Mobile Computing :—

→ term describing one's ability to use technology while moving.

→ requires wireless network to support outer mobility and handoff from one network to the next network.

→ It is the mobility of physical and virtual objects.

→ Physical objects : wireless devices
Virtual " : data in bits/bytes.

→ User of mob. comp. environment can access data, information and other logical objects from any device in any network while moving.

→ Allows a user to perform a task from anywhere using a computing device in the public, corporate and personal information spaces.

→ ~~The~~ Mob. Comm is a process of communication on a mobile device. It is also tx of data to & from handheld devices.

⇒ Mobile Computing : The computing environment is mobile and moves along with the user.

* Anywhere, anytime information : i.e the information is available anywhere all the time.

* Virtual Home Environment : an environment in a foreign network such that the mobile user can experience the same computing environment as they have at home or corporate computing enviroment.

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switched networks.

→ 2G (Second generation) –

→ 2G uses FDMA and TDMA.

→ 2G services are also called as Personal communications service or PCS in the United States.

1. Personal Digital cellular (PDC) –

→ developed and used exclusively in Japan.

→ It uses TDMA.

→ It uses 25 KHz carrier, π/4DQPSK modulation with 3-timeslot.

2. General Packet Radio Service (GPRS) –

→ 2.5G.
i.e between 2G and 3G.

→ provides moderate speed data transfer by using unused TDMA channels.
e.g. GSM system.

→ GPRS is packet switched i.e multiple users share the same transmission channel only transmitting when they have data to send.

3. GSM (Global system for Mobile Communication) –

→ Originally from Groupe Special Mobile.

→ It is a digital mobile telephony system that is widely used in Europe and other parts of the world.

→ GSM uses TDMA and is most widely used of the 3 digital wireless telephony technologies (TDMA, GSM and CDMA)

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7. Power Management : This field indicates the power of a station after successful transmission of frame.

8. More data : This field is used to indicate a receiver that a sender has more data to send.

9. Wired Equivalent Privacy (WEP) : This field indicates the standard security mechanism of 802.11.

10. Order : If this bit is = set (1), then the received frame must be processed in strict order.

→ Duration ID : Indicating the period of time in which the medium is occupied for frame transfer.

→ Address 1 to 4 : The four address field contains IEEE 802.MAC address.

→ Sequence Control : A sequence number is maintained to filter duplicate frames.

→ Data : MAC frame may contain arbitrary data, which is transferred from sender to receiver.

→ checksum (CRC) : 32-bit checksum is used to protect the frames.

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→ MAC Management :-

→ The MAC Management is responsible for providing the following functionality.

- Synchronization : Function to support finding a wireless LAN, synchronization of internal clock.
- Power Management : Function to control transmitter activity for power conservation without missing a frame.

i.e → switch off transceiver whenever it is not needed.

→ 2 power saving states for a station :
sleep and awake.
buffering of data in senders.

→ If a sender wants to communicate with a power saving station it has to buffer data if the station is asleep.

→ The sleeping station has to wakeup periodically and stay awake for a certain time. During this time, all senders can announce the destinations of their buffered data frames.

Roaming :-

→ Moving between access points is called roaming.
The steps for roaming between access points are

1. A station decides that the current link quality to its access point AP1 is too poor. The station then starts scanning for another access point.
2. Scanning involves the active search for another BSS and can be used for setting up a new BSS. Scanning is of 2 types.
   → Passive scanning means listening into the medium to find other networks.
   → Active scanning comprises sending a probe on each channel and waiting for a response to join the new BSS.
3. The station then selects best access point for roaming based on signal strength and sends an association request to the selected access point AP 2.
4. The new association point AP2 answers with an association response. If the response is successful, the station has roamed to the new access point.
5. The access point accessing an association request indicates the new station in its BSS to the distribution system. The DS then updates its database, which contains the current location of the wireless station.

Mobile IP :—

→ It supports the mobility of host in internet.

→ Supporting mobility is a difficult task as,

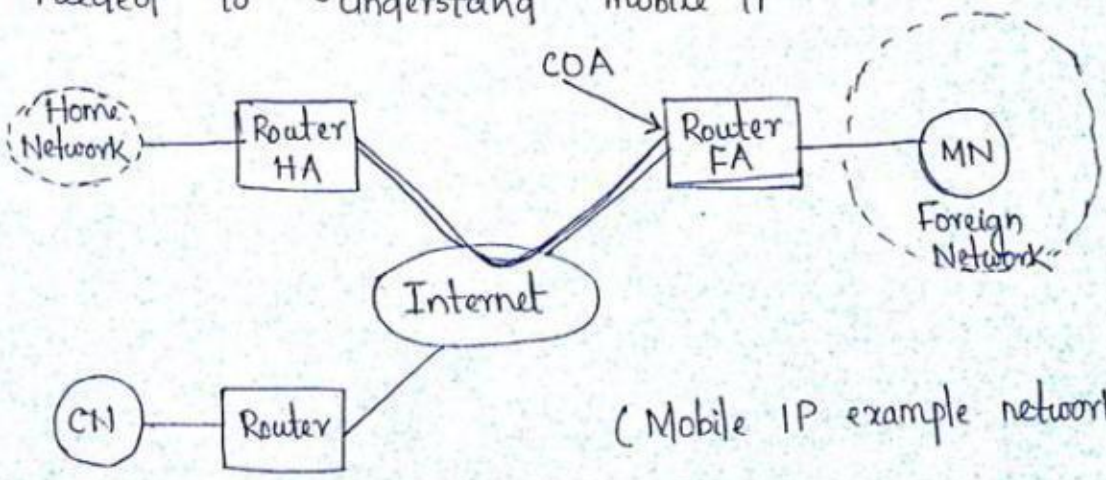
(1) A host sends an IP packet with header containing a destination address and other fields. The destination address not only determines the receiver of the packet, but also physical subnet of the receiver. Routers in the internet look at the destination address of incoming packets and forward them according to look up table.

(2) So moving to a new location means assigning of new address. It is almost impossible to find a host in the internet which has just changed its address. Especially the domain name server (DNS) needs some time before it updates its internal tables.

(3) Routers are built for extremely fast forwarding, but not for fast updates of routing table.

Example of Mobile IP —

→ The following defines several entities and terms needed to understand mobile IP.



(Mobile IP example network)

→ Mobile Node (MN) :—

→ A mobile node is an end-system or router that can change its point of attachment to the internet using mobile IP.

→ The MN keeps its IP address and can continuously communicate with any other system in the internet as long as link-layer connectivity is given.

→ MNs are not necessarily small devices such as laptops with antennas or mobile phones, a router onboard an aircraft can be a powerful mobile node.

→ Correspondent node (CN) :—

→ At least one partner is needed for communication. Here CN represents that partner for MN. The CN can be a fixed or mobile node.

→ Home network —

→ The homenetwork is the subnet the MN belongs to with respect to its IP address.

→ No mobile IP support is needed within the home network.

→ Foreign network —

→ It is the current subnet the MN visits and which is not the home network.

→ Foreign agent (FA) —

→ The FA can provide several services to the MN during its visit to the foreign network.

→ The FA can have the COA acting as tunnel endpoint and forwarding packets to MN.

→ The FA can be the default router for the MN.

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→ FAs can also provide security services because they belong to the foreign network as opposed to the MN which is only visiting.

→ For mobile IP functioning, FAs are not necessarily needed. Typically an FA is implemented on a router for the subnet the MN attaches to.

→ <u>Care of address (COA)</u> :-

→ It defines the current location of the MN from an IP point of view.

→ All IP packets sent to the MN are delivered to the COA, not directly to the IP address of the MN.

→ Packet delivery towards the MN is done using a tunnel.

→ The COA marks the tunnel endpoint, i.e the address where packets exit the tunnel.

→ There are two different possibilities for the location of the COA :

1. Foreign agent COA :

→ The COA could be located at the FA i.e the COA is an IP address of the FA.

→ The FA is the tunnel end-point and forwards packets to the MN. Many MN using the FA can share this COA as common COA.

2. Co-located COA :

→ The COA is co-located if the MN temporarily acquired an additional IP address which acts as COA.

→ This address is now topologically correct, and the tunnel endpoint is at the MN.

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→ co-located addresses can be acquired using services such as DHCP.

→ The problem associated is: the need for additional addresses if MNs request a COA.

→ <u>Home agent (HA)</u> :—

→ The HA provides several services for the MN and is located in the ~~home~~ home network.

→ The tunnel for packets toward the MN starts at the HA.

→ The HA maintains a location registry, i.e it is informed of the MN's location by the current COA.

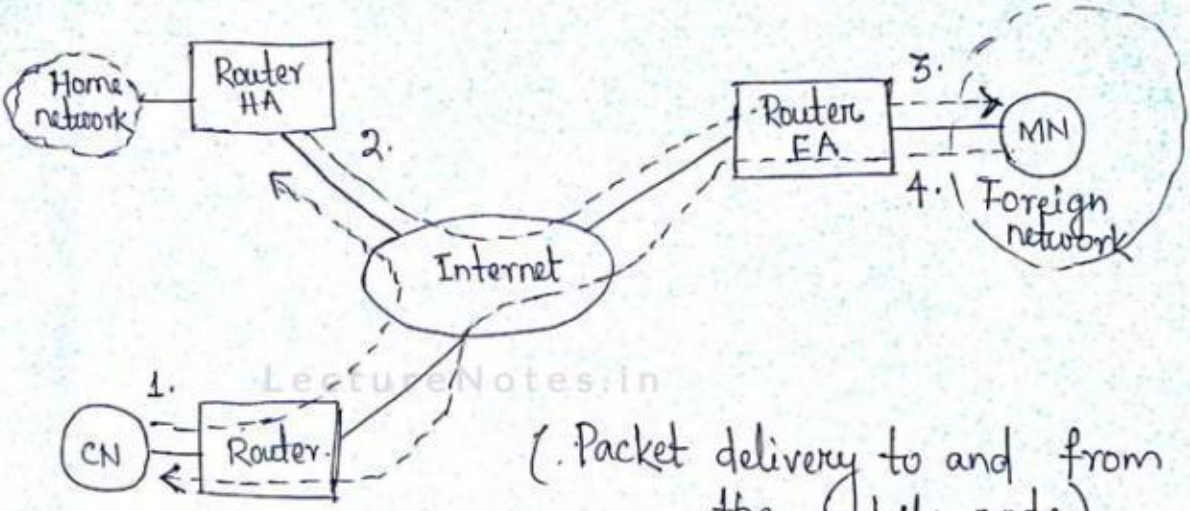
→ Three alternatives for the implementation of an HA exist.

1. The HA can be implemented on a router that is responsible for the home network. ~~This is the best option~~

2. The HA could also be implemented on an arbitrary node in the subnet. One disadvantage of this solution is the double crossing of the router by the packet if the MN is in a foreign network.

3. The HA could be again on the router but this time only acting as a manager for MN's belonging to a virtual home network. All MNs are always in a foreign network with this solution.

IP Packet Delivery :—



(Packet delivery to and from the mobile node)

→ A mobile node (MN) is an end system or router that can change its point of attachment to internet using mobile IP.

→ The ~~printer~~ partner to MN for communication is called correspondent node (CN)

→ The home network is the subnet, to which the MN belongs to with respect to its IP address.

→ Foreign network is the current network the MN visits.

→ Packet delivery steps —

Step 1

→ A CN wants to send an IP packet to the MN. Mobile IP has to support hiding the mobility of the MN.

→ So CN doesnot let ~~to~~ know anything about MN's location. It sends the packet as usual to the IP address.

Step 2

→ The packet ~~router~~ routes the packet to the router responsible

for the home network of MN.

→ The HA gets the information that MN is not present in its home network.

→ Then the packet is not forwarded into the subnet as usual.

→ An extra header is added to the packet containing the address of new network. This process is called encapsulation.

→ Then the packet moves to the foreign network showing the COA as new destination.

Step - 3 :

→ The foreign agent now decapsulates the packet, i.e removes the additional header and forwards the original packet to MN with CN as source and MN as destination.

Step - 4 :

→ The MN sends the packet as usual with its own fixed IP address as source and CN's address as destination.

→ The router with the FA acts as default router and forwards the packet in the same way as it would do for any other nodes in foreign network.

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Agent advertisement and discovery :-

→ The initial problem of an MN after moving is how to find a foreign agent.

→ For this, foreign agents and home agents advertise their presence periodically using special agent advertisement message.

→ These advertisement message becomes the broadcast into the subnet. For these advertisements Internet control message protocol (ICMP) message according to RFC 1256 are used with some mobility extensions.

→ A mobile node (MN) in a subnet can receive agent advertisements from either from its home agent or foreign agent. By this the MN discovers its own location.

→ After advertisements and agent discovery the MN can receive a COA. Then MN moves to registration.

Registration :-

→ After having COA, the MN has to register with HA. The main purpose of registration is to inform the HA of the current location so that the packets intended for the node forwarded to correct destination.

→ Registration is done in following two ways :

(I) If the COA is co-located, the MN sends registration request to the home agent and HA sends registration reply. This procedure is also performed when the MN returns to the home network.

(II) If the COA is at FA, the MN sends its registration request to the FA containing its COA. The FA

→ GSM digitizes and compresses data, then sends it down a channel with two other streams of user data each in its own timeslot.

CDMA 2000 –

→ It is a hybrid 2.5G/3G protocol of mobile telecommunications standards that use CDMA, a multiple access scheme for digital radio, to send voice, data and signaling data between mobile phones and cell sites.

→ CDMA is a mobile digital radio technology that transmits streams of bits and whose channels are divided using codes (PN sequences).

→ CDMA permits many radios to share the same frequency channel.

Enhanced Data Rates for GSM Evolution (EDGE) –

→ Enhanced Data rates for GSM Evolution (EDGE) or Enhanced GPRS (EGPRS) is a digital mobile phone technology that allows to increase data transmission rate and improve data transmission reliability.

→ Uses 2.75G network technology.

→ High speed data applications capable of such as video services and other multimedia.

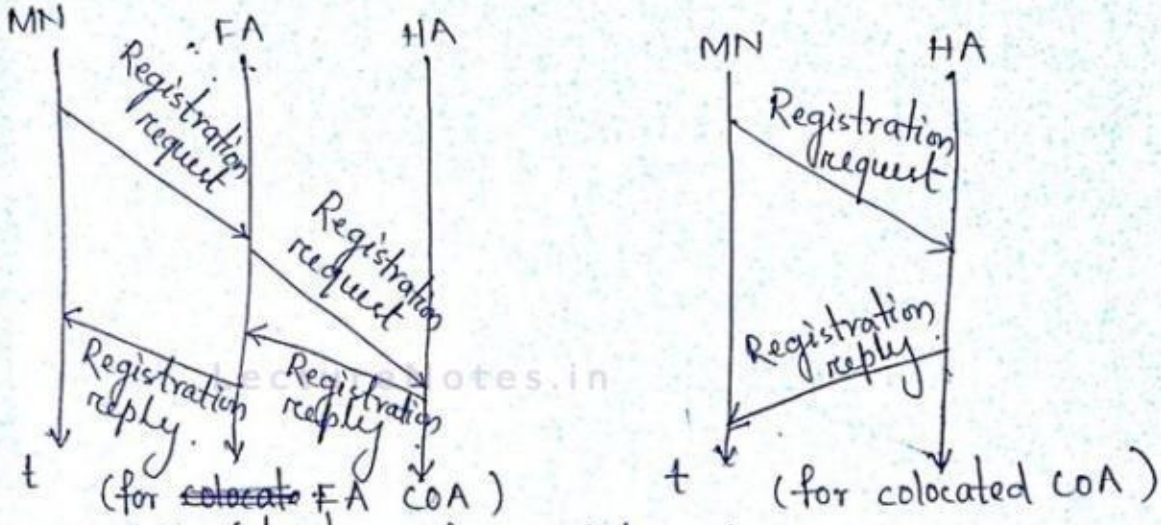
→ 3G (Third Generation) –

→ 3G has the ability to transfer simultaneously both voice data (telephone call) and non-voice data (such as downloading information, exchanging email and instant messaging).

→ First country to introduce 3G is Japan.

uses spread spectrum technique

forwards the request to the HA. The HA now sets up a mobility binding containing mobile nodes home IP address and current CoA.



(Registration of a mobile node via the FA or directly with the HA)

Tunnelling and encapsulation :-

Tunneling :

→ During forwarding packets between HA and CoA a tunnel establishes a virtual pipe for data packets between HA and FA.

→ Here HA is the tunnel entrypoint and FA is the tunnel end point.

→ Packets entering a tunnel are forwarded inside the tunnel and leave the tunnel unchanged.

Encapsulation :

→ Encapsulation is the mechanism of taking a packet consisting of a packet header and ~~data~~ putting it into the data part of the new packet.

→ The reverse operation i.e taking a packet out of the datapart of another packet is called decapsulation.

⑤ WCDMA

→ The International Telecommunication Union (ITU) ~~began studies on the globalization~~ identified 230 MHz of spectrum in the 2GHz band to implement the IMT-2000 system on a worldwide basis for satellite and terrestrial components.

Aim :- is to provide universal coverage enabling terminals to have seamless roaming across multiple networks.

→ The network using WCDMA is called UMTS.

→ UMTS (Universal mobile telecom services) uses WCDMA as radio access technology.

→ This network started evolving from GSM network.

→ The entire network is divided into two subnet.

(I) Radio access network (RAN)

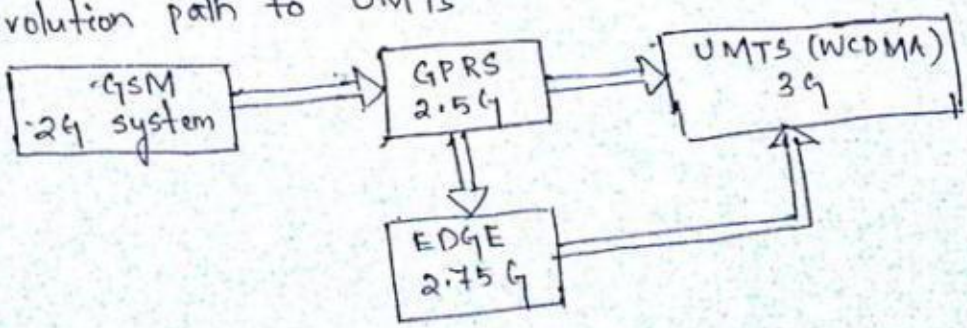
(II) Core network (CN)

→ The first release of UMTS is focused to change the radio access network (RAN).

→ The network for radio access is called as Universal Terrestrial Radio Access Network (UTRAN).

→ The next releases changed the core network to make it all IP network.

→ Evolution path to UMTS



→ The radio access is based on direct-spread (DS) technique with chiprate of 3.84 MHz.

→ It uses a PN sequence to spread the user traffic over the same frequency band of 5MHz.

→ In the receiver side, the same PN code is used to demodulate the data.

→ As it is wider than the conventional CDMA-one system, so it is referred as wideband CDMA (W-CDMA).

→ W-CDMA supports two modes of duplexing.

- FDD and
- TDD to separate the uplink and downlink traffic.

→ For uplink FDD uses 1920 – 1980 MHz and for downlink " 2110 – 2170 MHz band.

→ In TDD different timeslots for uplink and downlink are assigned in same frequency band. It supports asynchronous data transfer.

→ As WCDMA requires a 5MHz spectrum allocation, the RF equipments used for air interface has to be completely changed.

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→ UMTS network Architecture —

→ The major changes is made in radio access network which is based on WCDMA and Asynchronous Mode of Transmission (ATM).

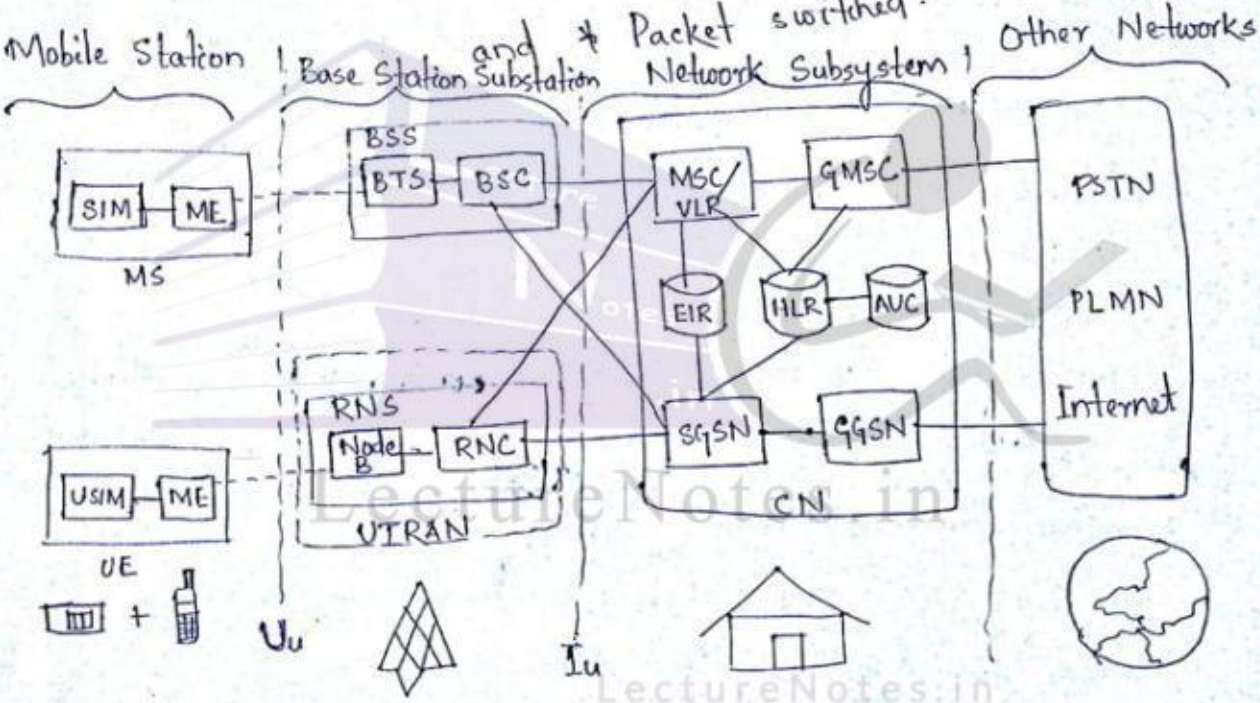
→ The UMTS architecture has 3 main functional entities.

(i) user equipment (UE)

(ii) UMTS (UTRAN)

(iii) Core Network (CN) which is also divided into

* Circuit switched (CS)
* Packet switched.



(UMTS Network Architecture)

→ User Equipment (UE): —

→ UE replaces MS used in GSM/GPRS network.

→ Every UE contains one or more USIM which is a user subscription to UMTS mobile network.

→ It contains all relevant data that enable access into

the subscripted network.

→ USIM is downloadable and can be accessed via air interface and modified by network.

→ It can also store JAVA applications.

Node B :—

→ The base station used in UMTS is known as Node-B which replaces BTS.

→ It provides the physical radio link between the UE and the network.

→ The access technique used by Node B is CDMA and supports high data rates.

→ It performs following tasks

(i) power control

(ii) reports to RNC

(iii) combines the received signal coming from multiple sectors of the antenna.

→ Three types of Node-B are possible.

(i) UTRA-FDD Node B

(ii) UTRA-TDD Node B'

(iii) Dual mode Node B.

→ **Radio Network Controller (RNC) :—**

→ It replaces BSC of GSM/GPRS network. It is interfaced with CS of a GSM core network to handle circuit-switched calls and with SGSN for packet data transport.

→ It is also interconnected to other RNCs which is a new feature in UMTS.

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→ It segrigates the packet switched and circuit switched calls and routes to appropriate location.

→ RNC performs the tasks as admission control, radio bearer management, power control and general management.

3G MSC :-

→ It is much superior than 2G MSC. It has to handle speech across the ATM over the interface for circuit switched connection with adaptive multirate.

→ So a new node is connected between RNC and MSC called interworking functions (IWF) which is responsible for transcoding speech into 64kbps PCM.

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(3)

BLUETOOTH

→ It is an open specification for radio system.

→ It provides the network infrastructure to enable short range wireless communication of data and voice.

→ It comprises of a hardware component and a software component.

→ Bluetooth technology allows users to make adhoc wireless connections between devices like mobile phones, desktop or notebook computers without any cable.

→ It can transfer data at a speed of about 720 Kbps within 50 meters (150 feet) of range or beyond through walls, clothing and even luggage bags.

Bluetooth Protocol :-

→ It consists of a → radio unit
a → link control unit
and → a support unit for link management and host terminal interface functions.

→ The Bluetooth radio is built into a small microchip and operates in a globally available frequency band ensuring interoperability worldwide.

→ It uses the unlicensed 2.4 GHz ISM (Industrial Scientific and Medical) frequency band.

→ There are 79 available Bluetooth channels spaced 1 MHz apart from 2.402 GHz to 2.480 GHz.

→ Depending on the class of the device, a bluetooth radio can transmit upto 100 mW (20 dBm) to minimum of

1 mW (0 dB) of power.

→ It uses frequency hopping for low interference and fading, uses TDD scheme for full duplex transmission and transmits using GFSK modulation.

→ Bluetooth protocol uses a combination of circuit and packet switching.

→ The channel is slotted and slots can be reserved for synchronous packets.

→ Piconet and Scatternet : — (Bluetooth Architecture)

→ Bluetooth supports both unicast (point-to-point) and multicast (point-to-multipoint) connections.

→ It uses the concept of master and slave.

→ In a master-slave protocol a device cannot talk as and when they desire. They need to wait till the time the master allows them to talk.

→ The master and slaves together form a piconet.

→ The master determines the hopping pattern in the piconet and the slaves have to synchronise to this pattern.

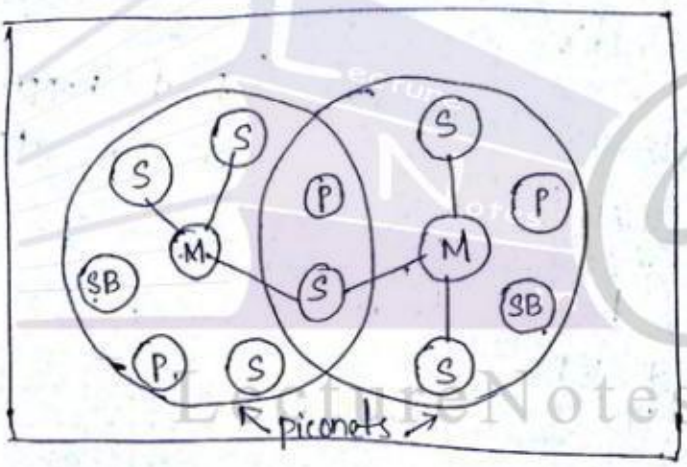
→ Two additional types of devices are also present: Parked (P) and standby (SB).

→ Parked devices cannot actively participate in the piconet but are known and can be reactivated within some milliseconds.

→ Stand-by devices do not participate in piconet.

→ Each piconet has exactly one master and upto seven simultaneous slaves.

→ More than 200 devices can be parked.
→ Several of these piconets can be linked together to form a larger network in an ad hoc manner.
→ The topology can be thought as a flexible, multiple piconet structure. This network piconets are called scatternet.
→ A scatternet is formed when a device from one piconet also acts as a member of another piconet. In this scheme a device being master in one piconet can simultaneously be a slave in the otherone.



(Bluetooth Scatternet as a combination of Piconets)

Radio Architecture –

→ Bluetooth radio is an integral part of a Bluetooth device as it provides an electrical interface for transfer of packets on a modulated carrier frequency using wireless bearer services (CDMA, GSM, DECT).
→ The radio operates in the 2.4 GHz ISM (Industrial Scientific Medicine) band which requires a very small and efficient antenna (smart antenna)

→ a good RF frontend (LNA, Up-converter, down-converter) on chip

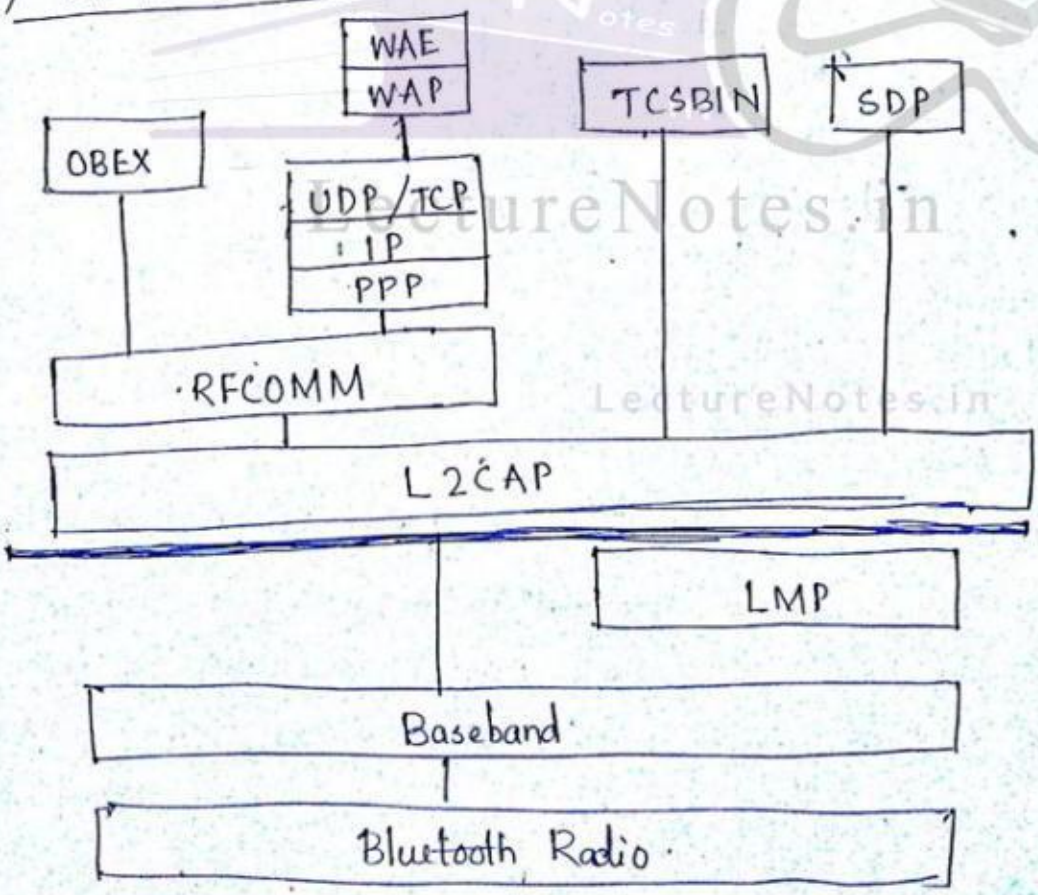
→ power controller

→ GFSK modulator

and → a transmit/receive switch for it work as a transceiver.

→ Transmitter uses GFSK (Gaussian Freq. shift keying) where a binary one is represented by a positive frequency deviation and a binary zero by a negative frequency deviation.

→ Bluetooth Protocol stack :- (Fast hopping rate of 1600 hop/sec)



(Bluetooth Protocol stack)

1. W-CDMA –

→ Wideband Code Division Multiple Access

→ higher speed transmission protocol used in Japanese FOMA system.

→ wideband spread-spectrum mobile air interface using CDMA to achieve higher speeds and support more users.

2. Universal Mobile Telecommunications systems (UMTS) –

→ UMTS using W-CDMA supports upto 14.0 Mbits/s data transfer rates.

→ Types of Wireless Technology –

Wireless technology is broadly divided into 3 types.

1. Wireless LAN - IEEE 802.11
2. Wireless WAN – GSM, CDMA
3. Wireless PAN – Bluetooth.

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→ Bluetooth protocol stack can be thought of combination of multiple application specific stacks.

→ Different applications run over one or more vertical slices from this protocol stack.

→ These are -

RFCOMM (Radio Frequency communication)

TCS Binary (Telephony control specification)

SDP (Service Discovery Protocol).

→ Each application environments use a common datalink and physical layer.

→ Bluetooth protocol stack can be divided in to four basic layers according to their functions.

→ These are -

* Bluetooth Core Protocols comprises of Baseband
* Link Manager Protocol (LMP)
* Logical Link control and Adaptation Protocol (L2CAP)
* and Service Discovery Protocol (SDP)

(1) Baseband :-

→ It is the physical layer of the Bluetooth which manages the physical channels and links.

→ It also provides error correction, hop selection, Bluetooth Security etc.

(2) Link Manage Protocol (LMP) :-

→ It is responsible for link set up with other devices.

→ When the Bluetooth devices come within each other's radio range, the LMP engages itself in peer-to-peer

message exchange.

→ It also provides various security functions.

L2CAP :-

→ It is a data link control protocol on the top of the baseband layer providing logical channels between bluetooth devices.

→ Baseband :—

→ It is the physical layer of the Bluetooth which manages physical channels and links apart from other services like error correction, data whitening, hop selection and Bluetooth security.

