COMP3234B Computer and Communication Networks

Assignment 3 (8%)

Due by: 23:59 Wednesday April 17, 2024

Total mark is 100.

1. (25 marks) [IP (Learning Outcomes 1, 2, 5)]

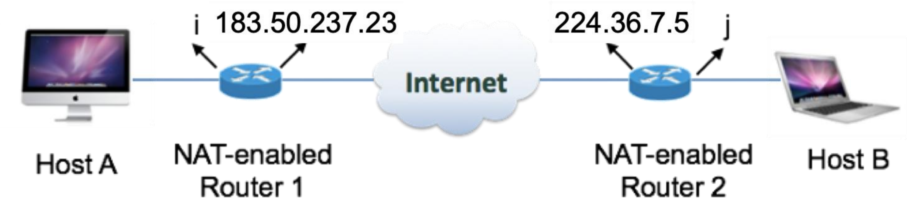
Consider a router with 5 interfaces that interconnects five subnets, numbered 0 through 4. Suppose that Subnets 0 and 2 are each required to support up to 520 interfaces, Subnets 1 and 4 are each required to support up to 56 interfaces, and Subnet 3 is required to support up to 300 interfaces. Also suppose IP addresses of all the interfaces in all subnets are required to have network address 139.247.112.0/20.

(1) Assign network addresses in the form a.b.c.d/x for the five subnets (a network address is like 200.23.16.0/23 that we give on page 27 of lecture slides 9_Network_I_COMP3234B_s2024.pdf), which lead to smallest subnets satisfying the above requirements. Note that the IP address ranges among subnets should not overlap.

(2) Based on the network addresses you gave, provide a forwarding table for the router, which has five entries and can be used to forward each datagram (destined to each subnet) to the correct link interface based on longest prefix matching.

2. (23 marks) [NAT (Learning Outcomes 2, 5)]

Consider two hosts participating in a peer-to-peer application to request data from each other, as shown in the following figure. Each host is connected to the Internet via a NAT-enabled router. The external IP addresses of the two routers are given in the figure. Suppose host A runs a server process on port 9191 and a client process on port 2761, and host B runs a server process on port 6262 and a client process on port 7945. When host A requests data from host B, host A's client process sends the request to the server process on host B; and when host B requests data from host A, host B's client process sends the request to the server process on host A.



(1) Suppose host A resides in an institutional network 172.16.0.0/12 and host B resides in

a home network 192.168.0.0/16. Allocate an IP address to host A's interface, router 1's interface i, host B's interface, router 2's interface j, respectively.

(2) What rule needs to be installed on router 1 and router 2, respectively, to enable host A and host B to each serve as a server behind a NAT-enabled router?

(3) Consider host A is sending a request to host B. Use the assigned IP addresses and the installed rules in previous questions. Complete the mapping to be added to the NAT translation table on router 1 (you can assign the WAN side port number yourself):

NAT Translation Table on Router 1	
LAN side	WAN side

Give the following information in the request sent out from host A, in the request after it has passed through router 1, and in the request after it has passed through router 2:

Request sent out from host A	
Source IP address:	
Source port number:	
Destination IP address:	
Destination port number:	

Request sent out from router 1	
Source IP address:	
Source port number:	
Destination IP address:	
Destination port number:	

Request sent out from router 2	
Source IP address:	
Source port number:	
Destination IP address:	
Destination port number:	

Give the following information in the response sent out from host B, in the response after it has passed through router 2, and in the response after it has passed through router 1:

Response sent out from host B	
Source IP address:	
Source port number:	
Destination IP address:	

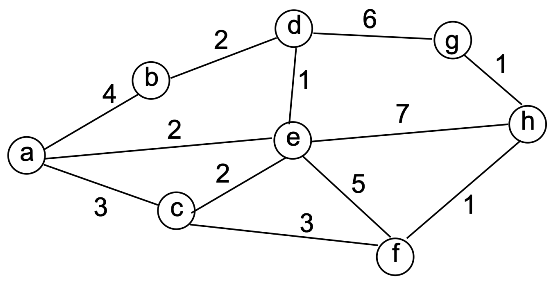
Destination port number:	

Response sent out from router 2	
Source IP address:	
Source port number:	
Destination IP address:	
Destination port number:	

Response sent out from router 1	
Source IP address:	
Source port number:	
Destination IP address:	
Destination port number:	

3. (23 marks) [Dijkstra’s Algorithm (Learning Outcome 3)]

You are given a network in the following figure, where the number marked on each link indicates the respective link cost.



(1) Use Dijkstra’s algorithm to find the least-cost paths from node a to all the other nodes in the network. Show your steps of the algorithm execution, by drawing a table like the following to illustrate each step of the algorithm. Give the resulting least-cost-path tree from node a to all the other nodes. [Note: N’ is the set of nodes whose least-cost paths are known; D(x) is the current estimate of the least path cost from node a to node x; p(x) is the predecessor node of x along the current least-cost path from node a to node x.]

