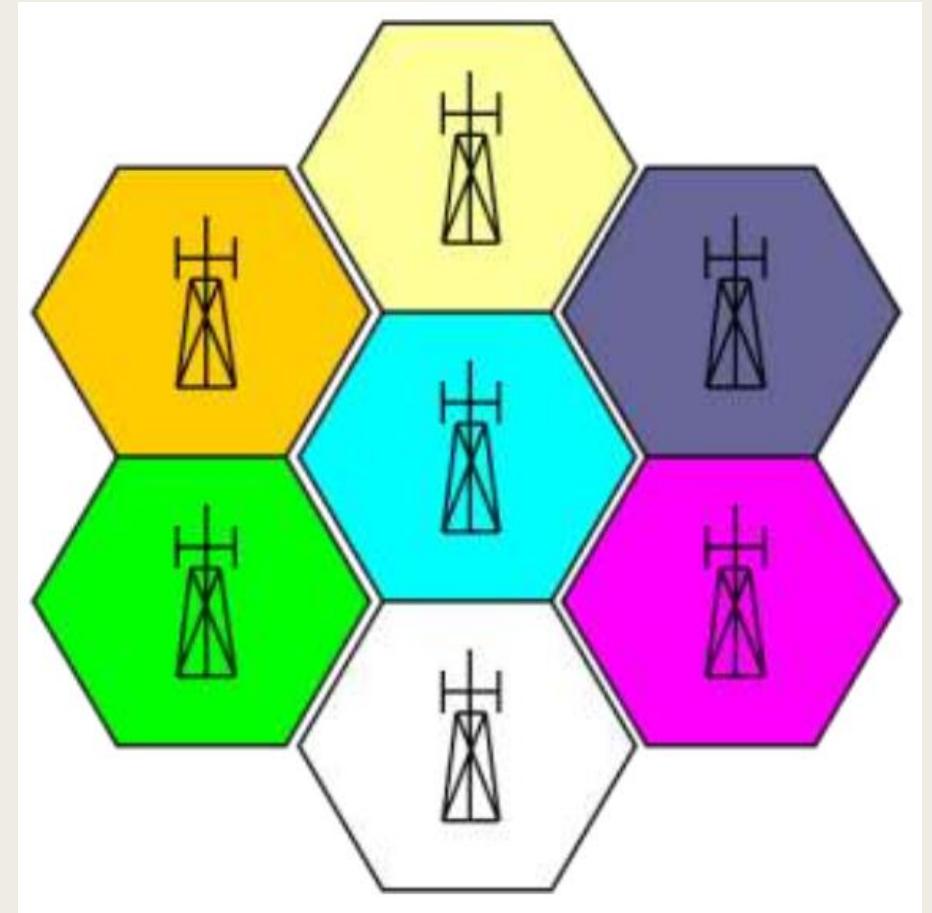
# Capacity of Cellular System

The capacity of cellular systems can be increased by:

- **Frequency borrowing :**
    - Taking frequencies from adjacent cells by congested cells.

- **Cell splitting:**
    - Dividing the cells into the smaller cells.
    - The radio frequencies are reassigned, and transmission power is reduced.



Cell Splitting

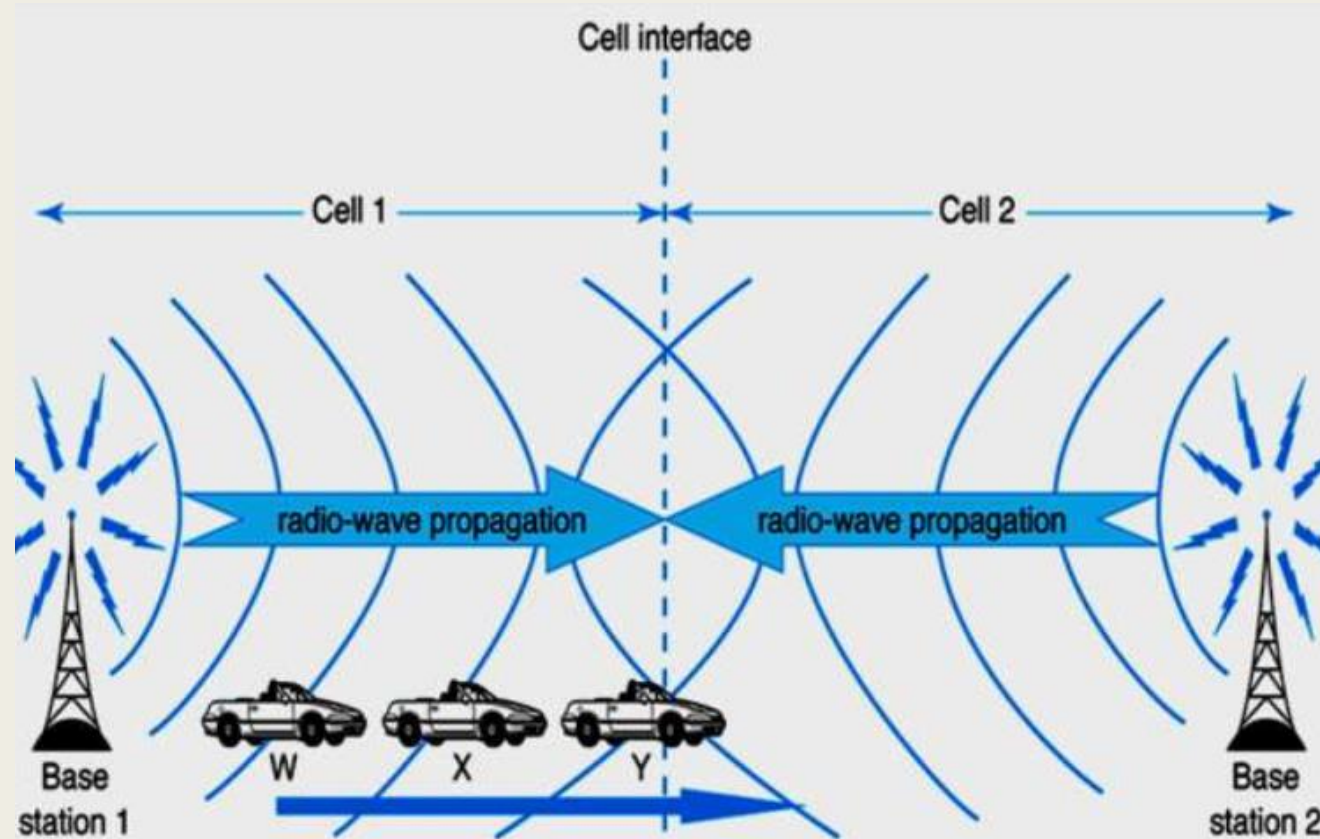http://www.ccs.neu.edu/home/futrelle/teaching/com1204sp2001/Farley/Cell basics14.html

