Introduction to Mobile Computing

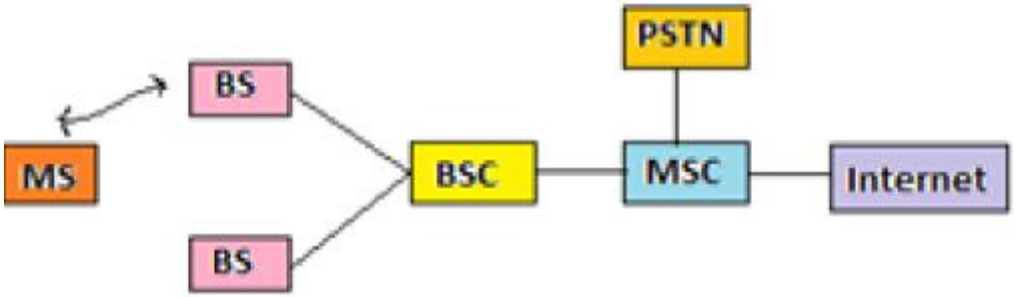
- Mobile computing:
  - Technology that allows transmission of data without any physical connection.
  - PDA,Smart cell, Laptop
  - Mobile computing component:
    - Movable device, network, software
- Mobile Computing Functions characteristic:
  - User mobility
  - n/w mobility
  - Bearer mobility
  - Device mobility
  - Session Mobility
  - Service mobility
  - Host mobility

Different wireless Technology

- Generation of Wireless Technology
  - 1G
  - 2G
  - 3G
  - 4G
  - 5G

First Generation, 1G

- Circuit-switched technology.
- based on technology called as Advanced
- Advanced Mobile Phone System (AMPS)
- FDMA (Frequency Division Multiple Access).
  - Speed-2.4 kbps
  - Allows voice calls in 1 country
  - Use analog signal.
  - Poor voice quality
  - Poor battery life
  - Large phone size
  - Limited capacity
  - Poor handoff reliability
  - Poor security
  - Offered very low level of spectrum efficiency



Second Generation (2G)

- based on GSM
- Used Digital Signalling.
- Characteristics:
  - Data speed was upto 64kbps
  - Use digital signals
  - Enables services such as text messages, picture messages and MMS(Multimedia message)
  - Provides better quality and capacity.
  - Uses TDMA/CDMA
  - Provides International roaming

2G

- **Advantages:**
- The digital voice encoding allows digital error checking
  - increase sound quality
  - lowers the noise level

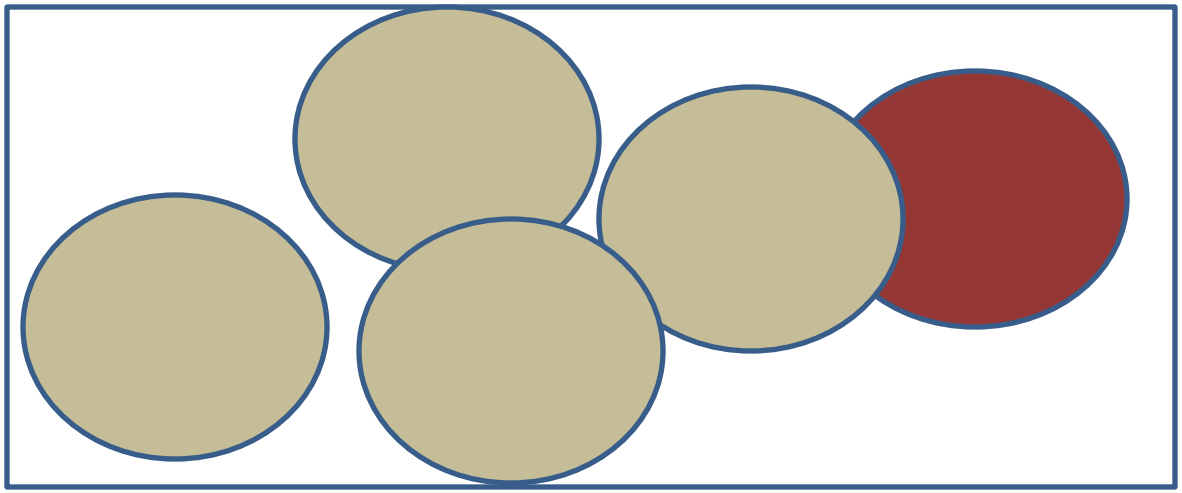
Going all-digital allowed for the introduction of digital data transfer.

- SMS –“short message service”
- E-mail

2G

Disadvantages

- Cell towers had a limited coverage area.
- Built mainly for voice services and slow data.



Third Generation (3G)

- 3G is based on GSM and was launched in 2000
- Uses W-CDMA
- Wide Band Wireless Network
- Called UMTS
- The main features of 3G are:
  - Speed 2 Mbps
  - Increased bandwidth and data transfer rates to accommodate web-based applications and audio and video files.
  - Provides faster communication
  - High speed web/more security/video conferencing/3D gaming
  - Expensive fees for 3G licenses services
  - High bandwidth requirement
  - Expensive 3G phones

Fourth Generation (4G)

- LTE (Long Term Evolution) is considered as 4G technology
- main features of 4G are :
  - Capable of provide 10Mbps-1Gbps speed
  - High quality streaming video
  - Combination of Wi-Fi and Wi-Max
  - Low cost per-bit
  - Fully IP-based wireless internet.
  - Ad Hoc Networking.
  - IPv6 Core.
  - OFDM used instead of CDMA.

Orthogonal Frequency Division Modulation (OFDM)

Basic idea:

Using a large number of parallel narrow-band subcarriers instead of a single wide-band carrier to transport information.

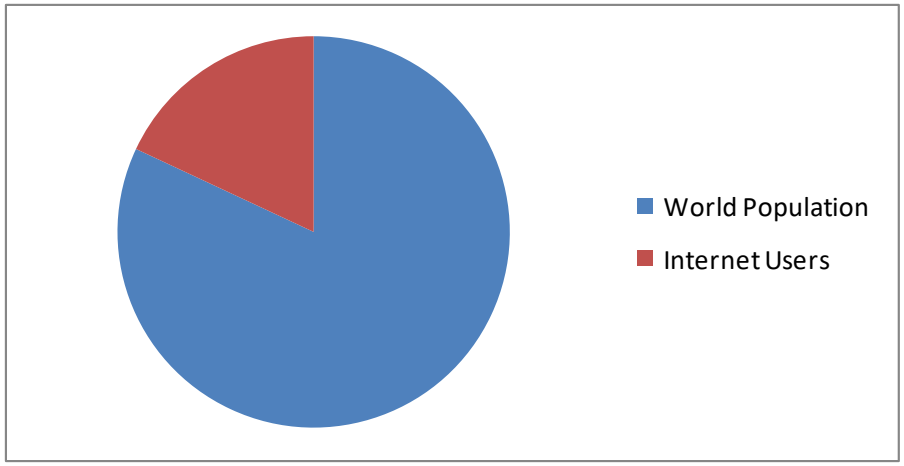
- **Advantages:**

-Very easy and efficient in dealing with multi-path.

-Robust again narrow-band interference

G4

- Earth's population stands at around 6.6 billion.
- The Internet has a population of just 1.3 billion.



- **IPv6** uses 128 bits for IPv6 addresses which allows for 340 billion billion billion billion **(3.4×10^{38})** unique addresses.