→ It lies on the top of Bluetooth radio in Bluetooth stack and essentially acts as a link controller and works with link manager for carrying out link level routines like link connection and power control.

→ It also manages asynchronous and synchronous links, handles packets and does paging and inquiry to access and inquire the Bluetooth device.

→ Baseband transceiver applies a TDD scheme.

→ ACL and SCO links —

→ Baseband handles two types of links:

→ SCO (Synchronous Connection Oriented)

→ ACL (Asynchronous Connection Less) link.

→ The SCO link is a symmetric point-to-point link between a master and a single slave in the piconet.

→ The master maintains the SCO link by using reserved slots at regular intervals (circuit switched type). It mainly carries voice information.

→ The master can support upto 3 simultaneous SCO links while slaves can support 2/3 SCO links. SCO packets are used for 64KB/s speech transmission.

→ The ACL link is a point-to-multipoint link between the master and all the slaves participating on the piconet.

→ Only a single ACL link can exist. For most ACL ~~pakets~~ packets packet retransmission is applied.

→ Logical channels :—

→ Bluetooth has 5 logical channels to transfer different types of information.

→ LC (Logical control) and LM (Link Manager) channels are used in the link level while UA, UI and US channels are used to carry asynchronous, isosynchronous and synchronous use information.

→ Bluetooth Addressing :—

→ There are basically four types of device addresses in Bluetooth :

* BD_ADDR : 48 bit Bluetooth device address. It is divided into LAP, UAP and NAP.

* AM_ADDR : 3bit active member address used for broadcasting messages.

* PM-ADDR : 8-bit member address that is assigned to parked slaves.

* AR_ADDR : The access request address is used by the parked slave to determine the slave-to-master half slot in the access window it is allowed to send access messages.

→ Bluetooth Packets :—

→ The data on the piconet channel is conveyed through packets.

- The general packet is ~~show~~ as below :

ACCESS CODE (72)	HEADER (54)	PAYLOAD (0-2754

(Bluetooth Packets)

→ Access code is used for timing synchronization, offset compensation, paging and inquiry.

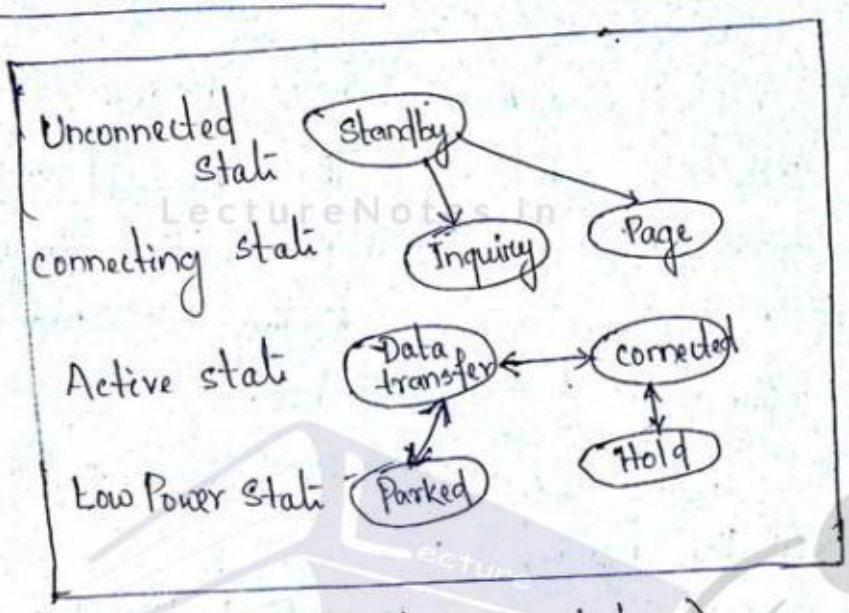
→ 3 types of access code are there
- channel Access code (CAC) - identifies a piconet
- Device Access code (DAC) - paging and its responses
and - Inquiry Access code (IAC) - inquiry purpose.

→ The header contains information for packet acknowledgement, packet numbering for out of order packet reordering, flowcontrol, slave address and

error check for header.

→ The packet payload can contain either voice field, data field or both.

→ Controller states :—



(Bluetooth controller states)

→ Bluetooth controller operates in two major states ;

→ standby

→ connection

→ There are seven substates which are used to add slaves or make connections in the piconet. These are page, page scan, inquiry, inquiry scan, master response and inquiry response.

→ The standby state is the default low power state in the Bluetooth unit. Only the native clock is running and there is no interaction with any device whatsoever.

→ In the connection state, the master and slave can exchange packets using the channel (master) access

code and the master Bluetooth clock.

→ The hopping scheme used is the channel hopping scheme.

→ A connection between two devices occurs in the following fashion.

→ First, master uses the GIAC and DIAC to inquire about the Bluetooth devices in the range. If any nearby Bluetooth device is listening for these inquiries it responds to the master by sending its address and clock information to the master.

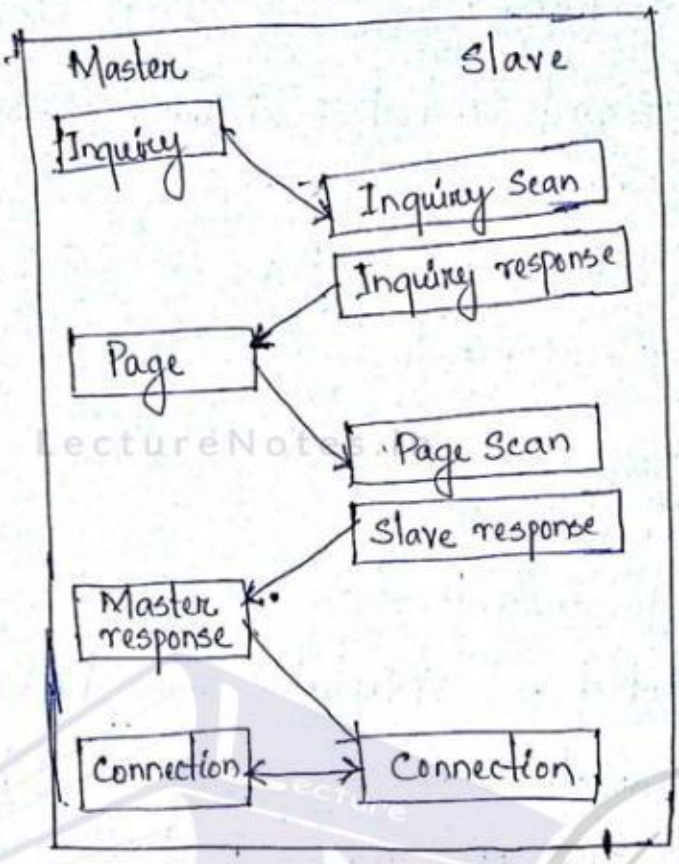
→ After sending, the slave starts listening for page message from the master.

→ The master after discovering the bluetooth devices may page these devices for connection set up.

→ The slave in pagescan mode if paged by this master will respond with its device access code (DAC).

→ The master after receiving the response from the slave may respond by transmitting the master's real time clock, master's BD_ADDR, the BCH parity bits and the class of the device (FHS packet).

→ After slave has received this FHS packet, both enter into connection state.



(Connection setup between master and slave)

→ Link Manager Protocol (LMP) :-

→ Link manager is used for managing the security, link set up and control.

→ It talks to the other link manager to exchange information and control messages through the link controller using some predefined link-level commands.

→ When two Bluetooth devices come within eachother's radio range, link managers of either device discover each other.

→ LMP then engages itself in peer-to-peer message exchange.

→ Functions of Link Manager :-

* Administration and control of all link actions.
* Monitoring state changes.
* Monitoring transmission modes
* Monitoring synchronization.
* Device Pairing
* Handling data encryption
* Handling device authentication..

→ Logical Link Control and Adaptation Protocol (L2CAP) :-

→ It provides connection-oriented and connectionless data services to upperlayer protocols with protocol multiplexing capability, segmentation and reassembly operation and group abstractions.

→ It permits higher level protocols and applications to transmit and receive L2CAP packets upto 64 Kilobytes in length.

→ L2CAP only supports ACL links.

→ Service Discovery Protocol (SDP) :-

→ It enables a Bluetooth device to join a piconet.

→ Using SDP a device inquires what services are available in a piconet and how to access them.

→ SDP uses a client server model, where the server has a list of services defined through service records.

→ Cable Replacement Protocol :-

→ This protocol stack has only one member, e.g. Radio Frequency communication (RFCOMM).

→ RFCOMM :-

→ This is a serial line communication protocol and is based on ETSI 07.10 specification.

→ The cable replacement protocol emulates RS-232 control and data signals over Bluetooth baseband protocol.

→ It provides a reliable data stream, multiple concurrent connections, flow control and serial cable line settings.

→ Telephony Control Protocol :-

→ It consists of two protocol stacks namely Telephony control specification Binary (TCS BIN) and the AT-commands.

→ TCSBIN is a bit oriented protocol which defines the call control signaling protocol for set up of speech and data calls between Bluetooth devices.

→ It defines a set of AT-commands by which a mobile phone can be used and controlled as a modem for fax and data transfers.

AT – Attention.

→ Adopted Protocols —

→ PPP, TCP/IP :-

These are standard Internet protocols defined by IETF. These are used as the lower layer protocols of the WAP stack.

→ OBEX :-

It is a session protocol defined by IrDA. This protocol is also utilized by bluetooth thus enabling the possibility for application to use either the Bluetooth radio or IrDA technologies.

→ WAP/WAE :-

Bluetooth may be used as a bearer technology for transporting between a WAP client and a nearby WAP server.

→ WAP operates on top of the bluetooth stack using PPP and the TCP/IP protocol suite.

Circuit Switching : — Radio frequency (3kHz to 300GHz)

→ It establishes a dedicated radio channel between transmitter and receiver for the entire duration of the call.

→ It provides a connection-oriented service.

→ It is best suited for dedicated voice-only traffic where data is continuously sent over long period of time

→ Wireless datanetworks are not well supported by circuit switching due to their short, brusty transmission which are after followed by period of inactivity. Often the time required to establish a circuit exceeds the duration of data transmission.

Packet Switching (Virtual Switching) —

→ It is a connectionless service where there is no dedicated connection (radio resource) for entire duration of the call.

→ It allows a large no. of data users to remain virtually connected to the same physical channel of the network.

→ The packet switching break the entire message into smaller units for transmission and recovery called packets.

→ when a message is broken into packets a certain amount of control information is added to each packets to provide source and destination ~~identi-~~ identification, as well as error recovery provision.

LectureNotes.in

WLL (Wireless Local Loop) :-

→ provides two-way calling services to the stationary or fixed users, which is intended to replace its wireline counterpart.

→ This system connects a subscriber to PSTN using wireless technology and use radio signals to provide standard telephone service.

→ It is a broadcast connection system that uses high frequency radio links to deliver voice and data without fiberoptic cables.

Configuration :-

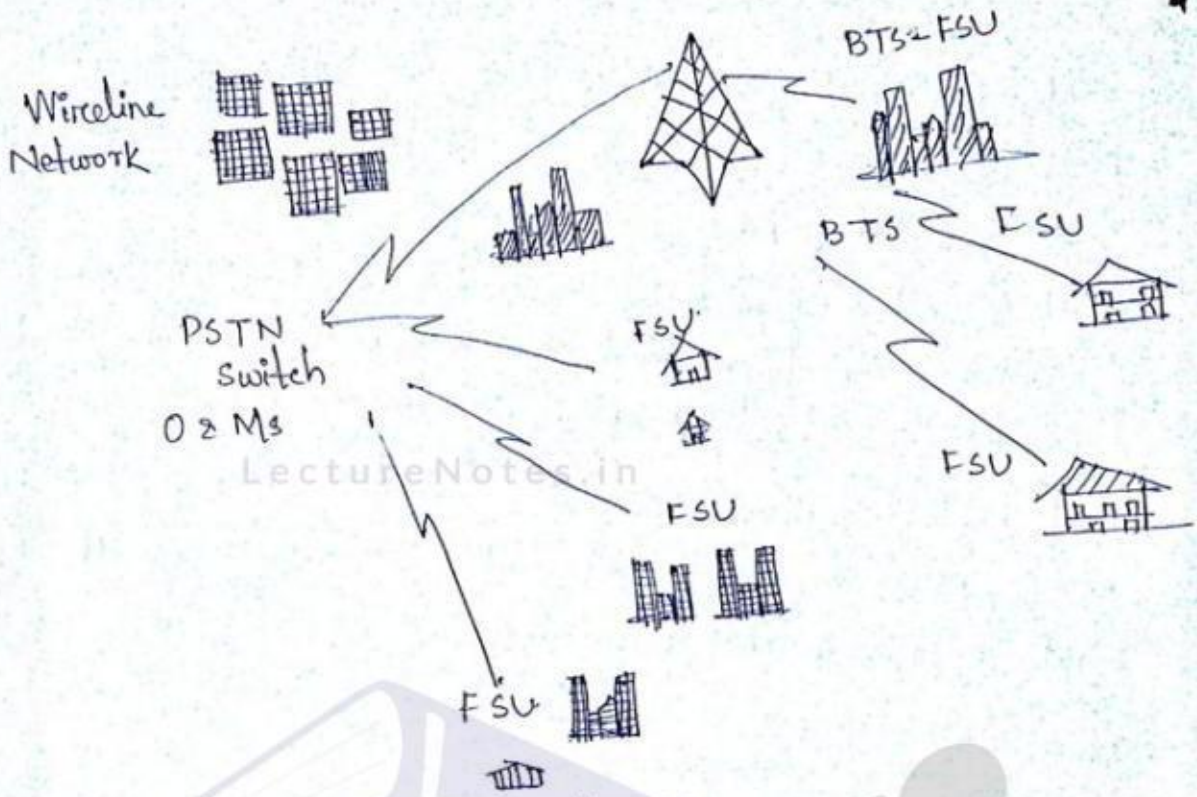
→ A WLL system provides service for one or more shells. Each shell includes a BS antenna mounted on top of a building. Individual subscriber has a fixed antenna mounted on a building that has an unobstructed line of connection to base antenna.

→ From BS link $\xrightarrow[\text{wireless}]{\text{wired/}}$ switching center

→ Switching center is typically a telephone company local office which provides connection to local and long distance telephone network.

→ WLL uses (OFDM) orthogonal frequency division multiplexing technology for data transmission.

LectureNotes.in



(WLL Configuration)

<u>FSU</u>

→ The fixed subscriber unit (FSU) is an interface between subscriber's wired devices and WLL network.

→ The wired devices can be computers or facsimiles as well as telephones.

→ FSU can be acronymed as RSU (Radio subscriber unit) or HFWNIU (Hit fixed wireless network interface unit).

→ FSU performs channel coding/decoding, modulation/demodulation; and transmission/reception of signal via radio, according to the air interface specification.

→ FSU also performs the source coding/decoding.

→ It also supports the computerized devices to be

connected to the network by using voice-band modems or dedicated data channels.

→ FSU is integrated with the handset or it can be a high capacity centralized FSU serving more than one subscriber.

→ The BS is implemented usually by two parts, the base station transceiver station (BTS) and the base station controller (BSC).

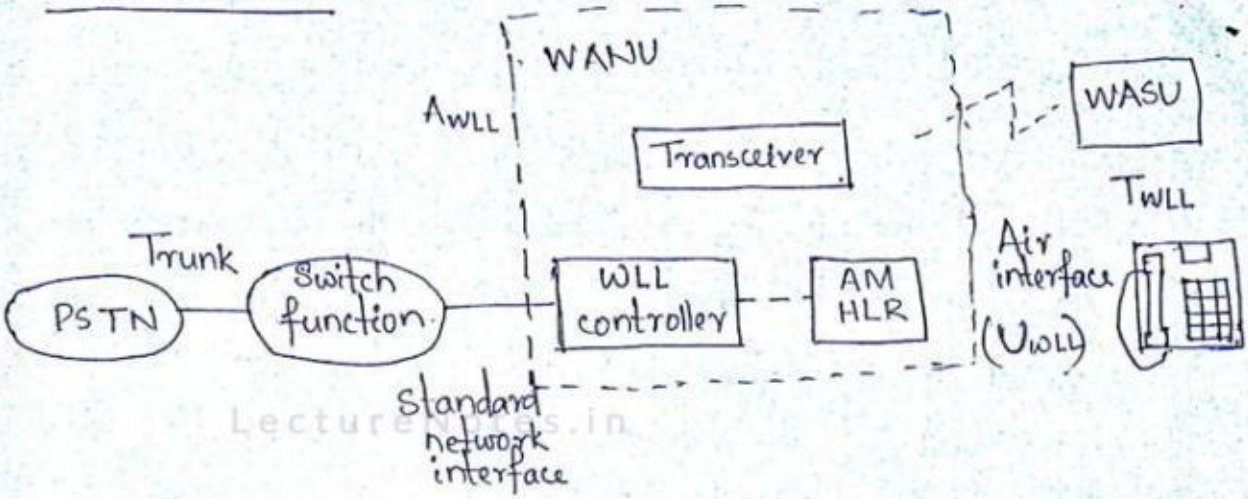
→ BTS performs channel coding/decoding and modulation/demodulation as well as transmission/reception of signal via radio.

→ BSC controls one or more BTSs and provides an interface to the local exchange (switch) in the central office.

→ An important role of BSC is to transcode between the source codes used in wired network and that at the air-interface. From the above roles, a BSC is often called the radio port control unit (RPCU) or the transcoding and network interface unit (TNIU).

LectureNotes.in

Architecture :—



(WLL Architecture)

→ Here,
Wireless access network unit (WANU) consists of the
* Base station transceivers (BTS) or radioports (RP)
* the radio controller (RPCU)
* an access manager (AM)
* and home location register (HLR)

→ A_{WLL} → ~~switch~~ interface between the WANU and the switch.

→ U_{WLL} → the air interface between the WANU and the user side.

→ The WANU provides → the authentication and privacy of the air interface
→ radio resource management
→ limited mobility management
→ and over the air registration of subscriber units (SUs).

→ It is also required to provide
- Operation and Maintenance (OAMP)
- routing, billing and switching functions as appropriate or necessary.

→ The WANU also provides protocol conversion and transcoding of voice and data.

→ WASU – (Wireless Access Subscriber Unit) provides an air interface towards the network and a traditional interface T_{WLL} to the subscriber.

→ This interface includes protocol conversion and transcoding, authentication functions, local power, OAMP, dual tone multifrequency (DTMF), dialtone.

→ In this reference model the switching fabric (SF) can be a digital switch with or without Advanced Intelligent Network (AIN) capability, an ISDN switch or a mobile switching center (MSC).

→ The architecture consists of 3 major components.

1. WANU (Wireless Access Network Unit)
2. WASU (Wireless Access Subscriber Unit)
3. SF (Switching Fabric)

→ 1. WANU (Wireless Access Network Unit) –

→ It consists of several BST or radio parts, a RPCU (Radio port control unit), an AM (access Manager, Responsible for working of RPCU), a HLR.

→ It is responsible authentication, air registration of subscriber.

→ It may also be required to provide OAM, routing, billing, switching, protocol conversion. Trans-coding of voice and data.

→ 2. WASU (Wireless Access Subscriber Unit) —

→ It provides an air interface 'UWIL' towards network and 'TWIL' interface towards subscriber.

→ It is responsible for voice trans-coding authentication and signaling function.

→ 3. SF (Switching Fabric) —

→ It is associated with a switch that can be a digital switch, MSC, ISDN switch.

→ The transmission between WANU and SF can be leased line, microwave or optical fiber.

→ Switch is connected to WANU through "AWIL" interface.

→ WLL Technologies :-

→ WLL is based on one of the 4 categories.

1. Satellite - Based systems
2. Cellular - Based systems
3. Low - Tier PCS or Microcellular - Based Systems
4. Fixed Wireless Access Systems.

1. Satellite - Based Systems -

→ These systems provide telephony services for rural communities and isolated areas such as islands.

→ It is of 2 types.

* Technology designed specifically for WLL applications.
* Technology piggybacked onto mobile satellite systems as an adjunct service.

→ The technology for WLL applications offers quality and grade of service comparable to wireline access, but it may be expensive.

→ The piggybacked technology promises to be less costly but due to bandwidth restrictions, may not offer the quality and grade of service comparable to plain old telephone service (POTS).

e.g. HNS telephony earth station (TES) technology.

2. Cellular - Based Systems —

→ These systems provide large power, large range, medium subscriber density and medium circuit quality WLL services.

→ Cellular WLL technologies are primarily used to expand the basic telephony services.

→ Typically they operate in the mobile frequency bands at 800 - 900 MHz, 1.8 - 1.9 GHz and sometimes at 450 MHz or 1.5 GHz.

→ This approach offers both mobility and fixed wireless access from the same cellular platform.

3. Low - Tier PCS or Microcellular - Based Systems -

→ It provides low power, small range, high subscriber density and high circuit quality WLL services.

→ These technologies are considered to facilitate rapid market entry and to expand the capacity of the existing infrastructure.

→ They are typically operated at 800 MHz, 1.5 GHz, 1.8 GHz and 1.9 GHz frequency bands.

4. Fixed Wireless Access Systems —

→ These systems are proprietary radio systems designed specifically for fixed wireless applications, which may or may not be extensible to PCS or cordless.

→ Disadvantage: its limitation on toll quality voice and signaling transparency.

INTERNATIONAL MOBILE TELECOMMUNICATION (IMT2000) —

→ It is known as 3G or 3rd Generation.

→ It is a family of standards for mobile telecommunications defined by the International Telecommunication Union, which includes EDGE, UMTS and CDMA2000 as well as DECT and WiMAX.

→ Services include wide area wireless voice telephone, video calls and wireless data, all in a mobile environment

→ 3G allows simultaneous use of speech and dataservice and higher dataratates (upto 14.0 Mbit/s on downlink and 5.8 Mbit/s on uplink).

→ IMT200 is the global standard for 3rd generation mobile communication.

→ Vision :—

→ Common worldwide spectrum.

→ Multiple radio environment (LAN, satellite, cordless, cellular)

→ Worldwide roaming capability.

→ High quality, enhanced security and performance.

→ small terminal for worldwide use.

→ Integration of satellite and terrestrial system.

→ Services Provided —

→ High bearer rate capabilities.

→ 2Mbps for fixed environment.

→ 384 kbps for indoor and outdoor pedestrian environment.

→ 144 kbps for vehicular environment.

→ Standardization work –

→ Europe – ETIS – UMTS (Universal Mobile Telecommunication system)

→ Japan – ARIB (Association of Radio Industries and Business) – WCDMA

→ USA – TIA (Telecom Industry Association) – CDMA 2000

→ Features

→ Data rates :-

→ Min datarate of 2Mbit/s for stationary or walking users

→ 384 kbit/s in a moving vehicle.

→ Security :-

→ greater degree of security than 2G predecessors.

→ uses KASUMI block crypto instead of older A5/1 stream cipher.

→ end-to-end security is offered.

→ Applications –

→ Mobile TV :- A provider redirects a TV channel directly to the subscriber's phone where it can be watched.

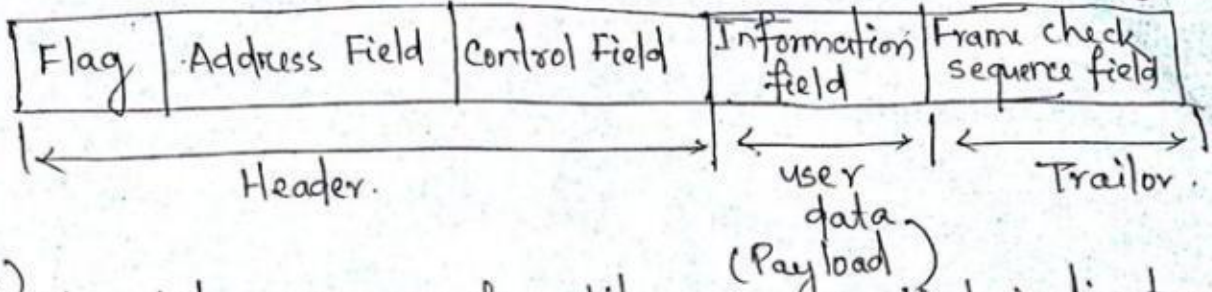
→ Video on demand :- A provider sends a movie to the subscriber's phone.

→ Video conferencing :- subscribers can see as well as talk to each other.

→ Tele-medicine :- a medical provider monitors or provides advice to the potentially isolated subscriber.

LectureNotes.in

→ The structure of transmitted packets are as shown:



(a) → Flag bits are specific bit sequence that indicates the begining and end of each packet.

→ (b) The address field contains source and destination address.

→ (c) The control field defines some specific functions like acknowledgement, automatic repeat requests (ARQs) and packet sequencing.

→ (d) Frame cheak sequence field is used for error detection.

→ The receiver assembles the packets in proper sequence and produces the entire information.

→ In packet switching the channel is utilized only for transmitting brusts of information showing excellent channel efficiency.

LectureNotes.in

→ Location-based services :- a provider sends localized weather or traffic conditions to the phone or the phone allows the subscriber to find nearby businesses or friends.

→ Spectrum allocation for IMT 2000

1. 1885 – 2025 MHz and 2110 – 2200 MHz as coreband.
2. 1710 – 1885 MHz and 2500 – 2690 MHz as additional band.

→ Fundamental changes in IMT2000 –

(1) In radio access point of view : Higher data rates.
- 144 kbps at vehicular speed.
- 384 kbps at pedestrian speed.
- 2 Mbps at fixed location.

(2) In network point of view : Addition of packet switched (PS) service.

→ Path from 2G to 3G :-

(1) Evolutionary upgradation of GSM/GPRS to TDMA single-carrier (IMT-SC) popularly known as EDGE. Its 3.5G version is EDGE evolution.

(2) Evolutionary upgradation of IS-95 (CDMA one) to CDMA multi-carrier (IMT-MC) popularly known as CDMA 2000. Its 3.5G version is EV-DO and the pre 4G version is UMB.

(3) Revolutionary upgradation of GSM family to CDMA Direct spread (IMT-DS) popularly known as UMTS and its technology is WCDMA. Its 3.5G version is HSPA and pre 4G version is LTE.

LectureNotes.in

W-CDMA :—

→ Wideband codedivision multiple access (W-CDMA) is the main access technology to be implemented in 3G cellular systems.

→ The radio access technology is Direct-sequence spread spectrum (DSSS).

→ Each user is spreaded upto 5 MHz bandwidth with chiprate of 3.84 MHz.

→ W-CDMA supports multi-rate transmission of signals by spread factor control.

→ The network using W-CDMA is called UMTS.

→ Key features of WCDMA processing units are as follows.

* Asynchronous base stations
* chipping rate of 3.84 MHz
* Multirate transmission of signals by spread factor control.
* Use of variable data rates.

→ PROTOCOL ARCHITECTURE :—

→ The protocol architecture consists of 3 layers

1. L1 - Physical layer
2. L2 - Datalink layer
3. L3 - Network layer.

→ The physical layer of WCDMA uses DSSS technique.

→ It supports 2 modes of operation like TDD and FDD.

→ offers different transport channels to MAC.

LectureNotes.in

→ Transport channel is characterized by how info is transferred over radio interface.

→ Logical channel is characterized by type of information transferred.

→ L2 is split into following sublayer: RLC, MAC, PDCP, BMC.

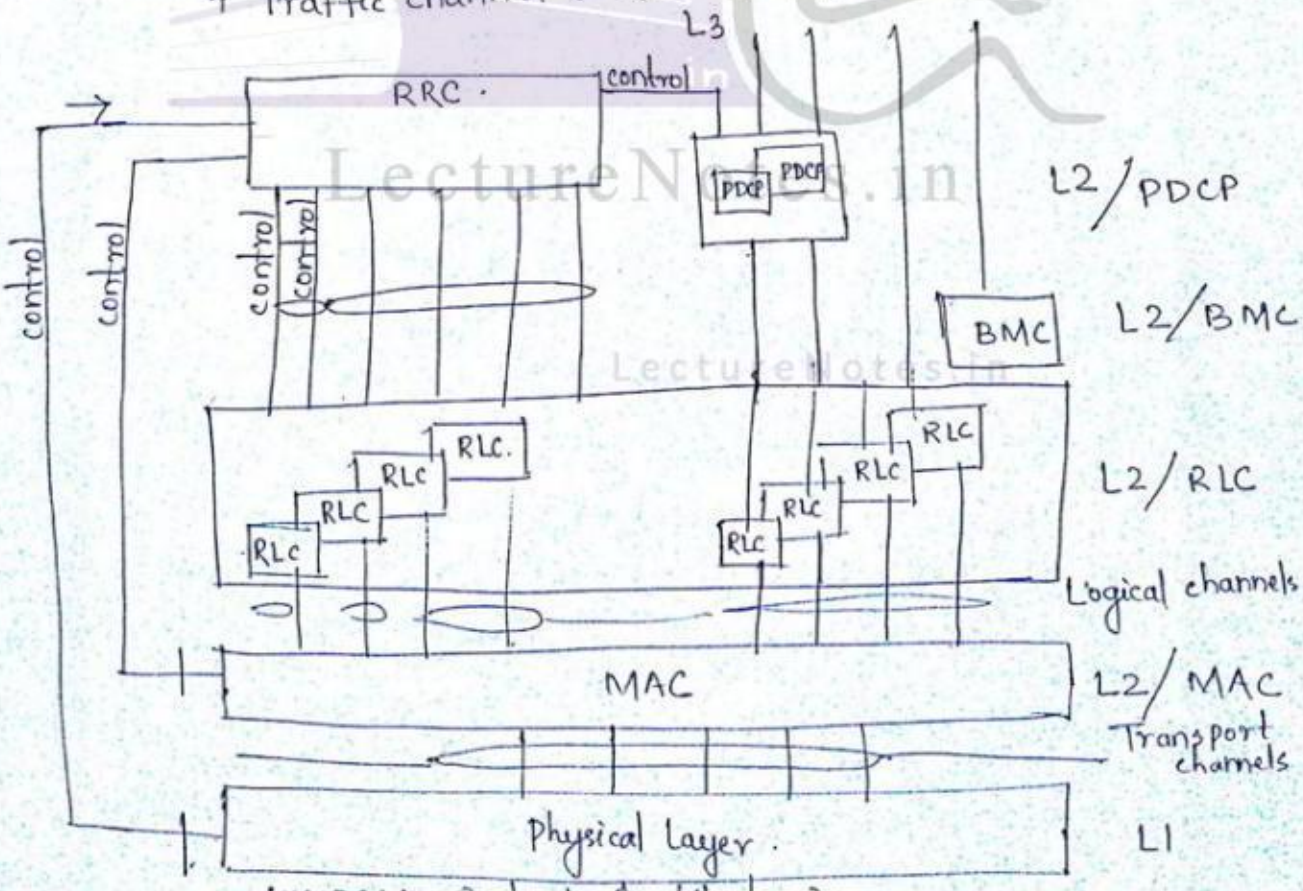
→ Logical Channels —

→ MAC layer provides data transfer services on logical channel.

→ Each Logical channel type is defined by the type of information that is transferred.

→ Logical channels are classified into two groups.

* Control channel : to transfer control information
* Traffic channel : to transfer user information.



(WCDMA Protocol Architecture)

→ Logical Control channels —

→ Logical control channels are as follows.

	Use	
1. Broadcast control channel (BCCH)	— Broadcasting system control information	— Downlink channel.
2. Paging control channel (PCCH)	— to know location cell of the mobile station in the cell connected state	— Downlink channel.
3. Common control channel (CCCH)	— transfer control inform^n between network and mobile stations	— Bidirectional channel.
4. Dedicated control channel (DCCH)	— transfer control inform^n between MS and network	→ point-to-point bidirectional channel
5. ODMA common control channel (OCCCH)	— transmits control information between MSs	— Bidirectional channel.
6. ODMA Dedicated control channel (ODCCH)	— transmits control information between MSs	— Point-to-point bidirectional channel.

→ Logical Traffic channels —

1. Dedicated Traffic Channel (DTCH) :-

Point to point channel, dedicated to one mobile station for the transfer. DTCH can exist both in uplink and downlink

2. ODMA Dedicated Traffic Channel :-

Point-to-point channel, dedicated to one mobile station for the transfer. DTCH can exist both in uplink and downlink.

→ An ODTCH exists in relay link.

→ Transport channels —

→ It is defined by how and with what characteristics data is transferred over the air interface.

