COMPUTER SCIENCE & INFORMATION TECHNOLOGY

Computer Networks

Comprehensive Theory
with Solved Examples *and* Practice Questions

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Computer Networks

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Computer Networks

Goal of the Subject

The main goal of networking is "Resource sharing", and it is to make all programs, data and equipment available to anyone on the network without the regard to the physical location of the resource and the user.

A second goal is to provide high reliability by having alternative sources of supply. For example, all files could be replicated on two or three machines, so if one of them is unavailable, the other copies could be available.

Another goal is saving money. Small computers have a much better price/performance ratio than larger ones. This goal leads to networks with many computers located in the same building. Such a network is called a LAN (Local Area Network).

Another closely related goal is to increase the systems performance as the work load increases by just adding more processors. With central mainframes, when the system is full, it must be replaced by a larger one, usually at great expense and with even greater disruption to the users.

Computer networks provide a powerful communication medium. A file that was updated/modified on a network can be seen by the other users on the network immediately.

Computer Networks

INTRODUCTION

Although Computer network is a vast subject on its own, in this book we tried to keep it around the GATE syllabus. Each topic required for GATE is crisply covered with illustrative examples and each chapter is provided with Student Assignment at the end of each chapter so that the students get the thorough revision of the topics that he/she had studied. This subject is carefully divided into eight chapters as described below.

1. **Networking Fundamentals and Physical layer:** In this chapter we discuss transmission medium, noise that cause bit errors, types of transmission media, concept of protocol layering. Finally we discuss the IP addressing, Subnetting and Network address translation.
2. **Data Link layer:** In this chapter we discuss Delays in computer networks, Protocol layering, Circuit-switched and Packet switching. Data link layer functions, farming methods, error correction and detection methods, Sliding window protocols for flow control the Static and dynamic channel allocation methods. Then we finally discuss Networking devices like Repeaters, Hubs, Bridges, Switches, Routers and Gateways.
3. **Network Layer:** In this chapter we discuss the classification of routing algorithms, Distance vector and Link state routing protocols. We also cover congestion control algorithms at network layer, Internet protocol, and finally we cover the network layer protocols namely ARP, RARP, ICMP and IPv4 & NAT.
4. **Transport Layer Protocols:** In this chapter we discuss the TCP protocol as connected oriented service and reliable service provider, TCP congestion control, TCP timers and finally we discuss UDP.
5. **Application Layer and Protocols:** In this chapter we discuss the various protocols used at application layer: DNS, HTTP, SMTP, Telnet, UDP, FTP etc.

■■■■

CHAPTER 1

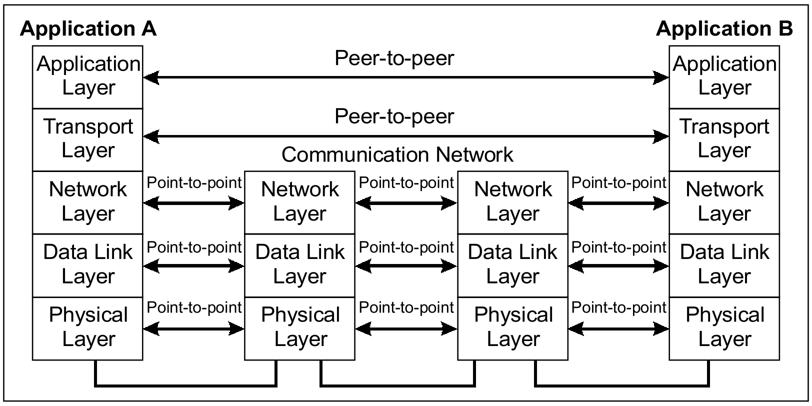
Networking Fundamentals and Physical Layer

1.1 INTRODUCTION

1.1.1 Protocol Layering

There are several advantages of protocol layering.

1. Protocol layering enables us to divide a complex task into several smaller simpler tasks. This is referred to as modularity.
2. It allows to separate the services from the implementation.
3. Intermediate systems need only some layers but not all layers. Protocol layering helps us in designing the system or devices with required number of layers implemented in it.



1.1.2 OSI layer vs TCP/IP layer

OSI (Open System Interconnection)	TCP (Transmission Control Protocol/ Internet Protocol)
• OSI provide layer function and also defines functions of all layers	• TCP/IP model the transport layer does not guarantees delivery of packets
• IN OSI model the transport layer guarantees the delivery of packets	• Follows vertical approach
• Follows horizontal approach	• TCP/IP does not have a separate presentation layer
• OSI model has a separate presentation layer	• TCP/IP model cannot be used in any other application
• OSI is a general model	• The network layer in TCP/IP model provides connectionless services
• Network layer of OSI model provide both connection oriented and connectionless service	• TCP/IP model does not fit any protocol
• Protocols are hidden in OSI model and are easily replaced as the technology changes	• In TCP/IP replacing protocol is not easy
• OSI model defines services, interfaces and protocols very clearly and makes clear distinction between them	• In TCP/IP it is not clearly separated its services, interfaces and protocols.
• It has 7 layer	• It has 5 layers

The Open Systems Interconnection (OSI) model is a standard "reference model" created by the International Organization for Standardization (ISO) to describe how the different software and hardware components involved in a network communication should divide labor and interact with one another.