# Cont…

- **Cell sectoring:**
  - Sectorization consists of dividing an omnidirectional (360 degree) view from the cell site into non-overlapping slices called sectors.

- **Microcells:**
  - Microcells range from about a hundred meters to a kilometer in diameter.
  - The aim of creating microcells are increasing the capacity of cellular network in areas where population is high.

# Handoffs

❑ The term **handover** or **handoff** refers to the process of transferring an <span style="color:red">ongoing call</span> or <span style="color:red">data session</span> from one channel connected to the core network to another.

❑



Cell interface

Cell 1 ←——————→ Cell 2

radio-wave propagation ← → radio-wave propagation

Base station 1

W    X    Y

Base station 2

Mobile unit traveling away from base station 1 and towards base station 2

https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsd GRvbWFpbnxhd2ttYmNzMm5kfGd4OjU1YjI3YmE0ZTQ3OTliNmI

# Types

❑ **Hard handoff** is one in which the channel in the source cell is released and only then the channel in the target cell is engaged. Thus the connection to the source is broken before the connection to the target is made.

❑ **Soft handoff** is one in which the channel in the source cell is retained and used for a while in parallel with the channel in the target cell. In this case the connection to the target is established before the connection to the source is broken.

# Types
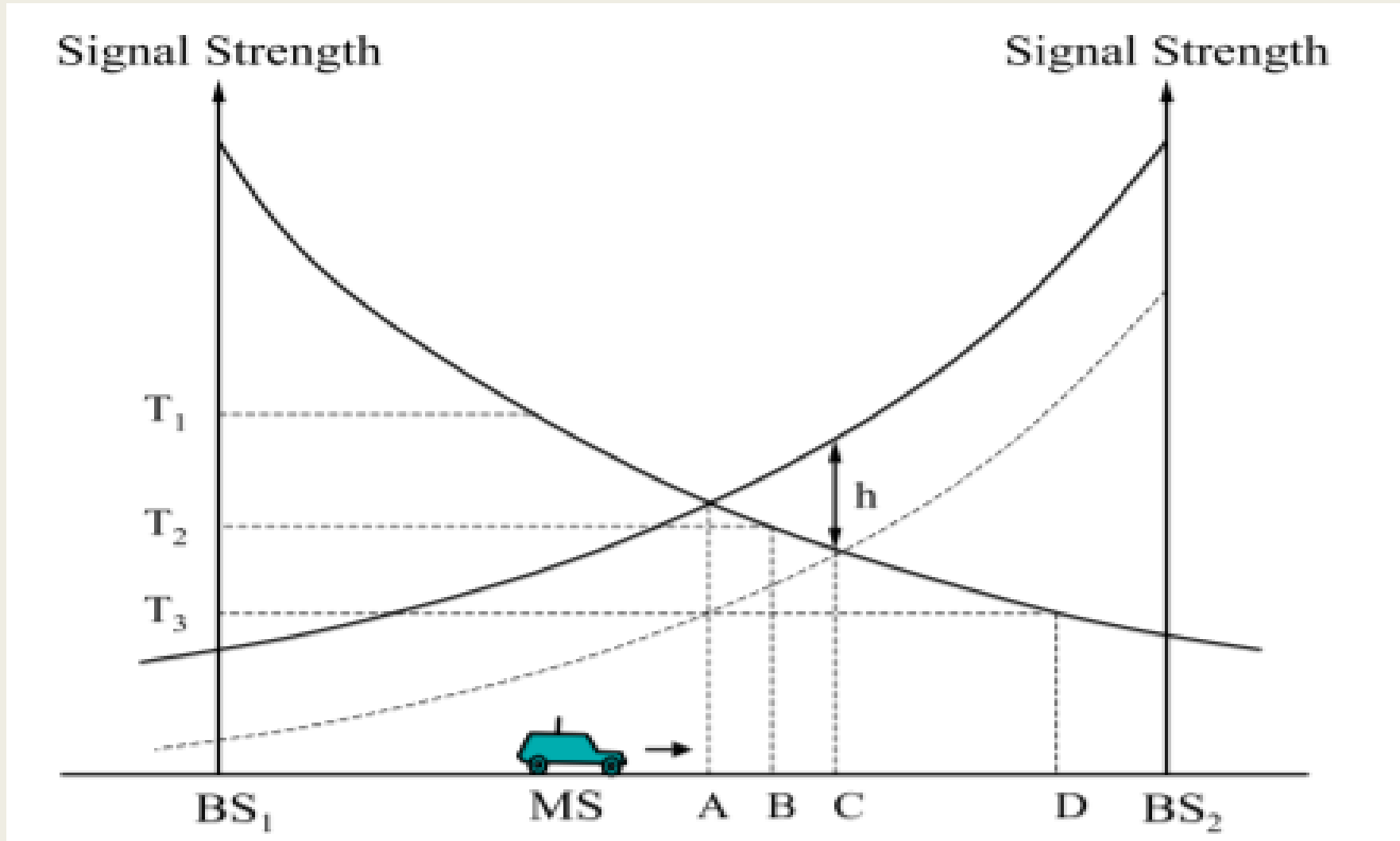


Hard Handoff

Soft Handoff
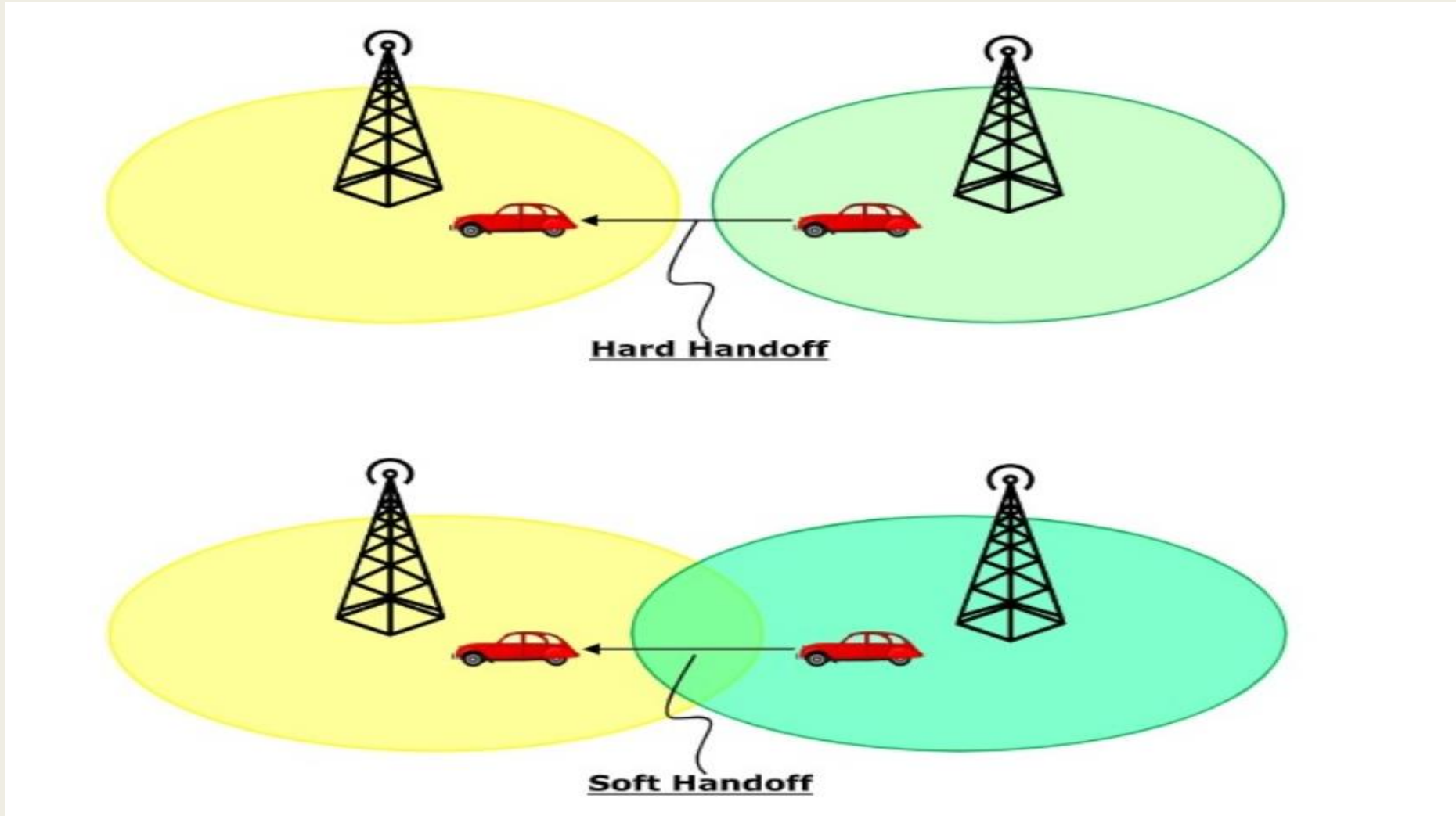
# Variation in Signal Strength for Potential Handoff