→ 2 types of transport channels:

1. Dedicated channels
2. Common channels

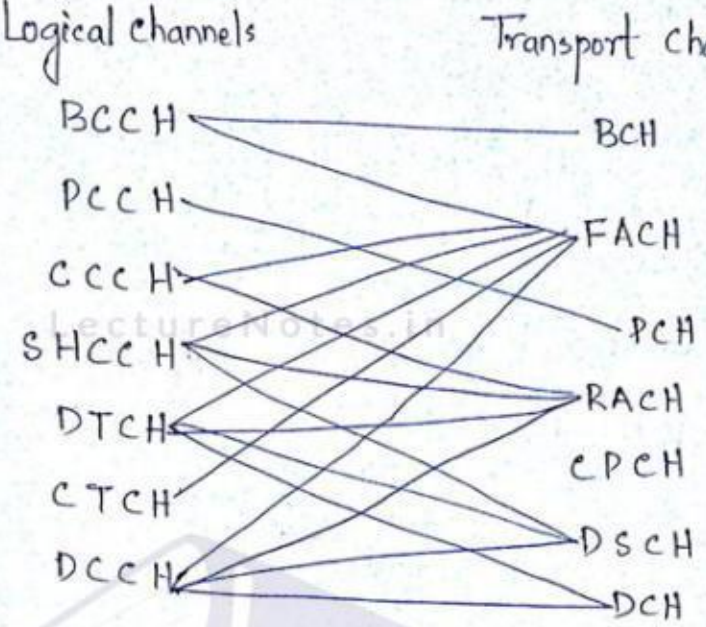
→ There is one dedicated transport channel i.e DCH.

→ Common Transport channels

1. Broadcast channel (BCH) → (Downlink) → used to broadcast system and cell specific information.
2. Forward access channel (FACH) → (Downlink) → Transmitted over entire cell using beam forming antennas.
3. Random access channel (RACH) → (uplink) → received from the entire cell.
4. Common packet channel (CPCH) → (uplink) → for transmission of bursty data traffic.
5. Downlink shared channel (DSCH) → (Downlink) → shared by several mobile stations.
6. Paging channel (PCH) → (Downlink) → transmitted over entire cell.

LectureNotes.in

→ Mapping between logical and transport channels →



→ Physical channel

→ The transport channels are mapped on the physical channel.

→ A timeslot is a unit which consists of field containing bits. The no. of bits/timeslot depends on the physical channel.

→ Normally physical layer consists of 2 uplink and one downlink channel.

→ Uplink Physical Channels —

→ There are 2 uplink dedicated and 2 common physical channels.

1) The uplink dedicated physical datachannel (uplink DPDCH) and the uplink dedicated physical control channel (uplink DPCCH).

(2) The physical random access channel (PRACH) and physical common packet channel (PCPCH)

LectureNotes.in

→ DPDCH → used to carry dedicated data generated at L2 and above.

DPCCH → used to carry control information generated by Layer-1.

PRACH → used to carry the RACH.

PCPCH → used to carry the CPCH transport channel.

→ <u>Downlink Physical channels</u> —

→ There is one downlink dedicated physical channel, one shared and 5 common control channels.

1. Downlink dedicated physical channel (DPCH)
2. Primary downlink shared channel (DSCH)
3. Primary and secondary common pilot channels (CPICH)
4. Primary and secondary common control physical channels (CCPCH)
5. Synchronisation channel (SCH)

→ DPCH → transmitted time multiplexed with control information generated at Layer L.

DSCH → shared by users based on code multiplexing.

CPICH → carries a predefined bit/symbol sequence. It is of 2 types.

<u>Primary CPICH</u>: There exist one primary CPICH per cell. It is broadcasted over the entire cell.

→ Secondary CPICH : There may be zero, one or more secondary CPICH. They are broadcasted over only a part of the cell.

→ CCPCH : used to carry BCH.

2 types of CPCCH.

→ Primary CPCH : It is used to carry BCH.

→ Second CPCH : It is used to carry FACH and PCH

→ Synchronisation channel (SCH) :

used for searching the cell.

→ It consists of 2 subchannels.

→ Primary SCH : consists of a modulated code of length 256 chips.

→ Secondary SCH : consists of repeatedly transmitting a length 15 sequence of modulated codes of length 256 chips.

LectureNotes.in

CDMA 2000 –

→ It is a family of 3G mobile technology standards which use CDMA channel access to send voice data and signaling data between mobile phones and cell sites.

→ It is also known as IMT Multi Carrier (IMT MC).

→ CDMA2000 specification was developed by the Third Generation Partnership Project2 (3GPP2).

→ Mobile data communications at speeds ranging from 144 Kbps to 2Mbps.
→ 144 kbps at mobile speed.
→ 384 kbps at pedestrian speed
→ 2 Mbps at fixed location.
→ High resolution video and multimedia services.

→ **Protocol Architecture** –

→ In CDMA2000, four different protocols are specified.

1. Physical layer – Layer 1
2. MAC sublayer – Layer 2
3. Link Access Control (LAC) sublayer (Layer 2)

→ **CDMA 2000 Physical Layer (Layer 1)** –

→ It is responsible for

* transmitting and receiving bits over the physical medium
* carrying out coding functions to perform error control at the bit and frame levels.

→ CDMA2000 has proposed two kinds of multiplexing FDD and TDD.

LectureNotes.in

→ Physical channels are distinguished in two groups.

* Dedicated Physical channel (DPHCH)
* Common Physical channel (CPHCH)

→ CDMA2000 MAC sublayer —

→ In MAC sublayer, there are 4 different entities.

* Radio Link Protocol (RLP)
* Signaling Radio Burst Protocol (SRBP)
* Common channel multiplex sublayer
* Dedicated channel Multiplex sublayer.

→ The RLP handles user packet data and it performs in the dedicated channel multiplex sublayer.

→ The SRBP handles common channel signaling using the radio burst techniques.

→ The common channel multiplex sublayer performs the mapping between the logical ~~contro~~ common channels.

→ Dedicated channel multiplex sublayer performs the mapping between the logical dedicated channel (i.e those channels are dedicated to specific users) and the physical dedicated channels.

LectureNotes.in

OSI Model :- (APSTNDP)
(Open Systems Interconnection)

Application
↓
Presentation
↓
Session
↓
Transport
↓
Network
↓
Datalink
↓
Physical

TCP/IP :-

Application
↓
TCP or UCP
↓
IP
↓
Datalink
↓
Physical.

LectureNotes.in

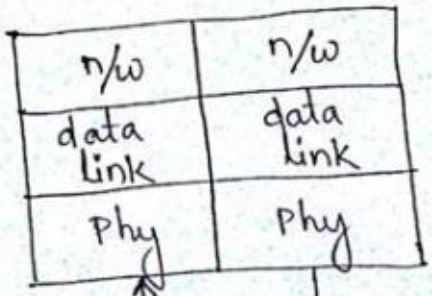
X.25 protocol

S

Application
↓
Transport
↓
Network
↓
Datalink
↓
Physical

D

Application
↓
Transport
↓
Network
↓
Datalink
↓
Physical



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→ CDMA2000 LAC Sublayers

→ The signaling LAC entity provides a data link protocol. It ensures that signaling data generated by the upper layers are correctly delivered across the air link.

→ It is also responsible for the delivery of user packet data across air interface.

→ Both LAC and RLP are implementing datalink protocol but the difference is,

* RLP provides a best effort transport of user packet data whose delivery is not allowed.
* LAC provides a reliable delivery of signaling data, as the signaling data is very important to protect in any communication network to ensure a smooth operation.

→ Spectrum allocation for IMT 2000

→ 1885 - 2025 MHz and 2110 - 2200 MHz as coreband.

→ 1710 - 1885 MHz and 2500 - 2690 MHz as additional band.

→ ~~866~~ 806 - 960 MHz as additional band.

→ Voice and Data channel ~~(F-FCH)~~ —

→ CDMA 2000 forward traffic channel has following physical channels.

(i) Fundamental channel (F-FCH) — (Forward control channel)

→ It can support data, voice or signaling multiplexed with one another at any rate from 750 bps to 14.4 Kbps.

(ii) Supplementary channel (F-SCH) — (for shared channel)

→ It supports high data rate services. The n/w may schedule transmission on the F-SCH on a frame by frame basis.

(iii) Dedicated control channel (F-DCCH) — (For Dedicated control channel)

→ It is used for signalling or bursty data sessions.

→ Benefits of CDMA 2000 :-

1. Increased voice capacity :- CDMA 1X supports 3G traffic channels per sector per RF (26 Erlangs/sector/RF) using EVRC (Enhanced Variable Rate coder) Vocoder.

2. Higher data throughput :-
CDMA 2000 1X network support peak data rate of 153.6 kbps.
CDMA 2000 1X EVDO supports peak data rate of 2.4 Mbps in 1.25 MHz RF bandwidth.

WML (WIRELESS MARKUP LANGUAGE) —

→ WML was designed to describe the content and format for presenting data on devices with limited bandwidth, limited screen size and limited user input capability.

→ It is designed to work with telephone keypads, stylus and other input devices common to mobile, wireless communication.

→ WML permits the scaling of displays for use on two-line screens found in some small devices as well as the larger screens found on smartphones.

→ Ordinary PC uses HTML (Hypertext Markup Language).

→ To translate HTML coded webpage into WML with content and format suitable for wireless devices, much of the information like graphics and animation must be stripped away.

→ WML presents mainly text-based information that attempts to capture the essence of webpage and that is organized for easy access for users of mobile devices.

→ Important features of WML —

* Text and image support :-

Formatting and layout commands are provided for text and limited image capability.

* Deck/card organizational metaphor :-

→ The small, well defined units of WML documents used for user interaction is called cards.

→ Users navigate by moving back and forth between cards.

→ A card specifies one or more unit of interaction (a menu, a screen of text, or a text entry field).

→ A WML deck is similar to an HTML page in that it is defined by a web address (URL) and is the unit of content transmission.

* Support for navigation among cards and decks :-

→ WML includes provisions for event handling, which is used for navigation or executing scripts.

→ In an HTML-based web browser, a user navigates by clicking on links. At a WML-capable mobile device, a user interacts with cards, moving forward and back through the deck.

→ WML is tagged language, similar to HTML, in which individual language elements are delineated by lowercase tags enclosed in angle brackets.

→ The WML definition of a card begins with the non visible portion, which contains executable elements, followed by visible content.

→ e.g. consider the following simple deck with one cardform :

```
<wml>
    <card id = 'card 1'>
    <p>
        Hello WAP World
    </p>
    </card>
</wml>
```

→ The tags <wml>, <card>, and <p> enclose the deck, cards and paragraph respectively.

→ Like HTML, most elements end with a terminating tag that is identical to the starting tag with the addition of the character "/".

→ When a wireless device receives this code, it will display the message "hello WAP world" on the terminal's screen.

→ **WML script :**

→ WML script is a scripting language with similarities to JavaScript.

→ It is designed for defining script-type programs in a user device with limited processing power and memory.

LectureNotes.in

→ Important capabilities of WML script include the following:

* Check the validity of user input before it is sent to the content server.
* Access device facilities and peripherals.
* Interact with user without introducing round trips to the origin server (e.g. display an error message).

→ Key WML script features include the following.

* JavaScript-based scripting language :- WML script is subset of JavaScript, with some extensions.
* Procedural logic :- WML script adds the [Lower of proudural logic] to the Wireless Application Environment (WAE), discussed subsequently.
* Event based :- WML script may be invoked in response to certain user or environmental events.
* Compiled implementation :- WML script can be compiled down to a more efficient byte code that is transported to the client.
* Integrated into WAE :- WML script is fully integrated with the WML browser. This allows authors to construct their service using both WML and WML Script.
* Efficient extensible Library support :- WML script can be used to expose and extend device functionality without changes to the device software.

WAP :-

→ In a mobile network, wireless data are delivered with several constraints. As mobile devices are of small size and weight. It has smaller display and keyboard, less powerful CPU and small memory capacity. It has limited bandwidth, low degree of reliability. Hence the protocol used for internet is not suitable for mobile network.

→ In order to address above mentioned problem, Ericson, Motorola, Nokia and phone.com founded wireless application protocol (WAP) forum. The WAP forum has drafted a set of global wireless protocol specifications for many wireless networks. Most handset manufacturers have committed to WAP enabled devices.

→ To converge wireless data and Internet, WAP integrates a lightweight web browser into handheld devices with limited computing and memory capacities. The WAP implemented in both the WAP gateway and WAP handsets enable a mobile user to access Internet web application through client-server model.

WIRELESS APPLICATION PROTOCOL :—

→ WAP is an universal open standard developed by the WAP forum to provide web browsers to mobile users of wireless phones and other wireless terminals.

→ WAP standard represents the first successful attempt to establish a broadly accepted environment for delivering information, data and services to both enterprise and consumer users over wireless networks.

→ WAP is based on existing internet standard such as IP, XML, HTML and HTTP.

→ It also includes security features.

WAP Architecture :—

→ The WAP standard is a set of standards which together define

(1) how wireless data handset communicates with the wireless network and how contents and services are delivered and executed to their handsets.

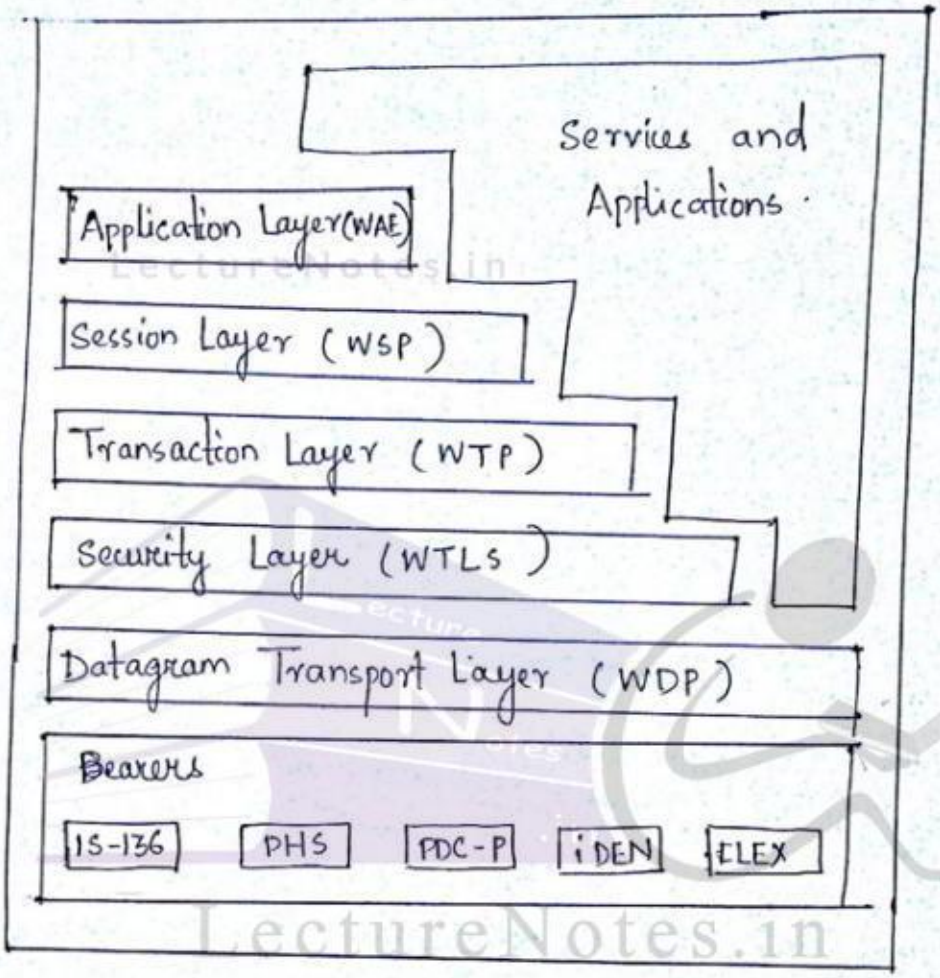
→ Using these standards the handset can establish a connection to a WAP data infrastructure, request content and services from infrastructure.

(2) WAP is based on layered architecture. The WAP stack is similar to the OSI network model. The architecture consists of a set of services encompassing network protocol, security and application environment.

→ The WAP standard is layered i.e one layer rests on top of another and therefore depend on another to provide services.

→ Each layer in the network infrastructure are exposed to the interface layer above it and also exposed an interface directly to application and services.

(3) These layers are symmetric i.e they run both on the client device and network infrastructure.



(WAP Protocol Stack)

Advantages –

→ Layering allows the design of each protocol to evolve independently of the other protocol. Each layer assumes that the layer below it has a particular set of capabilities and provides a particular set of capabilities to the layer above it.

→ Layering allows subset of the standard to be implemented.

→ Layering permits effective bridging to internet protocol used over both internet and www are layered.

→ Layering supports the principle of separability. Functionality is distributed among different elements of network infrastructure.

Disadvantages —

→ Layered protocol implementation is more difficult to optimize and maintain.

→ Layered protocol tends to be less efficient.

→ Components of WAP standard.

1. Bearer Adaptation :-

→ Wireless networks employ a variety of protocols for exchanging messages, packets or frames to and from the client device.

→ Dozens of these network protocols, also known as bearer protocols.

→ Each bearer protocol is associated with a particular type of network infrastructure, and each infrastructure is associated with particular regions of the world.

(1) The Advanced Mobile Phone System (AMPS) is an analog communication infrastructure that is still used throughout much of the world, including North America. Geographic cells are used to separate conversions taking place over the same frequency.

(2) Cellular Digital Packet Data (CDPD) is a 19.2 kbps digital packet service that uses free space in a voice network to transmit data. It uses Frequency

OSI Model :-

Application :- user application process.

Presentation :- File transfer, management, access etc.

Session :- Syntax management.

Transport :- End-to-end message transfer connection arrangement. Flow control.

Network :- Routing → responsible for source to destination delivery of single packet.

Datalink :- → LLC (Logic Link Control) → Error control.
→ MAC (Medium Access Control)
→ Multiple Access Protocol.

Physical :- Data formatting, modulation, forward error correction, encryption, equalisation, synchronisation.

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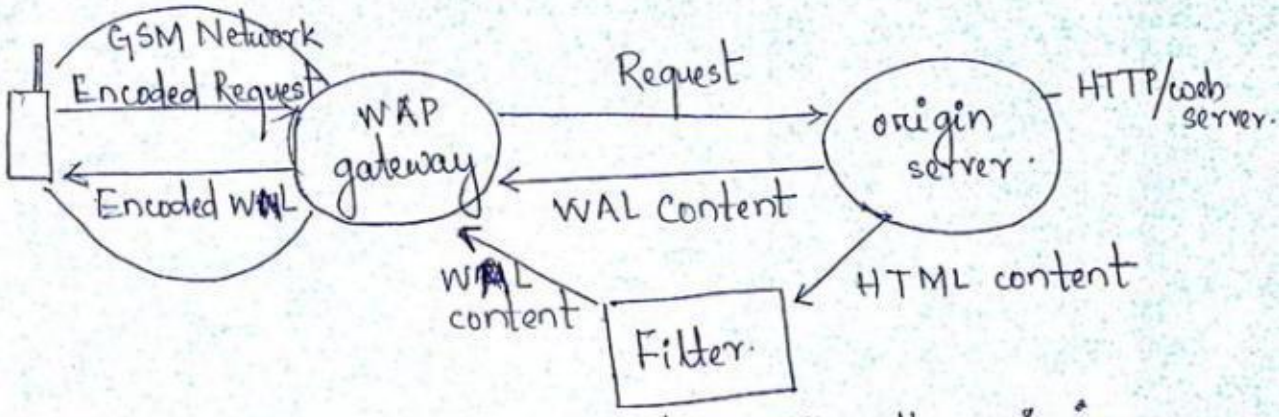
Division Multiplexing (FDM), in which the transmitter sends each packet on a different frequency. CPPD is deployed in various parts of the United States and Canada.

(3) CDMA was developed during World war 2 by Qualcomm for the U.S military is now widely used within the United states, Canada and parts of Asia. CDMA is a spread-spectrum technology that tags each conversion with its own digital sequence.

(4) The GSM communication standard runs in the 800 MHz band and has emerged as the standard in Europe, Australia, and most of Asia. It relies on the combination of TDM and FDM to achieve benefits similar to those provided by CDMA.

(5) The Personal Digital Cellular (PDC) system provides both telephony and data services and is widely used in Japan. Like GSM, it combines TDM and FDM capabilities.



→ A WAP handset communicates with the origin server through mobile network.

→ The origin server is a standard Hyper Test Transfer Protocol (HTTP)/web server. On the origin server, a given resource resides in or is to be created.

→ The WAP Gateway is located between the Internet and mobile network. It receives the WAP request from the handset, decode the request from binary format into test format, and forwards it to the origin server.

→ The origin server receives WAP request and returns the required content.

→ The origin server only provides HTML content and thus can't understand WML. The content received by the WAP handset are encoded in the compact binary format of wireless markup Language (WML) so that they can be efficiently delivered in the bandwidth limited mobile network.

→ So HTML response of the origin server is first sent to an HTML filter. It translates the HTML text into WML format. The WAP Gateway

verifies HTTP header and WML content sent from the origin server and encodes them into WML bytecodes. The result is then sent to the WAP handset.

WAP Gateway :-

→ The WAP Gateway is located between the origin service and mobile network.

→ The WAP Gateway utilizes web proxy technology to provide efficient wireless access to the Internet. A proxy plays role of both server and client.

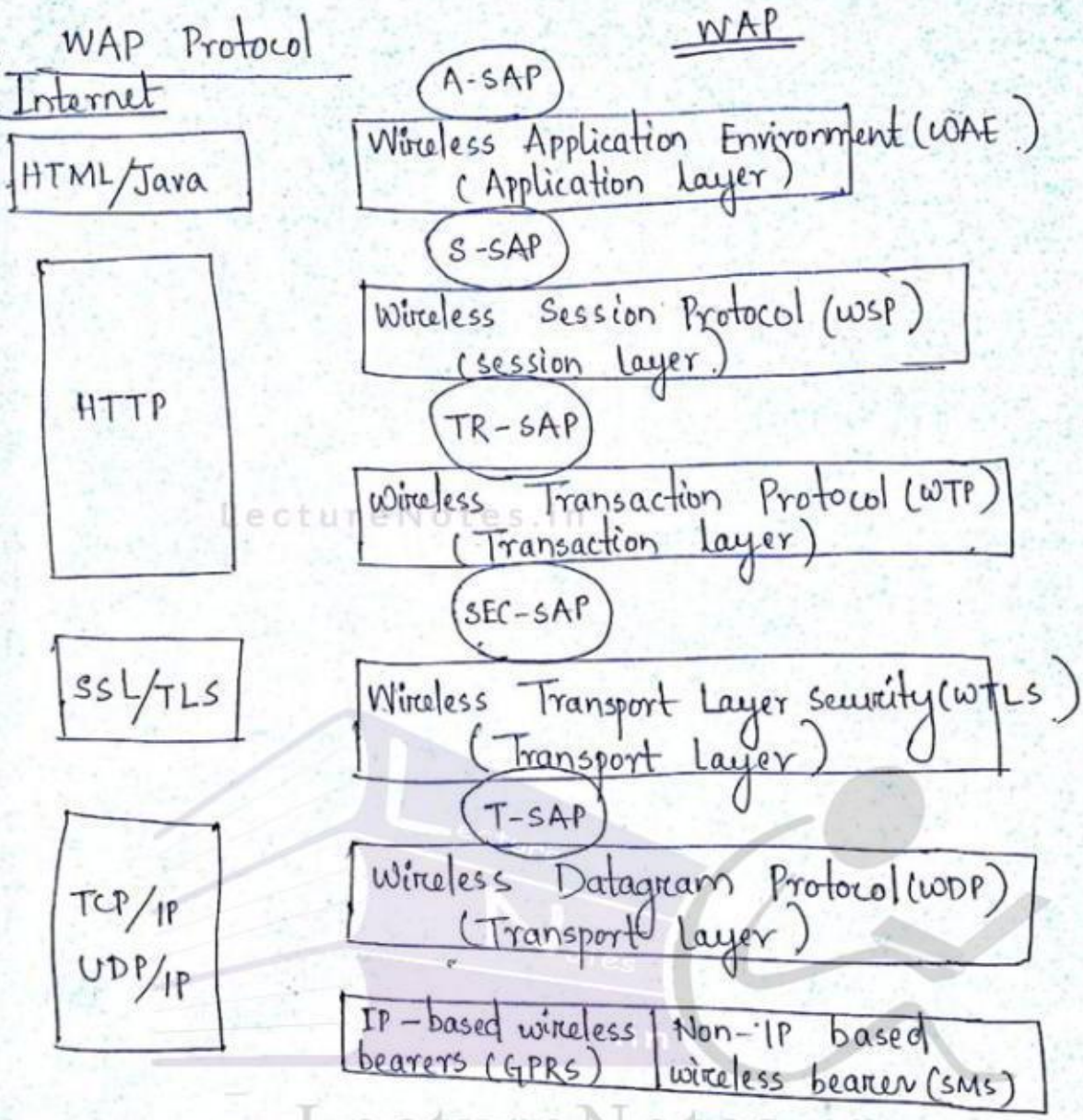
→ WAP handset can't directly communicate with the origin server. The WAP Gateway serves as a proxy to handle the requests to the origin servers.

→ On the Internet side, the WAP Gateway translates requests from the WAP protocol stack to the Internal protocol stack.

→ The WAP Gateway supports the DNS service to resolve the domain name used in URL (Uniform resource location).

→ It also provides quick response to the WAP handsets by aggregating data from different origin servers, and by catching frequently used informations.

WAP Protocol



→ **WDP (Wireless Datagram Protocol) :—**

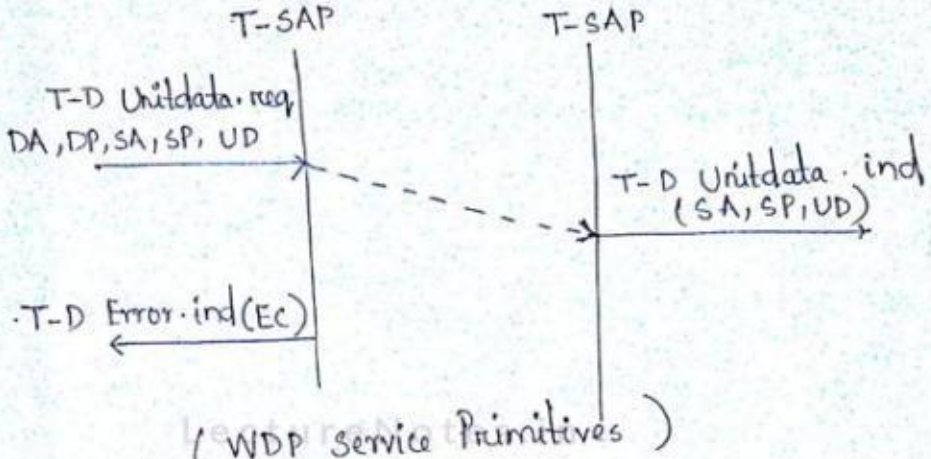
→ The transport layer protocol in WAP is called WDP. It operates above the bearer services and offers a consistent service to upper layers.

→ WDP offer similar functions like UDP through T-SAP.

→ UDP provides port addressing for IP based bearer services.

→ WDP offers source and destination port numbers used for multiplexing and demultiplexing of data.

→ The service is initiated by sending a datagram.



(WDP Service Primitives)

The datagram is,

→ T-D unitdata.req with Destination Address (DA), Destination Port (DP), Source Address (SA), Source Port (SP) and user data (UD).

→ DA and SA are unique address of receiver and sender which can be IP address or PSTN number.

→ T-D Unitdata.ind service indicates the reception of data. Here DA, DP are optional.

→ If that request can't be fulfilled by WDP, then an error is indicated with T-D Error.ind service.

→ An error code (EC) is returned indicating reason for the error to higher layers.

→ WTLS (Wireless Transport Layer Security) :-

→ WTLS is a security protocol based on TLS.

→ If requested by an application, a security service (WTLS) can be integrated into the WAP architecture on top of WDP.

→ WTLS can provide different levels of security for privacy, authentication and data integrity.

→ WTLS takes into account the low processing power

and very limited memory capacity and it is useful for cryptographic algorithms.

→ WTLS supports datagram and connection oriented transport layer protocols.

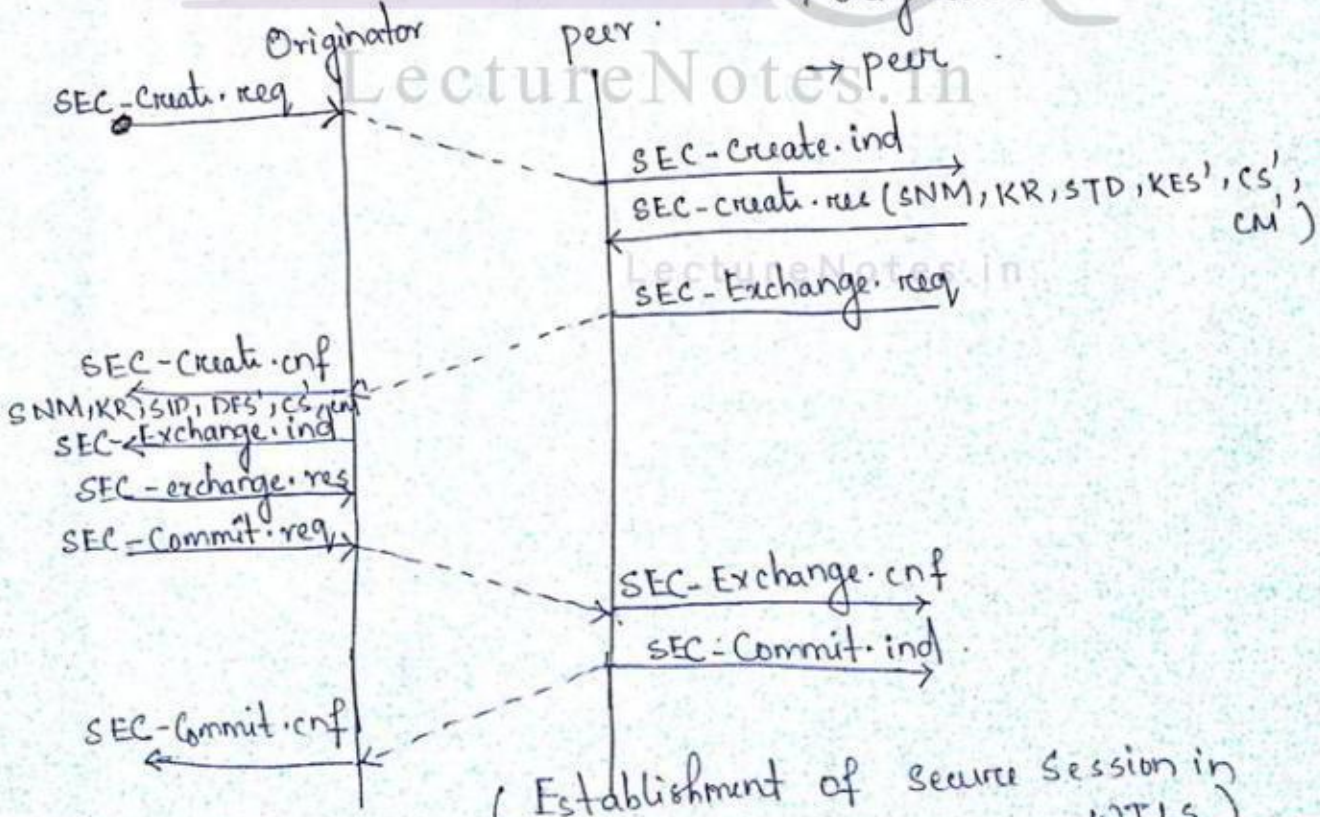
→ WTLS provides the following features:

* Data integrity – It ensures that data sent between the terminal and server is unchanged and uncorrupted.
* Privacy – Ensure that data transmitted between terminal and server is private and can't be seen by any intermediate parties.
* Authentication – WTLS contains facilities to establish the authenticity of terminal and service.

→ WTLS divides the whole transaction by 2 sections.

→ Originator

→ peer



(Establishment of secure session in WTLS)

→ First step is to initiate the session with

SEC - Create. req.

parameters are SA, SP of the originator and DA, DP of peer.

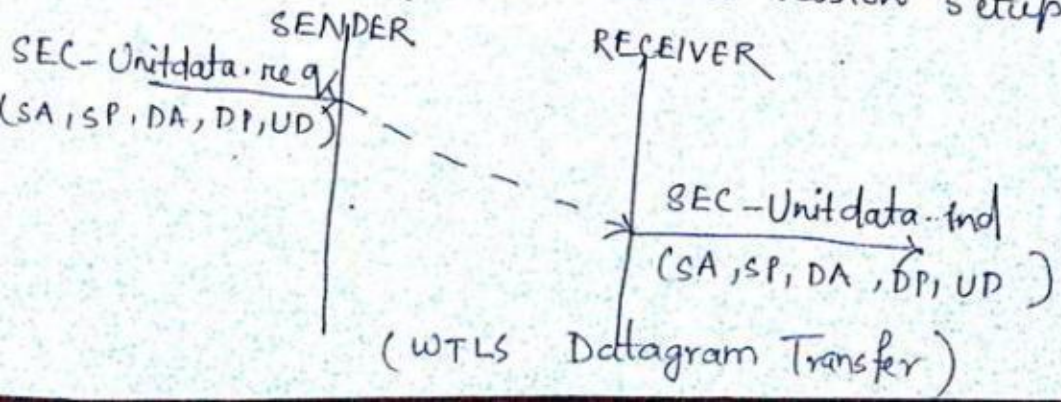
→ The originator proposes a key exchange suites (KES) eg RSA a cipher suite (CS) eg. DES, a compression method CM.

