**Sample Questions for PhD Entrance Test**

**Part B: Computer Networks**

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Note: Sample questions are only to indicate the level of difficulty for PhD admission test preparation. However, similar questions may not be set in exam.

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1. Suppose that the spectrum of a channel is between 3 MHz and 4 MHz; and $SNR_{dB} = 24$dB. Assume that we can achieve the theoretical limit of channel capacity. Then, how many signalling levels are required?

2. Consider a point-to-point link 50 km in length. At what bandwidth would propagation delay (at a speed of $2 \times 10^8$m/s) equal transmission delay for 100-byte packets?

3. An NRZ-L signal is passed through a filter with modulation and filtering constant $d = 0.5$ and then modulated onto a carrier. The data rate is 2400 bps. Evaluate the bandwidth for ASK and FSK. For FSK assume that the two frequencies used are 50 kHz and 55 kHz.

4. Two hosts are connected via a packet switch with $10^7$ bits per second links. Each link has a propagation delay of 20 microseconds. The switch begins forwarding a packet 35 microseconds after it receives the same. If 10000 bits of data are to be transmitted between the two hosts using a packet size of 5000 bits, the time elapsed between the transmission of the first bit of data and the reception of the last bit of the data is _____ $\mu s$.

5. Consider a source computer (S) transmitting a file of size 106 bits to a destination computer (D) over a network of two routers (R1 and R2) and three links (L1, L2, and L3). L1 connects S to R1; L2 connects R1 to R2; and L3 connects R2 to D. Let each link be of length 100 km. Assume signals travel over each link at a speed of 108 meters/second. Assume that the link bandwidth on each link is 1 Mbps. Let the file be broken down into 1000 packets each of size 1000 bits. Find the total sum of transmission and propagation delays in transmitting the file from S to D.

6. A new broadcast service is to transmit digital music using an FM radio channel, with a transmission bandwidth of 200 kHz. Stereo quality audio signals are to be transmitted using a digital modem over the FM channel. The audio signal has a bandwidth of 20 kHz. The quantizer uses 24 bits/sample.
   - Determine the minimum bit rate to be supported for the digital stereo audio signal.
   - Determine the minimum number of points required in the signal constellation of the digital modem to accommodate the stereo audio signal.
   - Using Shannon's capacity theorem, compute the minimum SNR required (in dB) to support the stereo audio over the FM channel.

7. For the bit stream 01001110 sketch the waveforms for NRZI, Pseudoternary, and Differential Manchester encoding schemes. The figure should clearly specify the voltage levels, transitions with respect to bit duration and all the bits with timing. Assume that the signal level for the preceding bit for NRZI was a high; the most recent preceding 1 bit (AMI) has a negative voltage; and the most recent preceding 0 bit (pseudoternary) has a negative voltage.

8. For a bipolar encoding scheme, consider a sequence of pulses at the receiver represented by their voltage levels + - 0 + - 0 - +. Are there any errors in the transmission? Can the receiver also identify which bits are in error? Justify your answers.

9. The message 11001001 is to be transmitted using the CRC polynomial $(x^3 + 1)$ to protect it from errors. The message that should be transmitted is _____.

10. Consider a three-stage circuit switch. Assume that there are a total of $N$ input lines and $N$ output lines for the overall three-stage switch. If $n$ is the number of input lines to each stage-1 crossbar and the number of output lines from each stage-3 crossbar. Assume each stage-1 crossbar has one output line going to each stage-2 crossbar, and each stage-2 crossbar has one output line going to each stage-3 crossbar.

    - Prove that in such configuration the switch to be strict sense non-blocking if the number of stage-2 crossbar switches equals $(2n - 1)$ at least.
    - Calculate the total number of crosspoint in all the crossbar switches for a non-blocking Clos network having above configuration.
    - Assuming a large number of input lines to each crossbar (i.e. large value of $n$), what is the minimum number of crosspoints for a nonblocking configuration?

11. For CSMA/CD to work in standard Ethernet, a restriction on frame size is required. Why does it so, and how the minimum frame size is calculated?

12. A network has a data transmission bandwidth of 20 Mbps. It uses CSMA/CD in the MAC layer. The maximum signal propagation time from one node to another node is 40 microseconds. What is the minimum size (in bytes) of a frame in the network?

