Chapter 1:- Introduction to Mobile Computing

1.1 Introduction.

- In ancient times for long distance communication letter, fire, flags were used.
- Later telegraphy and telephony were used both techniques were wireline.
- First wireless radio broadcast transmission took place in 1909.
- There was one transmitter called radio station. Information such as news, music is transmitted from radio station to receiver equipment

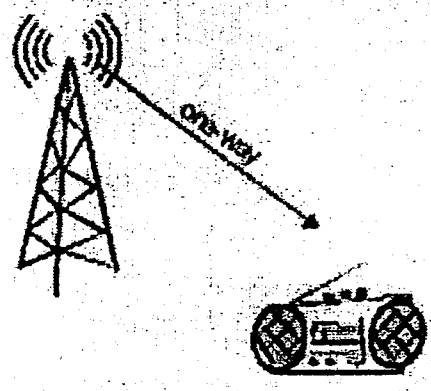

Fig. 1.1 Transmission

- Mobile: means a computing device may be PDA, smart cell phone, laptop, that allow user to complete computing tasks without being connected to a network.
- **Mobile computing**: a technology that allows transmission of data, via computer without having to be connected to a physical link(base network)
- Mobile computing environment contains 3 components – a computer (movable), a network (wired or wireless) and co-ordination software that ties them together.
- Benefits of mobile computing :
  - Improving data collection process
  - Improving data accuracy
  - Reducing paperwork
  - Eliminating redundant data entry

- Reducing billing error
- Allow faster adaptation to changing business conditions
- Customer satisfaction
- Providing access to previously unavailable information

1.2 Different generations of wireless technology.

❖ What Is Wireless?

- The term "wireless" refers to communications sent without wires or cables.
- Wireless technologies and devices, includes cellular communications, networking between computers with wireless adapters, and wireless computer accessories. Wireless communications travel over the air via electromagnetic waves (radio frequencies, infrared, satellite, etc.).
- Examples: Examples of wireless devices include cell phones, PDAs, GPS systems, wireless mice, wireless keyboards, remote controls, wireless routers, wireless network cards, and pretty much anything else that doesn't use wires to transmit information.

➢ Wireless communication has the following advantages:

- Information can be quickly to the consumers.
- Working professionals can work and access Internet anywhere and anytime without carrying cables or wires wherever they go. Consumes time and improves the productivity.
- Doctors, workers and other professionals working in remote areas can be in touch with medical centers through wireless communication.
- Urgent situation can be alerted through wireless communication. The affected regions can be provided help and support with the help of these alerts through wireless communication.
- Wireless networks are cheaper to install and maintain.

➢ Disadvantages of Wireless Technology:

- The growth of wireless network has enabled us to use personal devices anywhere and anytime. This has helped mankind to improve in every field of life but this has led many threats as well.

- Security - Wireless network has led to many security threats to mankind. It is very easy for the hackers to grab the wireless signals that are spread in the air. It is very important to secure the wireless network so that the information cannot be exploited by the unauthorized users.
- This also increases the risk to lose information. Strong security protocols must be created to secure the wireless signals like WPA and WPA2. Another way to secure the wireless network is to have wireless intrusion prevention system.
- Speed - Significantly slower than a wired network (2 – 50 times slower, see below).
- Range - The typical range of a common 802.11g network with standard equipment is on the order of tens of meters. While sufficient for a typical home, it will be insufficient in a larger structure. To obtain additional range, repeaters or additional access points will have to be purchased. Costs for these items can add up quickly.

Generations of wireless technology

First Generation of wireless system (1G)

- The first generation of wireless communication system developed in 1980's.
- This generation based on analog system. This system has speed up to 2.4kbps.
- Some key features of this generation are following –
  - AMPS (Advance Mobile Phone System) were launched by the US and it was the 1G mobile systems.
  - Uses FDMA (Frequency Division Multiple Access) technique with 30 KHZ.
  - Allows user to make voice calls in 1 country.
- Dis-Advantages of 1G
  - Poor voice quality.
  - Poor battery life.
  - Large phone size.

- No security at all since voice calls were played back in radio towers, making these calls susceptible to unwanted eavesdropping by third parties.
- Limited capacity.
- Poor handoff reliability.

Second Generation of wireless system (2G)

- Developed in 1980's and completed in early 1990's.
- This generation based on digital system. This system has speed up to 64kbps.
- Some key features of this generation are following –
  - Offered additional services such as digital voice, SMS (short message service), e-mail and semi global facility.
  - 2G technologies enabled the various mobile phone networks to provide the services such as text messages, picture messages and MMS (Multi Media Messages).
  - 2G technology holds sufficient security for both sender and the receiver.
  - All text messages are digitally encrypted. This digital encryption allows for the transfer of data in such a way that only the intended receiver can receive and read it.
  - Second generation technologies are either time division multiple access (TDMA) or code division multiple access (CDMA).
  - TDMA allows for the division of signal into time slots. CDMA allocates each user a special code to communicate over a multiplex physical channel.
  - GSM (Global System Mobile Communication) technology was the first one to help establish international roaming. This enabled the mobile subscribers to use their mobile phone connections in many different countries of the world.

➢ Dis-Advantages of 2G

- 2G requires strong digital signal to help mobile phone work .If there is no network coverage in any specific area, digital signals would weak.
- These systems are unable to handle complex data such as videos.

Third Generation of wireless system (3G)

- The use of 3G technology is also able to transmit packet switch data efficiently at better and increased bandwidth.
- The spectral efficiency of 3G technology is better than 2G technologies.
- Spectral efficiency is the measurement of rate of information transfer over any communication system. 3G is also known as IMT-2000.
- Transmission speed from 125 kbps to 2 Mbps.
- Superior voice quality.
- Good clarity in video conference.
- Data are sent through technology called packet switching.
- Voice calls are interpreted using circuit switching.
- Fast communication, Internet, mobile, e-mail, PDA, information surfing, on-line shopping, banking, multimedia messaging service (MMS), 3D gaming multi-gaming etc.

➢ Dis-Advantages of 3G

- Expensive fees for 3G licenses service.
- Expensive 3G phones.
- Large cell phones.
- Higher bandwidth requirement.
- It was challenge to build infrastructure for 3G.

Fourth Generation of wireless system (4G)

- high speed wireless network that can transmit multimedia data
- The speeds of 4G can theoretically be promised up to 1Gbps.
- Features of this generation are following:
  - Faster & more reliable.
  - Speed up to 100 Mbps.
  - Both cellular and broadband multimedia services everywhere.
  - High performance.
  - Easy global roaming.
  - Low cost
- Dis-Advantages of 4G
  - Use of battery is more.
  - Hard to implement.
  - Need complicated hardware.
  - Expensive equipment required to implement next generation network.

Fifth Generation of wireless system (5G)

- The technology 5G presents the high resolution for sharp, passionate cell phone every day and give consumers well shape and fast Internet access.
- The 5G technology provides billing limits in advance that the more beautiful and successful of the modern era.
- The 5G technology also allows users of mobile phones, cell phone records for printing operations.
- The 5G technology for large volume data distribution in Gigabit, which also maintains close ties to almost 65,000.
- The technology gives you 5G carrier distribution gateways to unprecedented maximum stability without delay.

- The information from the data transfer technology 5G organize a more accurate and reliable results.
- Using remote control technology to get the consumer can also get a 5G comfort and relax by having a better speed and clarity in less time alone.
- The 5G technology also support virtual private network.
- The uploading and downloading speed of 5G technology touching the peak.
- The 5G technology network offering enhanced and available connectivity just about the world.
- 5G network is very fast and reliable

Generation→ Features↓	1G	2G	3G	4G	5G
Deployment	1970 – 1980	1990 - 2001	2001-2010	2011	2015-20 onwards
Data Rates	2kbps	14.4-64kbps	2Mbps	200 Mbps to 1 Gbps	1Gbps and higher
Technology	Analog Cellular Technology	Digital Cellular Technology: Digital narrow band circuit data Packet data	Digital Broadband Packet data: CDMA 2000 EVDO UMTS EDGE	Digital Broadband Packet data: WiMax LTE Wi-Fi	wwww Unified IP seamless combination of broadband LAN PAN MAN WLAN
Service	Analog voice service No data service	Digital voice with higher clarity SMS, MMS Higher capacity packetized data	Enhanced audio video streaming video conferencing support Web browsing at higher speeds IPTV support	Enhanced audio, video streaming IP telephony HD mobile TV	Dynamic Information access, Wearable devices with AI Capabilities
Multiplexing Switching	FDMA	TDMA, CDMA	CDMA	CDMA	CDMA
Core Network	PSTN	PSTN	Packet N/W	Internet	Internet
Standards	MTS AMTS IMTS	2G:GSM 2.5:GPRS 2.75:EDGE	IMT-2000 3.5G-HSDPA 3.75G:HSUPA	Single unified standard LTE, WiMAX	Single unified standard
WEB Standard		www	www(IPv4)	www (IPv4)	wwww (IPv6)
Handoff	Horizontal only	Horizontal only	Horizontal & Vertical	Horizontal & Vertical	Horizontal & Vertical
Shortfalls	Low capacity, Unreliable handoff, Poor voice links, Less secure	Digital signals were reliant on location & proximity, required strong digital signals to help mobile phones	Need to accommodate higher network capacity	Being deployed	Yet to be implemented

Fig. 1.2 Comparison of 1G to 5G Technologies

Radio channel access schemes:

Mobile cellular system uses various techniques to allow multiple users to access same radio spectrum at same time.

