Subject: Advanced Computer Network (CS348)

Assignment 1 (ACN)

1). What do you mean by OSI model? What are OSI layers? Explain in detail with suitable example and diagrams.

Ans⇒

OSI Model.

- A logical and conceptual model that defines network communication used by systems open to interconnection and communication with other systems.
- It also defines a logical network & effectively describe computer packet transfer by various using various layers of protocols.

* Characteristics

- A layer should only be created where definite levels of abstraction are needed.
- The function of each layer should be selected as per internationally standardized protocols.
- Each layer relies on next lower layer to perform primitive functions. Every level should able to provide services to next higher layer.
- Changes made in one layer shouldn't need changes in other layers.

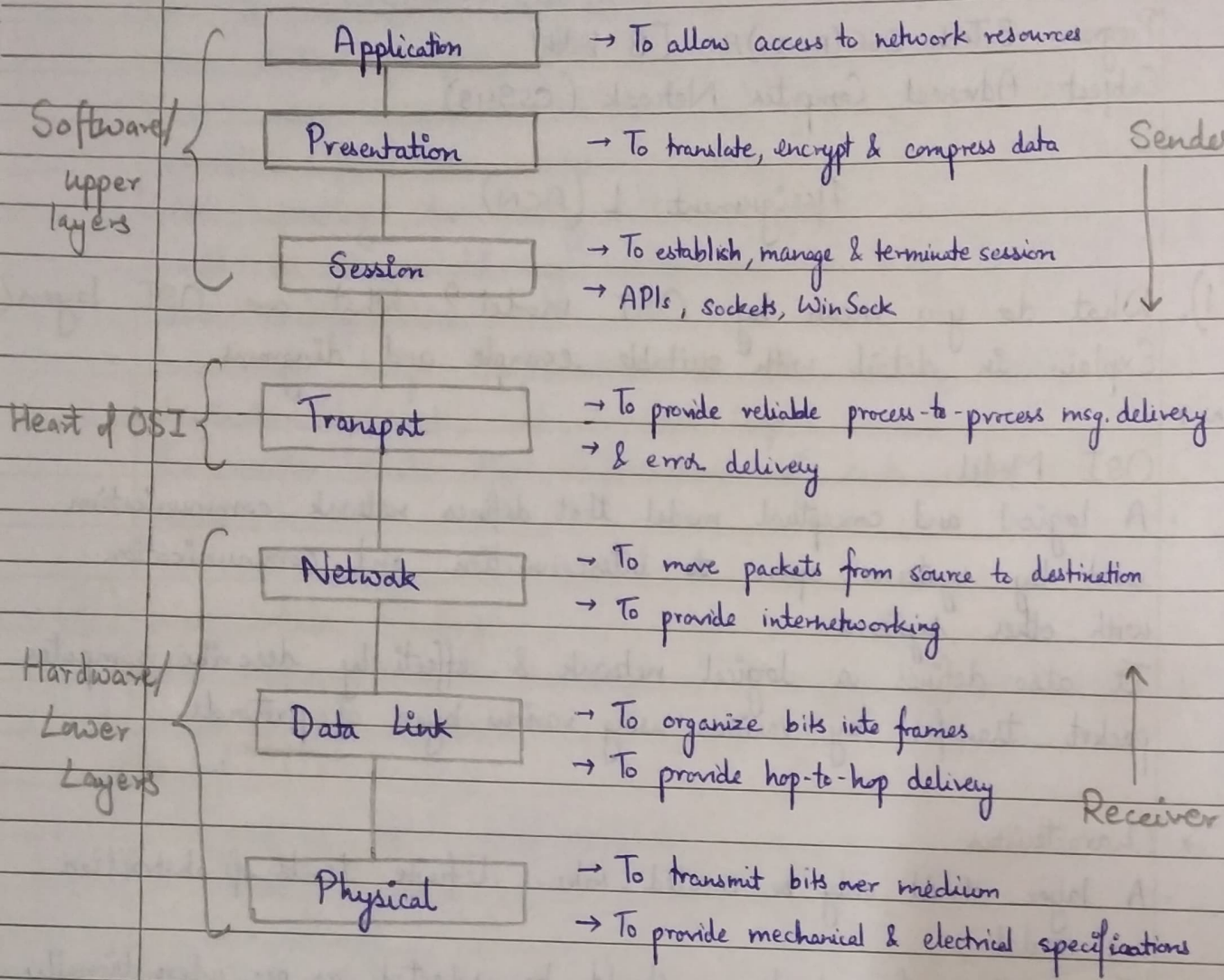
* Why use OSI model?

- Helps to understand communication over a network.
- Troubleshooting is easier by separating functions into different layers.
- Helps understand new technologies as they are developed.
- Allows to compare primary functional relationships on various network layers.