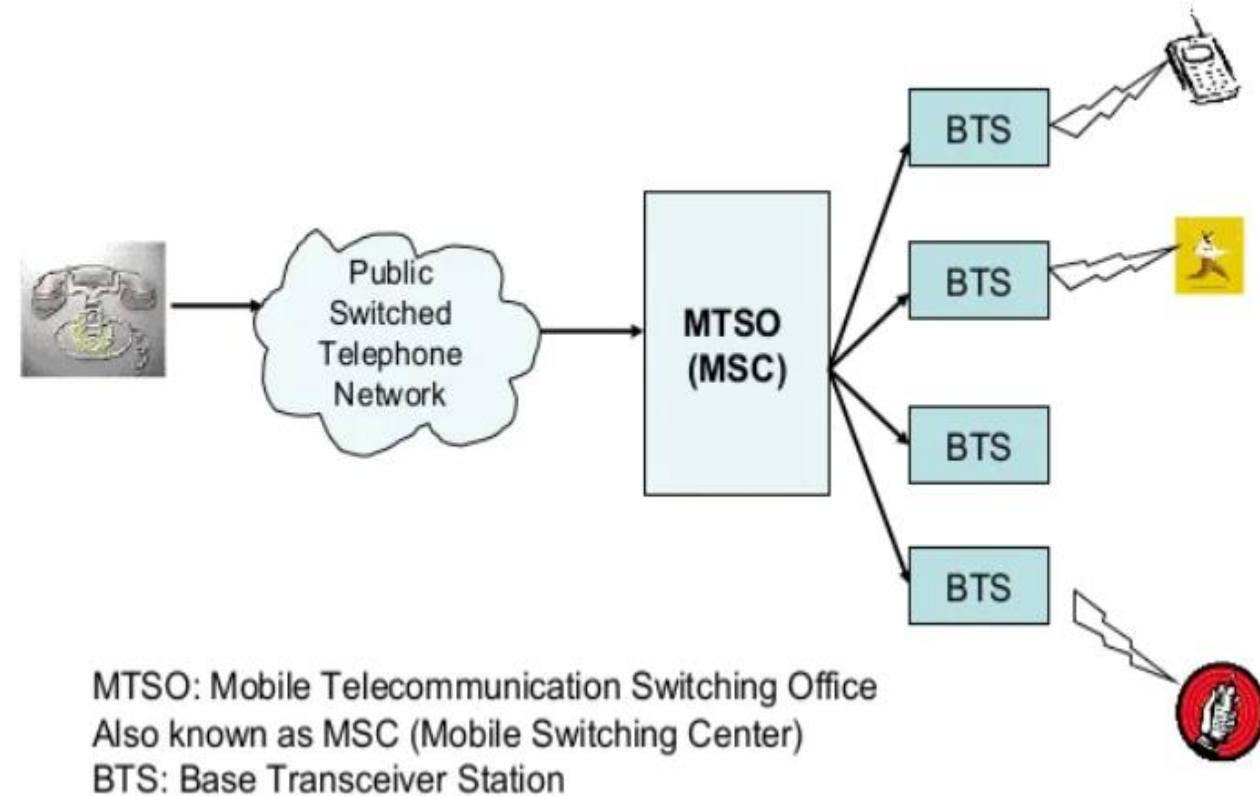https://www.tutorialspoint.com/handoff-in-mobile-connections

# AMPS

# Overview

- AMPS is known as the first generation (1G) analog commercial cellular systems.
- It is based on Analog modulation.
- Frequency allocated by FCC on 824-849 MHz for downlink and 869-894 MHz for uplink traffic.
- No of Channels: 832 channels: 30 kHz, can be shared by two providers.
- 416 channels in each cell , 21 channels for control, 395 channels for voice.
- Each cell uses some set of frequencies not used by any of its neighbors.
- Reuse factor 7

# AMPS System Architecture

## COMPONENTS:

- Public Switch Telephone Network (PSTN)
- Mobile Telephone Switching Office (MTSO)
- Cell site with antenna
- Mobile Subscriber Unit (MSU)



MTSO: Mobile Telecommunication Switching Office
Also known as MSC (Mobile Switching Center)
BTS: Base Transceiver Station

- ❑ **PSTN:** Public Switched Telephone Network (PSTN) is an agglomeration of an interconnected network of telephone lines owned by both governments as well as commercial organizations.

