General Information:

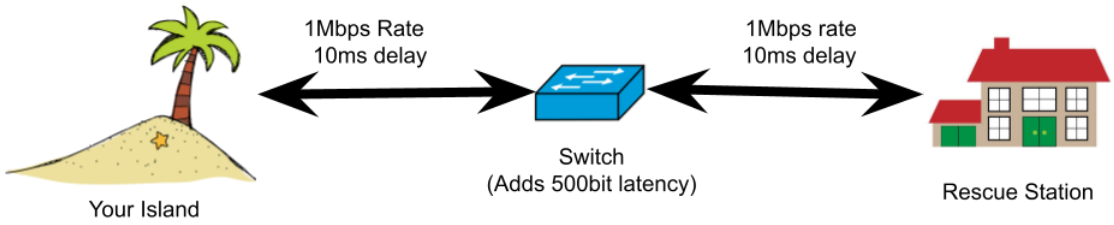
This is a closed book/laptop *practice* examination. You should practice with **110 minutes** to answer as many questions as possible. The number in parentheses at the end of each question indicates the number of points given to the question. There are **7 questions** on this exam (check to make sure you have all of them), and there are a total of **120 points.** Write all of your answers directly on this paper. Make your answers as concise as possible. If there is something in the question that you believe is open to interpretation, then please go ahead and interpret, but state your assumptions in your answer. Remember to **READ THE ENTIRE QUESTION** before answering, as later questions will build on earlier answers.

Note: The contents of this exam may (likely will) be different than the final, and you will need to study additional topics not covered on this practice exam to do well on the final!

Q1 Link Model:

You're stranded on a remote island, and you come across an old computer with a messaging tool that can communicate with a rescue station.

The message is transmitted across two links that each have a one-way propagation delay of 10 ms and are connected by a switch that starts retransmitting after the first 500 bits have been received. The bandwidth is 1 Mbps. You send a message that is 100 KB.



a) How much time does it take for your whole message to get received by the rescue station?

b) What is the one-way bandwidth-delay product of the end-to-end connection made up of the two links and the switch?

c) After receiving your complete message, the rescue station immediately sends an acknowledgement that is 1KB in size. How long will it take from the moment the first bit was transmitted of the original message you sent until the last bit of the acknowledgement from the station reaches your island?

d) Bad news, the rescue station will not come get you, but they decide they are willing to upgrade the links between you and their station! If you could either double the capacity or halve the latency of this connection, which would you prefer? Justify your answer in ~1-2 sentences.

Q2 Software Defined Networking

a) We talked about SDN in the context of layer 2 networks. Why might SDN principles not be as applicable at layer 3? In other words, what problem are layer 3 networks attempting to solve that SDN does not directly address?

b) Software defined networks split networking responsibilities into a control plan and a data plane. What about today's programmable switching hardware makes this attractive?

c) What is one advantage of the SDN approach to operating a network, and one disadvantage? (Hint: think about in which situations SDN might be less appropriate?)

Q3 Layers, Like Parfaits or Onions

For each subquestion, provide a concise description while fully expressing your answer. Adding extra elaboration that is incorrect will result in lost points.

a) What is the purpose of ARQ, and in what layer does it typically occur?

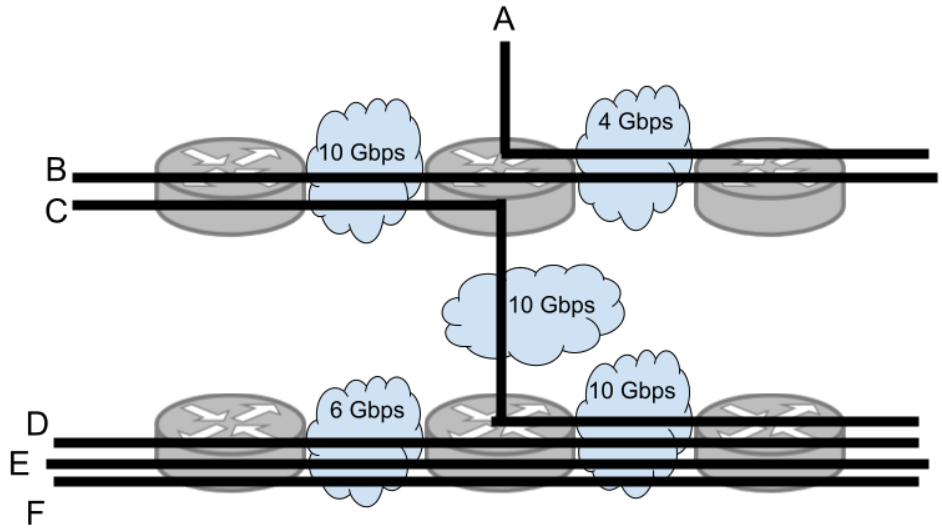
b) What is the difference between switching and routing, and in which network layer does each typically occur?

c) What is clock recovery, and in what layer does it typically occur?

d) What is congestion control, and in what layer does it typically occur?

Q4 Resource Allocation

You are operating the following network, where each “cloud” of intermediate links has a capacity listed in the cloud. If no capacity is listed, you may assume the capacity is infinite.



a) What is the min-max fair allocation of flow bandwidth in this network?

Flow A:

Flow B:

Flow C:

Flow D:

Flow E:

Flow F:

b) What is one way in which min-max flow “fairness” could be considered unfair? Justify your answer in ~1-2 sentences.

Q5 Transport Comparisons

a) What are the differences between the restrictions on message size for messages sent by UDP and TCP?

b) Describe a scenario where UDP is a better choice than TCP. Explain why.

c) Describe a scenario where TCP is a better choice than UDP. Explain why.

d) QUIC is a new transport protocol designed for web browsing that is a key part of the HTTP/3 standard. QUIC is built on top of UDP– why was UDP used as the basis for this new protocol instead of TCP?

Q6 TCP Design

a) What is congestion collapse?

b) State two things TCP's end-to-end congestion control implements to prevent congestion collapse:

c) Since congestion causes loss when buffers overflow, it might seem like congestion can be mitigated (worked around) by increasing buffer space to infinity. Is this true? Why or why not?

d) It is said that setting buffer size equal to link bandwidth * RTT (ie BDP, bandwidth delay product) is optimal. In one sentence, explain why this is the case. Suggest one reason why estimating the BDP might be challenging in a real-world network.

Q7 Authentication via Secrets & Crypto

a) How are individual certificates used to build up a Public-Key Infrastructure (PKI)?

b) What is a root certificate in a PKI, and why are they important?

c) In ~2-3 sentences, explain how to use a PKI to generate a provably authentic message.

d) It's commonly understood that Public Key (asymmetric) cryptography tends to be slower and has more message overhead than symmetric cryptography. How can these approaches be used together to get the key-handling behavior of asymmetric cryptography but the efficiency of symmetric cryptography to authenticate a long message?