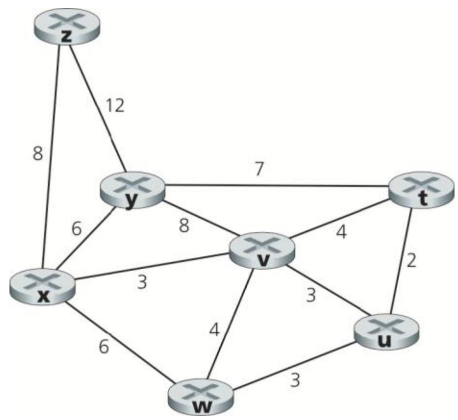
Problem 1

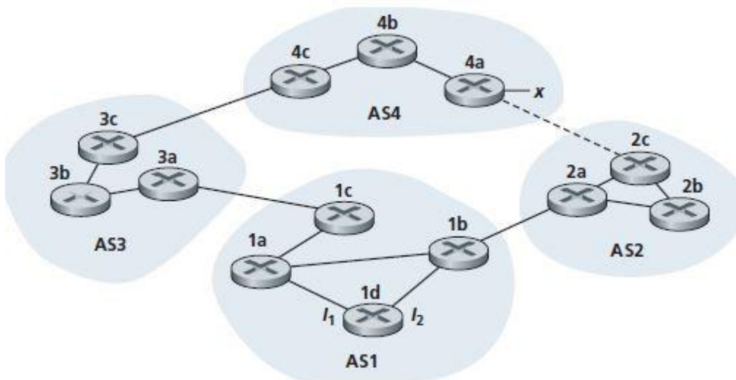
Consider the following network. With the indicated link costs, use Dijkstra's shortest-path algorithm to compute the shortest path from x to all network nodes. Show how the algorithm works by computing a table similar to Table 5.1 in the textbook.



N'	D(y),P(y)	D(z),P(z)	D(u),P(u)	D(v),P(v)	D(w),P(w)	D(t),P(t)
x	6,x	8,x	inf	3,x	6,x	inf
xv	6,x	8,x	6,v		6,x	7,v
xvy		8,x	6,v		6,x	7,v
xvyu		8,x			6,x	7,v
xvyuz					6,x	7,v
xvyuzw						7,v
xvyuzwt						

Problem 2

Consider the network shown below. Suppose AS3 and AS2 are running OSPF for their intra-AS routing protocol. Suppose AS1 and AS4 are running RIP for their intra-AS routing protocol. Suppose eBGP and iBGP are used for the inter-AS routing protocol. Initially suppose there is no physical link between AS2 and AS4.



At some time T, the prefix *x* appears in AS4, adjacent to the router 4a. From which routing protocol (OSPF, RIP, eBGP, or iBGP):

(a)Router 3c learns about prefix *x*?

(b)Router 3a learns about prefix *x*?

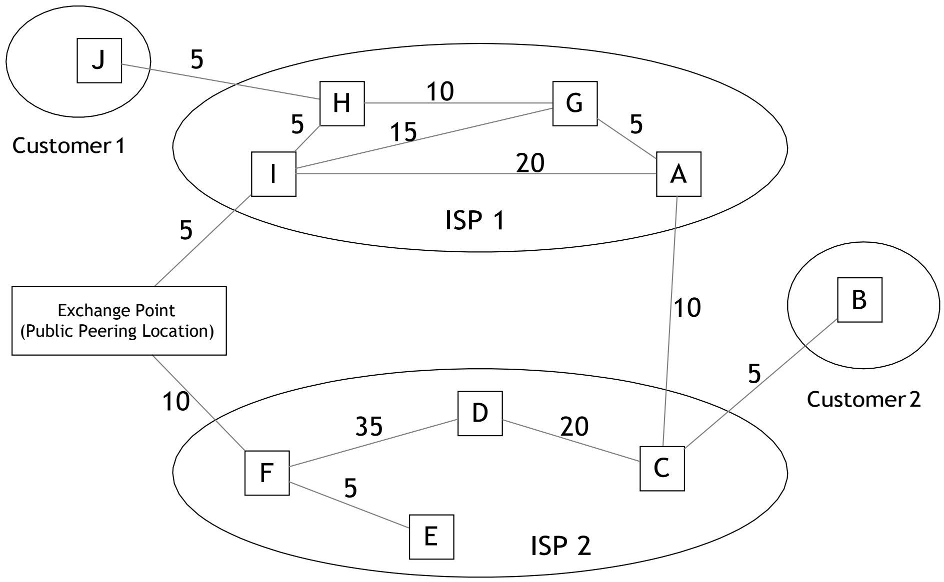
(c)Router 1c learns about prefix *x*?

(d)Router 1d learns about prefix *x*?

(a) eBGP . from router 4c.
(b) iBGP . from iBGP started by router 3c.
(c) eBGP. From router 3a.
(d) iBGP. From iBGP started by router 1c.

Problem 3

Consider the following topology. The cost metric of a link denotes the one-way propagation delay on the link in msec (assuming the delays are symmetric). The two ISPs ISP 1 and ISP 2 are peers. CIDR is used for addressing and BGP is used for inter-domain routing. Assume that both ISPs always try to enforce hot-potato routing above all other routing policies. What is the one-way propagation delay between Customer 1 and Customer 2? Is the routing between two customers symmetric or asymmetric?



From b to J: 5+10+5+10+5=35
From J to b: 5+5+5+10+35+20+5=85
Thus the routing is asymmetric.