13. A network has a data transmission bandwidth of $(20 \times 10^6)$ bits per second. It uses CSMA/CD in the MAC layer. The maximum signal propagation time from one node to another node is 40 microseconds. The minimum size of a frame in the network is _____ bytes.

14. A pure ALOHA network transmits 200-bit frames on a shared channel of 200 Kbps.

    - What is the requirement to make this frame collision-free?
    - What is the throughput if the system (all stations together) produces 2000 frames per second?

15. Consider a simplified time slotted MAC protocol, where each host always has data to send and transmits with probability $p = 0.2$ in every slot. There is no backoff and one frame can be transmitted in one slot. If more than one host transmits in the same slot, then the transmissions are unsuccessful due to collision. What is the maximum number of hosts which this protocol can support, if each host has to be provided a minimum through put of 0.16 frames per time slot?

16. Consider a token ring network with a length of 2 km having 10 stations including a monitoring station. The propagation speed of the signal is $2 \times 10^8$ m/s and the token transmission time is ignored. If each station is allowed to hold the token for 2 microsecond, the minimum time for which the monitoring station should wait (in $\mu s$) before assuming that the token is lost is _____.

17. Calculate the end-to-end delay, between the source and destination hosts in a network with 4 routers between them. Assume the following: the network is NOT congested (i.e. queueing delay is insignificant), all packets are $10,000$ bits in length, each link is 5 kilometers long, the processing time is 10 msec at the source host and at each router, the transmission rate of each link is 1 Mbps, the propagation speed of each link is $2.5 \times 10^8$ meters/second.

18. Suppose $N$ packets arrive simultaneously to a link at which no packets are currently being transmitted or queued. Each packet is of length $L$ and the link has transmission rate $R$. What is the average queuing delay for the $N$ packets? Now suppose that $N$ such packets arrive to the link every $LN/R$ seconds. What is the average queuing delay of a packet?

19. X and Y are the only two stations on an Ethernet. Each has a steady queue of frames to send. Both X and Y attempt to transmit a frame, collide, and X wins the first backoff race. At the end of this successful transmission by X, both X and Y attempt to transmit and collide. What is the probability that X will win the second backoff race?

20. Consider a simplified time slotted MAC protocol, where each host always has data to send and transmits with probability $p = 0.4$ in every slot. There is no backoff and one frame can be transmitted in one slot. If more than one host transmits in the same slot, then the transmissions are unsuccessful due to collision. What is the maximum number of hosts which this protocol can support, if each host has to be provided a minimum throughput of 0.0864 frames per time slot?

21. Prove that the throughput in Slotted ALOHA is double than that in Pure ALOHA.

22. Ten 9600-bps lines are to be multiplexed using TDM. Ignoring overhead bits in the TDM frame, what is the total capacity required for synchronous TDM? Assuming that we wish to limit average TDM link utilization to 0.8, and assuming that each TDM link is busy 50% of the time, what is the capacity required for statistical TDM?

23. In a TDM medium access control bus LAN, each station is assigned one time slot per cycle for transmission. Assume that the length of each time slot is the time to transmit 100 bits plus the end-to-end propagation delay. Assume a propagation speed of $2 \times 10^8$ m/sec. The length of the LAN is 1 km with a bandwidth of 10 Mbps. The maximum number of stations that can be allowed in the LAN so that the throughput of each station can be 2/3 Mbps is _____.

24. What is the channel capacity for a teleprinter channel with a 300-Hz bandwidth and a signal-to-noise ratio of 3 dB, where the noise is white thermal noise?

25. In the network 200.20.11.144/27, the fourth octet (in decimal) of the last IP address of the network which can be assigned to a host is _____.

26. Multicast addresses for two groups are 231.24.60.9 and 238.212.24.9. What are the corresponding 48-bit Ethernet addresses (in hexadecimal) for a LAN using TCP/IP?

27. The forwarding table for router R1 is given below. What will be the forwarding interface if a packet arrives at R1 with destination address 180.70.65.140?

| *Network Address / Mask* | *Next Hop* | *Interface* |
|---|---|---|
| 180.70.65.192/26 | - | m0 |
| 180.70.65.128/25 | - | m1 |
| 201.4.22.0/24 | - | m2 |
| Default | 180.70.65.200 | m3 |

28. An organization is granted a block of IPv4 addresses with the beginning address 101.124.74.0/24. The organization needs to have 3 sub-blocks of addresses to use in its three subnets: one sub-block of 10 addresses, one sub-block of 60 addresses, and one sub-block of 120 addresses. Design the sub-blocks and show the first and last address of each sub-block.