Chitra

Date ___/___/_____ Page No.: _____

Layers of OSI model



Upper Layers

- Deals with application issues & mostly implemented in softwares.
- Close to end system user.
- Communication from one end-user to another begins by using interaction b/w application layer.

Lower Layers

- Handle activities related to data transport.
- Implemented both in hardware & software.

Date ___/___/_____ Page No.: _____

① Physical Layer

- Helps to define the electrical and physical specifications of the data connection.
- Establishes the relationship b/w a device & a physical transmission medium.
- Not concerned with protocols or other such higher-layer items.
- Carry a bit stream over a physical medium.

Protocols: RS232, 100Base TX, ISDN, 11.

Hardware: Network adapters, ethernet, repeaters, networking hubs, etc.

* functions

i). Line configuration
   - Defines the way how 2 or more devices can be connected physically
ii). Data transmission
   - Defines transmission mode b/w 2 devices on the network.
iii). Topology
   - Defines the way how network devices are arranged.
iv). Signals
   - Determines the type of signals used for transmission of data
v) Physical characteristics of interfaces & media.
vi). Representation of bits.
vii). Data Rate
viii). Synchronization of bits

Date __/__/____ Page No.: ____

② Data-Link Layer

- Error correction which can occur at physical layer.
- Allows to define the protocol to establish & terminate a connection b/w 2 connected network devices.
- IP address understandable layer, which helps to define logical addressing so that endpoint should be identified.
- Helps to implement routing of packets through a network.
- Helps to define the best path, to take data from source to destination.

* Sublayers

i). Media Access Control (MAC)
- Control how devices in network gain access to medium & permits to transmit data.

ii). Logical Link Control (LLC)
- Identity & encapsulating network-layer protocols & allows you to find the errors.

* Protocols: RAPA, PPP, frame relay, ATM, fiber cable.

* functions

i). framing to divide data into frames.
ii). Allows to add header to frame to define physical address of source & destination node.
iii). Adds logical addresses of sender & receiver.
iv). flow & access control b/w the sending & receiving nodes.
v). Error control to detect damaged or lost frames & retransmit them.
vi). Provide a mechanism to transmit data over independent networks which are linked together.

Chitra

Date ___/___/_____ Page No.: _____

③ Network layer

- Manages device addressing, tracks the location of devices on the network.
- Determines the best path to move data from source to destination based on the network conditions, the priority of service, etc.
- Responsible for routing and forwarding the packets.
- Provides functional and procedural means of transferring variable data sequences from one node to another in "different networks".

* Protocols: IP, ICMP, IPSEC, ARP, MPLS.

* functions

i). Internetworking
   - Provides a logical connection b/w different devices.

ii). Addressing
   - Identify the device on the internet, by adding the source & destination address to the header of the frame.

iii). Routing
   - Determines the best optimal path out of the multiple paths from source to destination.

iv). Packetizing
   - Receives information from upper layer & convert them into packets

Date __/__/____ Page No.: ____

④ Transport Layer

- Provide data transport from a process on a source node to a process on a destination node.
- Hosted using single or multiple networks, and also maintains the quality of service functions.
- Determines how much data should be sent where & at what rate.
- Helps ensure data units are delievered error-free & in sequence.
- Control reliability of a link through flow control, error control, and segmentation / desegmentation.
- Offers acknowledgement of successful data transmission & sends next data in case no errors occurred.

* Protocols: TCP, UDP

* functions

i) Service-point addressing
   - Transmit data from one node to another & transmit the message to the correct process.

ii) Segmentation and reassembly
   - Message is divided into segments, & each segment is assigned with a sequence number uniquely identifying them. The message is reassembled ~~the cross~~ based on sequence numbers

iii) Connection control
   - Provides 2 services: connection-oriented service & connectionless service.

iv) flow control
   - Perform end-to-end rather than across a single link.

v) Error control
   - Ensure the message reach at destination without any error.

Chitra

Date ___/___/_____ Page No.: _____

(5) Session Layer

- Controls dialogue b/w nodes and helps to establish & terminate the connections b/w local and remote application.
- Request for a logical connection which should be established on end user's requirement.
- Handles all the important log-on or password validation.
- Mostly implemented in application environments that use remote procedure calls.

* Protocols: NetBIOS, SAP

* functions:

i). Dialog control
   - Creates a dialog b/w 2processes or allow communication b/w 2processes which can be either half-duplex or full-duplex.

ii). Synchronization
   - Allows the process to add a checkpoint into the data stream.

iii). Establishes, maintains & ends a session.

Date ___/___/_____ Page No.: _____

(6) Presentation Layer

- Allows to define the form in which the data is to exchange b/w the 2 communicating entities.
- Helps to handle data compression & data encryption.
- format & encrypt data which should be sent across networks.
- Also called "Syntax layer".

* Protocols: MPEG, ASCH, SSL, TLS

* functions:

i) Character code translation from ASCII to EBCDIC.
ii) Data compression to reduce the no. of bits to be transmitted.
iii) Data encryption
iv) Provides user interface & support for services like email, file transfer.

