[CS 335A] Assignment 4 - Network Layer

To route or not to route?: that is not even a question!

Deadline: 13/12/2021
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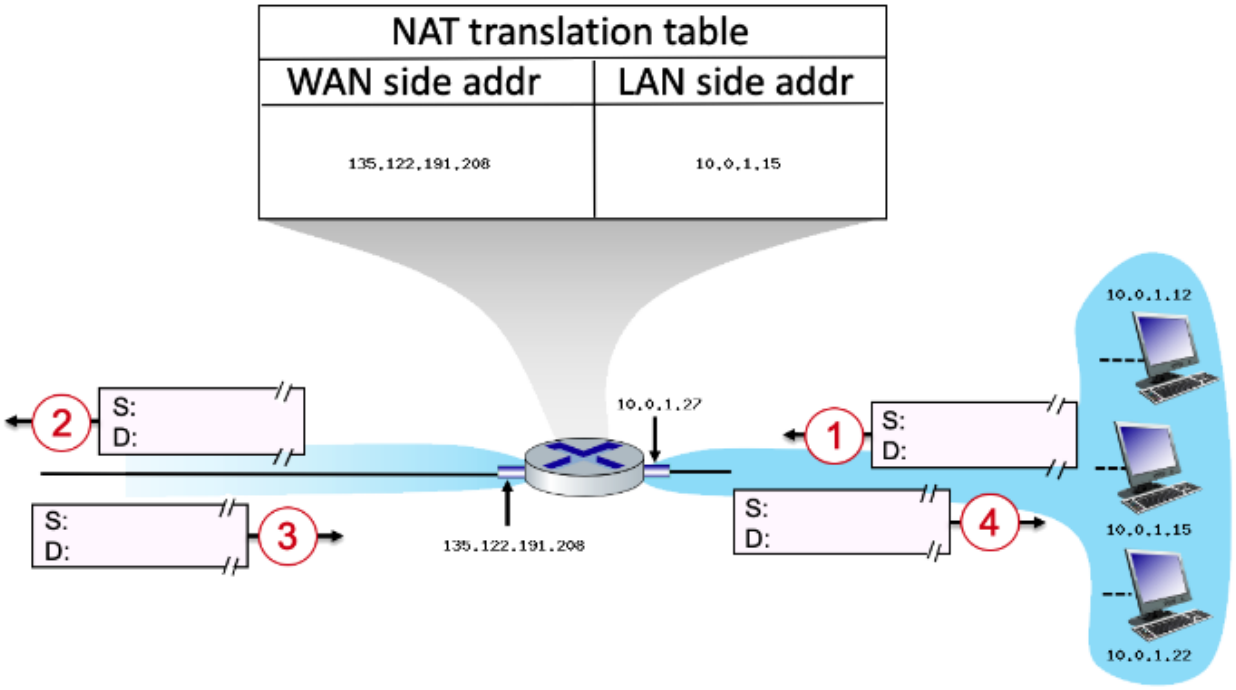
Part 1: Theory(50 pts)

Question 1 [15 pts]

A) Which are the main differences between link-state (LS) vs. distance-vector (DV) algorithms? How does this difference affect the time required by the nodes of the network to find the optimal paths (converge time) and what is the overhead of the nodes during this process? **(10 pts)**
B) Describe BGP; Position BGP in an algorithm family; **(8 pts)**

Question 2 [10 pts]

Describe the Network Address Translation (NAT) **(5 pts)** and the way it works in the scenario below **(5 pts)**: Three hosts, with private IP addresses 10.0.1.12, 10.0.1.15, 10.0.1.22 are in a local network behind a NAT'd router that sits between these three hosts and the larger Internet. IP datagrams being sent from, or destined to, these three hosts must pass through this NAT router. The router's interface on the LAN side has IP address 10.0.1.27, while the router's address on the Internet side has IP address 130.122.191.208. Suppose that the host with IP address 10.0.1.15 sends an IP datagram destined to host 128.119.166.190. The source port is 3444, and the destination port is 80. ***NOTE:*** *Showcase your results by designing a similar topology. Make any necessary assumptions.*



Question 3 [5 pts]

In the following questions choose the correct statements. **Select one or more statements in each question**

A. Which of the following statements correctly identifies the differences between routing and forwarding? Select one or more statements

- ☐ Routing refers to determining the route taken by packets from source to destination.
- ☐ Routing refers to moving packets from a router's input to appropriate router output
- ☐ Forwarding refers to moving packets from a router's input to appropriate router output.
- ☐ Forwarding refers to determining the route taken by packets from source to destination.

