1. Explain how a receiver detects the end of a frame with length-based framing, sentinel-based framing, clockbased framing (e.g., SONET).

Calculated from length sent at start of frame

2. Describe a problem associated with communicating between heterogeneous architectures on a network.

A process on a Sun host could generate data at a faster rate than a process on an Intel host could process it.

The data might have different endianness.

3. What is head-of-line blocking, and when does it occur?

It occurs when the first packet in line is waiting to be served by some processor while other packets behind it could be simultaneously served

4. Explain the effect of layering on end-to-end bandwidth.

Reduces bandwidth because headers have to be added to each layer.

5. Explain a drawback of forwarding packets with source routing.

Topology takes a long time to update at the source.

6. Explain a drawback of datagram-based forwarding.

Each packet must contain full destination address, Router must maintain global state, Large amount of forwarding information

7. Explain a drawback of virtual-circuit-based forwarding.

Typically must wait 1 RTT for setup, cannot dynamically avoid failures, must reestablish connection, global address path information still necessary for connection setup

8. What delay is relevant and what bandwidth is relevant for computing the delay-bandwidth product of two links in series?

Sum of the delays of the two links and minimum of the bandwidths of the two links.

9. What channel should you configure your WiFi to and why?

1, 6, 11 because they are orthogonal

10. Explain what frequency-hopped spread spectrum modulation is, and a motivation for using it.

Frequency-hopped spread spectrum modulation uses 80 1Mhz sub-bands in a 2.4 GHz band and transmits over a random sequence of frequencies. The motivation was to minimize interference within the network and prevent malicious attackers.

11. Suppose packets on a wireless link consist of N data bits and H header bits each, where H is fixed. Suppose bits are received in error with probability P, independently of each other, and that N is adjusted to maximize the throughput of data in bits per second. If P gets larger, does the optimal value of N get larger or smaller? Why?

The optimal value of N gets smaller so that we can ensure that at least some packets get through.

12. Consider a frame consisting of two characters of four bits each. Assume that the probability of error is 10-3 , independent for each bit. What is the probability that the frame is received correctly? Add a parity bit to each character. Now what is the probability?

(1-10-3)8 (1-10-3)10

13. Name and explain two effects that complicate the process of signal transmission.

Attenuation (signal loses power after traveling a long distance) and noise (random interference).

14. To provide more reliability than a single parity bit can give, an error detecting coding scheme uses one parity bit for checking all the odd numbered bits and a second parity bit for all the even numbered bits. What is the hamming distance of this code?

1 to append the second parity bit and 1 to flip the first parity bit.

15. Explain why a CSMA/CD type protocol cannot be used in a wireless environment.

Collision at receiver might not be detected by sender

16. For a small data packet, which is more relevant, bandwidth or latency? Explain.

Latency because the entire packet will be able to fit on the wire, so bandwidth is not a big concern.

17. Why does Ethernet use binary exponential backoff during contention resolution?

Avoid repeated collisions

18. Describe the role of the receiver in Ethernet. How is this different from the role of the receiver in IEEE 802.11?

The receiver in Ethernet simply receives packets, but the receiver in IEEE 802.11 has to send CTS and ACK messages.

19. Why does Ethernet have a minimum packet size? How is it determined?

So the sender can detect a collision. It is determined by the longest RTT.

20. What do “learning” bridges actually learn? What do the use this information for?

Learning bridges learn which hosts live on which LAN. They use this to optimize how they forward frames.

21. How do sniffers work? Will they work on all networks?

Sniffers listen in on transmitted packets. They only work on wired networks in promiscuous mode and they work on all wireless networks.

22. Why does Ethernet used fixed time slots during backoff? What could go wrong if the fixed slots were not used?

So a full transmission can be completed during the backoff period. There would be more collisions otherwise.

23. What is the role of the NAV in IEEE 802.11?

NAV (Network Allocation Vector) is updated based on overheard RTS/CTS/DATA/ACK packets and tells stations listening how long the medium will be busy for. Virtual Carrier Sense

24. An approach to building special purpose hardware for massive high-speed switching fabrics is to use a Batcher sorting network followed by a self routing Banyan network. Why is the Batcher network included?

Banyan fabrics require that the input are sorted in ascending order. Batcher does mergesort so it will guarantee ascending order to avoid contention.