(7) Application Layer

- Interacts with application program, closest to the end-user.
- Interact with software to implement a communicating component.
- Interpretation of data is always outside the scope of OSI model.

* Protocols: SMTP, HTTP, FTP, POP3, SNMP

* functions

i) Identify communication patterns, determining resource availability & synchronizing communication.
ii) Allow users to log on to a remote host.
iii) Provide various e-mail services
iv) Offers distributed database sources & access for global information about various objects & services.

* Routing
The process of selecting an optimal path for transfer of packets in a network b/w source & destination.

* forwarding
The action of transferring a packet to next router by each router when a packet arrives at one of its interfaces.

* Non-adaptive routing
- Static routing
- Do not change selected routing decisions for transferring data packets.
- Construct a static routing table in advance to determine the path.
- Changing topology & traffic conditions do not affect routing decisions.
- Eg :- flooding, Random walk.

* Adaptive Routing
- Dynamic routing
- Make routing decisions dynamically whilst transferring packets.
- Construct routing table depending on network conditions (traffic, topology)
- Compute optimal path, based upon hop-count, transit time & distance.

* Handoff
The process of transferring an ongoing session (call/data) from one channel connected to the core network to another.

* Routing Table
- A set of rules, used to determined where the packets travelling over the IP network will be directed.
- Entries :- Network ID, Subnet Mask, Next Hop, Outgoing Interface, Metric
↓
min hop count

Chitra

"No religion has mandated killing others as a requirement for its sustenance or promotion." –Dr.A.P.J.Abdul Kalam

a). flooding

It is an non-adaptive routing technique following the method: when a data packet arrives at a router, it is sent to all the outgoing links except the one it has arrived on.

Types of flooding

↓

i). Uncontrolled flooding

- Each router unconditionally transmits the incoming data packets to all its neighbors.

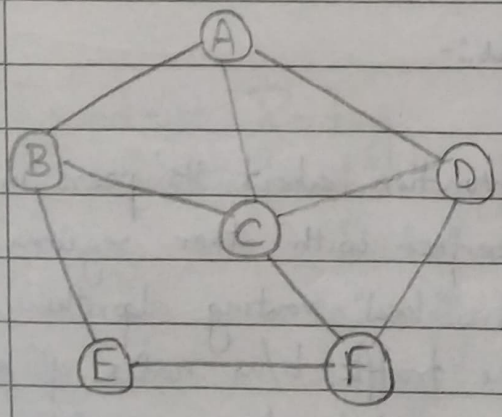
ii). Controlled flooding

- Use some methods to control the transmission of packets to neighboring nodes.
- Popular algorithms: Sequence Number Controlled flooding (SNCf)
  Reverse Path forwarding (RPf)

iii). Selective flooding

- Routers don't transmit the incoming packets in every available path, rather only along those paths which are heading towards approximately in the right direction.

Example:-



Using flooding (A is initial sender)

- A will send packets to B, C & D
- B will send packets to C & E.
- C will send packets to B, D & F
- D will send packets to C & F
- E will send packets to F
- F will send packets to D/C & E.

Date ___/___/_____ Page No.: _____

Advantages of flooding
- Simple to setup & implement
- Extremely robust
- Always the shortest path is chosen
- All nodes, either directly or indirectly connected, are visited. This is the main criteria in case of broadcast messages

Disadvantages of flooding
- Create an infinite no. of duplicate data packets, unless some process is adapted to damp packet generation.
- Wasteful, if only a single destination needs the packet
- Network may be clogged with unwanted & duplicate data packets. This hampers delivery of other data packets.

Applications :- Bridging, Peer-to-peer file sharing, low rate data comms, distributed DBs.

b). Hierarchical Routing, Broadcast Routing, Multicast Routing & Distance Vector Routing.

① Hierarchical Routing
- 'Divide' & 'conquer' strategy
- The network is divided into different regions and a router for a particular region knows only about its own domain & other routers.
- The network is viewed at 2 levels :-
  * Sub-network level
    → Each node in a region has information about its peers in the same region & about region's interface with other regions.
    → Different regions may have different "local" routing algorithms.
    → Each local algorithm handles the traffic b/w nodes of same region & also directs the outgoing packets to appropriate interfaces.

