MOBILE COMMUNICATIONS (18KP4CSELCS4:A)

V.CHEZHIYAN
Assistant Professor
Department of Computer science
KNGAC, Thanjavur.

Mobile Communications (18KP4CSELCS4:A**)**
Syllabus

- ***Objective: To improve skills in mobile communication technology.***

- Unit - I : Introduction : Applications - A Short History Of Wireless Communication-A Market For Mobile Communication -Some Open Research Topics. A Simplified Reference Model: Medium Access Control (MAC): Motivation For Specialized MAC -SDMA - FDMA - TDMA - CDMA – Comparison.
- Unit - II : Telecommunication Systems : GSM Mobile Services - System Architecture - Radio Interface - Protocols - Localization And Calling - Handover - Security - New Data Services. Satellite Systems : History - Applications – Basics: GEO,LEO,MEO -Routing - Localization - Handover. Broadcast Systems: Cyclical Repetition of Data - Digital Audio / Video Broadcasting - Convergence.

Communication is simply the act of transferring information from one place, person or group to another.

Every communication involves (at least) one sender, a message and a recipient.

A communication device can thus exhibit one of the following characteristics: - Fixed wired ,Mobile and wired , Fixed and wireless and Mobile and wireless

Wireless Communication is a method of transmitting information from one point to other, without using any connection like wires, cables or any physical medium. Generally, in a communication system, information is transmitted from transmitter to receiver that are placed over a limited distance.

- Mobile Communication is the use of technology that allows us to communicate with others in different locations without the use of any physical connection (wires or cables). ... It is an electric device used for full duplex two way radio telecommunication over a cellular network of base stations known as cell site.

- Mobile communication is talking, texting or sending data or image files over a wireless network. An example of mobile communication is chatting on the cell phone with a friend. An example of mobile communication is sending email from a computer using a wireless network at your place.

- The term “MOBILE”

The term was initially used in the 1980s to describe computers that you could take with you and use while you were on-the-go. ... "Mobile" evolved into an umbrella term that now describes laptops, tablets, and smart phones.

There are two kinds of Mobility

a). User Mobility -users who have access to similar communication services at different places. Example: User can have a mobile and he can login to his mail account from any desktop to check or compose emails.

b). Device portability - Device portability refers to the movement of a communication device with or without a user.

- Applications

  *vehicles

  Broadcast information, personal communication, remote areas.

  A local ad-hoc network for the fast exchange of information.

  Vehicle data from buses, trucks, trains and high speed train can be transmitted in advance for maintenance.

  In ad-hoc network, car can comprise personal digital assistants (PDA), laptops, or mobile phones connected with each other using the Bluetooth technology.

  *Emergencies-Hospitals,*Business,*Infotainment,*Location independent services

A short History of wireless communication

- 1794 –claude chappe invented – optical telegraph
- 1843- commercial Telegraph
- 1864 – Heinrich Hertz – wave transmission
- 1876 – Graham Bell- invention of Telephone
- 1879- James C.Maxwell- Electromagnetic fields
- 1881- First voice and video service in telephone
- 1895- Gulielmo Margoni- Long wave Transmission
- 1920 – commercial Radio systems
- 1933- Edwin Armstrong – Frequency Modulation
- 1983- GSM
- 1991- Fully digital systems
- 2000- Higher data ratesThe development from 1G to 4G and now into LTE and beyond to 5G has accelerated the rate of advance in most technologies.

Some open Research Topics

- Interference
- Regulations and Spectrum
- Low Bandwidth
- High delays, large delay variation
- Lower security, simple to attack
- Shared medium
- Ad-hoc networking

A Simplified Reference Model

Layers involved In wireless and Mobile environment

- Physical layer – responsible for conversion of stream of bits into signals
- Data link layer-responsible for reliable point to point connection one sender and several receiver
- Network layer- responsible for routing packets through a network
- Transport layer- to establish an end to end connection
- Application layer- finally connected to applications.