FDMA (Frequency Division Multiple Access)

TDMA (Time Division Multiple Access)

CDMA (Code Division Multiple Access)

SDMA (Space Division Multiple Access)

- FDMA
  - System divides the spectrum into several frequency channels
  - Each user is allocated two channels
  - One for uplink and another for downlink communication
  - No other user is allocated same channel at same time
  - It is analog technique.
  - Channel must be separated by strips of unused bandwidths to prevent overlapping of signals

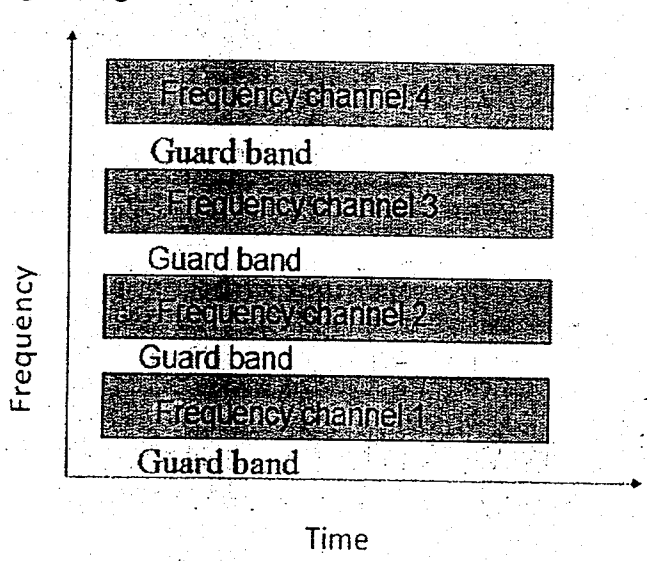

Fig.1.3 FDMA

- TDMA
  - In it entire available bandwidth is used by one user but only for short period of time.
  - Frequency channel is divided in time slots and these are periodically allocated to same user so that user cannot use other time slots.
  - Separate time slots is required for uplink and downlink
  - Time slot is allocated to each user during which it can send and receive data.

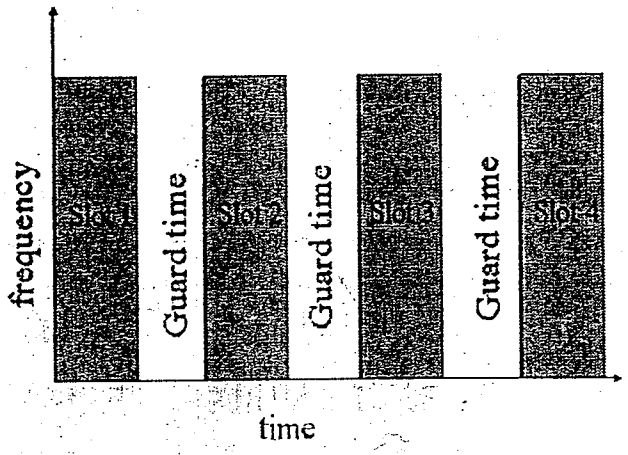

Fig.1.4 TDMA

➢ **CDMA**

- All users occupy same frequency at same time and signals are separated from each other by special codes
- Each user is assigned a code which is used to transform a user's signal to spread spectrum-coded version
- The receiver then uses same spreading code to transform spread spectrum back to original user's data stream

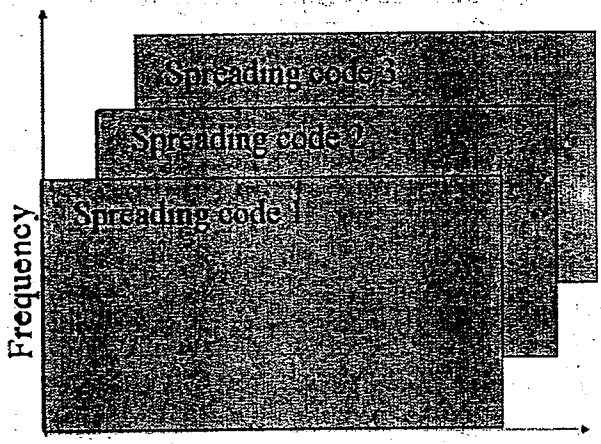

Fig.1.5 CDMA

➢ **SDMA**

- Multiple mobiles can communicate with a single base station on the same frequency.
- By using highly directional beams and/or forming nulls in the directions of all but one of the mobiles on a frequency, the base station creates multiple channels using the same frequency, but separated in space

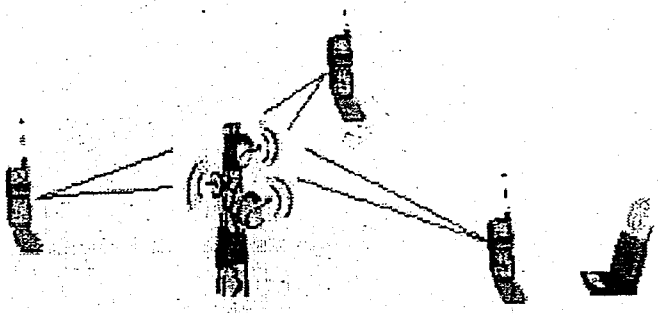

Fig.1.6 SDMA

1.3 Basics of Cell, Cluster and Frequency reuse Concept.

➢ Cell

- The area where wireless transmission between mobile phones and base station takes place is called cell.
- Transmission of data occurs between mobile phone and base station (BS).
- Mobile phone is responsible for user's data transmission and reception, a base station is capable to handle several calls of subscribers
- Transmission of user data from base station to mobile phone is called downlink (DL).
- Transmission of data from mobile phone to base station is called uplink(UL)
- Single cell system is quite limited.
- The farther subscriber from base station, lower the quality of radio link.
- If the subscriber leaves the supply area of cell, no more communication is possible.
- To overcome this limitation cellular system were introduced.

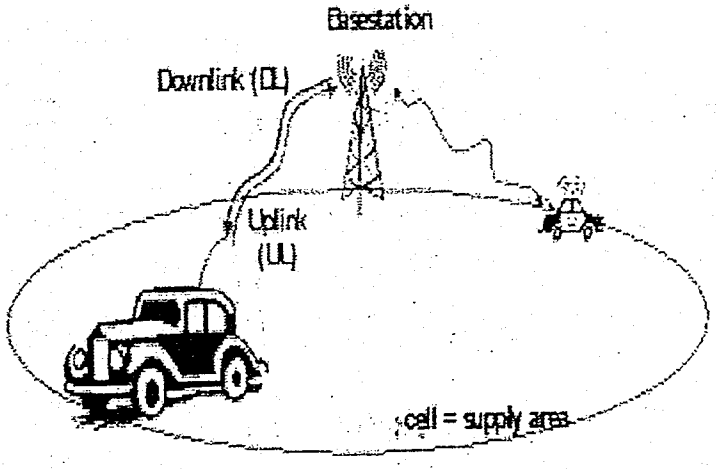

Fig. 1.7 Cell System

➢ Cellular system

- Cellular system contains several cells, which can overlap.
- So a large area can be supported by mobile communication service
- If a subscriber moves from one cell to another then system makes a new radio resource available in neighboring cell, then call is handed over from one cell to next one. By doing so service continuation is guaranteed, this process is called handover(HO)
- Working conditions of cellular system:
  - The power level of transmitter in single cell must be limited in order to reduce interference with the neighboring cells.
  - Neighboring cells cannot share the same channel. In order to reduce interference, frequency must be reused.

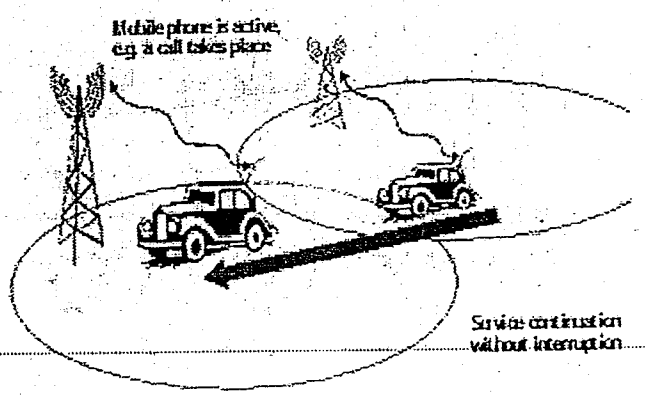

Fig. 1.8 Handover process

- Advantages of cellular structure:
  - Higher capacity higher no. of users
  - Less transmission power needed
- Problems of cellular structure:
  - Fixed network needed for base station
  - Handover necessary
  - Interference with other cells.

➢ **Cluster** – a group of cells. No channels are reused in a cluster

- The available radio channels are divided into different cells within a cluster.
- The no. of cells in a cluster must be determined so that cluster can be repeatedly continuous within the area of operator.
- The typical clusters contains 4,7,12 or 21 cells
- The large no. of cells in the cluster, greater the distance between cells sharing same frequency, this reduces interference.
- The same frequency are reused again in other cluster
- The total no. of channels per cell depends on no. of available channel and type of cluster used.

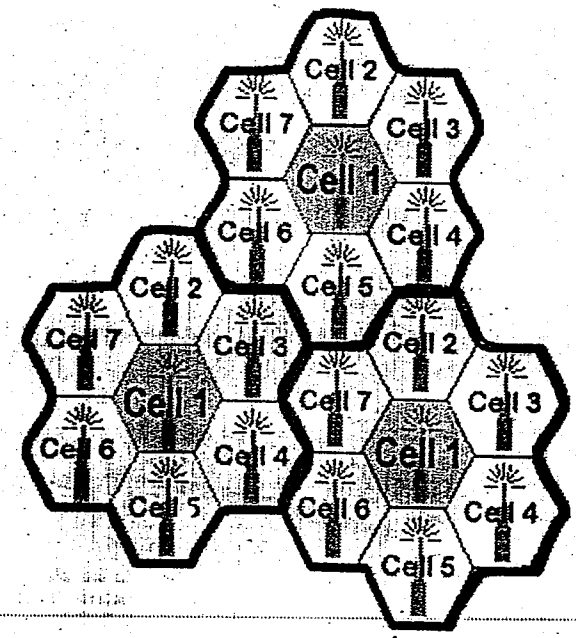

Fig. 1.9 Cluster size=7

Frequency reuse

- As small no. of radio channel frequencies are available in mobile system so need of reuse of radio channel to carry more than one conversation at a time is must. So frequency reuse is required.
- The concept of frequency reuse is assigning to each cell a group of radio channel used with in small area.
- Cells are assigned channel different from neighboring cell.
- Same group of channel is used in different cells that are far enough from each other so that their frequencies do not interfere.

