GAIKWAD-PATIL
GROUP OF INSTITUTIONS

# Elective II-Mobile Computing

## UNIT 1

## History of Wireless Communication
## A simplified Reference Model

Session(2019-2020)

1. Explain the structure of communication system with suitable reference model. (S-16,17,W-17,18)

2. Distinguish between Wireless and Wired Network. (W-12,S-18)

3. Write a short note on Antennas. (S-13)

4. Write about the history of mobile communication with the overview of some wireless.

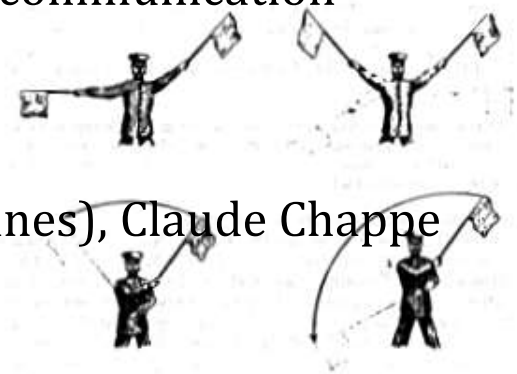
5. What are the difference type of antennas and their uses. (S-16,17,18,W-17,18)

6. Write a short on multiplexing. (W-13,S-11,….)

7. What are different applications of Wireless Communication? Discuss with their categories. (W-16,17,S-16)

# Early history of wireless communication

- Many people in history used light (modulated) for communication
  - heliographs, flags („semaphore“), ...
  - 150 BC smoke signals for communication; (Polybius, Greece)
  - 1794, optical telegraph (long distance comm. lines), Claude Chappe



- Here electromagnetic waves are of special importance:
  - 1831 M. Faraday demonstrates electromagnetic induction
  - J. Maxwell (1831-79): theory of electromagnetic Fields, wave equations (1864)
  - H. Hertz (1857-94): demonstrates with an experiment the wave character of electrical transmission through space (1888, in Karlsruhe, Germany, at the location of today’s University of Karlsruhe)

# History of wireless communication I

- 1895 Guglielmo Marconi
  - first demonstration of wireless telegraphy (digital!)
  - long wave transmission, high transmission power necessary (> 200kw)
- 1907 Commercial transatlantic connectic
  - huge base stations (30 100m high antennas)
- 1915 Wireless voice transmission New York - San Francisco
- 1920 Discovery of short waves by Marconi
  - reflection at the ionosphere
  - smaller sender and receiver, possible due to the invention of the vacuum tube (1906, Lee DeForest and Robert von Lieben)
- 1926 Train-phone on the line Hamburg - Berlin
  - wires parallel to the railroad track

# History of wireless communication II

- 1928 many TV broadcast trials (across Atlantic, color TV, TV news)
- 1933 Frequency modulation (E. H. Armstrong)
- 1958 A-Netz in Germany
  - analog, 160MHz, connection setup only from the mobile station, no handover, 80% coverage, 1971 11000 customers
- 1972 B-Netz in Germany
  - analog, 160MHz, connection setup from the fixed network too (but location of the mobile station has to be known)
  - available also in A, NL and LUX, 1979 13000 customer in D
- 1979 NMT at 450MHz (Scandinavian countries)
- 1982 Start of GSM-specification (Groupe Speciale Mobile)
  - goal: pan-European digital mobile phone system with roaming
- 1983 Start of the American AMPS (Advanced Mobile Phone System, analog, 850MHz)
- 1984 CT-1 standard (Europe) for cordless telephones

# History of wireless communication III

- 1986 C-Netz in Germany
  - analog voice transmission, 450MHz, hand-over possible, digital signaling, automatic location of mobile device
  - Was in use until 2000, services: FAX, modem, X.25, e-mail, 98% coverage
- 1991 Specification of DECT
  - Digital European Cordless Telephone (today: Digital Enhanced Cordless Telecommunications)
  - 1880-1900MHz, ~100-500m range, 120 duplex channels, 1.2Mbit/s data transmission, voice encryption, authentication, up to several 10000 user/km$^2$, used in more than 50 countries
- 1992 Start of GSM (Global system for Mobile Comm.)
  - in D as D1 and D2, fully digital, 900MHz, 124 full duplex channels
  - automatic location, authen., encryption on wireless links, hand-over, cellular
  - roaming in Europe - now worldwide in more than 170 countries
  - services: data with 9.6kbit/s, FAX, voice, ...multimedia data streaming transport

# History of wireless communication IV

- 1994 E-Netz in Germany
  - GSM with 1800MHz, smaller cells
  - As Eplus in D (1997 98% coverage of the *population*)
- 1996 HiperLAN (High Performance Radio Local Area Network)
  - ETSI, standardization of type 1: 5.15 - 5.30GHz, 23.5Mbit/s
  - recommendations for type 2 and 3 (both 5GHz) and 4 (17GHz) as wireless ATM-networks (up to 155Mbit/s)
- 1997 Wireless LAN - IEEE802.11
  - IEEE standard, 2.4 - 2.5GHz and infrared, 2Mbit/s
  - already many (proprietary) products available in the beginning
- **1998 Specification of GSM successors**
  - for UMTS (Universal Mobile Telecommunication System) as European proposals for IMT-2000
- Iridium
  - 66 satellites (+6 spare), 1.6GHz to the mobile phone

1998- beginning of Mobile Communication(Satellites with Iridium System)

Satellite: Broadcast distribution medium , can be used with

Broadcasting (Big /Heavy )