- MAC
- The **medium access control** (MAC) is a sublayer of the data link layer of the open system interconnections (OSI) reference model for data transmission. ...
- It **controls** the transmission of data packets via remotely shared channels. It sends data over the network interface card
- **Media access control** becomes **important** when several computers share the same communication circuit, such as a point-to-point configuration with a half-duplex configuration that requires computers to take turns, or a multipoint configuration in which several computers share the same circuit.
- If two computers simultaneously place signals on the wire, a collision can occur and data might be corrupted unless a method is used to resolve the collision gracefully.
- **Media access control** methods act like traffic lights by permitting the smooth flow of traffic on a network, and they prevent or deal with collisions

- There are five basic access or multiplexing methods: frequency division multiple access (**FDMA**), time division multiple access (**TDMA**), code division multiple access (**CDMA**), orthogonal frequency division multiple access (OFDMA), and spatial division multiple access (**SDMA**
- **Space-division multiple access** (**SDMA**) is a channel access method based on creating parallel spatial pipes (focused signal beams) using advanced antenna technology next to higher capacity pipes through spatial multiplexing and/or diversity, by which it is able to offer superior performance in radio multiple access communication systems (where multiple users may need to use the communication media simultaneously)
- **Frequency-division multiple access** (**FDMA**) is a channel access method used in some multiple-access protocols. FDMA allows multiple users to send data through a single communication channel, such as a coaxial cable or microwave beam, by dividing the bandwidth of the channel into separate non-overlapping frequency sub-channels and allocating each sub-channel to a separate user. Users can send data through a sub channel by modulating it on a carrier wave at the sub channel's frequency. It is used in satellite comm systems and telephone trunk lines

- TDMA- which stands for **Time Division Multiple Access**, is a critical technology in digital two-way radio.

- Time Division Multiple Access (**TDMA**) is a digital cellular telephone communication technology. It facilitates many users to share the same frequency without interference. Its technology divides a signal into different timeslots, and increases the data carrying capacity.

CDMA - Technology - Code Division Multiple Access (**CDMA**) is a sort of ... Conversely, when signals are received from several **mobile** stations, the base station ...

CDMA (Code-Division Multiple Access) refers to any of several protocols used in second-generation (2G) and third-generation (3G) wireless communications. 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.

SDMA	TDMA	FDMA	CDMA
Segment spaced into cells or sectors.	Segments sending time into disjoint time slots demand driven or fixed patterns.	Segment the frequency band into disjoint subbands	Spread the spectrum using orthogonal codes.
Only one terminal can be active in one cell or one sector.	All terminals are active for short periods of time on same frequency.	Every terminal has its own frequency uninterrupted	All terminals can be active at the same place at the same moment uninterrupted.
Cell structure, directed antennas	Synchronization in time domain	Filtering in the frequency domain.	Code plus special receivers.
Continuous	Discontinuous	Continuous	Continuous
Depends on cell area	Limited	Limited	No absolute limit on channel capacity but it is an interference limited system
Very simple, increases capacity per	Established fully digital, flexible	Simple, established, robust	Flexible, less frequency planning needed, soft handover
Inflexible, antennas typically fixed	Guard space needed (multipath propagation), synchronization difficult	Inflexible, frequencies are scarce resource	Complex receivers, needs more complicated power control

TELECOMMUNICATION SYSTEMS
UNIT - II

Unit – II

Global system for Mobile communications

- GSM

  The Global System for Mobile Communications (**GSM**) is a standard developed by the European **Telecommunications** Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks used by mobile devices such as mobile phones and tablets.

  GSM is the successful digital Mobile telecommunication system today.

  It is a typical second generation system.

  The primary goal of GSM was to provide a mobile phone system that allows a users to roam around their continent.

  A GSM system that has been intialy deployed in European countries for railroad systems in GSM-Rail.

  GSM-R offers 19 channels for rail road operators for voice and data.

  GSM has mainly designed for rail and voice services .

