Last Minute Notes for Computer Networks

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Computer Networks is an important subject in the GATE Computer Science syllabus. It encompasses fundamental concepts like Network Models, Routing Algorithms, Congestion Control, TCP/IP Protocol Suite, and Network Security. These topics are essential for understanding how data is transmitted, managed, and secured across networks.

This article provides **Last Minute Notes for Computer Networks** that focuses on the most important topics that are frequently asked in GATE.

Table of Content

- OSI Model
- Basics of Computer Networks
- Data Link Layer
- Network Layer
- Transport Layer
- Session Layer
- Presentation Layer
- Application Layer
- Important Port number and transport mode used by Protocols

Basics of Computer Networks

Network Topologies

- **Mesh Topology:** In a mesh topology, every device is connected to another device via a particular channel. If suppose, N number of devices are connected with each other, then a total number of links is required to connect NC_2.
- **Bus Topology:** Bus topology is a network type in which every computer and network device is connected to a single cable. If N devices are connected, then

the number of cables required is 1 which is known as backbone cable, and N drop lines are required.
- **Star Topology:** In star topology, all the devices are connected to a single hub through a cable. If N devices are connected to each other, then the no. of cables required N.
- **Ring Topology:** In this topology, it forms a ring connecting devices with exactly two neighboring devices.

Read more about Network Topologies.

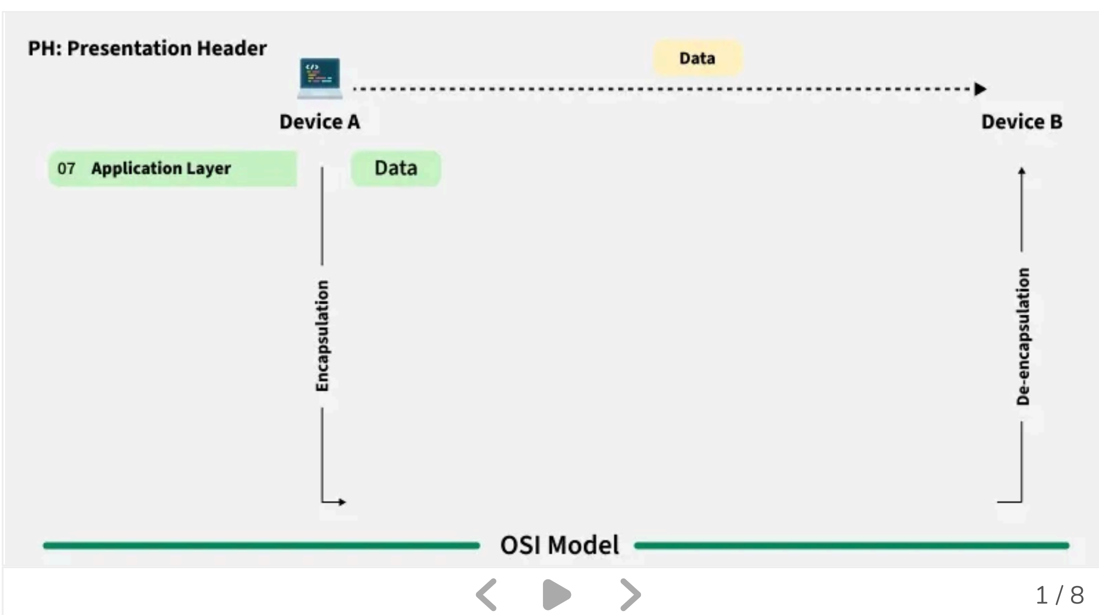
Transmission Modes

- **Simplex Mode** : the communication is unidirectional, as on a one-way street. Only one of the two devices on a link can transmit, and the other can only receive.
- **Half-duplex Mode** : each station can both transmit and receive, but not at the same time.
- **Full-duplex Mode** : both stations can transmit and receive simultaneously.