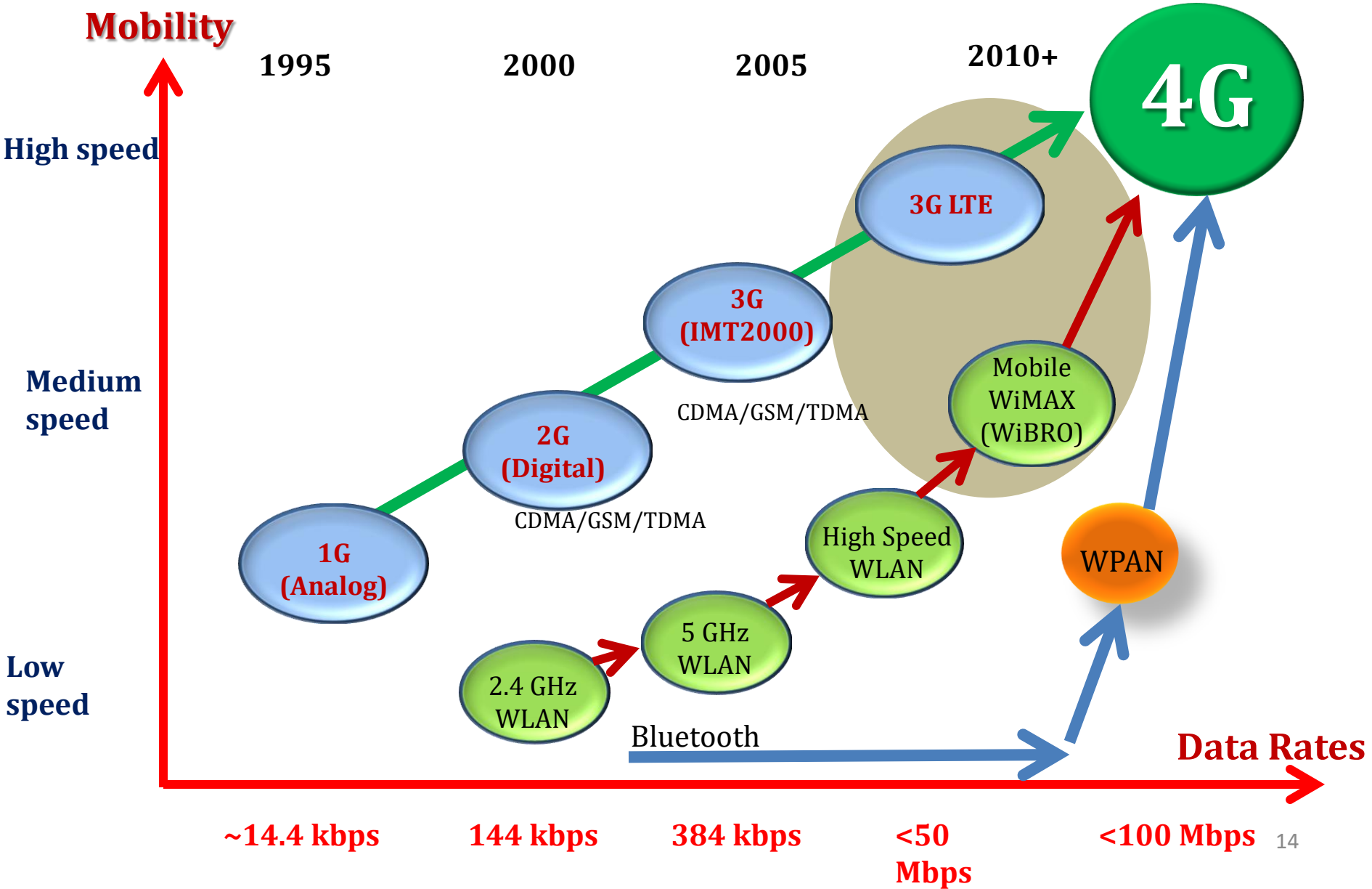
IPv6 vs. IPv4

Feature	IPv4	IPv6
Deployed	1978	1999
Address format	129.5.255.2/16	2001:0ba0:01e0:d001:0000:0000:d0f0:0010
Address Space	Over 10^9; possible addresses	Over 10^{38}; possible addresses
Packet Size	Variable size- time consuming to handle	Fixed size (40 Octets) More efficient
Security	-limited: no authentication or encryption at IP level. -Dependence on higher level protocols; vulnerable to **DoS** and address deception or **spoofing** attacks.	-Authentication(validation of packet origin). -Encryption(privacy of contents) -requires administration of "security associations" to handle key distributions.
Quality of Service	-Defined but not generally used	-Flow labeling -Priority -Support for real-time data and multimedia distribution.

Fifth Generation (5G)

- main focus of 5G will be on -Wireless World Wide Web (WWWW).
- The main features of 5G are :
  - It is highly supportable to WWWW (wireless World Wide Web)
  - High speed, high capacity
  - Provides large broadcasting of data in Gbps.
  - Multi-media newspapers, watch TV programs with the clarity(HD Clarity)
  - Faster data transmission that of the previous generation
  - Large phone memory, dialing speed, clarity in audio/video
  - Support interactive multimedia, voice, streaming video, internet and other
  - More effective and attractive

Technology moving towards 4G

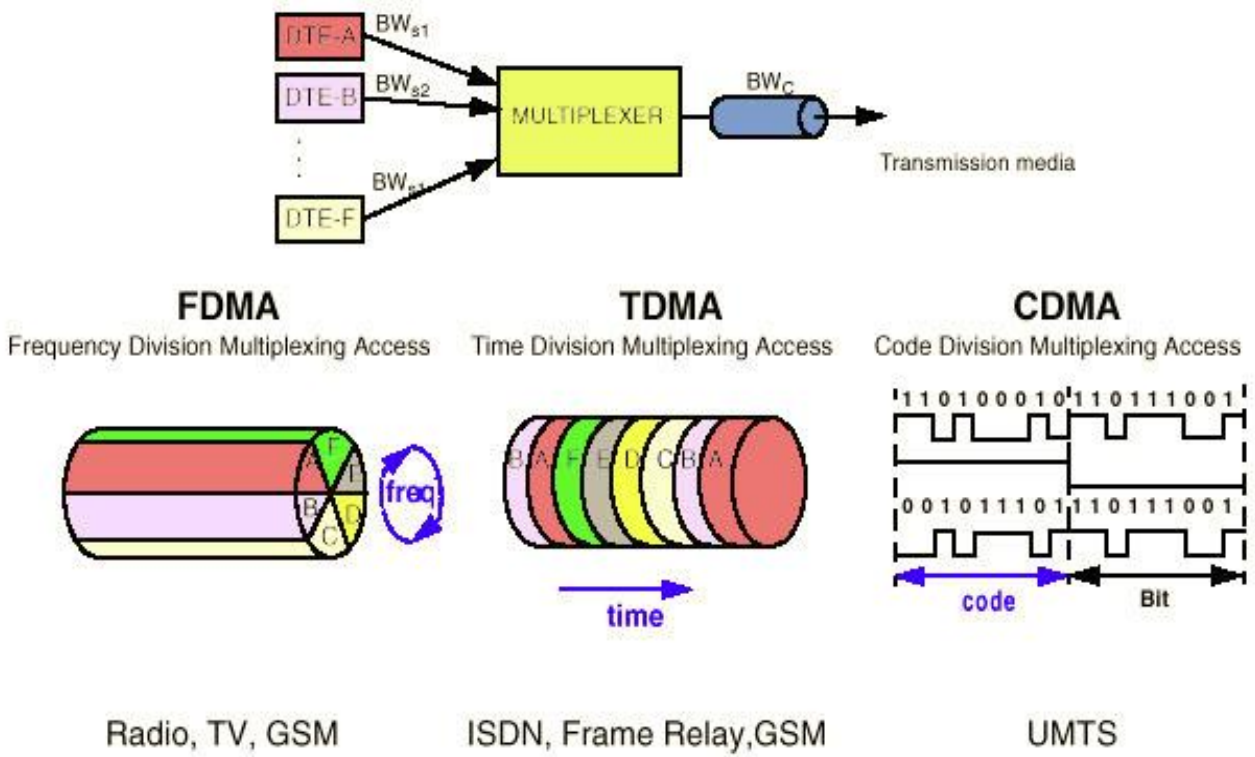


comparison

Technology	1G	2G	3G	4G	5G
Start/Deployment	1970-80	1990-2004	2004-10	Now	Soon (probably by 2020)
Data Bandwidth	2Kbps	64 Kbps	2 Mbps	1 Gbps	Higher than 1 Gbps
Technology	Analog	Digital	CDMA 2000, UMTS,EDGE	Wi-Max, Wi-Fi, LTE	WWWW
Core Network	PSTN	PSTN	Packet N/W	Internet	Internet
Multiplexing	FDMA	TDMA/CDMA	CDMA	CDMA	CDMA
Switching	Circuit	Circuit,Packet	Packet	All Packet	All Packet
Primary Service	Analog Phone Calls	Digital Phone Calls and Messaging	Phone calls, Messaging, Data	All-IP Service (including Voice Messages)	High speed, High capacity and provide large broadcasting of data in Gbps
Key differentiator	Mobility	Secure, Mass adoption	Better Internet experience	Faster Broadband Internet, Lower Latency	Better coverage and no droped calls, much lower latency, Better performance
Weakness	Poor spectral efficiency, major security issue	Limited data rates, difficult to support demand for internet and e-mail	Real performance fail to match type, failure of WAP for internet access	Battery use is more, Required complicated and expensive hardware	?