- Mobile services

- GSM offers
  - several types of connections
    - voice connections, data connections, short message service
  - multi-service options (combination of basic services)
- Three service domains
  - Bearer Services – interface to the physical medium (transparent for example in the case of voice or non transparent for data services)
  - Telematic Services – services provided by the system to the end user (e.g., voice, SMS, fax, etc.)
  - Supplementary Services – associated with the tele services: call forwarding, redirection, etc.

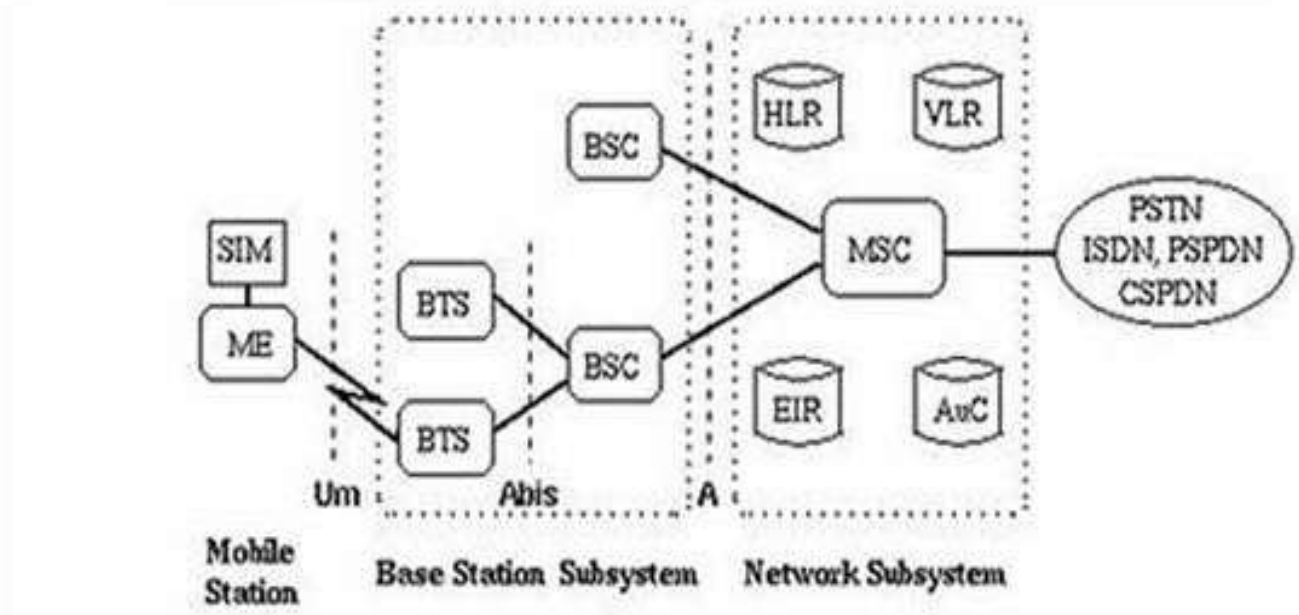
- Bearer services
- Telecommunication services to transfer data between access points
  - R and S interfaces – interfaces that provide network independent data transmission from end device to mobile termination point.
  - U interface – provides the interface to the network (TDMS, FDMA, etc.)
- Specification of services up to the terminal interface (OSI layers 1-3)
  - Transparent – no error control of flow control, only FEC
  - Non transparent – error control, flow control
- Different data rates for voice and data (original standard)
  - voice service (circuit switched)
    - synchronous: 2.4, 4.8 or 9.6 Kbps.
  - data service (circuit switched)
    - synchronous: 2.4, 4.8 or 9.6 kbit/s
    - asynchronous: 300 - 1200 bit/s
  - data service (packet switched)
    - synchronous: 2.4, 4.8 or 9.6 kbit/s
    - asynchronous: 300 - 9600 bit/s

- Tele services
- Additional services: Non-Voice-Teleservices
  - group 3 fax
  - voice mailbox (implemented in the fixed network supporting the mobile terminals)
  - electronic mail (MHS, Message Handling System, implemented in the fixed network)