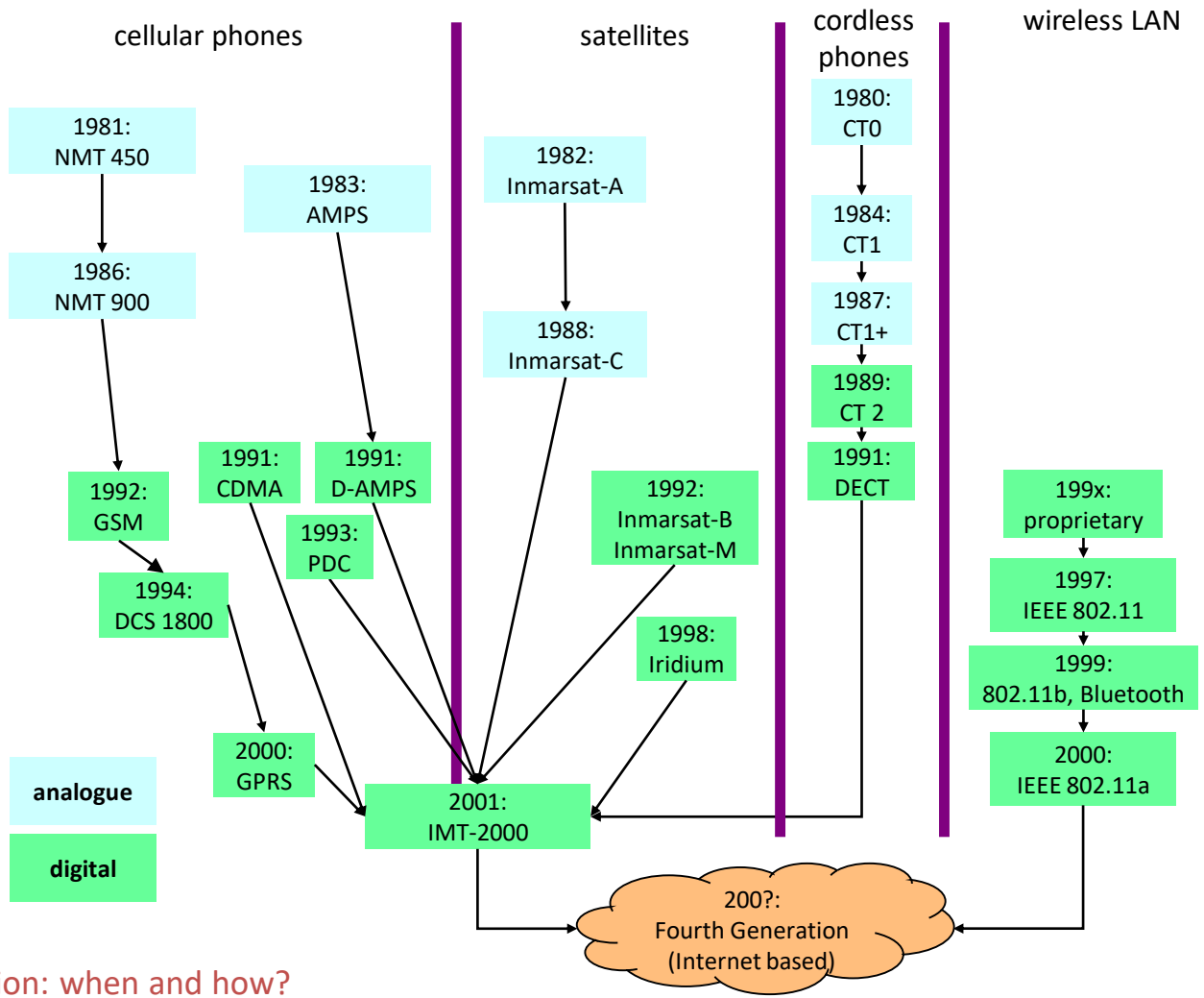
Iridium – marked the beginning of small and truly portable mobile satellites telephone including data services…

66 satellites , 1.6 GHz band

# History of wireless communication V

- 1999 Standardization of additional wireless LANs
  - IEEE standard 802.11b, 2.4-2.5GHz, 11Mbit/s
  - Bluetooth for piconets, 2.4Ghz, <1Mbit/s
- Decision about IMT-2000
  - Several "members" of a "family": UMTS, cdma2000, DECT, …
- Start of WAP (Wireless Application Protocol) and i-mode
  - First step towards a unified Internet/mobile communicaiton system
  - Access to many services via the mobile phone
- 2000 GSM with higher data rates
  - HSCSD offers up to 57,6kbit/s
  - First GPRS trials with up to 50 kbit/s (packet oriented!)
- UMTS auctions/beauty contests
  - Hype followed by disillusionment (approx. 50 B$ payed in Germany for 6 UMTS licences!)
- 2001 Start of 3G systems
  - Cdma2000 in Korea, UMTS in Europe, Foma (almost UMTS) in Japan

# Wireless systems: overview of the development



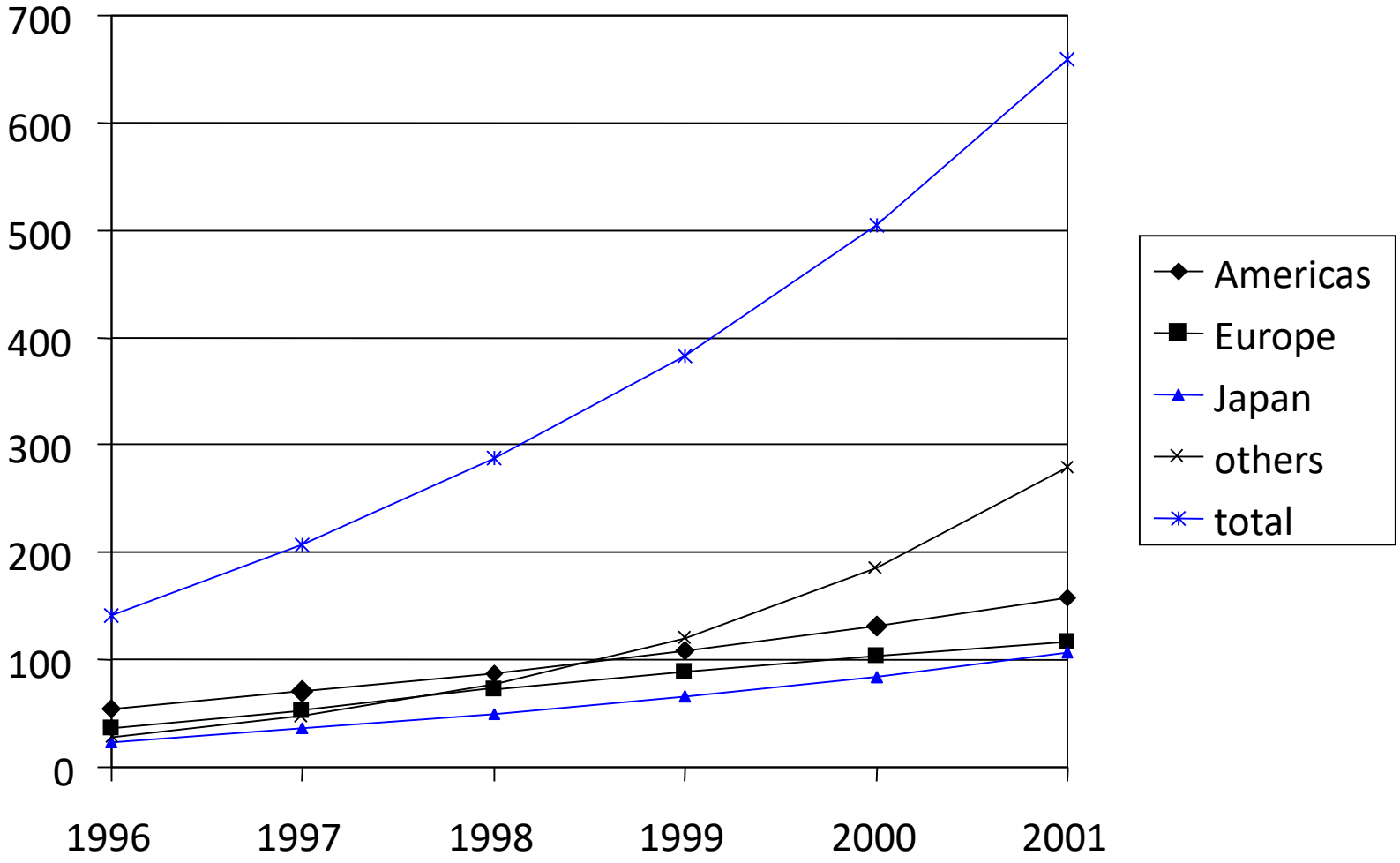

4G – fourth generation: when and how?