B. What is the purpose of the Dynamic Host Configuration Protocol (DHCP)?

- ☐ To configure the interface speed to be used, for hardware like Ethernet, which can be used at different speeds.
- ☐ To get the 48-bit link-layer MAC address associated with a network-layer IP address.
- ☐ To configure the set of available open ports (and hence well-known services) for a server.
- ☐ To obtain an IP address for a host attaching to an IP network.

C. What is meant by Head of Line (HOL) blocking?

- ☐ A queued datagram receiving service at the front of a queue prevents other datagrams in the queue from receiving service.
- ☐ A queued datagram waiting for service at the front of a queue prevents other datagrams in the queue from moving forward in the queue.
- ☐ In a block error code, the first bytes of the code indicates the type of coding being used.

D. Check one or more of the following statements about the OSFP protocol that are true

- ☐ OSPF is an intra-domain routing protocol.
- ☐ OSFP uses a Dijkstra-like algorithm to implement least-cost path routing.
- ☐ The Open Shortest Path First (OSPF) Internet routing protocol implements a Bellman-Ford distance-vector routing algorithm.
- ☐ OSPF is an interdomain routing protocol.
- ☐ OSPF implements hierarchical routing

E. Which of the statements below about ICMP are true?

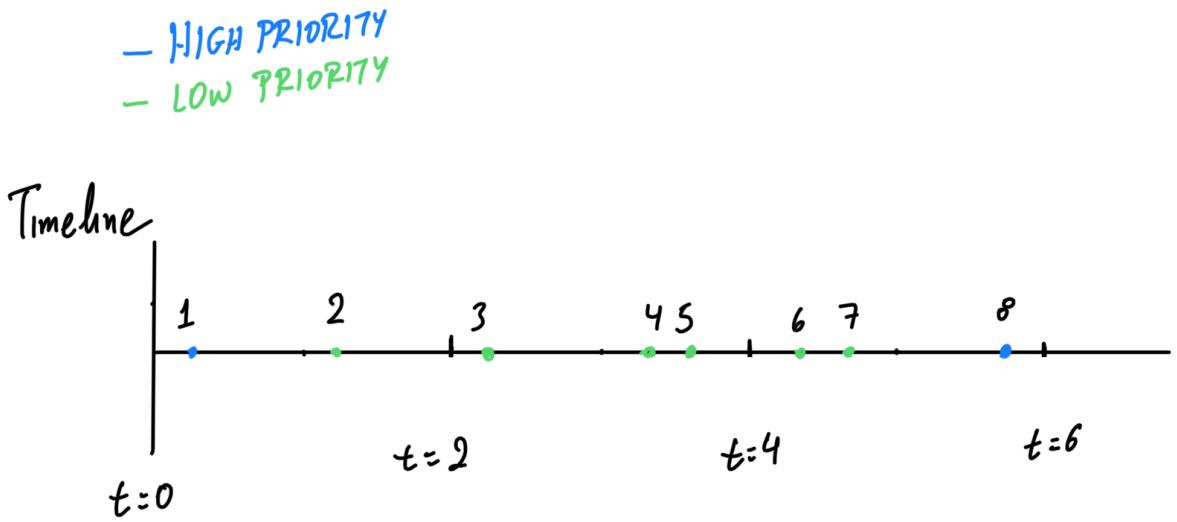
- ☐ ICMP is used by hosts and routers to communicate network-level information.
- ☐ ICMP communicates information between hosts and routers by marking bits in the IP header.
- ☐ ICMP messages are carried in UDP segments using port number 86.
- ☐ The TTL-expired message type in ICMP is used by the traceroute program.
- ☐ ICMP messages are carried directly in IP datagrams rather than as payload in UDP or TCP segments.

Question 4 [10 pts]

Consider the arrival of 8 packets to an output link at a router as indicated by the figure below. For simplicity, we will consider the time to be “slotted”, with a slot beginning at t = 0, 1, 2, 3, etc. Packets can arrive at any time during a slot, and multiple packets can arrive during a slot. At the beginning of each time slot, the packet scheduler will choose only one packet, among those queued (if any), for transmission according to the packet scheduling discipline (that you will select below). Each packet requires exactly one slot time to transmit, and so a packet selected for transmission at time t, will complete its transmission at t+1, at which time another packet will be selected for transmission, among those queued. Present the exact order and at what time each packet arrives for the following scheduling scenarios:

a. FIFO **(5 pts)**
b. Priority Scheduling **(5 pts)**

Showcase your results for each packet as the following example: **Time: t=1, Packet: x**