Radio Channel access scheme

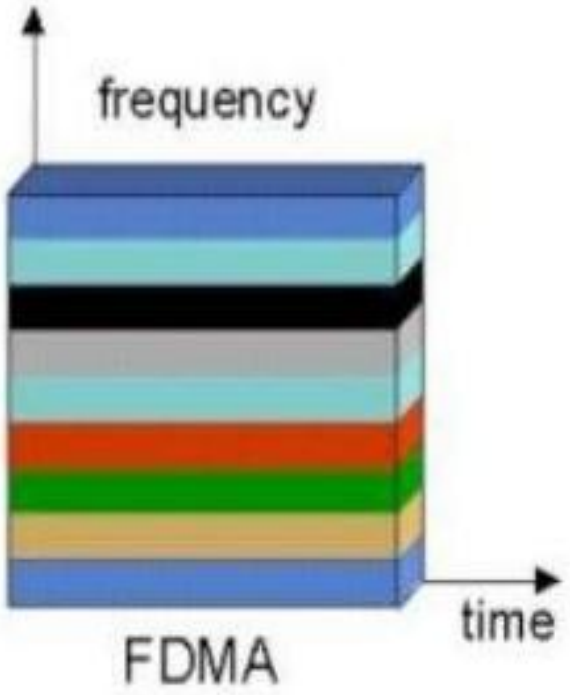
- FDMA
- TDMA
- CDMA
- SDMA



FDMA

Frequency Division Multiple Access (FDMA)

- FDM is used to multiplex continuous signal.
- Each user transmits with no limitations in time, but using only a portion of the whole available frequency bandwidth.
- Different users are separated in the frequency domain.



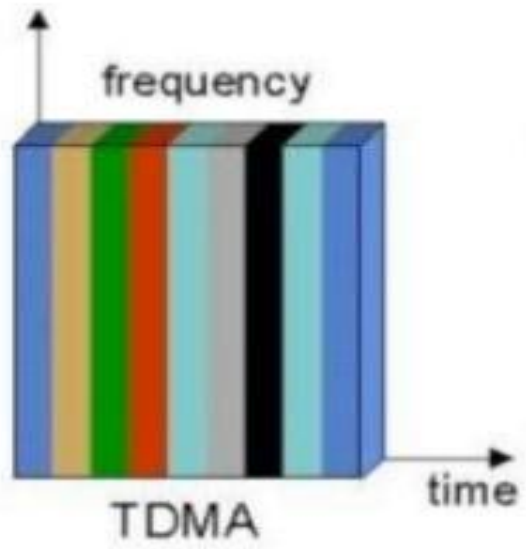
- The major disadvantage of FDMA is the relatively expensive and complicated bandpass filters required.

- Required Gaurd Band
- Used in 1G

TDMA

Time Division Multiple Access (TDMA)

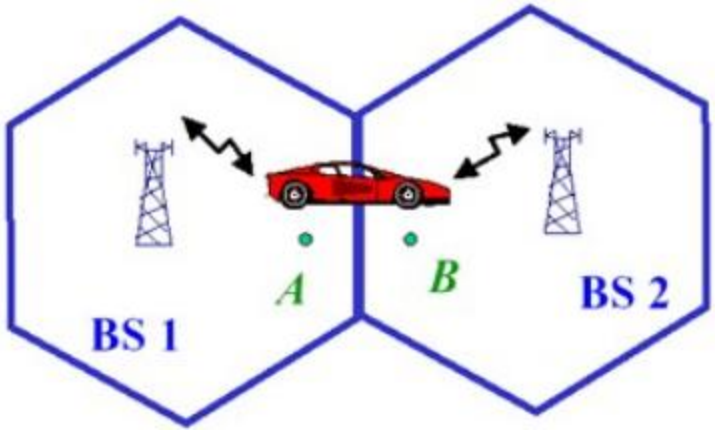
- Each user is allowed to transmit only within specified time intervals (Time Slots). Different users transmit in different Time Slots.
- When users transmit, they occupy the whole frequency bandwidth(separation among users is performed in the time domain).



- Entire Bandwidth is available to the user for limited time
- Separate time slots required for uplink and downlink
- Guarded time slots are required
- Used in GSM

Basic cell Cluster and frequency reuse

- CELL: area between BS and Mobile
- Implements SDMA
- Uplink and downlink.
- Cellular system: contains several overlapping cells
- Handsoff.

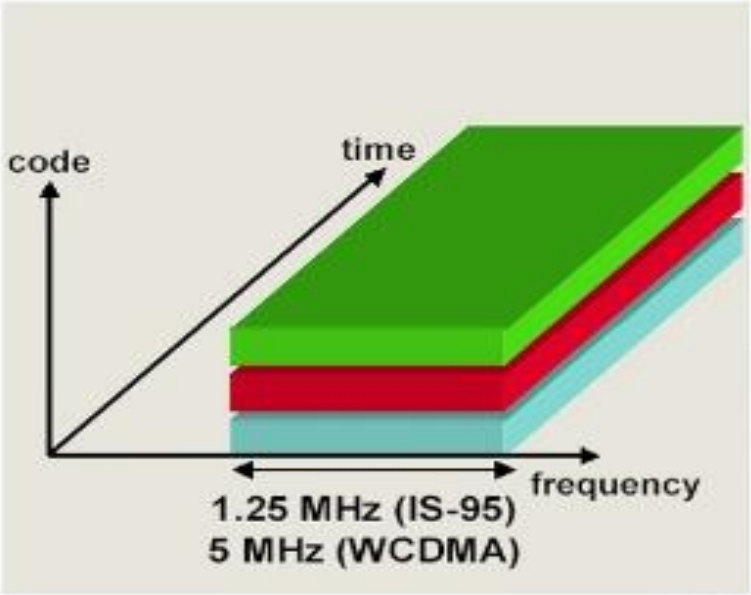


CDMA

- Code Division multiple Access
- Users separated by Special Codes.

Basic diagram of CDMA

- There exist a new dimension with time and frequency.
- The new dimension represent the code which provided by the operator for the user.



Difference Between GSM and CDMA

Features	GSM	CDMA
Stands For	Global System for Mobile communication	Code Division Multiple Access
Evolution	1990	1995
Presence	Europe, Asia and Middle East	US and Asian Countries
Handset Compatibility	850/900/1800/1900 MHz	850/1900 MHz
Switching B/W Service Providers	Simply Change Your SIM Card	Handset Needs To Be Changed
Handset Availability	Wide Range of Handsets Available In The Market	A Limited Range of Handsets Support CDMA
Voice Quality	Fluctuates From Time To Time	Comparatively Better Voice Quality
Data Transfer Speed	Lower Data Speed	BREW Facilitates Faster Data Transfer
International Roaming	Easy And Convenient	Hardly Any CDMA Network Provider Offers International Roaming
International Usage	Easy To Use	Difficult To Use