# Foundation: ITU-R - Recommendations for IMT-2000

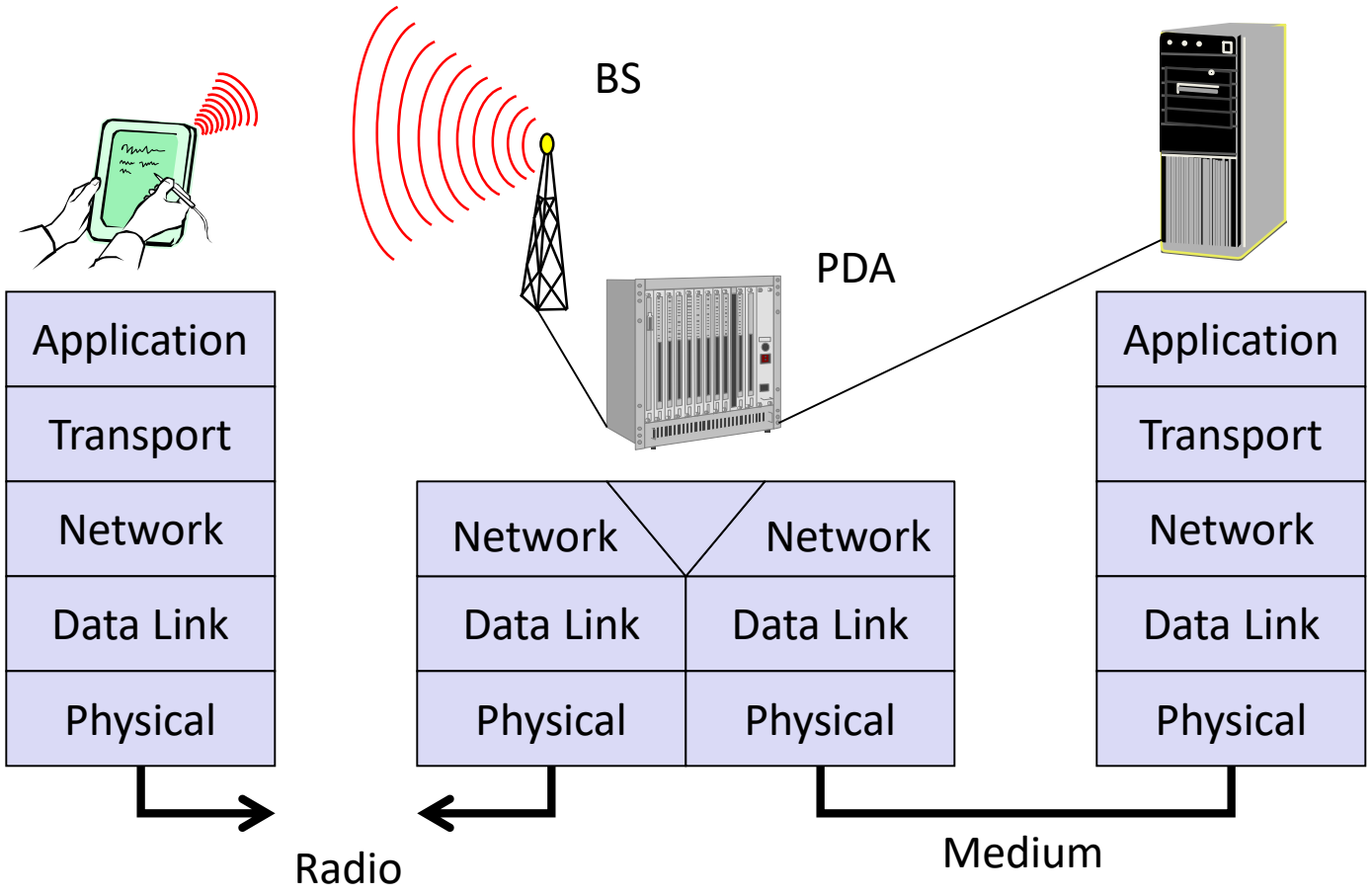
- M.687-2
  - IMT-2000 concepts and goals
- M.816-1
  - framework for services
- M.817
  - IMT-2000 network architectures
- M.818-1
  - satellites in IMT-2000
- M.819-2
  - IMT-2000 for developing countries
- M.1034-1
  - requirements for the radio interface(s)
- M.1035
  - framework for radio interface(s) and radio sub-system functions
- M.1036
  - spectrum considerations
- M.1078
  - security in IMT-2000
- M.1079
  - speech/voiceband data performance
- M.1167
  - framework for satellites
- M.1168
  - framework for management
- M.1223
  - evaluation of security mechanisms
- M.1224
  - vocabulary for IMT-2000
- M.1225
  - evaluation of transmission technologies
- . . .

- http://www.itu.int/imt

# Worldwide wireless subscribers (old prediction 1998)



# Simplified Reference Model



**Base Station:** Radio Transceiver Internet networking unit (wireless link with fixed link)

**Physical Layer:**

Stream of bits into signal  Signals back into a bit stream

**Frequency selection, generation of carrier frequency , signal detection , modulation of data and encryption**

# Data Link Layer:

Accessing the medium, multiplexing of different data streams, correction of transmission errors, and synchronization

Reliable point to point connection between two devices or point to multi point connection