→ The peer answers with parameter for SNM (Sequence Number Mode), KR (Key Refresh) cycle (i.e how often keys are refreshed within this secure session), the SID (Session Identifier) which is unique with each peer and DES', CS', CM'.

→ Peer issues a SEC-exchange primitive. i.e it wishes to perform public key authentication with the client.

→ In secure session, the originator answers with its certificate and issues a SEC-Commit.req primitive. This primitive indicates that the handshake is completed for originator's side and originator want to switch into new transaction.

→ The certificate delivered to the peer side and SEC - Commit is indicated. This concludes the full handshake for secure session setup.



(WTLS Datagram Transfer)

→ WTP (Wireless Transaction Protocol) :-

→ WTP runs on top of a datagram service and provides transaction oriented protocol that is suitable for implementation in thin clients such as mobile phones.

→ WTP offers following advantages

* Improved reliability over datagram services
* Improved efficiency over connection oriented services.
* Support for Transaction oriented services

→ WTP supports 3 classes of transaction service :

1. Class 0 : Unreliable with no result message
2. class 1 : Reliable with no result message.
3. class 2 : Reliable with one result message

→ WTP achieves reliability using duplicate removal, retransmission, acknowledgements and unique transaction identifier.

→ For reliable transmission of messages 3 service primitives are offered by WTP are as follows :

1. TR-invoke : It is used to initiate a transaction.
2. TR-result : It is used to send back a result of a previously initiated transaction.
3. TR-abort : It is used to abort a normal transaction.

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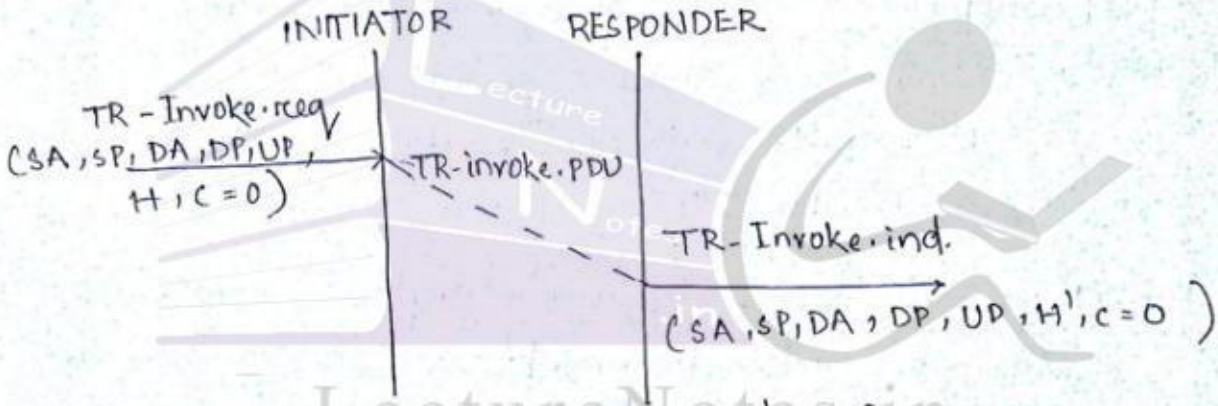
1. WTP class-0

→ (Unreliable with no result message)

→ It offers an unreliable transaction service without a result message.

→ The transaction is stateless and can not be aborted. Service is requested with TR-invoke.

→ The parameters used in the request are Source Address (SA), Destination Address (DA), Source Port (SP), and Destination Port (DP).



(class 0 Basic Transaction)

→ The WDP entity at the initiator sends an invoke PDU which the responder receives.

→ The WTP entity at the responder then generates a TR-Invoke.ind primitive with same parameters.

→ In this class responder does not acknowledge the message and initiator doesnot perform any retransmission.

2. WTP class-1 &

(Reliable with no result message)

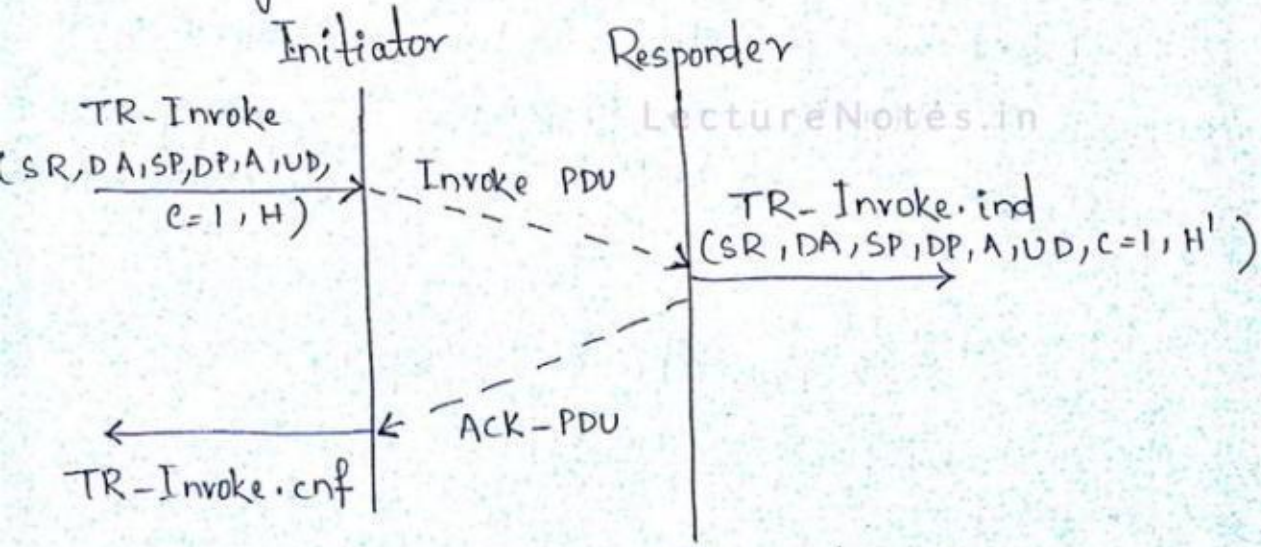
→ It offers reliable transaction service with no result message.

→ The initiator sends an invoke PDU after a TR-Invoke.req from a higher layer.

→ This time class equal to 1 and no user acknowledgement has been selected.

→ The responder signals income invoke PDU by a TR-invoke to the higher layer. This specification allows the user on the responder side to send acknowledgement.

→ For initiation, transaction ends with reception of acknowledgement. The responder gives the transaction state for some time to be able to retransmit the acknowledgement if it receives the same invoke PDU again.



(class 1 Basic Transaction)

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OSI Model —
Open System Interconnection

→ The OSI model defines a networking framework to implement protocols in seven layers.

→ Control is passed from one layer to the next, starting at the application layer in one station.

→ The OSI model takes the task of internetworking and divides that up into a vertical stack that consists of the following layers.

→ **Layer 1 (Physical)** —

→ This layer conveys the bit stream - electrical impulse, light or radio signal through the network at the electrical and mechanical level.

→ It provides the hardware means of sending and receiving data on a carrier, including defining cables, cards, and physical aspects.

→ Fast ethernet, RS232 and ATM are protocols with physical layer components.

→ **Layer-2 (Datalink)** —

→ At this layer, data packets are encoded and decoded into bits.

→ It furnishes transmission protocol knowledge and management and handles errors in the physical layer, flow control and frame synchronization.

→ Datalink layer is divided into 2 sublayers.

1. Media Access control (MAC)
2. Logical link control (LLC)

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3. WTP class-2

(Reliable with one result message)

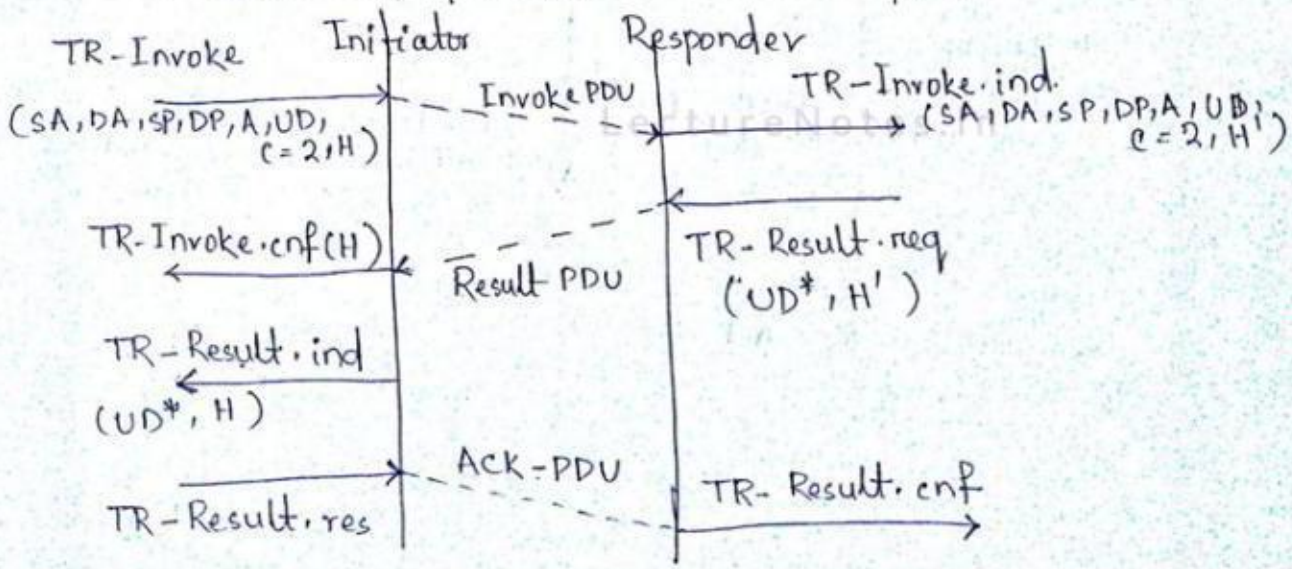
→ class 2 transaction service provides the reliable request/response transaction.

→ A user on initiation side sends an invoke PDU to the responder. The WTP entity on responder's side indicates the request with TR-Invoke.ind.

→ The responder now waits for processing of the request. The user on responder side can give the result to the WTP entity on the responder side using TR-result-request.

→ The result PDU can now send back to initiator which implicitly acknowledges the invoke PDU.

→ The initiator can indicate successful transmission of invoke message and result with 2 services TR-Invoke.cnf and TR-Result.ind. A user may respond to this with TR-Result.res. An acknowledgement PDU is then generated which finally triggers the TR-Result.cnf primitive on the responder's side.



(WTP class 2 Transaction)

WSP (Wireless Session Protocol) :-

→ WSP provides a connection oriented service on top of WTP.

→ It provides a consistent interface between two session services (client and server).

→ WSP protocol is based on concept of request and a reply.

→ Each WSP protocol data unit consists of a body (containing WML script) and a header (containing information about the data).

→ WSP provides application with in interface for two session services.

i.e the connection oriented session services operates above WTP and connectionless session service operates above WDP.

→ WSP offers the following features for content exchange:

1. Session Management :-

→ It introduces a session that can be established from a client to a server and may exist for a longtime.

→ It is responsible for suspending and resuming a session of a mobile during its operation.

2. Capability Negotiation :-

→ Client and server can agree upon a common level of functionality to set upon a common level of functionality to set the capacity of a mobile.

3. Content Encoding :-

→ It defines encoding for transferring the contents.

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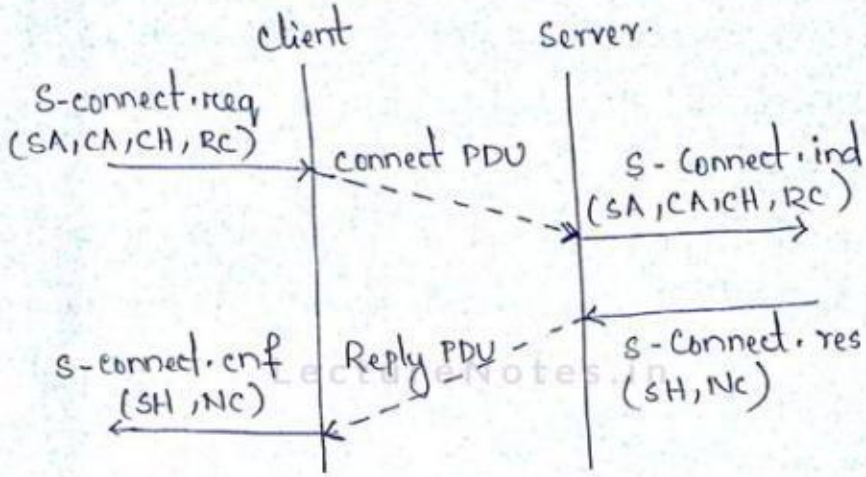
(1) WSP Session Establishment :—



→ Session Establishment involves the exchange of s-Connect primitives.

→ A WSP client requests a session with a WSP user by issuing an s-Connect.req.

→ Parameters are Server Address (SA)
client Address (CA)
client Header (CH)
requested capabilities (RC)

→ The client transfers the PDU to server where s-Connect.ind primitive indicates a new session and answers with s-Connect.res.

→ The parameters are Server Header (SH) and negotiated capabilities (NC).

→ The PDU is then transferred to client. s-Connect.cnf confirms the session establishment.

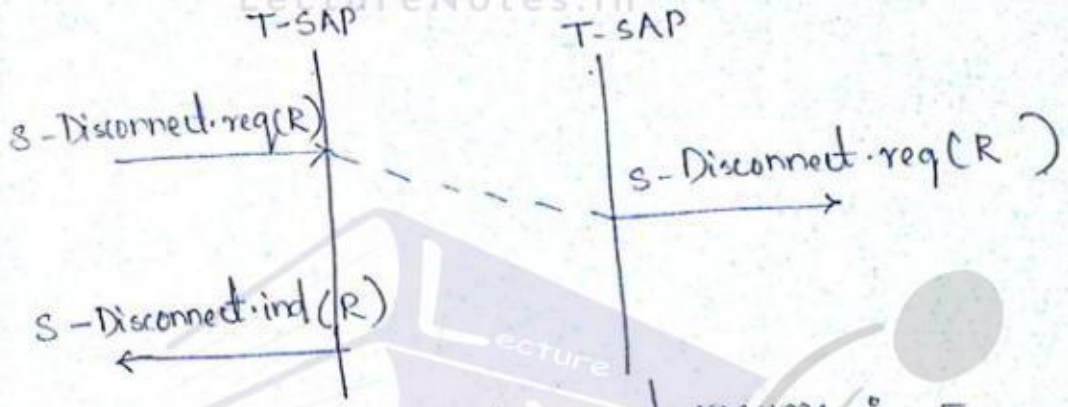
(2) WSP Session Termination -

→ Termination is done by using the s-Disconnect.req service primitive.

→ These primitive aborts all current method used to transfer data.

→ Disconnection is indicated on both sides using S-Disconnect.ind ~~when~~ for network error, protocol error, congestion, maximum packet size exceed etc.

LectureNotes.in



(3) WSP session suspension and resume :-

→ If a client notices that the bearer network will be unavailable due to roaming to another network or the user switches off the device, the client can suspend the session.

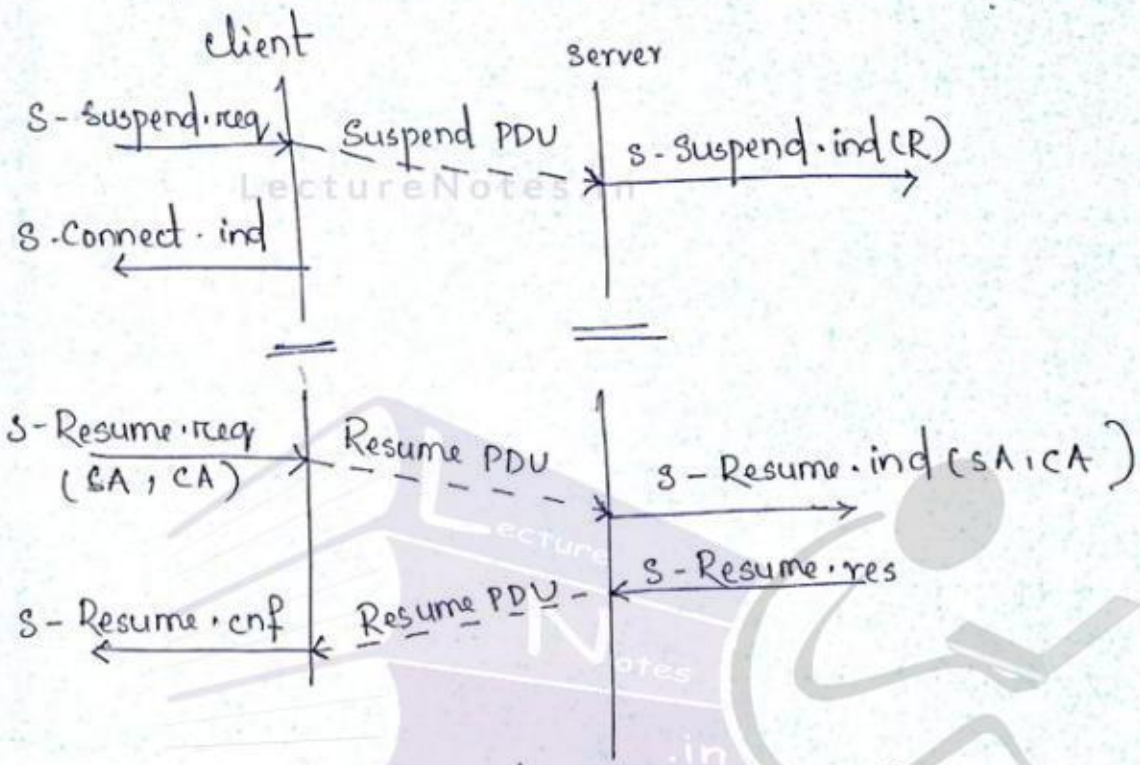
→ Session suspension will automatically abort all data transmission and freeze the current state of the session on the client and server side.

→ A client suspends a session with S-Suspend.req, WTP transfers the suspend PDU to server with class 0 transaction.

→ SP will signal the suspension with S-Suspend.ind on the client and server side. The only parameter is the reason (R) for suspension.

→ Reasons can be a user request or a suspension initiated by the service provider. A client can later resume a suspended session with S-Resume.req.

→ The parameters are SA, CA (Client Address)



→ WAE (Wireless Application Environment) –

Objective : to provide an interoperable environment to build wireless services among operators and service providers.

→ It offers a framework for the integration of different World wide web and mobile telephony application.

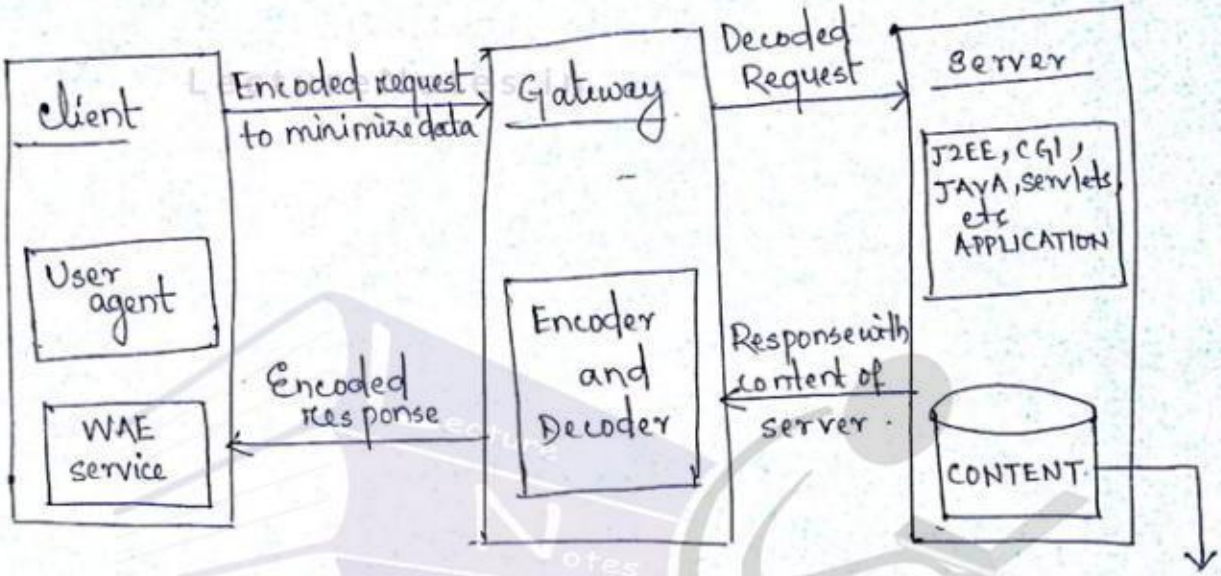
→ The major elements of WAE are :

* Wireless Telephony Application (WTA) :-
  - → A collection of telephonic features for call mechanism.
  - → Using WTA, application developers can use micro browser to originate telephone calls.

→ Goal of WAE —

→ to minimize over the air traffic and resource consumption on handheld device.

→ Goal can be implemented using WAE logical model.



(WAE Logical Model)

* Content Generator :- Application or services on origin servers that produce standard content formats in response to requests from user agents in the mobile terminal.

* User Agent :- It signifies an agent who works on behalf of the user. In WWW and WAE content user agent is the user facing browser software.

* Wireless Markup Language (WML) :- It is a mark-up language optimized for use in wireless devices similar to HTML.

→ In Logical Model

→ a client uses an encoded request for an operation on a remote server.

→ Encoding is necessary to minimize data sent over the air and to save resources on the handheld device.

→ Decoders in a gateway translate the encoded request into a standard request as understood by origin server.

→ The gateway transfers this request to the origin server.

→ Origin server will respond to the request.

→ The gateway encodes the response and transfers the encoded response with the content to the client.

LectureNotes.in

→ Virtual Private Network (VPN) :—

→ It is a private data network that makes use of the public telecommunication infrastructure, maintaining privacy through the use of a tunneling protocol and security procedures.

→ VPN can be contrasted with a system of owned or leased lines that can only be used by one company.

→ Main purpose of VPN is to ~~provide~~ give the company the same capabilities as private leased lines at much lower cost by using the shared public infrastructure.

→ VPN makes it possible to have the same protected sharing of public resources for data.

→ VPN works by using the shared public infrastructure while maintaining privacy through security procedures and tunneling protocols such as the Layer Two Tunneling Protocol (L2TP).

→ Features in a well designed VPN —

→ Security

→ Reliability

→ Scalability

→ Network Management

→ Policy Management.

→ Implementation of VPN —

→ VPN is usually implemented in software. It includes

→ Each site for VPN should be connected to internet.

→ The VPN software is run on a router on each site.

LectureNotes.in

→ Working of VPN —

→ Routers with VPN software works like normal router, filtering packets.

→ VPN performs the following functions:

* A router implementing VPN software is configured such that
  1. It rejects all incoming packets except those that arrive from a router which belongs to the authorized network.
  2. It rejects all outgoing packets except those which belong to the authorized network.
* VPN software encrypts each outgoing packet before transmission. Received packets are decrypted.

→ Goals of VPN —

1. Confidentiality —
   → protects the privacy information being exchanged between communicating parties.
2. Integrity —
   → ensures that information being transmitted over the public Internet is not altered in any way during transit.

→ It uses ~~one~~ 3 technologies.

* One-way hash functions:
  → fixed length output based on arbitrary length input.
* Message-authentication codes:
  → simply adds a key to hash functions

3. Digital signatures –
— public key cryptography.

3: Authentication —

→ It ensures the identity of all communicating parties.
→ VPN use one or more forms of authentication.
① Password authentication or Digital certificates.
②.

→ Types of VPN —

(1) Remote Access VPN —

→ Also called a virtual private dial up network (VPDN).
→ It is a used to LAN connection used by a company that has employees who need to connect to the private network from various remote locations.
→ A corporation that wishes to set up a large remote access VPN will outsource to an enterprise service provider (ESP).
→ The ESP sets up a network access server (NAS) and provides the remote users with desktop client software for their computers.
→ The telecommuters can then dial a toll-free number to reach the NAS and use their VPN client software to access the corporate network.
→ Remote access VPNs permit secure, encrypted connections between a company's private network

→ The MAC sublayer controls how a computer on the network gains access to the data and permission to transmit it. The LLC Layer controls frame synchronization, flow control and error checking.

e.g. PPP, FDDI, ATM, IEEE 802.5/802.2, IEEE 802.3/802.2, HDLC, Frame Relay.

→ Layer 3 (Network) :-

→ This layer provides switching and routing technologies, creating logical paths, known as virtual circuits, for transmitting data from node to node. Routing and forwarding are functions of this Layer, as well as addressing, internetworking, error handling, congestion control and packet sequencing.

e.g. AppleTalk DDP, IP, IPX.

→ Layer 4 (Transport) :-

→ This layer provides transparent transfer of data between end systems or hosts, and is responsible for end-to-end error recovery and flow control.

→ It ensures complete data transfer.

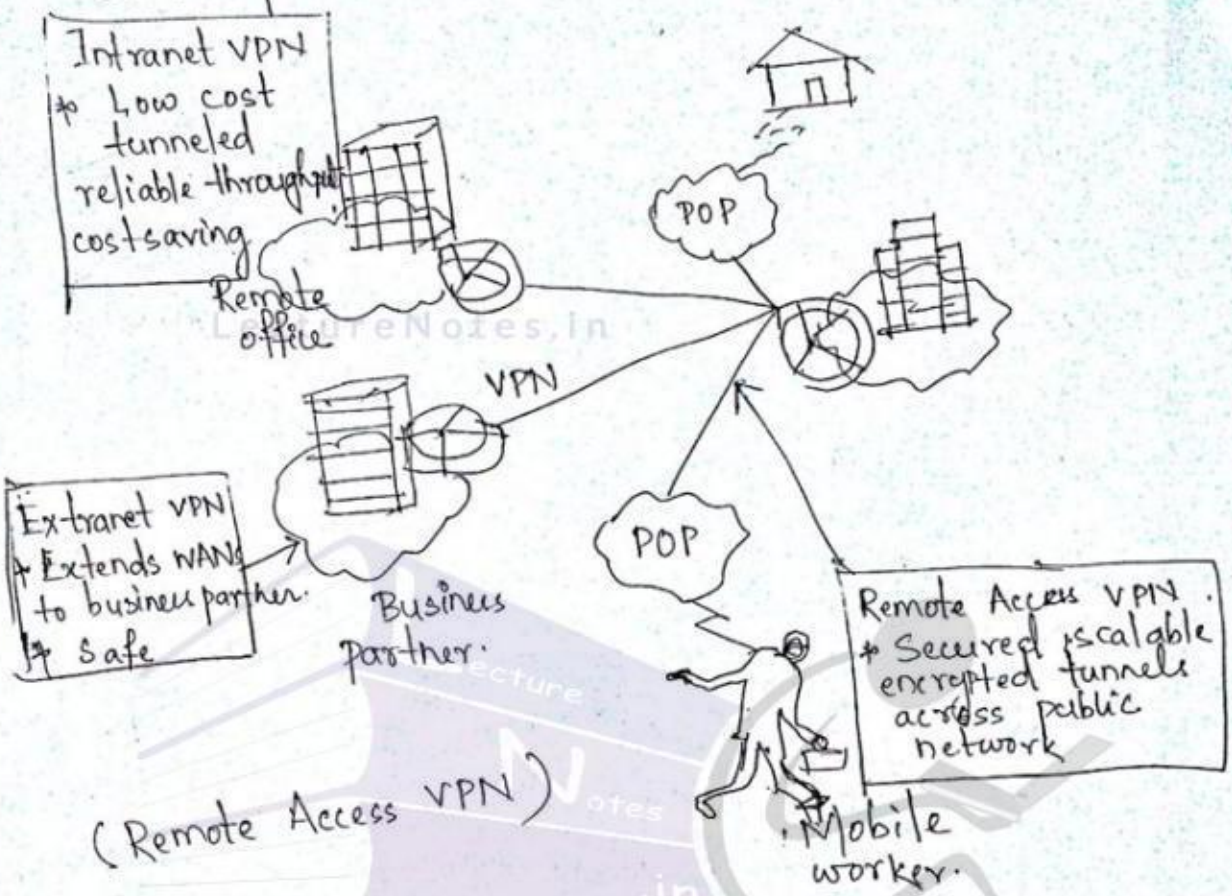
e.g. SPX, TCP, UDP.

→ Layer 5 (Session) :-

→ It establishes, manages and terminates connections between applications.

→ The session layer sets up, co-ordinates, and terminates conversations, exchanges, and dialogues between the applications at each end.

and remote users through a third-party service provider.



(Remote Access VPN)

(2.) site-to-site VPN —

→ Through the use of dedicated equipment and large scale encryption, a company can connect multiple fixed sites over a public network such as the Internet.

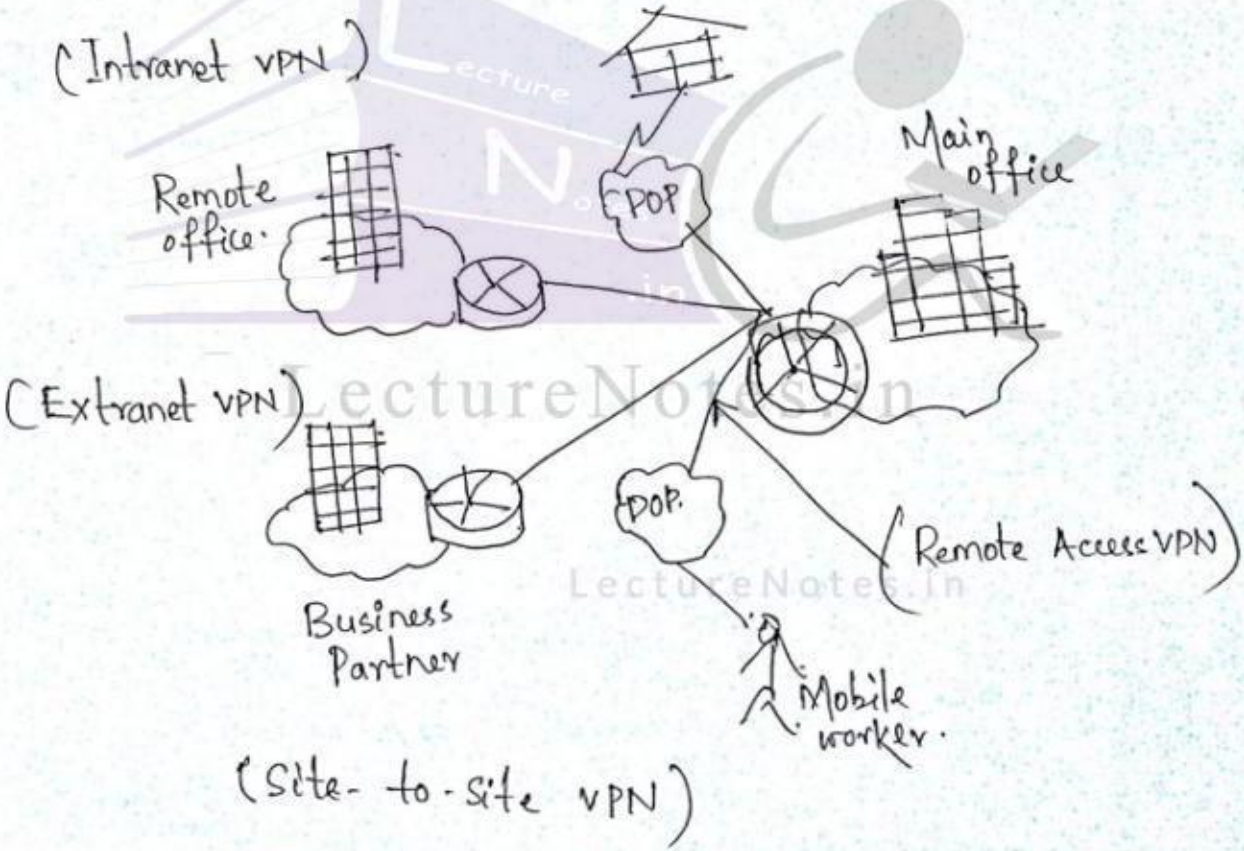
→ Site-to-site VPNs can be one of two types:

* Intranet-based —

→ If a company has one or more remote locations that it wishes to join in a single private network, it can create an intranet VPN to connect LAN to LAN.

* Extranet based -

- when a company has a close relationship with another company (for example, a partner, supplier or customer) it can build an extranet VPN that connects LAN to LAN and that allows all of the various companies to work in a shared environment.



Satellite Systems

→ Satellite is a specialized wireless receiver/transmitter that is launched by a rocket and placed in orbit around the earth.