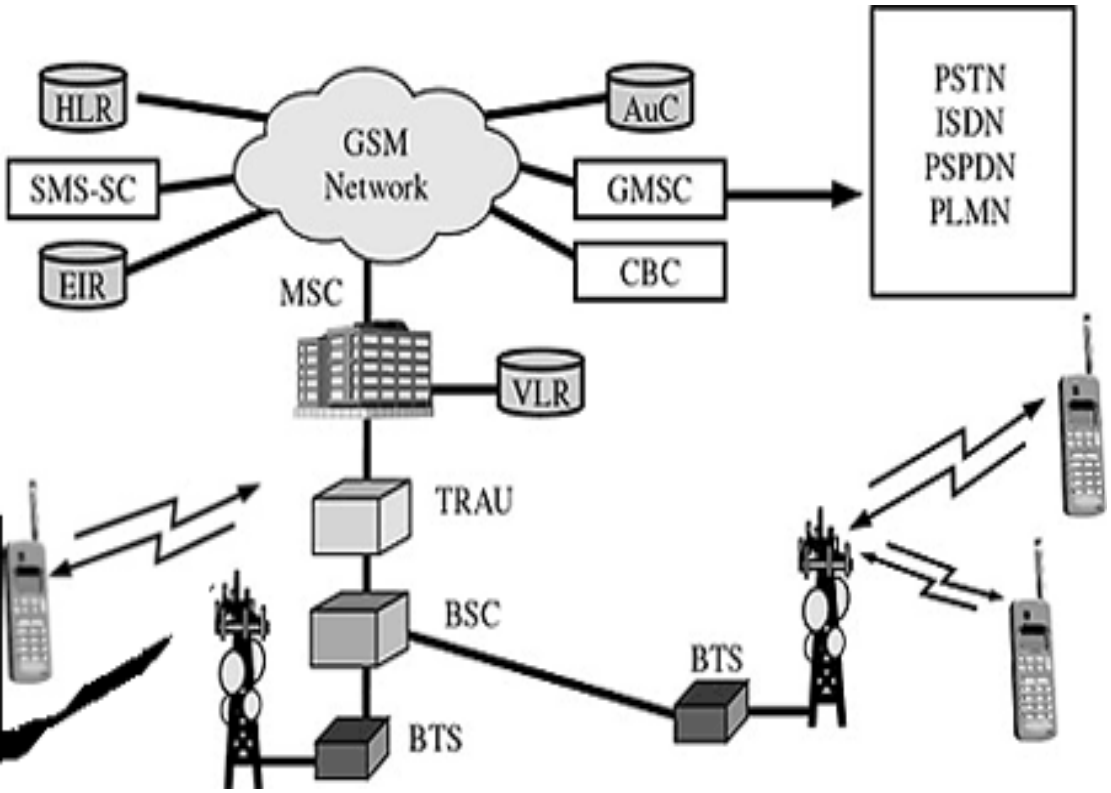
SDMA

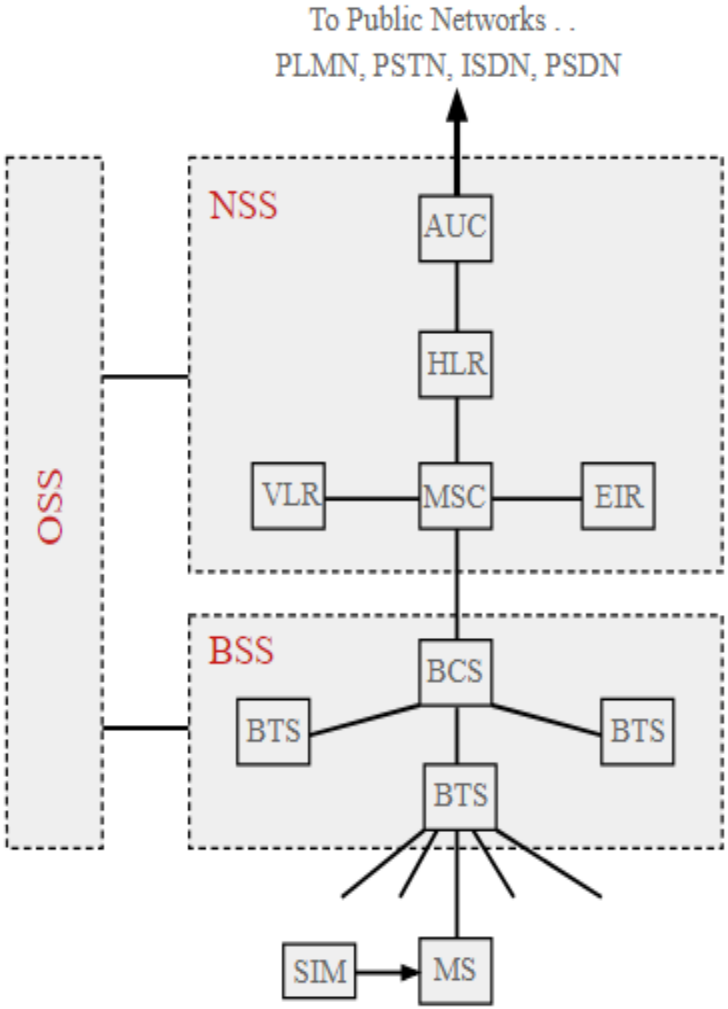
- Space Division Multiple Access
- BS creates multiple channel using same frequency by separation of cell
- Uses Cell clusters

- Advantage of small sized Cellular structure:
  1. Higher capacity
  2. Less transmission power
  3. Local interference only
  4. Robustness
- disadvantage of small sized Cellular structure:
  1. Infrastructure needed
  2. Handover needed
  3. Frequency planning
- Clusters:
  - Group of cells
  - No channel is reused in cluster
  - The larger the cluster: lesser the interference

GSM architecture

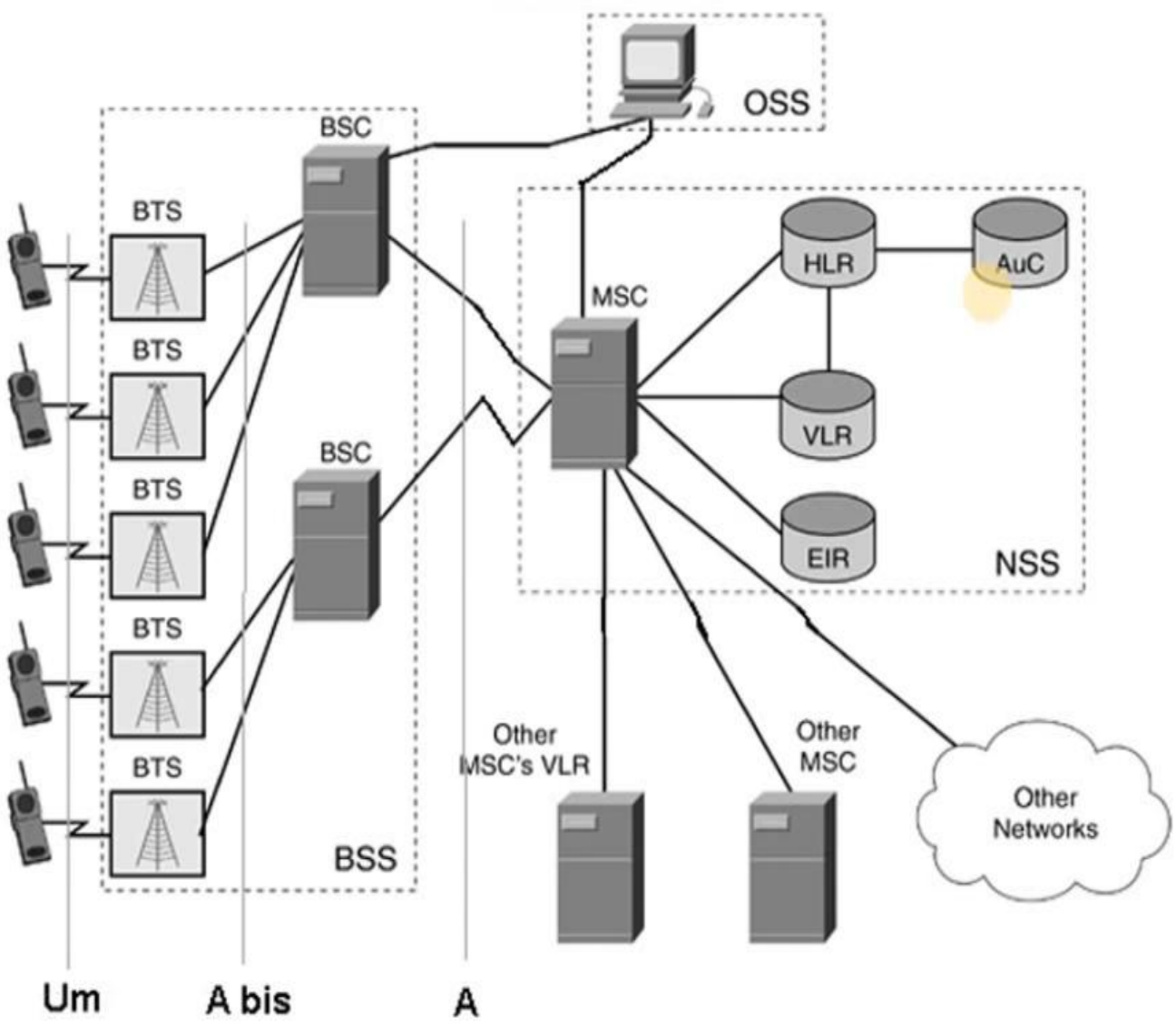
- Network and Switching Subsystem (NSS)
- Base-Station Subsystem (BSS)
- Mobile station (MS)
- Operation and Support Subsystem (OSS)