**Network Layer:**

Routing of packets through network

Addressing, routing , Device location, handover

**Transport Layer:**

est end to end connection

Quality of service, flow and congestion control

TCP UDP over wireless link

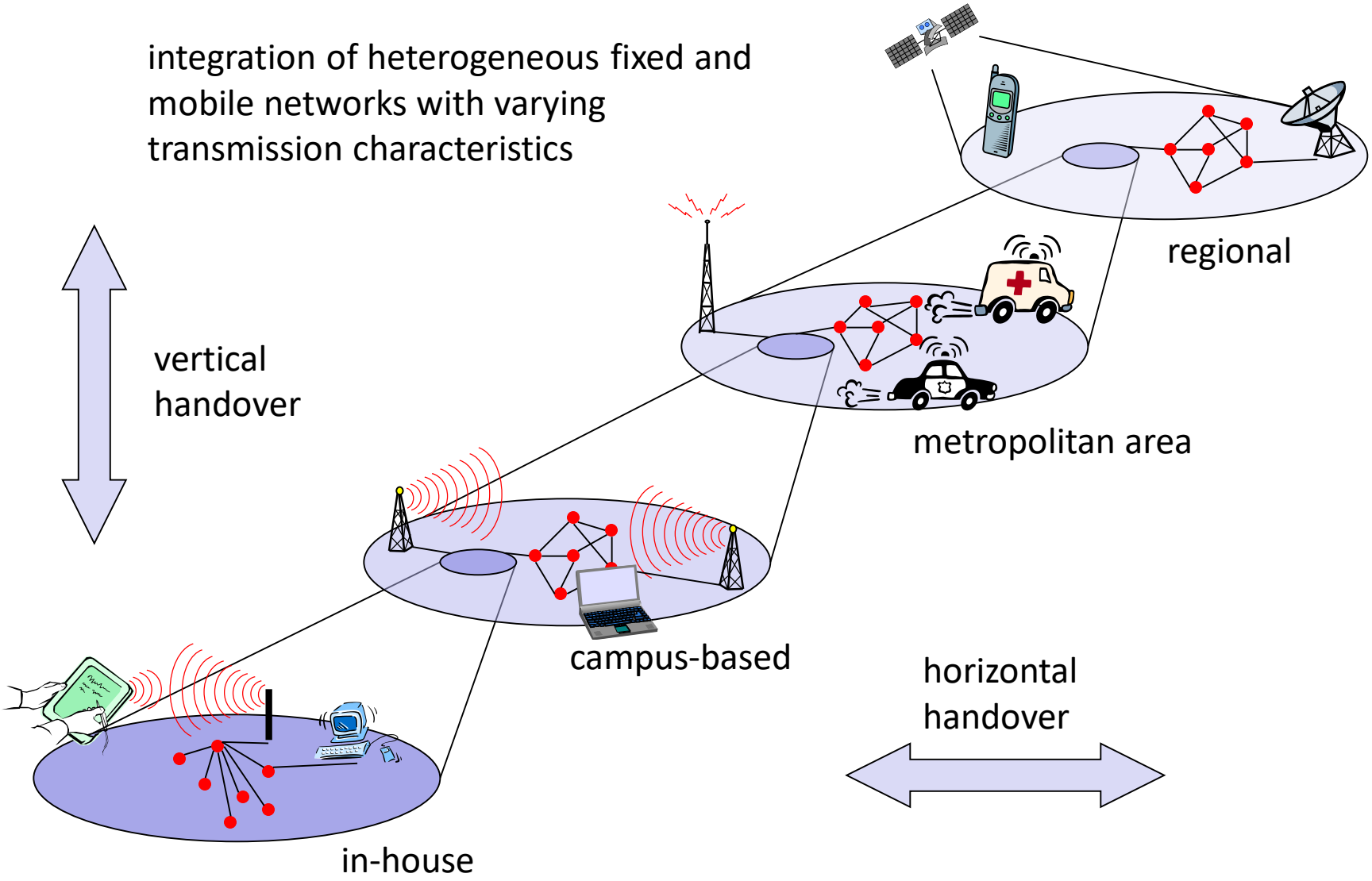
**Application Layer:**

# Influence of mobile communication to the layer model

| | |
|---|---|
| Application layer | – service location<br>– new applications, multimedia<br>– adaptive applications |
| Transport layer | – congestion and flow control<br>– quality of service |
| Network layer | – addressing, routing, device location<br>– hand-over |
| Data link layer | – authentication<br>– media access<br>– multiplexing<br>– media access control |
| Physical layer | – encryption<br>– modulation<br>– interference<br>– attenuation<br>– frequency |

# Overlay Networks - the global goal

integration of heterogeneous fixed and mobile networks with varying transmission characteristics

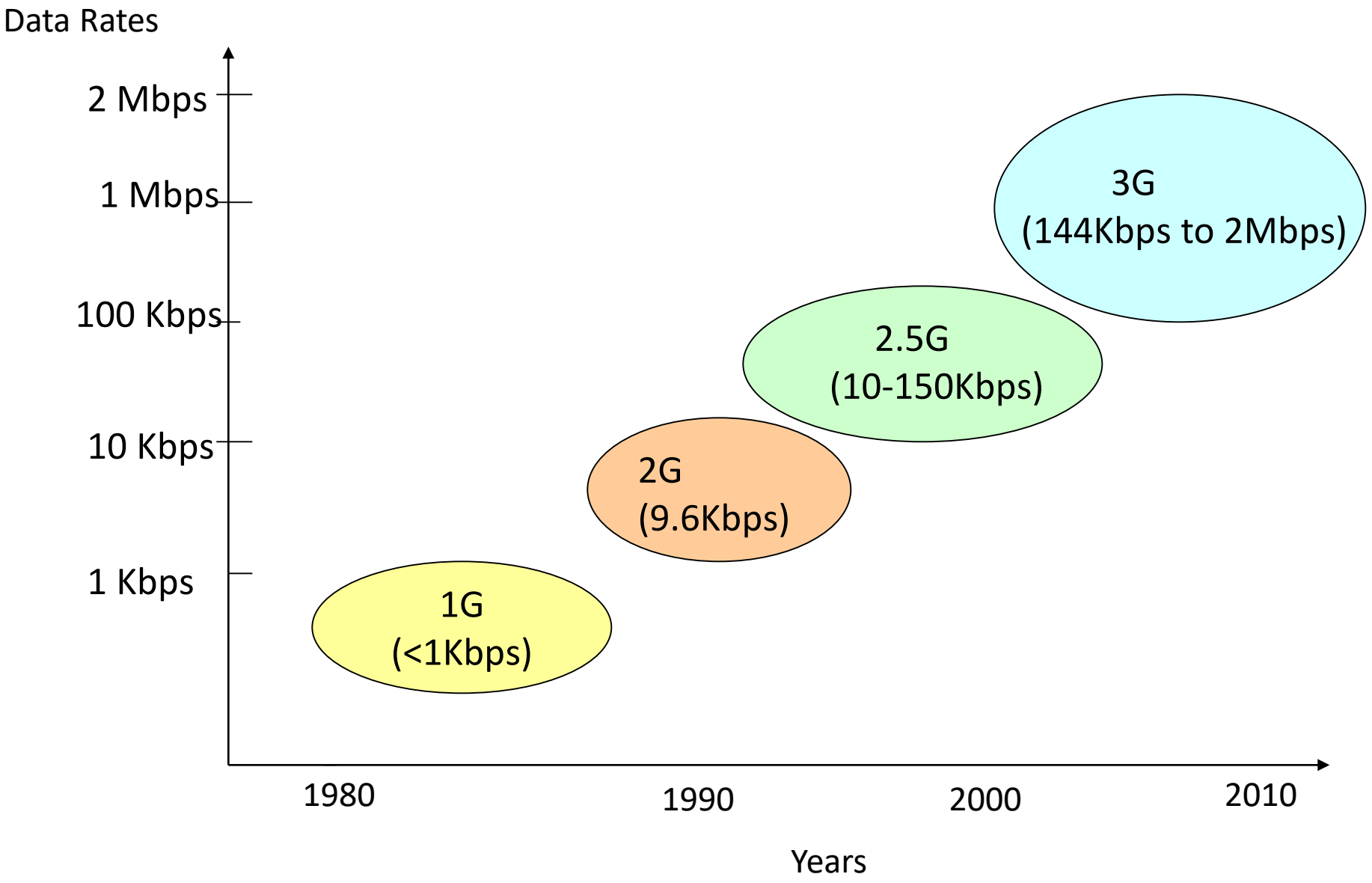


# Wireless networks in comparison to fixed networks

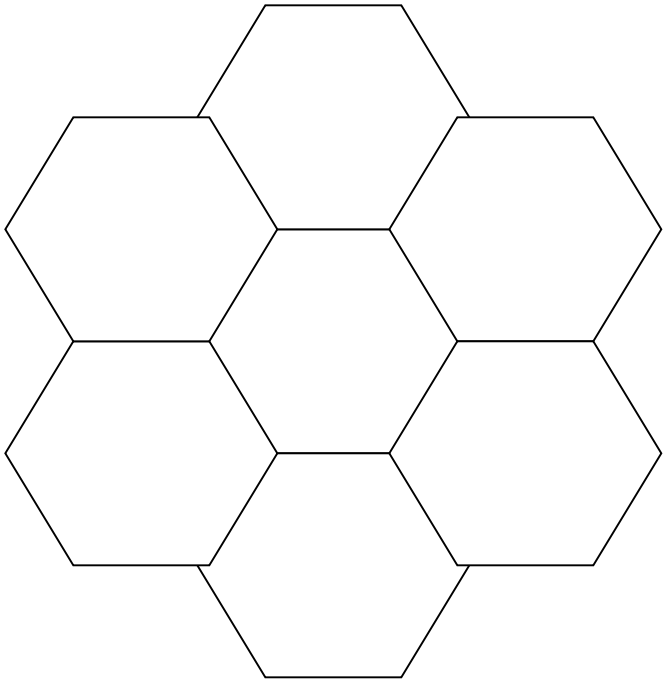
- Higher loss-rates due to interference
  - emissions of, e.g., engines, lightning
- Restrictive regulations of frequencies
  - frequencies have to be coordinated, useful frequencies are almost all occupied
- Low transmission rates
  - local some Mbit/s, regional currently, e.g., 9.6kbit/s with GSM
- Higher delays, higher jitter
  - connection setup time with GSM in the second range, several hundred milliseconds for other wireless systems
- Lower security, simpler active attacking
  - radio interface accessible for everyone, base station can be simulated, thus attracting calls from mobile phones
- Always shared medium
  - secure access mechanisms important