→ There are hundreds of satellites currently in operation.

→ Used for weather forecasting, television broadcast, amateur radio communications, Internet communications and the Global Positioning System (GPS).

→ History of satellites

1957 - First satellite - SPUTNIK
1960 - First reflecting communication satellite - ECHO
1963 - First geostationary satellite - SYNCOM
1965 - First commercial satellite - EARLY BIRD
1982 - First mobile satellite with telephone system - INMARSAT - A
1983 - First mobile satellite with telephone system and data communication - INMARSAT - C

→ Features of Satellite Orbit —

→ Satellite orbit can be elliptical or circular.

→ Complete rotation time is related to distance between satellite and earth, mass of satellite and gravitational acceleration.

→ Newton's gravitational Law can be applied to compute the attractive force F_g and centrifugal force F_c.

$$F_g = mg(R/r)^2, \quad F_c = mr\omega^2$$

where $r = (gR^2/(2\pi f)^2)^{1/3}$

where g = gravitational acceleration ($9.8\ m/sec^2$)

m = mass of satellite

F_r = rotational Frequency

ω = angular velocity $= 2\pi f$

R = radius of earth (6370 km)

→ The inclination angle is defined as angle between equatorial plane and plane described by the satellite orbit.

→ Inclination angle = 0° means that satellite is exactly above the equator.

→ If the satellite doesnot have a circular orbit, the closest point to earth is called perigee.

→ The elevation angle is the angle between the center of satellite beam and the plane tangential to earth surface.

→ satellite communication can be affected by propagational loss of signal.

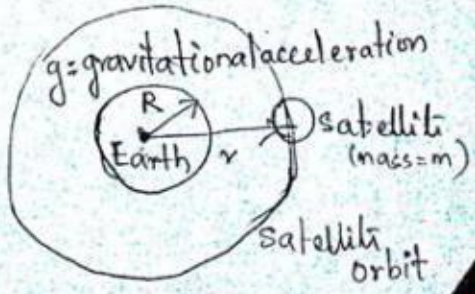
→ The attenuation of the signal power depends on distance between a receiver on earth and satellite and additional on satellite.

→ The Loss 'L' depends on distance r between sender and receiver and calculated as

$$L = 4\pi r f / c^2$$

r = carrier frequency

c = speed of light.



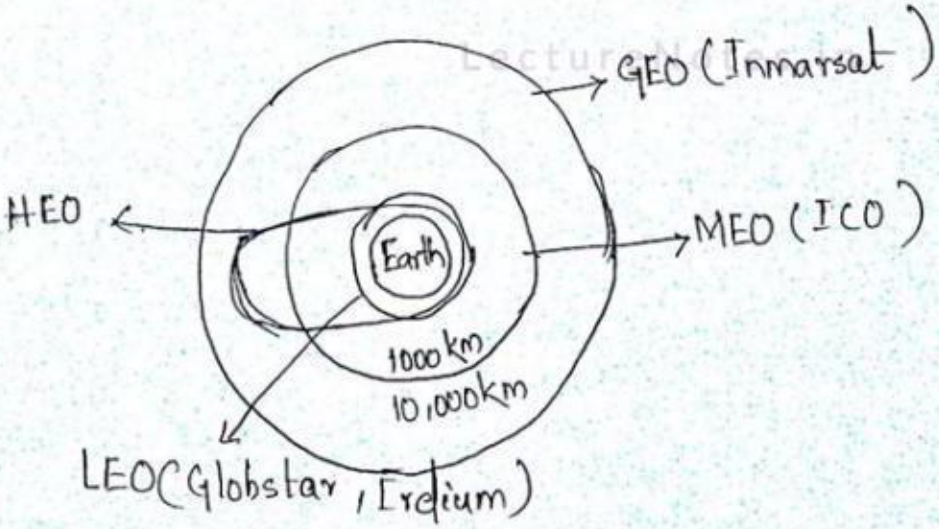
→ Application –

(1) Traditional
- → Weather satellite
- → Radio & TV broadcast
- → Military application

(2) Telecommunication
- → Global Telephone communication
- → Global mobile communication
- → Connection for communication in remote area.

→ Types of Satellite systems –

→ There are 4 general system designs, which are differentiated by the type of orbit in which the satellites operate:
- → Geostationary orbit (GEO)
- → Low-earth orbit (LEO)
- → Medium-earth orbit (MEO)
- → Highly Elliptical orbit (HEO)



(Orbits of Different satellites)

(v) Geostationary (GEO) –

→ GEO orbits earth at a fixed distance of 35,786 kms (22,300) miles.

→ Speed of satellite at this altitude matches that of Earth's rotation, thereby keeping the satellite stationary over a particular spot on the Earth.

e.g.. INTELSAT, Inmarsat etc.

→ These satellites orbit the Earth above the equator and cover 1/3rd of the Earth's surface at a time.

→ It supports voice, data and video services, most often providing fixed services to a particular region.

Pros

→ greater availability of bandwidth than LEO and MEO.

→ provides two-way data, voice and broadcast services.

→ more cost effective for carrying high-volume traffic

Cons

→ requires line of sight communication paths between terrestrial antenna and satellites.

→ They are few in numbers and placed in a fixed location over the Earth.

Summary –

→ Constellation cost - low.

→ covers 34% of the earth.

→ Placed 36,000 km above earth surface

→ Satellite visibility - 24 hrs. Lifet

→ Medium Earth Orbit (MEO) —

→ Also called ICO (Intermediate circular orbit)

→ Operate about 10,000 kms (bet. 1500 and 6500 miles) above earth. i.e lower than GEO orbit and higher than LEO.

→ MEOs can operate effectively with smaller, mobile equipment and with less latency (signal delay).

→ Typically, MEO constellations have 10 to 17 satellites distributed over two or three orbital planes.

Pros

→ require fewer satellites than LEOs.

→ reduces overall system complexity and cost.

→ higher capacity than LEO.

→ flexible in meeting shifting market demand for either voice or data services.

Cons

→ shorter life expectancy than GEOs.

→ ~~used~~ weaker and more subject to interference

Summary —

- Placed 6,000 - 20,000 km above the earth surface.
- Life time - 10 - 15 years.
- Visibility - 2 - 4 hours.
- Constellation cost - medium

e.g. ICO, ORBLINK

(3) → Low Earth Orbit (LEO) —

→ fly about 1,000 kms above earth (bet 400 miles and 1600 miles)

→ takes less than two hours to orbit the Earth,

→ 2 types of LEOs are there.

Big LEOs

Little LEOs.

→ Little LEOs —

→ very small

→ weight like a human being

→ use little b.w for communication.

→ can employ mechanisms to maximize capacity

→ can provide short messaging, low b.w data transport such as paging, fleet tracking & remote monitoring of stationary monitors.

e.g. Orbcomm, Final Analysis and Leo One.

→ Big LEOs —

→ designed to carry voice and data.

→ used in satellite phones or global mobile personal communications system (GMPCS) services.

→ offers mobile data services.

e.g. Iridium, Globalstar.

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Pros

→ low transmission delay.

→ low cost

Cons

→ highly complex and sophisticated control and switching systems.

→ shorter lifespan

Summary,

→ Placed above 500-2000 km above earth surface.

→ Lifetime .. 4-8 hours

→ Visibility - 10-20 minutes

→ Constellation cost high

e.g. Globalstar, IRRIDIUM.

(4) Highly Elliptical Orbit (HEO) —

→ orbit the Earth in an elliptical path.

→ HEO path is not centered on the Earth unlike LEO, MEO and GEO.

→ move around the Earth faster.

e.g. Ellipso, Pentriad.

Pros

→ maximizes the satellites timespent over populated areas.

→ requires few satellites than LEOs.

Cons

→ coverage is not so satisfactory as other orbital designs.

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→ It deals with session and connection co-ordination.

e.g. NFS, NetBios names, RPC, SQL.

→ Layer 6 (Presentation) —

→ It provides independence from differences in data representation (e.g. encryption) by translating from application to network format and viceversa.

→ The presentation layer works to transform data into the form that the application layer can accept.

→ This layer formats and encrypts data to be sent across a network, providing freedom from compatibility problems.

→ It is sometimes called the syntax layer.

e.g. ASCII, EBCDIC, TIFF, GIF, PICT, JPEG, MPEG, MIDI.

→ Layer 7 (Application) —

→ This layer supports application and end user processes.

→ Communication partners are identified, quality of service is identified, user authentication and privacy are considered and any constraints on data syntax are identified.

→ Everything at this layer is application specific.

→ This layer provides application services for file transfers, e-mail and other network software services.

→ Telnet and FTP are applications that exist entirely in the application level.

→ Tiered application architectures are part of this layer.

e.g. WWW browsers, NFS, SNMP, Telnet, HTTP, FTP.

* Nomadic Computing : Comp. environment is nomadic and moves along with the mobile user.

* Pervasive computing : it is pervasive in nature and can be made available in any environment

* Ubiquitous computing : it is present every where but nobody can notice it.

Mobile Computing Devices

→ Mobile device : wide range of consumer electronics. i.e it can connect to internet like,

1. Personal Digital Assistant (PDA) :-

→ PDAs are handheld devices that combine elements of computing, telephone/fax, Internet and networking in a single device.

→ A typical PDA can function as a cellular phone, fax sender, Web browser and personal organizer.

→ PDAs began as pen based, using a stylus rather than a keyboard for input mostly. they also incorporati handwriting recognition features.

→ Some PDAs can also react to voice input by voice recognition.

→ Now PDAs are available in either a stylus or keyboard version (called datapad).

e.g : Palm pilot, Revo, Sony clie, Hewlett-Packard Jornado, Casio Cassiopedia, Compaq iPad, Toshiba Pocket PC etc.

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Host Layers	Media Layers
→ Application	→ Transport
→ Presentation	→ Network
→ Session	→ Datalink
	→ Physical

→ The OSI Model is a conceptual model that characterizes and standardizes the communication functions of a telecommunication or computing system without regard of their underlying internal structure and technology.

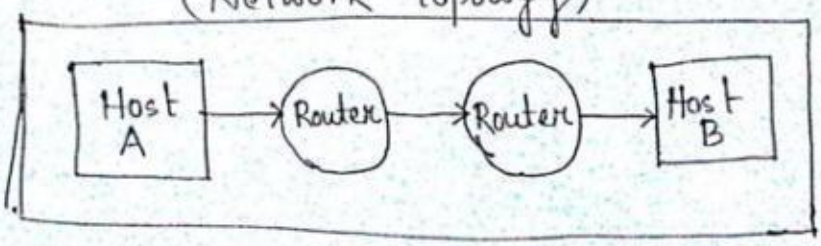
→ Its goal is the interoperability of diverse communication systems with standard protocols. The model partitions a communication system into abstraction layers. The original version of the model is defined in seven layers.

→ A layer serves the layer above it and is served by the layer below it.

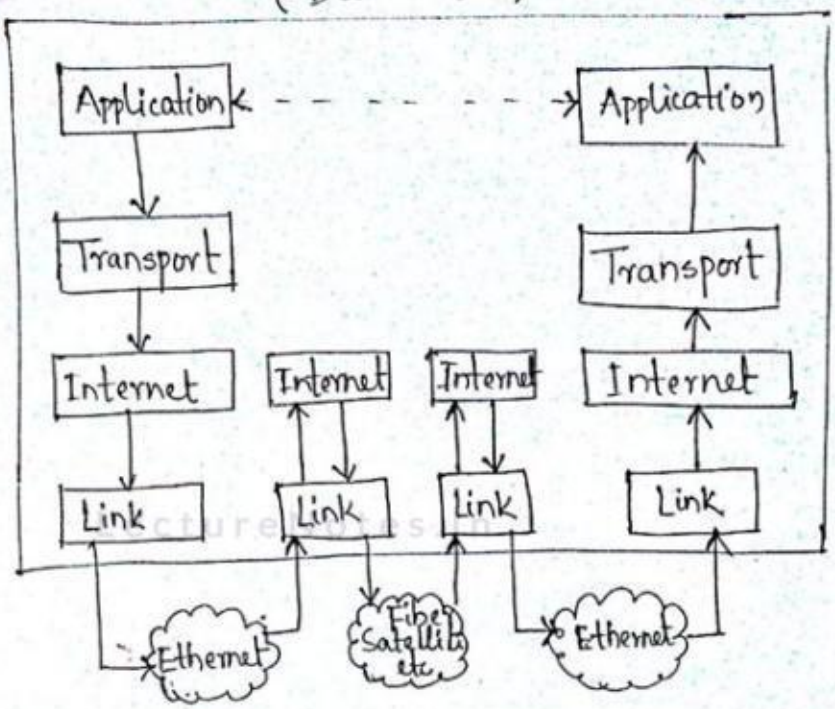
e.g. a Layer that provides error-free communications across a network provides the path needed by applications above it, while it calls the next lower layer to send and receive packets that comprise the contents of that path.

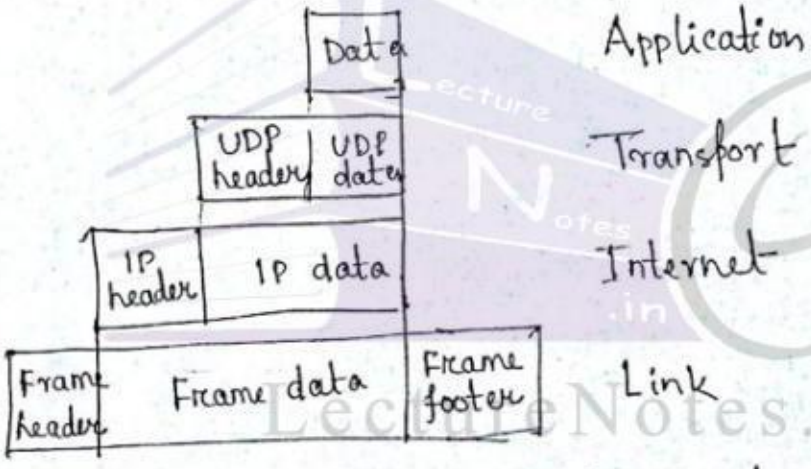
→ Two instances at the same layer are visualized as connected by a horizontal connection in that layer.

(Network topology)



(Data Flow)





→ Two internet hosts connected via two routers and the corresponding layers used at each ~~top~~ hop.

→ The application on each host executes read and write operations as if the processes were directly connected to each other by some kind of data pipe.

→ Every other detail of the communication is hidden from each process.

→ The underlying mechanisms that transmit data between the host computers are located in the lower protocol layers.

TCP/IP :—

→ The Internet protocol suite is the computer networking model and set of communications protocols used on the Internet and similar computer networks.

→ It is commonly known as TCP/IP, because its most important protocols, the Transmission Control Protocol (TCP) and the Internet Protocol (IP), were the first networking protocols defined in this standard.

→ TCP/IP provides end-to-end connectivity specifying how data should be packetized, addressed, transmitted, routed and received at the destination.

→ This functionality is organized into four abstraction layers which are used to sort all related protocols according to the scope of networking involved.

→ From lowest to highest, the layers are the link layer, containing communication technologies for a single network segment (link), the internet layer, connecting hosts across independent networks, thus establishing internetworking, the transport layer handling host-to-host communication and the application layer, which provides process to process application data exchange.

Link → Internet → Transport → Application

Link ↓ comm^n tech. for a single net. segment →

Internet ↓ connecting hosts across independent networks →

Transport ↓ Handling host-to-host communication →

Application ↓ process to process application data exchange.

PERSONAL COMMUNICATION SYSTEM :—

→ PCS stands for Personal Communication System.

→ Objective : to enable communication with a person at any place and in any form.

→ It also manages their individual call services according to their service by providing unlimited reachability and accessibility.

→ Sprint was the first company to set up a PCS network, which was a GSM-1900 network in the Baltimore-Washington metropolitan area in the USA.

→ PCS promises to provide a wide range of Locations and equipment independent services to a large no. of users.

→ According to the definition given by the US Federal Communications Commission (FCC), PCS is the system by which every user can exchange information with everyone at any time in any place through any type of service using a single personal telecommunication number (PTN).

→ The Key factors of PCS are

1. Reachability with respect to Location (Home, office, in public, in transit)
2. Accessibility with respect to Device (cellular phone, wired-phone, fax etc)
3. Management of service.

→ Features

1. Multiple Environments
2. Multimedia Service with highquality
3. Multiuser types
4. Global roaming capability
5. Single personal telecommunication number
6. Very high capacity
7. Universal handset
8. Service Security.

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→ Features of PCS :—

1. Multiple Environments —

→ It can provide ubiquitous access to service, no matter whether the user is at home, in the office, in the car etc. To achieve this objective, PCS should be able to integrate the current public switched telephone network (PSTN), integrated services digital networks (ISDN), the cordless system, the terrestrial mobile system, the satellite system and the wireless PBX, to provide a sufficiently standardized environment such that ubiquitous communication is possible.

2. Multimedia services with High Quality :—

→ PCS promises to provide a wide range of services to users including high quality voice, varible rate data, full motion video, high resolution images etc.

→ The counter parts of those services available in ISDN will also be available in the wireless environment with the same quality.

3. Multi User Types :—

→ PCS will provide services to various users with different requirements e.g Different service delay, different error performance etc by defining interfaces for negotiations between the user and the system.

4. Global Roaming Capability :—

→ PCS will have the capability to support global roaming. The user is no longer tied to one point

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or one network but can roam throughout the whole system (perhaps around the world) and still be reached.

→ This is very important feature of PCS and it overcomes the regional nature of some current systems.

→ Mobility at various speeds will be supported and the service quality will be ensured for the moving user.

5. Single Personal Telecommunication Number (PTN) —

→ The user can reach through a single personal number no matter where he is and what kind of device he uses.

→ PTN is the basis of personal mobility.

6. Very High Capacity : —

→ The potential demand for PCS is estimated to be one connection per adult.

→ This high market penetration will require very high system capacity.

7. Universal Handset : —

→ A single small handset will be used to access all the available services of the system.

→ This design is difficult due to the constraints of low battery power and affordability.

8. Service Security : —

→ Since heterogeneous systems are integrated and roaming is allowed, security threats such as illegal access

and eavesdropping are aggravated.

→ More advanced authentication and protection technologies are required.

→ Important issue here is how to implement and manage the database involved in the authentication procedure.

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PCS ARCHITECTURE :—

→ It consists of 2 parts.
  → Radio network
  → Wireline Transport network.

1. Radio Network :—

→ PCS users carry mobile stations (MS) to communicate with a BS in a PCS network.
→ MS is also referred to as handset or mobile phone.
→ The ~~ration~~ radio coverage of a base station (BS) is called cell.
→ In GSM network each cell is controlled by BSC which are connected to MS through BS.
→ The BSC are connected to MSC by Landlines.

2. Wireline Transport Network :—

→ MSC is a telephone exchange configured specially for mobile applications.
→ It interfaces the MSC (via BS) with PSTN.
→ MSCs are also connected with mobility database to track the location of MS and roaming management.
→ The databases are HLR and VLR.
→ HLR contains the authentication information like IMSI (International Mobile subscriber Identity), identification information like name, address of the subscriber, billing information like prepaid or postpaid, operator selection, denial of service to a subscriber etc.

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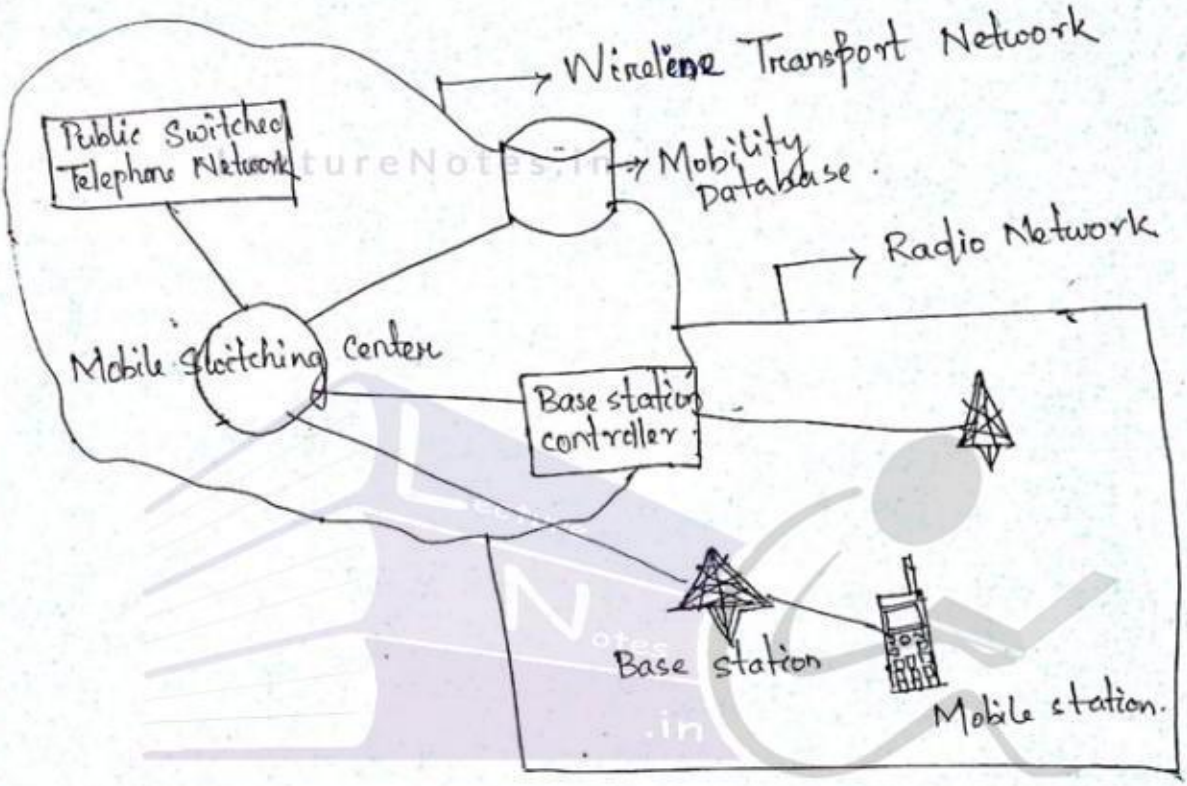
→ VLR gives information about the location area of the subscriber while on roaming and power off status of the handset.



(PCS network Architecture)

Mobility Management :—

→ Mobility management function handles the function that arises due to mobility of the subscriber.

→ Main objective : of MM is location tracking and call set up.

→ There are two aspects of mobility in a PCS network

1. Handoff
2. Roaming.

→ Handoff :-

→ Depending on the mobility of MS, the handoff is divided into two categories.

1. Inter-BS Handoff / Inter cell Handoff.
2. Inter-system Handoff / Inter MSC Handoff.

* Inter-BS Handoff / Inter cell Handoff :-

→ Here MS usually moves from one BS to another BS under one MSC.

→ Action taken for communication :

1. The MS momentarily suspends conversation and initiates the hand-off procedure by picking a channel in new BS. Then it resumes the conversation in old BS.
2. When MSC receives that signal, he transfers the information to the new BS and sets up new conversation path to MS through that channel.
3. After MS has been transferred to new BS, it starts the conversation channel with new BS and then MSC disconnects the link with old BS.

* Inter-System Handoff / Inter-MSC Handoff :-

→ MS moves from one BS to another connected to two different MSCs.

→ Action taken for communication -

1. MSC1 requests MSC2 to perform handoff measurement on the ~~et~~ call in progress.
2. MSC2 then selects a BS by interrogating the signal quality and sends the information to MSC1.

2. Smartphones :—

→ Smartphones combine both mobile phone and handheld computers into a single device.

→ It allow users to store information (e.g. email), install programs, along with using a mobile phone in one device.

e.g. Smartphone could be a mobile phone with some PDA functions integrated into the device or viceversa.

e.g. Sony Ericson, Palm Tree, Blackberry, Nokia ..etc..

3. Tablet PC :-

→ A type of notebook computer that has an LCD screen on which we can write using a stylus.

→ The handwriting is digitized and can be converted to standard text through handwriting recognition, or it can remain as handwritten text.

→ It also have a keyboard or a mouse for input.

e.g. Samsung Q1, Toshiba Portege, Fujitsu Lifebook, Motion computing, IBM thinkpad.

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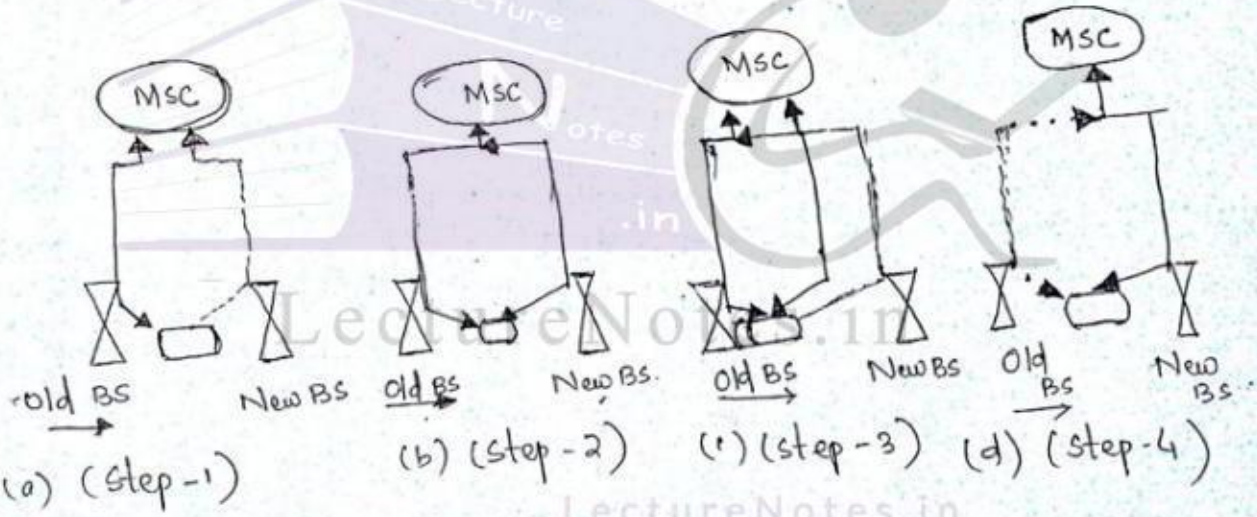
3. Then MSC1 asks MSC2 to setup a voice channel.

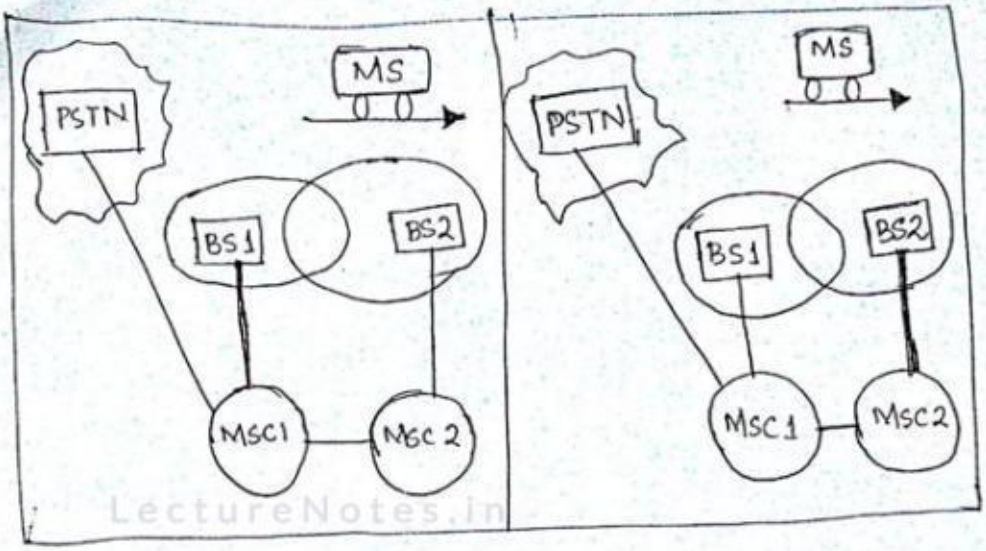
4. Assuming that a voice channel is available in BS2, MSC2 instructs MSC1 to start radio link transfer.

5. MSC1 sends the MS a handoff order. Now MS can access BS2 of MSC2. MSC2 informs MSC1 that handoff is successful. MSC1 then connects call path to MSC2.

6. In the inter ~~symbol~~ system handoff process, anchor MSC is always in call path before and after handoff.



(Inter - BS link Transfer)

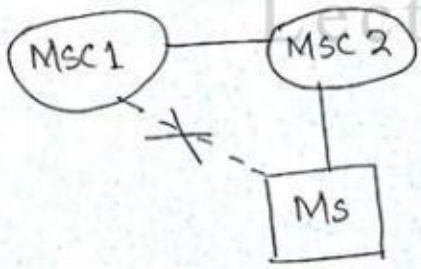


(Inter system Handoff)

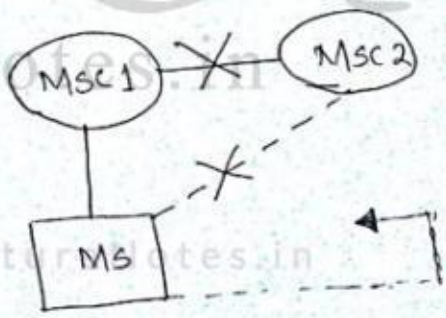
Path Minimization :-

→ When MS moves to MSC 3, MSC 2 may be removed from the call path. The link between MSC 1 and MSC 2 is disconnected and MS connects to MSC 3 directly.

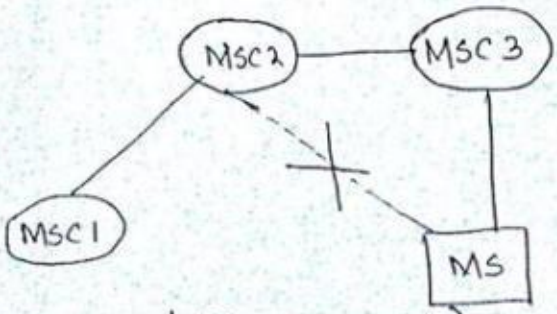
→ This process is called path minimization.



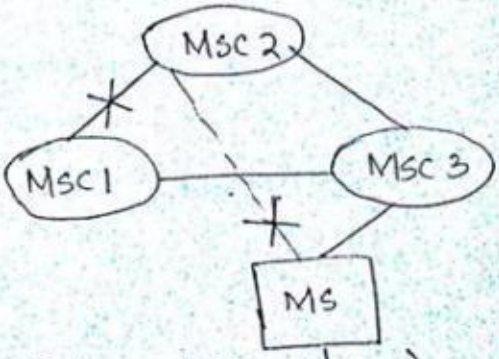
(Handoff forward)



(Handoff Backward)



(Handoff to 3rd)



(Path minimization)

Roaming Management :—

→ Two basic operations are performed under roaming management.

1. Registration (Location update): where MS informs the system about its current location.

2. Location tracking: Process during which a system locates MS. Location tracking is required when network attempts to deliver call to a mobile user.

→ The roaming management follows a two level strategy where two tier systems of home and visited databases are used.

→ when a user subscribes to the services of a network, a record is created in the system's database called HLR. This is called as home system of the mobile user.

→ HLR is a network database, where MS's identity, profile, current location and validation period is stored.

→ When the mobile user visits a new network other than home system, a temporary record for the mobile user is created in the VLR of visited system.

→ VLR temporarily stores information for visiting subscribers so that corresponding MSC can provide service.

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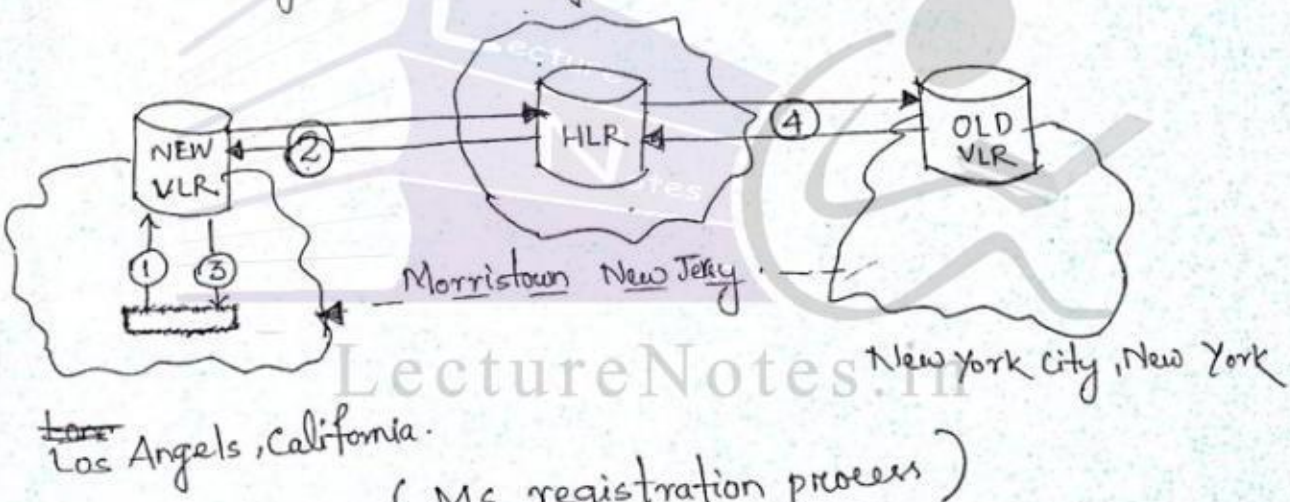
Steps for Registration procedure :-

1. When mobile user enters into new PCS network, it must register in VLR of new system.
2. The new VLR informs mobile user's HLR regarding the current location and address of user. The HLR sends an acknowledgement which includes MS's profile to the new VLR.
3. New VLR informs MS about successful registration.
4. HLR sends a deregistration message to cancel the location record of MS in old VLR. The old VLR acknowledges the deregistration.