It defines a seven-layer set of functional elements, ranging from the physical interconnections at Layer 1 (also known as the physical layer, or PHY interface) all the way up to Layer 7, the application layer.

The Transmission Control Protocol (TCP) and the Internet Protocol (IP) are two of the network standards that define the Internet.

IP defines how computers can get data to each other over a routed, interconnected set of networks. TCP defines how applications can create reliable channels of communication across such a network. Basically, IP defines addressing and routing, while TCP defines how to have a conversation across the link without garbling or losing data. TCP/IP grew out of research by the U.S. Dept. of Defense and is based on a loose rather than a strict approach to layering. Many other key Internet protocols, such as the Hypertext Transfer Protocol (HTTP), the basic protocol of the Web, and the Simple Mail Transfer Protocol (SMTP), the core e-mail transfer protocol, are built on top of TCP. The User Datagram Protocol (UDP), a companion to TCP, sacrifices the guarantees of reliability that TCP makes in return for faster communications.

TCP/IP doesn't map cleanly to the OSI model, since it was developed before the OSI model and was designed to solve a specific set of problems, not to be a general description for all network communications.

ISO/OSI Layer	TCP/IP Model	Sample Protocols	Devices
7. Application	Application	**SOAP, XML**	**XML Appliances**
6. Presentation		HTTP, HTTPS FTP TELNET SMTP, NTP	Content Service Switch Layer 4-7 Switches
5. Session			
4. Transport			
3. Network	Transport	TCP, UDP	Router, Layer-3 Switch
2. Data Link	Network	IP, ICMP, IGMP, IPX	Switches, Bridges
1. Physical	Link	Network Interface: Ethernet, Token Ring, FDDI	Hubs, Repeaters

Two layers in the OSI model, session and presentation, are missing from the TCP/IP protocol suite. These two layers were not added to the TCP/IP protocol suite after the publication of the OSI model. The application layer in the suite is usually considered to be the combination of three layers in the OSI model. The OSI model did not replace the TCP/IP protocol suite because it was completed when TCP/IP was fully in place and because some layers in the OSI model were never fully defined.

1.1.3 Similarities between OSI Model and TCP/IP Model

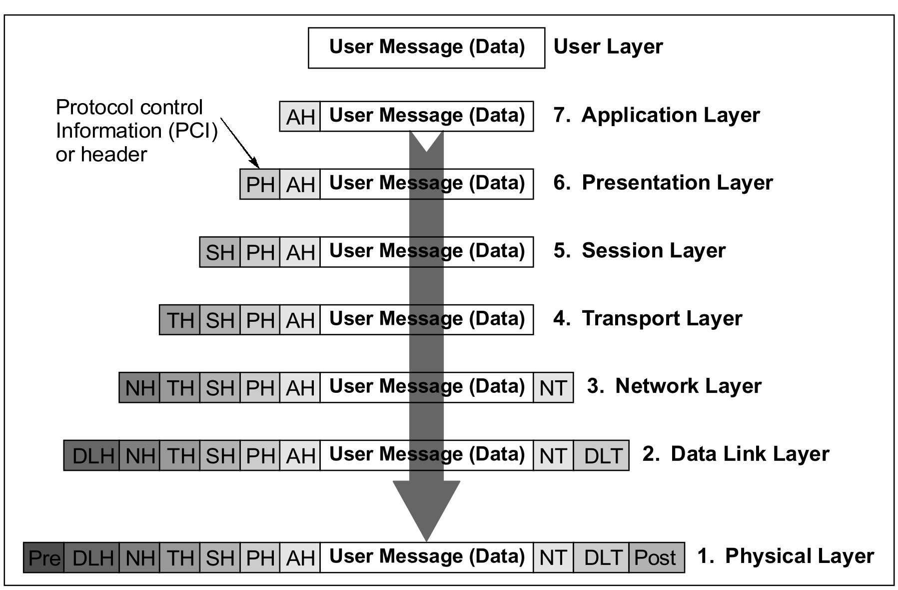
1. Both of them use a layered architecture to explain data communication process in computer networks.
2. Each layer performs well-defined functions in both models.
3. Similar types of protocols are used in both models.
4. OSI and TCP/IP reference models are open in nature.
5. Both models give a good explanation on how various types of network hardware and software interact during a data communication process.
6. Data hiding principle is well maintained on each layer in the two models. The core level functional details of each layer are not revealed to other layers.
7. Transport layer defines end-end data communication process and error-correction techniques in both the models.
8. OSI and TCP/IP reference models process data in the form of packets to perform routing.

1.1.4 Encapsulation and Decapsulation

Messages generated by application are encapsulated by every layer before passing on to the layer below it. Information that is encapsulated where is from layer-to-layer. This encapsulated information is also called as 'header'.

The TCP header information includes the port address, Ack information, checksum and other useful information. The network layer header includes source and destination IP address, header checksum, fragmentation information and other useful information.

Data link layer includes the MAC address information, error control, error detection, error correction and other useful information.