  - Short Message Service (SMS)
    alphanumeric data transmission to/from the mobile terminal using the signaling channel, thus allowing simultaneous use of basic services and SMS (160 characters

- Supplementary services
- Services in addition to the basic services, cannot be offered stand-alone
- May differ between different service providers, countries and protocol versions
- Important services
  - identification: forwarding of caller number
  - suppression of number forwarding
  - automatic call-back
  - conferencing with up to 7 participants
  - locking of the mobile terminal (incoming or outgoing calls)

GSM ARCHITECTURE



SIM Subscriber Identity Module
ME Mobile Equipment
BTS Base Transreceiver station
BSC Base Station Controller
HLR Home Location Register
VLR Vistor Location Register
MSC Mobile service switching center
EIR Equipment Identity Register
AuC Authentication Center

- **3. Network and switching subsystem (NSS)**

- The NSS is responsible for the network operation. It provides the link between the cellular network and the Public switched telecommunicates Networks
- In particular the switching subsystem consists of:
- Mobile switch center (MSC)
- Home location register (HLR)
- Visitor location Register (VLR)
- Authentications center (Auc)
- Equipment Identity Register (EIR)
- Interworking Functions (IWF)

- The GSM network architecture consists of three major subsystems:
- Mobile Station (MS)
- Base Station Subsystem (BSS)
- Network and Switching Subsystem (NSS)
- The wireless link interface between the MS and the Base Transceiver Station (BTS), which is a part of BSS. Many BTSs are controlled by a Base Station Controller (BSC). BSC is connected to the Mobile Switching Center (MSC), which is a part of NSS. Figure shows the key functional elements in the GSM network architecture
- **1. Mobile Station (MS):**
- A mobile station communicates across the air interface with a base station transceiver in the same cell in which the mobile subscriber unit is located.
- **2. Base Station Subsystem (BSS):**
- A base station subsystem consists of a base station controller and one or more base transceiver station. Each Base Transceiver Station defines a single cell. A cell can have a radius of between 100m to 35km, depending on the environment.

- Radio interface
- The interface in a GSM system is Um, the radio interface comprises many mechanisms for multiplexing and media access.
- Media access combines TDMA and FDMA .

GSM specifies two basic groups of logical channels

* traffic channels and control channels.

Traffic channels (TCH) : GSM uses a TCH to transmit user data.

Two basic categories of TCHs are 1. full-rate TCH (TCH/F) and half-rate TCH(TCH/H).

Control channels : Many different CCHs are used in a GSM system to control medium access:

Broadcast control channel (BCCHH)

Common control channel(CCCH)

Dedicated control channel (DCCH)

- Protocols - Signaling protocols

Signaling between entities in a GSM network requires higher layers, for this the LAPDm protocol has been defined.

Link access procedure for the D-channel(LAPD) in ISDN systems.

Signalling system No.7 (SS7) is used for signaling between an MSC and a BSC.

This protocol also transfers all management information between MSCs, HLR, VLRs,AuC,EIR and OMC.

Localization and calling

The fundamental future of GSM is the automatic, worldwide localization of users.

To provide this, GSM performs periodic location updates. HLR always contains information about the current location and VLR currently responsible for the MS informs the HLR about location changes.

Changing VLRs with uniterrupted availability of all services is also called **roaming**

- Handover – Cellular systems require handover procedures, as single cell do not cover the whole service area.

- Two basic reason for handover –
- 1. Moves out of range of a BTS
- 2. The wired infra stucture may decide the traffic in one cell is too high and shift some MS to other cells with lower load.

- Four possible handover scenarios in GSM:
- Intra-cell **Handover**: within a cell.
- Inter-cell, intra-BSC **handover**: MS stays within the control of the same BSC.
- Inter-BSC, intra MSC **handover**: Controlled by MSC.
  perform **handovers** between cells controlled by different BSCs.
- Inter MSC handover

- Security :- The security services offered by GSM are

- Access control and authentication – user needs a secret PIN to access the SIM.
- Confidentiality- user –related data is encrypted
- Anonymity – all data is encrypted before transmission.