Chitra

Date ___/___/___

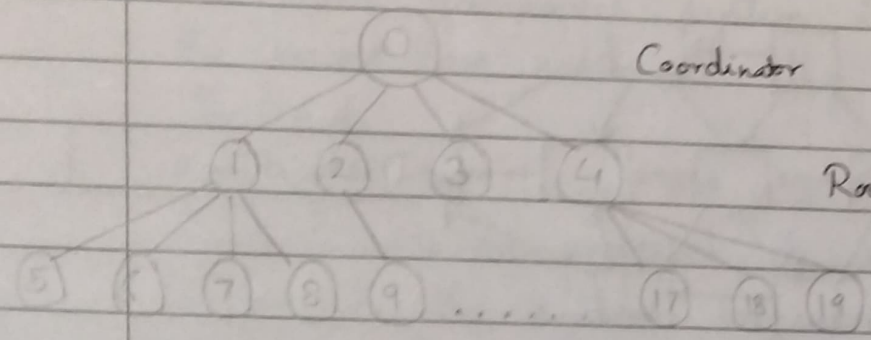
Page No. ___

* Network Level
  - → Each region is considered as a single node connected to its interface node.
  - → Routing algorithms at this level handle the routing of packets b/w 2 interface nodes, and is isolated from intra-regional transfer.

The interfaces need to store information about:-
- All nodes in its region which are at one level below it.
- Its peer interfaces.
- At least one interface at a level above it; for outgoing packages.

Advantages
- Smaller sizes of routing tables.
- Substantially lesser calculations & updates of routing tables.

Disadvantages
- Once the hierarchy is imposed on the network, it is followed & possibility of direct paths is ignored.
- May lead to sub-optimal routing.



Hierarchical Routing Structure

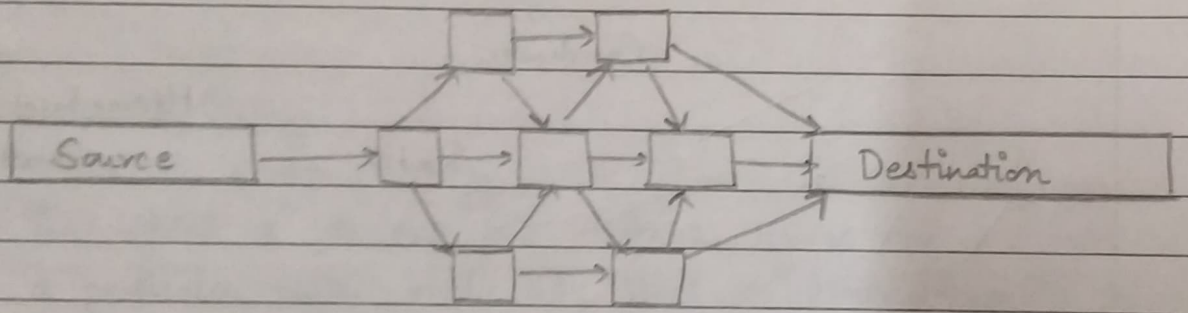
(2) Broadcast Routing.

By default, broadcast packets aren't routed and forwarded by the routers on any network. Routers create broadcast domains.
But it can be configured to forward broadcasts in some special cases.
A broadcast message is destined to all network devices.

Broadcast routing can be done in 2 ways:-

a. A router creates a data packet and then sends it to each host one by one. The router, thus, creates multiple copies of single data packet with different destination addresses. All packets are sent as unicast, but because they are sent to all, it stimulates as if router is broadcasting.
This method consumes lots of bandwidth and router must have destination address of each node.

b. When router receives a packet that is to be broadcasted, it simply floods those packets out to all interfaces. All routers are configured in the same manner.
This method is easy on router's CPU, but may lead to multiple or duplicate packets in the network.
(In RPF, router knows in advance about its predecessor from which it should receive broadcast → detect & discard duplicates).

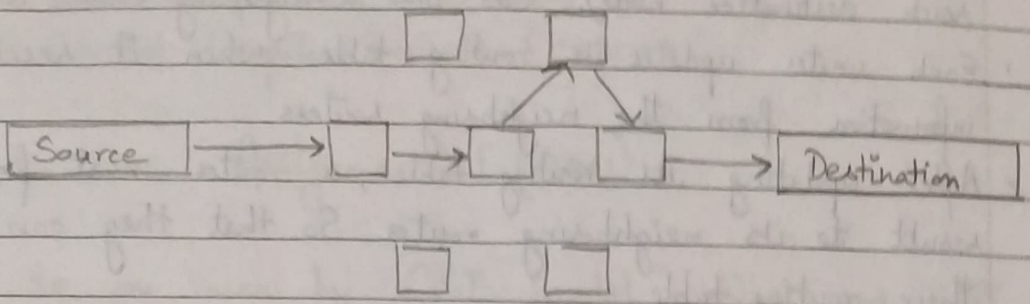


③ Multicast Routing

- A special case of broadcast routing with significant difference & challenges
- Data is sent to only nodes which want to receive them
- The router must be aware of nodes, ready to accept the multicast packets (or streams), then only it should move forward.

Date ___/___/_____ Page No. _____

- It works spanning tree protocol to avoid looping and reverse path forwarding (RPF) to detect & discard duplicates.



(4) Distance Vector Routing

- Dynamic routing protocol.
- Every router in the network creates a routing table which helps them in determining the shortest path through the network.
- All the routers in network are aware of every other router in the network and they keep on updating their routing table periodically.
- This protocol uses the principle of Bellman-ford's algorithm.
- The entire autonomous system is considered a graph, where the routers are nodes and the network are paths connecting the node.