OSI Layer and Message passing

Example 1.1 Let us consider the telephone channel having bandwidth B = 4 kHz. Assuming there is no noise, determine channel capacity for the following encoding levels: ((a) 2 and (b) 128.

Solution:

(a) C = 2B = 2 × 4000 = 8 Kbits/s

(b) $C = 2 \times 4000 \times \log_2 128 = 8000 \times 7 = 56$ Kbits/s

Effects of Noise

When there is noise present in the medium, the limitations of both bandwidth and noise must be considered. A noise spike may cause a given level to be interpreted as a signal of greater level, if it is in positive phase or a smaller level, if it is negative phase. Noise becomes more problematic as the number of levels increases.

Shannon Capacity (Noisy Channel)

In presence of Gaussian band-limited white noise, Shannon-Hartley theorem gives the maximum data rate capacity

$$C = B \log_2 (1 + S/N),$$

Signal to noise ratio is represented in dB (decibel).

$\log_{10}$ (S/N) is in bells

$10 \times \log_{10}$ (S/N) is in decibels

+ve value of S/N means signal power is dominating, where as –ve value of S/N represents noise power is dominating signal.

Where S and N are the signal and noise power, respectively, at the output of the channel. This theorem gives an upper bound of the data rate which can be reliably transmitted over a thermal-noise limited channel.

Example: Suppose we have a channel of 3000 Hz bandwidth, we need an S/N ratio (i.e. signal to noise ration, SNR) of 30 dB to have an acceptable bit-error rate. Then, the maximum data rate that we can transmit is 30,000 bps. In practice, because of the presence of different types of noises, attenuation and delay distortions, actual (practical) upper limit will be much lower.

NOTE: In case of extremely noisy channel, C = 0. Between the Nyquist Bit Rate and the Shannon limit, the result providing the smallest channel capacity is the one that establishes the limit.

Example 1.2 A channel has B = 4 KHz. Determine the channel capacity for each of the following signal-to-noise ratios: (a) 20 dB, (b) 30 dB, (c) 40 dB.

Solution:

(a) $C = B \log_2 (1 + S/N) = 4 \times 10^3 \times \log_2 (1 + 100) = 4 \times 10^3 \times 3.32 \times 2.004 = 26.6$ kbits/s

(b) $C = B \log_2 (1 + S/N) = 4 \times 10^3 \times \log_2 (1 + 1000) = 4 \times 10^3 \times 3.32 \times 3.0 = 39.8$ kbits/s

(c) $C = B \log_2 (1 + S/N) = 4 \times 10^3 \times \log_2 (1 + 10000) = 4 \times 10^3 \times 3.32 \times 4.0 = 53.1$ kbits/s

Example 1.3 A channel has B = 4 KHz and a signal-to-noise ratio of 30 dB. Determine maximum information rate for 4-level encoding.

Solution:

For B = 4 KHz and 4-level encoding the Nyquist Bit Rate is 16 Kbps.

Again for B = 4 KHz and S/N of 30 dB the *S*hannon capacity is 39.8 Kbps.

The smallest of the two values has to be taken as the Information capacity I = 16 Kbps.

- The **bit rate** represents the number of bits sent per second, whereas the **baud rate** defines the number of signal elements per second in the signal. Depending on the encoding technique used, baud rate may be more than or less than the data rate.
- In the standard Manchester coding there is a transition at the middle of each bit period. A binary **1** corresponds to a **low-to-high transition** and a binary **0** to a **high-to-low transition** in the middle.
- In Differential Manchester, inversion in the middle of each bit is used for synchronization.
- IP defines how computers can get data to each other over a routed, interconnected set of networks. TCP defines how applications can create reliable channels of communication across such a network.

Student's Assignment

Q.1 For a class B network an appropriate mask with 200 subnets each with 220 systems is
(a) 255.255.255.254 (b) 255.255.255.0
(c) 255.255.255.220 (d) 255.255.200.220

Q.2 Consider the following statements regarding OSI model
(*i*) It divides the network communication into smaller and simpler components, aiding component development, design and troubleshooting.
(*ii*) It allows multiple-vendor development through standardization of network components.
(*iii*) It prevents the changes in one layer from affecting the other layers, allowing for quicker development.
(*iv*) It usually do not correspond exactly to the protocol stack running on an actual system.
Which of the above are true?
(a) (*i*) and (*iv*) only (b) (*ii*) and (*iii*) only
(c) (*i*), (*ii*) and (*iv*) only (d) All of these

Q.3 An organization is granted the block 190.76.0.0/16. The administrator wants to create 1024 subnets using 10 bits. The first and last addresses in subnet 1024 respectively are
(a) 190.76.255.0/26 and 190.76.255.255/26
(b) 190.76.255.1/16 and 190.76.255.255/16
(c) 190.76.255.192/26 and 190.76.255.255/26
(d) 190.76.255.192/16 and 190.76.255.255/16

Q.4 What is the netmask of gateway interface in a sub-C network where only 14 hosts exist and IP address of one of the hosts in 193.146.129.76?
(a) 255.255.129.76
(b) 255.255.129.240
(c) 255.255.255.240
(d) 255.255.255.255

Q.5 The number of bits in IPv6 address is
(a) 64 (b) 128
(c) 256 (d) None of these