- Authentication
- Authentication based on the SIM, which stores the individual authentication key Ki, the user identification IMSI.

- Encryption

  To ensure privacy, all messages containing user-related information are encrypted in GSM over the air interface.

- New Data services
- This system is called HSCSD {high speed circuit switched **data**}. A more progressive step is the introduction of packet- oriented traffic in GSM, i.e., shifting the paradigm from connections/telephone thinking to packets/internet thinking. The system is called GPRS {general packet radio **service**}.
- General Packet Radio Service (**GPRS**) is a packet oriented **mobile** data standard on the 2G and 3G cellular communication network's global system for **mobile** communications (GSM). ... It provides moderate-speed data transfer, by using unused time division multiple access (TDMA) channels in, for example, the GSM system. The General packet radio service(GPRS) provides packet mode transfer for applications.
- GPRS offers a point-to-point)PTP) packet transfer service.
- The GPRS architecture introduces two new network elements, which are called GPRS Support nodes (GSN) and gateway GPRS support node (GGSN).

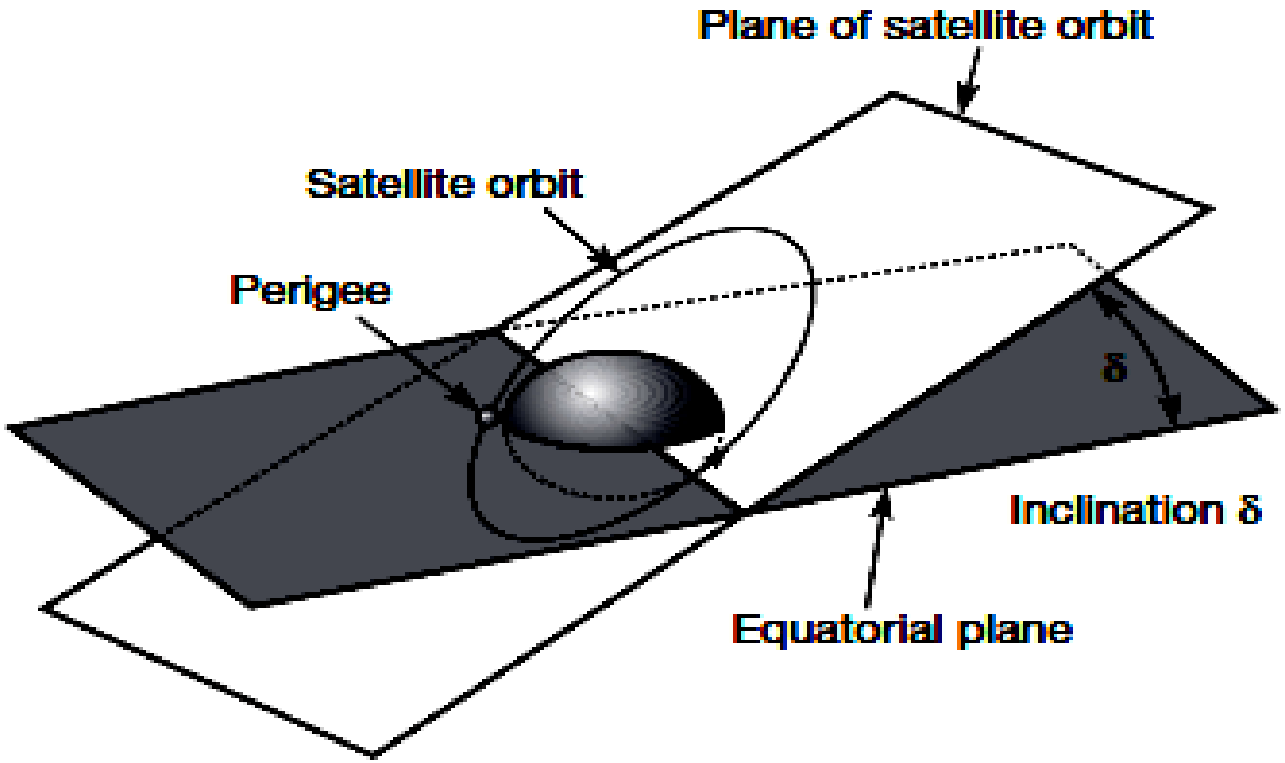
Satellite systems

- Satellites orbit around the earth. Depending on the application, these orbits can be circular or elliptical. Satellites in circular orbits always keep the same distance to the earth‟s surface following a simple law:
- The attractive force *Fg of the earth due to gravity equals m·g (R/r) 2 The centrifugal force Fc trying to pull the satellite away equals m·r·ω2 The variables have the following meaning: m is the mass of the satellite; R is the radius of earth with R = 6,370 km; ri s the distance of the satellite to the centre of the earth; g is the acceleration of gravity with g = 9.81 m/s2; ω is the angular velocity with ω = 2·π·f, f is the frequency of the rotation. To keep the satellite in a stable circular orbit, the following equation must hold: Fg = Fc, i.e., both forces must be equal. Looking at this equation the first thing to notice is that the mass m of a satellite is irrelevant (it appears on both sides of the equation). Solving the equation for the distance r of the satellite to the centre of the earth results in the following equation:*

- The distance *r* = ***(g·R2/(2·π·f)2)1/3***
- From the above equation it can be concluded that the distance of a satellite to the earth‟s surface depends on its rotation frequency.

- Important parameters in satellite communication are the *inclination and elevation angles. The inclination angle δ (figure 1.1) is defined between the equatorial plane and the plane described by the satellite orbit. An inclination angle of 0 degrees means that the satellite is exactly above the equator. If the satellite does not have a circular orbit, the closest point to the earth is called the perigee*