25. Describe “label swapping”, and how it is used when setting up virtual circuits.

Problem - each VCI is unique ID, ID space becomes full

Solution - Map the VCI to a new value at each hop

Allows for locally unique VCI instead of globally unique VCI

26. Why is the port number needed for TCP and UDP communication?

Port is needed to distinguish traffic from different applications

27. Why is determining and handling byte order left up to the programmer and not handled by the operating system?

Swapping bytes depends on the data type but the socket layer doesn’t know the data types

28. Explain the efficiency of Manchester encoding.

Need to XOR clock and data, so only ½ efficiency

29. What is the relationship between bit rate and baud rate?

The relationship depends on the number of bits encoded in each symbol

30. What is the effect of a wireless signal traveling over multiple paths to a receiver?

Signal reflects off surfaces, effectively causing self-interference

31. Why can’t we really represent a wireless “link” as a node with a circular radius?

There’s too much interference for the link to be able to only receive in a circular radius.

32. Explain the difference between transmission range and interference range in a wireless network.

Transmission range is where a transmission can be successively received, interference range is where a transmission might not be received but can still interfere with other transmissions. Interference range is larger than transmission range.

33. What is the impact of using different interframe spacing in IEEE 802.11?

Creates different priority levels for different types of traffic

34. Why does a node in 802.11 suspend its collision counter when the medium is busy?

Message is being transmitted, wait for message to be delivered

35. What is the impact of a contention window in 802.11 that is too small? Too large?

Large CW - large backoff intervals, can result in larger overhead

Small CW - larger number of collisions

36. Given an example of when the use of 802.11 can lead to unfairness?

Occurs when one node has backed off much more than some other node

37. In a multihop wireless network, why can’t the full link bandwidth be utilized on all links?

Transmission ranges overlap, so the full bandwidth cannot be utilized due to collisions

38. Why is buffering needed in switches?

Output port buffering needed to queue packets until output port available to send

Input port buffering needed to temporarily hold received packets until they can be processed

39. When does contention happen in a switch?

Contention happens when some packets are destined for the same output port, resulting in some packets getting delayed or dropped

40. How does a knockout switch solve the scalability problem?

A knockout switch guarantees in a fair way that no more than L < N packets get through to an output port.

41. Can distance vector routing detect loops? What about when techniques like split horizon and poisoned reverse are used?

Yes but it can only detect 2-hop loops.

42. What is the effect of setting “infinity” to 16 in distance vector routing?

Limits the size of the network

43. Why doesn’t link-state routing scale to large networks?

Amount of information stored at each node is large

44. Why are metrics like link utilization and delay difficult to use effectively in routing?

The network changes too often

45. What could cause the Internet checksum algorithm to fail to detect an error?

One field is incremented by 1, the other is decremented by 1, the sum is still 0.

46. Explain signal-to-noise ratio.

SNR is the ratio between signal power and noise power. The lower the SNR the higher the Bit Error Rate (BER).

47. Explain how attenuation affects communication.

Attenuation means the signal gets weaker over larger distances. It makes the signal less accurate and harder to receive.

48. What protocol was the precursor for both the Ethernet and Wi-Fi MAC protocols?

ALOHA

49. The sequence number field in the TCP header is 32 bits long, which is big enough to cover over 4 billion bytes of data. Even if this many bytes were never transferred over a single connection, why might the sequence number still wrap around from 232 — 1 to 0?

acking bytes not packets, start byte is random for 1) to prevent malicious attempts at guessing the start and 2) to account for leftover inflight packets

51. For TCP, why does the maximum packet lifetime, T, have to be large enough to ensure that not only the packet, but also its acknowledgements, have vanished?

Have to make sure any new connection that is started does not think ACKs are for new packets

52. Caching is an important mechanism whereby frequently used information is replicated in order to provide fast access at different physical locations. Name three instances of caching discussed in the course that arise in the context of standard Internet operation.

DNS, routing tables, NAT

53. At what OSI layer do Internet routers typically operate?

Network layer

54. What Hamming distance is necessary for n-bit error detection? n-bit error correction?

n-bit error detection requires Hamming distance of n+1

n-bit error correction requires Hamming distance of 2n+1

55. If SWS=RWS=5 in a sliding window protocol, if packet numbers do not wrap around, if packets do not arrive out of order, and if the next frame expected (NFE) is currently 17, why can't the receiver next receive a packet with sequence number 10?

