CSEE 4911: Computer Networks — Due on Tuesday, April 10th, 2012

Assignment #4 – Network Layer

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How to read this assignment : Exercise levels are indicated as follows

- ($\rightarrowtail$) "elementary": the answer is not strictly speaking obvious, but it fits in a single sentence, and it is an immediate application of results covered in the lectures.

  Use them as a checkpoint: it is strongly advised to go back to your notes if the answer to one of these questions does not come to you in a few minutes.
- ($\curvearrowright$) "intermediary": The answer to this question is not an immediate translation of results covered in class, it can be deduced from them with a reasonable effort.

  Use them as a practice: how far are you from the answer? Do you still feel uncomfortable with some of the notions? which part could you complete quickly?
- ($\looparrowright$) "tortuous": this question either requires an advanced notion, a proof that is long or inventive, or it is still open.

  Use them as an inspiration: can you answer any of them? does it bring you to another problem that you can answer or study further? It is recommended to work on this question only AFTER you are done with the rest!

Exercise 1: NAT (0pt, included for practice) and ICMP (20 pt) Complete the Wireshark lab for ICMP. We also recommend you complete the lab for NAT as a practice for the next exercice.

Exercise 2: Compatibility of NAT and Multi-Homing (4 pt)

1. ($\curvearrowright$) Many companies have a policy of having two (or more) routers connecting the company to the Internet to provide some redundancy in case one of them goes down. Is this policy still possible with NAT? Explain your answer.

Exercise 3: Collision in the multicast world (5 pt)

1. ($\curvearrowright$) Find the size of the Internet IPv4 multicast address space. Suppose two multicast groups randomly choose a multicast address. What is the probability that they select the same address? What is the probability that if 1000 multicast groups simultaneously choose their multicast address at random, two (or more) groups interfere?

Exercise 4: Counting bits to configure a network (0 pt, included for practice)

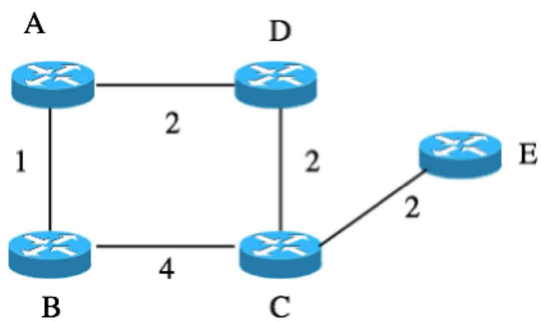
You operate the network for a 8-floor building. Each floor operates a local network that is connected to a dedicated router, and wishes to have a separate subnet. You have received from your ISP the portion of addresses 199.129.202.000/24 for the whole building.

1. ($\rightarrowtail$) Assuming that you assign address ranges of equal size to each floor, in increasing order by floor number, what is the subnet of the 3th floor?

2. ($\curvearrowright$) How many additional PCs can this floor accomodate?

Exercise 5: Result of a distance vector protocol (4 pt)

Consider the network shown in the figure. Assume a distance vector routing protocol is used.



1. (↣) Assume first that poison reverse is not used. Give the state table for nodes A, B, C and D after the protocol has converged (i.e., containing their current cost and next hop for each destination, along with the vectors they receive from each of their neighbors).

2. (↣) Same question with poison reverse implemented between the routers?

3. (↷) After the protocol has converged the first time, the link C–E breaks. Which values of the tables will converge, with and without poison reverse? What if, instead, the link A–D breaks?

Exercise 6: Getting across a router (6 pt)

Consider the following set of packets that reside on the input ports of a router and need to be transferred to the output ports across a crossbar switch, where P_i:A→B means that the packet P_i must be transferred from incoming port A to outgoing port B:

$$\mid P_1\text{: } 1 \to 2 \mid P_2\text{: } 2 \to 1 \mid P_3\text{: } 2 \to 1 \mid P_4\text{: } 3 \to 2 \mid P_5\text{: } 3 \to 4 \mid P_6\text{: } 4 \to 1 \mid P_7\text{: } 4 \to 3$$

Assuming transfers of type A→B and B→A are permitted simultaneously, and that packet P_i is in front of packet P_j on an input queue whenever the incoming port is the same and $i < j$:

1. (↣) Assume packets can be processed in any order (i.e., ones at the front of a queue do not have to be processed first) What is the maximum number of transfers that can occur in the first round? Which set of packets achieve this maximum?

2. (↣)What if packets must be processed in the order of arrival. What is the maximum number of transfers that can occur in the first round? Which sets of packets achieve this maximum?

3. (↷) What is the minimum number of rounds needed to transfer all packets across the crossbar? Explain the result in one sentence (i.e, how it's easy to see that fewer rounds could not be used to transfer all packets, regardless of schedule). Give an example.

4. (↷) Give an example of a poor scheduling choice that maximizes the number of packets that can be sent in parallel across the crossbar each round, but where head-of-line blocking leads to additional rounds being needed beyond the minimum to forward all packets.

Exercise 7: Routing is expensive but testing is cheap (1 pt)

Imagine that you have to compute all the shortest paths from a source s in a graph containing N vertices and M edges. Depending on the implementation, doing this computation can take between $O(N^2)$ and $O(M \ln(N))$. You find somewhere on your machine a solution of a previous computation and you are wondering if it is actually the solution that you are looking for.

1. ($\looparrowright$) Prove that it is possible to us only $O(M)$ operations and determine if this solution is exact.

2. ($\curvearrowright$) Imagine the situation occurs regularly. You observe that most of the time the solution you found from previous computation was in fact the correct one, especially for large networks (*i.e.*, you observe that the probability that the solution is wrong is $O(1/N)$). Can you provide an algorithm that provide the solution and use only $O(M)$ operations in expectation.