Problem 4

Network Address Translation (NAT) is the translation of an IP address used within one network to a different IP address known within another network. A NAT capable router essentially translates private IP address within a network to public IP addresses that can be visited publicly. A simple NAT-capable router will have mappings between the private addresses within the network to the public address(es) that it uses. Suppose that the router has a single public address 131.179.176.1 which it uses for all communication with hosts that are not part of the private network. The private network used is subnet 10.0/16. The router multiplexes its public IP address(es) as needed and keeps track of the multiplexing in a NAT translation table.

Assume that the router multiplexes the public address using ports starting from 8000 and then increments the port number by one for each new entry. For example, if a host behind the router with address and port 10.0.0.5:5000 sends a message to an external server 8.8.8.8:53, then the entry in the NAT table would be filled in as below.

Table 1: NAT Translation Table

IP:port within private network	IP:port outside private network
10.0.0.5:5000	131.179.176.1:8000
...	...

The next time the router will use port 8001 to establish a new connection and so on.

(a) Draw the resulting NAT Translation Table at the end of the following message exchanges following the format of Table 1 (including the original entry):

(1) 10.0.0.6:5000 sends a message to 172.217.11.78:80

(2) 10.0.0.10:6000 sends a message to 204.79.197.200:80

(3) 10.0.1.101:6001 sends a message to 206.190.36.45:80

(4) 10.0.0.10:6000 sends a message to 204.79.197.200:80

(5) 10.0.1.101:6001 sends a message to 172.217.11.78:80

(6) 10.0.0.7:7000 sends a message to 63.245.215.20:80

(7) 204.79.197.200:80 sends a message to 131.179.176.1:8002

(8) 204.79.197.200:80 sends a message to 131.179.176.1:8003

(b) For simplicity, let us assume that message format is MSG <Sender, Receiver>. In that case, if a host in the private network with IP address and port 10.0.0.5:5000 sends a message to 132.239.8.45:80. Then the message received at the router and leaving at the router would look as follows:

Message Received from Host: MSG <10.0.0.5:5000, 132.239.8.45:80>

Message Sent from Router: MSG <131.179.176.1:8000, 132.239.8.45:80>

List the messages, in the same format shown above, received from the host at the router and the message sent from the router for the following messages:

(1) 10.0.0.6:5000 sends a message to 172.217.11.78:80

(2) 10.0.0.10:6000 sends a message to 204.79.197.200:80

Assume the entries from your NAT Translation Table in (a) to do this.

(a)

IP:port within private network	IP:port outside private network
10.0.0.5:5000	131.179.176.1:8000
10.0.0.6:5000	131.179.176.1:8001
10.0.0.10:6000	131.179.176.1:8002
10.0.1.101:6001	131.179.176.1:8003
10.0.0.7:7000	131.179.176.1:8004

(b) Message Received from Host: MSG <10.0.0.6:5000, 172.217.11.78:80>
Message Sent from Router: MSG <131.179.176.1:8001, 172.217.11.78:80>

Message Received from Host: MSG <10.0.0.10:6000, 204.79.197.200:80>
Message Sent from Router: MSG <131.179.176.1:8002, 204.79.197.200:80>

Problem 5

In this problem, you will derive the efficiency of a CSMA/CD like multiple access protocol. In this protocol, time is slotted and all adapters are synchronized to the slots. Unlike slotted ALOHA, however, the length of a slot (in seconds) is much less than a frame time (the time to transmit a frame). Let S be the length of a slot. Suppose all frames are of constant length $L = kRS$, where R is the transmission rate of the channel and k is a large integer. Suppose there are N nodes, each with an infinite number of frames to send. We also assume that $d_{prop} < S$, so that all nodes can detect a collision before the end of a slot time. The protocol is as follows:

- If for a given slot, no node has possession of the channel, all nodes contend for the channel; in particular, each node transmits in the slot with probability p. If exactly one node transmits in the slot, that node takes possession of the channel for the subsequent $k - 1$ slots and transmits its frame.
- If some node has possession of the channel, all other nodes refrain from transmitting until the node that possesses the channel has finished transmitting its frame. Once this node has transmitted its frame, all nodes contend for the channel.

Note that the channel alternates between two states: the productive state, which lasts exactly k slots, and the non-productive state, which lasts for a random number of slots. The channel efficiency is defined as the ratio of $k/(k + x)$, where x is the expected number of consecutive non-productive slots.

(a)For fixed N and p, determine the efficiency of this protocol.

(b)For fixed N , determine the p that maximizes the efficiency.

(a) after k consecutive slots, the probability of success in a single slot is when one node transmit and all other nodes do not transmit. This has the probability of $p' = NP(1-P)^{N-1}$. we know the Expectation of binomial distribution is np'. In this case, we want the expectation to be 1. Thus n= 1/p'. Thus the number of non productive slots x is n-1= 1/p' – 1. Thus the efficiency is

$$\frac{k}{k+x} = \frac{k}{k+\frac{1}{p'}-1} = \frac{k}{k+\frac{1}{\mathrm{NP}(1-\mathrm{P})^{\mathrm{N}-1}}-1}$$

(b) to maximize the efficiency, we want $\mathrm{NP}(1-\mathrm{P})^{\mathrm{N}-1}$ to reach maximum. Taking the derivative And equating to 0, we get the optimal P to be 1/N. Thus P=1/N maximize the efficiency.