- ❑ **MTSO:** The MTSO performed the following functions:
  - ➢ Interconnecting calls within thin the Cellular network and to other PSTNs
  - ➢ Compiling billing information, registration, authentication, location updating, and call routing.

- ❑ **The Cell Site:** The term cell site is used to refer to the physical location of radio equipment that provides coverage within a cell.

## ❑ Mobile Subscriber Units (MSUs)

> ➢ The mobile subscriber unit consists of a control unit and a transceiver that transmits and receives radio transmissions to and from a cell site.

> ➢ The following three types of MSUs are available:
>   - the mobile telephone (typical transmit power is 4.0 watts)
>   - the portable (typical transmit power is 0.6 watts)
>   - the transportable (typical transmit power is 1.6 watts)

# Disadvantages:

- Low calling capacity

- Limited spectrum

- No room for spectrum growth

- Poor data communications

- Minimal privacy

- Inadequate fraud protection

# GSM

# GSM - Specifications

❑ Original specifications for the GSM system:
  - ❑ Good subjective voice quality
  - ❑ Low terminal and service cost
  - ❑ Support for international roaming
  - ❑ Support for handheld terminals
  - ❑ Support for new services
  - ❑ Spectrum efficient
  - ❑ Compatible with ISDN

https://www.gsma.com/newsroom/wp-content/uploads/2012/12/IR63300.pdf

# Performance characteristics of GSM

- **Communication**
  - mobile, wireless communication; support for voice and data services
- **Total mobility**
  - international access, chip-card enables use of access points of different providers
- **Worldwide connectivity**
  - one number, the network handles localization
- **High capacity**
  - better frequency efficiency, smaller cells, more customers per cell
- **High transmission quality**
  - high audio quality and reliability for wireless, uninterrupted phone calls at higher speeds (e.g., from cars, trains)
- **Security functions**
  - access control, authentication via chip-card and PIN
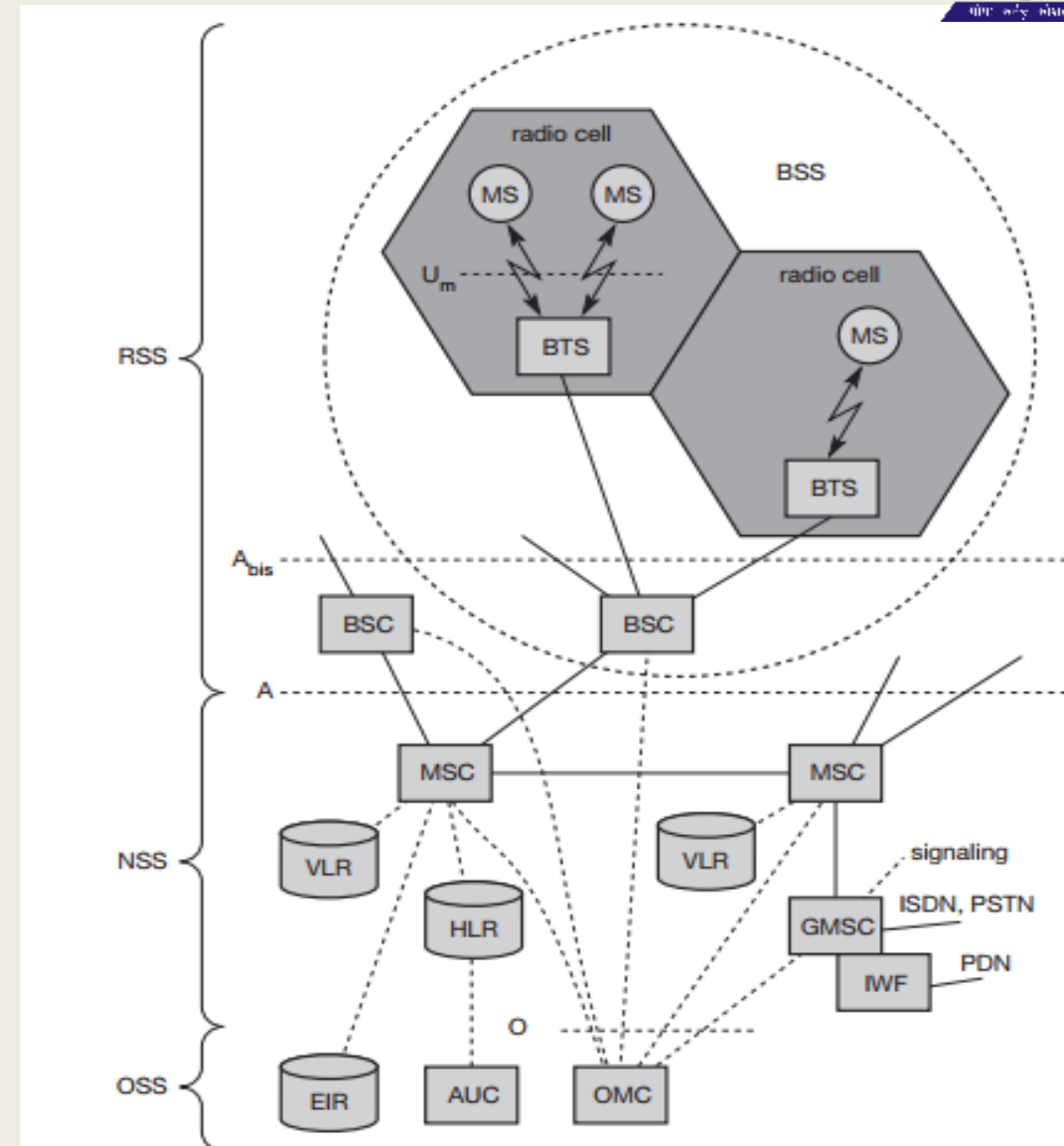
# Disadvantages of GSM