Q.6 In Hexadecimal colon notation, a 128-bit long IPv6 address is divided into ________ sections, each comprising ________ hexadecimal digits.
(a) 4, 2 (b) 8, 4
(c) 16, 2 (d) 4, 8

Q.7 Given the following IP address and network mask, what is the broadcast address?
IP : 160.168.30.100
Net Mask : 255.255.240.0
(a) 160.168.31.255 (b) 160.168.30.255
(c) 160.168.240.255 (d) 160.168.255.255

Q.8 The Router connecting company's network to the Internet applies the mask 255.255.252.0 to the destination address of incoming IP packets. Find the corresponding subnetwork for the destination IP address of packet 159.133.7.220.
(a) 159.133.7.0 (b) 159.133.0.0
(c) 159.133.4.0 (d) 159.133.6.0

Q.9 Let X and Y be the number of 0's in the binary notation of network ID and Direct Broadcast Address (DBA) respectively for the IP address 200.25.80.67 (classfull address). The value of $X \log_2 Y$ is _______.

Q.10 For a class C network if IP address of a computer is 200.99.39.112 and subnet mask is 255.255.255.224 the decimal value of last octet of last host of sixth subnet is _______.

Q.11 Match **List-I** and **List-II** and select the correct answer using the codes given below the lists:

List-I (Packets)

A.

	Source IP	Destination IP
Data	250.255.255.255	50.50.50.50

B.

	Source IP	Destination IP
Data	24.50.48.30	255.255.255.255

C.

	Source IP	Destination IP
Data	24.66.50.77	24.50.30.20

List-II
1. Unicast packet within network
2. This packet never exists
3. Limited broadcasting

Codes:

	A	B	C
(a)	1	2	3
(b)	2	3	1
(c)	3	1	2
(d)	2	1	3

Q.12 Consider a class C network has an IP address of one of the computers is 202.23.65.119. Which of the following can be host on network?
(a) 202.23.65.0
(b) 202.23.0.0
(c) 0.0.0.119
(d) None of these

Q.13 An organization is granted the block 190.76.0.0/16. The administrator wants to create 1024 subnets using 10 bits. What is the first and last addresses in last subnet which can assign to host?
(a) 90.76.255.0/26 and 190.76.255.255/26
(b) 190.76.255.1/16 and 190.76.255.255/16
(c) 190.76.255.193/26 and 190.76.255.254/26
(d) 190.76.255.192/16 and 190.76.255.255/16

Q.14 Consider the following IP address:
(*i*) 210.15.16.62
(*ii*) 210.15.16.94
(*iii*) 210.15.16.127
(*iv*) 210.15.16.191

Which of following IP address may represents last host of any subnet if subnet mask is 255.255.255.224?
(a) (*i*) and (*ii*)
(b) (*i*) and (*iii*)
(c) (*ii*) and (*iv*)
(d) (*iii*) and (*iv*)

Q.15 A router uses the following routing table:

Network Address	Mask	Interface
205.32.0.0	/25	R0
205.32.16.0	/26	R1
205.32.32.0	/24	R2
205.32.16.32	/27	R3

Find the next hop (where router will send the packet), if the router has IP address "205.32.16.63".
(a) R0
(b) R1
(c) R2
(d) R3

Q.16 An organization is granted the block 172.89.0.0/16. The administrator wants to create 1024 subnets using 10 bits. The first and last addresses of any host in subnet 1024 respectively are
(a) 172.89.255.0/26 and 172.89.255.255/26
(b) 172.89.255.1/26 and 172.89.255.245/26
(c) 172.89.0.1/26 and 164.76.255.255/26
(d) 172.89.0.1/26 and 172.89.255.245/26

Q.17 If the broadcast address of the subnet is given as 173.140.31.255, which of the following mask cannot suit the above address?
(a) 255.255.240.0
(b) 255.255.248.0
(c) 255.255.192.0
(d) Both (b) and (c)

Q.18 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I
A. Passive scanning
B. Active scanning
C. Association

List-II
1. Assigning a one or two word SSID to the access point.

2. Creating a virtual wire between itself and AP by the wireless station.
3. Scanning channels and listening for beacon frames.
4. Broadcasting a probe frame that will be received by all APs within the wireless Host's range.

Codes:

	A	B	C
(a)	3	2	1
(b)	3	4	2
(c)	4	2	1
(d)	4	3	1

Q.19 In a block of addresses, we know the IP address of one of the host is 128.44.82.16 / 25. Which of the following represent first address and last addresses that can be assign to host in the block?
(a) 128.44.82.0 and 128.44.82.126
(b) 128.44.82.1 and 128.44.82.127
(c) 128.44.82.1 and 128.44.82.126
(d) 128.44.82.0 and 128.44.82.127

Q.20 In the network 143.128.67.235 / 20, if x represent the decimal value of 3rd octet and y represent the decimal value of 4th octet of last IP address assigned to any host, then value of $x \times y$ is ________.

Q.21 Consider a IP address 201.24.58.69 in classful address, if the number of 1's in directed broadcast address is *a* and number of 1's in network ID, of the given IP address is *b*, value of $a + b$ ________.