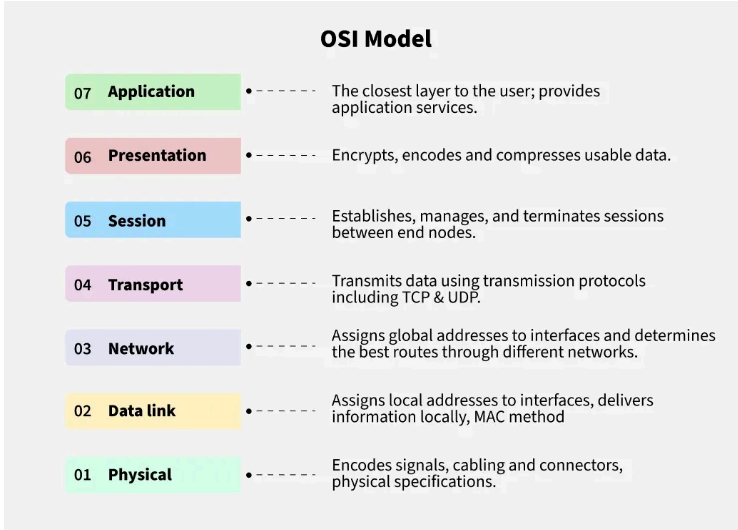
Read more about Transmission modes.

OSI Model

OSI stands for **Open Systems Interconnection**. It has been developed by ISO– **International Organization for Standardization**, in the year 1984. It is a seven-layer architecture with each layer having specific functionality to perform.



Understanding Layers of OSI Model



Layers and their uses:

OSI Model	DoD Model	Protocols	Devices / Apps
Layer 5, 6, 7	Application	DNS, DHCP, NTP, SNMP, HTTPS, FTP, SSH, TELNET, HTTP, POP3...etc.	Web server, Mail server, Browser, Mail client ...etc.
Layer 4	Host to Host	TCP | UDP	Gateway
Layer 3	Internet	IP, ICMP, IGMP	Router, Firewall layer 3, Switch
Layer 2	Network access	ARP (MAC), RARP`	Bridge, Layer 2 switch
Layer 1		Ethernet, Token ring	Hub

OSI MODEL LAYERS

Physical Layer

The Physical Layer in the OSI model is responsible for the actual transmission of raw data bits over a physical medium. It manages how data is encoded into signals and transmitted through the communication medium.

Transmission Media

[Transmission media] is the physical path between the sender and receiver where the data travels. It can be classified into **guided media** (wired) and **unguided media** (wireless).

Guided Media (Wired):

- **Twisted Pair Cable**: Consists of pairs of insulated copper wires twisted together. It's the most common medium for local area networks (LANs).
    - **Shielded Twisted Pair (STP)**: Includes a shield around the wires to reduce electromagnetic interference.
    - **Unshielded Twisted Pair (UTP)**: Commonly used in Ethernet cables.

- **Coaxial Cable**: Consists of a central conductor, insulating material, metal shield, and outer insulating layer. Used in older Ethernet networks and cable TV.
- **Fiber Optic Cable**: Uses light signals to transmit data. It has high data rates, minimal signal loss, and is immune to electromagnetic interference. Common in long-distance and high-speed applications.

Unguided Media (Wireless):

- **Radio Waves**: Used in wireless LANs (Wi-Fi), cellular networks, and Bluetooth. It works over a range of frequencies.
- **Microwave**: High-frequency radio waves used for point-to-point communication. Requires line-of-sight between transmitter and receiver.
- **Infrared**: Short-range communication medium, often used in remote controls and short-distance communication like Bluetooth.
- **Satellite**: Used for long-distance communication and broadcast services. It requires communication through satellites orbiting Earth.

Switching Techniques

Circuit Switching

- In circuit switching, dedicated communication path is established for the entire communication session.
- Example: Traditional telephone networks (PSTN).
- Advantages: Predictable and continuous data flow.
- Disadvantages: Inefficient use of resources; path reserved even when idle.

Message Switching

- In message switching, entire message is sent to an intermediate node, stored, and forwarded until it reaches the destination.
- **Example**: Email systems.
- Advantages: Efficient use of resources and no dedicated path.
- Disadvantages: Delays due to storing and forwarding large messages.

Packet Switching

- In packet switching, data is divided into packets that are routed independently to the destination.
- **Example**: The Internet (TCP/IP).
- Advantages: Efficient, flexible, scalable.

- Disadvantages: Potential for packet reordering, overhead for packet headers.

Data Link Layer

Basics

Transmission Delay (Td) = Length of packet/Bandwidth

Propagation Delay (Pd) = Distance/Velocity

Round Trip Time is the overall time taken in transmitting a packet, it is also known as minimum acknowledgment waiting time.

