CS 4438/9868 Internet Algorithmics
Assignment 1: Graduate and Undergraduate Students
Due date: October 1 at 11:55 pm

To answer some of the questions you will need to use network related UNIX or Windows commands.

1. (5 marks) Use the `host` (`/usr/sbin/host` or `/usr/bin/host`, depending on where you are logged on) command in any UNIX server where you have an account or the `nslookup` Windows command, to determine the IP address of at least one of the computers in the UWO's computer network. To use the commands you need to open a command window or a console and type either `host symbolic_name` or `nslookup symbolic_name`, where `symbolic_name` is the symbolic name of the computer. (1) Report both, the symbolic name and IP address of the machine that you have selected. (2) Assuming the classful IP addressing scheme, which class of IP addresses (A, B, C, D, or E) are assigned to the computers in the University's network? (3) Which is the prefix (network number) shared by all IP addresses in this network? (4) Up to how many different computers can belong to this network?

   If you do not know the symbolic name of any UWO computer, you can use the name of a web server ("www" plus the department and UWO address, like www.csd.uwo.ca, www.math.uwo.ca, www.uwo.ca, ...)

2. (15 marks) Use the `ping` command to estimate the number of actual computers in the UWO network assuming the classful IP addressing scheme. To do this, generate a list L of at least 20 random IP addresses of the class and network number that you determined in the previous question. Issue a `ping` command for each one of these IP addresses (`ping IP_ADDRESS` and determine the fraction of L that corresponds to actual computers. Use this fraction to estimate the size of the University's network.

   (1) Show the first 20 addresses in the list L that you used, (2) the fraction of addresses that correspond to actual machines, and (3) your estimate for the size of the network.

3. (5 marks) (1) Find the IP address of your computer in CIDR notation: `ip address / number of bits of network number`. (2) Report the network number and computer number for your machine in binary format. (3) Up to how many computers can belong to the subnetwork to which your computer is connected?

   (4) Find the MAC or physical address of your network card (if your computer has an ethernet and a wireless network cards, report the MAC address of any of them). A MAC address is 48 bits and it has the format dd:dd:dd:dd:dd:dd or dd-dd-dd-dd-dd-dd, where dd is an hexadecimal number.

   To get the above information in UNIX use the command `ip addr`. Carefully read the information printed by the command and try to figure out the answer to the above questions.

   In Windows use the `ipconfig /all` command. This command does not give the CIDR notation explicitly, instead the command reports the IPv4 address and the subnet mask. The number of bits equal to 1 in the subnet mask indicates the number of bits that form the network number (please read the notes from the book Computer Networks and Internets, Section 21.10).

4. (10 marks) Use the `traceroute` UNIX command or the `tracert` Windows command (`traceroute symbolic_name` or `tracert symbolic_name`) to find the number of hops between your computer and remote destinations (e.g. to servers hosting Web sites). The maximum number of hops between two computers in the Internet is called the *diameter of the Internet*. Report on the maximum number of hops that you can find. Include the list of servers contacted by `traceroute` or `tracert` and their geographical locations. To try to find the geographical

location of an IP address you can use one of several available Web services, like *IP Lookup* (https://whatismyipaddress.com/ip-lookup), or *IP Location* (www.iplocation.net).

5. (10 marks) Download the network analyzer called Wireshark from www.wireshark.org and install it on your computer. Run the program and select a network adapter where you see some activity (a wiggly line shows network activity). Click on the blue icon at the upper left corner to start capturing packets. Open in a browser the website of the Department of Computer Science and once the page has been loaded, click on the red square on the upper left corner of Wireshark's window to stop capturing packets. Find a network packet containing a datagram that was sent by your computer (to do this find a packet whose source address matches the IP address of your computer and whose protocol is HTTP).

   - Show the first 34 bytes of the package in hexadecimal notation.
   - Show the MAC source address and the MAC destination address contained in the header of the network packet in hexadecimal notation.
   - For the datagram contained in this network packet, show the following information in decimal notation or dotted decimal notation: (a) Protocol version number, (b) Header length, (c) Total length of datagram, (d) Time to live, (e) Source IP address and destination IP address.

   If you are unable to run Wireshark, there are some network packets in the course's website that you can use to answer the above questions, but please try to run Wireshark and use it to learn to capture network packets. There are several online Wireshark tutorials, if you need help.

6. (10 marks) Consider a network with a bus topology where 2 computers, A and B, wish to transmit messages at the same time. After a collision is detected each computer stops transmitting and waits for a random time selected from $\{1, 2, ..., d\}$. Upon waiting for the randomly selected time each computer checks the bus to to see if it is free, and if so it starts transmitting again. If a new collision is detected the above process is repeated, until one of the processors is able to successfully transmit. Assume that $d = 3$ and that after each collision the value of d is multiplied by 3, so for multiple collisions d has values 3, 3^2, 3^3, ...