Q.22 Consider a class B network with 100 subnets each with 160 system. What is the subnet mask of this network?
(a) 255.255.255.190
(b) 255.255.255.0
(c) 255.255.254.0
(d) 250.255.254.128

Q.23 An organization is granted the block 178.52.0.0/16, the administrator wants to create 510 subnets, what is the first and last IP address respectively in the last subnet that can be assign to the host?
(a) 178.52.255.120/25, 178.52.254.254/25
(b) 178.52.255.129/16, 178.52.255.129/16
(c) 178.52.255.128/26, 178.52.255.254/25
(d) 178.52.255.129/25, 178.52.255.254/25

Q.24 Consider the following IP addresses and which of the following IP address may represents last host of any subnet, given subnet mask is 255.255.255.224?
(i) 196.24.63.127
(ii) 196.24.63.94
(iii) 196.24.63.62
(a) (i) and (ii)
(b) (ii) and (iii)
(c) (i) and (iii)
(d) Only (i)

Answer Key:

1. (b)	**2.** (d)	**3.** (c)	**4.** (c)	**5.** (b)
6. (b)	**7.** (a)	**8.** (c)	**9.** (96)	**10.** (222)
11. (b)	**12.** (c)	**13.** (c)	**14.** (a)	**15.** (d)
16. (d)	**17.** (c)	**18.** (b)	**19.** (c)	**20.** (20066)
21. (28)	**22.** (c)	**23.** (d)	**24.** (b)	

Student's Assignments Explanations

1. (b)

Given:
Number of subnets = 200 ($2^7 < 200 < 2^8$)
Number of systems per subnet = 220
Default mask for class B = 255.255.0.0
(i.e., 16 bits for NID and 16 Bits for HID)

Check whether $\boxed{200 \times 220 < 2^{16}}$

Now, $\dfrac{16\text{ bits}}{\text{NID}} = \dfrac{16\text{ bits}}{\dfrac{8\text{ bits}}{\text{SID}} \quad \dfrac{8\text{ bits}}{\text{HID}}}$

We can use 255 . 255 . 255 . 0

2. (d)

(*i*) OSI model reduces complexity by breaking network communication into smaller and simpler components. It provides a teaching tool to help network administrators understand the communication process used between networking components.

CHAPTER

2

Data Link Layer

2.1 INTRODUCTION

Communication at the data link layer is node-to-node. The data link layer provides services to the network layer; it receives services from the physical layer. The scope of the data link layer is node-to-node. When a packet is travelling in the Internet, the data link layer of a node (host or router) is responsible for delivering a datagram to the next node in the path.

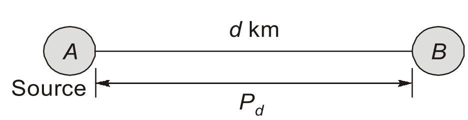
We encapsulate and decapsulate at each node because IP address information is present in packet, which is encapsulated by frame.

TCP/IP model did not define any protocol for data link layer and physical layer. Therefore we can define our on protocol for data link and physical layer.

2.2 DELAYS IN COMPUTER NETWORKS

(a) Propagation delay (P_d)

It is the time taken by 1 bit to traverse the link

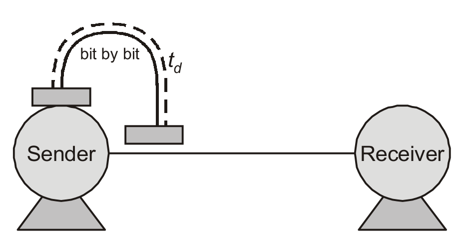


$\boxed{P_d = \frac{d}{V}}$; V is the velocity of signal on the link and usually it's value is given as 2.1×10^8 ms^{-1}

(b) Transmission delay (T_d)

The time taken to push the entire frame

or packet bits into the wire $t_d = \frac{L}{B}$;



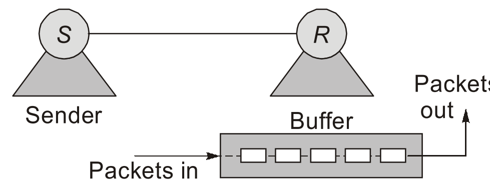
Where L - Frame size in bits and B - Bandwidth.

If L increase t_d increases

If B increase t_d decreases.

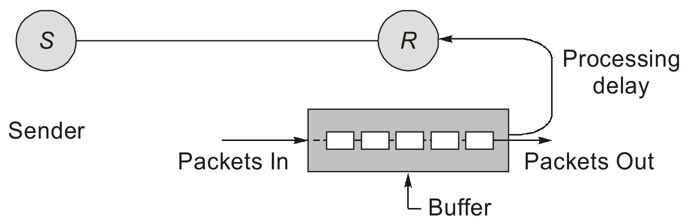
(c) Queuing delay

Time for which packet stays in the buffer is called queuing delay. It is taken by receiver for processing.



(d) Processing delay

The time router takes to process the packet header is called 'processing delay'. During processing of a packet routers may check a bit level error in packet that occur during transmission.



Link layer Addressing

The source and destination Ip addresses define the two ends but cannot define which links the datagram should pass through. A link-layer address is sometimes called a link address, sometimes a physical address, and sometimes a MAC address.