(MS registration process)

→ To originate a call, MS first contacts with MSC in the new PCS network.

→ The call request is forwarded to VLR for approval.

→ If it is approved, MSC sets up the call to the user following the standard PSTN procedures.

1. If a wireless phone attempts to call a mobile subscriber, the call is forwarded to switch called the originating

switch in PSTN. The switch makes a query to HLR to find current VLR of MS. The HLR queries the VLR in which MS resides to get a comunicable address.

2. The VLR returns the address to switch through HLR.
3. Based on address, a communication link is established between MS through visited MSC.

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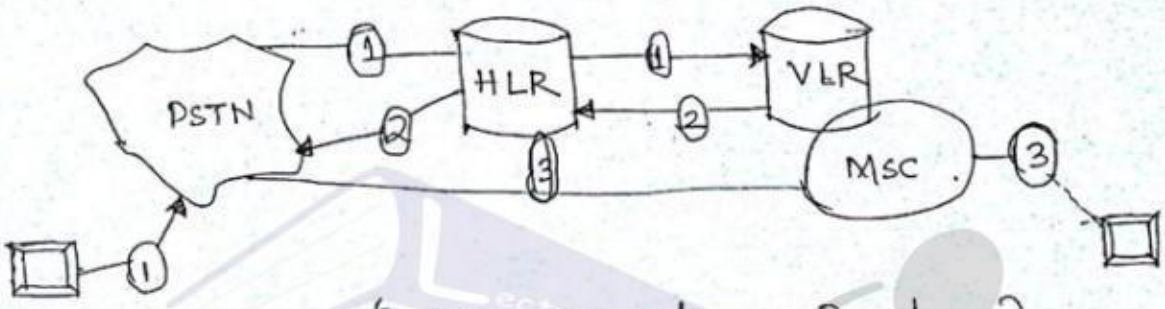

(PCS Call Delivery Procedure)

HLR :- Home locations Register
VLR :- Visitors location Register.

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System Overview :

→ GSM (Global System for Mobile Communication)

* most popular standard for mobile phones in the world.
* widely used in Europe and other parts of the world.
* It uses a variation of time division multiple access (TDMA) and is most widely used of the 3 digital wireless telephony technologies (TDMA, GSM and CDMA).
* GSM digitizes and compresses data and then sends it down a channel with two other streams of user data each in its own time slot.
* GSM system had to meet certain business objectives:
  - → Support for International Roaming
  - → Good speech Quality
  - → Ability to support handheld terminals
  - → Low terminal and service cost
  - → Spectral efficiency.

→ GSM is a cellular network, which means that mobile phones connect to it by searching for cells in the immediate vicinity.

→ 5 different cell sizes in a GSM network like macro, micro, pico, femto and umbrella cell.

→ The coverage area of each cell varies according to the implementation environment.

→ Macro cells can be regarded as cells where the base station antenna is installed on a mast or a building above average roof top level.

→ Micro cells are cells whose antenna height is under average roof top level, they are typically used in urban areas.

→ Pico cells are small cells whose coverage diameter is a few dozen meters; they are mainly used indoors.

→ Femtocells are cells designed for use in residential or small business environments and connect to the service provider's network via a broadband internet connection.

→ Umbrella cells are used to cover shadowed regions of smaller cells and fill in gaps in coverage between those cells.

* GSM uses a combination of FDMA and TDMA.

→ The GSM system has an allocation of 50 MHz bandwidth in the 900 MHz frequency band.

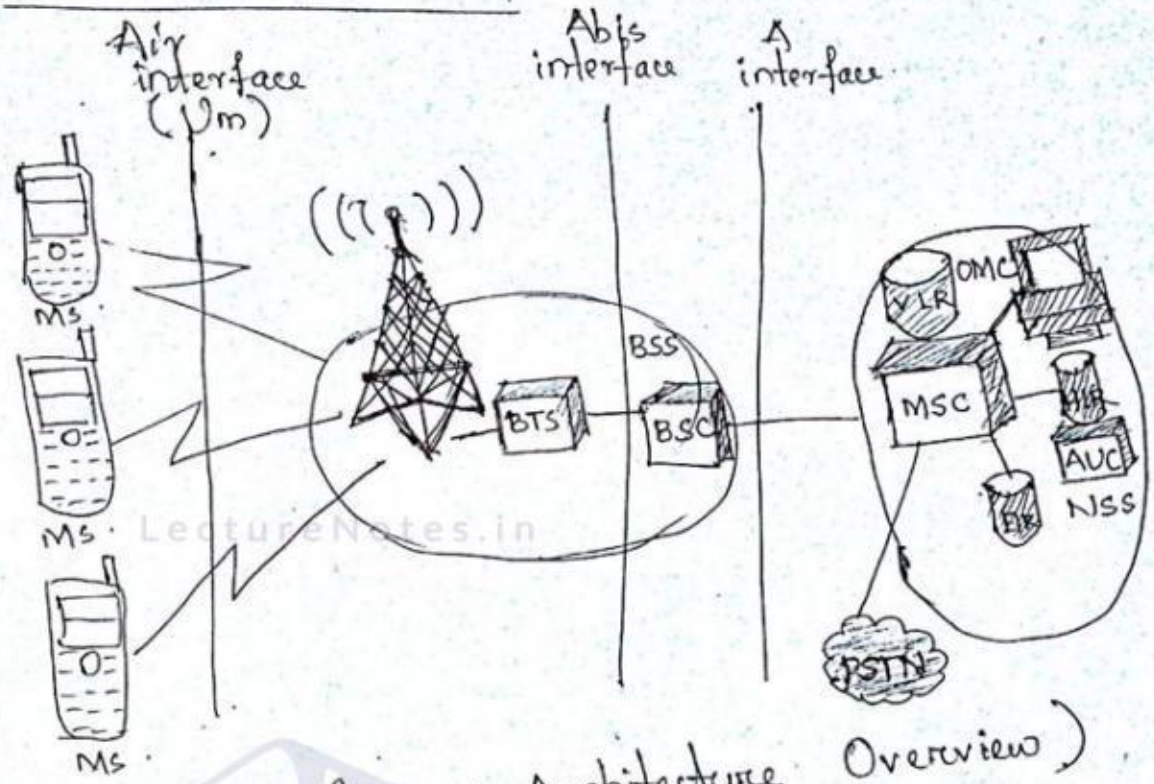
→ Using FMA, this band is divided into 124 channels each with a carrier bandwidth of 200 KHz.

→ Using TDMA, each of these channels is further divided into 8 time slots. Therefore with combination of FDMA and TDMA we can realize a maximum of 992 channels for transmit and receive.

→ Cell : Cell is the basic service area: one BTS covers one cell. Each cell is given a Cell Global Identity (CGI) a number that uniquely identifies the cell.

→ Location Area : A group of cells form a Location Area. This is the area that is paged when a subscriber gets an incoming call. Each Location Area is assigned a Location Area Identity (LAI). Each Location Area is served by one or more BSCs.

→ GSM Architecture :-



(GSM Architecture Overview)

MSC : Mobile switching center
BSC : Base station controller
BTS : Base transceiver station
TRX : Transceiver
MS : Mobile station
OMC : Operations and Maintenance centre
PSTN : Public switched telephone network
BSS : Base station sub-system
HLR : Home location register
VLR : Visitor Locations register.
AUC : Authentication centre

→ GSM network can be divided into 4 groups.

1. MS (Mobile Station)
   ~~(Mobile Equipment)~~
2. BSS (Base Station Subsystem)
3. NSS (Network Switching Subsystem)
4. OSS (Operation and Support subsystem)

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1. MS (Mobile Station) :-

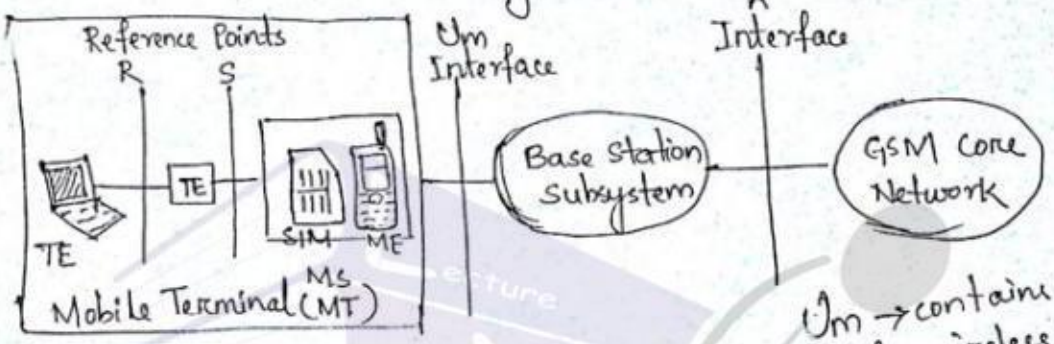
→ MS is used by a mobile subscriber to communicate with the mobile network.

→ Many types of MS's exist to make and receive calls.

→ Manufacturers of MS offer a variety of design and features to meet the need of different market.

→ The mobile station consists of :

- Mobile Equipment (ME)
- Subscriber identity module (SIM).



(GSM Mobile Terminal)

Um → contains mechanism for wireless transmission (TDMA/FDMA)

A → BSS is connected to NSS via this.

Abis → consists of 16 or 64 Kbit/s.

→ ME (Mobile Equipment)

(cellular phone without SIM card)

→ ME has a unique international mobile equipment identity (IMEI) which is used by EIR.

→ The numbers of GSM terminal types are defined within the GSM specification and are distinguished by their power O/P rating.

→ The range or coverage area of an MS dependent on the O/P power capabilities and consequently different ranges.

e.g. handheld MSs have a lower O/P power and shorter range than car installed MSs with a roof mounted antenna.

→ SIM (Subscriber Identity Module) :-

→ SIM card used in phones are smart processor cards.

→ It possesses a processor and a small memory. SIM stores permanent and temporary data about the mobile, the subscriber and the network.

→ It contains a serial no., PIN, PUK (Pin Unblocking Key), an authentication key (Ki), IMSI (International Mobile Subscriber Identity).

→ The SIM can be plugged into any GSM mobile terminal. This brings the advantages of security and portability for subscriber.

e.g. Subscriber A's mobile terminal may have been stolen. However A's own SIM can be used in another person's mobile terminal and the calls will be charged to subscriber A.

→ PIN Management :-

→ A SIM is required to have a PIN function even if it is deactivated by a user. PIN consists of 4 to 8 digit.

→ An initial PIN is loaded by the network operator at subscription time, afterwards the PIN including the length can be charged by the user.

→ The user can decide whether to use the PIN function or not by activating an appropriate SIM-ME function called the PIN disabling function and can be blocked by a ~~ad~~ authorized person.

→ If an incorrect PIN is entered, the user is informed. After 3 consecutive incorrect entries the SIM is blocked, even the SIM has been removed or the Mobile is switched off.

Mobile Computing Function :—

1. User mobility –

→ User should be able to move from one physical location to another location and use the same service. The service could be in the home network or a remote network. i.e same internet access as in office at newyork or any other country

2. Network mobility –

→ User should be able to move from one physical location to another network and use the same service.

e.g. If user moves from Hongkong to NewDelhi, uses the GSM phone to access corporate application through WAP (Wireless application protocol)

→ In home network he uses GPRS where as in Delhi he accesses it over GSM network.

3. Bearer mobility –

→ User should be able to move from one bearer to another and use the same service.

for eg: Banglore (WAP in his home network) —moves→ Coimbatore (WAP not supported so voice or SMS bearer to access same application)

4. Device mobility –

→ User should be able to move from one device to another and use the same service.

e.g. sales representatives using their desktop computer in homeoffice.

But during day (moving on street) use Palmtop.

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Blocking / Unblocking of SIM :—

→ When a SIM is blocked GSM network operations are forbidden and is done using PUK (Pin unblocking Key)

→ The PUK is an 8-digit numerical code. If it is entered incorrectly the user is informed.

→ The user can make 10 attempts to enter the PUK before the system blocks entry, in which the subscriber contacts their network operator.

Function of MS

Function is,

* transmission of signal from MS to BTS (using uplink)
* reception of signal from BTS to MS. (using downlink).

2. BSS (Base station Subsystem) :—

→ The BSS is responsible for all the radio related functions in the system like

* Radio communication with the mobile unit in a certain area
* Handover of calls in progress between calls.
* Management of all radio network resource and cell configuration
* Monitors quality
* Controls the power transmitted by BTS or MS.
* Generates a handover to another cell when required.

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→ BSS contains two components :

* BTS
* BSC

BTS :— (Base Transceiver Station)

→ Consists of all radio equipments (e.g. antenna, signal processing & amplifier required for transmission)

→ It is placed in the center of a cell and its transmitting power defines the size of a cell.

→ It is connected to MS via Um interface and connected to BSC via Abis Interface.

→ It manages the radio resources for BTSs. It handles and handover the radio frequency, radio channel set up from one BTS to another.

→ Function of BTS depends upon following aspects :

* Radio resources
* signal processing
* Signalling link management
* synchronization
* Local maintenance handling
* Functional supervision and testing

→ **BSC (Base station controller) :—**

→ It connects the BTS and MSC of NSS. It manages radio resources for one or more BTS.

→ It handles and Handover the radio frequency, radio channel setup from one BTS to another.

Functions :-

(1) Radio Network Management-

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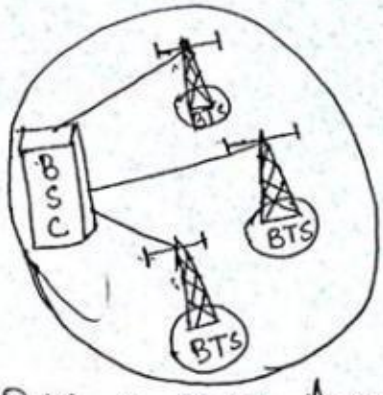
(2) BTS Management
(3) Handling MS connection.



(BSC & BTs Arrangement in GSM system)

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3. NSS (Network Switching Subsystem) :-

→ The NSS combines the call rotating switches (MSC and GMSC) with data base registered required to keep track of subscriber's movements and use of the system.

→ Key elements of NSS are:
- → MSC
- → VLR
- → HLR

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→ MSC (Mobile switching centre) :-

→ The mobile services switching centre is an exchange which performs all the switching and signalling functions for mobile stations located in a geographical area designated as the MSC area.

→ These are high performance digital ISDN switches.

→ It is used for connection between mobile phone to mobile phone within same network. It is used for connection between mobile phone to fixed phone within a network.

→ It manages BSC within a geographical area.

→ Functions of MSC
- → switching and Call Routing
- → Service Provisioning
- → Communication with HLR
- → Communication with VLR
- → communication with other MSCs.
- → Direct access to Internet services.

→ GMSC (Gatway MSC) –

→ Connection for another network MSC handles all the signaling needed for connection set up and connection release.

→ Function of GMSC :

→ A gatway mobile switching centre (GMSC) is a device which routes traffic entering mobile network into correct destination.
- → The GMSC accesses the network's HLR to find the location of the required mobile subscriber.
- → A particular MSC can be assigned to act as a GMSC.
- → The operator may decide to assign more than one GMSC.

→ HLR (Home Location Register) :-

→ The HLR is a centralized network database that stores and manages all mobile services belonging to a specific operator. It acts as a permanent store for a person's subscription information untill that subscription is cancelled.

→ It provides call routing and roaming facility by combining with MSC and VLR.

→ It is considered as a Database which stores the information about the subscriber within covering area of MSC.

→ Information includes

→ location of the mobile

→ & all the service providing information, when a phone is powered off this information is stored in HLR.

→ It is also a database but contains a temporary copy of some important information stored in HLR.

→ If a new MS user comes into location area, then VLR will provide relevant information by bringing it from HLR.

→ Functions of HLR

→ Subscription of Database management.

→ communication with MSC.

→ communication with VLR.

→ communication with GMSC.

→ " " AUC.

→ VLR (Visitor Location Register) –

→ It is a temporary storage device of GSM network.

→ It stores subscribers subscription information for MS which are within the particular MSC service Area.

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→ There is one VLR for each MSC service area.

→ The following occurs when Mobiles move into a new service area

→ The VLR checks its database to determine whether or not it has a record for the MS (based on the subscribers IMSI)

→ When the VLR finds no records for the MS, it sends a request to the subscriber's HLR for a copy of the Mobile's subscriptions.

→ The HLR passes the information to the VLR and updates its location information for the subscriber. The HLR instruct the old VLR to delete the information it has on the MS.

→ The VLR stores its subscription information for the mobile, including the latest location and station (idle).

(4) OSS (Operation and Support subsystem) –

→ It contains necessary function for network operation and maintenance. The key elements of OSS are

- OMC
- EIR
- AUC.

→ OMC (operation and Maintenance center)

→ It is connected to different components of NSS and BSC. It controls the traffic load of BSS.

→ EIR (Equipment Identity Register)

→ A database that contains a list of all valid mobile equipment with in the network where each MS is

identified by IMEI.

→ EIR contains a list of IMEI of all valid terminals.

→ An IMEI is marked invalid if it is stolen.

→ EIR allows the MSC to forbid calls from this stolen terminal.

→ This equipment identification procedure uses the identity of the equipment it self (IMEI) to ensure that the MS terminal equipment is valid.

→ AUC (Authentication Center) –

→ It is defined to protect used identity and transmission.

→ It is a protected database and stores a copy of secret information stored in SIM card.

→ These data help to verify user's identity.

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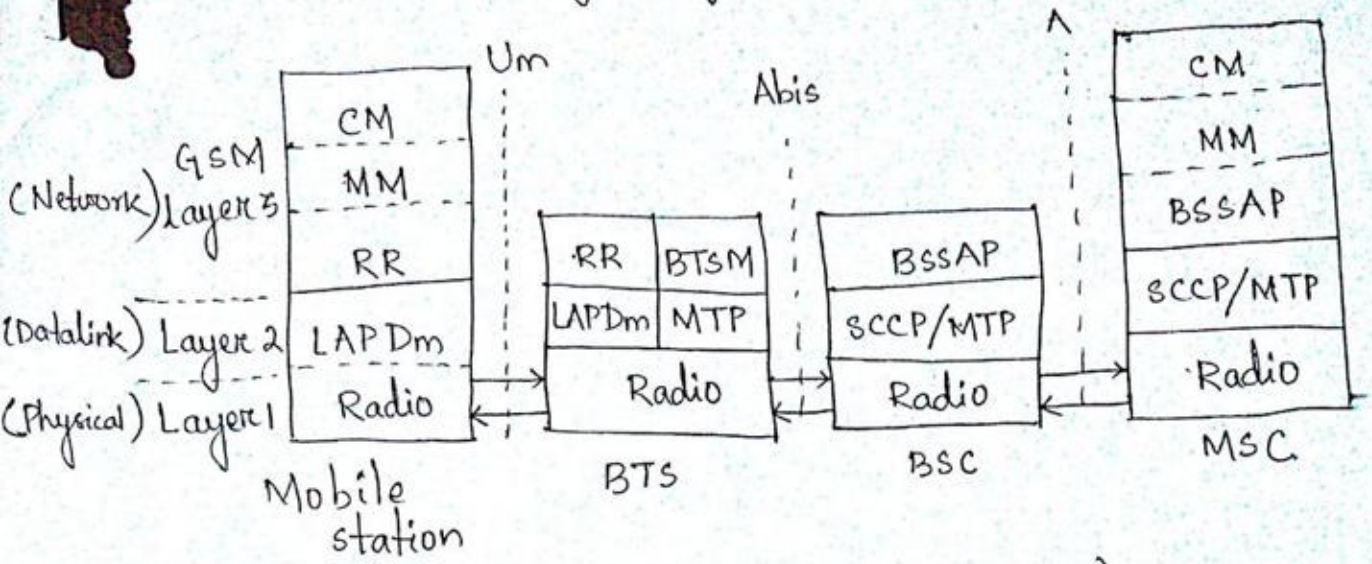
→ GSM Network Signalling :—



(GSM Network signalling)

LAPDm :- Link Access Procedure D-channel Managed

RR :- Radio Resource

MM :- Mobility Management

CM :- Call Management

BTSM :- BTS Management

BSSAP :- BSS Application Protocol

SCCP :- Signaling Connection Control Part

MTP :- Message Transfer Protocol

→ The signaling protocol in GSM is structured into 3 layers.

→ Layer 1 → Physical Layer

→ Layer 2 → Datalink layer

→ Layer 3 → Network Layer

→ MS-BTS :—

→ The physical layer between MS & BTS is called Um interface. It performs the following functions.

→ Full or half duplex access
→ Provides TDMA, FDMA and CDMA
→ Framing of data.

→ Here the datalink layer controls the flow of packets to and from network layer and provides access to various services like :

* Connection : Provides connection between two terminals.
* Teleservices : Services offered by a mobile network to users like : MMS, SMS, fax etc.

→ The datalink layer present between MS & BTS is LAPDm (Link Access Protocol). Its functions are :
→ Dataflow control
→ Acknowledged/unacknowledged data Transmission
→ Address and sequence no. check
→ Segmentation.

→ LAPDm protocol describes the standard procedure in GSM for accessing D-channel Link.

→ The network layer has 3 sublayers.

* CM (Call Management) :-
→ Supports call establishment, maintenance, termination.
→ supports Functioning of SMS.
→ support DTMF (Dual tone multiple frequency) signaling.

* MM (Mobility Management) :-
→ Controls the issue regarding mobility management,

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location updating and registration.

* RRM (Radio Resource Management) :-

→ Manages radio resources such as : frequency assignment, signal measurement.

→ BTS - BSC signalling protocols —

→ The physical layer between BTS & BSC is called Abis interface, where voice is coded by using 64 kbps PCM.

→ The connection between BTS and BSC is through a wired network.

→ The datalink layer is LAPDm.

→ Network Layer protocol is called BTS Management which interact with BSSAP.

→ BSC - MSC signalling protocol :-

→ The physical layer between BSC & MSC is called A-interface.

→ Datalink layer protocol between BSC & MSC is MTP (Message Transfer Protocol) & SCCP (Signaling Connection Control Protocol).

→ MTP and SCCP are part of the SS7 (signaling System No. 7) used by interface A.

→ Network layer protocols at the MSC are CM, MM and BSSAP (Base subsystem Application Part).

(5) Session mobility —

→ User should be able to move from one user environment to another.

e.g. CDMA network continues if it gets disconnected due to some reason and again restarted.

(6) Service mobility —

→ User should be able to move from one service to another.

e.g. a user writing his mail, user can use another service browser (service) and moves between them using the taskbar.

(7) Host mobility —

→ The user device can be either a client or a server. when it is a server or host, some of the complexities change. In case of host mobility, the mobile IP needs to be taken care of.

→ The mobile computing functions can be logically divided into following major segments.

1. User with device
2. Network
3. Gateway
4. Middle_ware
5. Content.

User with device :-

→ The user device could be a fixed device like desktop computer in office or a portable device like mobile phone.

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→ GSM Interfaces :-

1) The Radio Interface (MS to BTS) -

→ Um radio interface (between MS and BTS) is the most important in any mobile radio system.

→ It addresses the demanding characteristics of the radio environment.

→ The physical layer interfaces to the data link layer and radio resource management sublayer in the MS and BS and to other functional units in the MS and network subsystem (which includes the BSS and MSC) for supporting traffic channels.

→ The physical interface comprises a set of physical channels accessible through FDMA and TDMA.

→ The radio resource layer manages the dilog between the MS and BSS concerning the management of the radio connection, including connection establishment, control, release, and changes during handover.

→ The mobility management layer deals with supporting functions of location update, authentication, and encryption management in a mobile environment.

→ The SMS protocol of this layer supports the high level functions related to the transfer and management of short message services.

→ Abis Interface (BTS to BSC) : —

→ Abis is a standard interface which performs interconnection between the BTS and the BSC.

→ The primary functions are -
- traffic channel transmission
- terrestrial channel management
- the radio channel management

→ This interface supports two types of communication links.
- traffic channels at 64kbps carrying speech or user data for a full or half-rate radio traffic channel
- signalling channels at 16 kbps carrying information for BSC - BTS and BSC - MSC signaling.

→ Two types of messages are handled.
- transparent (bet- MS & BSC-MSC & don't require analysis by BTS)
- non- transparent. (require BTS analysis)

→ A interface : — (BSC to MSC)

→ It allows interconnection between the BSS radio base subsystem and the MSC.

→ The physical layer of A interface is a 2 Mbps standard Consultative Committee on Telephone and Telegraph (CCITT) digital connection.

→ The signaling transport uses Message Transport Part (MTP) and signaling Connection Control Part (SCCP) of SS7.

→ Mobility Management in GSM :-

→ Mobility management function handles the function that arises due to mobility of the subscriber.

→ Main objective : Location tracking & call setup.

→ The current location of MS is maintained by a 2-level hierarchical strategy with HLR & VLR.

→ When an MS visit a new location it registers in VLR of visited location. HLR is informed about the registration.

→ The registration process of MS moving from one VLR to another VLR follows the following steps.

1. MS periodically listens to the BCCH (Broadcast Control Channel) broadcast from BSS. If the MS detects that it has entered into a new location area, it sends a registration message to the new VLR by using SDCCH (Standalone Dedicated Control Channel) channel.

   SDCCH : Used only for signaling & for short message.
   BCCH : Provides system information.

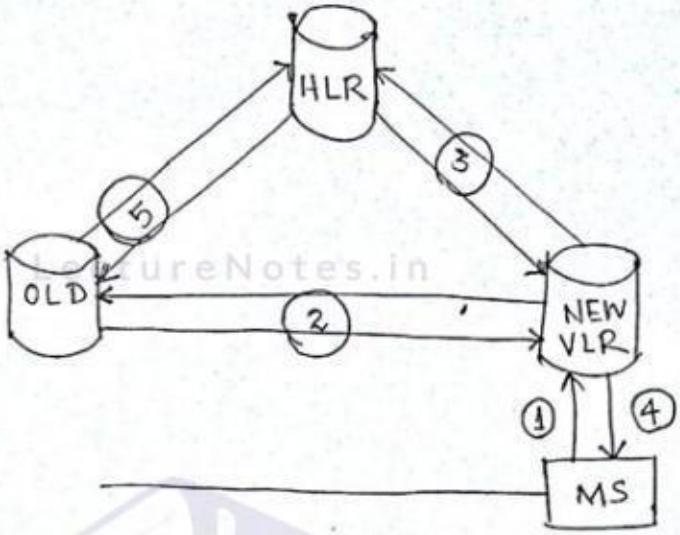
2. The new VLR communicates with old VLR to find HLR of MS. The new VLR then performs authentication process.

3. After MS is authenticated, new VLR sends a registration message to HLR. If the registration request is accepted, the HLR provides new VLR with all relevant subscriber information.

4. The new VLR informs the MS of successful registration.

5. Then the HLR sends a deregistration (Cancellation)

message to old VLR. The old VLR cancels the record for MS & sends an acknowledgement to the HLR regarding cancellation.



(GSM Mobility Management)

(1) GSM Location Update :—

→ Location update occurs when an MS moves from one LA to another.

→ Basic location update procedure handles
- → Inter - LA
- → Inter - MSC
- → Inter - VLR.

→ CASE - 1 (Inter - LA) :—

→ MS moves from LA 1 to LA 2, where both LAs are connected to same MSC.

1. A location update request message is sent from MS to MSC through BTS. In the new location MS is identified by TMSI (Temporary mobile subscription Identity) which is in alias of MSI.
2. The MSC forwards the location update request to VLR

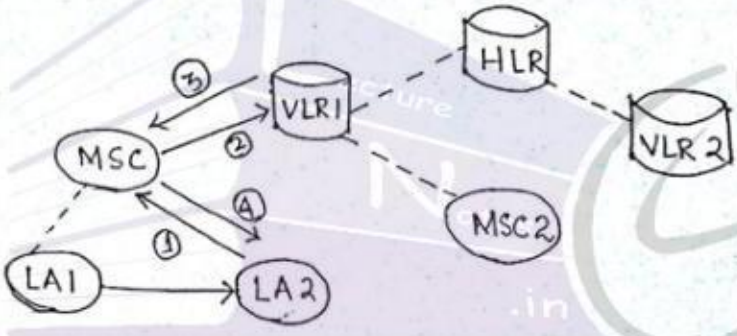
by a message,

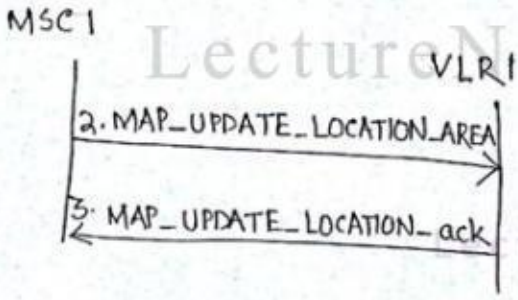
MAP_UPDATE_LOCATION_AREA.

→ This message includes

* Add of MSC
* TMSI of MS
* Provides LAI (LA Identity)
* Target LA.

3. VLR notices that both LA1 and LA2 belong to same MSC. It updates the LA1 field of VLR and replies an ACK to MS.





(Inter LA registration Message Flow)

CASE 2: (Inter MSC)

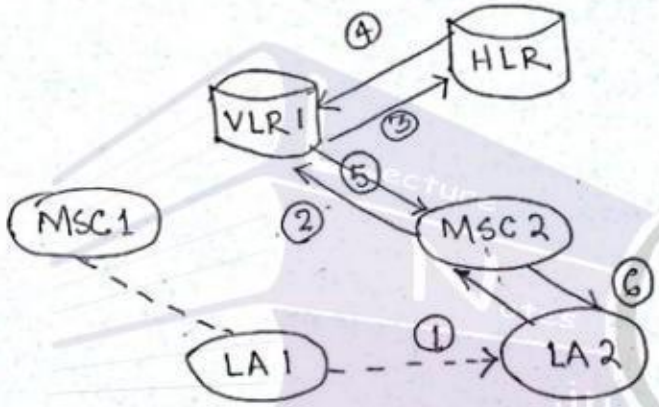
→ The two LAs belong to different MSCs of same VLR.

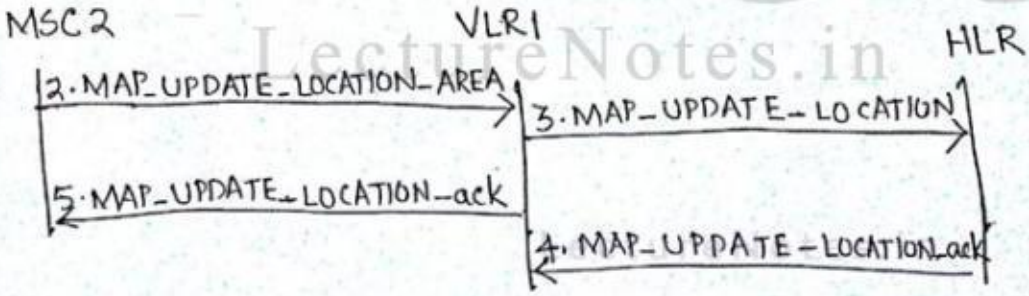
1. The location update request is sent from MS to VLR.
2. The VLR notices that previous LA and target LA belong to MSC1 and MSC2. Both MSC are connected to

same VLR. The VLR updates the LA1 and the MSC field of the VLR record and derives the HLR address of MS. The VLR sends the MAP_UPDATE_LOCATION message to the HLR.

3. By using the received IMSI, the HLR identifies the MS's record. The MSC number field of the record is updated. An acknowledgement is sent to VLR.

