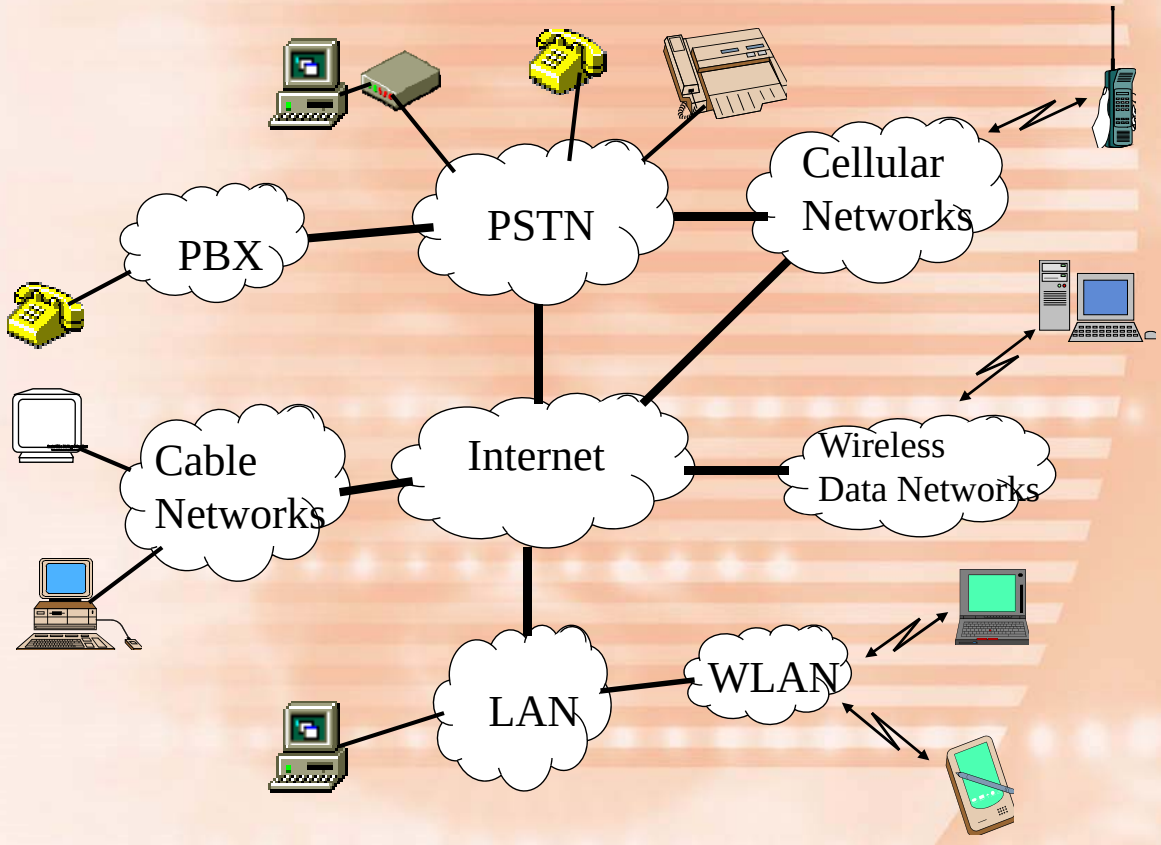
Computer Networks and Communications

Lect No (10)