# Cellular Systems

# Overview


Data Rates
2 Mbps
1 Mbps
100 Kbps
10 Kbps
1 Kbps
1G
(<1Kbps)
2G
(9.6Kbps)
2.5G
(10-150Kbps)
3G
(144Kbps to 2Mbps)
1980
1990
2000
2010
Years

# “Cell”ular Structure



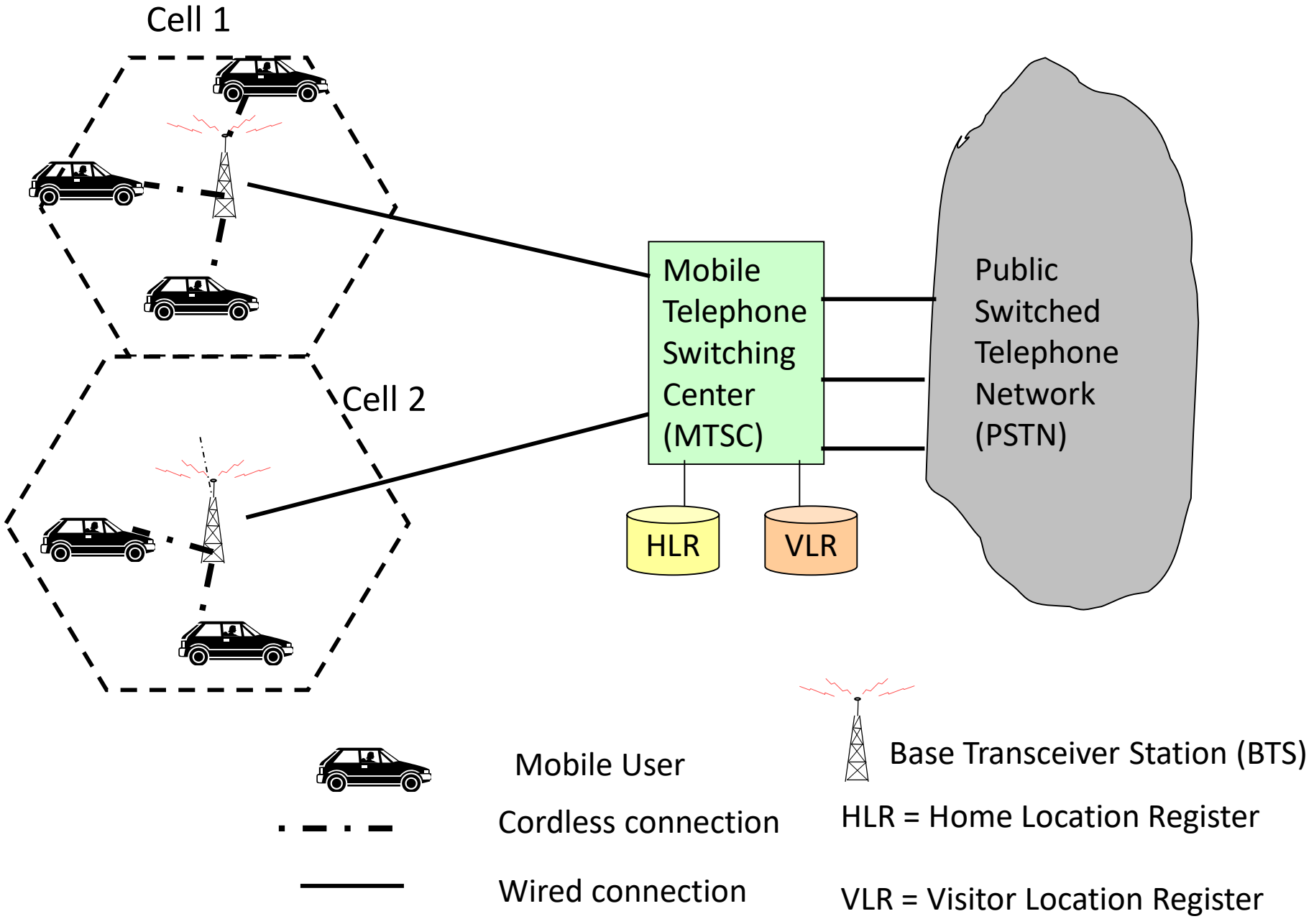
# Properties of Cell structure

- Typical Cell sizes
  - some cites few hundred meters
  - country side few tens of kilometers
- Advantages of cell structures:
  - more capacity due to frequency reusage
  - less transmission power needed
  - more robust, tolerate failures
  - deals interference, transmission area locally
- Problems:
  - fixed network needed for the base stations
  - handover (changing from one cell to another) necessary
  - interference with other cells

# Cellular networks: From 1G to 3G

- 1G: First generation wireless cellular: Early 1980s
  - Analog transmission, primarily speech: AMPS (Advanced Mobile Phone Systems) and others
- 2G: Second generation wireless cellular: Late 1980s
  - Digital transmission
  - Primarily speech and low bit-rate data (9.6 Kbps)
  - High-tier: GSM, IS-95 (CDMA), etc
  - Low-tier (PCS): Low-cost, low-power, low-mobility e.g. PACS
- 2.5G: 2G evolved to medium rate (< 100kbps) data
- 3G: future  Broadband multimedia
  - 144 kbps - 384 kbps for high-mobility, high coverage
  - 2 Mbps for low-mobility and low coverage
- Beyond 3G: research in 4G

# A Cellular Network



## Cell

Basic geographic unit of a cellular system.