Simplified GSM Network Architecture Diagram

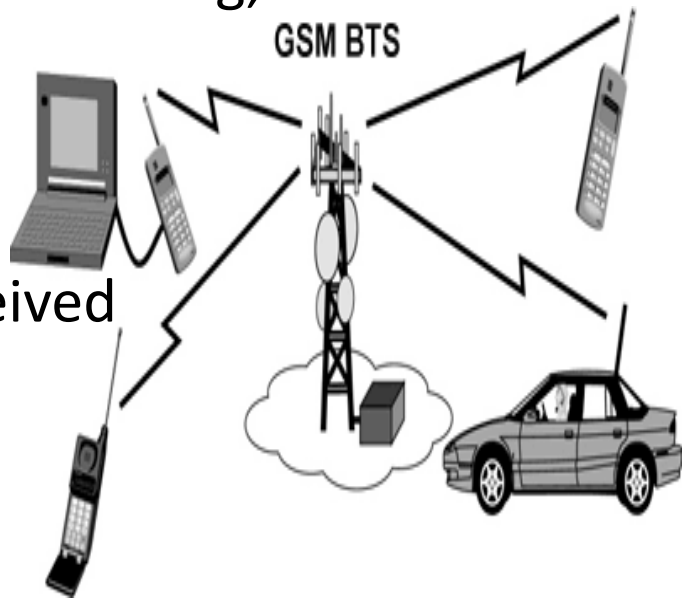
GSM ARCHITECTURE



- **Mobile Station (MS)**
  - Mobile Equipment (ME)
  - Subscriber Identity Module (SIM)
- **Base Station Subsystem (BSS)**
  - Base Transceiver Station (BTS)
  - Base Station Controller (BSC)
- **Network Switching Subsystem(NSS)**
  - Mobile Switching Center (MSC)
  - Home Location Register (HLR)
  - Visitor Location Register (VLR)
  - Authentication Center (AUC)
  - Equipment Identity Register (EIR)

BSS(BASE STATION SUBSYSTEM)

- **The Base Transceiver Station (BTS)**
  - radio transceivers that define a cell and handles the radio link protocols with the MS
  - Task :
    - Encoding, encrypting, multiplexing, modulating, and feeding the RF signals to the antenna
    - Time and frequency synchronizing
    - Voice through full- or half-rate services
    - Decoding, decrypting, and equalizing received signals
    - Random access detection
    - Timing advances
    - Uplink channel measurements



- **The Base Station Controller (BSC)**
  - It handles radio channel setup, frequency hopping, and handovers
  - handles intercell handover.
  - It assigns and releases frequencies and time slots for the MS.
  - Manages power transmission to the BTS
  - Reallocation of frequencies among BTSs

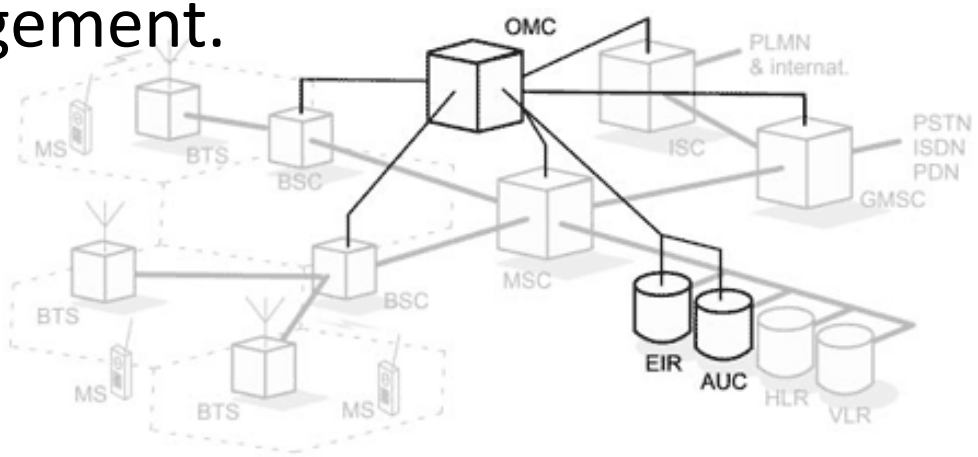
Network Switching Subsystem (NSS)

- ***Mobile Services Switching Centre (MSC):***
  - registration, authentication, call location, inter-MSC handovers and call routing to a roaming subscriber.
  - It also provides an interface to the PSTN
- ***Home Location Register (HLR):***
  - database contains all the administrative information with last known location

- ***Visitor Location Register (VLR):***
  - contains selected information temporarily from the HLR
  - Uses for roaming call
- ***Authentication Centre (AuC):***
  - It is used for authentication and for ciphering on the radio channel.
  - Uses secret key stored in SIM
- ***Equipment Identity Register (EIR):***
  - Uses IMEI for device authentication in network

Operation and Support Subsystem (OSS)

- used to control the traffic load of the BSS.
- Tasks:
  - Administration and commercial operation (subscription, end terminals, charging and statistics).
  - Security Management.
  - Network configuration, Operation and Performance Management.
  - Maintenance Tasks.



Noise and its effect

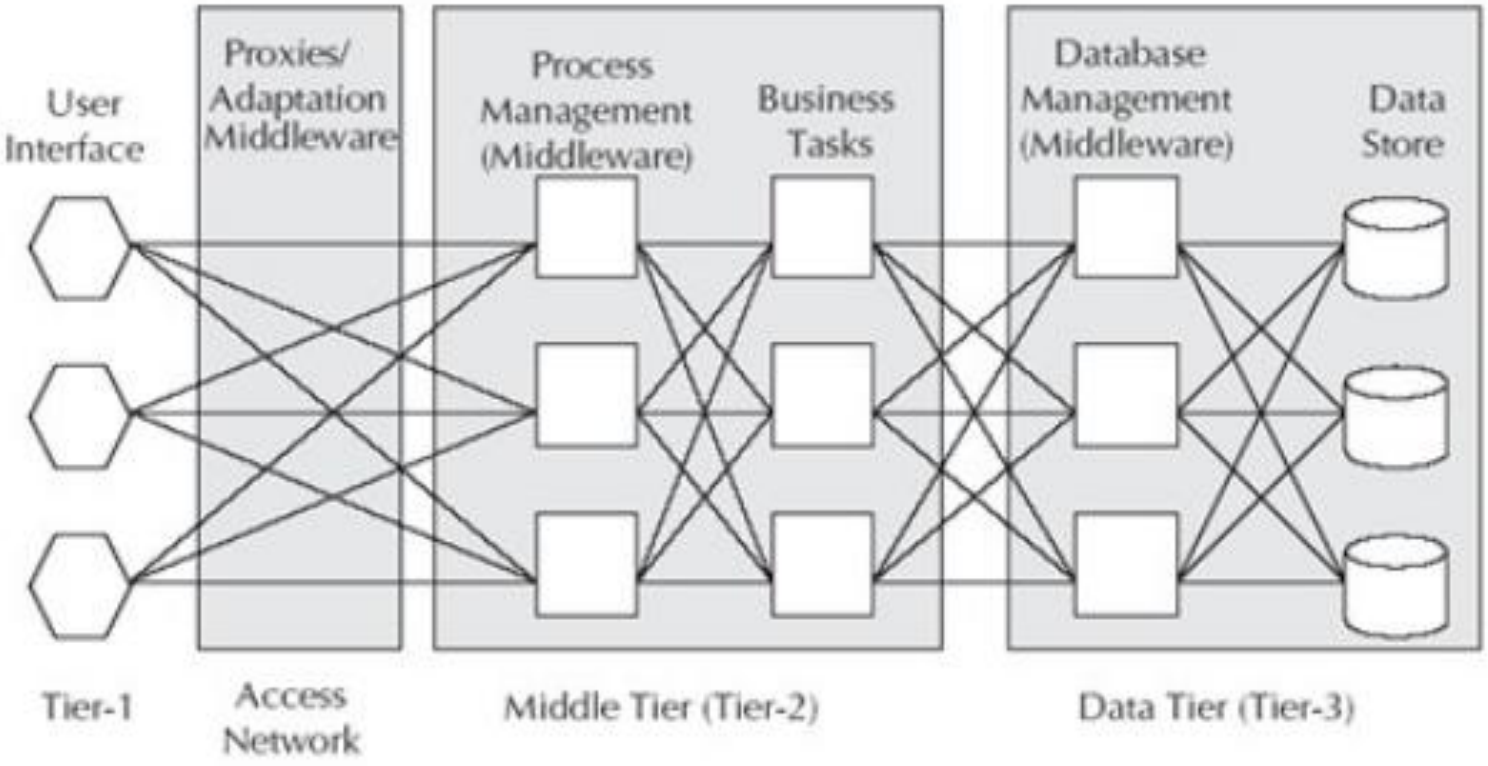
- Any undesirable signal in communication.

- **Thermal noise** (or **white noise**)
  - Due to thermal agitation of electrons
  - It is present in all electronic devices and transmission media, and is a function of temperature.
  - Cannot be eliminated, and therefore places an upper bound on communications system performance.
- Intermodulation noise
  - When signals at different frequencies share the same transmission medium, the result may be intermodulation noise.
  - Signals at a frequency that is the sum or difference of original frequencies or multiples of those frequencies will be produced.
  - E.g., the mixing of signals at f1 and f2 might produce energy at frequency f1 + f2. This derived signal could interfere with an intended signal at the frequency f1 + f2.