Each path has some cost associated with it. The paths with smaller costs are preferred to reach the destination. Each router in the system organizes this information in a routing table, which is send out to its neighboring routers after regular intervals.

This process repeats for all the routers, and thus, the routing table of every router is updated periodically.

* Only distance vectors are exchanged, not "next hop" values
* Routing tables are prepared (n-1) times, if there are 'n' routers

Date ___/___/_____ Page No.: _____

Steps of DVR:-

- Cost is considered as the hop count (no. of networks passed to reach destination node). Cost b/w 2 neighboring routers is set to 1.
- Each router updates its routing table when it receives the information from the neighboring routers
- After updating its routing table, a router must forward its result to its neighboring router. So that they can update their routing table.
- Each router keeps 3 information in its routing table, viz., destination network, cost & next hop.
- The router sends the information of each route as a record R.

(5) Link State Routing.

- Each router shares the knowledge of its neighbourhood with every other router in the internetwork
- Keys
  - Knowledge about neighbourhood
  - flooding
  - Info sharing
- Phases
  - Reliable flooding (initial state ⇒ knows neighbor's cost
    final state ⇒ know entire graph)
  - Route calculation (Dijkstra's Algorithm) - Iterative
- Pros
  - fast network convergence
  - Topological Map
  - Hierarchical design
  - Event-driven updates
- Cons
  - Memory requirements
  - Processing requirements
  - Bandwidth requirements

Date __/__/____ Page No.: ____

Q2). What is the difference b/w IPv4 and IPv6? Explain with suitable example & diagrams.

Ans ⇒ IPv4 or Internet Protocol version 4 is the underlying technology that makes it possible for us to connect our devices to the web.

IPv4 is running out of addresses due to its widespread usage from the prolification of so many connected devices. IPv6 is the next generation address standard intended to supplement & eventually replace IPv4.

Property	IPv4	IPv6
Simplicity	Complex	Simpler
Size	Header is smaller in size.	Header is much bigger in size
Address size	Addresses are 32-bit binary numbers	Addresses are 128-bit binary numbers.
Header size	20-60 bytes	fixed 40 bytes
Separation	Binary bits separated by dot(.)	Binary bits separated by colon(:)
No. of header fields	12 header fields	8 fields
Addressing method	Numeric addressing method	Alphanumeric addressing method
No. of classes	Offers 5 classes of IP addresses (A to E)	Allows storing an unlimited no. of IP addresses.

Chitra

Date ___/___/_____ Page No.: _____

Property	IPv4	IPv6
Representation	Address representation is in decimal notation	Address representation is in hexadecimal notation.
Checksum	Checksum field is available	No provision for checksum field.
Encryption & Authentication	Not provided.	Supported
Broadcast	Supports broadcast	Doesn't support broadcast.
Subnet Mask	Support variable length subnet mask	Doesn't support VLSM.
Mapping of MAC addresses	ARP (Address Resolution Protocol) is used.	NDP (Neighbor Discovery Protocol) is used.
Optional fields	Has optinal optional fields	Doesn't have optional fields but extension headers are available.
Example.	127.0.0.1	2001:0db8:0000:0000:0000:0000:ff00:7874

* IPv6 header

field headers

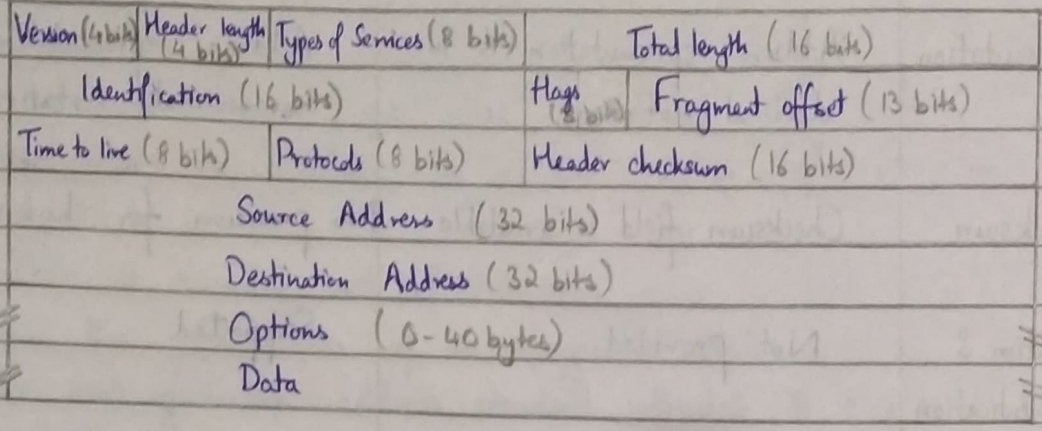
Version (4 bits)	Priority/Traffic class (8 bits)	flow label (20 bits)	
Payload Length (16 bits)		Next header (8 bits)	Hop-limit (8-bits)
Source Address (128 bits)			
Destination Address (128 bits)			
Extension headers 1			
. . .			
. . .			