When a datagram passes from the network layer to the data-link layer, the datagram will be encapsulated in a frame and two data-link addresses are added to the frame header. These two addresses are changed every time the frame moves from one link to another.

NOTE: MAC addresses are represented using 48 bits (12 hexadecimal digits separated by a colons).

Types of Addresses

1. **Unicast address:** Each host or each interface of a router is assigned a unicast address. A frame with a unicast address destination is destined only for one entity in the link.
   A3: 34: 45: 11: 92: F1
2. **Multicast address:** Multicasting means one-to-many communication.
   A2: 34: 45: 11: 92: F1
3. **Broadcast address:** A frame with a destinations broadcast address is sent to all entities in the link.
   FF: FF: FF: FF: FF: FF

2.3 DATA LINK LAYER FUNCTIONS

Concerned with reliable, error-free and efficient communication between adjacent machines in the network through the following functions:

Data Framing

The term "frame" refers to a small block of data used in a specific network. The data link layer groups raw data bits to/from the physical layer into discrete frames with error detection/correction code bits added.

Framing methods:
- Character count.
- Starting and ending characters, with character stuffing.
- Starting and ending flags with bit-stuffing.
- Physical layer coding violations.

Error Detection/Correction

Error detection:

- Include enough redundant information in each frame to allow the receiver to deduce that an error has occurred, and to request a retransmission.
- Uses error-detecting codes.

Error correction:

- Include redundant information in the transmitted frame to enable the receiver not only to deduce that an error has occurred but also correct the error.
- Uses error-correcting codes.

Services to the Network Layer

Unacknowledged connectionless service - best effort:

The receiver does not return acknowledgments to the sender, so the sender has no way of knowing if a frame has been successfully delivered.

When would such a service be appropriate?

(a) When high layers can recover from errors with little loss in performance. That is, when errors are so infrequent that there is little to be gained by the data link layer performing the recovery. It is just as easy to have higher layers deal with occasional lost packets.

(b) Independent frames sent without having the destination acknowledge them.

(c) For real-time applications requiring "better never than late" semantics. Old data may be worse than no data. For example, should an airplane bother calculating the proper wing flap angle using old altitude and wind speed data when newer data is already available?. Also used in real time applications such as speech video etc.

Acknowledged connectionless service-acknowledged delivery:

- The receiver returns an acknowledgment frame to the sender indicating that a data frame was properly received.
- Likewise, the receiver may hand received frames to higher layers in the order in which they arrive, regardless of the original sending order.
- Typically, each frame is assigned a unique sequence number, which the receiver returns in an acknowledgment frame to indicate which frame the ACK refers to. The sender must retransmit unacknowledged (e.g., lost or damaged) frames.

Acknowledged connection-oriented service-reliable delivery: Frames are delivered to the receiver reliably and in the same order as generated by the sender. Connection state keeps track of sending order and which frames required retransmission. For example, receiver state includes which frames have been received, which ones have not etc. The data link guarantees that each frame sent is received exactly once and in right order.

Flow Control

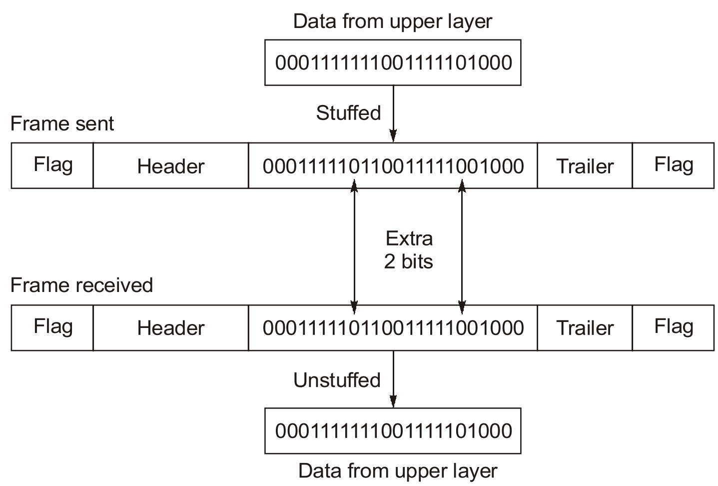
There are several protocols to control the rate at which sender transmits frames and at a rate acceptable to the receiver, and the ability to retransmit lost or damaged frames. This ensures that slow receivers are not swamped by fast senders and further aids error detection/correction.

Several flow control protocol exist, but all essentially require a form of feedback to make the sender aware of whether the receiver can keep up.

Stop-and-wait protocols:

- A positive acknowledgment frame is send by the receiver to indicate that the frame has been received and to indicate being ready for the next frame.
- Positive Acknowledgment with Retransmission (PAR); uses timeouts

NOTE: Bit stuffing is the process of adding one extra 0 whenever five consecutive 1's follow a 0 in the data.



Example 2.1 The following character encoding is used in a data link protocol: A: 01000111 B: 11100011 FLAG: 01111110 ESC: 11100000 Show the bit sequence transmitted (in binary) for the four-character frame A B ESC FLAG when each of the following framing methods is used:

(a) Byte count.
(b) Flag bytes with byte stuffing.
(c) Starting and ending flag bytes with bit stuffing.