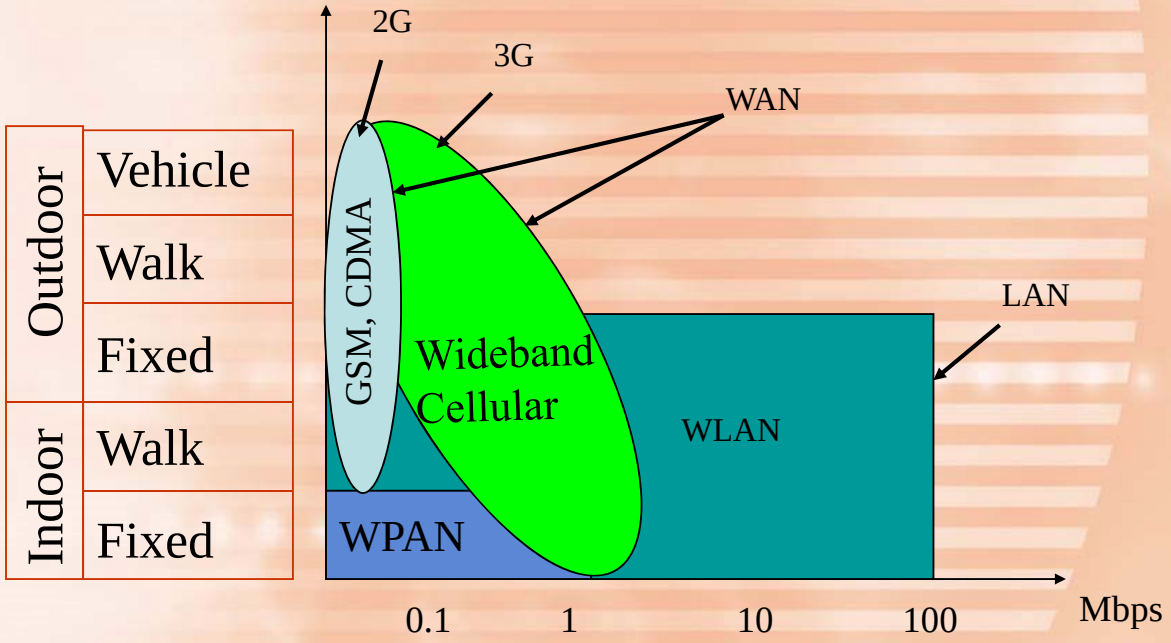
Cellular Wireless Network

Data and Computer Communications, 10th Edition by William Stallings, (c) Pearson Education - Prentice Hall, 2013

Network Technologies



Wireless Networks



WPAN – Wireless Personal Area Network

Wireless Networks

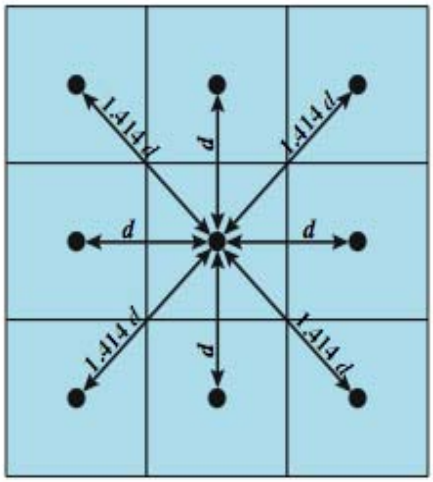
Design considerations:

- Limited bandwidth.
- Noisy channel and Multipath propagation.
  >> Interference.
- Limited coverage: Roaming
- Security.
- Power consumption.

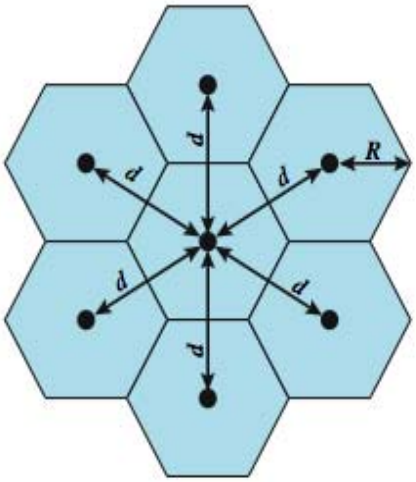
Cellular Wireless Networks

- key technology for mobiles, wireless nets etc
- developed to increase mobile phone capacity
- based on multiple low power transmitters
- area divided into cells
  - in a tiling pattern to provide full coverage
  - each with own antenna
  - each with own range of frequencies
  - served by base station
  - adjacent cells use different frequencies to avoid crosstalk

Cellular Geometries



(a) Square pattern

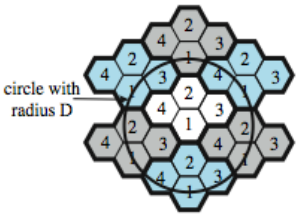


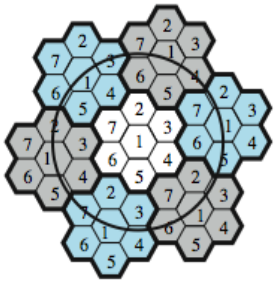
(b) Hexagonal pattern

Frequency Reuse

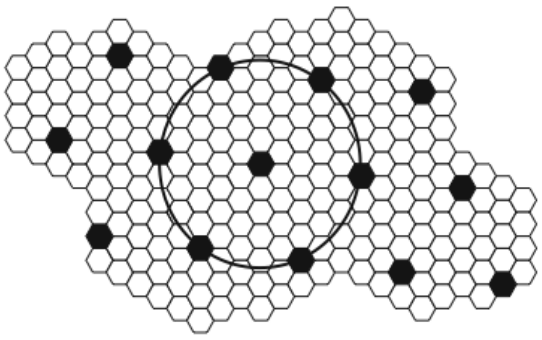
- must manage reuse of frequencies
- power of base transceiver controlled
  - allow communications within cell on given frequency
  - limit escaping power to adjacent cells
  - allow re-use of frequencies in nearby cells
  - typically 10 – 50 frequencies per cell
  - example for Advanced Mobile Phone Service (AMPS)
    - N cells all using same number of frequencies
    - K total number of frequencies used in systems
    - each cell has K/N frequencies
    - K=395, N=7 giving 57 frequencies per cell on average