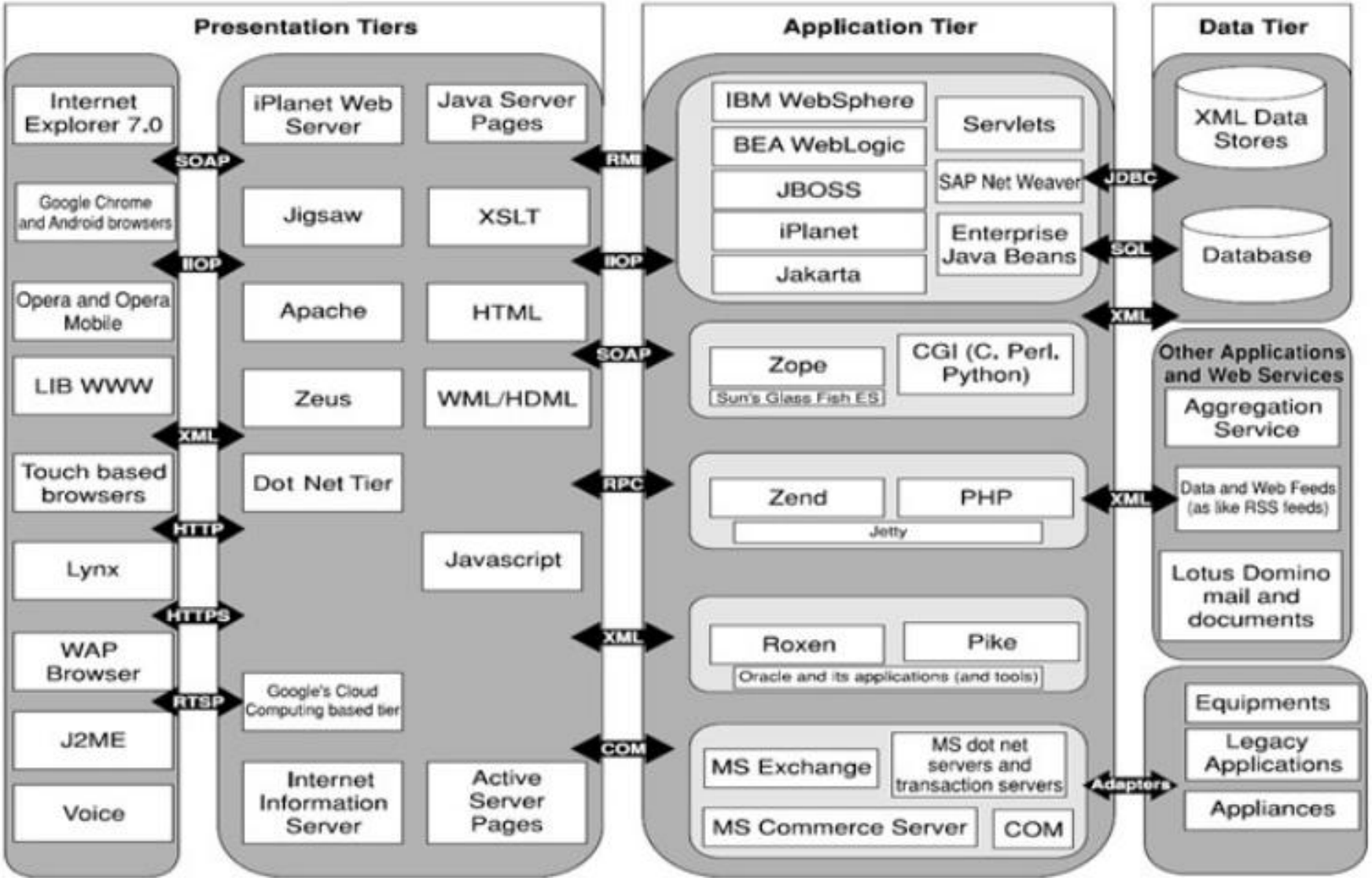
- Crosstalk
  - It is an unwanted coupling between signal paths. It can occur by electrical coupling between nearby twisted pairs.
  - Typically, crosstalk is of the same order of magnitude as, or less than, thermal noise.
- Impulse noise
  - Impulse noise is non-continuous, consisting of irregular pulses or noise spikes of short duration and of relatively high amplitude.
  - It is generated from a variety of cause, e.g., external electromagnetic disturbances such as lightning.
  - It is generally only a minor annoyance for analog data.
  - But it is the primary source of error in digital data communication.

Mobile computing architecture

- Contains
  - User interface(Presentation Layer)
  - Process management(Application layer)
  - Data management



Mobile Computing Architecture



Presentation tier

- The layer of applications that run on the client device and offer all the user interfaces.
- It is responsible for presenting information to the end-user.
- Users receive information through: screens, speakers, vibration.
- Users send information through: keyboards, pens, touch screens.
- It includes web browsers, WAP browsers, customized client programs.
- It should be context-aware and device-independent.

application Layer

- Is the engine of a ubiquitous application.
- It performs business logic; processing user input, obtaining data, making decisions, and transcoding of data for rendering in Tier-1.
- It includes technologies like Java, JSP, .Net services, PHP.
- Presentation and database-independent.
- Decisions on rendering, network management, security, datastore access, need for different middleware software.
- A middleware can be categorized into:
  - **Message-Oriented Middleware (MOM)**: Connects different applications through asynchronous exchange of messages. It provides a message queue between any 2 interoperating apps with a temporary storage location if busy or out of service. It is peer-to-peer, publish/subscribe fashion.

- **Transaction Processing Middleware:** Provides tools and environment for developing transaction-based distributed applications. It includes management features like restarting failed processes, dynamic load balancing, and enforcing consistency of distributed data. It optimizes the use of resources.
- **Database Middleware**: runs between app and DB, ex: DB connectors as ODBC.
- **Distributed Objects and Components**: ex: CORBA, an open distributed object computing infrastructure. It simplifies common network programming tasks; object registration, location, activation, request multiplexing, error handling, and operation dispatching.
- **Transcoding Middleware**: Transcode one format of data to another format to suit the need of the client; content adaptation to fit the need of the device, i.e. PDA screen, network bandwidth needs. i.e., Internet Content Adaptation Protocol (ICAP), that transcodes HTTP messages.

Data tier

- Used to store data
- Can use XML
- Database middleware-Helps business logic to run independently and transparently from database vendors.

Design consideration for Mobile computing

- Application type: Native v/s AIR(Adobe Integrated Runtime)
- Storage
- Connections and bandwidth
- State management : Handling interrupt
- Memory and battery usage
- Graphics:UI/UX
- Cloud computing

Characteristics of mobile communication

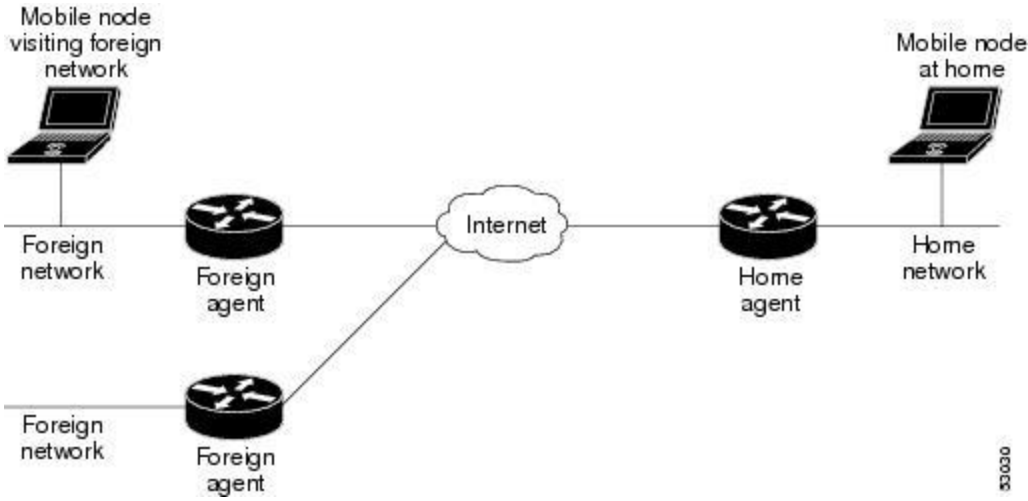
- Portability
- Social interactivity
- Context sensitivity
- Connectivity