Solution:

(a) Message is of 4 bytes length. So specify the byte count (00000100) just before the message.
00000100 ABESC FLAG

(b) FLAG AB ESC ESC ESC FLAG FLAG

(c) **01111110** 01000111 110100011 111000000011111010 **01111110**

Example 2.2 he following data fragment occurs in the middle of a data stream for which the byte stuffing algorithm described in the text is used : A B ESC C ESC FLAG FLAG D. What is the output after stuffing?

Solution:

FLAG A B ESC ESC C ESC ESC FLAG ESC FLAG D FLAG

Example 2.3 What is the maximum overhead in byte stuffing algorithm?

Solution:

Maximum overhead occurs when all the bytes are only ESC and FLAG bytes. In that case there will be 100% percent overhead.

Example 2.4 One of your classmates, Suresh Reddy, has pointed out that it is wasteful to end each frame with a flag byte and then begin the next one with a second flag byte. One flag byte could do the job as well, and a byte saved is a byte earned.

Student's Assignment

Q.1 A Go-Back-N ARQ uses a window of size 15. How many bits are needed to define the sequence number?
(a) 15 (b) 4
(c) 16 (d) 5

Q.2 Even-parity checking function
(a) Passes data unit with even number of 1's
(b) Passes data unit with odd number of 1's
(c) Passes data unit with even number of 0's
(d) Passes data unit with odd number of 0's

Q.3 Sliding Window Protocol is
(a) Used to manage the protocols in the Windows Operating Systems
(b) Used to filter the packets in farewells
(c) Used to control the flow of frames in data communications
(d) Used to exchange Windows among remote hosts

Q.4 In a Go-back NARQ, if the window size is 63, what is the range of sequence numbers?
(a) 0 to 63 (b) 0 to 64
(c) 1 to 63 (d) 1 to 64

Q.5 In Go-back-N ARQ, if frames 4, 5 and 6 are received successfully, the receiver may send an ACK ______ to the sender.
(a) 5 (b) 6
(c) 7 (d) Any of these

Q.6 For a sliding window of size $n-1$ (n sequence numbers), there can be maximum of _____ frames sent but unacknowledged
(a) 0 (b) $n-1$
(c) n (d) $n+1$

Q.7 For stop and wait ARQ, for n data packets sent, ________ acknowledgments are needed.
(a) n (b) $2n$
(c) $n-1$ (d) $n+1$

Q.8 What is the remainder obtained by dividing $x^7 + x^5 + 1$ by the generator polynomial $x^3 + 1$?
(a) $x^4 + x^2 - x$ (b) $x^2 + x + 1$
(c) $-x^2 + x + 1$ (d) $x^3 + x - 1$

Q.9 A channel has a bit rate of 20 Kbps and a propagation delay of 100 msec. For what sizes does stop and wait gives an efficiency of 50%?
(a) 250 bits (b) 500 bits
(c) 1000 bits (d) 4000 bits

Q.10 The maximum window size for data transmission using selective repeat protocol with n bit frame sequence number is
(a) 2^n (b) 2^{n-1}
(c) $2^n - 1$ (d) 2^{n-2}

Q.11 In a sliding window ARQ scheme, the transmitter's window size is N and the receiver's window size is M. The minimum number of distinct sequence numbers required to ensure correct operation of the ARQ scheme is
(a) Min (M, N) (b) Max (M, N)
(c) M + N (d) MN

Q.12 The following is a set of codewords:

00000000
00000011
00001001
00001010
00001100
00010100
00101011

Which of the following is the minimum Hamming distance between them?
(a) 4 (b) 2
(c) 1 (d) 3

Q.13 A channel has a bit rate of 4 Kbps and a propagation delay of 20 msec. For what range of frame sizes does stop-and-wait give an efficiency of at least 50%?

Q.14 The distance from earth to a distant planet is approximately 9×10^{10} m. What is the channel utilization in Kbps if a stop-and-wait protocol is used for frame transmission on a 64 Mbps point-to-point link? Assume that the frame size is 32 KB and the speed of light is 3×10^8 m/s.

Q.15 When 2 or more bits in a data unit has been changed during the transmission, the error is called

(a) Random error (b) Burst error
(c) Inverted error (d) None of these

Q.16 Which one of the following is a data link protocol?
(a) Ethernet
(b) Point to point protocol
(c) HDLC
(d) All of the above

Q.17 Which one of the following is the multiple access protocol for channel access control?
(a) CSMA/CD (b) CSMA/CA
(c) Both (a) and (b) (d) None of these

Q.18 The Techniques of temporarily delaying outgoing acknowledgments so that they can be hooked onto the next outgoing data frame is called.
(a) Piggybacking
(b) Cyclic redundancy check
(c) Fletcher's checksum
(d) None of these

Q.19 Baud means?
(a) The number of bits transmitted per unit time
(b) The number of bytes transmitted per unit time
(c) The rate at which the signal changes
(d) None of these

Q.20 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I	List-II
A. Repeaters	1. Data link layer
B. Bridges	2. Network layer
C. Routers	3. Physical layer

Codes:

	A	B	C
(a)	2	3	1
(b)	3	1	2
(c)	3	2	1
(d)	2	1	3

Q.21 Two Ethernets can be interconnected by the following device, which operates on the data link layer,
(a) Hub (b) Switch
(c) Router (d) Gateway

Q.22 Which one of the following statements is false?
(a) Packet switching leads to better utilization of bandwidth resources than circuit switching.
(b) Packet switching results in less variation in delay than circuit switching.
(c) Packet switching requires more per -packet processing than circuit switching.
(d) Packet switching can lead to reordering unlike in circuit switching.