Flow Control Mechanisms

Stop & Wait Protocol Only one data packet can be shared over the link and the sender has to wait for the positive acknowledgment so that it can send another packet. It leads to poor efficiency and poor resource utilization.

$$\text{Efficiency or Line utilization(E)} = \text{Useful Time/Total Time} = T_d(\text{frame}) / [T_d(\text{frame}) + 2P_d + Q_d + P_{rd} + Td(\text{ACK})]$$

$$\text{Throughput} = \text{Length of frame/Total Time} = L / [T_d(\text{frame}) + 2P_d + Q_d + P_{rd} + Td(\text{ACK})]$$

Sliding Window Protocol

Go Back N

It is also known as “conservative protocol”, and uses cumulative/piggybacking acknowledgments. The receiver window size is 1, and the sender window size is $2^k - 1$ where K is the number of bits received for the window size in the header.

$$\text{Efficiency or Line utilization(E)} = \text{Useful Time/Total Time} = N * T_d(\text{frame}) / [T_d(\text{frame}) + 2P_d + Q_d + P_{rd} + Td(\text{ACK})]$$

$$\text{Throughput} = N * \text{Length of frame/Total Time} = N * L / [T_d(\text{frame}) + 2P_d + Q_d + P_{rd} + Td(\text{ACK})]$$

Selective Repeat ARQ

Selective Repeat ARQ retransmits only the lost or corrupted frames instead of all subsequent frames, ensuring higher efficiency and reduced redundancy compared to Go-Back-N.

```
Efficiency or Line utilization(E)=Useful Time/Total Time
                                                    =N*Td(frame)/
[Td(frame)+2Pd+Qd+Prd+Td(ACK)]
```

Properties	Stop and wait	Go back N	Selective repeat
efficiency	1 / (1+2a)	N / (1+2a)	N / (1+2a)
buffer	1 + 1	N + 1	N + N
sequence number	1 + 1	N + 1	N + N
retransmission	1	N	1
bandwidth	low	High	Moderate
CPU	low	Moderate	High
implementation	low	Moderate	Complex

Comparison of Data Link Layer Protocols

Framing in DLL : Framing provides a way for a sender to transmit a set of bits that are meaningful to the receiver.

- **Character/Byte Stuffing:** Used when frames consist of character. If data contains ED then, a byte is stuffed into the data to differentiate it from ED.
- **Bit stuffing** : Sender stuffs a bit to break the pattern i.e. here appends a 0 in data = 0111 **0** 1.

Medium Access Control Protocols

They manage how devices share a common communication medium and ensure efficient and collision-free data transmission. MAC protocols are generally classified into the following categories:

A. Contention-Based Protocols

In these protocols, devices compete for the medium, and collisions may occur. They are suitable for networks with more traffic.

Examples :

- ALOHA
  - **In Pure ALOHA**, devices transmit data whenever they want. Collisions are resolved using retransmissions.
  - **In Slotted ALOHA**, the transmission time is divided into slots, reducing the probability of collisions.

- CSMA (Carrier Sense Multiple Access)
    - **In CSMA**, devices sense the medium before transmitting.
    - **CSMA/CD (Collision Detection)** is used in Ethernet, it detects collisions and retransmits data.
    - **CSMA/CA (Collision Avoidance)** is used in wireless networks (e.g., Wi-Fi), it avoids collisions by sending RTS/CTS (Request to Send/Clear to Send) signals.

B. Controlled Access Protocols

These protocols avoid collisions by controlling access to the medium. Examples :

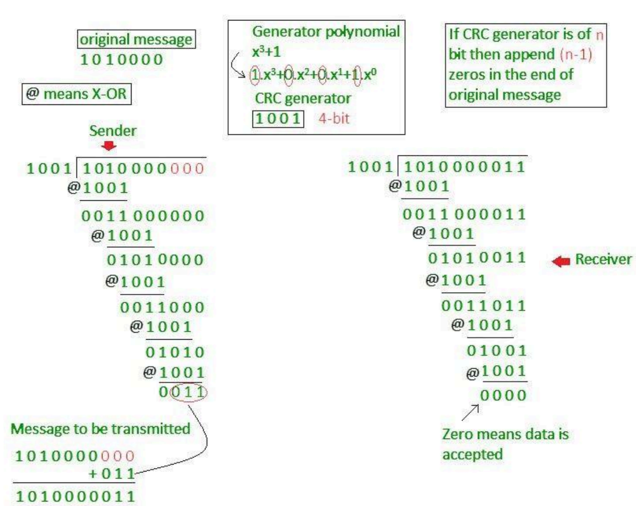
- In polling, a central device polls others to grant them access to the medium.
- **Token Passing**: A token circulates in the network, and only the device holding the token can transmit.

