Indian Institute of Technology Delhi
Department of Computer Science and Engineering
COL334/672: Computer Networks
Major Examination, Diwali 2021

Full Marks: 75 **Time: 3 hours**

All parts of the same question must be answered together
Be precise in your answers, and state any assumptions made
If there are multiple ways to perform a computation, state which one you are using

Question 1 [6+4 = 10 marks]

(a) Host A needs to send four data items 0x3456, 0xABCC, 0x02BC, and 0xEEEE to host B. What is the checksum computed at host A? Suppose that the second data item has been changed to 0xABCE during transmission. What would be the checksum computed by host B? Would it be possible for B to detect which data item has been corrupted?

(b) Frames arrive randomly at a 50 Mbps channel for transmission. If the channel is busy when a frame arrives, it waits for its turn in a queue. Frame length is exponentially distributed with a mean of 5,000 bits/frame. For each of the following frame arrival rates, give the delay experienced by the average frame, including both queueing time and transmission time:

i. 90 frames/sec
ii. 900 frames/sec

Question 2 [3+3+3+4+2 = 15 marks]

(a) 50 stations on a pure ALOHA network share a 1 Mbps channel. Assume the frame size to be 1000 bits, and each station is sending 10 frames per second. Would there be any scenario where the network is collision-free? If yes, describe the scenario.

(b) Consider the delay of pure ALOHA versus slotted ALOHA at low load. Which one is less? Explain your answer.

(c) In a CSMA/CD network with a data rate of 10 Mbps, the minimum frame size is found to be 512 bits for the correct operation of the collision detection process. What should be the minimum frame size if we increase the data rate to 100 Mbps? To 1 Gbps? To 10 Gbps?

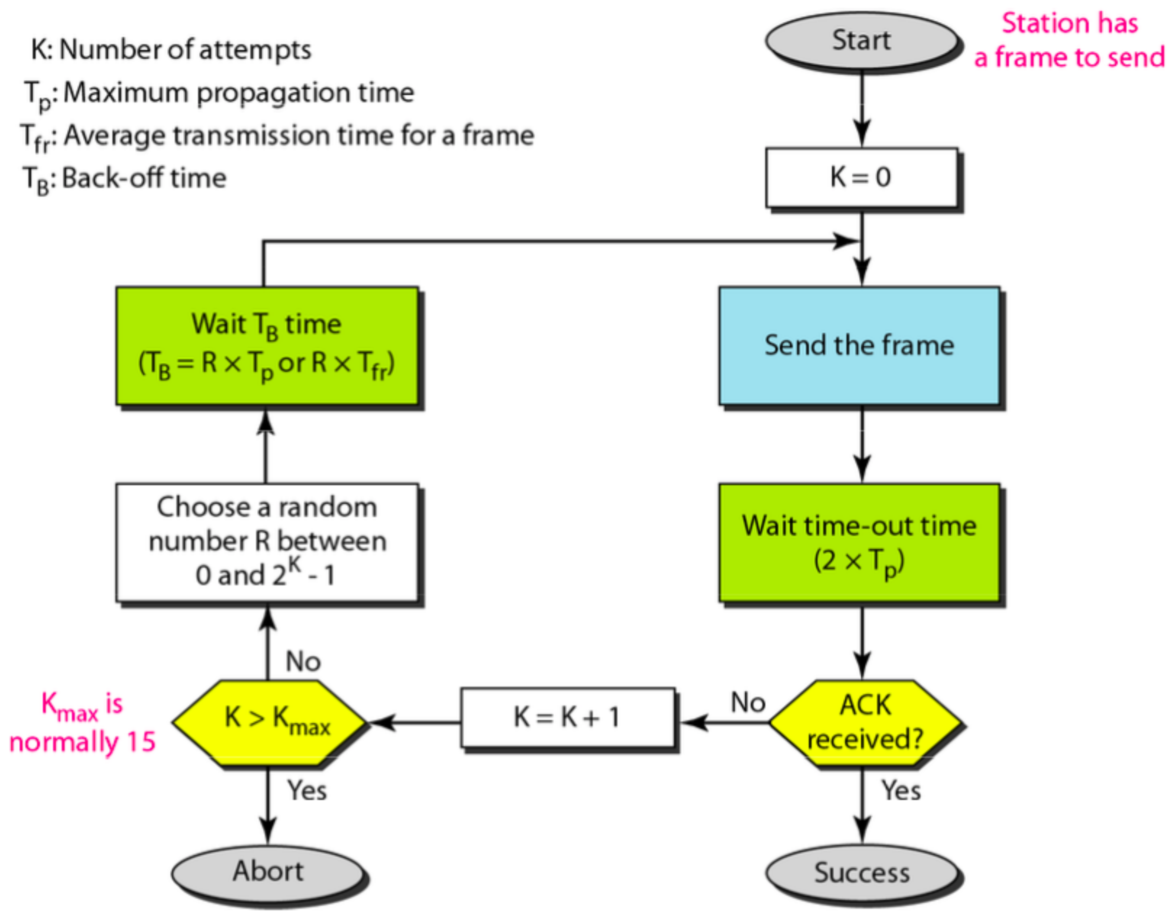
(d) In a CSMA/CD network with a data rate of 5 Mbps, the distance between station A and C is 800 m, and the propagation speed is 2.2 x 10^8 m/s. Station A starts sending a long frame at time t1 = 0; station C starts sending a long frame at time t2 = 4. Assume that the size of the frame is long enough to guarantee the detection of collision by both stations. Find:

i. The time when station C hears the collision (t3)
ii. The time when station A hears the collision (t4)
iii. The number of bits station A has sent before detecting the collision.
iv. The number of bits station C has sent before detecting the collision

(e) Describe a mechanism to facilitate collision free transmission over a shared wired channel.