1.4 Noise and its effect on mobile.

- Noise is any undesired signal in a communication circuit that degrades the quality of signals and data. Noise occurs in digital and analog systems, and can affect files and communications of all types, including text, programs, images, audio, and telemetry.
- There are varieties of noise, however the four most important to the telecommunication are thermal noise, intermodulation noise, crosstalk and impulse noise.
- **Thermal noise:** occurs in all transmission media and communication equipment. Every equipment element and the transmission medium itself contribute thermal noise, if the temperature of that element or medium is above absolute zero. The more heat generated or applied, the greater the level of thermal noise.
- **Intermodulation (IM):** noise is the result of the presence of intermodulation products. If two signals of frequencies F1 and F2 are passed through a nonlinear device or medium, the result will contain IM products. The products result when two (or more) signal mixes together.
- **Crosstalk:** disturbance caused by electric and magnetic field of one communication signal affecting a signal in nearby circuit. In telephone circuit crosstalk results in hearing from another circuit. In wireless communication crosstalk results in channel interference.

- **Impulse noise**: it includes unwanted, instantaneous sharp sounds caus by electromagnetic interference, scratches on disks. Voltage change i adjacent

1.5 Understanding GSM and CDMA.

- CDMA (Code Division Multiple Access) and GSM (Global System fo Mobiles) are shorthand for the two major radio systems used in cell phones
- These two technologies differ in the way calls and data travel over the mobile phone networks take place.

➢ GSM

- GSM was initially developed in Europe.
- GSM phones make use of a SIM card to identify the user's account.
- The use of the SIM card allows GSM network users to quickly move their phone number from one GSM phone to another by simply moving the SIM card.
- Frequency band - the frequency range specified for GSM is 1,850 to 1,990 MHz (mobile station to base station).
- Duplex distance - The duplex distance is 80 MHz, Duplex distance is the distance between the uplink and downlink frequencies. A channel has two frequencies, 80 MHz apart.
- Channel separation - The separation between adjacent carrier frequencies. In GSM, this is 200 kHz.
- Modulation - Modulation is the process of sending a signal by changing the characteristics of a carrier frequency. This is done in GSM via Gaussian minimum shift keying (GMSK).
- Transmission rate - GSM is a digital system with an over-the-air bit rate of 270 kbps.
- Access method —GSM utilizes the time division multiple access (TDMA) concept. TDMA is a technique in which several different calls may share the same carrier. Each call is assigned a particular time slot.

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CDMA

- Code division multiple access (CDMA) is a channel access method used by various radio communication technologies.
- As the term implies, CDMA is a form of multiplexing, which allows numerous signals to occupy a single transmission channel, optimizing the use of available bandwidth.
- It uses Spread spectrum techniques because of its security and resistance to jamming.
- CDMA can effectively reject narrow band interference. Since narrow band interference affects only a small portion of the spread spectrum signal, it can easily be removed through notch filtering without much loss of information.
- In a CDMA system, the same frequency can be used in every cell, because channelization is done using the pseudo-random codes.
- Reusing the same frequency in every cell eliminates the need for frequency planning in a CDMA system.
- CDMA systems use the soft hand off, which is undetectable and provides a more reliable and higher quality signal.

Difference between GSM and CDMA

The major difference between the two lies in terms of the technology they use, security factors, their global reach and the data transfer speeds.

- **Technology:** - The CDMA is based on spread spectrum technology which makes the optimal use of available bandwidth. It allows each user to transmit over the entire frequency spectrum all the time. On the other hand GSM operates on the wedge spectrum called a carrier. This carrier is divided into a number of time slots and each user is assigned a different time slot so that until the ongoing call is finished, no other subscriber can have access to this. GSM uses both Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) for user and cell separation. TDMA provides multiuser access by chopping up the channel into different time slices and FDMA provides multiuser access by separating the used frequencies.

- **Security:** - More security is provided in CDMA technology as compared with the GSM technology as encryption is inbuilt in the CDMA. A unique code is provided to every user and all the conversation between two users are encoded ensuring a greater level of security for CDMA users. Therefore, the CDMA phone calls are more secure than the GSM calls. In terms of encryption the GSM technology has to be upgraded so as to make it operate more securely.
- **Global Reach:** - GSM is in use by 76% of users as compared to CDMA which is in use by 24% users.
- **Data Transfer Rate:** - CDMA has faster data rate as compared to GSM as EVDO data transfer technology is used in CDMA which offers a maximum download speed of 2 mbps. GSM uses EDGE data transfer technology that has a maximum download speed of 384 kbps which is slower as compared to CDMA. For browsing the web, to watch videos and to download music, CDMA is better choice as compared to GSM.
- **Radiation Exposure:** - GSM phones emit continuous wave pulses, so there is a large need to reduce the exposures to electromagnetic fields focused on cell phones. On the other hand CDMA cell phones do not produce these pulses.

1.6 Basics of GSM architecture and services.

- **GSM Architecture**

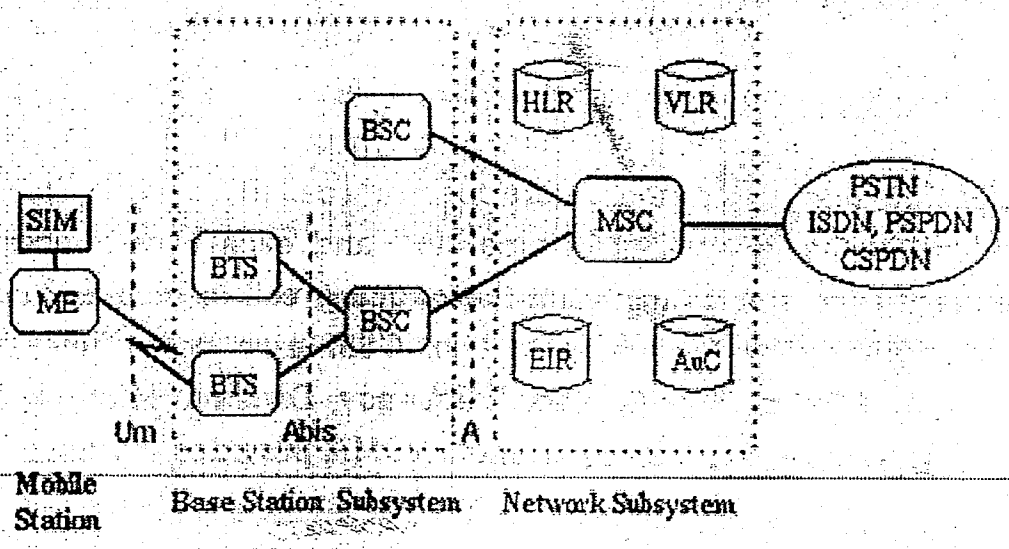

Fig. 1.10 Architecture of GSM network

- GSM network can be divided into four main parts:
  - **The mobile station (MS)**
  - **The base station subsystem (BSS)**
  - **The network and switching subsystem (NSS)**
  - **The operation and support subsystem (OSS)**

Mobile Station

- It consists of two main elements:

Mobile equipment or terminal (MS) – there are different types of terminals:

- Fixed terminals are installed in cars with a output power of 20 W
- GSM portable terminal with output power of 8 W
- Handheld terminals with output power from 2 W to 0.8 W.

Subscriber identity module (SIM) – activates and operates a terminal, by inserting SIM into terminal user can access all subscribed services.

- SIM card is protected by four-digit Personal Identification Number (PIN)
- SIM card contains International Mobile Subscriber Identity (IMSI)
- Another advantage of SIM card is mobility of users, it also personalize a terminal.

Base Station Subsystem

- It connects Mobile Station (MS) and NSS. It is incharge of Transmission and reception. Performs many functions like – Radio resource control, Frequency hopping, Digital signal processing.
- It can be divided in two parts :

Base Transceiver Station (BTS) or Base Station –

- BTS has a set of transceivers to talk to MS
- One BTS can cover more than one cell.
- Its transmitting power defines size of a cell.

- BTS is connected to BSC via A'bis interface with a transmission rate of 2Mbps.

Base Station Controller (BSC) –

- BSC controls several BTSs
- BSC manages channel allocation & Handover of calls from one BTS to another
- BSC is connected to MSC via A interface
- BSC has a database for all its BTS's

Network and Switching Subsystem

- Manage communication between mobile users and other users. It also includes databases needed to store information about subscribers and to manage their mobility.
- NSS has following main components-

The Mobile services Switching Centre (MSC) –

- It is central component of the NSS. The MSC performs switching functions of the network. It also provides connection to other networks.
- MSC performs following main functions :
- Call setup, supervision and release
- Digit collection and translation
- Call routing
- Billing information collection
- Mobility management like registration, location update
- Paging and alerting
- Management of radio resources during a call
- Echo cancellation
- Manage connections to BSS, other MSCs and ISDN
- Interrogation of appropriate registers

The Gateway Mobile Services Switching Center (GMSC) --

- GMSC has additional connections to other fixed networks such as PSTN and ISDN. It is in charge of routing calls from fixed networks to GSM user.

Home Location Register (HLR) --

- A Database in GSM system that stores information of user belonging to covering area of MSC
- It also stores current location of these user and services to which they have access.
- Service restrictions details
- Mobile terminal characteristics
- Location of user corresponds to SS7 address of Visitor Location Register (VLR)

Visitor Location Register (VLR) --

- Contains information from a user's HLR to provide subscribed services to visiting users.
- When a user enters the covering area of new MSC, the VLR associated to this MSC will request information of this user from its HLR
- There is one VLR per MSC
- VLR also have information about features currently activated, temporary mobile station identity, and current location information about mobile.

The Authentication Center (AuC) –

- Associated with HLR, it contains authentication parameters that are used on initial location registration, subsequent location updates and on each call setup request.
- Authentication is a process to verify user SIM
- Secret data and verification algorithm are stored in AuC.
- Authentication and radio channel encryption can be carried out within visited network

The Equipment Identity Register (EIR) –

- It is the database of all IMEIs. Stores information about mobile equipment.
- It contains list of all valid terminals.
- EIR allows forbidding calls from stolen terminals

The GSM Internetworking Unit (GIWU) --

- It corresponds to an interface to various networks for data communication.
- During these communications, the transmission of speech and data can be altered.