Error Control

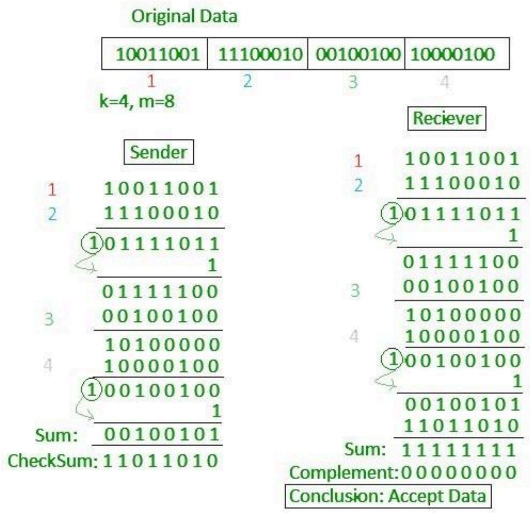
- **Hamming Code**: Hamming Code is a set of error-correction codes that can be used to detect and correct the errors that can occur when the data is moved or stored from the sender to the receiver.

```
Redundant bits: 2  r  ≥ m + r + 1
where, r = redundant bit, m = data bit
```

- **Cyclic Redundancy Check** : CRC uses a polynomial generator on both the sender and receiver sides to detect the error in the transmitted data. Example: Let's data to be send is 1010000 and divisor in the form of polynomial is x^3+1. CRC method discussed below.



- **Checksum**: Checksum is more reliable than other modes of error detection, it uses a checksum generator on the sender side and a checksum checker on the receiver side. Example:



Network Layer

Class Full Addressing is an IP addressing method that divides the address space into five classes: **A, B, C, D, and E**, based on the first few bits of the IP address. Each class has a fixed network and host portion.

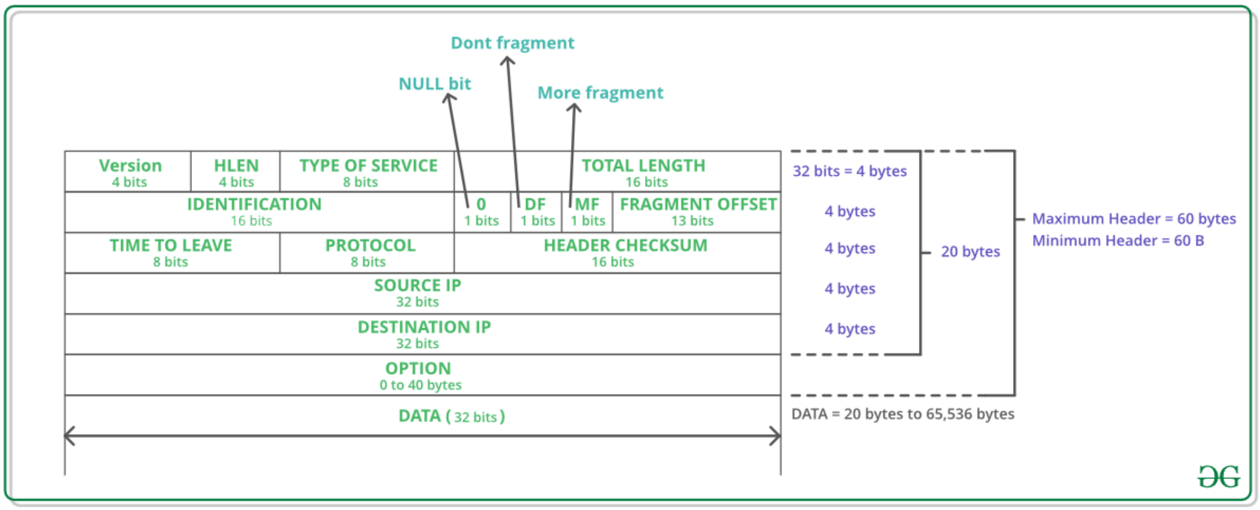
Address Class	First octet (Decimal)	First octet bits (red bits don't change)	Network (N) and Host (H) portion	Default Subnet Mask
A	1 – 127	0000 0000 – 0111 1111	N.H.H.H	255.0.0.0
B	128 – 191	1000 0000 – 1011 1111	N.N.H.H	255.255.0.0
C	192 – 223	1100 0000 – 1101 1111	N.N.N.H	255.255.255.0
D	224 – 239	1110 0000 – 1110 1111	n/a (multicast)	
E	240 – 255	1111 1111 – 1111 1111	n/a (experimental)	