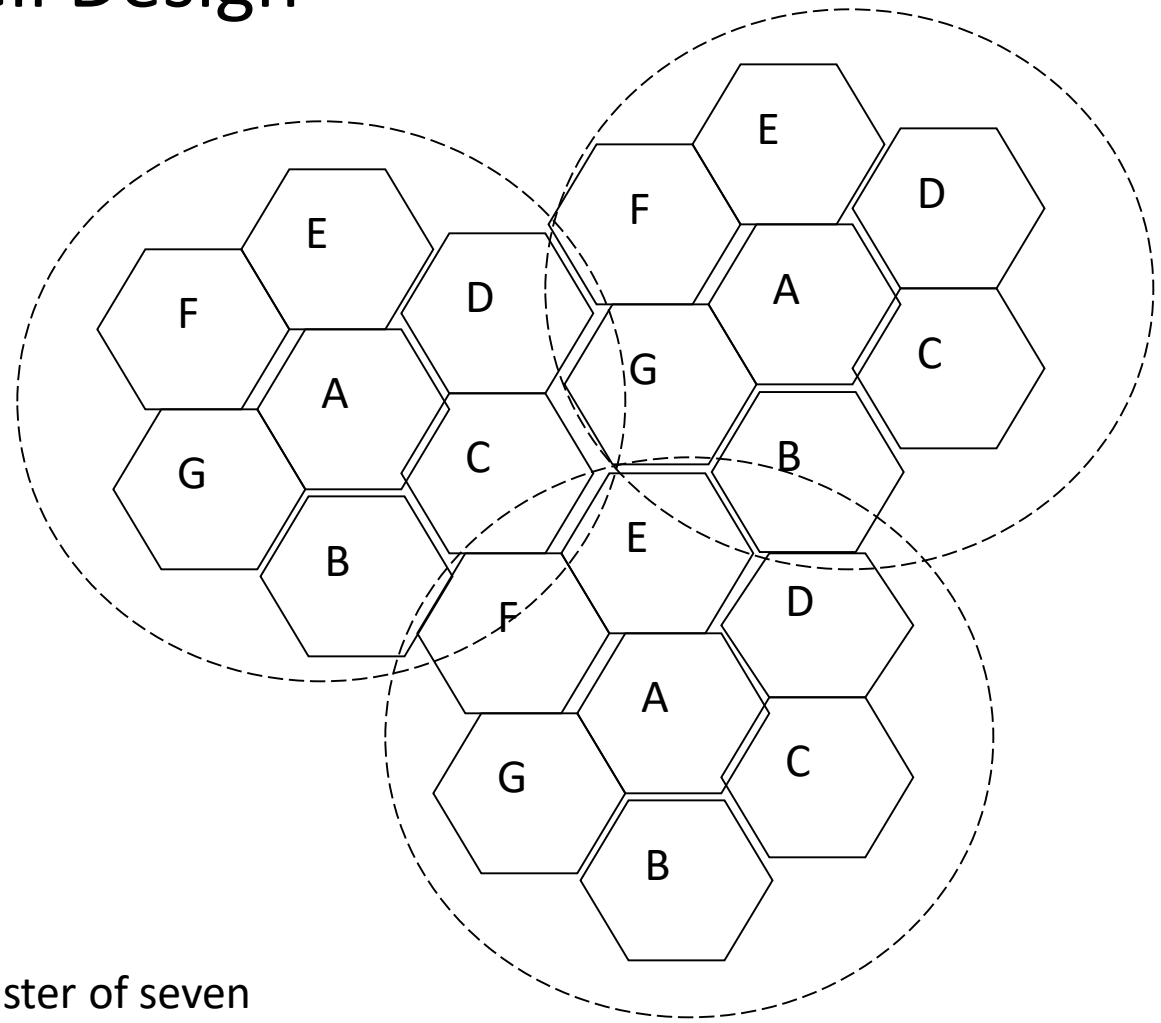
Macro Cell: large cells for remote and sparely populated areas

Micro Cell: Densely populated areas. By splitting the existing areas into smaller cells, the available channels are increased as well as the capacity of the cells

Selective Cell: The cells should be defined in a such way that they prove their existence.

Umbrella Cell: Covers several micro cell.

# Cell Design

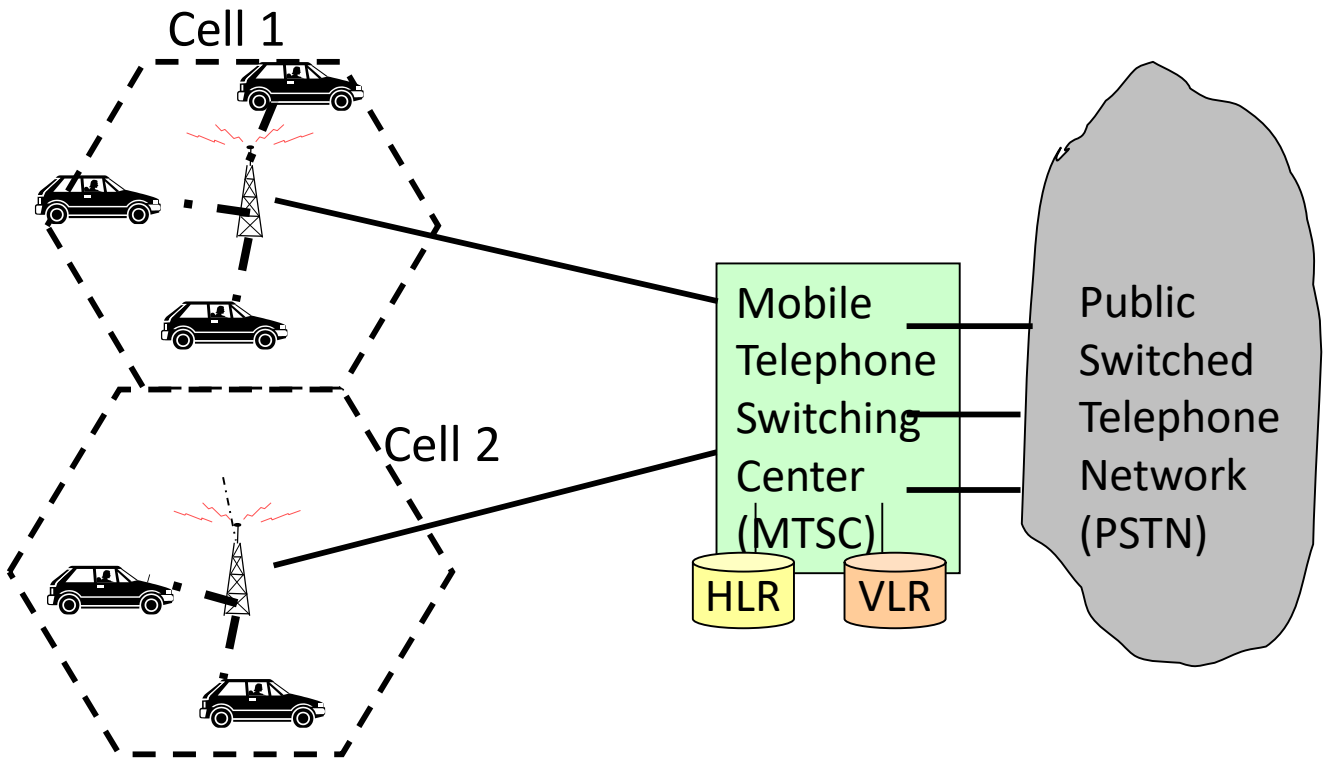



- Cells grouped into a cluster of seven
- Letters indicate frequency use
- For each frequency, a buffer of two cells is used before reuse
- To add more users, smaller cells (microcells) are used
- Frequencies may not need to be different in CDMA (soft handoff)

# Overview of Location Services

- Cell-id based location.
  - assigned an id of the cell that you are in.
  - cell-id is stored in a database.
  - As you move from one cell to another, you are assigned a different cell-id and the location database is updated.
  - most commonly used in cellular networks. (HLR, VLR)
- Neighborhood polling: Connected mobile units only move to adjacent cells
- Angle of arrival (AOA). the angle at which radio waves from your device "attack" an antenna is used to calculate the location of the device.
- Time taken. In this case, the time taken between the device and the antenna is used to calculate the location of the device.
- Network assisted Global Positioning System (GPS). a GPS chip is installed inside a phone and thus the location of the user is tracked.