- No end-to-end encryption of user data.
- No full ISDN bandwidth of 64 kbit/s to the user.
- Reduced concentration while driving.
- Abuse of private data possible.
- Roaming profiles accessible.
- High complexity of the system.
- Several incompatibilities within the GSM standards.

# Architecture of the GSM system

- ❑ GSM is a PLMN (Public Land Mobile Network)
  - ❑ several providers setup mobile networks following the GSM standard within each country
  - ❑ subsystems
    - ❑ RSS (radio subsystem): covers all radio aspects
    - ❑ NSS (network and switching subsystem): call forwarding, handover, switching
    - ❑ OSS (operation subsystem): management of the network



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https://theweekbeforesemester.github.io/mobilecomputing/2018/11/03/GSMArchitecture.html?hcb=1

## Mobile Station

- The mobile station (MS) is the starting point of a mobile wireless network. The MS can contain the following components:
    - Mobile terminal (MT)—GSM cellular handset
    - Terminal equipment (TE)—PC or personal digital assistant (PDA)
- The MS can be two interconnected physical devices (MT and TE) with a point-to-point interface or a single device with both functions integrated.

## Base Transceiver Station

- When a subscriber uses the MS to make a call in the network, the MS transmits the call request to the base transceiver station (BTS). The BTS includes all the radio equipment (i.e., antennas, signal processing devices, and amplifiers) necessary for radio transmission within a geographical area called a cell. The BTS is responsible for establishing the link to the MS and for modulating and demodulating radio signals between the MS and the BTS.

# Base Station Controller

- A Base Station Controller (BSC) is a high-capacity switch with radio communication and mobility control capabilities. The functions of a BSC include radio channel allocation, location update, handover, timing advance, power control and paging.

## Base Station Subsystem

- A GSM network is comprised of many base station subsystems (BSSs), each controlled by a BSC. The BSS performs the necessary functions for monitoring radio connections to the MS, coding and decoding voice, and rate adaptation to and from the wireless network. A BSS can contain several BTSs.

## Mobile Switching Center (MSC)

- Digital ISDN switch that sets up connections to other MSCs and to the BSCs.

- Wired (fixed) backbone of a GSM network and can switch calls to the public switched telecommunications network (PSTN).

## Visitor Location Register (VLR)

- It is a database attached to an MSC to contain information about its currently associated mobile stations.

## Home Location Register (HLR)

- It is a database used for storing and managing subscriptions. When an individual buys a subscription from one of the GSM operators, he or she is registered in the HLR of that operator.

❑ **Equipment Identity Register**
  - ❑ The equipment identity register (EIR) is a database that stores the international mobile equipment identities (IMEIs) of all the mobile stations in the network.
  - ❑ Provides security features such as blocking calls from handsets that have been stolen.

❑ **Authentication Center**
  - ❑ Associated with the HLR is the authentication center (AuC); this database contains the algorithms for authenticating subscribers and the necessary keys for encryption to safeguard the user input for authentication.

❑ **Visitor Location Register**
  - ❑ The visitor location register (VLR) is a distributed database that temporarily stores information about the mobile stations that are active in the geographic area for which the VLR is responsible.

# Operation subsystem

- The OSS (Operation Subsystem) enables centralized operation, management, and maintenance of all GSM subsystems.

- **Components**
  - **Authentication Center (AUC)**
    - generates user specific authentication parameters on request of a VLR.
  - **Equipment Identity Register (EIR)**
    - registers GSM mobile stations and user rights.
    - stolen or malfunctioning mobile stations can be locked and sometimes even localized.
  - **Operation and Maintenance Center (OMC)**
    - different control capabilities for the radio subsystem and the network subsystem.

# DECT

## Overview

❑ DECT (Digital European Cordless Telephone) standardized by ETSI (ETS 300.175-x) for cordless telephones.

❑ standard describes air interface between base-station and mobile phone.