Frequency Reuse Patterns



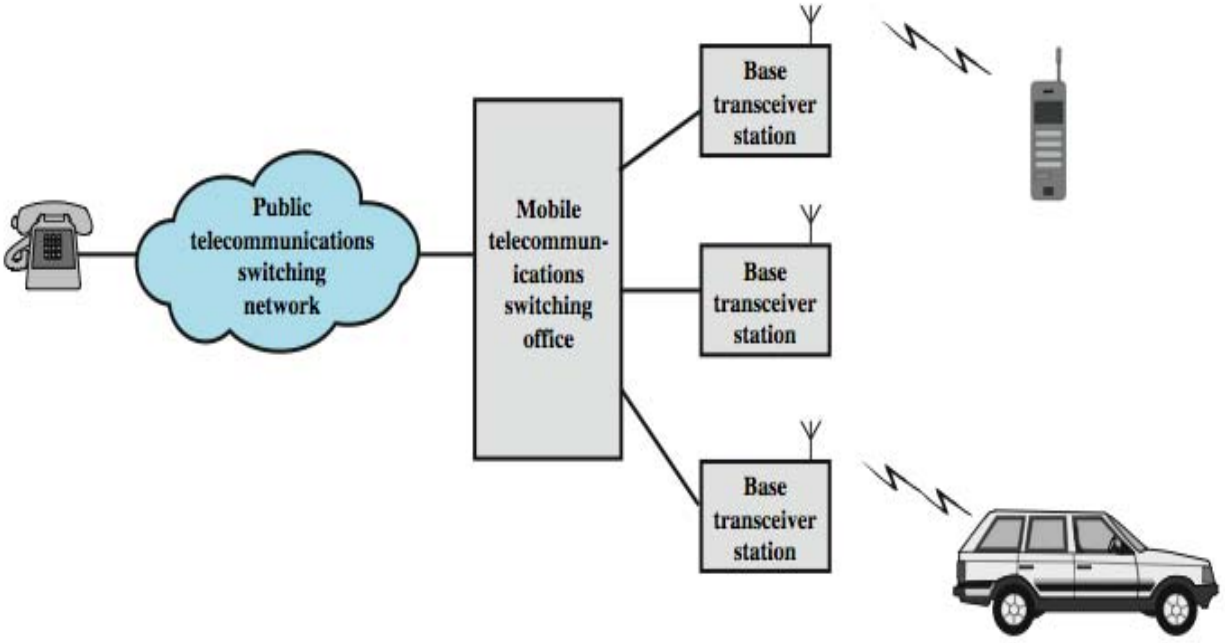


(a) Frequency reuse pattern for $N = 4$ (b) Frequency reuse pattern for $N = 7$

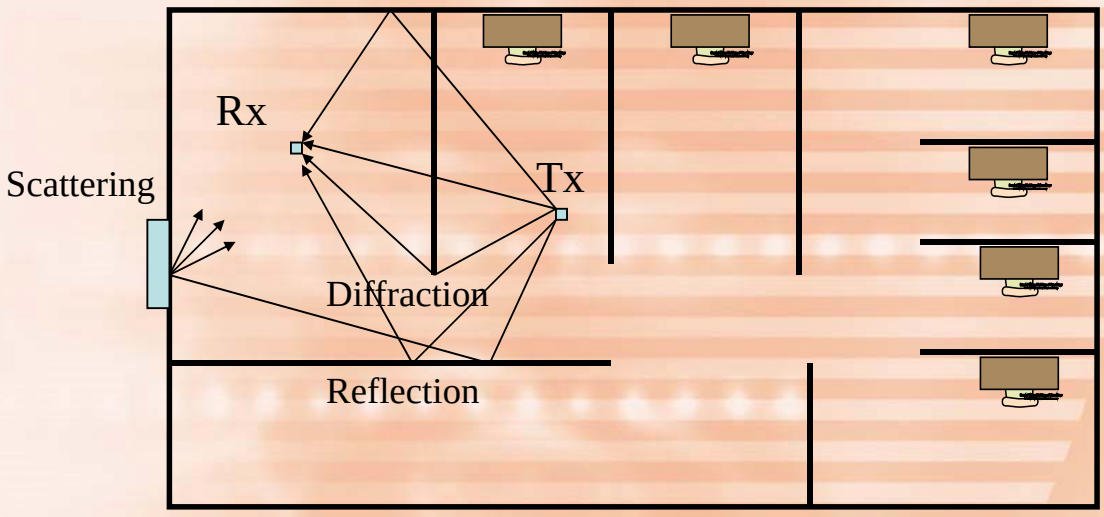


(c) Black cells indicate a frequency reuse for $N = 19$

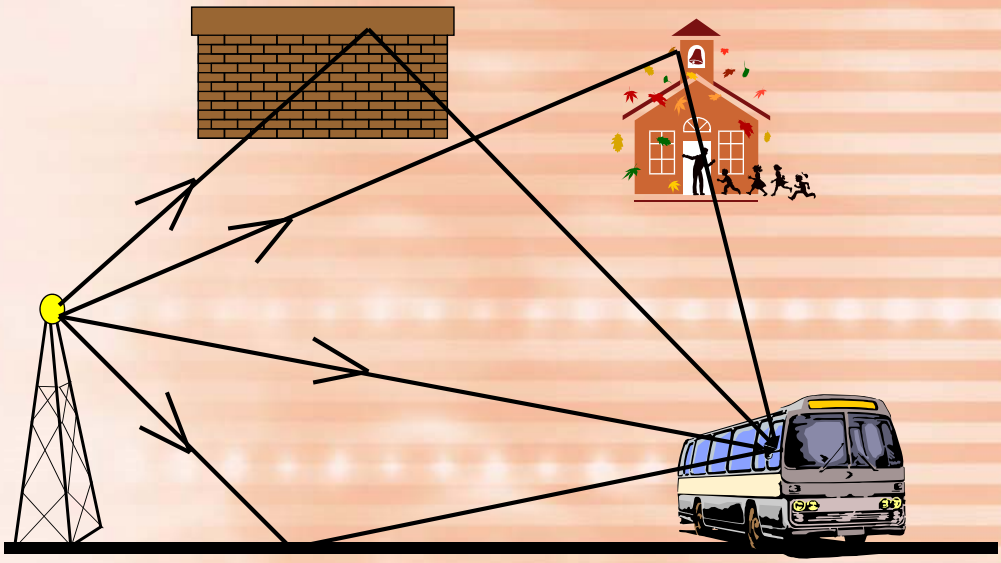
Overview of Cellular System



Radio Propagation: Indoor area



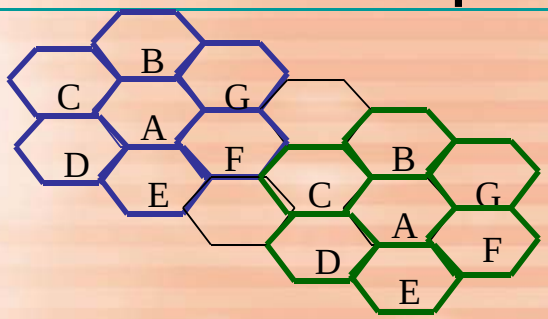
Radio Propagation: Outdoor area



Signal Coverage

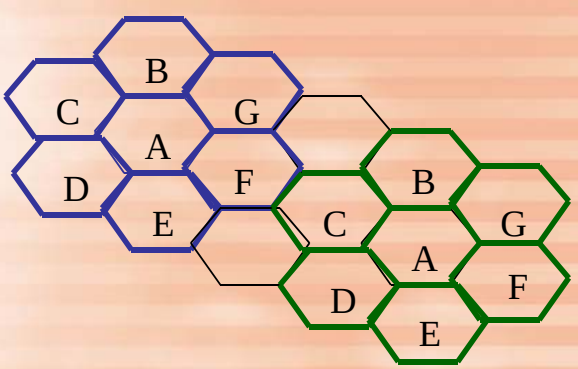
- Essential for design and deployment of wireless networks.
- Influenced by the radio frequency of operation and the terrain.
- Path-loss model:
  - Used to calculate the coverage area of wireless base stations and access points.
  - Used to calculate the maximum distance between two terminals in an ad hoc network.
  - Relates the loss of signal strength to distance between two terminals.

Cellular Topology



- Multi-base station network configuration that exploits the frequency reuse concept.
- Utilize the limited spectrum to support multiple users separated by distance.
- Adjacent cells assigned different frequencies to avoid interference or crosstalk.
- Objective is to reuse frequency in nearby cells.
  - 10 to 50 frequencies assigned to each cell
  - Transmission power controlled to limit power at that frequency escaping to adjacent cells.

Cellular Topology



- Number of simultaneous users:

$$n = \frac{m\left(W/N\right)}{B}$$

n – number of simultaneous users.