Angle of inclination



APPLICATIONS OF SATELLITES

- Weather Forecasting
- Radio and TV Broadcast
- Military Satellites
- Navigation Satellites
- Global Telephone
- Connecting Remote Areas

TYPES OF SATELLITES (BASED ON ORBITS)

- **Geostationary or geosynchronous earth orbit (GEO)**
- GEO satellites are synchronous with respect to earth. Looking from a fixed point from Earth, these satellites appear to be stationary. These satellites are placed in the space in such a way that only three satellites are sufficient to provide connection throughout the surface of the Earth (that is; their footprint is covering almost 1/3rd of the Earth). The orbit of these satellites is circular.
- **Low Earth Orbit (LEO) satellites:**
- These satellites are placed 500-1500 kms above the surface of the earth. As LEOs circulate on a lower orbit, hence they exhibit a much shorter period that is 95 to 120 minutes. LEO systems try to ensure a high elevation for every spot on earth to provide a high quality communication link. Each LEO satellite will only be visible from the earth for around ten minutes.
- **Medium Earth Orbit (MEO) satellites:**
- MEOs can be positioned somewhere between LEOs and GEOs, both in terms of their orbit and due to their advantages and disadvantages. Using orbits around 10,000 km, the system only requires a dozen satellites which is more than a GEO system, but much less than a LEO system.

Routing

- One solution: inter satellite links (ISL) reduced number of gateways needed , forward connections or data packets within the satellite network as long as possible , only one uplink and one downlink per direction needed for the connection of two mobile phones .Problems: more complex focusing of antennas between satellites high system complexity due to moving routers higher fuel consumption thus shorter lifetime Iridium and Teledesic planned with ISL Other systems use gateways and additionally terrestrial networks
- Localization of mobile stations
- Mechanisms similar to GSM Gateways maintain registers with user data. HLR (Home Location Register): static user data. VLR (Visitor Location Register): (last known) location of the mobile station. SUMR (Satellite User Mapping Register): satellite assigned to a mobile station. positions of all satellites Registration of mobile stations . Localization of the mobile station via the satellite's position. requesting user data from HLR updating VLR and SUMR Calling a mobile station localization using HLR/VLR similar to GSM connection setup using the appropriate satellite.