4. The acknowledgement is forwarded to MS.





(Inter MSC registration Message Flow)

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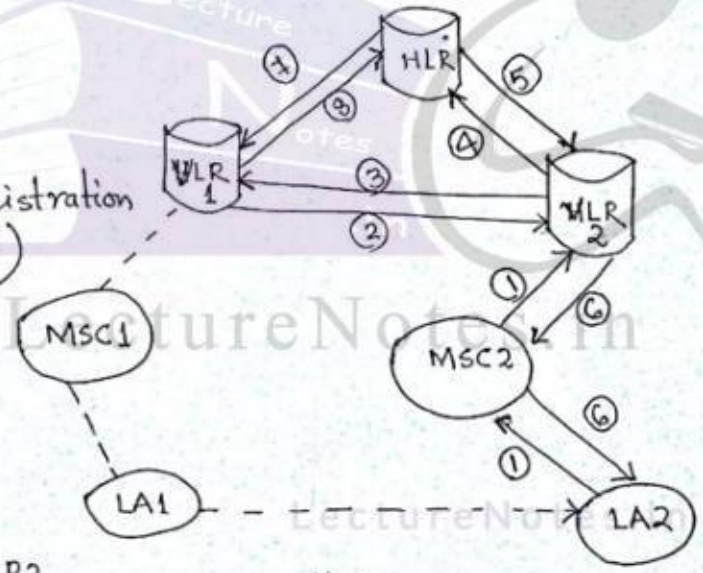
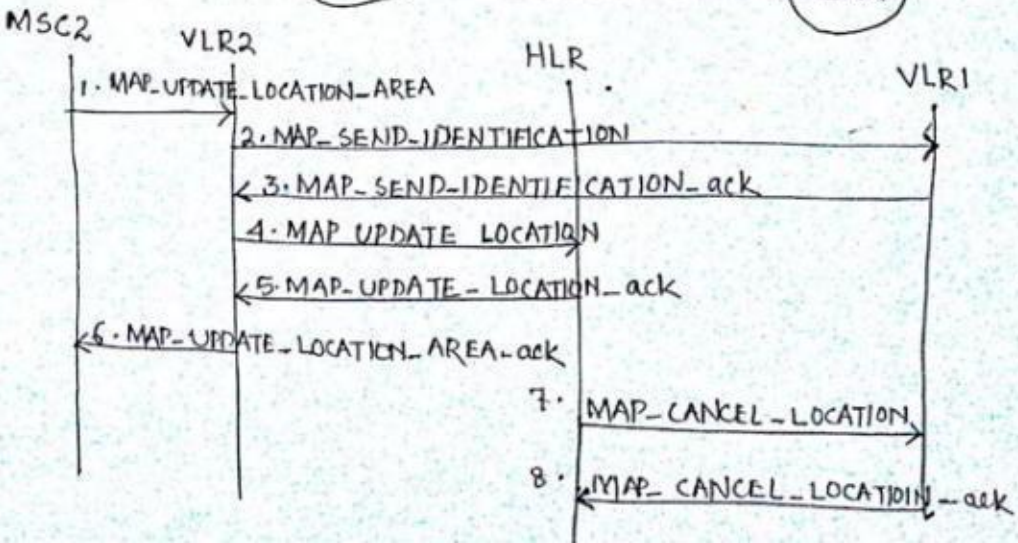
Case 3: (Inter VLR)

→ Here two LA belong to different VLR.

1. The location update request is sent from MS to VLR.
2. From MAP_UPDATE_LOCATION_AREA msg, VLR2 identifies the previous VLR of MS i.e VLR1.
3. It sends a message MAP_SEND Identification to HLR. This message provides TMSI of MS, ~~and sends registration message~~ which is used to identify the MS in VLR.
4. VLR2 creates a VLR record for MS and sends registration message to update HLR.
5. The obsolete record of MS in VLR1 is deleted.

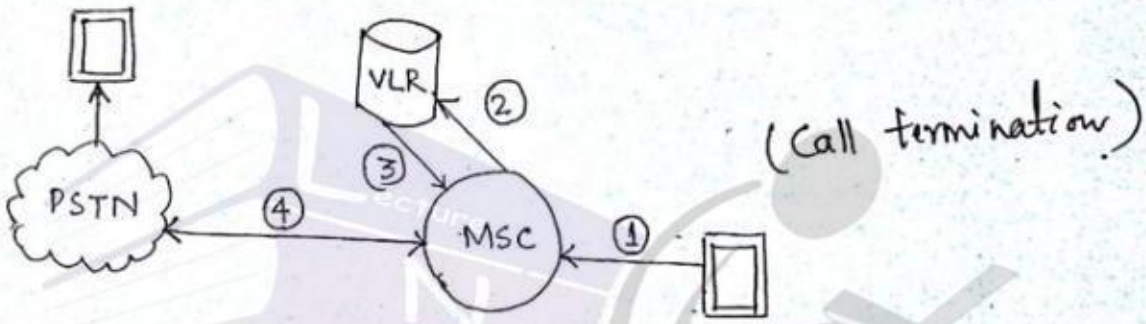
(Inter VLR Registration Message Flow)

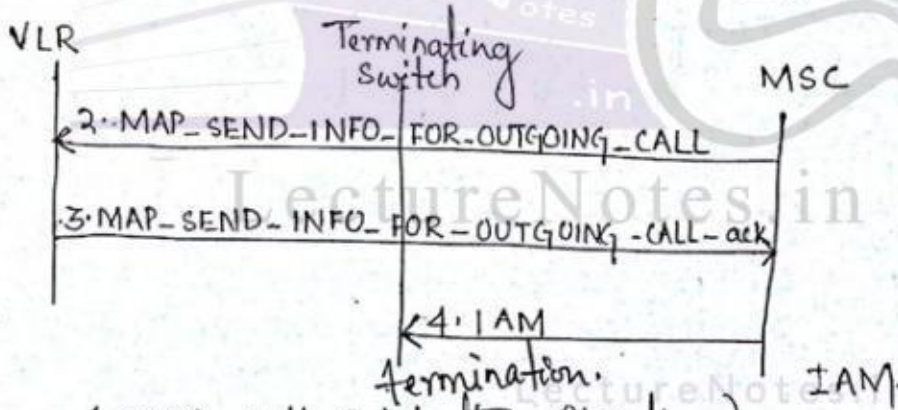




(2) GSM Call Origination :—

1. MS sends the call origination request to MSC.
2. MSC forwards the request to VLR by sending MAP-SEND-INFO-FOR-OUTGOING-CALL.
3. VLR checks MS's profile and sends an ACK to MSC to grant call request.
4. MSC setsup communication link according to standard PSTN call set up procedure.





(GSM call ~~Origination~~ termination Operation)

IAM → Initial Addressing Message.

GMSC → Gatway MSC.

(3) Call Termination :—

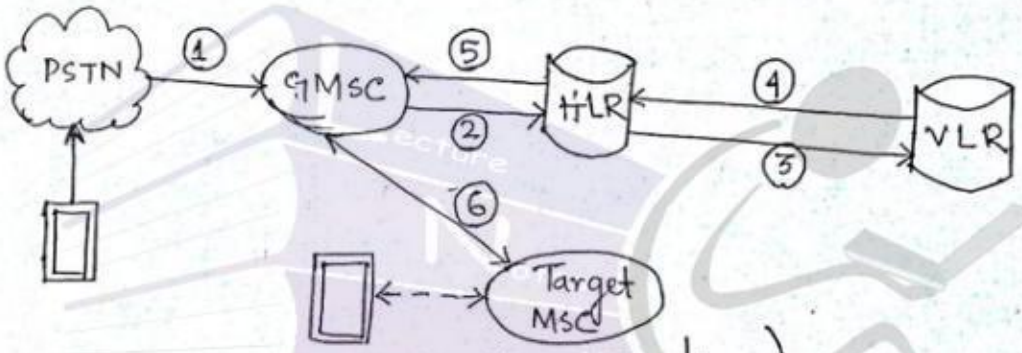
→ When mobile station number is dialed by PSTN user, call is routed to GMSC by IAM (Initial Addressing Message) message

1. To obtain routing information, GMSC interrogates HLR by sending MAP-SEND-ROUTING-INFORMATION to HLR.

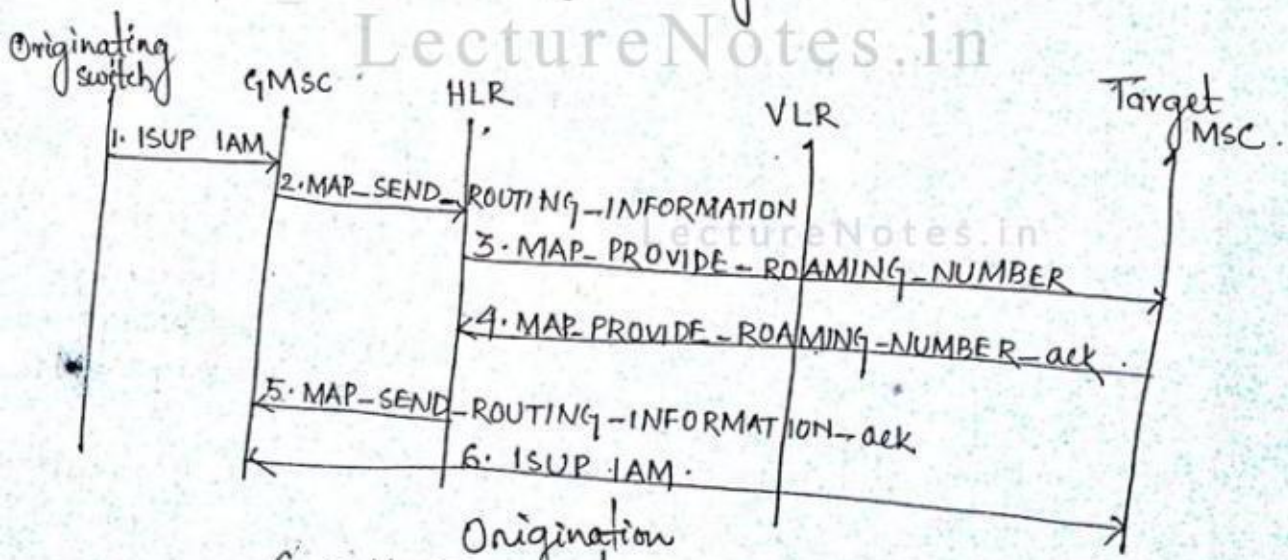
2. HLR sends a MAP_PROVIDE_ROAMING_NUMBER msg to VLR to obtain MSRN (MS Roaming Number). The message consists of IMSI, MSC number etc.

3. The VLR creates the MSRN by using MSC number stored in VLR record of MS. The MSRN no is sent back to GMSC through HLR.

4. MSRN provides address of target MSC where the MS resides. Then a message is directed from GMSC to target MSC to set communication link.



(Call origination)



(Call ~~Termination~~ Origination Operation)

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GPRS

→ General Packet Radio Service (GPRS) is a packet oriented mobile data service available to users of the 2G cellular communication systems global system for mobile communications (GSM), as well as in the 3G systems.

→ In 2G systems, GPRS provides data rates of 56 – 114 kbit/s.

→ GPRS is a mechanism to transport highspeed data over GSM.

→ It has the ability to offer data in small packet at speed of 14.4 kbps to 171.2 kbps. GPRS is a speed enhanced data transmission service designed for GSM system.

→ Speed enhanced data transmission takes place by packetizing of data and simultaneous transmission of packets over different channels.

→ GPRS standard is defined by ETSI (European Telecommunication Standard Institute).

→ GPRS is a packet oriented service for mobile data transmission and their access to internet. It uses unused slots and channels in TDMA mode of a GSM for packetized transmission from a mobile station.

→ Services :

→ GPRS upgrades GSM data services providing :

- Multimedia messaging services (MMS)
- Short message service (SMS)
- Push to talk over cellular (PoC/PTT)
- Instant messaging and presence - wireless village.
- Internet applications for smart devices through wireless application protocol (WAP)

e.g: laptops, desktops, fixed telephones, mobile phones, digital TV set-top box, palmtop computers, pocket PCs, two way pagers, handheld terminals etc.

Network —

→ when a user is mobile, he will be using different networks at different places at different time.
e.g. GSM, CDMA, iMode, Ethernet, wireless LAN, Bluetooth etc.

Gateway —

→ It is required to interface different transport bearers. These gateway convert one specific transport bearer to another transport bearer.
e.g. from a fixed phone (with voice interface) we access a service by pressing different keys on the telephone. These keys generate DTMF (Dual tone Multi Frequency) signal.
→ These analog signals are converted into digital data by the IVR gateway to interface with a computer application. Other examples are WAP gateway, SMS gateway etc.

Middleware —

→ It is more of a function rather than a separate visible node.
→ Here middleware handles presentation and rendering of the content on a particular device. It will also handle the security and personalization for different users.

Content —

→ It depicts the origin server and its contents.
It can be mass market, personal or corporate content
Origin server will have some means to access the database and storage device.

- Point-to-point (PTP) service: inter networking with the internet (IP).
- Future enhancements: flexibility to add new functions, such as more capacity, more users, new accesses, new protocols, new radio networks.

→ Goals of GPRS :—

→ GPRS is the first step towards an end-to-end wireless infrastructure and has the following goals:
- Open architecture
- Consistent IP services
- Same infrastructure for different air interfaces.
- Integrated telephony and Internet infrastructure.
- Leverage industry investment in IP.
- Service innovation independent of infrastructure.

→ Benefits of GPRS :—

→ Higher Data Rate :—

→ Users of GPRS benefit from shorter access times and higher data rates.

→ In conventional GSM, the connection set up takes several seconds and rates for data transmission are restricted to 9.6 kbit/s.

→ GPRS in practice offers session establishment times below one second and ISDN-like data rates upto several ten kbit/s.

→ Easy Billing :—

→ GPRS packet transmission offers a more user friendly billing ~~the~~ than that offered by circuit switched services.

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→ In ckt switched services, billing is based on the duration of the connection.

→ This is unsuitable for applications with bursty traffic. The user must pay for the entire airtime even for idle periods when no packets are sent. (e.g. when the user reads a Web page).

→ Again, in packet switched services, billing can be based on the amount of transmitted data. The advantage for the user is that the user can be 'online' over a long period of time but will be billed based on the transmitted data volume.

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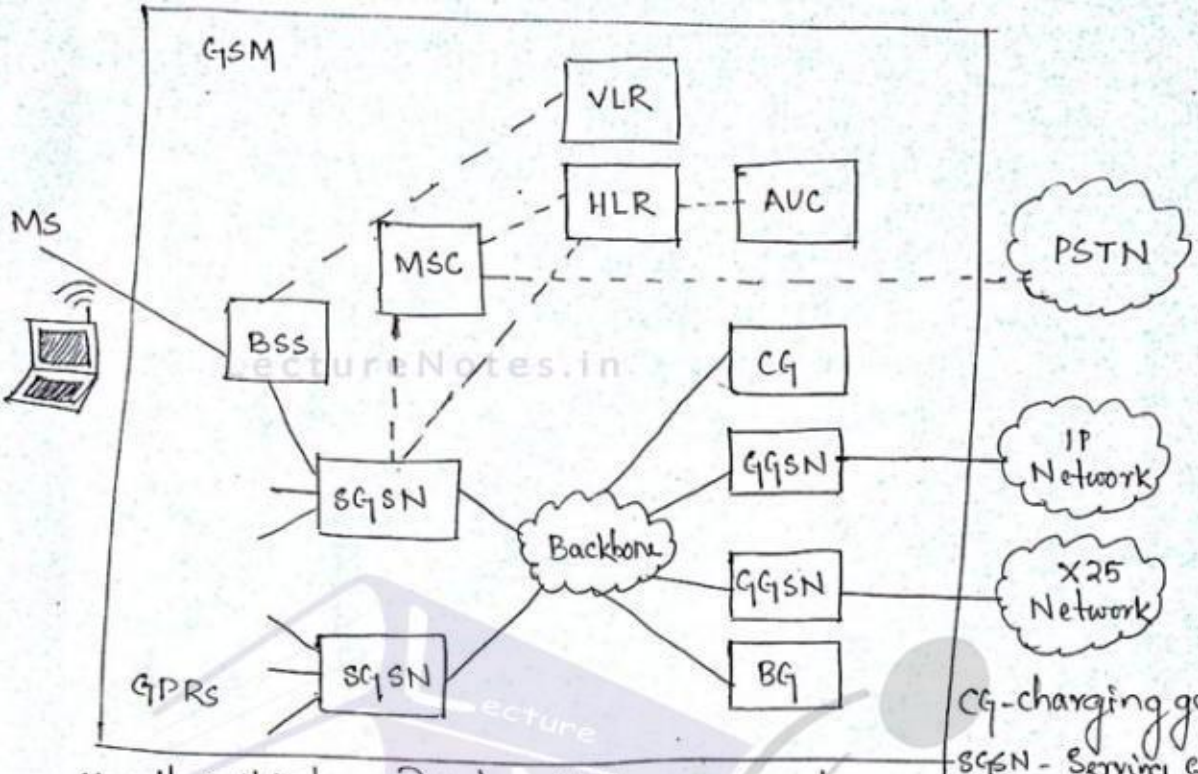
⇒ GPRS Architecture :—



CG-charging gateway
SGSN - Serving GPRS support Nodes
GGSN - Gateway GPRS support nodes
BG → Border Gateway.

Circuit Switched --- Packet switched --- Signaling ----

(GPRS Architecture)

→ GPRS uses GSM architecture for voice.

→ GPRS supports a class of network nodes to offer packetdata. These nodes are called as GPRS support nodes.

→ GSN (GPRS Support Nodes) are responsible for delivery and routing of data packets between MS and external packet data network (PDN).

→ An MS having GPRS capability stores CKSN (Cipher Key Sequence No) similar to cipher key stored in SIM & GSM.

→ It also stores a TLLI (Temporary Logical link identity) similar to TMSI.

→ BSS system existing in the network needs enhancement to recognize and packet data.

→ BTS also needs to be upgraded to support packet data transportation. HLR needs enhancement to register GPRS user profile and respond to queries originating from GSN.

→ The GPRS system brings some new network elements to an existing GSM network.
There elements are :

→ PCU
→ SGSN
→ GGSN
→ BG
→ CG

1. Packet Control Unit (PCU) :—

→ The PCU separates the circuit switched and packet switched traffic from the user and sends them to the GSM and GPRS networks respectively.

→ It also performs most of the radio resource management functions of the GPRS network.

→ The PCU can be either located in the BTS, BSC or some other point between the MS and the MSC.

→ There will be at least one PCU that serves a cell in which GPRS services will be available.

→ Frame Relay technology is being used at present to interconnect the PCU to the GPRS core.

2. Serving GPRS Support Node (SGSN) :—

→ SGSN is the most important element of the GPRS network.

→ The SGSN of the GPRS is equivalent to the MSC of the GSM network. There must be at least one SGSN in a GPRS network.

→ One coverage area is associated with every SGSN. As the network expands and the number of subscribers increases, there may be more than one

a SGSN in a network.

→ The SGSN has the following functions:

→ Protocol conversion (e.g. IP to FR)

→ Ciphering of GPRS data between the MS and SGSN.

→ Data compression is used to minimise the size of transmitted data units.

→ Authentication of GPRS users.

→ Mobility management as the subscriber moves from one area to another and possibly one SGSN to another.

→ Routing of data to the relevant GGSN when a connection to an external network is required.

→ Interaction with the NSS (i.e MSC/VLR, HLR, EIR) via the SS7 network inorder to retrieve subscription information.

→ Collection of charging data pertaining to the use of GPRS users.

→ Traffic statistics collections for network management purposes.

3.→ Gateway GPRS Support Node (GGSN) : —

→ The GGSN is the gateway to external networks. Every connection to a fixed external data network has to go through a GGSN.

→ The GGSN acts as the anchor point in a GPRS data connection even when the subscriber moves to another SGSN during roaming.

→ The GGSN may accept connection request from SGSN that is in another PLMN. Hence the concept of coverage area does not apply to GGSN.

→ There are usually two or more GGSNs in a network for redundancy purposes and they back up each other up in case of failure.

→ The functions of a GGSN are

→ Routing mobile-destined packets coming from external networks to the relevant SGSN.

→ Routing packets originating from a mobile to the correct external network.

→ Interfaces to external IP networks and deals with security issues.

→ Collects charging data and traffic statistics.

→ Allocates dynamic or static IP addresses to mobiles either by itself or with the help of a DHCP or a RADIUS server.

→ Involved in the establishment of tunnels with the SGSN and with other external networks and VPN.

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→ GGSN is simply a router to an IP sub-network.

→ When the GGSN receives data addressed to a specific user in the mobile network, it first checks if the address is active.

→ If it is active, GGSN forwards the data to the SGSN serving the mobile.

→ If address is inactive, the data is discarded.

→ The GGSN also routes mobile originated packets to the correct external network.

4. Border Gateway :-

→ The BG is a router that can provide a direct GPRS tunnel between different operators' GPRS networks. This is called an inter-PLMN data network.

→ It is more secure to transfer data between two operators' PLMN networks through a direct connection rather than via the public Internet.

→ The Border Gateway (BG) will commence operation once the GPRS roaming agreements between various operators have been signed.

→ It will essentially allow a roaming subscriber to connect to company intranet through the Home GGSN via the visiting PLMN network.

5. Charging Gateway (CG) :-

→ GPRS users have to be charged for the use of the network.

→ In GSM network, charging is based on the destination, duration and time of call.

→ GPRS offers connectionless service to users, so it is not possible to charge subscribers on the connection duration.

→ Charging has to be based on the volume, destination, QoS and other parameters of a connectionless data transfer.

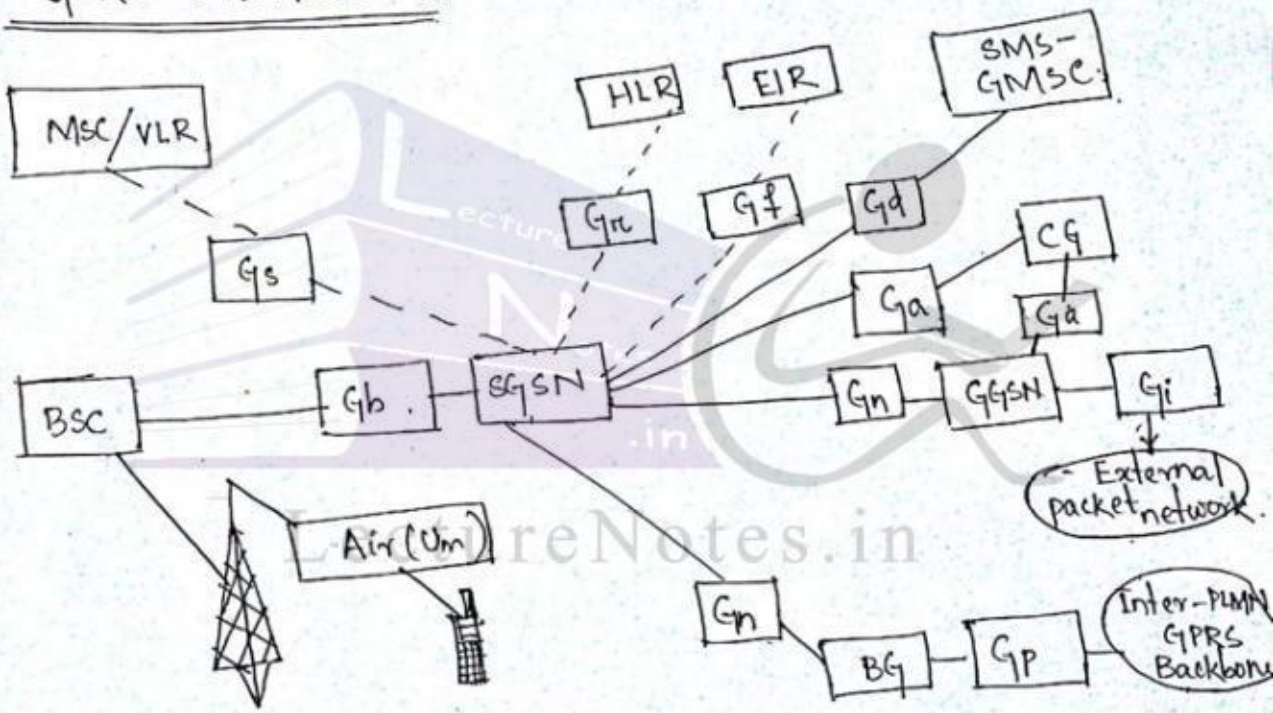
→ GPRS charging data are generated by all the SGSNs and GGSNs in the network. This data is called as Charging Data Records or CDRs.

→ One data session may generate a no. of CDRs, which needs to be collected and processed.

→ The CG collects all of those records, sorts them, processes it, and passes it on to the Billing system.

→ Here the GPRS subscriber is billed for the data trasaction.

GPRS Interfaces :—



— Signalling and data

- - - Signalling.

→ The GPRS system introduces new interfaces to the GSM network.

→ Connections from the GPRS system to the NSS part of the GSM network are implemented through the SS7 network.

→ The GPRS element interfacing with the NSS is SGSN. The important interfaces to the NSS are the SGSN-HLR (Gr), SGSN-EIR (Gf), and SGSN-MSC/VLR (Gs).

→ The other interfaces are implemented through the intra-PLMN backbone network (Gn), the inter-PLMN backbone network (Gp) or the external networks (Gi)

→ The interfaces used by the GPRS system are

* Um - between an MS and GPRS fixed network part
The Um is the access interface the MS uses to access the GPRS network. The radio interface to the BTS is the same interface used by the existing GSM network with some GPRS specific changes.

* Gb — between a SGSN and a BSS. The Gb interface carries the GPRS traffic and signalling between the GSM radio network (BSS) and the GPRS network.
→ Frame relay based network service is used for this interface.

* Gn — between two GSNs within the same PLMN. Gn provides a data and signalling interface in the Intra-PLMN backbone.
→ The GPRS Tunnelling Protocol (GTP) is used in the Gn (and in the Gp) interface over the IP based backbone network.

* Gp - between two GSNs in various PLMNs.
→ provides security, routing etc.

* Gr → between SGSN and the HLR.
  → Gr gives SGSN access in HLR.
  → HLR can be located in a different PLMN, than the SGSN (MAP).

* Ga → between GSNs and CG inside the same PLMN.
  → Ga provides a data and signalling interface.
  → used for sending the charging data records generated by GSNs to the CG.

* Gs → between a SGSN and a MSC
  → SGSN can send location data to the MSC or receive paging requests from the MSC via this optional interface.
  → Improves the effectiveness of the radio and network resources.

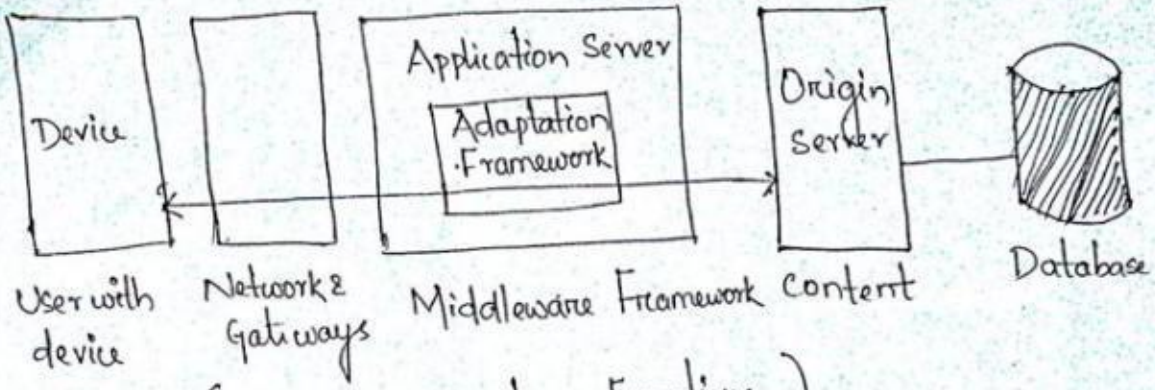
* Gd → between the SMS-GMSC and an SGSN and between SMS-IWMSC and an SGSN.
  → used for more efficient use of the SMS services (MAP)

* Gf → between SGSN and EIR.
  → used for equipment information

* Ge → between GGSN and HLR.
  → can be used if the GGSN needs to forward packets to an MS that is not active.

* Gi → between GGSN and external network.

* R → between terminal equipment and mobile termination.



(Mobile Computing Functions)

→ Mobile Computing Architecture :—

3-tier architecture.

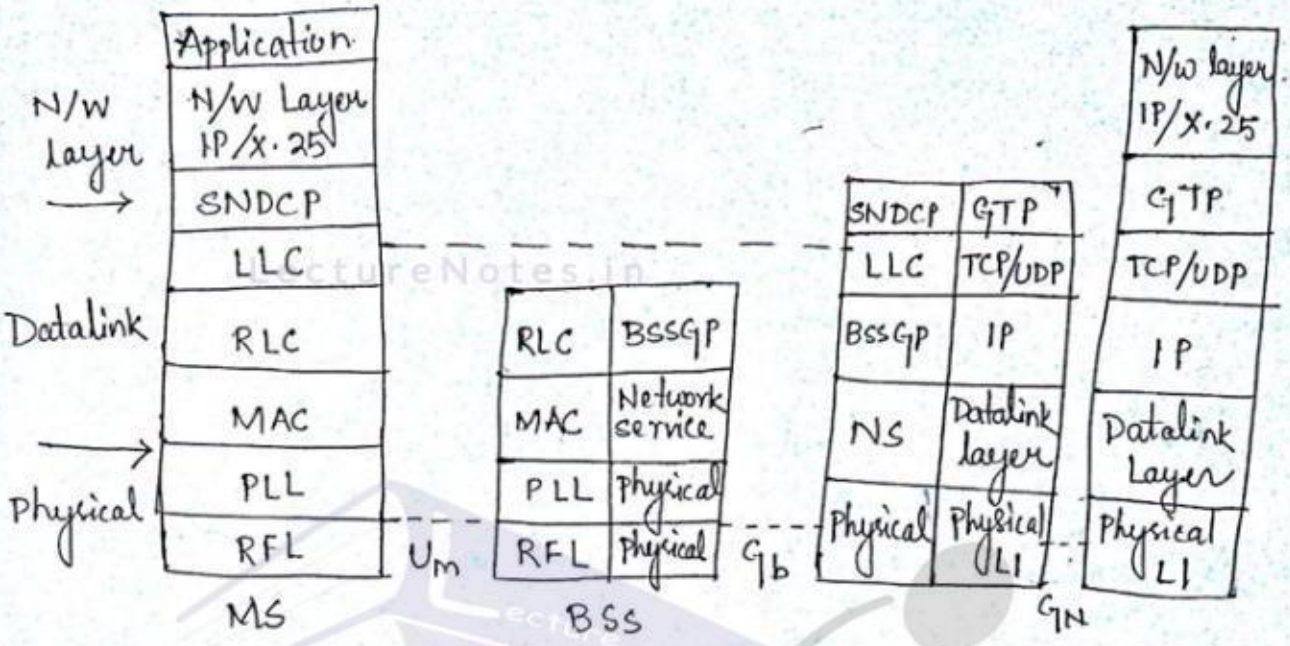
1st layer: User Interface or Presentation Tier
(deals with user facing device handling and rendering)

2nd layer: Process Management or Application Tier
(for application programs or process management where business logic and rules are executed.
→ Also capable of accomodating hundreds of users.

3rd layer: Database Management or Data Tier.
(for database access and management)

→ This 3 tier architecture provides increased performance, flexibility, maintainability, resusability and scalability while hiding the complexity of distributed processing from the user.

GPRS Network Protocol :—



(GPRS Networking Protocol)

SNDCP : Subnetwork Dependent Convergence Protocol

LLC : Logical Link Control

RLC : Radio Link Control

MAC : Medium Access Control

PLL : Physical Link Layer

RFL : Radio Frequency LAYER

BSSGP : BSS GPRS Protocol

GTTP : GPRS Tunneling Protocol

TCP : Transmission Control Protocol

IP : Internet Protocol.

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⇒ Transmission protocols in Um Interface :—

1. Physical Layer :—

→ The physical layer can be divided into the Radio Frequency (RF) layer and Physical Link Layer.

→ The Radio Frequency (RF) is the normal GSM physical radio layer. It performs the modulation of physical waveform based on sequence of bits received from PLL.

→ The RF layer specifies :

* The carrier frequency characteristics and GSM radio channel structures
* The radio modulation scheme used for the data.
* The radio transmitter and receiver characteristics as well as performance requirements.

→ The Physical Link layer supports multiple MSs sharing a single physical channel and provides communication between the MSs and the network.

→ Network control handovers are not used in the GPRS service instead routing area updates and cell updates are used.

→ The PLL is responsible for :

* Forward Error Correction (FEC) coding, allowing the detection and correction of transmitted code words and the indication of incorrectable codewords.
* The interleaving of one RLC Radio Block over four bursts in consecutive TDMA frames.

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2. Medium Access Control (MAC) :—

→ The MAC protocol handles the channel allocation and the multiplexing i.e the use of physical layer functions.

→ The RLC and the MAC together form the OSI Layer 2 protocol for the Um interface.

→ The GPRS MAC function is responsible for:

* Providing efficient multiplexing of data and control signalling on both the uplink and downlink. This process is controlled by the network. On the downlink, multiplexing is controlled by a scheduling mechanism. (e.g. in response to a service request).
* Mobile originated channel access, contention resolution between channel access attempts, including collision detection and recovery.
* Mobile terminated channel access, scheduling of access attempts, including queuing of packet accesses :
* Priority handling :

3. The Radio Link Control (RLC) :—

→ The RLC protocol offers a reliable radio link to the upper layers.