It can receive 12-21

56. What does TCP use in addition to an estimate of RTT to calculate timeouts for adaptive retransmission?

Jacobson algorithm, standard deviation of RTT

57. Suppose a dynamic routing algorithm is employed to try to make routing tables correspond to least cost paths. What types of routing metrics are prone to producing load oscillations?

anything that represents load (delay, queue size)

58. Explain in words (no equations) what the memoryless property of a random, exponentially distributed lifetime is.

The probability of an occurrence does not depend on past instances of that occurrance

59. What does UDP provide in addition to those services contained in IP?

port space to support multiplexing, checksum (for IPv6)

60. What is the difference between congestion avoidance and congestion control?

congestion avoidance tries not to push the system towards contention, congestion control restores the system once it has reached a congested state

61. How does TCP guarantee that new connections do not receive segments from previous incarnations of the connection?

goes into the time wait state and waits for 2 \* the maximum time, random sequence numbers

62. Describe the responsibilities of hosts and routers using DECbit to avoid congestion.

Routers identify congestion, hosts act to avoid congestion

Routers monitor length over last busy + idle cycle, set congestion bit if average queue length is greater than 1 when packet arrives

Hosts echo congestion bit back to the source, records how many packets resulted in set bit, modifies CongestionWindow size

63. Give an argument why the leaky bucket algorithm should allow just one packet per tick, independent of how large the packet is

reduces per-packet overhead, use this approach when per-packet overhead is greater than the per-byte overhead

64. Explain the fundamental conflict between tolerating burstiness and controlling network congestion.

not on the exam!

65. Why does TCP begin by multiplicatively increasing its congestion window? What is "slow" about this approach?

66. Give an example of scheduling discipline that is not work-conserving.

TDMA is not work conserving, fair queuing is work conserving (anything round-robin or FIFO based)

67. Why doesn't the adaptive time out mechanism of TCP update EstimatedRTT in case an ACK is received for a segment that was retransmitted?

draw a picture, see PS6

68. If all the links in the Internet were to provide the reliable-delivery service, would the TCP reliable-delivery service be completely redundant? Why or why not?

failure at routers, endpoints, example of the end-to-end argument

69. With Go-Back-N, is it possible for the sender to receive an ACK for a packet that falls outside of its current window?

ACK could be given for LAR, send window starts at LAR+1

70. Why does TCP use a 32-bit sequence number space instead of calculating a tighter bound based on RTT and link speed? Assume that complexity is minimal and that saving two bytes of header space {for example} is worthwhile.

The rtt is dynamic.

calculating tighter bound is difficult, bound could be too tight, making the sequence number space larger is safe

71. Explain what “fair” means for flows traversing a router

Min-max fairness - no one uses more than requested, everyone gets the same service

72. Explain the relationship between ~~physical distance~~ throughput and end-to-end latency in a TCP connection.

smaller latency results in higher throughput because send window increases on flows with lower latency, higher latency is penalized due to the congestion

73. Under what circumstances does TCP Vegas increase its window size?

ExpectedRate - ActualRate < α

74. Recall that with IP tunneling, we said that an IP datagram is carried inside of another IP datagram. How does the IP router at the end of the multicast tunnel know that the outer datagram contains an inner IP datagram (as opposed to simply being a normal IP datagram that should be forwarded along)?

not on exam!

75. TCP waits until it has received three duplicate ACK before performing a fast retransmit. Why do you think the TCP designers chose not to perform a fast retransmit after the first duplicate ACK for a segment is received?

leaves time for packets delivered out of order, no specific reason for 3

76. What traditional network class was under the most pressure before CIDR? Why?

Class B

77. Explain how fair queueing prevents flows from "saving up credit."

select the min among flows with packets, reduces short term fairness but improves long term fairness

78. Suppose the throughput for a particular TCP connection is limited primarily due to the fact that one of the links it traverses is heavily congested. The congested link is shared by several TCP connections. How does the propagation delay for the TCP connection affect the throughput it receives?

(see 72)

79. In RED gateways, explain why MaxThreshold is actually less than the actual size of the available buffer pool.

gives the network time to react to losses

80. What is the maximum bandwidth attainable on a TCP connection with RTT=100 milliseconds? Explain how TCP options can be used to raise this limit.

max window size = 64 KB by default, options can be set to raise that

81. As we have seen many times in class, a sliding window abstraction can be used to bound transmission rates. Why would anyone propose a rate-based mechanism, given that buffer (window) space is intrinsically available from the end hosts?

rate-based gives smoother use as opposed to window-based which is burstier because rate-based gives far cleaner specification of the time when packets are sent

82. List the contents and explain the purpose of each segment transmitted when a TCP connection closes in a typical way.

FIN J - Client tells server application is finished

ACK J + 1 - Server acknowledges FIN message

FIN K - Server tells client application is finished

FIN K + 1 - Client acknowledges FIN message

83. Intuitively, what is the goal of TCP Vegas? Why is this goal desirable?

congestion avoidance

84. How does CIDR solve the problems of inefficient address allocation and limited number of networks associated with the traditional class model?

supernetting (TODO: explain more)

85. How does fast retransmission improve TCP's overall utilization of network resources?

Doesn’t wait for a timeout

86. Compare the problem solved by Nagle's algorithm to silly window syndrome and describe the similarities between the two problems.