Class Full Addressing

IPv4 Datagram Header

- **VERSION***:* Version of the IP protocol (4 bits), which is 4 for IPv4
- **HLEN:** IP header length (4 bits), which is the number of 32 bit words in the header. The minimum value for this field is 5 and the maximum is 15.
- **Type of service:** Low Delay, High Throughput, Reliability (8 bits)
- **Total Length:** Length of header + Data (16 bits), which has a minimum value 20 bytes and the maximum is 65,535 bytes.
- **Identification***:* Unique Packet Id for identifying the group of fragments of a single IP datagram (16 bits)
- **Flags***:* 3 flags of 1 bit each : reserved bit (must be zero), do not fragment flag, more fragments flag (same order)

- **Fragment Offset:** Represents the number of Data Bytes ahead of the particular fragment in the particular Datagram. Specified in terms of number of 8 bytes, which has the maximum value of 65,528 bytes.
- **Time to live***:* Datagram's lifetime (8 bits), It prevents the datagram to loop through the network by restricting the number of Hops taken by a Packet before delivering to the Destination.
- **Protocol:** Name of the protocol to which the data is to be passed (8 bits)
- **Header Checksum***:* 16 bits header checksum for checking errors in the datagram header
- **Source IP address***:* 32 bits IP address of the sender
- **Destination IP address***:* 32 bits IP address of the receiver
- **Option:** Optional information such as source route, record route. Used by the Network administrator to check whether a path is working or not.



Subnetting

Subnetting dividing a bigger network into a smaller network to maintain the security of the network is known as subnetting.

Implementation : Let's consider a network **192.168.1.0/24** (subnet mask: 255.255.255.0), we need to create **4 subnets**.

- **Find the Number of Subnets**:

```
2^n≥Number of Subnets
Here, n=2 (since 2^2 = 4).
```

- **Determine the New Subnet Mask**:

```
Original subnet mask: /24
Add n=2 bits for subnetting: /26
New subnet mask: 255.255.255.192
```

- **Find Subnet Ranges**:

Subnet size = 2^{32}–New Prefix=2^{32-26}=64 IP addresses per subnet.
Usable IPs per subnet = 64–2=62 (excluding network and broadcast addresses).

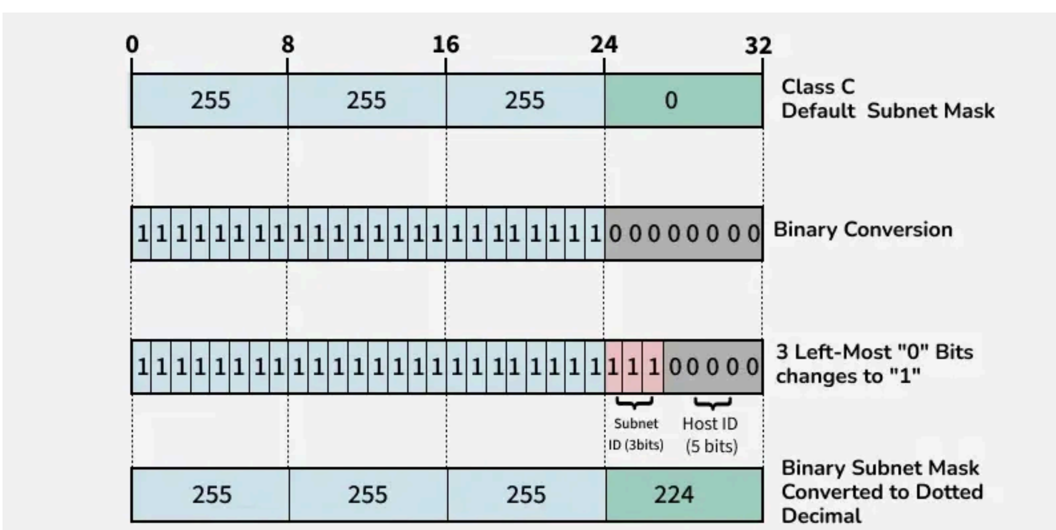
- **Subnets**:

```
Subnet 1: 192.168.1.0 to 192.168.1.63
Subnet 2: 192.168.1.64 to 192.168.1.127
Subnet 3: 192.168.1.128 to 192.168.1.191
Subnet 4: 192.168.1.192 to 192.168.1.255
```