→ Two modes of operation of the RLC layers are defined for information transfer

→ unacknowledged

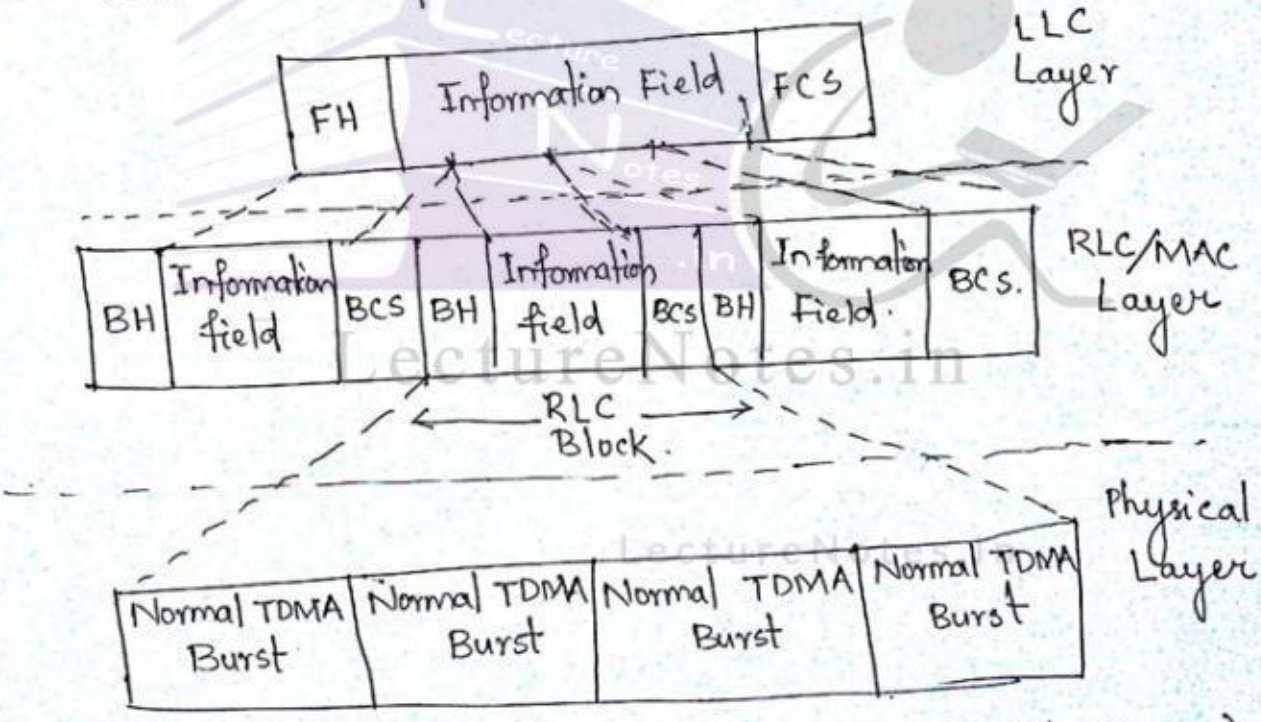
and → acknowledged.

LectureNotes.in

→ The RLC layer can support both modes simultaneously

→ The RLC function is responsible for:

* Providing transfer of Logical Link Control layer PDUs (LLC - PDU) between the LLC layer and the MAC function. (PDU → Protocol data units)
* Segmentation and reassembly of LLC - PDUs into RLC Data Blocks.
* Backward Error Correction (BEC) procedures enabling the selective retransmission of uncorrectable code words. This process is generally known as Automatic Request for Retransmission (ARQ).



(Segmentation of LLC - PDUs into RLC datablocks)

FH - Frame Header

FCS = Frame Check Sequence

BH = Block Header

BCS = Block Check Sequence (when SDCCH coding is used, BCS corresponds to the Firecode)

(4) Logical Link Control (LLC) :—

→ The LLC layer offers a secure and reliable logical link between the MS and the SGSN for upper layer protocols, and is independent of the lower layers.

→ The LLC conveys signalling, SMS and Subnetwork Dependent Convergence Protocol (SNDCP) packets.

→ SNDCP exists between the MS and the SGSN and provides a mapping and compression function between the network layer (IP or X.25 packets) and the lower layers.

→ It also performs segmentation, reassembly and multiplexing.

→ Two modes of operation of the LLC layer are defined for information transfer:

- → unacknowledged
- → acknowledged

→ The LLC layer can support both modes simultaneously.

→ Acknowledged Mode : Here the receipt of LLC-PDUs is confirmed. The LLC layer retransmits LLC-PDUs if confirmation has not been received within a certain timeout period.

→ Unacknowledged Mode :-

- → there is no confirmation required for LLU-PDUs.
- → Signalling and SMS is transfered.
- → In this mode the LLC layer offers the

following two options.

(1) Transport of protected information means that if errors occur within the LLC information field, the frame will be discarded.

(2) Transport of unprotected information means that if errors occur within the LLC information field, the frame will not be discarded.

(5) SNDCP (Subnetwork Dependent Convergence Protocol) :-

→ It is a convergence protocol used to transfer data packet and voice data between SGSN and MS through IP/X.25.

→ Network layer protocols are intended to be capable of operating over a wide variety of subnetworks and datalinks.

→ GPRS supports several network layer protocols providing protocol transparency for the users of the service.

→ To enable introduction of new network layer protocols to be transferred over GPRS without any changes to GPRS, all functions related to the transfer of Network layer Protocol Data Units (N-PDUs) are carried out in a transparent way by the GPRS network. This is one of the requirements of SNDCP.

→ Another requirement of SNDCP is to provide functions that help to improve channel efficiency. This is achieved by means of compression techniques.

⇒ Transmission protocols in the Gb interface :-

→ Gb allows many users to be multiplexed over the same physical link using Frame Relay (FR).

→ Bandwidth is allocated to a user upon activity (when data is sent or received) and is reallocated thereafter.

→ This is in contrast to the A- interface where a single user has the exclusive use of a dedicated physical resource throughout the lifetime of a call irrespective of activity.

→ GPRS signalling and user data are sent in the same transmission plane and therefore no separate dedicated physical resources are required to be allocated for signalling purposes.

→ Data rates over the Frame Relay Gb interface may vary for each user without restriction from zero data to the maximum possible line rate (e.g. 1984 kbit/s, which is the maximum available bit rate of a 2Mbit/s (E1) link).

1. Physical Layer Protocol :-

→ Several physical layer configurations and protocols are possible at the Gb interface and the physical resources are allocated by Operation & Maintenance (O&M) procedures.

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2. Network Services Layer :—

→ The Gb interface Network Services layer is based on Frame Relay.

→ Frame Relay virtual circuits are established between the SGSN and BSS.

→ LLC PDUs from many users are statistically multiplexed onto these virtual ckts.

→ These virtual ckts may traverse a network of Frame Relay switching nodes, or may just be provided on a point to point link between the BSC and the SGSN.

→ Frame Relay is used for signalling and data transmission over the Gb interface.

3. Base Station System GPRS Protocol (BSSGP) :—

→ The BSS-GPRS Protocol (BSSGP) transfers control and signaling information and user data between a BSS and the SGSN over the Gb interface.

(1) → The primary function of BSSGP is to provide Quality of service (QoS) and routing information that is required to transmit user data between a BSS and an SGSN.

→ (2) The secondary function is to enable two physically distinct nodes, the SGSN and BSS to operate node management control functions. There is a one to one relationship between the BSSGP protocol in the SGSN and in the BSS. If one SGSN handles multiple BSS, the SGSN has to have one BSSGP protocol device for each BSS.

→ The main functions for the BSSGP protocol are to:

→ Provide a connectionless link between the SGSN and the BSS.

→ Transfer data in an unconfirmed way between the SGSN and the BSS.

→ Provide for bi-directional control of the dataflow between the SGSN and the BSS.

→ Handle paging requests from the SGSN to the BSS.

→ Give support for deleting old messages in the BSS, for example when an MS changes BSS.

→ Support multiple layer 2 links between the SGSN and the BSS.

⇒ Transmission Protocols in the Gn interface :—

→ The Gn interface forms the GPRS backbone network.

1. Layer 1 and layer 2

→ The L1 and L2 protocols are vendor dependent OSI layer 1 and layer 2 protocols that carry the IP datagrams for the GPRS backbone network between the SGSN and GGSN.

2. Internet Protocol (IP) —

→ The IP datagram in Gn is only used in the GPRS backbone network.

→ The GPRS backbone (core) network and the GPRS subscribers use different IP addresses.

→ This makes the GPRS backbone IP network invisible to the subscribers and viceversa.

→ GPRS backbone network carries the subscriber IP or X.25 traffic in a secure GPRS tunnel.

3. TCP or UDP

→ TCP/UDP are used to carry the GPRS Tunnelling Protocol (GTP) PDUs across the GPRS backbone network.

→ TCP is used for user X.25 data and UDP is used for IP data and signalling in the Gn interface.

4. GPRS Tunnelling Protocol (GTP) –

→ GTP allows multi-protocol packets to be tunnelled through the GPRS backbone between GPRS support nodes (GSNs).

→ GTP is defined both for Gn and Gp interfaces.

→ Two modes of operation of the GTP layer are supported for information transfer between the GGSN and SGSN.

→ unacknowledged (UDP/IP)

→ acknowledged (TCP/IP)

→ UDP/IP is used when the user data is based on connectionless protocols such as IP.

→ TCP/IP is used when the user data is based on connection oriented protocols such as X.25.

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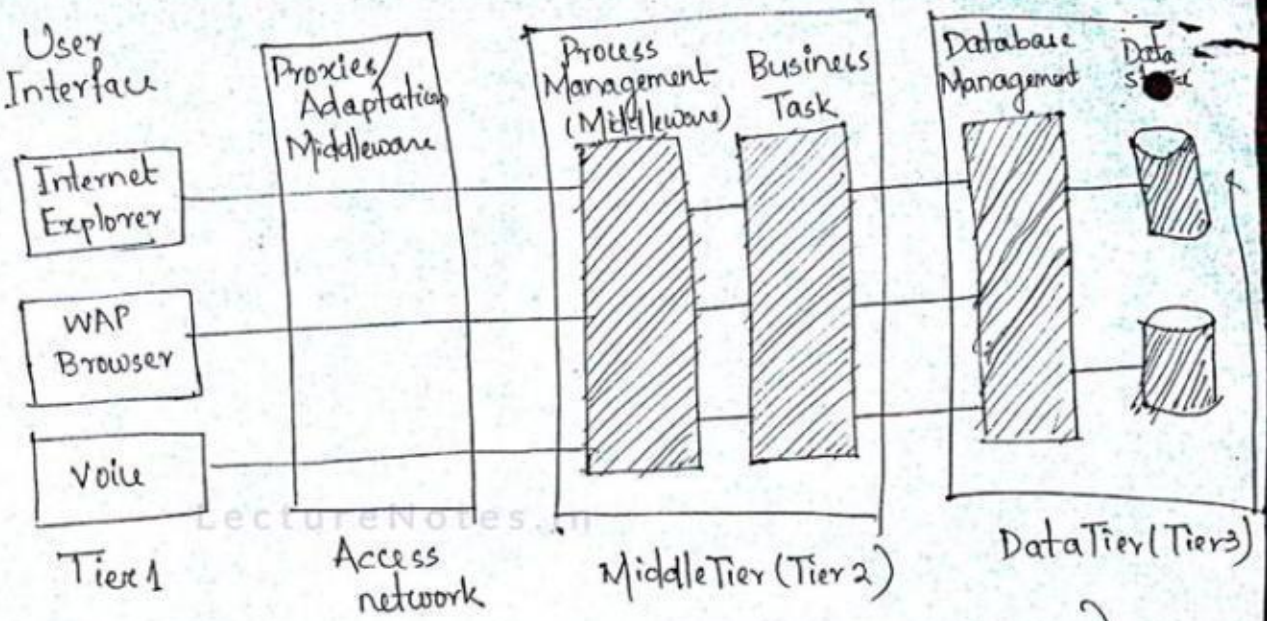

(Three Tier Architecture for Mobile computing)

Wireless Technology —

→ It is the use of communication of information over a distance without the use of electrical conductors or wires.

Evolution

→ 0G (Zero Generation)

1. Push To Talk (PTT) —
(Press to Transmit) is a method in half duplex communication.

2. Mobile Telephone system (MTS) —
→ earliest mobile telephone standards.
→ Operator assisted both directions,
i.e. call → PSTN → mobile operator → phone → Ring

~~Mobile operator~~.
→ Originated with the Bell system in St. Louis on 1946.

LectureNotes.in

→ GPRS- Data Routing :—

→ GPRS network is required for routing of data packets from a mobile user.

→ Requirement is of 2 types.

→ data packet routing

→ mobility management.

1. Data Packet Routing :—

→ GGSN interacts with the external data network. The GGSN updates the location directory using routing information supplied by SGSNs.

→ 3 important routing schemes are there.

* Mobile Originated message :- This path begins at the GPRS mobile and ends at the host.

* Network-initiated message when the MS is in its home network :- This path begins at the host and ends at the GPRS mobile.

* Network-initiated message when the MS roams to another GPRS network :- This path begins at the host of visited network and ends at the GPRS mobile.

2. Mobility Management :—

→ MM is required to track MS location within each PLMN.

⇒ An MS can be any of the following 3 stages in the GPRS system.

→ The three-state model is unique to packet radio.

1. Active state :-

→ Data is transmitted between an MS and the GPRS network only when MS is in Active state.

→ In active state the SGSN knows the cell location of the MS.

→ Packet transmission to an active MS is initiated by packet paging to notify the MS of an incoming data packet.

→ The data transmission proceeds immediately after packet paging through the channel is indicated by the paging message. This reduces the battery usage significantly.

→ When an MS has a packet to transmit, it must access the uplink channel. The uplink channel is shared by a no. of MSs and its use is allocated by a BSS.

→ BSS allocates an unused channel to the MS and sends an access grant message in reply to the random access message.

2. Standby state :-

→ In standby state only the routing area of the MS is known.

→ When the SGSN sends a packet to an MS that is in the standby state, a packet paging message is sent to the routing area.

→ On receiving the packet paging message, the MS relays its cell location to the SGSN to establish the active state.

Idle State :-

→ In Idle state, the MS doesnot have a logical GPRS context activated or any packet switched public data network addresses allocated.

→ In this state, the MS can only receive those multicast messages that can be received by any GPRS MS.

Routing Updates :-

→ When an MS which is in an active or a stand by state moves from one routing area to another within the service area of one SGSN, it must perform a routing update.

→ i.e the routing area information in the SGSN is updated, and the success of the procedure is indicated in the response message.

WIRELESS LAN

→ It is a LAN without wires.

→ Goal: is to replace office cabling to enable quicker access to internet and to higher flexibility communication.

→ WLAN Application —

→ WLAN is best suited for dynamic environment. The applications are -

1. Cross Building Interconnect -
   - → used to connect LANs in nearby building using a point-to-point wireless link.
   - → using bridges and router devices

2. Nomadic Access -
   - → is a wireless link between LAN hub and a mobile data terminal equipped with an antenna such as laptop or notepad computer.
   - → useful in extended environment such as a campus.

3. Ad Hoc Networking -
   - → is a peer-to-peer network setup temporarily to meet some immediate need.
     e.g. a group of employees, each with a laptop computer, may converse in a conference room for business.
   - → link for network is done for the duration of the meeting.

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→ WLAN Requirements

→ Throughput : MAC protocol should make as efficient use as possible of wireless medium to maximize capacity.

→ Number of nodes : need to support 100s of nodes across multiple cells.

→ Connection to backbone LAN : an interconnection structure is required.

→ Service area : coverage area diameter of 100 to 300m

→ License free operation : can buy and operate without a secure license for freq. band.

→ Handoff / roaming : should enable MSs to move from one cell to another.

→ Dynamic configuration : should permit dynamic and automated addition, deletion and relocation of end systems without disruption to other users.

→ Battery power consumption : WLAN have features to reduce power consumption while not using the network, such as sleep mode.

→ WLAN Advantages —

→ Mobility
→ Low implementation cost
→ Installation speed and simplicity
→ Network Expansion
→ Reliability
→ Scalability
→ Usage of ISM band.

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→ WLAN Technology

1. Infrared (IR) LANs —

→ limited to a single room, as IR light does not penetrate walls.

→ 3 transmission techniques are used.

(i) Direct beam IR to create point-to-point links

(ii) Omnidirectional configuration (B.s mounted on the ceiling)

(iii) diffused configuration

(IR txs are focused at a point on diffusely reflecting ceiling)

2. Spread Spectrum LANs —

→ makes use of a multiple cell arrangement.

2 topologies used.

1. Hub topology :- hub is mounted on the ceiling and connected to backbone wired LAN

2. Peer-to-peer technology :- No hub is there. MAC algorithm such as CSMA is used to control access.

3. Narrowband microwave —

→ WLAN operate at microwave frequencies but do not use spread spectrum.

→ Narrowband uwave = uwave radio frequency band for signal transmission with relatively narrow bandwidth.

→ Types of WLAN :—

1. IEEE 802.11 —

→ In 1997, IEEE finalized the initial specification for WLAN.

→ specifies 2.4GHz frequency band
datarate of 2Mbps.

2. Hyper LAN —

→ Began in Europe in 1996 by ETSI (European Telecom. standard Institute)

→ .5 GHz frequency band.
24 Mbps bandwidth

3. BLUETOOTH : —

→ promoted by big industry leaders like IBM, ERICSON, NOKIA.

→ was named after Harold Bluetooth, king of Denmark.

→ 1 Mbps datarate
2.2 GHz band.

→ Also known as PAN (Personal area network)

4. MANET :-

→ It is a working group to investigate and develop the standard for mobile ad-hoc network (MANET).

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IEEE 802.11 :

→ It specifies the most famous family of WLANs in which many products are available.

i.e ~~group~~ the number in the standard indicates, it belongs to the group of 802.x LAN standard.

→ Primary goal: the specification of a simple and robust WLAN which offers time bounded and asynchronous services.

Architecture :

→ BSS (Basic service set) is the smallest building block of a WLAN, which consists of some number of stations executing the same MAC protocol.

→ BSS may be isolated or it may connect to a backbone distribution system (DS) through an access point (AP).

→ The AP functions as a bridge and a relay point.

→ If one station in BSS wants to communicate with another station in the same BSS, the MAC frame is first sent from originating station to the AP and from AP to destination station.

→ IBSS —

→ when all the stations in the BSS are mobile stations, with no connection to other BSSs, the BSS is called an independent BSS (IBSS).

IBSS is an ad hoc network.

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ESS — (Extended service set)

→ An ESS consists of two or more basic service sets interconnected by a distribution system.

→ The distribution system is a wired backbone LAN but can be any communication network. The ESS appears as a single logical LAN to the logical link control level.

AP — (Access Point)

→ An AP is implemented as part of a station.

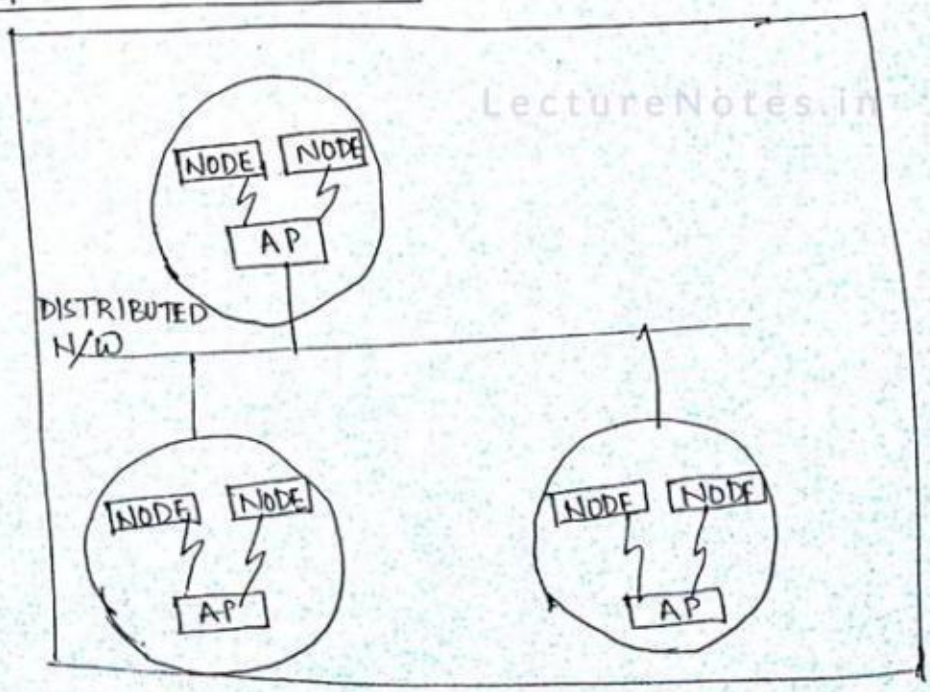
→ The AP is the logic within a station that provides access to the DS by providing DS services in addition to acting as a station.

→ WLAN are of 2 types:

1. Infrastructure mode
2. Ad-hoc mode.

1. Infrastructure Mode :—

→



WLAN in infrastructure mode.

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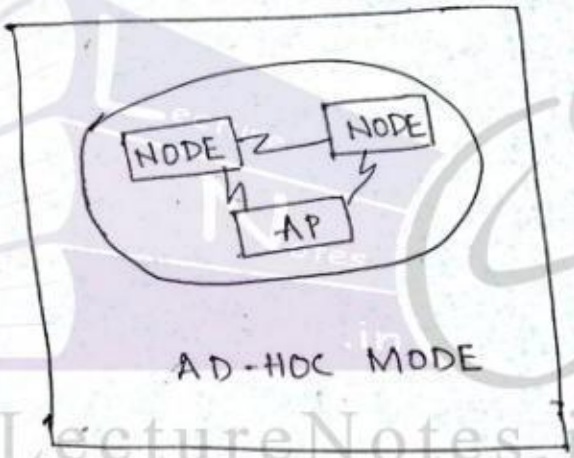
→ Here MSs are connected with BS or access point.

→ This is similar to star network communication takes place between wireless nodes and access point but not directly between wireless devices.

→ Here access points acts as a bridge to other network.

Ad-hoc Mode :—



(WLAN in Ad-hoc mode)

→ In ad-hoc mode there is no access point.

→ A number of MS can communicate directly with eachother

→ Nodes can communicate if they can reach each other physically i.e they are given each other radio range.

3. Advanced Mobile Telephone System (AMTS) –

→ It is a radio communication, mainly used in Japanese portable radio systems.

→ It worked on the 900MHz band.

→ 1G (First Generation) –

Introduced in 1980s.

→ Analog cell phones standard.

→ Diff. between 1G & 2G is,
the radio signals that 1G networks use are analog (modulated to higher freq) while 2G networks are digital (encoded to digital signals).

→ uses FDMA for modulation.

1. Advanced Mobile Phone System (AMPS) –

→ It is the analog mobile phone system standard developed by Bell Labs, officially introduced in America in 1983.

→ It is first generation cellular technology that uses separate frequencies or channels.

2. Cellular Digital Packet Data (CDPD) –

→ represents a major step towards making our nation a wireless information society.

→ It transmits digital packet data at 19.2 kbps.

→ It is a specification for supporting wireless access to the Internet and other public packet

→ IEEE 802.11 Services :—

→ IEEE 802.11 defines the following services that need to be provided by the wireless LAN.

1. Distribution :—

→ It is the primary service used by stations to exchange MAC frames when the frame must traverse the DS to get from a station in one BSS to a station in another BSS.

2. Integration :—

→ enables transfer of data between a station on an IEEE 802.11 LAN and a station on an integrated IEEE 802.X LAN.

Integrated ⇒ wired LAN.

→ The integration service takes care of address translation, media conversion logic required for exchange of data.

3. Association :—

→ establishes an initial association between a station and an AP.

→ Before a station can transmit or receive frames on a wireless LAN, its identity and address must be known.

→ For this, a station must establish an association with an AP within a particular BSS.

LectureNotes.in

4. Reassociation :—

→ Enables an established association to be transferred from one AP to another, allowing a mobile station to move from one BSS to another.

5. Disassociation :—

→ A notification from either a station or an AP that an existing association is terminated.

→ A station gives this notification before leaving an ESS.

6. Authentication :—

→ used to establish the identity of stations to each other.

→ This service is used by stations to establish their identity with stations they wish to communicate.

7. Deauthentication :—

→ This service is invoked whenever an existing authentication is to be terminated.

8. Privacy :—

→ used to prevent the contents of message from being read by other than the intended recipient.

→ The standard provides for the optional use of encryption to assure privacy.

LectureNotes.in

Protocol Architecture :—

802.11 MAC Management			MAC Layer
Frequency Hopping	Direct Sequence	Infrared	PLCP sublayer
			PMD sublayer.

(IEEE 802.11 protocol architecture)

→ The protocol architecture consists of 2 layers.

— Physical layer

— MAC layer.

→ **Physical Layer** —

→ It is subdivided into → physical layer convergence protocol (PLCP)

and

— physical medium dependent sublayer (PMD).

→ The MAC layer comprise medium access, fragmentation of user data, encryption.

→ The PLCP layer provides carrier sense signal called clear channel assesment. It delivers the incoming frame from wireless medium to MAC protocol Data Unit (MPDU) for data transfer.

→ PMD layer handles modulation and encoding or decoding of signals. It provides the actual transmission and reception of physical layer entity between MS through wireless medium.

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→ IEEE 802.11 supports 3 different physical layers.

→ one layer based on infra-red

→ two layers based on radio transmission.

→ All PHY variants include the provision of the clear channel assessment signal (CCA). This is needed for the MAC mechanisms controlling medium access and indicate if the medium is currently idle.

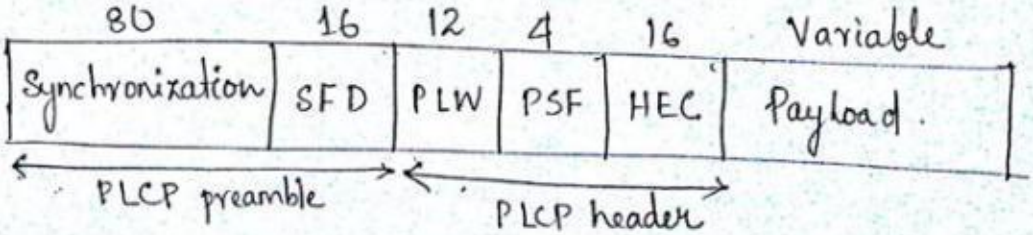
→ The PHY Layer offers a service access point (SAP) with 1 or 2 Mbits/transfer rate to the MAC layer.

→ <u>Frequency Hopping Spread Spectrum (FHSS)</u> :—

→ FHSS is a spread spectrum technique which allows for the coexistence of multiple networks in the same area by separating different networks using different hopping sequences.

→ Standard specifies Gaussian shaped FSK (frequency shift keying) GFSK as modulation for the FHSS.

→ Frame of the physical layer used with FHSS.



(IEEE 802.11 PHY frame using FHSS)

→ Frame consists of 2 basic parts.
- PLCP part (permeable and header)
- payload part.

→ PLCP part is always transmitted at 1 Mbit/s, payload can use 1 or 2 Mbit/s.

→ The functions of the field of the frame are

* Synchronization :- The PLCP permeable starts with 80bit synchronization, which is a 010101... bit pattern. It is used for synchronization of potential receivers and signal detection by the CCA.

* Start frame delimiter (SFD) :-

→ 16 bits indicate = the start of the frame and provide frame synchronization.

→ The SFD pattern is 0000110010111101.

* PLCP_PDU length word (PLW) :-

→ First field of the PLCP header.

→ indicates = length of the payload in bytes including the 32 bit CRC at the end of the payload.

→ PLW ranges between 0 and 4095.

* PLCP signaling field (PSF) :-

→ 4 bit field.

→ indicates datarate of the payload following i.e. 0000 - 1 Mbit/s (Lowest datarate)

1111 - 8.5 Mbit/s (highest data rate)

* Header Error check (HEC) :-

→ PLCP header is protected by a 16-bit checksum.

→ Direct Sequence Spread Spectrum :—

→ DSSS is the alternative spread spectrum method separating by code and not by frequency.

→ IEEE 802.11 DSSS PHY uses 2.4 GHz ISM band and offers 1 and 2 Mbit/s datarates.

→ uses Differential BPSK (DBPSK) for 1 Mbit/s transmission and differential QPSK (DQPSK) for 2 Mbit/s as modulation schemes.

128	16	8	8	16	16	Variable
Synchronization	SFD	Signal	Service	Length	HEC	Payload.

PLCP preamble ← → PLCP header

(IEEE 802.11 PHY frame using DSSS)

→ The field of the frame are –

* Synchronization :- first 128 bits use for synchronization, energy detection, frequency offset compensation.
  → It only consists of scrambled 1 bit.

* Start Frame Delimiter (SFD) :- 16 bit field used for synchronization at the beginning of the frame and consists of the pattern 1111001110100000.

* Signal :- indicates the datarate of the payload.
  0 x 0A indicates = 1 Mbit/s
  0 x 14 " = 2 Mbit/s.

MAC Layer :-

→ It is responsible for controlling the access medium,
- roaming
- authentication
- power conservation etc.

→ The basic services provided by MAC Layer -
- mandatory asynchronous data service
- optional time bound service.

→ Asynchronous service is available in adhoc medium and both services in infrastructure mode.

→ Access mechanisms defined under IEEE 802.11 are
* Carrier Sense Multiple Access with collision Avoidance
* Request to Send/clear to Send.

→ These methods are called as Distributed Co-ordination Function (DCF) and offers asynchronous service.

→ Access mechanism using CSMA/CA -

→ The mandatory access mechanism is based on carrier sense multiple access with collision avoidance CSMA/CA.

→ It employs a random backoff mechanism with carrier sense and collision avoidance to reduce the probability of collision between 2 frames.

→ The mechanism behind CSMA/CA is -
* when a wireless station wants to communicate, it first listens to its medium to check if it can sense radio wave from any other station.

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* If the medium is free for a specified time then the station is allowed to transmit. This time interval is called Distributed Inter Frame Space (DIFS).

* If the current device senses carrier signal of another device on the same frequency, it doesnot transmit and initiates a random timeout.

* After the timeout has expired, the wireless station again listens to the radio spectrum and if it still senses another station transmitting, initiates another random timeout.

* When it doesnot sense another wireless station transmitting it starts transmitting its own carrier signal to communicate with other station.

* The receiving station checks the CRC of the received packet and sends an acknowledgement. Receipt of the acknowledgement indicates to the transmitter that no collision occurred. If the sender doesnot receive the acknowledgement then it retransmits the fragments until it receives acknowledgement.

→ Access mechanism using RTS/CTS :—

→ It is used to solve the problems of hidden terminals.

→ This problem occurs if one station can receive two others, but those stations cannot receive eachother.

→ The two stations may sense the channel is idle, send a frame and cause a collision at the receiver in the middle.

→ In order to reduce the probability of two stations

∴ colliding because they can't sense each other's presence, the standard defines a mechanism called Virtual Carrier Sense (VCS). It is like -

* A station wants to transmit a packet first transmits a short control packet called RTS (Request to send) which includes source, destination and duration of transaction.

* The destination station after receiving this request packet responds with a response control packet called CTS (clear to send), which includes same duration information.

* All stations receiving either RTS or CTS set their virtual carrier sense indicator called Network Allocation Vector (NAV) for the given duration and uses this information together with physical carrier sense when sensing the medium. This mechanism reduces the probability of a collision on the receiver side by a station.

* The transmitter station when receives the CTS after sending a RTS, it reserve the medium busy until the end of transaction.

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→ MAC Frames :—

bytes	2	2	6	6	6	2	6	0-2312	4
	Frame Control	Duration ID	ADD 1	ADD 2	ADD 3	Sequence Control	ADD 4	DATA	CRC.

Bits	2	2	4	1	1	1	1	1	1	1	1
	Protocol Version	Type	Subtype	TO DS	From DS	More Fragment	Retry	Power Mgmt	More Data	WEP	Order

(IEEE 802.11 MAC packet structure)

→ The MAC frame format contains following fields -

1. Frame Control :

→ It is of two bytes and contains several sub-fields.

1. Protocol Version :- It is of 2-bit and indicate current protocol version.

2. Type :- This field determines function of a frame.
   e.g. management (00)
   control (01)
   Data (10)

3. Subtype :- If the above frame type is again sub-divided into various types.
   Ex. RTS is a control frame with subtype 1011.

4. To DS/From DS : Frames can be transmitted between MS and AP. This field contains the address of source and destination Distributed system.

5. More Fragment : This field is set to 1 if frames are of type data and management.

6. Retry : If current frame is a retransmission of a earlier frame then this bit is set to 1.