❑ **Characteristics**

   ❑ frequency: 1880-1900 MHz

   ❑ channels: 120 full duplex

   ❑ duplex mechanism: TDD (Time Division Duplex) with 10 ms frame length

   ❑ multiplexing scheme: FDMA with 10 carrier frequencies

   ❑ modulation: digital, Gaussian Minimum Shift Key (GMSK)

   ❑ power: 10 mW average (max. 250 mW)

   ❑ range: aprox. 50 m in buildings, 300 m open space

# Protocol Architecture

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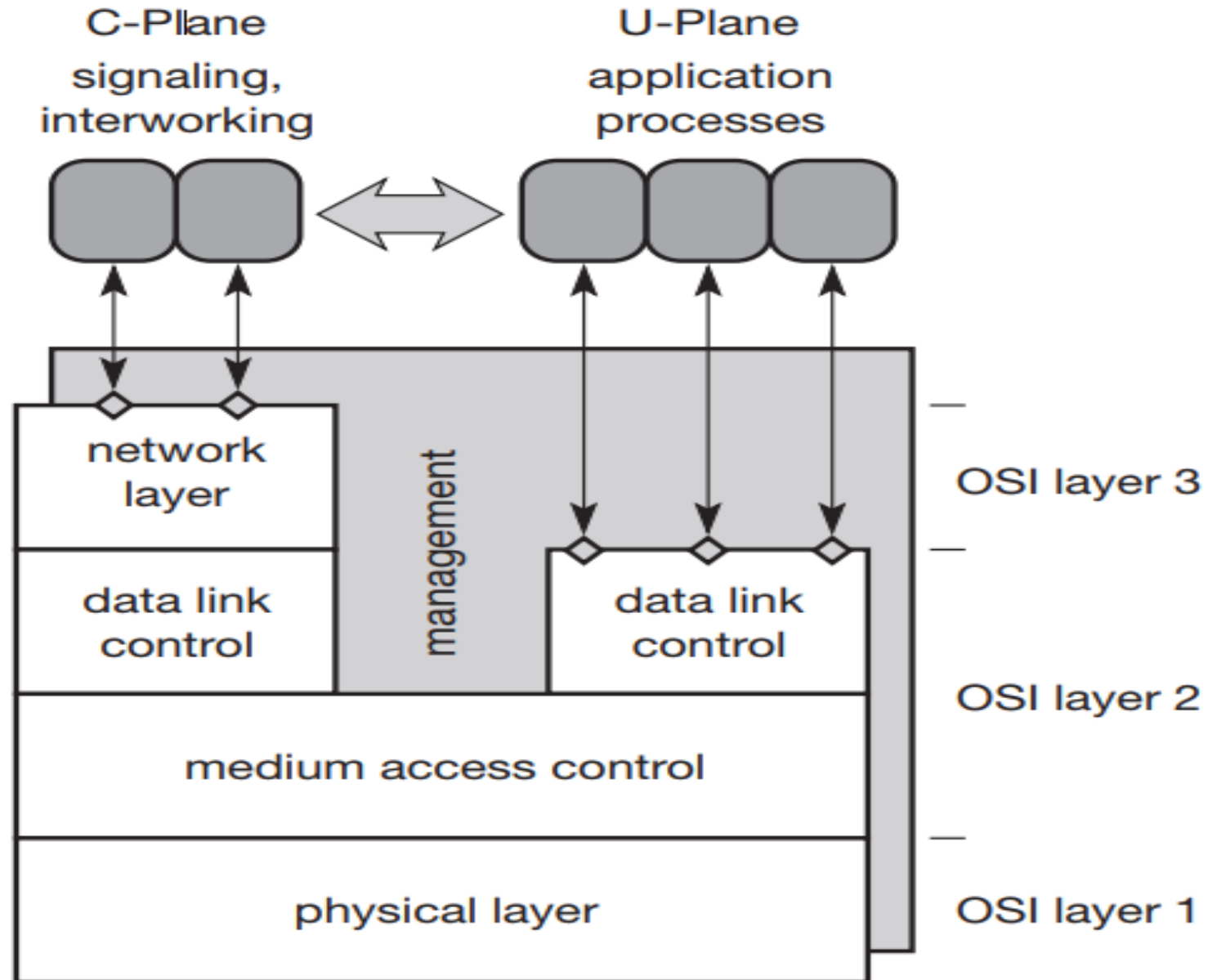
## Physical layer

❑ Physical layer is responsible for:

➢ modulation/demodulation

➢ generation of the physical channel structure with a guaranteed throughput

➢ controlling of radio transmission

• channel assignment on request of the MAC layer

• detection of incoming signals

• sender/receiver synchronization

• collecting status information for the management plane

# MAC layer

MAC layer is responsible for:

- Maintaining basic services, activating/deactivating physical channels
- Multiplexing of logical channels
  - e.g., C: signaling, I: user data, P: paging, Q: broadcast
- Segmentation/reassembly
- Error control/error correction

❑ **Data link control layer**
  ❑ creation and keeping up reliable connections between the mobile terminal and base station
  ❑ two DLC protocols for the control plane (C-Plane)
    · **Lb protocol** - connectionless broadcast service, paging functionality
    · **Lc+LAPC protocol** - point to point, in-call signaling, adapted to the underlying MAC service
  ❑ several services specified for the user plane (U-Plane)
    · **null-service**: offers unmodified MAC services
    · **frame relay:** simple packet transmission
    · **frame switching:** time-bounded packet transmission
    · **error correcting transmission:** uses FEC, for delay critical, time- bounded services.