The Operation and Support Subsystem (OSS)

- It has centralized operation and maintenance console (OMC). All the network elements are connected to OMC.
- OMC links to BTS via parent BSC.
- OMC keeps record of all faults occurred
- OMC can also do traffic analysis
- It also performs accounting and billing functions.
- Monitors and control all network entity

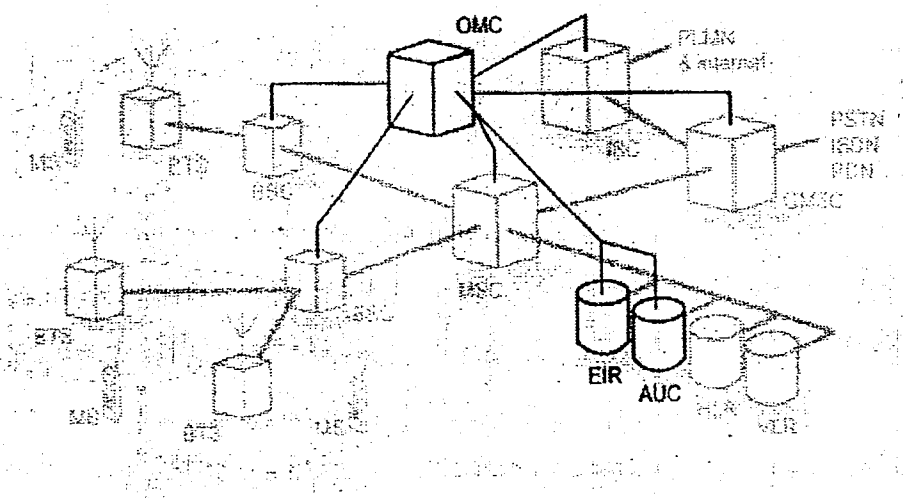

Fig. 1.11 Operation and Maintenance Console

Cellular services

- Cellular services operators are providing many value added services. Basically three categories of services are provided by cellular operators:

- Teleservices: voice service, SMS, Teletex etc.
- Bearer services: data services
- Supplementary services: call forwarding, call baring, call wait etc.

Voice service – Most important teleservice i.e. telephony. Here speech communication takes place. Cellular operator must provide good voice quality for customer.

SMS (Short Messaging Services) – Used to convey short messages like news, jokes etc. A message of maximum of 160 characters can be sent. If mobile is powered off message is stored. With SMS Cell Broadcast (SMS-CB), a message of max 93 characters can be broadcast to all mobiles in certain area.

MMS (Multimedia Messaging Service) - Messages include multimedia objects (images, audio, video, rich text). Its main standardization effort is done by 3GPP, 3GPP2. It has been designed to work with mobile packet data services such as GPRS.

LBS (Location Based Services) – It provide location specific information to mobile users moving from location to location. There are many types of LBS –

- Location Based Information: provides location of particular place to user. It can provide list of shopping malls, restaurant nearer to mobile user. It can also alert mobile user to remind purchase of specific terms whenever she is closer to area which is closer to vendors of such items.
- Location Based Billing: through this user can establish personal zones such as a home work zone and work zone, with this user can enjoy flat-rate calling at home and special rate calling at other defined zones.
- Location Based Emergency services
- Location based tracking

VAS (Value-Added Service) – all services beyond standard voice calls and fax transmissions

Mobile VAS services can be mainly categorized into 3.

- Consumer VAS
- Network VAS
- Enterprise VAS

1.7 Different modes used for mobile communication.

- It defines the direction of the flow of information between two communication devices i.e. it tells the direction of signal flow between the two devices.
- There are three ways or modes of data transmission: Simplex, Half duplex (HDX), Full duplex (FDX)

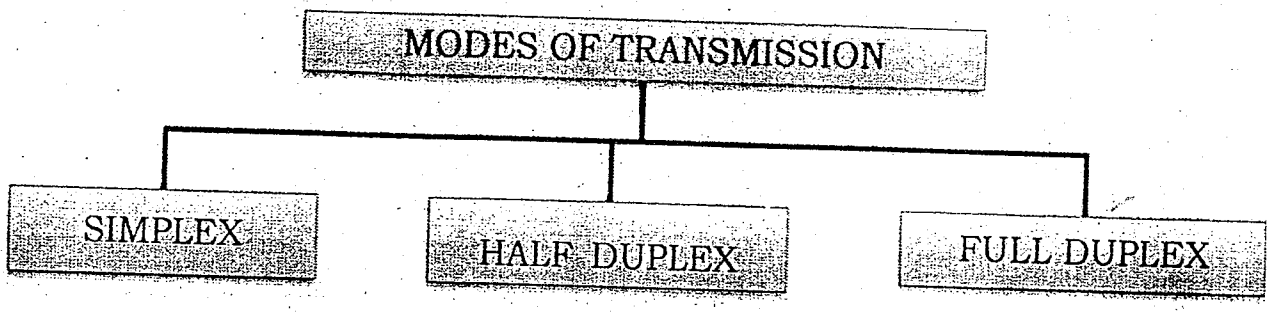

Fig. 1.12 Modes for mobile communication

❖ Simplex

- In it Communication can take place in one direction connected to such a circuit are either a send only or receive only device. There is no mechanism for information to be transmitted back to the sender. Communication is unidirectional. TV broadcasting is an example.
- Examples of Simplex mode:
  - A Communication between a computer and a keyboard involves simplex duplex transmission. A television broadcast is an example of simplex duplex transmission.
  - Another example of simplex transmission is loudspeaker system. An announcer speaks into a microphone and his/her voice is sent through an amplifier and then to all the speakers.

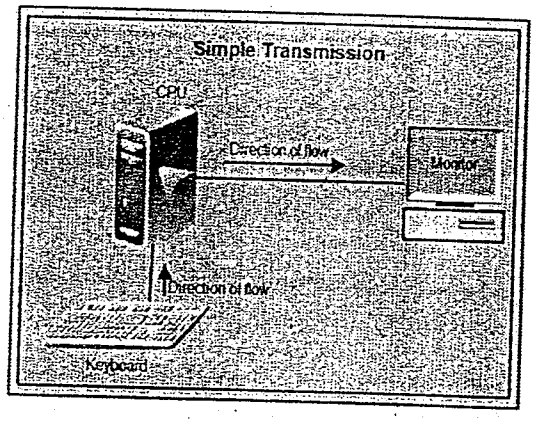

Fig. 1.13 Simplex

❖ **Half Duplex :**

- A half-duplex system can transmit data in both directions, but only in one direction at a time that mean half duplex modes support two-way traffic but in only one direction at a time.
- Both the connected devices can transmit and receive but not simultaneously. When one device is sending the other can only receive and vice-versa.
- Examples of half duplex application include line printers, polling of buffers, and modem communications (many modems can support full duplex also).

- A walkie-talkie operates in half duplex mode. It can only send or receive a transmission at any given time. It cannot do both at the same time.
- As shown in fig. computer A sends information to computer B. At the end of transmission, computer B sends information to computer A. Computer A cannot send any information to computer B, while computer B is transmitting data.

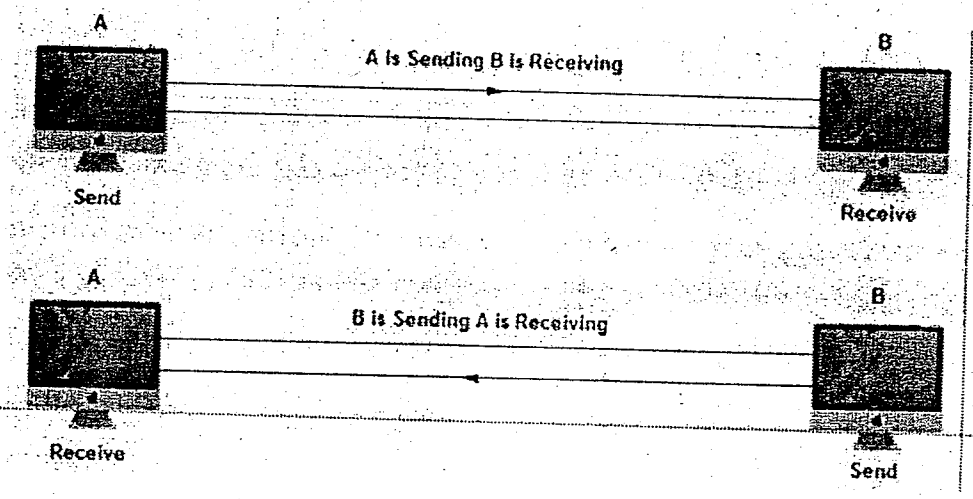

Fig. 1.14 Half duplex

❖ Full Duplex

- A full duplex system can transmit data simultaneously in both directions on transmission path. Full-duplex method is used to transmit the data over a serial communication link. Full-duplex transmission, the channel capacity is shared by both communicating devices at all times.
- Truly bi-directional system. The link may contain two separate transmission paths one for sending and another for receiving.
- Example of Full duplex mode:
  - Telephone networks operate in full duplex mode when two persons talk on telephone line, both can listen and speak simultaneously.