Question 5 [10 pts]

Consider a datagram network using 32-bit host addresses. Suppose a router has four links, numbered 0 through 3, and packets are to be forwarded to the link interfaces as follows:

Destination Address Range	Link Interface
11100000 00000000 00000000 00000000 through 11100000 00111111 11111111 11111111	0
11100000 01000000 00000000 00000000 through 11100000 01000000 11111111 11111111	1
11100000 01000001 00000000 00000000 through 11100001 01111111 11111111 11111111	2
otherwise	3

A. Provide a forwarding table that uses longest prefix matching, and forwards packets to the correct link interfaces. **(5 pts)**
B. Describe how your forwarding table determines the appropriate link interface for datagrams with destination addresses: **(5 pts)**
    1. 11001000 10010001 01010001 01010101
    2. 11100000 01000000 00000000 00000000
    3. 11100001 01000000 11000011 00111100
    4. 11100001 10000000 00010001 01110111
    5. 11100000 01000000 10010000 01101010

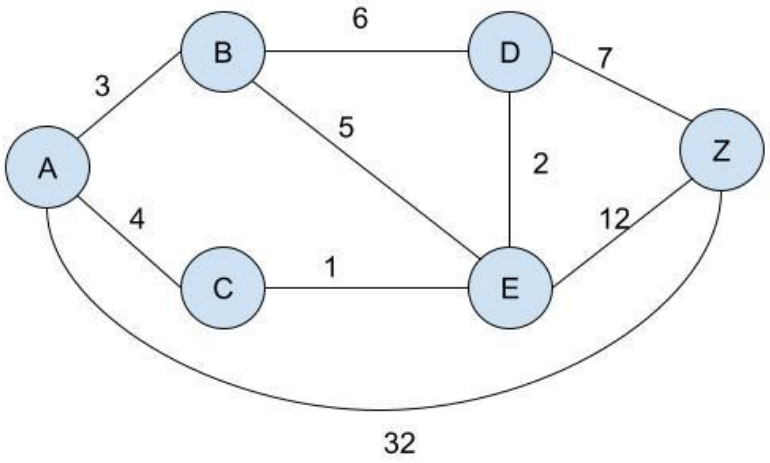
Part 2: IP Fragmentation (12 pts)

IP fragmentation occurs when a network datagram is too large to be encapsulated into a single frame and hence needs to be split. The **maximum transmission unit (MTU)** is the size of the largest protocol data unit (PDU) that can be communicated in a single network layer transaction. Hence, during its' path from the source to the destination, a packet could be divided multiple times. The new network datagrams that will occur use the fields "more" to signal that there are more fragments in order to reconstruct the initial network datagram. Moreover, the "offset" field indicates which part of the initial payload this fragment contains. It must be mentioned that the payload size of each fragment must be a multiple of 8. For more information visit https://ipwithease.com/fragmentation-offset/ (It will help you).

In this exercise, we want to send an IP datagram of size 5000 Bytes from host S to R. Hosts S and R are three hops away, i.e., there are three links between them. The first link, L_a , has MTU=6000, the second L_b has MTU=1500 and the third L_c MTU=580. Assume IP header of 20 Bytes. How many IP datagrams will R receive, if all of them are received correctly? Report the fragment offset they will have in their IP header, the size of their payload in Bytes and the value of the "More fragments" flag they will have.

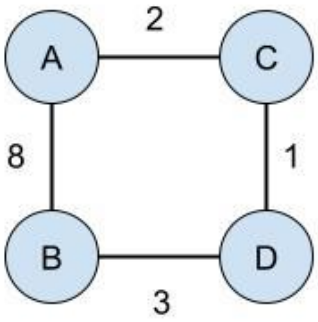
Part 3: Link-State Routing Algorithm (15 pts)

Consider the following network with the cost of its links. Please present the optimal (cost efficient) paths starting node A to the other nodes of the network using Dijkstra algorithm.



Part 4: Distance-Vector Routing Algorithm (20 pts)

1. What are the events in the Distance-Vector Routing Algorithm that “trigger” a router to transmit distance vector information to its neighbors? **(5 pts)**
2. How many times will the nodes of the following network exchange vectors, during a distance-vector algorithm before the network converges? Present the final Distance-vector and the path for each node. **(10 pts)**



3. In the aforementioned network topology, describe a scenario that is likely to cause the count to infinity problem. Suggest a way to address the problem. ***NOTE:*** *Make any necessary assumptions in the existing topology*.**(5 pts)**