29. An IP router with a Maximum Transmission Unit (MTU) of 1500 bytes has received an IP packet of size 4404 bytes with an IP header of length 20 bytes. Find the values of the relevant fields (total length, Fragmentation offset, more fragments flag) in the header of the IP fragments generated by the router for this packet.

30. A sender uses stop-and-wait ARQ protocol for reliable transmission of frames. Frames are of size 1000 bytes and the transmission rate at sender is 80 Kbps. Size of an acknowledgement is 100 bytes and the transmission rate at receiver is 8 Kbps. The one-way propagation delay is 100 milliseconds. Assuming no frame is lost and negligible queuing delay, compute the channel efficiency and sender's throughput (in bytes/sec).

31. Consider a TCP sender uses fast retransmit. The sender sends segments at the rate of 1 segment every 100 ms and the receiver sends back the ACKs without delay. Let a segment is lost, and the RTT of the link is 800 ms. The lost segment will be retransmitted after how much interval of time? Assume the sender's window size is large enough and it keeps sending segments.

32. In Selective-Repeat ARQ, the size of sender and receiver windows can be at most $2^{m-1}$ where $m$ is the number of bits used to represent the sequence numbers in sender window. Why does it so? Explain using figures having sending and receiving windows, and $m = 2$.

33. What is the value of the receiver window ($rwnd$) for host A if the receiver, host B, has a buffer size of 5000 bytes and 1000 bytes of received but unprocessed data? If the value of congestion window ($cwnd$) is 4500 bytes then what will be the value of sending window?

34. Let the size of congestion window of a TCP connection be 32 KB when a timeout occurs in TCP Tahoe. The round trip time of the connection is 100 msec and the maximum segment size used is 2 KB. How much time (in msec) taken by the TCP connection to get back to 32 KB congestion window?

35. Consider two TCP senders connected to a router X, and two receivers connected to router Y. The two routers are connected by a link that has a bandwidth 2 Mbps. Assume that the MSS is 1 KB, and the one-way propagation delay for both connections is 50 ms. Let $cwnd_1$ and $cwnd_2$ be the values of the senders' congestion windows. Assume that $cwnd_1 = cwnd_2$. What is the smallest value of $cwnd_i$ for which the link joining the two routers stays busy all the time?

36. A 1 Mbps satellite link connects two ground stations. The altitude of the satellite is $36,504$ km and speed of the signal is $3 \times 10^8$ m/s. What should be the packet size for a channel utilization of 25% for a satellite link using go-back-127 sliding window protocol? Assume that the ACK packets are negligible in size and that there are no errors during communication.

37. While opening a TCP connection, the initial sequence number is to be derived using a time-of-day (ToD) clock that keeps running even when the host is down. The low order 32 bits of the counter of the ToD clock is to be used for the initial sequence numbers. The clock counter increments once per milliseconds. The maximum packet lifetime is given to be 64s. What is the minimum permissible rate at which sequence numbers used for packets of a connection can increase?

38. Consider a $128 \times 10^3$ bits/second satellite communication link with one way propagation delay of 150 milliseconds. Selective retransmission protocol is used on this link to send data with a frame size of 1 KB. Neglect the transmission time of acknowledgement. The minimum number of bits required for the sequence number field to achieve 100% utilization is _____.

39. Suppose the upload rate of a server is 10 Mbps, the upload rate of each peer is 1 Mbps, and the download rate of each peer is 10 Mbps. There are 50 peers, and the size of the file to be distributed is 50 Mb. What is the minimum distribution time (i.e., the minimum time it takes to get a copy of the file to all 50 peers) if P2P architecture is used?

40. Consider a simple model for distributing a file to a fixed set of peers. Denote the upload rate of the server's access link by $u_s$, the upload rate of the $i$th peer's access link by $u_i$, and the download rate of the $i$th peer's access link by $d_i$. Consider distributing a file of $F$ bits to $N$ peers using a P2P architecture. Assume a fluid model where the server can simultaneously transmit to multiple peers. For simplicity assume that $d_{min} = min\{d_1, d_2, \ldots, d_N\}$, and $d_{min}$ is very large so that peer download bandwidth is never a bottleneck. Suppose that $u_s \leq (u_s + u_1 + ... + u_N)/N$. Specify a distribution scheme that has a distribution time of $F/u_s$.