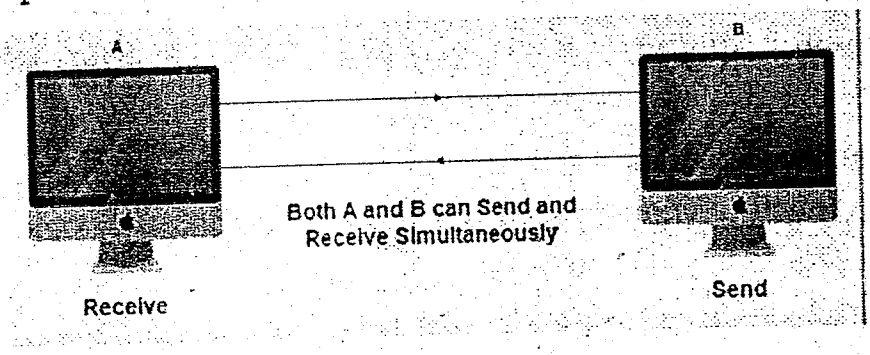

Fig. 1.15 Full duplex

1.8 Architecture of Mobile Computing.

The three tiers in a three-tier architecture are:

- **Presentation Tier**: Occupies the top level and displays information related to services available on a website. Deals with the user facing device handling, includes user interfacing components. This tier communicates with other tiers by sending results to the browser and other tiers in the network.
- **Application Tier:** Also called the middle tier, logic tier, business logic or logic tier, this tier is pulled from the presentation tier. It controls application functionality by performing detailed processing. It is capable of accommodating hundreds users.
- **Data Tier:** Houses database servers where information is stored and retrieved. Data in this tier is kept independent of application servers or business logic.

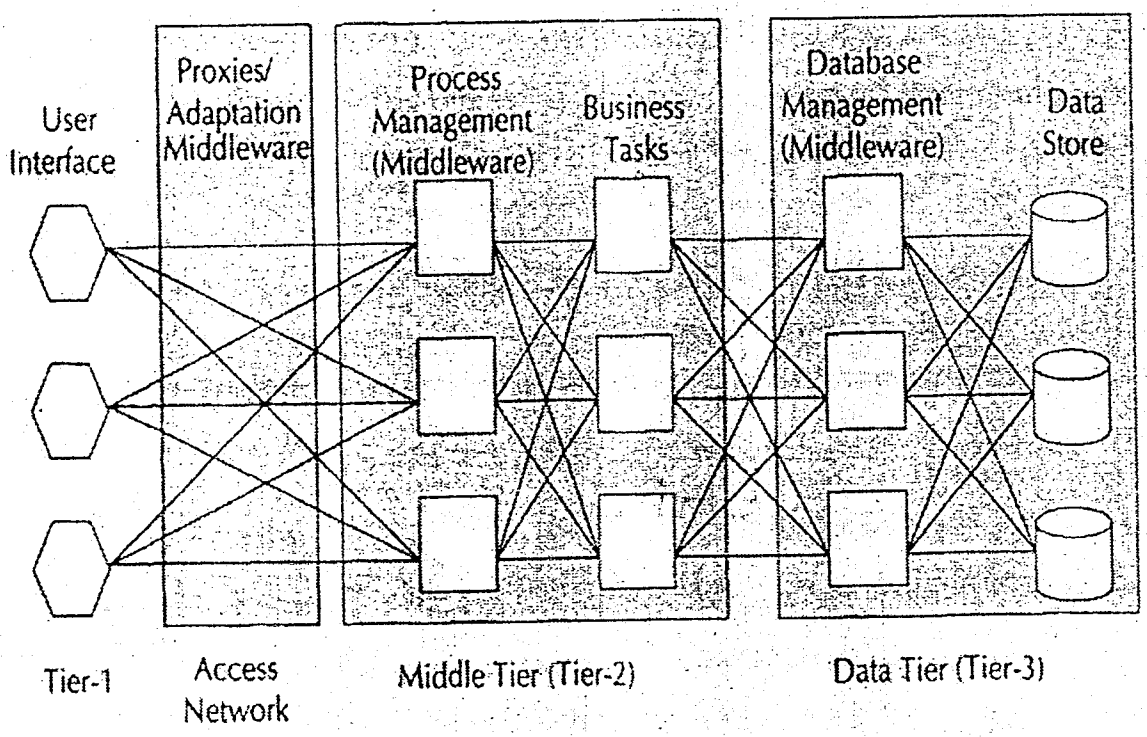

Fig. 1.16 Three tier Architecture

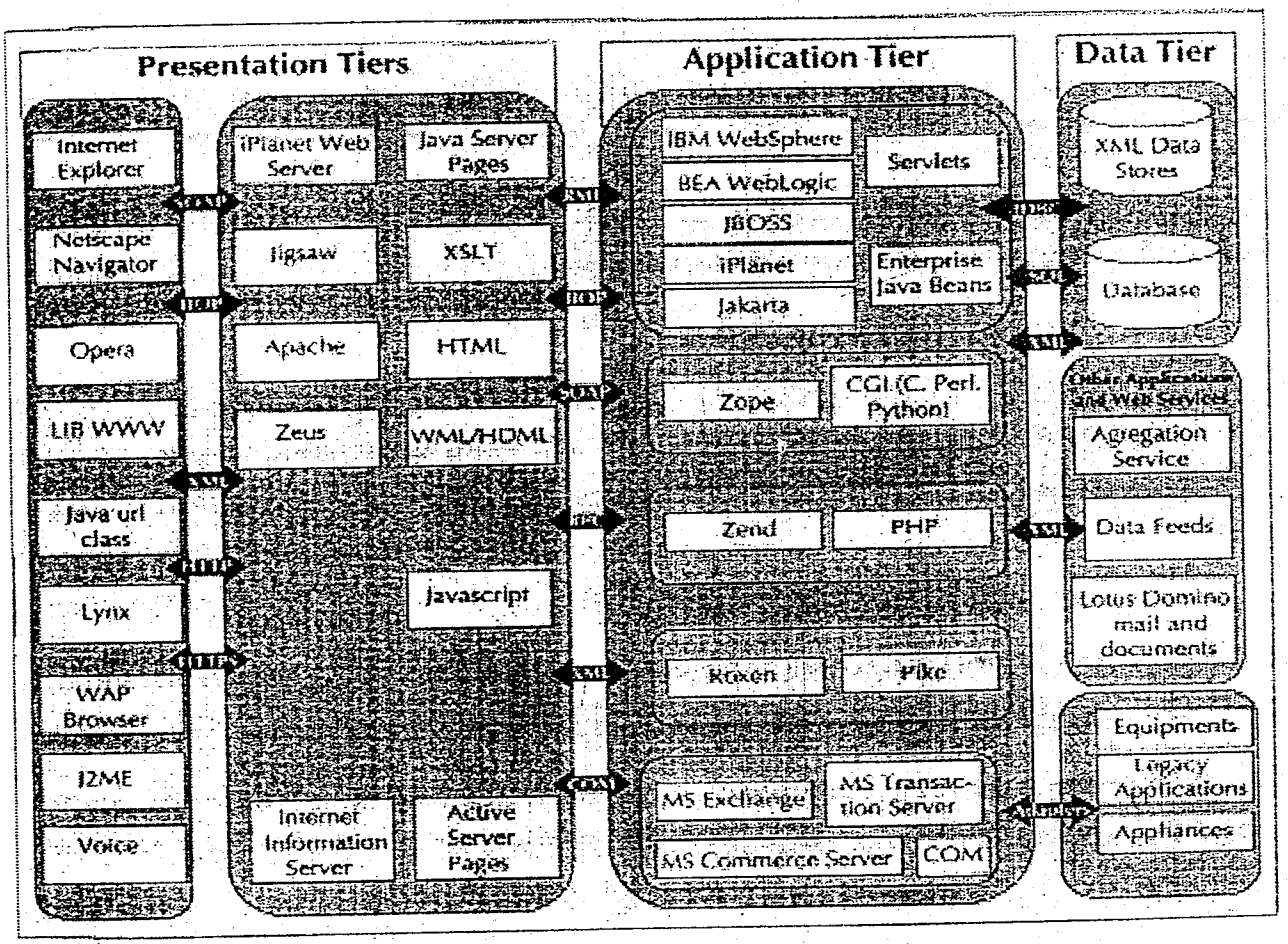

Fig. 1.17 Three tier Architecture of Mobile Computing

1.9 Design consideration for Mobile Computing

- Mobile computing has grown hugely popular over last several years. The developers need to build both customer and enterprise applications. The developers have started building applications that are ubiquitous and multiscreen capable but have to build a mobile application that will work on every phone.
- You can build mobile application with following certain considerations:
  - **Application Type:** what type of application you want to build? Native application or a Flash/AIR based application. In native application programs are developed for use on a particular platform device. Whereas AIR (Adobe Integrated Runtime) is a platform developed for mobile applications using Adobe Flash, Action Script. For trivial application go native. For complex applications, go Flash.
  - **Platform fragmentation:** If your application does not work well on some devices. Find out other ways to filter out your application from the devices.
  - **Storage:** There is no such thing as a 1 TB SD card. Use the phone's data memory.
  - **Connection and bandwidth:** Understand that users pay for every byte transmitted and received. Before you open up data connection or before you start downloading data from service, warn user.
  - **Tombstoning:** Handle system interrupts effectively. In it when OS terminates an application process when the user navigates away from application. OS maintains application last state (i.e. last viewed page). If user navigates back to application the OS restarts application and passes state data back to application.
  - **Memory usage:** Design applications that do well, no problem if it occupies more than 30-40 MB.
  - **Battery:** Battery consumption is very important. If your application utilizes the hardware sensors, you may need to build appropriate model to conserve battery.
  - **Graphics:** Design application with good graphics and UI. Spend more time in formulating the UI.

- **Cloud computing:** When you are building a mobile application that connects to the cloud, you need to understand the semantics of the cloud. The response returned from the cloud varies and it is your application's responsibility to handle such disparities. The cloud need not understand the semantics of the client but the client should understand the semantics of the cloud. Cloud provides elasticity and performance to applications, so always build applications that are controlled by the cloud.
- **Build solutions**: don't just build applications, build solutions.

1.10 Characteristics of Mobile Communication

- **Portability:** The Ability to move a device within a learning environment or to different environments with ease.
- **Social Interactivity:** The ability to share data and collaboration between users.
- **Context Sensitivity:** The ability to gather and respond to real or simulated data unique to a current location, environment, or time. For eg. When we click text.doc file then automatically it opens in word.
- **Connectivity:** The ability to be digitally connected for the purpose of communication of data in any environment. Eg. Through call, message, services and content.
- **Individual:** The ability to use the technology to provide scaffolding on difficult activities and lesson customization for individual learners

1.11 Application of Mobile Communication.

➢ In nearly every factory floor and industrial setting, communication links carry vital information between machinery, control, and monitoring devices.