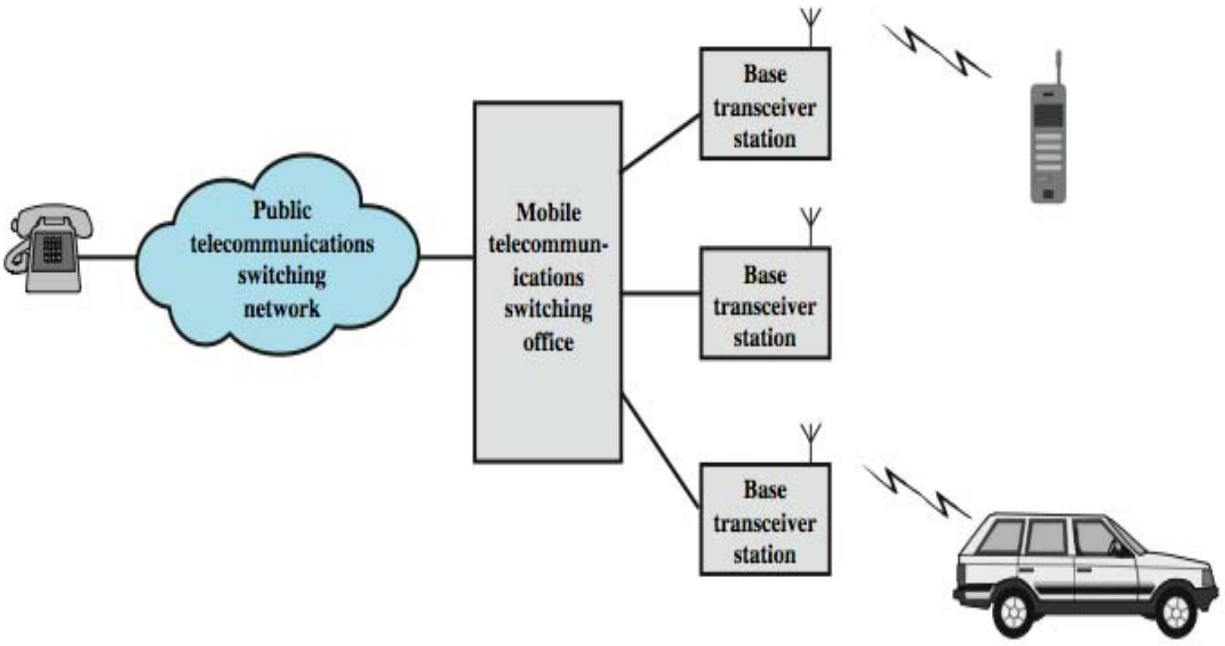
m – number of cells required.

N – frequency reuse factor.

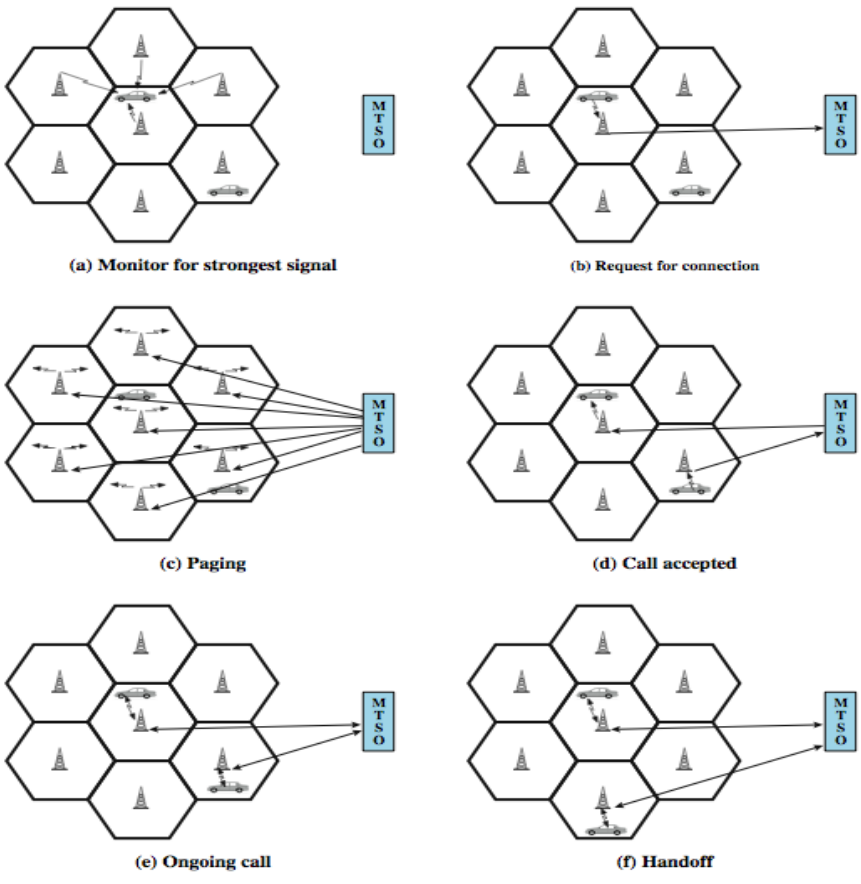
W – total available spectrum.