❑ **Network layer**
  ❑ *offers services to request, check, reserve, control, and release*
  ❑ **main tasks**
    ➢ call control: setup, release, negotiation, control
    ➢ call independent services: call forwarding, accounting, call redirecting
    ➢ mobility management: identity management, authentication, management of the location register

# UMTS

# Universal Mobile Telecommunication System (UMTS):

➢ UMTS is most popular 3G wireless standard.

➢ UMTS is an upgrade from GPRS with much more bandwidth.

➢ Combines the infrastructure of the GSM network with superior technology of the CDMA air interface.

➢ Incorporates the developments made for the GPRS and EDGE networks

➢ Data rates for UMTS are:

  ➢ 144 Kbps for rural and 384 Kbps for urban outdoor.

  ➢ 2048 Kbps for indoor and low range outdoor

  ➢ New Spectrum is allocated for those technologies i.e. 2500 to 2690,1710-1885 and 806-960 MHz for UMTS.
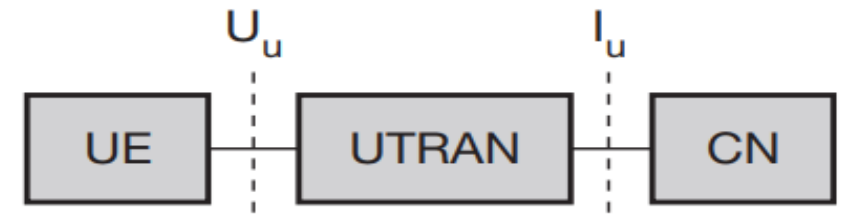
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- ➢ Full packet driven architecture
  - ➢ For voice and for data transmissions.
  - ➢ Packet based networks allow for an increased amount of traffic on a medium.

- ➢ The only time part of that medium is blocked is when a device is transmitting or receiving.
- ➢
- ➢ Consider how often in your phone calls you actually say nothing
  - » Natural pause between words
  - » Taking a breath
  - » Waiting for a response
  - » Thinking of something to say

# UMTS System Architecture

➢ The UTRA network (UTRAN) handles cell level mobility and comprises several radio network subsystems (RNS). The functions of the RNS include radio channel ciphering and deciphering, handover control, radio resource management etc.

➢ The UTRAN is connected to the user equipment (UE) via the radio interface.



➢ The CN contains functions for inter-system handover, gateways to other networks (fixed or wireless), and performs location management if there is no dedicated connection between UE and UTRAN.

https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbW Fpbnxhd2ttYmNzMm5kfGd4OjU1YjI3YmE0ZTQ3OTliNmI

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# Advantages:

❑ High-speed data transmission

❑ Improved voice quality

❑ Greater capacity

❑ Multi simultaneous services

❑ Global roaming across networks

❑ Improved security

❑ Service flexibility

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# Disadvantages:

- Expensive input fees for the 3G service licenses

- It is challenge to build the necessary infrastructure for 3G

- Expense of 3Gphones

- Lack of buy-in by 2Gmobile users for new 3G wireless services

- Large cell phones

# IMT 2000

# Overview:

**IMT-2000** systems are expected to provide support for :

- ❏ high transmission data rates for indoor and outdoor operations
- ❏ symmetrical and asymmetrical data transmission
- ❏ circuit-switched and packet-switched services
- ❏ voice quality comparable to wire-line quality
- ❏ greater capacity and improved spectrum efficiency
- ❏ several simultaneous services to end-users and terminals, for multimedia services
- ❏ global, i.e. international, roaming between different operational environments
- ❏ economies of scale through open global standards to meet the needs of the mass market.

# CDMA Based Cellular System

# Overview:

➢ Frequency dependent transmission impairments have less effect on signal.

➢ Multipath resistance chipping codes used for CDMA exhibit low cross correlation and low autocorrelation -- allows for multiple correlation receiver to separate out multipath pieces of the signal.

➢ Privacy is inherent since spread spectrum is obtained by use of noise-like signals

➢ Graceful degradation system gradually degrades as more users access the system --- soft limit, no real hard limit

# Limitations:

- Some interference remains arriving.

- Multipath signals not synchronized.

- Near-far problem signals closer to the receiver are stronger than signals farther away

- Requires fast and efficient closed loop power control to keep interference to weaker signals to a minimum

- Soft handoff uses signals in two cells and thus increases interference and uses more than the minimum numbers of channels

- Requires more complex transmitter and receiver for spread spectrum signal generation and reception

- More expensive

# Thank You!!!