- **For estate agents:** Estate agents can work either at home or out of field. With help of mobile communication they can be more productive. They can obtain current real estate information by accessing multiple listing services, which they can do from anywhere.

- **In courts:** Defense counsel can make use of mobile communication, when the opposing counsel references a case which they are not familiar. They can access information through online legal database services.
- **In companies:** Managers can use mobile computers in, critical presentations to major customers. They can access latest market share information. They can communicate with staff and other clients through video conferencing.
- **Government:** Applications Centre on assessments, inspections and work orders. Most of these applications involve auditing some sort of facility (food service, restaurant, nursing home, school).
- **Emergency services:** Ability to receive information on move where the emergency services are involved like information regarding the address, type and other details of incident can be quickly dispatched.
- **Healthcare:** The focus in this industry has been on automating patent records, medication dispersion and sample collection, patient identification.
- **Market research:** Automating the survey process has enabled these companies to get their data more accurately and quickly while being able to customize their queries at will.
- **Transportation:** Transforming freight damage inspections from pager to mobile computing greatly expedites the process and reduces costs by providing online reshipment inspections. Through GPS(global positioning system), mobile computing allows companies to provide better customer service by being continually aware of exactly where any given shipment is when in transit.
- **Credit card verification:** At Point of Sale (POS) terminals in shops when customer's user credit cards for transactions, the intercommunication required between the bank central computer and POS terminal, in order to effect verification of card usage, can take place quickly and securely using mobile unit.
- **Electronic mail:** Usage of mobile unit to send and read mails is a very useful asset for any business individual, as it allows us to keep in touch with other people around us. With help of mobile communication individual can have vast information at his/her fingertips.

1.12 Security Concern related to Mobile computing,

Mobile security or mobile phone security has become increasingly important in mobile computing. It is of particular concern as it relates to the security of personal information now stored on the smartphone.

- Device loss was the top concern. If an employee leaves a tablet or smartphone in a taxi cab or at a restaurant, for example, sensitive data, such as customer information or corporate intellectual property, can be put at risk.
- Application security was the second-ranking concern. One problem is mobile apps that request too many privileges, which allows them to access various data sources on the device. Many mobile apps -- especially free ones -- are built with ties to advertising networks, which makes contacts, browsing history extremely valuable to application developers. Leaked corporate contacts, calendar items and even the location of certain executives can put the company at a competitive disadvantage.
- Another concern is malicious or Trojan-infected applications that are designed to look like they perform normally, but secretly upload sensitive data to a remote server.
- Device data leakage was the third-ranking mobile security issue. Nearly all of the chief concerns identified in the mobile security survey, from data loss and theft to malicious applications and mobile malware, are sources of data leakage. Increased corporate data on devices increases the draw of cybercriminals
- Malware attacks were the fourth-ranking mobile security concern. Vast majority of mobile malware to be SMS Trojans, designed to charge device owners premium text messages.

➢ No company wants to lay open their secrets to hacker and other intruders, who will in terms, sell them to their competitors. It's important to take the necessary precautions to minimize these threats from taking place. Some of those measures include:

- Hiring qualified personnel.
- Installing Security Hardware and Software.

- Educating the Users on proper Mobile computing ethics.
- Auditing and developing sound, effective policies to govern mobile computing.
- Enforcing proper access rights and permissions.

1.13 Middleware and Gateway required for mobile computing.

- Middleware: Software layered between a user application and operating system.
- Examples: communication middleware, object oriented middleware, message oriented middleware, transaction processing middleware, database middleware ...etc.
- In mobile computing we need different types of middleware components and gateways at different layers of the architecture. These are:

- **Communication middleware:** - The application will communicate with different nodes and services through different communication middleware. Examples could be NT3270 for IBM mainframe or Javamail connector
- **Transaction processing middleware:** - In many cases a service will offer session oriented dialogue (SoD), for a session to maintain over the stateless Internet. This is done through an application server. The user may be using a device, which demands a short transaction whereas the service at the backend offers a SoD. In such cases a separate middleware component will be required to convert a SoD to a short transaction. Management of the Web components will be handled by this middleware as well.
- **Behaviour management middleware:** - For different devices we need different types of rendering. We can have applications which are developed specially for different types of rendering. For example, we can have one application for Web, another for WAP, and a different for SMS.
- **Communication gateways:** - Between the device and the middleware there will be network of networks. Gateways are deployed when there are different transport bearers or network with dissimilar protocols. For

example, we need an IVR gateway to interface voice with a computer, or a WAP gateway to access internet over a mobile phone.

➢ Middleware for mobile systems, either ad-hoc or nomadic, need to be light-weight systems, supporting asynchronous communication between components, for the reasons explained below.

- **Mobile Devices -> Light Computational Load.** Mobile applications run on Resource-scarce devices, with low amount of memory, slow CPU speed, limited battery power, etc. It is not feasible, because of resource limitations, to run heavy-weight middleware systems on these devices. It is therefore necessary to choose a lighter-weight middleware that causes a minimal overhead.
- **Intermittent Connection -> Asynchronous Communication.** Mobile devices connect to the network for short periods of time, mainly to access some data or to request a service. Even during these periods, the available bandwidth is by order of magnitude lower than in fixed distributed systems and it may suddenly drop to zero if an area with no network coverage is entered. In order to allow interaction between components that are not executing along the same timeline, an asynchronous form of communication is necessary. For example, it might be possible for a client to ask for a service, disconnect from the network, and collect the result of the request at some point later when able to reconnect.
- **Dynamic Context -> Awareness.** Unlike fixed distributed systems, mobile systems execute in an extremely dynamic context. Bandwidth may not be stable, services that are available in a particular moment may not be there a second later, because while moving the hand-held device loses connection with the service provider, etc. It is therefore not feasible for the application developer to foresee all the possible execution contexts and instruct (a priori) the middleware on how to behave in every situation. So the middleware has to interact with the application, making the application aware of execution context changes and dynamically tuning its own behavior using information the application passes down in return.

1.14 Making existing application Model enable.

- There are many applications that are now being used within the intranet or the corporate network. These application need to be made mobile computing capable. There are many ways by which this can be achieved:
  - Enhance existing application take the current application. Enhance the application to support mobile computing.
  - Rent an application from an ASP, there are many organizations that develop ubiquitous application and rent the same at a fee.
  - Write a new application; develop a new application to meet the new business requirement of the mobile computing.
  - Buy a packaged solution; there are many companies who are offering packaged solutions for various business areas starting from manufacturing to sales and marketing. Buy and install one.
  - Bridge the gap through middleware, use different middleware techniques to make existing application mobile computing enable. Through middleware, some additional security features can be added. By using a transcoding middleware, the application can be wireless-enabled and used through SMS (Short Message Service).

1.15 Mobile IP.

- Mobile IP is an Internet Protocol designed to support host mobility.
- Allows users to keep the same IP address, stay connected, and maintain ongoing applications while roaming between IP networks.
- The mobile device can span different types of wireless and wireline networks while maintaining connections and ongoing applications. Remote login, remote printing, and file transfers are some examples of applications where it is undesirable to interrupt communications while an individual roams across network boundaries.
- Also, certain network services, such as software licenses and access privileges, are based on IP addresses.
- **Features** of Mobile IP:
  - No geographical limitation

- No physical connection required: Mobile IP finds local IP routers and connect automatically.
- Modification to other routers and hosts is not required: Mobile IP leaves transport and other protocols unaffected.
- Supports security

❖ Components of a Mobile IP Network

Mobile IP has the following three components, as shown in Figure:

- Mobile Node
- Home Agent
- Foreign Agent

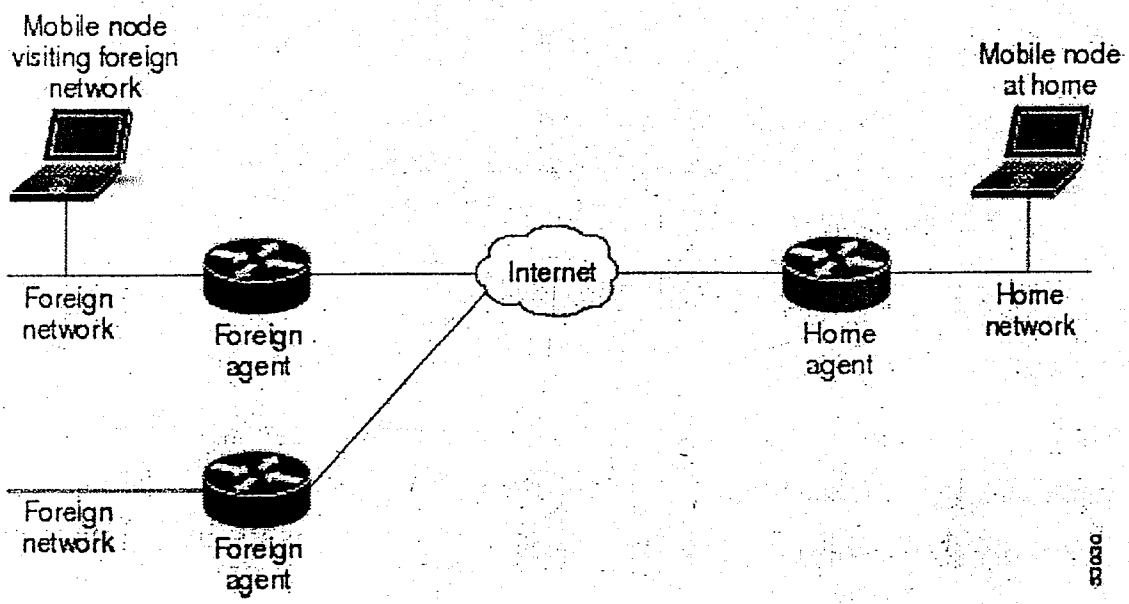

Fig. 1.18 Mobile IP Components and Relationships

➢ The Mobile Node is a device such as a cell phone, personal digital assistant, or laptop whose software enables network roaming capabilities.