B – bandwidth need per user.

Cellular System Overview



Call Stages



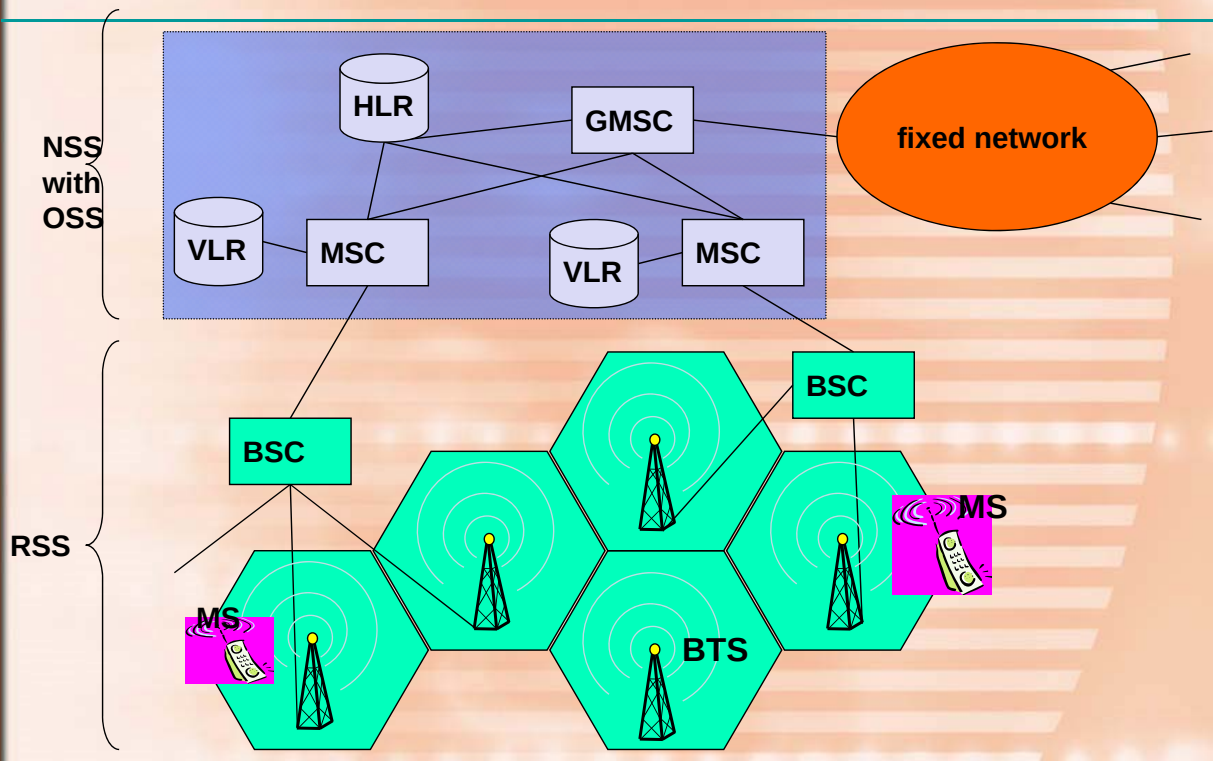
Cellular System Overview

- Mobile equipment (ME):
  - Physical terminal, includes radio transceiver, digital signal processors and subscriber identity module (SIM)
- Base Station (BS):
  - Includes an antenna, a controller, and a number of receivers.
  - Use multiple low-power transmitters.
  - Areas divided into cells, and each served by its own antenna.
  - Band of frequencies allocated.
- Mobile telecommunications switching office (MTSO):
  - Connects calls between mobile units.
- Two types of channels available between mobile unit and BS.
  - Control channels: used to exchange information having to do with setting up and maintaining calls.
  - Traffic channels: carry voice or data connection between users.