   Assume that only computers A and B wish to transmit. After detecting the first collision,

   - (1 marks) What is the probability that there will not be a second collision?
   - (9 marks) What is the probability that exactly 4 rounds of the above procedure are needed before one of the computers can transmit?

     Hint. During the first 3 rounds there will be collisions and in the 4-th round the computers choose different random waiting times. Hence, the probability that 4 rounds are needed is probability of a collision in first round $\times$ probability of collision in second round $\times \cdots \times$ probability of no collision in the last round

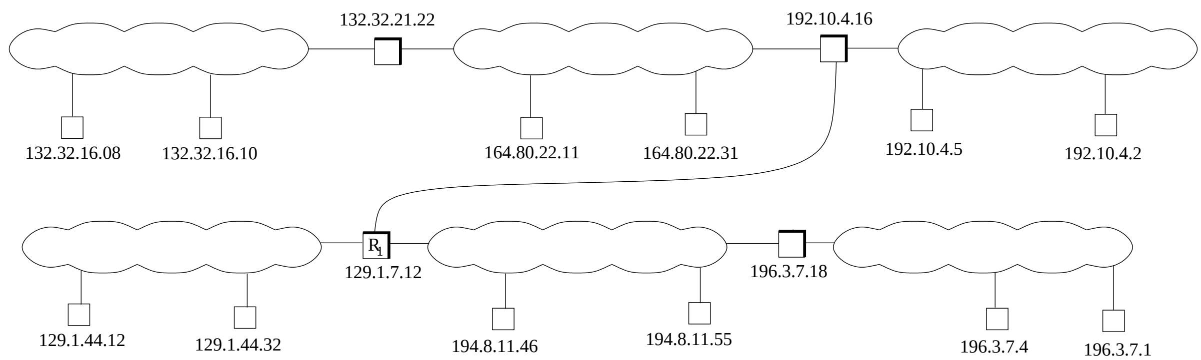
7. (10 marks) In the lectures we studied a simple error correction code known as the row and column code (also described in Section 8.11 of the book *Computer Networks and Internets*). Assume that computer A has a message m of 9 bits that it needs to send to computer B. Computer A arranges the bits into a matrix of 3 rows and 3 columns adding even parity bits for each row and column. Computer A sends the encoded message to B. Computer B receives the following message: 1010110010000110.

   Recover the message m from the bits received by B. If one bit was altered in the transmission, you must fix it. What is the message m? You must explain how you recovered the message m.

8. (15 marks) Show the routing table for router R_1 in the following internet. The routing table should have two columns, one for the destination and the other for the next hop. Assume the

classful IP addressing scheme. When R_1 is directly connected to the network containing the destination IP address, just write “deliver direct” in the corresponding entry of the routing table. For simplicity, assume that each router has only one IP address.

For your convenience, and to see how nice we are, we give the binary representations of the first byte of each IP address in the figure: 132 (10000100), 164 (10100100), 192 (11000000), 129(10000001), 194 (11000010), 196(11000100),.



9. (20 marks) Consider the internet shown in the following figure. Assume that computer A needs to send a message m of length 180 bytes to computer B. Show the packets that are transmitted through each one of the networks so message m is delivered to B. The maximum length of packets (including header and data) that each network can transport is as follows: (a) 1000 bytes for network 1, (b) 100 bytes for network 2, (c) 300 bytes for network 3. Use the following conventions:

- Each network packet has two parts: header and data. Specify a network packet as follows (include the square brackets):
  [**header**: source MAC addr., dest. MAC addr.; **data**: data]
- If a message is longer than the size of a network packet, the message will be split into several messages of the same size.
- The length of the network packet header in each network is 20 bytes.
- Specify datagrams as follows (include the curly brackets):
  {**header**: source IP addr., dest. IP addr.; **data length**: length}
- Assume that all IP datagrams have a header of length 20 bytes.
- To specify a MAC address just write “MAC addr. of x”; for example, “MAC addr. of A”, “MAC addr. of R_1”, and so on.
- To specify the IP address of a computer just write “IP addr. of x”; for example “IP addr. of A”, “IP addr. of R_2”, and so on.
- Show the packet(s) that are transported by each network as follows:
  Network 1 packet(s):
  [**header:** MAC addr. of X, MAC addr. of Y; **data**: D]
  ...
  Network 2 packet(s):
  ...