COMP 189: Homework #1

Assigned Jan 13, 2022
Due Jan 21, 2022

80 points total

For each problem, show all your work (required for credit). For answers requiring written answers, while no more than five or six sentences are expected, sufficient justification must be given for any position, opinion, or perspective taken.

Technical Exercises

1. Connectivity (5 pts)it

Using information on the site (http://www.submarinecablemap.com/), find the undersea cable that is closest to your hometown. What places in the world does it directly connect?

The undersea cable that is closest to my hometown of Montreal, Quebec is the Maple leaf Fibre cable. It connects Kingston, ON, Canada to Toronto, ON, Canada in Lake Ontario.

2. Bandwidth (10 pts)

Answer the following questions about bandwidth.

1. What is the maximum bandwidth of a wire that can transmit at most 30 bits in 2 seconds? (2 pts)

30bits/2seconds = 15 bits/second

2. You can type 6 characters in a second. What is the bandwidth of your hand-keyboard connection? (2 pts)

6characters/second x 8bits = 48 bits/second

3. You buy a new keyboard which has a weird layout. You type just as fast (hit keys just as quickly), but make a mistake every other letter. To correct a mistake it takes half a second (delete, carefully press the right key). What is the bandwidth of your hand-keyboard connection now? (6 pts)

- Every other character is a mistake. - It takes 1 second to write 6 characters (i.e., 0.166 seconds/character) - Thus, two correct characters takes 0.166 + 0.166 seconds + 0.5 seconds = 0.832 seconds for 3 characters (i.e., 2 correct and 1 incorrect character) - So, it would be 2.496 seconds for 6 correct characters + 3 incorrect characters. ➔ 9 characters / 2.496 = 3.6 characters/second

3. Broadcasting (25 pts)

In class we have discussed how the sending data using packets helps with error correction. Packets are also useful when broadcasting information. Broadcasting is when one computer wants to send information to a large number of computers (internet radio, for example, broadcasts the same music feed to an arbitrarily large number of computers).

In the following exercise, you will evaluate two different ways of implementing (called “policies”) a digital broadcast system. Assume that the network of interest consists of four computers, A, B, C, and D, which are physically connected as follows: B - A - C - D. In this problem, computer A wants to send a packet (containing a small file) to all three other computers (B, C, and D). Assume that no packets are lost.

1. Policy 1: computer A must send the data to each computer individually (e.g., it must send the data from A to B, to C, and to D). Compute the number of packets computer A will have to send in order to broadcast the file in this way. (5 pts)

Three packets, since the policy states that each data is sent separately (A→B, A→C, A→D passing through C).

2. Policy 2: in this policy, every computer passes the data it receives to its neighbors (e.g., whatever C sees, it immediately sends to A and D). Compute the number of packets computer A will have to send in order to broadcast the file in this way. (5 pts)

Two packets since the policy states that data can be shared (A→B, A→C, C→D), thus 2.

3. Use your results from above to explain why policy 2 is the basis for internet broadcasting? (5 pts)

Policy 2 is used for internet broadcasting because it prevents overload on the server since it’s sharing its load with its neighbours. This means there’s going to be less packets running and thus less bottleneck, resulting in more data stability.

4. Even the limited example above highlights an inefficiency with policy 2's approach to internet broadcasting. What is it? Give an instance in the example where this issue arises. (10 pts)

The issue with policy 2 is that if there is an error going through A→C then that error will also propagate from C→D whereas policy 1 would not have this issue since the packets would be sent separately.

4. TCP vs. UDP (30 pts)

Review the table on this page:

http://www.cyberciti.biz/faq/key-differences-between-tcp-and-udp-protocols

1. Give a detailed example of five packets (collectively comprising a single file) being sent via TCP. Make sure that your example highlights the key aspects of the TCP protocol --- ordering and guaranteed delivery. Like the example given in class, your example should explain the different conceptual steps involved in the generation of the packets, propagation of the data, and reassembly of the packets. *(10 pts)*

Take for example a decentralized internet design where the router is in your house is connected to an ISP server, servers in Montreal, Tokyo, Chicago and San Jose and the destination server is in Palo Alto.
Now, our computer makes a request to download a picture off a website. When that request reaches the Palo Alto server, this server will respond by sending an image broken down into 5 packets instead of the entire image.
Each of these packets are going to travel through the decentralized services independently to reach its final destination (the router in the house). These packets will take different paths using the servers above to get to the router.
Now assume every packet except packet 3 arrives at the router since it got lost somewhere along the path from Palo Alto to the router in the house. Meaning that the image is incomplete. The computer will notice this and send a request back to the origin server (Palo Alto) requesting only for packet 3. The Palo Alto server will then only provide packet 3 to the computer.
Once the entire 5 packets arrive to the computer, the computer will have to re-order the packets correctly and assemble them to form the correct picture.