Question 3 [5X3 = 15 marks]

(a) Consider the following block diagram of a medium access protocol. There are 4 stations (nodes) A, B, C and D; they are attached to a shared wired channel. Suppose at time t = 0, A has a frame to send to B. When B receives it and starts sending the ACK to A, C also starts transmitting a frame destined for D. If there is no more data to be sent, draw a timing diagram showing different events which occur during the data transmission process? Assume different parameter values as per your wish, but state your assumptions clearly.



(b) Consider the question (a) above and suppose the channel is wireless. Station A can not receive any communication from Station C, and vice versa. What is this problem called and how would it impact the data transmission process? Propose a protocol to overcome the issue. Draw a block diagram to explain the working of the protocol.

(c) You have an Airtel sim card registered in Delhi. You are traveling to Berlin, where the cellular operator O2 has tie-up with Airtel to provide data services to Airtel customers. Your friend with a Jio sim registered in Mumbai has sent a message to you. Describe the steps involved to deliver the message to your phone under (i) Direct Routing and (ii) Indirect Routing.

Question 4 [4.5+4.5+2 = 11 marks]

Hari is developing a Web site that has multiple replicated servers located through-out the Internet. He plans on using DNS to help direct clients to their nearest lightly-loaded server, and comes up with the following hierarchical scheme. Hari has divided his server replicas into three groups (east, west, and central) based on their physical location. A typical query occurs as follows:

- When a client makes a query for www.distributed.hb.com, the root.com name server is contacted first. It returns the name server (NS) record for ns1.hb.com (along with a corresponding Address A record). The cache TTL of this record is set to 1 day.
- The ns1.hb.com name server is then queried for the address. It examines the source of the name query and returns an NS record for one of {east-ns, central-ns, west-ns}.distributed.hb.com (along with a corresponding A record). The choice of which name server is based on where ns1 thinks the query came from.
- Finally, one of {east-ns, central-ns, west-ns}.distributed.hb.com is contacted and it returns an address (A) record for the most lightly loaded web server in its region.

The following questions are based on this design.

(a) Hari's name server software has only two choices for TTL settings for A and NS records - 1 day and 1 minute. What are reasonable TTLs for the following records? Briefly explain your choice.

i. NS record for {east-ns, central-ns, west-ns}.distributed.hb.com
ii. A record for {east-ns, central-ns, west-ns}.distributed.hb.com
iii. A record returned for the actual Web server

(b) Hari's Web site is especially popular among IITD students. The IITD network administrators estimate that there is one access from IITD every 5 minutes. Each access results in the application resolving the name www.distributed.hb.com. Assume the following:

- No other queries are made from IITD
- All IITD clients use the same local name server (e.g. 10.10.1.2)
- Web browsers do not do any caching on their own

How many accesses will be made to the following name servers each HOUR to resolve these queries? Use your answers to the previous question, and explain your calculation.

i. ROOT
ii. ns1.hb.com
iii. one of {east-ns, central-ns, west-ns}.distributed.hb.com

(c) Hari finds that many people are far away (i.e. communication has high latency) from the name servers that they use. Why might this be a problem for his scheme?

Question 5 [3X3 = 9 marks]

(a) You decide to modify the TCP stack on your desktop so you experience better performance (higher throughput when either sending, receiving, or both). Note that you only get to change your desktop's TCP -- you can't change that of the other endpoint with which you'll be communicating.

Suppose your stack originally supports both timeout-driven retransmission and fast retransmission. Among the following, which one would gain you the greatest benefit to your performance? Explain your answer.

i. disable timeout retransmissions (instead only retransmit using fast retransmission)
ii. disable exponential backoff of timeouts
iii. disable fast retransmission (instead only retransmit using timeouts)
iv. disable RTT estimation / RTO adaptation (use the initial values set for RTT and RTO) and explain why it would offer an improvement.

(b) A "Tail-drop" based congestion control system is simple: packets that arrive at a router when the buffers are full are simply dropped. Another alternative "Random Early Detection" works by pre-emptively dropping packets before the buffer becomes completely full. Which policy is more fair towards different traffic flows. Explain your answer.

(c) Alice and Bob are responsible for implementing Dijkstra's algorithm at the nodes in a network running a link-state protocol. On her nodes, Alice implements a minimum-cost algorithm. On his nodes, Bob implements a "shortest number of hops" algorithm. Give an example of a network topology with 4 or more nodes in which a routing loop occurs with Alice and Bob's implementations running simultaneously in the same network. Assume that there are no failures.
(Note: A routing loop occurs when a group of $k \geq 1$ distinct nodes, n_0 , n_1 , n_2 , …, n_(k-1) have routes such that n_i's next-hop (route) to a destination is n_(i+1 mod k).

Question 6 [5X3 = 15]
a) Explain what a nonce is and the reason for using a nonce.
b) Describe how a man-in-the-middle attack may be performed on a Wi-Fi network and the consequences of such an attack.
c) Explain how a man-in-the-middle attack on a Wi-Fi network can be defeated.
d) Outline the challenges & scope of key management.
e) A TCP packet is sent over an IPSec Virtual Private Network (VPN). In which of the following IPSec operation modes (there may be more than one) does the TCP header of the packet get encrypted? Explain your answer.

i. AH in tunnel mode
ii. AH in transport mode
iii. ESP in transport mode
iv. ESP in tunnel mode