# Cellular System




Handoffs (typically 30 mseconds):

1. At any time, mobile station (MS) is in one cell and under the control of a BS
2. When a MS leaves a cell, BS notices weak signal
3. BS asks surrounding BSs if they are getting a stronger signal
4. BS transfers ownership to one with strongest signal
5. MTSO assigns new channel to the MS and notifies MS of new boss

# Frequency Reuse

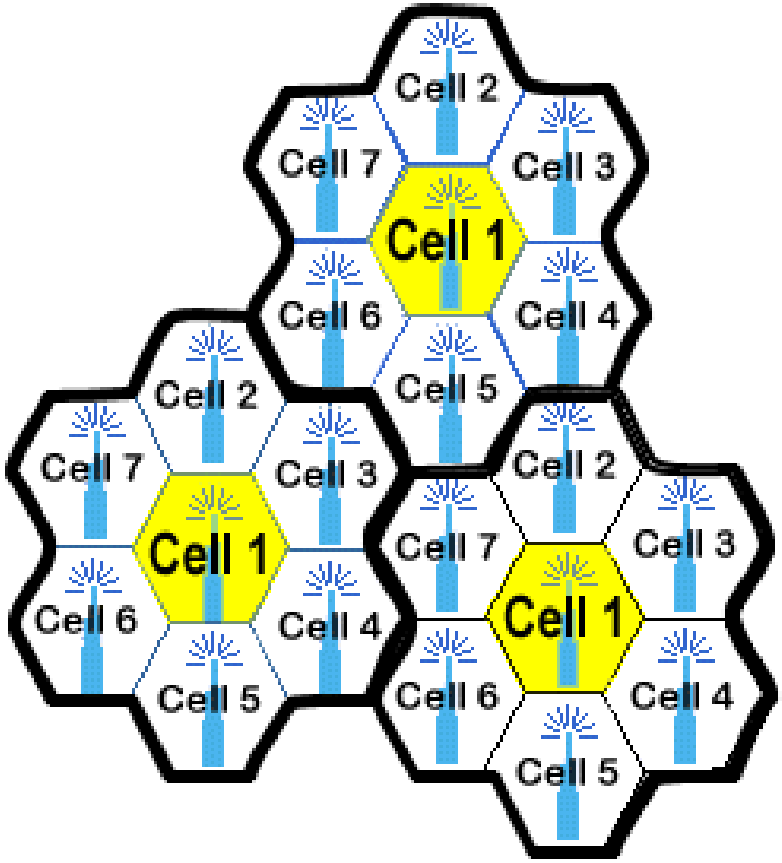
The concept of frequency reuse is based on assigning to each cell a group of radio channels used within a small geographic area

Cells are assigned a group of channels that is completely different from neighbouring cells

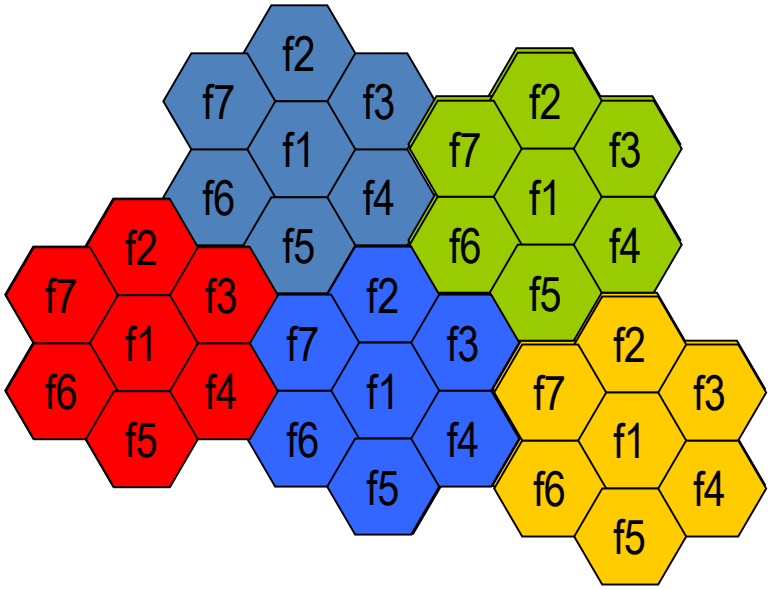
The coverage area of cells is called the footprint and is limited by a boundary so that the same group of channels can be used in cells that are far enough apart.

# Frequency Reuse

- Cells with the same number have the same set of frequencies



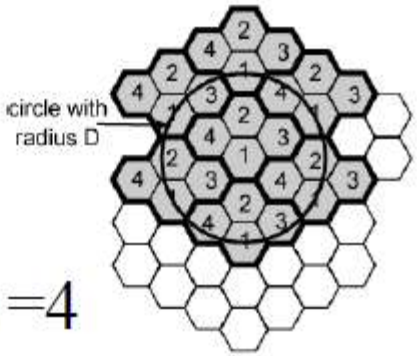
# Frequency Reuse using 7 frequencies allocations



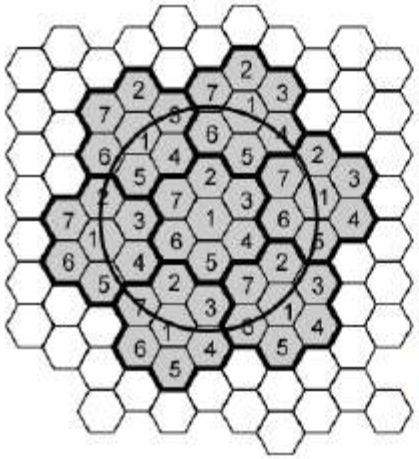

Each cell is generally 4 to 8 miles in diameter with a lower limit around 2 miles.

# Cellular Frequency Reuse

Cluster Size =4

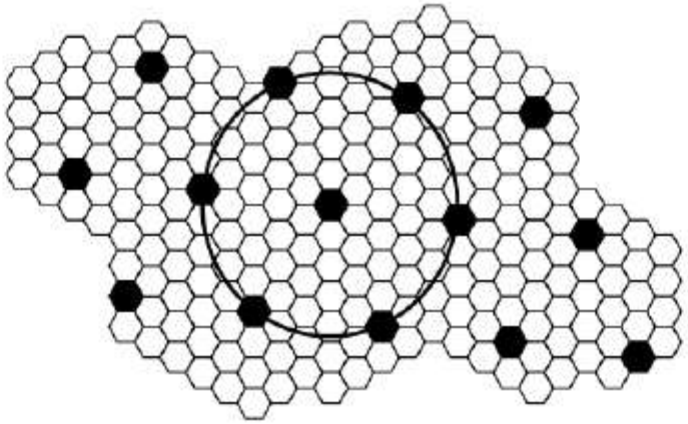



(a) Frequency reuse pattern for N = 4



(b) Frequency reuse pattern for N = 7

Cluster Size =7



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

Cluster Size =19

# Cellular Network Organization

- Cell design  (around 10 mile radius)
  - Served by base station consisting of transmitter, receiver, and control unit
  - Base station (BS) antenna is placed in high places (churches, high rise buildings) -
    - Operators pay around  $500 per month for BS
  - 10 to 50 frequencies assigned to each cell
  - Cells set up such that antennas of all neighbors are equidistant (hexagonal pattern)
- In North America, two 25-MHz bands allocated to AMPS
  - One for transmission from base to mobile unit
  - One for transmission from mobile unit to base