Chitra

"No religion has mandated killing others as a requirement for its sustenance or promotion." —Dr.A.P.J.Abdul Kalam

Date ___/___/_____ Page No.: _____

* IPv4 header



features of IPv4

- Connectionless protocol
- Allows creating a simple virtual communication layer over diversified devices
- Requires less memory & ease of remembering addresses.
- Already supported by millions of devices
- Offer video libraries & conferences.

features of IPv6

- Hierarchical addressing & routing infrastructure
- Stateful & stateless configuration
- Support for Quality of Services
- Ideal protocol for neighboring node interactions.

* Why IPv6?

- Expansion of IP addresses.
- Reduces header bandwidth.
- Improvement of routing performance
- More secure & confidential.
- faster speed → Lack of Network-address translation (NAT).

Chitra

Date ___/___/_____ Page No.: _____

Mobile IP - IETP standard protocol (Internet Engineering Task force)

- Communication protocol, created by extending IP
- Allow users to move from one network to another with same IP address.
- Ensures communication will continue without user's sessions or connection being dropped.
- Allow location-independent routing of IP datagrams.
- Each mobile node is identified by its home address disregarding its current location

Termindogies

1. Mobile Node: Hand-held communication device
2. Home network: Network to which mobile node originally belongs to
3. Home agent: Router in home network.
4. Home address: Permanent IP address assigned to mobile node (within HN).
5. foreign network: Current network the mobile node is visiting (away from HN).
6. foreign agent: Router in a foreign network to which mobile node is connected (Packets are sent from HA to FA, which delivers them to mobile node).
7. Correspondent node: Device on the internet communicating with mobile node.
8. Care-of-Address: Temporary address used by mobile node when away from HN.
9. foreign agent CoA: CoA is an IP address of FA.
   - FA is the tunnel end-point & forwards packets to mobile node.
   - Many mobile nodes using FA share this CoA as a common CoA.
10. Co-located CoA:
    CoA is ~~colat~~ co-located if mobile node temporarily acquires an additional IP which acts as CoA.
    - Can be acquired using services like DHCP.

Date ___/___/_____ Page No.: _____

Tunneling

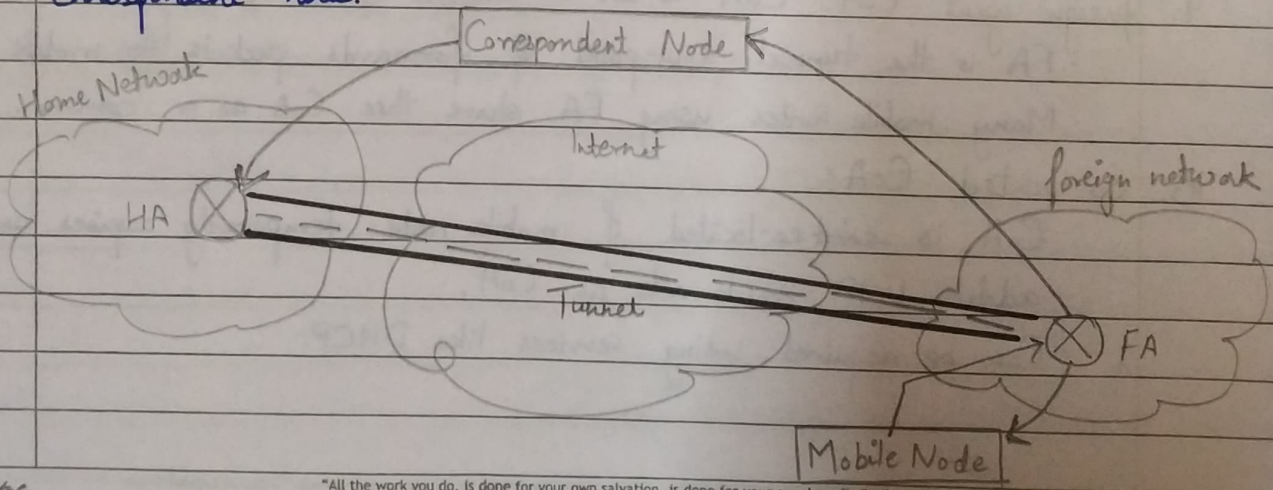
Establishes a virtual pipe for packets available b/w a tunnel entry & an endpoint
It is the process of sending a packet via a tunnel & it is achieved by a mechanism called encapsulation.

Working

The correspondent node sends data to mobile node. Data packets contains correspondant node's address (Source) & home address (destination). Packets reach home agent. But since mobile has moved to a foreign network, the foreign agent sents care-of-address to home agent. A tunnel is established b/w HA & FA by the process of tunneling.