Nagle’s algorithm deals with applications that send small pieces of data (TCP lecture slide 52) (problem at the sender), silly window syndrome - TCP only acknowledges half a MSS at a time (problem at the receiver)

87. IP hosts that are not designated routers are required to drop packets misaddressed to them, even if they would otherwise be able to forward them correctly. In the absence of this requirement, what would happen if a packet addressed to IP address A were inadvertently broadcast at the link layer?

designated receiver would receive too many copies of the same packet

88. Assuming that all routers and hosts are working properly and that all software in both is free of all errors, is there any chance, however small, that a packet will be delivered to the wrong destination?

DHCP assigns IP address to one machine, then that address is assigned to another machine

89. The original Internet mechanism for looking up names used central hosts.txt table, which was distributed to all hosts every few days. Describe two reasons why this mechanism is no longer used.

scalability, SPOF

90. Describe two advantages of using encapsulation (tunneling) for distributed internet applications such as virtual private networking.

abstracts a virtual network on top of a real network, which I can control

91. How does a RED gateway act to avoid congestion?

Probabilistically drop packets as the buffer gets too full

92. Under what circumstances may coarse-grained timeouts still occur in TCP even when the fast retransmit mechanism is being used?

The last packet in a window or burst gets dropped

93. Due to the use of CIDR, it is possible that the destination address on an incoming packet will match several entries in a routing table. In such a case, which routing entry or entries will be used for forwarding the packet?

longest prefix match

94. A class B network on the Internet has a subnet mask of 255.255.240.0. What is the maximum number of hosts per subnet?

all 1s is network number, cannot use that, all 0s is for broadcast, so total is 2n – 2

95. Most IP datagram reassembly algorithms have a timer to avoid having a lost fragment tie up reassembly buffers forever. Suppose a datagram is fragmented into four fragments. The first three fragments arrive, but the last one is delayed. Eventually the timer goes off and the three fragments in the receiver's memory are discarded. A little later, the last fragment stumbles in. What should be done with it?

treat it as a fragment of a packet I have never seen before

96. Give a potential disadvantage when Nagle's algorithm is used on a badly congested network.

If a packet is lost, new packets will never be sent until the buffer is full

97. Explain Karn's algorithm. Why do we need it?

Karn’s algorithm excludes retransmitted packets from the RTT estimate, this is needed to not overestimate the RTT.

98. Give the major reason why TCP does not behave well in wireless environments

TCP assumes congestion if packets are dropped, but packets can be dropped for other reasons in wireless environments

99. In queueing theory, explain why the arrival rate, λ, must be less than the service rate, µ.

buffer explodes if λ > µ

100.What is the difference between a cumulative and a selective acknowledgement?

Cumulative ACK are only sent for a block of consecutively received packets, selective ACK tell sender which packets were dropped

101. In a sliding window protocol, explain why would you ever use an RWS that is not equal to the SWS.

never makes sense for RWS to be greater than SWS, RWS represents how many out of order packets receiver wants to buffer

102.Describe the problem solved by sliding window based ARQ protocols.

Bandwidth control, reliable delivery

103. Describe two ways in which the topology of the Internet has evolved over the last ten years.

Initially a tree, now multiple backbones

104.Explain the main drawback of the stop-and-wait ARQ algorithm.

Only 1 packet is sent at a time

105.Why does TCP use a 32-bit sequence number space instead of calculating a tighter bound based on RTT and link speed? Assume that complexity is minimal and that saving two bytes of header space {for example) is worthwhile.

(same as 72)

106.With the selective repeat protocol, is it possible for the sender to receive an ACK for a packet that falls outside of its current window?

Yes, when the first packet of the window is dropped

107.Describe the pros and cons of using MTU discovery on a path prior to data transmission.

Pros - Don’t send more than MTU, so no fragmentation of the packet.

Cons - Send Above MTU = lots of overhead to fragment the packet, RRT to find the MTU, Worth finding MTU? → Path can change.

108.How can NAT be used to load balance a company’s servers?

The NAT gateway can round robin internal servers

109.What is the role of the root servers in DNS?

Authoritatively delegate top-level domains

110.How can an attacker poison a DNS cache and what is the impact?

Attacker can fake a DNS response and other users will be given this fake DNS response

111.What is the role of a BGP border router?

To share and update global routes

112. Why does BGP use path-vector routing?

Cannot use link state routing because it would expose internal structure, cannot use DV because it converges too slowly and there are loops