

Network Communication Exercises

These exercises are grouped into three parts. Part I contains routine exercises to help you understand the ideas directly presented in lectures. The exercises in Part II are designed to grow and deepen your understanding of principles that underpin network communication. These exercises extend the lecture material and invite you to think about 'why' questions and about optimisations to what was lectured as well as alternatives to what was lectured. Part III are open-ended, stretching questions that you could tackle in your mini research project.

I hope you enjoy working through these questions, puzzles and research questions!

John Fawcett, July 2023

Part I

1. For the network you're using right now, describe what's happening at OSI Layers 1–7. Remember that there will be several Layer-1 and Layer-2 networks between your computer and Zoom's servers.
2. 80% Depth Amplitude Modulation is a Layer-1 technology supporting a binary alphabet. It uses radio waves – sine waves – and changes the amplitude between 100% for a logic 1 and 20% for a logic 0. Suppose we use one period of the waveform for each symbol.
 - a. Sketch a graph showing how 1011 is encoded as sine waves over time.
 - b. How would you do clock recovery for this signal?
 - c. Why do you think 80% depth is used for logic 0? Why not 100% depth?
 - d. What problem would occur at the boundaries between symbols if we use $\frac{3}{4}$ of a period to encode each symbol?
 - e. As signal strength (amplitude) varies, the amplitude detected at the receiver will vary over time. In weaker spots, a logic 1 (100% amplitude) would look like 20% amplitude where the signal is stronger. How would you account for this background noise, minimising bit errors in the decoded signal?
3. If you are in a noisy room and want to talk to a particular friend, what physical and datalink (logical link control) protocols do you use in everyday life? Does that work for computers?
4. Why are Ethernet station addresses (also known as MAC addresses) 48 bits long?
5. Read up and explain how routing works on the Internet for IPv4.
6. How would you ensure that a receiver can put a sequence of messages back into the intended order? How would you discard duplicates, and retransmit lost messages?
7. ON/OFF Flow Control is one technique often seen at Layer-2 or Layer-4 to guarantee that messages are never lost. It is used over networks with a known maximum link latency (the time it can take any message to get from one side to the other). Why does it require us to know the maximum link latency?
8. How does Sliding Window Flow Control avoid the need to know the maximum link latency?
9. At which layer could you argue that it makes sense to encrypt the data? (Hint: there are several answers depending on what purpose the encryption serves.)

Part II

1. How does grouping IPv4 addresses into subnets help to reduce the size of global routing tables? What limits how effective this technique can be?
2. How does the TCP congestion control protocol work?

Part III

1. Research and write-up how the CSMA/CD Datalink protocol manages medium access control and collisions. Do any common network technologies use CSMA/CD?
2. Research and write-up how the CSMA/CA Datalink protocol manages medium access control and collisions. Do any common network technologies use CSMA/CA?
3. Research and write-up how the Token Ring Datalink layer works.
4. How is the Address Resolution Protocol (ARP) used to translate Layer-3 IPv4 addresses into Layer-2 Ethernet station addresses (ESA/MAC addresses)?