Each subnet has:

- **64 total addresses**
- **62 usable IPs**
- Subnet mask: **255.255.255.192 (/26)**

A **subnet mask** is a 32-bit number used in IPv4 to divide an IP address into network and host portions. It helps identify the size of the network and enables subnetting by determining which part of the address belongs to the network and which to the host.



Subnet Mask of Class C IP address

Supernetting: Multiple smaller networks are combined to form a bigger network, it is known as **Supernetting**. It is mainly used in router summarization, etc.

VLSM: Variable Length Subnet Mask is where the subnet design uses more than one mask in the same network which means more than one mask is used for different subnets of a single class A, B, C, or a network. It is also defined as the process of subnetting a subnet. It is used to increase the usability of subnets as they can be of variable size.

Internet Control Message Protocol: Since IP does not have an inbuilt mechanism for sending error and control messages. It depends on Internet Control Message Protocol(ICMP) to provide error control.

Difference between DVR and LSR:

Distance Vector Routing	Link State Routing
--> Bandwidth required is less due to local sharing, small packets and no flooding.	--> Bandwidth required is more due to flooding and sending of large link state packets.
--> Based on local knowledge since it updates table based on information from neighbors.	--> Based on global knowledge i.e. it have knowledge about entire network.
--> Make use of Bellman Ford algo	--> Make use of Dijkastra's algo
--> Traffic is less	--> Traffic is more
--> Converges slowly i.e. good news spread fast and bad news spread slowly.	--> Converges faster.
--> Count to infinity problem.	--> No count to infinity problem.
--> Persistent looping problem i.e. loop will there forever.	--> No persistent loops, only transient loops.
--> Practical implementation is RIP and IGRP.	--> Practical implementation is OSPF and ISIS.

Hop Count: Hop count is the number of routers between the source and destination network. The path with the lowest hop count is considered the best route to reach a network and therefore placed in the routing table.

Open shortest path first (OSPF): Open the shortest path first (OSPF) is a link-state routing protocol that is used to find the best path between the source and the destination router using its own SPF algorithm.
Designated Router(DR) and Backup Designated Router(BDR) election takes place in the broadcast network or multi-access network.

Routing Information Protocol (RIP): RIP is a dynamic routing protocol that uses hop count as a routing metric to find the best path between the source and the destination network. It is a distance vector routing protocol that has an AD value of 120 and works on the application layer of the OSI model. RIP uses port number 520.

ARP (Address Resolution Protocol)

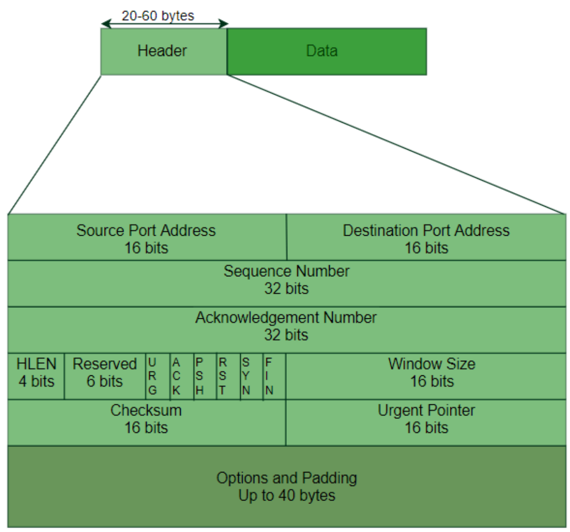
An ARP (Address Resolution Protocol) **request** is a network protocol used to map an **IP address** to its corresponding **MAC (Media Access Control) address** within a local network.