# Approaches to Increase Capacity

- Adding/reassigning channels - some channels are not used
- Frequency borrowing – frequencies are taken from adjacent cells by congested cells
- Cell splitting – cells in areas of high usage can be split into smaller cells
- Microcells – antennas move to buildings, hills, and lamp posts

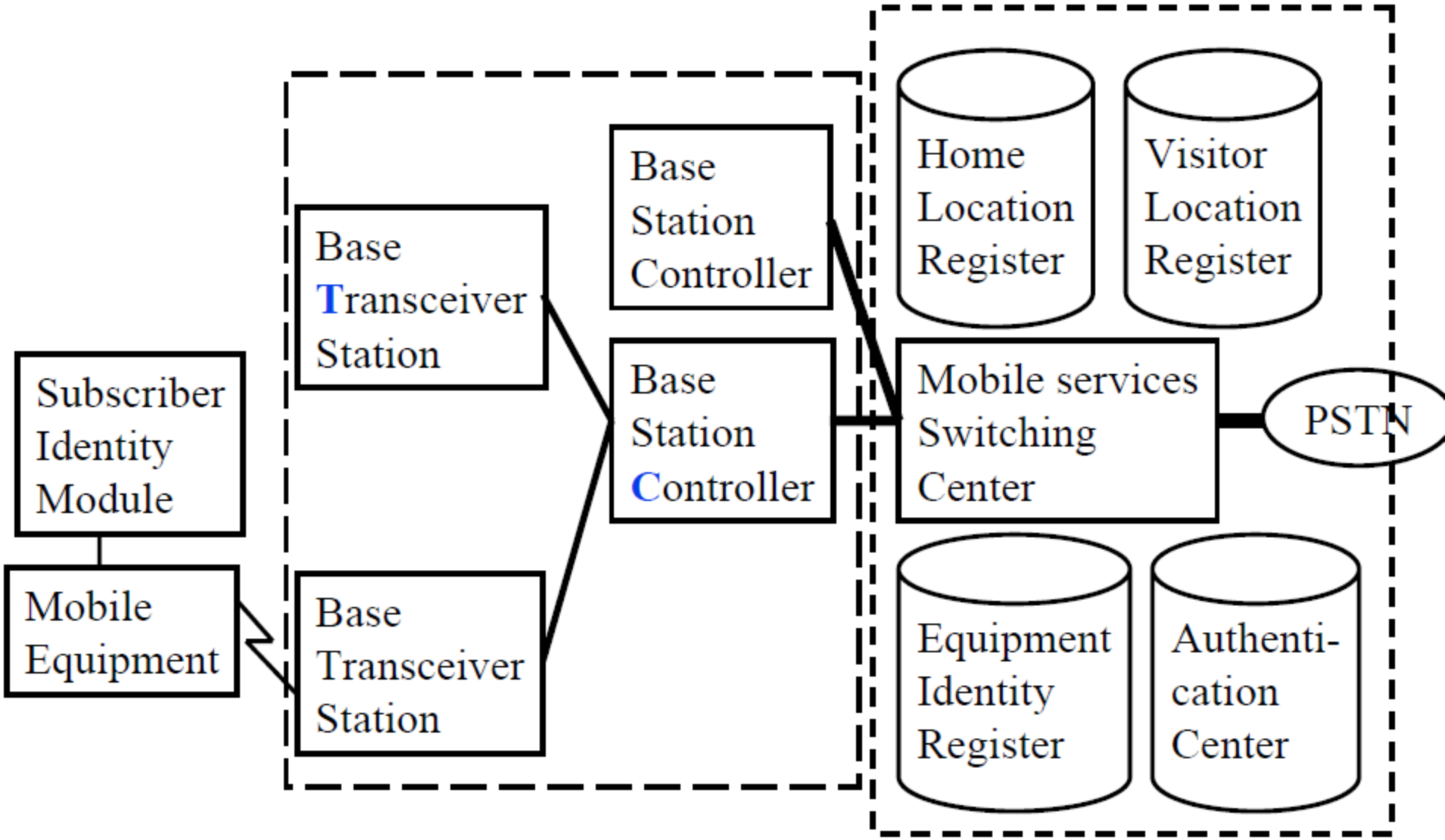
# Security Issues with 1G

- Analog cellular phones are insecure
- Anyone with an all band radio receiver can listen in (many scandals)
- Theft of airtime:
  - all band radio receiver connected to a computer
  - can record 32 bit serial number and phone number of subscribers when calling
  - can collect a large database by driving around
  - Thieves go into business - reprogram stolen phones and resell them

# Second Generation Cellular

- Based on digital transmission
- Different approaches in US and Europe
- US: divergence
  - Only one player (AMPS) in 1G
  - Became several players in 2G due to competition
  - Survivors
    - IS-54 and IS-135: backward compatible with AMPS frequency allocation (dual mode - analog and digital)
    - IS-95: uses spread spectrum
- Europe:  Convergence
  - 5 incompatible 1G systems (no clear winner)
  - European PTT development of GSM (uses new frequency and completely digital communication)

# Cellular Architecture



# Cellular Architecture (Cont)

- Base station controller (BSC) and Base transceiver station (BTS)
- One BTS per cell.
- One BSC can control multiple BTS.
  - Allocates radio channels among BTSs.
  - Manages call handoffs between BTSs.
  - Controls handset power levels
- Mobile Switching Center (MSC) connects to PSTN and switches calls between BSCs. Provides mobile registration, location, authentication. Contains Equipment Identity Register.

# Cellular Architecture (Cont)

- Home Location Register (HLR) and Visitor Location Register (VLR) provide call routing and roaming
- VLR+HLR+MSC functions are generally in one equipment
- Equipment Identity Register (EIR) contains a list of all valid mobiles.
- Authentication Center (AuC) stores the secret keys of all SIM cards.
- Each handset has a International Mobile Equipment Identity (IMEI) number.

# Advantages of Digital Communications for Wireless

- Voice, data and fax can be integrated into a single system
- Better compression can lead to better channel utilization
- Error correction codes can be used for better quality
- Sophisticated encryption can be used

# Differences Between First and Second Generation Systems

- Digital traffic channels – first-generation systems are almost purely analog; second-generation systems are digital
- Encryption – all second generation systems provide encryption to prevent eavesdropping
- Error detection and correction – second-generation digital traffic allows for detection and correction, giving clear voice reception
- Channel access – second-generation systems allow channels to be dynamically shared by a number of users

# Integrating Data Over Cellular

- Direct access to digital channel
- Voice and data using one handset
- PCS 1900 (GSM-1900)
  - 9.6 kbps circuit switched data
  - 14.4 kbps under definition
  - Packet mode specified
  - Short message service
- IS-95-based CDMA
  - 13 kbps circuit switched data
  - Packet mode specified
  - Short message service

# Cellular Architecture