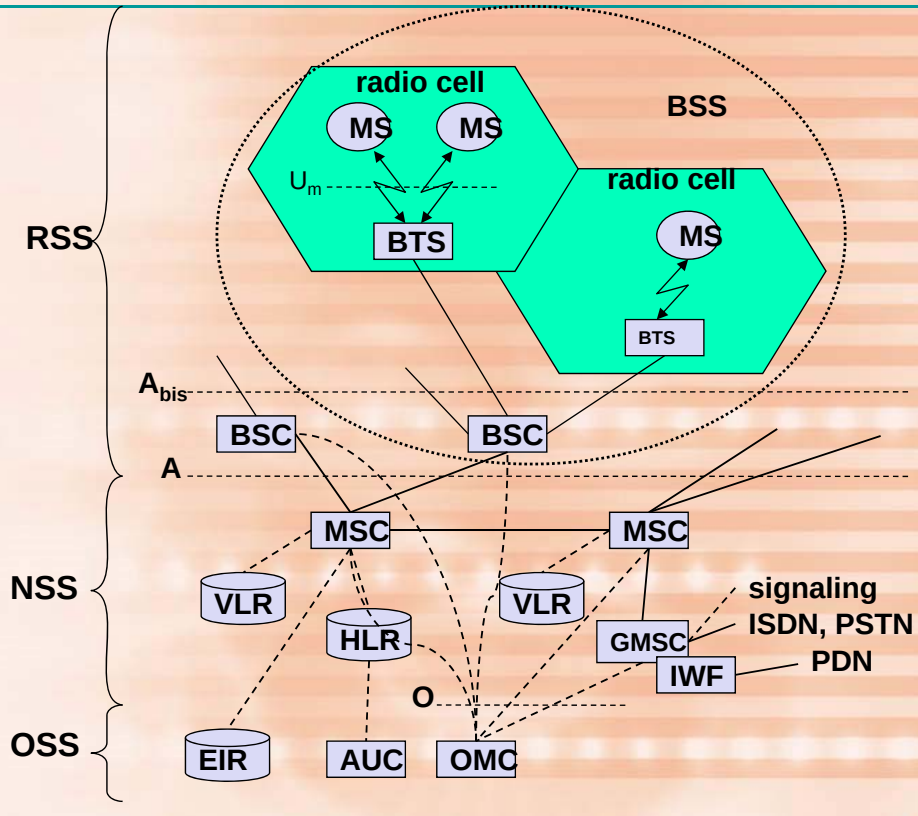
Cellular Systems

- First Generation Systems: Analog
  - Advanced Mobile Phone Service (AMPS): US, Australia, Southeast Asia.
  - Total Access Communication System (TACS): EU
  - Nippon Telephone and Telegraph (NTT): Japan
- Second Generation Systems: Digital
  - Global System of Mobile communications (GSM): Europe, Asia
  - Code Division Multiple Access (CDMA) systems (IS-95): US, Asia
- Third Generation Systems: Digital & High data rate
  - Wideband CDMA
  - CDMA2000

GSM: Overview



GSM: Overview



GSM: Overview

- Radio SubSystem (RSS): Covers all radio aspects.
- Network & Switching Subsystem (NSS):
- Operation SubSystem (OSS):
  - call forwarding, handover, switching, management of the network.

- Home location register (HLR): Stores information about each subscriber that belongs to it.
- Visitor location register (VLR): Maintains information about subscribers currently physically in the region.
- Authentication center database (AuC): Used for authentication activities, holds encryption keys.
- Equipment identity register (EIR): Keeps track of the type of equipment that exists at the mobile station.

Mobile Station (MS)

Equipment used by mobile service subscribers for access to services.

Mobile Equipment
Subscriber Identity Module (SIM)

Mobile stations are not fixed to one subscriber. A subscriber is identified with the SIM card.

Base Transceiver Station (BTS)

Base Transceiver Station (BTS)

- Wireless transmission
- Wireless diversity
- Wireless channel encryption
- Conversion between wired and wireless signals
- Frequency Hopping

❖BaseBand Unit:
voice and data speed adapting and channel coding

❖RF Unit:
modulating/demodulating, transmitter and receiver

❖Common Control Unit:
BTS operation and maintenance

Base Station Controller (BSC)

Managing Wireless network-BSS Monitoring BTS

Controls:

- Wireless link distribution between MS and BTS
- Communication connection and disconnection
- MS location, handover and paging
- Voice encoding, transecoding (TC), rate, adaptation,
- The operation and maintenance functions of BSS.

Mobile Service Switching Center (MSC)

- holds all the switching functions
- manages the necessary radio resources,
  - updating the location registration
  - carrying out the inter-BSC and inter-MSC tender
- Inter-working with other networks (IWF).

Home Location Register (HLR)

Manages the mobile subscribers database

- subscriber information
- part of the mobile location information
- 3 identities essential
  - the International Mobile subscriber Identity
  - the Mobile station ISDN Number
  - the VLR address

Visitor Location Register (VLR)

dynamically stores subscriber information needed to handle incoming/outgoing calls

- Mobile Station Roaming Number

When a roaming mobile enters an MSC area. This MSC warns the associated VLR of this situation; the mobile enters a registration procedure through which it is assigned a mobile subscriber roaming number (MSRN)

- Temporary Mobile Subscriber Identity, if applicable
- The location area in which the mobile has been registered
- Data related to supplementary service parameters

AUC/EIR

-Authentication Center(s) (AUC)

Providing the authentication key used for authorizing the subscriber access to the associated GSM PLMN.