RARP Protocol (Reverse Address Resolution Protocol)

Reverse Address Resolution Protocol (RARP) is a network protocol used to obtain an **IP address** for a device (like a diskless workstation) from its **MAC address**

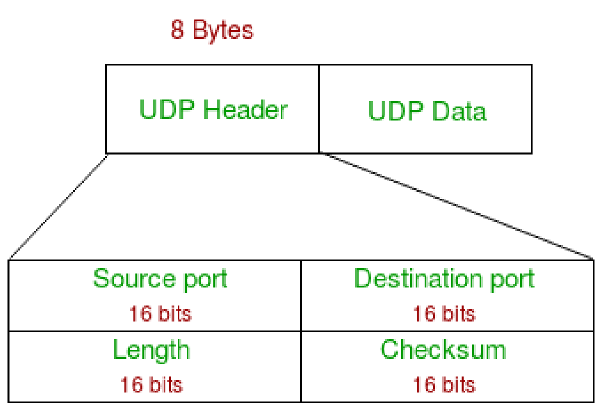
Transport Layer

- The **TCP header** is a fixed 20-byte (minimum) structure in the Transport Layer that includes fields such as source and destination ports, sequence and acknowledgment numbers, flags (e.g., SYN, ACK), and window size to ensure reliable and ordered data delivery.



- **TCP Congestion Control**
    - TCP Congestion Control manages network congestion by adjusting the data transmission rate .IT ensures efficient and reliable data delivery while avoiding network overload. It uses algorithms like:
        - Slow Start Phase **:** In this phase after every RTT the congestion window size increments exponentially
        - Congestion Avoidance Phase **:** This phase starts after the threshold value also denoted as **ssthresh.** The size of CWND (Congestion Window) increases additive. After each RTT cwnd = cwnd + 1.
        - Congestion Detection Phase **:** If congestion occurs, the congestion window size is decreased.
- **TCP 3-Way Handshake Process**

- The [TCP 3-Way Handshake Process] is implemented in following steps:
    - **Step 1 (SYN):** The client wants to establish a connection with the server, so it sends a segment with SYN(Synchronize Sequence Number) which informs the server that the client is likely to start communication and with what sequence number it starts segments with
    - **Step 2 (SYN + ACK)** : Server responds to the client request with SYN-ACK signal bits set. Acknowledgment (ACK) signifies the response of the segment it received and SYN signifies with what sequence number it is likely to start the segments with
    - **Step 3 (ACK):** In the final part client acknowledges the response of the server and they both establish a reliable connection with which they will start eh actual data transfer.
- **TCP Connection Termination**
    - TCP connection termination is a process that ends a Transmission Control Protocol (TCP) connection. TCP supports two types of connection releases like most connection-oriented transport protocols:
        - **Graceful connection release: T**he connection is open until both parties have closed their sides of the connection.
        - **Abrupt connection release: E**ither one TCP entity is forced to close the connection or one user closes both directions of data transfer.
- The **UDP header** is a simple 8-byte structure in the Transport Layer, containing four fields: **Source Port**, **Destination Port**, **Length**, and **Checksum**



Session Layer

- The session layer is responsible for establishing, maintaining, and terminating sessions in a network. The session layer manages data transmission for a certain time period.

- The session layer is responsible for the identification of entities participating in a session.
- It provides synchronization services to the data stream.

Presentation Layer

- The presentation layer translates the data packet from the network layer to the application layer and vice versa.
- The main responsibility of the Presentation layer is protocol conversion, data encryption/decryption, character conversion, and data compression.
- It sets standards for different systems to provide flawless communication.

Application Layer

Application Layer is the topmost layer of the OSI model and it directly interacts with web applications or application services. This layer provides several ways for manipulating the data (information) which actually enables any type of user to access the network with ease.

Functions of Application Layer

- Application Layer facilitates email sending and storing features.
- This layer allows users to access, retrieve and manage files from a remote computer.
- This layer provides services that include: E-mail, File transfer, directory services, network resources, etc.

Protocols in Application Layer

- Domain Name Server(DNS): DNS is a protocol used to translate human-readable domain names (e.g., www.example.com) into IP addresses (e.g., 192.168.1.1) to enable communication over the internet.