- Handover in satellite systems
- Several additional situations for handover in satellite systems compared to cellular terrestrial mobile phone networks caused by the movement of the satellites
- Intra satellite handover - handover from one spot beam to another mobile station still in the footprint of the satellite, but in another cell
- Inter satellite handover -handover from one satellite to another satellite mobile station leaves the footprint of one satellite
- Gateway handover - Handover from one gateway to another mobile station still in the footprint of a satellite, but gateway leaves the footprint Inter system handover
- Handover from the satellite network to a terrestrial cellular network - mobile station can reach a terrestrial network again which might be cheaper, has a lower latency etc. Mobile Communications Satellite

- Cyclical repetition of Data
- A broadcast sender of data does not know when a receiver starts to,listen to the transmission .While for radio or television there is no problem,transmission of the other important information,such as traffic or weather conditions ,has to be repeated to give receiver a chance to receive this information after having listened for a certain amount of time.
  The cyclical repetition of data blocks sent via broadcast systems is often called a broadcast disk

  Digital Audio Broadcasting

  Digital audio broadcasting (DAB), also known as digital radio and high-definition radio, is audio broadcasting in which analog audio is converted into a digital signal and transmitted on an assigned channel in the AM or (more usually) FM frequency range. DAB is said to offer compact disc (CD)- quality audio on the FM (frequency modulation) broadcast band and to offer FM-quality audio on the AM (amplitude modulation) broadcast band.

  DAB systems can use single frequency networks(SFN). The modulation scheme used is DQPSK. DAB uses two basic transport mechanisms:

  1. Main service channel(MSC)
  2. Fast information channel(FIC).

- Digital Video Broadcasting
  - Digital Video Broadcasting (DVB) is being adopted as the standard for digital television in many countries
- DVB systems distribute data using a variety of approaches, including:
- Satellite: DVB-S, DVB-S2 and DVB-SH
  - DVB-SMATV for distribution via SMATV
- Cable: DVB-C, DVB-C2
- Terrestrial television: DVB-T, DVB-T2
  - Digital terrestrial television for handhelds: DVB-H, DVB-SH
- Microwave: using DTT (DVB-MT), the MMDS (DVB-MC), and/or MVDS standards (DVB-MS)

DVB sends service information contained in data stream, which specifies the content of the container.

- Network information table (NIT)
- Service information table
- Time and date table

- DVB data broadcasting : Different contents of MPEG-2/DVB containers
  - Data pipe : simple , asynchronous end-to-end delivery of data; data is directly inserted in the payload of MPEG2 transport packets.
  - Data streaming: streaming oriented, asynchronous, synchronized or synchronous end-to-end delivery of data.
  - Multiprotocol encapsulation : transport of arbitary data network protocols on top of the MPEG-2 transport stream.
  - Data carousels : periodic transmission of data.
  - Object – carousels : periodic transmission of objects: platform independent.

  DVB for internet accsess

  Digital Video Broadcasting (DVB) provides the opportunity for high-speed *d*elivery direct to user's homes and offices. Most applications require full duplex communication, and the return path from the user to the Internet will be provided using lower speed terrestrial connections.

  Typical data rates per user are 5-30 Mbits/s for the downlink via satellite and a return channel with 33 kbits/s using standard modem, 64 kbits/s with ISDN.

- Convergence of broadcasting and Mobile communication

- Convergence between digital broadcast and mobile services can be described as a paradigm shift, which will change radio and TV from being a broad 'push' media, in future, to delivering a large amount of segmented channels with targeted 'pull' services customized to mobile users' constant changing demands and uses.

- To enable convergence of digital broadcasting systems and mobile communications system define interaction channels through GSM for DAB and DVB.
- For example, cell phones provide convergence in accessing media, streaming, and email in one device, but movement and usage of those features have become more seamless with time and feedback. Network professionals are also focusing on the security of these systems as the converge