-Equipment Identity Register(s) (EIR)

Handling Mobile Station Equipment Identity

Operation and Maintenance Center (OMC)

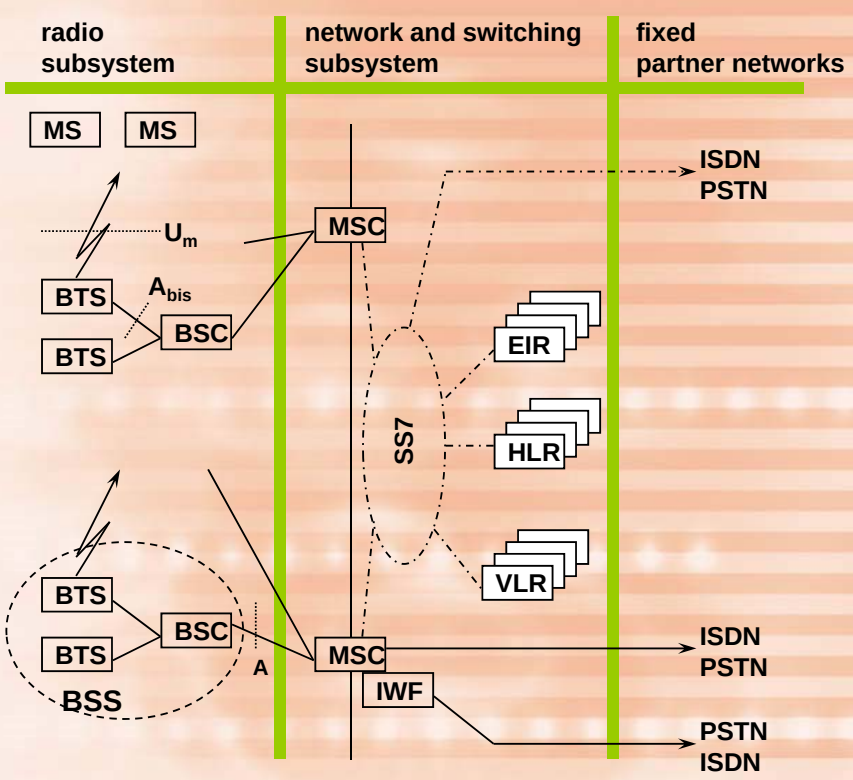
different control capabilities for the radio subsystem and the network subsystem

Gateway Mobile Switching Center (GMSC)

SS7

- Common channel signaling system no. 7 (i.e., ss7 or c7)
  - Is a global standard for telecommunications defined by the international telecommunication union (itu) telecommunication standardization sector (itu-t).
  - The standard defines the procedures and protocol by which network elements in the public switched telephone network (pstn) exchange information over a digital signaling network to effect wireless (cellular) and wireline call setup, routing and control.

GSM: Overview



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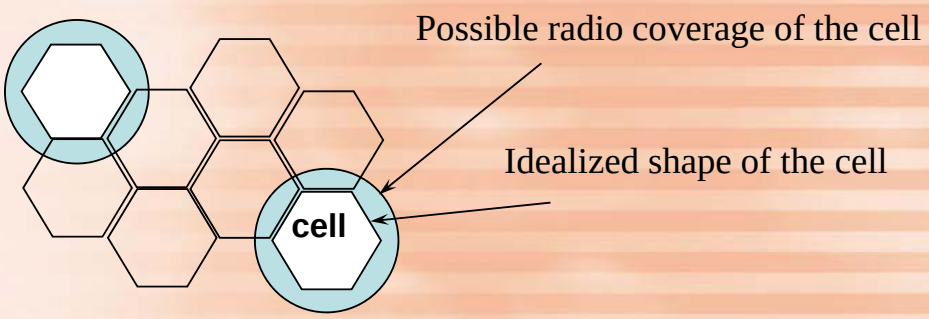
GSM: Overview



- Use of several carrier frequencies.
- Not the same frequency in adjoining cells.
- Cell sizes vary : 100 m up to 35 km (user density, geography, transceiver power etc).
- Idealized hexagonal shape (depends geography)
- If a mobile user changes cells → handover.

Third Generation Cellular Systems

- Voice quality comparable to the public switched telephone network.
- 144 kbps/384 kbps data rate support for outdoor mobile users.
- Support for 2.048 Mbps for indoor users.
- Support for both packet switched and circuit switched data services.
- An adaptive interface to the Internet to reflect efficiently the common asymmetry between inbound and outbound traffic.
- More efficient use of the available spectrum in general.
- Support for a wide variety of mobile equipment.
- Flexibility to allow the introduction of new services and technologies.

Required Reading

- **W. Stallings, "Data and Computer Communications (10th edition)," Pearson, Prentice-Hall, 2013.**

>> Chapter 10 –

Cellular Wireless Networks