Step	N'	D(b),p(b)	D(c),p(c)	D(d),p(d)	D(e),p(e)	D(f),p(f)	D(g),p(g)	D(h),p(h)
0								

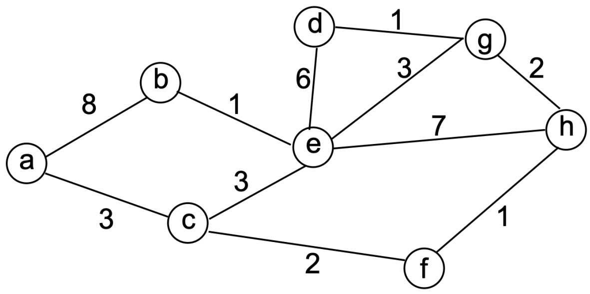
(2) Assume the link capacities in the network are all 2Gbps. At any given time, node a is sending data at a rate of 125 Mbytes/s to each of the other nodes (b, c, d, e, f, g and h), respectively, with probability p=0.1, i.e., at any given time, a is sending to b at a rate of 125 Mbytes/s with probability p, a is sending to c at a rate of 125 Mbytes/s with probability p, … and a is sending to h at a rate of 125 Mbytes/s with probability p.

(i) Consider circuit switching with TDM is used in the network. We need to set up 7 circuits for the data communication sessions a->b, a->c, a->d, a->e, a->f, a->g and a->h, respectively. Suppose the circuits follow least-cost paths you computed in part (1). Are the link capacities in the network sufficient for establishing the 7 circuits? Explain your answer.

(ii) Now consider packet switching is used in the network. What is the probability that no congestion occurs along link a-c at any time, while the data communication sessions from a to each of the other nodes follow the least-cost paths you computed in part (1)? Give your computation steps.

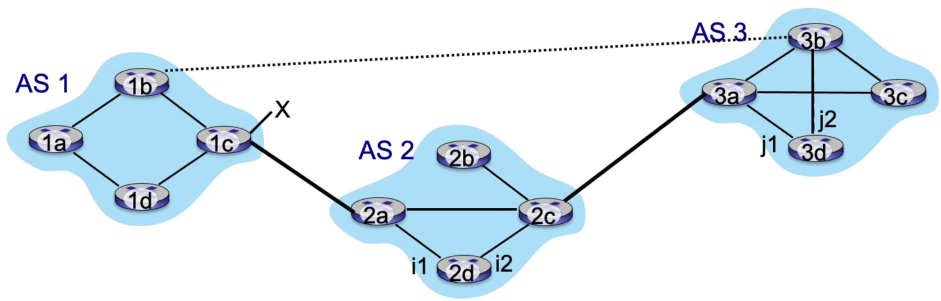
4. (16 marks) [Bellman-Ford Algorithm (Learning Outcome 3)]

Consider the network given below, where we assume that the costs are the same for both directions of each link. Use the Bellman-Ford algorithm to find the least-cost paths from nodes b, c, d, e, f, g and h to node a, by completing the given table to illustrate each iteration of the algorithm. Assume all nodes run the algorithm in a synchronous fashion. Here Dx(a) denotes the current estimate of the least cost from node x to node a; Sx(a) denotes the successor node along the current least-cost path from node x to node a. Note that this table form is a more concise way to illustrate relevant results in the algorithm iterations (different from the more detailed tables we see in lecture slides); you should be able to work out the table based on a good understanding of the Bellman-Ford algorithm. Put ∞ in a table cell if no least-cost path from the respective node to a is known yet. Please also draw the resulting least-cost-path tree rooted at a.



Iteration	$D_b(a)$, $S_b(a)$	$D_c(a)$, $S_c(a)$	$D_d(a)$, $S_d(a)$	$D_e(a)$, $S_e(a)$	$D_f(a)$, $S_f(a)$	$D_g(a)$, $S_g(a)$	$D_h(a)$, $S_h(a)$
0							

5. (13 marks) [Hierarchical Routing in the Internet (Learning Outcomes 2, 3)]
Consider the network shown below. Suppose AS1 and AS3 are running OSPF as their intra-AS routing protocol, and AS2 is running RIP as its intra-AS routing protocol. Suppose eBGP and iBGP are used for inter-AS routing. X is a subnet connected to router 1c. i1 and i2 are two interfaces of router 2d. j1 and j2 are two interfaces of router 3d. Initially suppose there is no physical link between AS1 and AS3. Suppose the costs of all links are the same.



(1) Router 3c learns about subnet X from which routing protocol (directly): OSPF, RIP, eBGP, or iBGP?

(2) Router 2a learns about subnet X from which routing protocol (directly): OSPF, RIP, eBGP, or iBGP?

(3) Give the entry (X, I) that router 2d puts in its forwarding table, once it learns about subnet X. Explain how you decide I.

(4) Now suppose that there is a physical link between AS1 and AS3, shown by the dotted line. Suppose router 3d learns that subnet X is accessible via AS2 as well as

via AS1. Consider that AS path with a smaller AS hop number is preferred first, and then an intra-AS path with the smallest cost to the respective gateway router connected to the NEXT-HOP of the AS path should be chosen. Give the entry (X, J) that router 3d puts in its forwarding table. Explain how you decide J.

(5) Now suppose there are two other ASes, AS4 and AS5, which lie on the path between AS1 and AS3 (AS4 and AS5 are not shown in diagram). Suppose router 3d learns that subnet X is accessible via AS path AS2 AS1 as well as via AS path AS5 AS4 AS1. What will J be set to in entry (X, J) in router 3d's forwarding table? Explain your answer.

Submission:

You can write your answers in a word document or other document at your choice. Please convert your answer document to a ***a3-yourstudentid.pdf*** file and submit the PDF file on Moodle before 23:59 Wednesday April 17, 2024:

(1) Login Moodle.
(2) Find "Assignments" in the left column and click "Assignment 3".
(3) Click "Add submission", browse your .pdf file and save it. Done.
(4) You will receive an automatic confirmation email, if the submission was successful.
(5) You can "Edit submission" to your already submitted file, but ONLY before the deadline.