➢ The Home Agent is a router on the home network serving as the anchor point for communication with the Mobile Node; it tunnels packets from a device on the Internet, called a Correspondent Node, to the roaming Mobile Node. (A tunnel is established between the Home Agent and a reachable point for the Mobile Node in the foreign network.)

- The Foreign Agent is a router that may function as the point of attachment for the Mobile Node when it roams to a foreign network, delivering packets from the Home Agent to the Mobile Node.
- The care-of address is the termination point of the tunnel toward the Mobile Node when it is on a foreign network. The Home Agent maintains an association between the home IP address of the Mobile Node and its care-of address, which is the current location of the Mobile Node on the foreign or visited network

❖ **How Mobile IP Works**

This section explains how Mobile IP works. The Mobile IP process has three main phases:

- Agent Discovery: - A Mobile Node discovers its Foreign and Home Agents during discovery.
- Registration: - The Mobile Node registers its current location with the Foreign Agent and Home Agent during registration.
- Tunnelling: - A reciprocal tunnel is set up by the Home Agent to the care-of address (current location of the Mobile Node on the foreign network) to route packets to the Mobile Node as it roams.

Agent Discovery

- During the agent discovery phase, the Home Agent and Foreign Agent advertise their services on the network. The Mobile Node listens to these advertisements to determine if it is connected to its home network or foreign network.
- The IRDP advertisements carry Mobile IP extensions that specify whether an agent is a Home Agent, Foreign Agent, or both; its care-of address; the types of services it will provide; and the allowed registration lifetime or roaming period for visiting Mobile Nodes. Rather than waiting for agent advertisements, solicitation also forces any agents on the link to immediately send an agent advertisement.
- If a Mobile Node determines that it is connected to a foreign network, it acquires a care-of address.
- A Foreign Agent care-of address is an IP address of a Foreign Agent that has an interface on the foreign network being visited by a Mobile Node. A

Mobile Node that acquires this type of care-of address can share the address with other Mobile Nodes.

- A colocated care-of address is an IP address temporarily assigned to the interface of the Mobile Node itself. A colocated care-of address represents the current position of the Mobile Node on the foreign network.
- When the Mobile Node hears a Foreign Agent advertisement and detects that it has moved outside of its home network, it begins registration.

Registration

- The Mobile Node is configured with the IP address and mobility security association (which includes the shared key) of its Home Agent.
- The Mobile Node uses this information along with the information that it learns from the Foreign Agent advertisements to form a Mobile IP registration request and sends the registration request.
- If the registration request is sent through the Foreign Agent, the Foreign Agent checks the validity of the registration request. If the registration request is valid, the Foreign Agent adds the visiting Mobile Node to its pending list before relaying the request to the Home Agent. If the registration request is not valid, the Foreign Agent sends a registration reply with appropriate error code to the Mobile Node.
- The Home Agent checks the validity of the registration request, which includes authentication of the Mobile Node. If the registration request is valid, the Home Agent creates a mobility binding (an association of the Mobile Node with its care-of address), a tunnel to the care-of address, and a routing entry for forwarding packets to the home address through the tunnel.
- The Home Agent then sends a registration reply to the Mobile Node through the Foreign Agent (if the registration request was received via the Foreign Agent) or directly to the Mobile Node. If the registration request is not valid, the Home Agent rejects the request by sending a registration reply with an appropriate error code.
- The Foreign Agent checks the validity of the registration reply. If the registration reply is valid, the Foreign Agent adds the Mobile Node to its visitor list, establishes a tunnel to the Home Agent, and creates a routing

entry for forwarding packets to the home address. It then relays the registration reply to the Mobile Node.

- Finally, the Mobile Node checks the validity of the registration reply. If the registration reply is not valid, the Mobile Node discards the reply. If a valid registration reply specifies that the registration is accepted, the Mobile Node is confirmed that the mobility agents are aware of its roaming. In the colocated care-of address case, it adds a tunnel to the Home Agent. Subsequently, it sends all packets to the Foreign Agent.
- The Mobile Node reregisters before its registration lifetime expires. The Home Agent and Foreign Agent update their mobility binding and visitor entry, respectively, during reregistration. In the case where the registration is denied, the Mobile Node makes the necessary adjustments and attempts to register again.
- Thus, a successful Mobile IP registration sets up the routing mechanism for transporting packets to and from the Mobile Node as it roams.

Tunneling

- The Mobile Node sends packets using its home IP address, effectively maintaining the appearance that it is always on its home network. Even while the Mobile Node is roaming on foreign networks, its movements are transparent to correspondent nodes.
- Data packets addressed to the Mobile Node are routed to its home network, where the Home Agent now intercepts and tunnels them to the care-of address toward the Mobile Node. Tunneling has two primary functions: encapsulation of the data packet to reach the tunnel endpoint, and decapsulation when the packet is delivered at that endpoint. The default tunnel mode is IP Encapsulation.
- Typically, the Mobile Node sends packets to the Foreign Agent, which routes them to their final destination, the Correspondent Node, as shown in Fig.

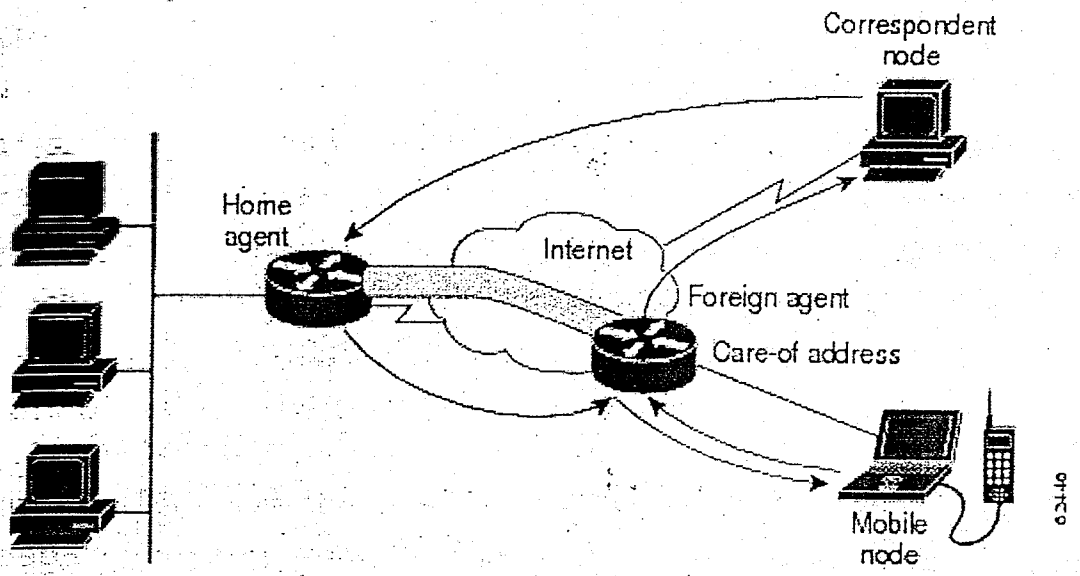

Fig. 1.19 Packet Forwarding

- However, this data path is topologically incorrect because it does not reflect the true IP network source for the data. Because the packets show the home network as their source inside a foreign network, an access control list on routers in the network called ingress filtering drops the packets instead of forwarding them. A feature called reverse tunneling solves this problem by having the Foreign Agent tunnel packets back to the Home Agent when it receives them from the Mobile Node. See Fig.

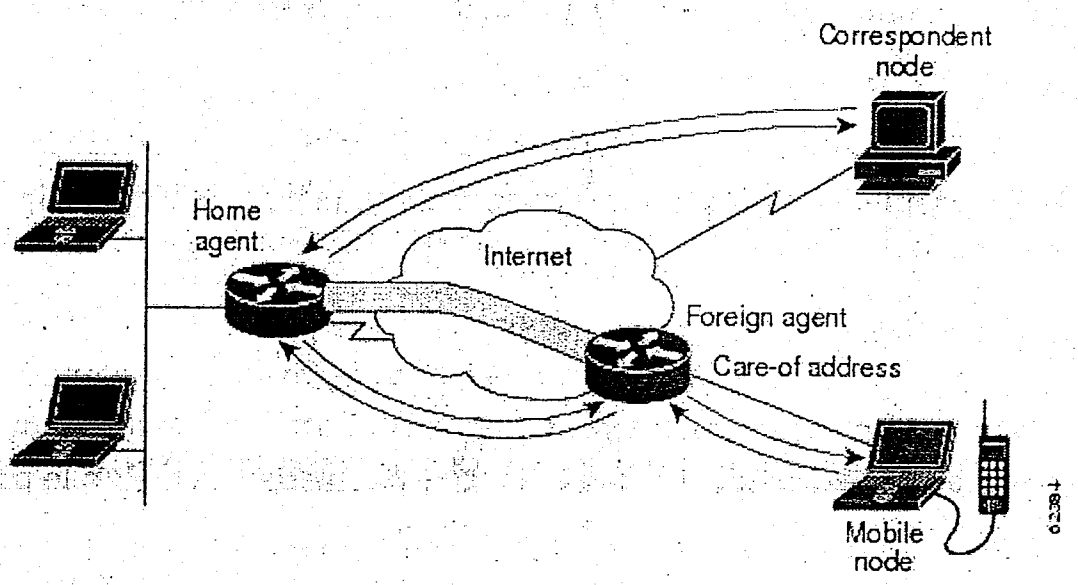

Fig. 1.20 Reverse Tunneling

- Tunnel MTU discovery is a mechanism for a tunnel encapsulator such as the Home Agent to participate in path MTU discovery to avoid any packet

fragmentation in the routing path between a Correspondent Node and Mobile Node. For packets destined to the Mobile Node, the Home Agent maintains the MTU of the tunnel to the care-of address and informs the Correspondent Node of the reduced packet size. This improves routing efficiency by avoiding fragmentation and reassembly at the tunnel endpoints to ensure that packets reach the Mobile Node.