The HA encapsulates the data packets into new packets in which source address ⇒ Home address & destination ⇒ Care-of-address & sends it through the tunnel to the FA. The FA, on another side of tunnel, receives the data packets, decapsulates them, & sends them to mobile node.

The mobile node, in response to data packets received, sends a reply in response to F.A, F.A directly sends reply to the correspondent node.



Chitra

Date ___/___/_____ Page No.: _____

Key Mechanisms in Mobile IP

1). Agent Discovery

- Agents advertise their presence by periodically broadcasting their agent ad messages.
- The mobile node observes whether the msg is from its own HN & determines whether it is in HN or FN.

2). Agent Registration

- Mobile node after discovering the FA sends a registration request (RREQ) to FA, which in turn sends RREQ to HA via care-of-address.
- The HA sends registration reply (RREP) to FA, which is forwarded to mobile node & completes the registration process.

3). Tunneling

- Establish a virtual pipe for packets available b/w tunnel entry & an endpoint
- Takes place to forward an IP datagram from HA to CoA.
- Achieved via encapsulation.

Route Optimizations in Mobile IP

- It adds a conceptual data structure (binding cache) to the correspondent node.
- Binding cache contains bindings for mobile node's HA & its current CoA.
- Everytime the HA receives an IP datagram, it sends a binding update to correspondent node to update the info in its binding cache.
- After this, CN can directly send tunnel packets to MN.

Page No.:

Date __/__/____

GSM

- Global System for Mobile Communication
- Open & digital cellular technology used for mobile communication.
- Uses 4 different frequency bands of 850MHz, 900MHz, 1800MHz & 1900MHz.
- Uses combination of fDMA & TDMA
- Digital cellular technology used for transmitting mobile voice & data services.

Different sizes of cells used in GSM

1. Macro : Base station antenna is installed.
2. Micro : Antenna height is less than avg. roof level
3. Pico : Small cells' diameter of few meters.
4. Umbrella : Covers shadowed regions (fill gaps b/w cells).

features of GSM:

- Support international roaming
- Support multiple handheld devices
- Access networks
- Low-cost mobile sets & devices
- Clear voice clarity
- Spectral / frequency efficiency.
- International ISDN compatibility.
- Support for new services.

Architecture

Consist of 3 major interconnected subsystems that interact with themselves & with users through certain network interface.

① BSS

- Base Station Subsystem
- Handles traffic & signalling b/w a mobile phone & network switching subsystem.
- Components:- BTS & BSC

② NSS

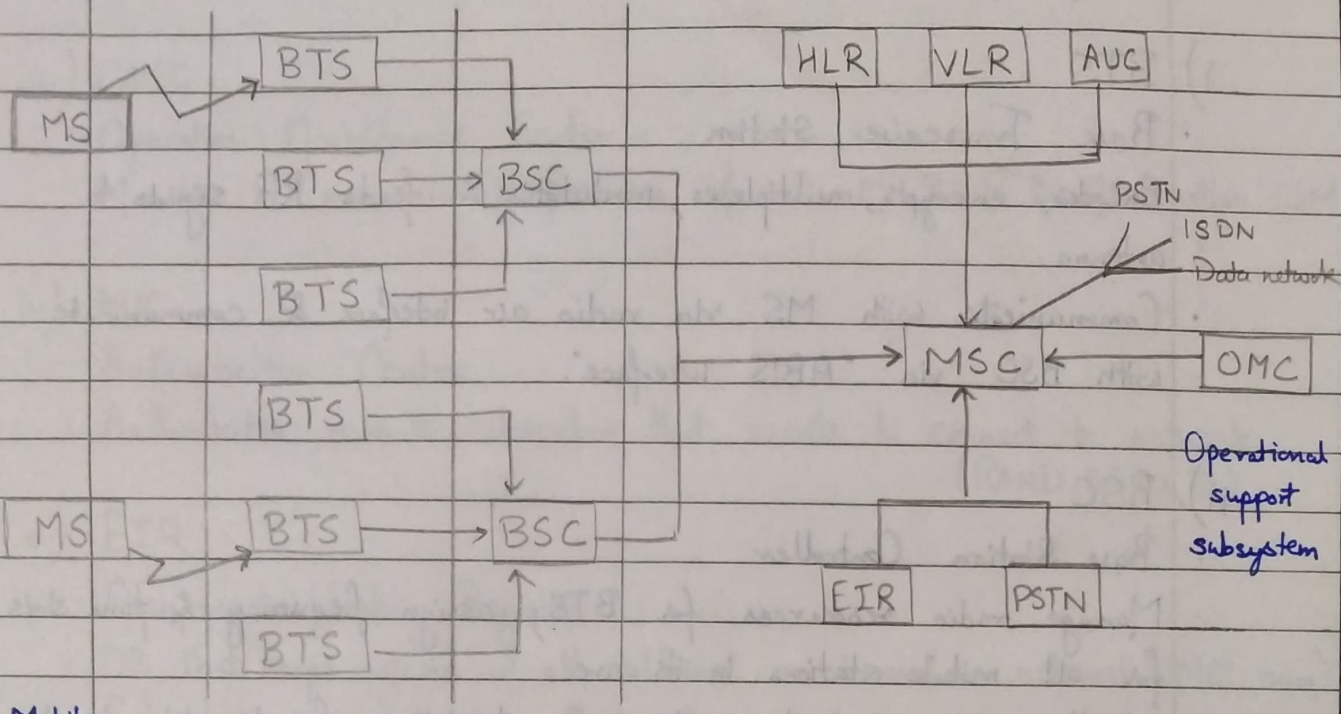
- Network & Switching subsystem.
- Core network of GSM, carries out call & mobility management functions.
- Components:- VLR, HLR, EIR