Q.23 With respect to Circuit Switching and Packet Switching, which of the following statement is incorrect?
(a) In circuit switching after data transfer begins, no busy conditions take place.
(b) In packet switching, each packet of the same message must follow the same route.
(c) In packet switching, each packet must contain the addressing information.
(d) In circuit switching, a circuit must be established on the network prior to the data transfer.

Q.24 Communication via circuit switching involves three phase which are
(a) Circuit establishment, Data transfer, Circuit disconnect
(b) Circuit establishment, Data compression, Circuit disconnect
(c) Data transfer, Data compression, Circuit disconnect
(d) Circuit established, Data compression, Circuit disconnect

Q.25 Assume 10 nodes are connected to a 1000 meter length of coaxial cable. Using some protocol, each node can transmit 500 frames/second, where the average frame length is 2600 bits. The transmission rate at each node is 104×10^6 bps. The efficiency of the protocol is ________ (in % upto two decimal places).

Q.26 Consider a 800 Kbps link. What is the maximum bandwidth (in Kbps) when pure aloha and slotted aloha is used is respectively?
(a) 147.2 Kbps, 294.4 Kbps
(b) 294.4 Kbps, 147.2 Kbps
(c) Can't be determined
(d) None of these

Q.37 Consider the following statements:

S_1 : Data link layer define the boundaries of frame because framing is always of fixed size.

S_2 : Bit stuffing is the process of adding one extra 0 after 6[th] bit whenever five consecutive 1's follow a 0 in the data, if 0111110 is assumed as a flag.

Which of the following option is correct?

(a) Only S_1 is true
(b) Only S_2 is true
(c) Both S_1 and S_2 are true
(d) Neither of S_1 or S_2 is true

Q.38 Match **List-I (Networking devices)** with **List-II (Property)** and select the correct answer using the codes given below the lists:

	List-I		List-II
A.	Hub	1.	Broadcast domain separator
B.	Bridge	2.	Collision domain separator
C.	Switch	3.	Broadcasting device

Codes:

	A	B	C
(a)	3	1	2
(b)	1	2	3
(c)	3	2	1
(d)	2	3	1

Q.39 Consider the following statements:

S_1 : IEEE 802.11 does not uses sequence number.

S_2 : The amount of data send in one time in limited by RTS frame (data = sender's data + ACK).

S_3 : IEEE 802.11 uses CSMA/CA medium access protocol.

S_4 : The exponential backoff mechanism reduces the probability of collision on retransmissions in ethernet.

Which of the following is true?

(b) Only S_1 and S_2
(b) S_2 and S_3
(c) Only S_2 and S_4
(d) All of the statements

Q.40 Let N stations share 60 kbps of slotted aloha channel. Frame size is 1024 bits which are send at every 40 seconds. The value of N is ________. (Upto 1 decimal places)

Answer Key:

1. (b)	**2.** (a)	**3.** (c)	**4.** (a)	**5.** (c)
6. (b)	**7.** (a)	**8.** (b)	**9.** (d)	**10.** (b)
11. (c)	**12.** (b)	**13.** (160)	**14.** (52.98)	**15.** (b)
16. (d)	**17.** (c)	**18.** (a)	**19.** (c)	**20.** (b)
21. (b)	**22.** (b)	**23.** (b)	**24.** (a)	**25.** (12.5)
26. (a)	**27.** (a)	**28.** (b)	**29.** (c)	**30.** (b)
31. (8)	**32.** (a)	**33.** (d)	**34.** (88)	**35.** (2000)
36. (111)	**37.** (d)	**38.** (c)	**39.** (b)	**40.** (862.5)

Student's Assignments — Explanations

1. (b)

In Go-Back-N, size of window < 2^n:

$\Rightarrow \quad 15 < 2^n$

When $n = 4$, above formula satisfied thus 4 bits are sufficient to satisfy the above condition.

2. (a)

In even-parity checking, data unit passes with even number of 1's.

3. (c)

Sliding window protocol is used to control the flow of frames in data communications.

4. (a)

If the window size is 63, then 6-bits are required to represent the window size.

$\Rightarrow$ In 6 bits, range of numbers possible are 0 to 63.

5. (c)

Acknowledgement number is always the one plus sequence number of the last received frame, thus when 4, 5 and 6 are received sequence packets then 7 would be the acknowledgement. Number on the acknowledgement packet.

6. (b)

In sliding window protocol, we can send the size of window (number of packets) without waiting for an acknowledgement. Hence, maximum $(n - 1)$ frames can be sent without acknowledgement.