2. Give a detailed example of five packets (collectively comprising a single file) being sent via UDP - with one packet being lost. Make sure that your example highlights the key differences between TCP and UDP --- no ordering and unguaranteed delivery. As for TCP, make sure that your example is detailed and explains the different conceptual steps involved as the packets are moved and processed in the computer network. *(10 pts)*

Assume we are on a video call on some platform and your computer wants to send a real-time recording of your camera to the computer of the person you are on call with.
Now, assume we have a decentralized internet design where the Palo Alto server is now the computer of the person you are on call with.
Your computer now breaks down the camera recording into five packets to send over to the destination, that being the other computer. Like mentioned above, each of the packets will travel independently over the network to get to the receiving computer. Unlike TCP, with UDP, the order of the packets arriving at the other computer is irrelevant. Meaning a packet will instantly start being processed once it arrives at the other computer, whereas TCP requires the packets to be delivered in an orderly fashion.
Assume now that 2 packets were lost on the way to the other computer. Unlike TCP, these computers will not notice this since there will not be any requests made to retrieve those 2 lost packets since UDP does not guarantee their deliveries.
This could potentially cause a lag in the video since the packet recording of that timeframe was never received by the other computer.

3. The UDP internet protocol is typically much faster than the TCP internet protocol (this is why it is used in games and video conferencing, for example) because it does not guarantee packet order or delivery. Why do these compromises make UDP faster? Describe a scenario in which UDP would be faster at transmitting the same information. *(5 pts)*

The reason UDP is so much faster than other protocols are because it does not care of the order the packets arrive and does not re-request packets that were not successfully

transferred from one server to the next. TCP on the other hand will re-request packets that were not successfully delivered and must order those packets properly which adds additional time to the request.
If we download an image using TCP, we are essentially guaranteeing receiving all packets which compromise that image in a correct order whereas if we were to do the same with UDP, the download would be much faster, but the packets that could potentially be lost on their way could not be retrieved as well as the packets might not be in correct order. This means we will get an incomplete and incorrect image.

4. Why is it ok for video conferencing to be built on top of UDP, despite the protocol's limitations? *(5 pts)*

Because during video conferencing we need real-time recording which requires the connection to be fast. UDP can accomplish this since it will send packets in a much quicker way that TCP for multiple reasons noted above (does not care for lost information, does not care for ordered packets) which will ensure getting as close to real-time as possible. Though it could cause a lag when not receiving some packets whereas TCP would not cause this but would be very far from real-time recording.

5. Binary Representation (10 pts)

Represent the following objects in binary using the formats described in class (or specified below). *(2 pts each)*

a. The number 81_{10}

81 // 2 = 40 R 1
40 // 2 = 20 R 0
20 // 2 = 10 R 0
10 // 2 = 5 R 0
5 // 2 = 2 R 1
2 // 2 = 1 R 0
1 // 2 = 0 R 1
➔ 1010001_2

b. The number 254_{10} using 12 bits.

254 // 2 = 127 R 0
127 // 2 = 63 R 1
63 // 2 = 31 R 1
31 // 2 = 15 R 1
15 // 2 = 7 R 1
7 // 2 = 3 R 1
3 // 2 = 1 R 1
1 // 2 = 1 R 1
➔ 11111110_2
We now have 8 bits representing the number 254_{10} in binary. We simply add four 0 to the left side to make it into a 12-bit binary number.
➔ $0000\ 1111\ 1110_2$

Verifying this: 1x2^7 + 1x2^6 + 1x2^5 + 1x2^4 + 1x2^3 + 1x2^2 + 1x2^1 + 0x2^0 = 254

c. What is 0110 1000 0110_2 in decimal notation?

0x2^11 + 1x2^10 + 1x2^9 + 0x2^8 + 1x2^7 + 0x2^6 + 0x2^5 + 0x2^4 + 0x2^3 + 1x2^2 + 1x2^1 + 0x2^0 = 1670_{10}

d. A 2x2 image containing a full intensity purple pixel and a dark grey (the lowest intensity possible) pixel. Use 4 bits for width and 4 bits for height and 2 bits for each color component.

WxHxP1xP2
W = 0010_2
H = 0010_2
Full intensity purple (P1) = 11 00 11
Dark grey (P2) = 01 01 01
Black = 00 00 00

WxHxP1xP2 = 0010 0010 0000 110011 0000 010101_2

e. The number 22_3 (the subscript "3" means this is written in base 3… there are only 3 digits).

2x3^1 + 2x3^0 = 8_{10}
8_{10} → Binary:

8 // 2 = 4 R 0
4 // 2 = 2 R 0
2 // 2 = 1 R 0
1 // 2 = 0 R 1
→ 1000_2

Discussion

1. Network structure (5 pts)

McGill is evaluating internet providers for the campus and is considering two options. The first option involves having all internet delivered by a single cable coming into the library. The second option involves paying for six cables (all still from the same provider) to enter the campus at various points (e.g., the library, Trottier, McConnell, etc...). Both options provide the same, total, bandwidth to McGill. Appealing to features of packet routing already covered in class, make a technical argument for why the second option, despite costing more, is better.

The second option is better for McGill even though it costs more since the school has a lot of students connected to the internet throughout the day which could potentially cause collisions. If we had a single internet cable, the packets would frequently collide in the single collision domain. But if we were to split this domain into 6 cables, we would have less collisions since the packets would travel in their respective cables and would cause less congestions meaning quicker internet speed.