Application of mobile communication

- You name it ☺

Mobile IP

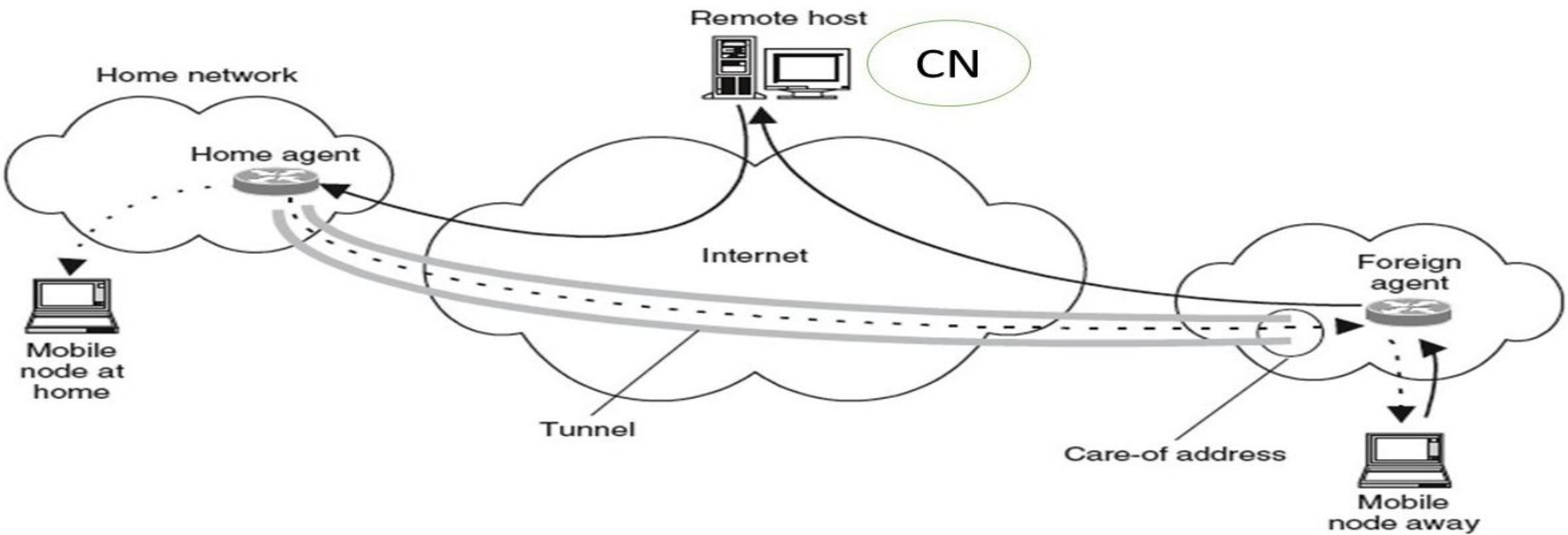
- Internet Engineering Task Force (IETF) standard communications protocol that supports host mobility
- Allow to keep same IP while On the GO.
- Components:
  - **Mobile Node**
  - **The Home Agent**
  - **The Foreign Agent**



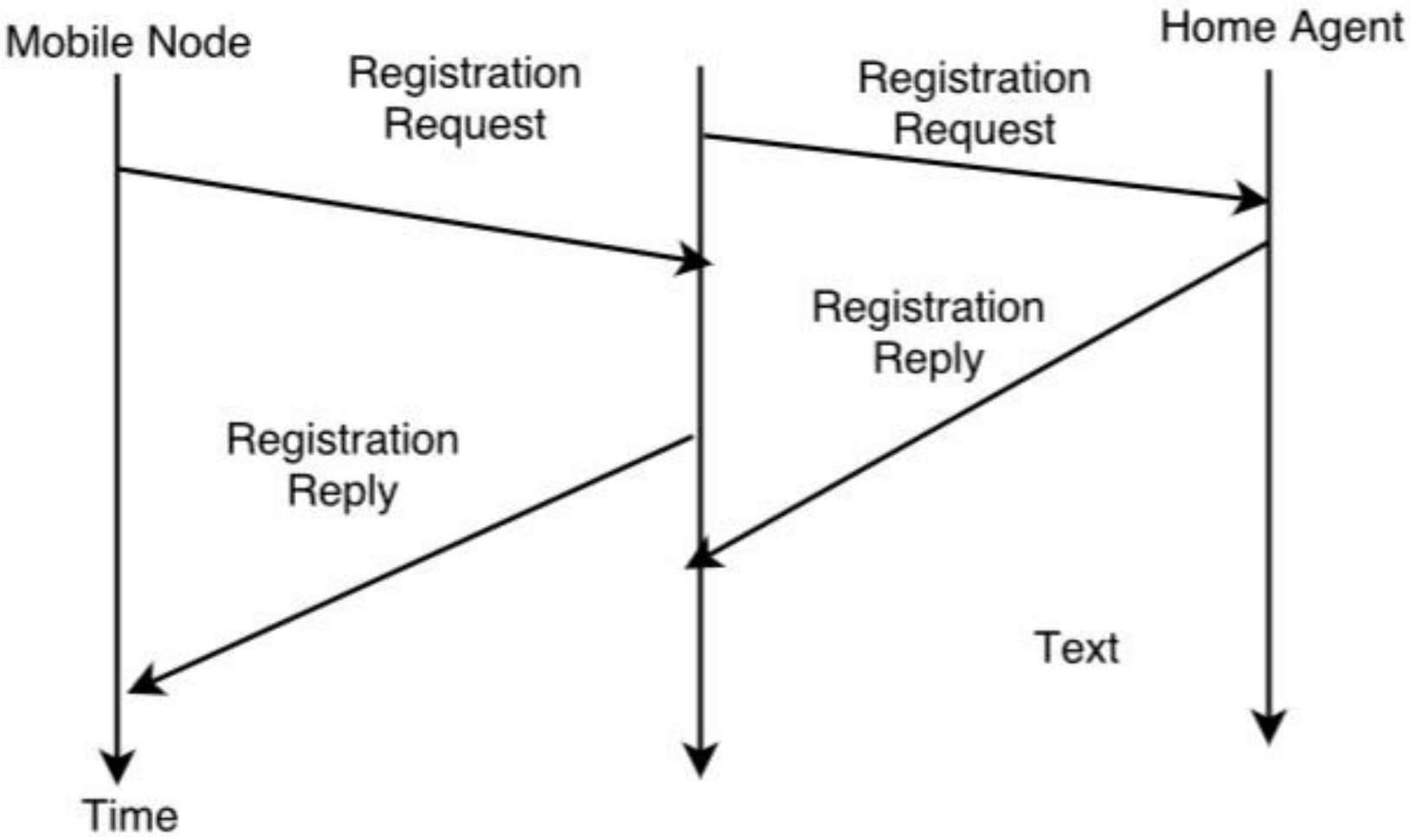
Phases of MIP

- **Phase I: Agent Discovery**
  - Home Agent and Foreign Agent advertise their services on the network by ICMP Router Discovery Protocol (IRDP)
  - This advertisement contains mobile IP extension(Home /foreign agent /both)
  - its care-of address;
  - the types of services it will provide such as reverse tunneling and generic routing encapsulation (GRE)
  - allowed registration lifetime or roaming period for visiting node

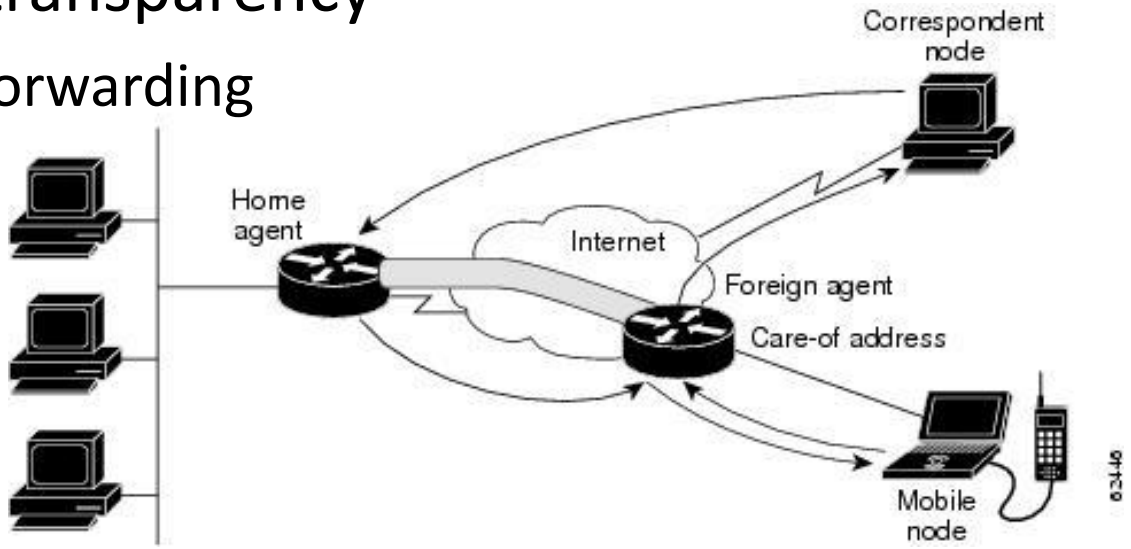
– If in a foreign network, it acquire care-of-address
  - Either Care-of address acquired from a Foreign Agent(Shared by other devices)
  - Colocated care-of address
– When the Mobile Node hears a Foreign Agent advertisement and detects that it has moved outside of its home network, it begins registration.