❖ **Security**

- Mobile IP uses a strong authentication scheme for security purposes. All registration messages between a Mobile Node and Home Agent are required to contain the Mobile-Home Authentication Extension (MHAE).
- The integrity of the registration messages is protected by a preshared 128-bit key between a Mobile Node and Home Agent. The keyed message digest algorithm 5 (MD5) is used to compute the authenticator value in the appended MHAE, which is mandatory. Mobile IP also supports the hash-based message authentication code (HMAC-MD5). The receiver compares the authenticator value it computes over the message with the value in the extension to verify the authenticity.
- Cisco IOS software allows the mobility keys to be stored on an authentication, authorization, and accounting (AAA) server.

1.16 Basic Mobile computing Protocol.

- **IrDA for Infrared** - Short for Infrared Data Association, a group of device manufacturers that developed a standard for transmitting data via infrared light waves.
- **SMS protocols** - Short Message Service (SMS) is a text messaging service component of phone, web, or mobile communication systems, using standardized communications protocols that allow the exchange of short text messages between fixed line or mobile phone devices. Mobile phones use this to send messages from one phone to another.
- **Wireless access protocols** - Wireless Application Protocol (WAP) is a technical standard for accessing information over a mobile wireless network. A WAP browser is a web browser for mobile devices such as mobile phones that uses the protocol. Wireless devices use this to send information over a wireless network.

- **802.11 For WiFi** - Applies to wireless LANs and provides 1 or 2 Mbps transmission in the 2.4 GHz band using either frequency hopping spread spectrum (FHSS) or direct sequence spread spectrum (DSSS). Wireless devices use this for the band width.
- **Bluetooth** - One of the oldest wireless protocols still broadly available, Bluetooth is used to synchronize data between phones and other battery-powered devices. Bluetooth requires a lower amount of power to operate than Wi-Fi and most other wireless protocols. In return, Bluetooth connections only function over relatively short distances, often 30 feet (10 m) or less and support relatively low data rates, usually 1-2 Mbps.
- **3G** - is generally considered applicable mainly to mobile wireless, it is also relevant to fixed wireless and portable wireless. A 3G system should be operational from any location on, or over, the earth's surface, including use in homes, businesses, government offices, medical establishments, the military, personal and commercial land vehicles, private and commercial watercraft and marine craft, private and commercial aircraft and space stations and spacecraft.
- **4G** - is the short term for fourth-generation wireless, the stage of broadband mobile communications that supersede the third generation (3G). End-to-end IP and high-quality streaming video will be among 4G's distinguishing features. Fourth generation networks are likely to use a combination of WiMAX and Wi-Fi.
- **CDMA** - Code-division multiple accesses is a form of multiplexing, which allows numerous signals to occupy a single transmission channel, optimizing the use of available bandwidth. CDMA employs analog-to-digital conversion (ADC) in combination with spread spectrum technology. The technology is used in ultra-high-frequency (UHF) cellular telephone systems in the 800 MHz and 1.9 GHz bands. IS-95 uses CDMA.
- **GSM** - Global system for mobile is a digital mobile telephone system that is widely used in Europe and other parts of the world. GSM uses a variation of TDMA and is the most widely used of the three digital wireless telephone technologies (TDMA, GSM, and CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1800 MHz frequency band.

- **WCDMA** - Wideband code-division multiple access is an ITU standard derived from CDMA, officially known as IMT-2000 direct spread. WCDMA supports mobile voice, images, data, and video communications at up to 2 Mbps (local area access) or 384 Kbps (wide area access). A 5 MHz wide carrier is used, compared with 200 KHz-wide carrier for narrowband CDMA.

1.17 Mobile communication via Satellite.

- A satellite is basically a self-contained communications system with the ability to receive signals from Earth and to retransmit those signals back with the use of a transponder—an integrated receiver and transmitter of radio signals.
- Satellite can cover a wide area on surface of earth.
- Satellites have to be light, as the cost of launching a satellite is quite expensive. So satellites must be small and made of lightweight and durable materials.
- Mostly satellites broadcast whatever they receive, but now a days satellite is also been used in packet data transmission.
- Satellite links can operate in different frequency bands and use separate carrier frequency for uplink and downlink.
- Uplink: connection base station to satellite
- Downlink: connection satellite to base station
- Modern satellites are often equipped with multiple transponders.

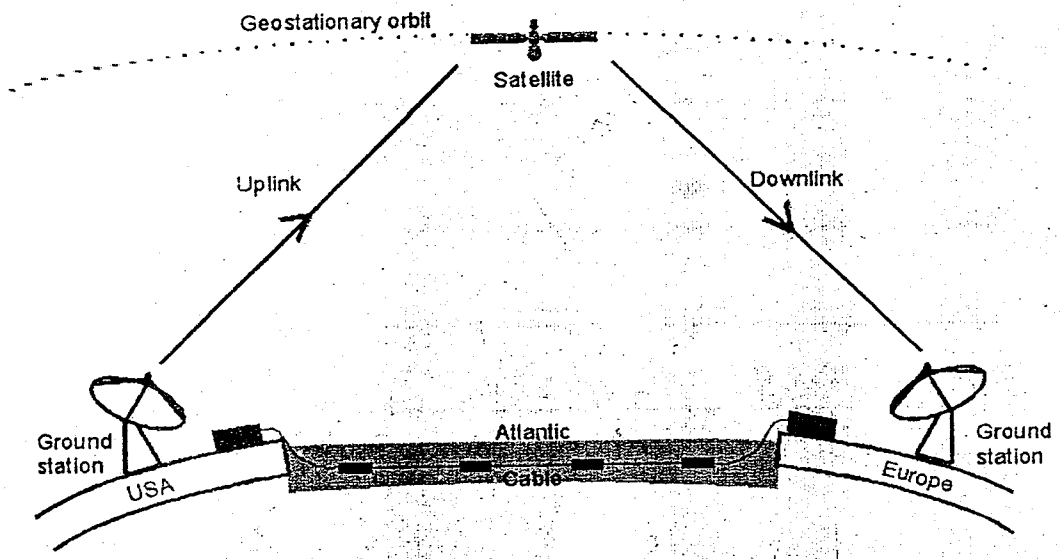

Fig. 1.21 Satellite Communication

❖ Satellite Orbits

Satellites can be positioned in orbits with different heights and shape (circular or elliptical). Based on orbital radius, all satellites fall into one of following three categories:

- LEO : Low Earth Orbit
- MEO : Medium Earth Orbit
- GEO : Geostationary Earth Orbit

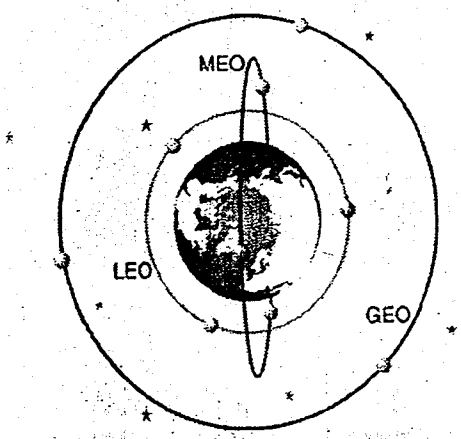

Fig. 1.22 Satellite Constellation

LEO

- Altitude range is between 200 and 1200 km above the Earth's surface Applications
- Orbit times are less. The lower altitude means higher velocities are required to balance the earth's gravitational field.

- The lower orbit means the satellite and user are closer together and therefore path losses are less than for other orbits such as GEO
- The round trip time, RTT for the radio signals is considerably less than that experienced by geostationary orbit satellites.
- Less energy is expended placing the satellites in LEO than higher orbits.

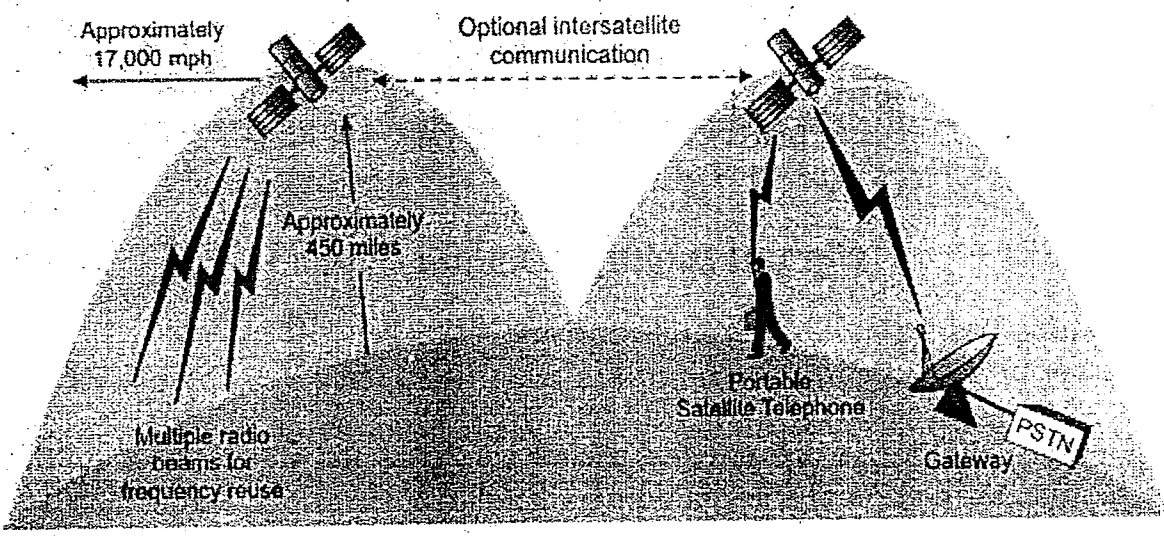

Fig. 1.23 LEO satellite system

- In the above diagram a portable satellite telephone is communicating with a landline phone.
- The satellite telephone communicates with the closest LEO satellite.
- When the satellite moves out to horizon, another LEO satellite continues the call
- Some systems may use satellite diversity to allow talking through more than one satellite at a time to avoid "call dropouts" from signal blockage.

IEO

- Altitude range is between 5000 and 12000 km above the Earth's surface Applications
- Comparison with LEO systems:
  - Slower moving satellites
  - Less satellites needed
  - Simpler system design
  - For many connections no hand-over needed