Chitra

Date ___/___/_____ Page No.: _____

③ OSS

- Operating Subsystem
- functional entity which network operator monitor & control systems.
- Components: OMC.



① MS

- Mobile system/station
- Comprises user equipment & software needed for communication with a mobile network.
- MS are connected to tower & that tower connected with BTS through TRX.
- TRX is a transciever which comprises transmitter & receiver.
- MS = Mobile equipment (ME) + SIM (Subscriber Identity Number)
  - ↳ IMEI number
  - ↳ IMSI number
- SIM → Allow users to send & receive calls & receive other subscriber services
  - → Contains network identification details & key info to activate the phone.

Chitra

Date / /

Page No.:

(2) BSS

- Radio subsystem
- Provides & manages radio transmission paths b/w mobile station & MSC.
- Manages interface b/w MS & all other subsystems of GSM.

i) BTS

- Base Transceiver Station
- Encodes, encrypts, multiplexes, modulates & feeds RF signals to antenna.
- Communicate with MS via radio air interface & communicate with BSC via "ABIS interface".

ii) BSC

- Base Station Controller
- Manage radio resources for BTS; assign frequency & time slots for all mobile stations in its area.
- Handles call setup, transcoding & adaptation functionality handover for each MS radio power control.
- Via "A interface"

(3) MSC

- Mobile Switching center
- Used for switching functions like call setup, release & routing
- Call tracing & call forwarding are performed.

i) VLR

- Visitor Location Register
- DB which contains exact location of all mobile subscribers currently present in service area of MSC.
- Contains IMSI, TMSI, IMS ISDN, MSRN, location, area authentication key.

Page No.:

Date ___/___/_____

ii). HLR
- Home Location Register
- DB containing pertinent data of subscribers authorized to use a GSM network.
- Contains IMSI, IMSISDN, prepaid/postpaid, roaming restrictions, etc.

iii). OMC
- Operation Maintenance Center.
- Monitor & maintain performance of each MS, BSC & MSC within GSM

iv). AUC
- Authentication Center
- Authenticates mobile subscriber that wants to connect in network. (RAND, SRES, K_i)

v). EIR
- Equipment Identity Register
- DB that keeps record of all allowed or banned in network (IMEI num)
- Sub-classes:- white list, black list, gray last

vi). PSTN
- Public switched telephone network.
- Connects with MSC.
- Originally, network of fixed line analog telephone systems.
- Digital core network & includes mobiles & other networks too.

Interfaces.
1. Air Interface: UM interface b/w MS & BTS
2. Abis Interface: BSS internal interface linking with BTS & BSC.
3. A Interface: Provide communication b/w BSS & MSC.

Chitra

Date ___/___/_____ Page No.: _____

CDMA

- Code Division Multiple Access
- Channel access method, supporting multiple access.
- Info by several transmitters can be sent simultaneously into a single communication channel.
- Users can access the whole bandwidth & doesn't limit frequency range of user.
- Multiple users can share a band of frequencies without any kind of undue interference b/w them.
- Makes use of spectrum technology along with analog to digital conversion.
- Used by radio & mobile communication technologies.
- 1.2 MHz channel

Characteristics:

- Allows more users to connect at a given time & thus provide improved data & voice communication capacity.
- full spectrum is used by all channels in CDMA.
- Eliminate interference & noise to improve network quality.
- Encode user transmissions into distinct & unique codes to secure them.
- Have a soft capacity ⇒ No particular limit to no. of users but with ↑ no. of users, performance ↓.

Advantages

- Increased user capacity
- More secure
- Have comparatively fewer dropouts.
- Lower call costs
- High quality of voice.
- Very low power requirement
- Problems (multipath, fading) do not occur.

Disadvantages

- Lack facility of intl. roaming.
- Performance ↓ with ↑ users
- Self-jamming problem occurs (loss of orthogonality)
- Channel pollution occurs
- Lack of handsets for CDMA technology.