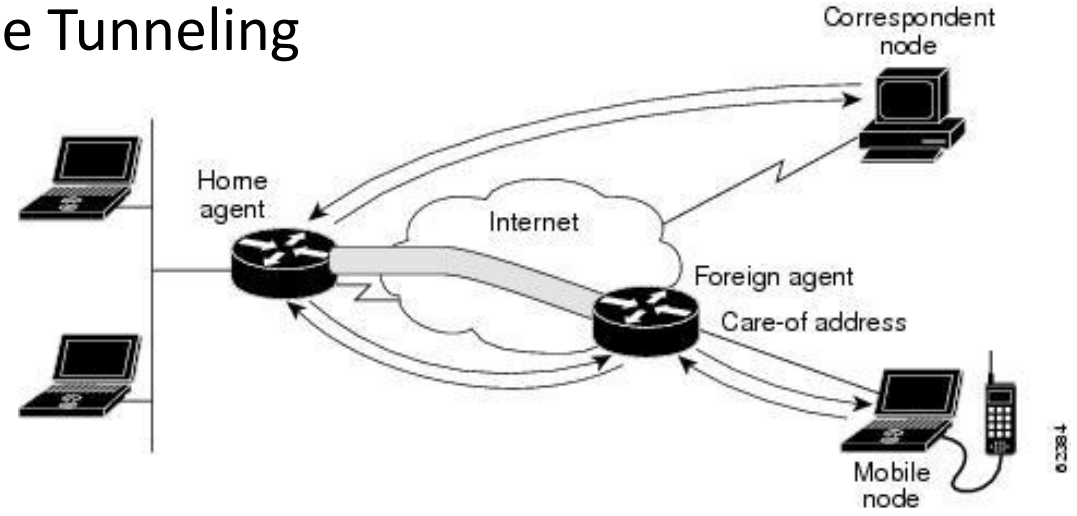
- **Phase-2 Registration**
  - Mobile node registers its current location. Mobile node contains its home IP and shared key.
  - send registration request to Home agent through Foreign agent or directly(if using Colocated COA)
  - If the registration request is sent through the Foreign Agent, the Foreign Agent checks the validity of the registration request(life time, tunnel encapsulation, reverse tunneling) and relay this request to home agent.
  - Home agent checks validity, if valid, creates routing entry and tunnel. And send registration reply to foreign node.


Mobile Node
Registration Request
Registration Request
Home Agent
Registration Reply
Registration Reply
Text
Time

- **Tunneling**
  - Provides transparency
    - Packet forwarding



    - Reverse Tunneling



- MTU Discovery mechanism to avoid fragmentation and data loss.
- Security authentication by Mobile Home authentication Extension(MHAE).
- Uses MD5

Mobile communication via satalite

- **communication satellite** is a **microwave repeater station** in a space that is used for telecommunication, radio and television signals
- Advantages of Satellite
  - The Coverage area is very high than that of terrestrial systems.
  - The transmission cost is independent of the coverage area.
  - Higher bandwidths are possible.
- Disadvantages of Satellite
  - Launching satellites into orbits is a costly process.
  - The bandwidths are gradually used up.
  - High propagation delay for satellite systems than the conventional terrestrial systems.

Satellite Communication Basics

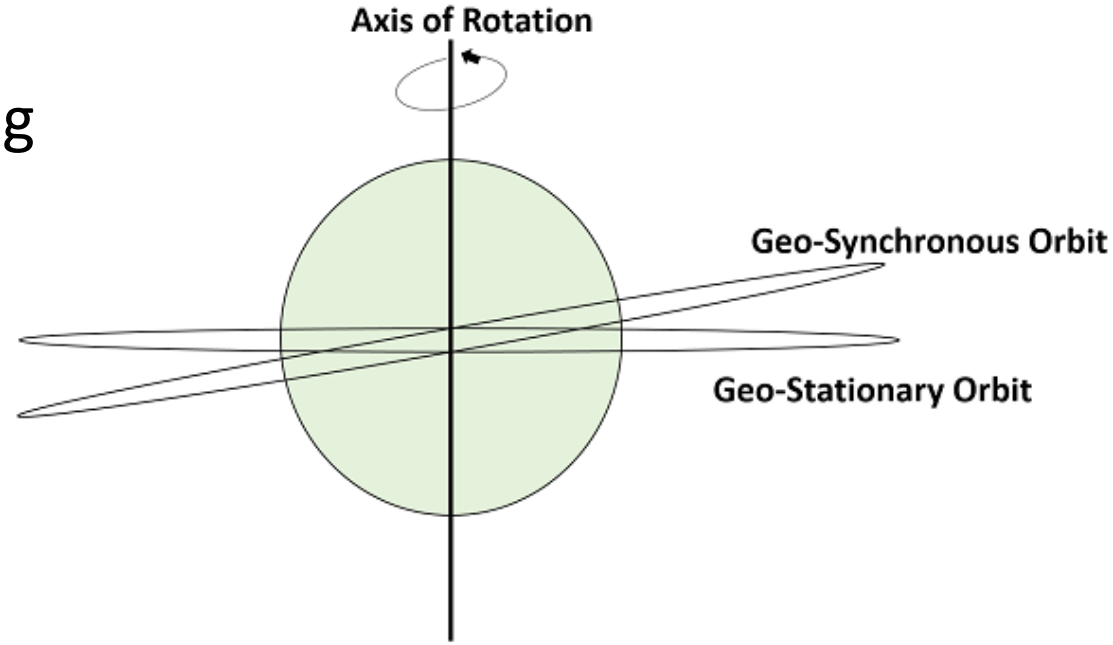
- **Satellite's footprint:** the area which receives a signal of useful strength from the satellite.
- **Uplink:**The transmission system from the earth station to the satellite through a channel
- **Downlink:**The system from the satellite to the earth station through the channel
- **Frequency Band:**C-Band(4-8GHz) Ku-Band (12-18GHz) Ka-Band(26.5-40GHz)

Earth Orbits

- Geo-synchronous Earth Orbit
- Geo-stationary Earth Orbit
- Medium Earth Orbit
- Low Earth Orbit

Geo-synchronous Earth Orbit (GEO) Satellites

- placed at an altitude of 22,300 miles above the Earth
- The same geo-synchronous orbit, if it is **circular** and in the plane of equator, it is called as geo-stationary orbit.
- Station Keeping: thrusters Used
- Use:
  - Weather forecasting
  - Satellite TVs
  - Satellite Radio



Medium Earth Orbit (MEO) Satellites

- orbit at distances of about 8000 miles from earth's surface
- Signals transmitted from a MEO satellite travel a shorter distance→ improved signal strength at the receiving end→ smaller, more lightweight receiving terminals can be used at the receiving end.
- Less Transmission Delay-Real Time Communication.
- Operating Frequency-2GHz and above

- Slower moving satellites
- less satellites needed
- simpler system design
- for many connections no hand-over needed
- higher latency, 70 - 80 ms
- higher sending power needed
- GPS

Low Earth Orbit (LEO) Satellites

- classified into three categories
  - little LEOs, big LEOs, and Mega-LEOs
- orbit at a distance of 500 to 1000 miles above the earth's surface.
- Little LEOs operate in the 800 MHz range
- Big LEOs operate in the 2 GHz or above range
- Mega-LEOs operate in the 20-30 GHz range.
- higher frequencies→ more information carrying capacity→ capability of real-time, low delay video transmission scheme.

- Smaller footprints, better frequency reuse
- Handover necessary from one satellite to another
- Many satellites necessary for global coverage
- More complex systems due to moving satellites