- Simple Mail Transfer Protocol (SMTP): SMTP is an application layer protocol. The client who wants to send the mail opens a TCP connection to the SMTP server and then sends the mail across the connection. The SMTP server is always in listening mode. As soon as it listens for a TCP connection from any client, the SMTP process initiates a connection on that port (25). After successfully establishing the TCP connection the client process sends the mail instantly.

- Post Office Protocol, Version 3 (POP3): POP3 retrieves emails by downloading them to a device, often deleting them from the server. It is suitable for single-device access.

- Internet Message Access Protocol, Version 4(IMAP4): IMAP4 accesses and syncs emails directly on the server. It allows multi-device synchronization and folder management.

- File Transfer Protocol (FTP): FTP is an application layer protocol that moves files between local and remote file systems. It runs on top of TCP, like HTTP. To transfer a file, 2 TCP connections are used by FTP in parallel: control connection and data connection.

- Hypertext Transfer Protocol (HTTP): HTTP is an application-level protocol that uses TCP as an underlying transport and typically runs on port 80. HTTP is a stateless protocol i.e. server maintains no information about past client requests.

Important Port number and transport mode used by Protocols

Port Number	TCP/UDP	Protocol Name
80	TCP	HTTP
443	TCP	HTTPS
21	TCP	FTP (to establish a connection between computers)
20	TCP	FTP (to transfer data)
22	TCP	SSH
25	TCP	SMTP
53	UDP	DNS

See Last Minute Notes on all subjects here.

Similar Reads

Computer Networks | Set 14

This question for practice purpose for GATE CS Exam. Ques-1: Which of the following is not true about Subnetting? (A) It can be applied only for single network. (B) It is use...

2 min read

Computer Networks | Set 13

These questions for practice purpose for GATE CS Exam. Ques-1: How many bits are allocated for network id (NID) and host id(HID) in the IP address 25.193.155.233? (A)...

3 min read

Introduction of Botnet in Computer Networks

A Network of compromised computers is called a botnet. Compromised computers are also called Zombies or Bots. This software is mostly written in C++ & C. The main...

5 min read

Difference between Ring Topology and Bus Topology in Computer Networks

Network topology deals with how devices are arranged and how they will communicate within a network. Ring and Bus are the most popular topology. Both...

5 min read

Protocol and Standard in Computer Networks

Protocols and standards are important in computer networks. They are like the rules and guidelines that allow different devices and systems to communicate and work...

9 min read

Types of Computer Networks

A computer network is a cluster of computers over a shared communication path that works to share resources from one computer to another, provided by or located on th...

11 min read

List of "Difference Between" Computer Networks Topics

Computer Network is a set of devices or systems that shares resources through links and it can be defined as a collection of nodes. A node can be any device capable of...

4 min read

Computer Networks - GATE CSE Previous Year Questions

In this article, we are mainly focusing on the Computer Networks GATE Questions that are asked in Previous Years with their solutions, and where an explanation is required,...

2 min read

Computer Networks | Set 2

Computer networks involve a complex system of connected devices that communicate with each other. Topics in this set might include protocols like TCP/IP, different types ...

5 min read

Computer Networks | Set 5

Following questions have been asked in GATE CS 2005 exam. 1) Packets of the same session may be routed through different paths in: (a) TCP, but not UDP (b) TCP and...

2 min read

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DevOps

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School Subjects

Mathematics
Physics
Chemistry
Biology
Social Science
English Grammar

Databases

SQL
MYSQL
PostgreSQL
PL/SQL
MongoDB

Competitive Exams

JEE Advanced
UGC NET
UPSC
SSC CGL
SBI PO
SBI Clerk
IBPS PO
IBPS Clerk

Free Online Tools

Typing Test
Image Editor
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Computer Network
Database Management System
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System Design

High Level Design
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Internships

Random Password Generator

DSA/Placements

DSA - Self Paced Course
DSA in JavaScript - Self Paced Course
DSA in Python - Self Paced
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Master Competitive Programming
Core CS Subject for Interview Preparation
Mastering System Design: LLD to HLD
Tech Interview 101 - From DSA to System Design [LIVE]
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Development/Testing

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React Native Course
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Machine Learning/Data Science

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Clouds/Devops

DevOps Engineering
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GATE

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