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Problem 1

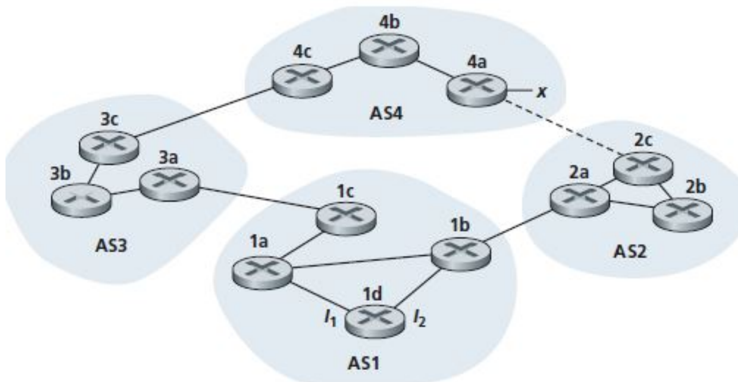
Will a BGP router always choose the loop-free route? Will a BGP router always select the loop-free route with the shortest AS-path length? Justify your answer.

Write your solution to Problem 1 in this box

1. BGP or Border Gateaway Protocol is an Inter-As routing protocol that obtains subnet reachability information from neighbor ASes and it will propagate it's own reachability information to all other routers with AS. That AS PATH is actually used to prevent the possibility of loop such as the router received a route with his own AS in AS PATH. However, it is not always choose loop-free route. Bad design could lead to a BGP that created a loop. For example, when it uses reflector, but the design is bad and does not match the physical topology. However, BGP router will always choose a loop-free route with the shortest AS-path because BGP have some elimination rules that to pick a loop-free route with a shortest AS-PATH length.

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?

Write your solution to Problem 2 in this box

2.
A. eBGP
B. iBGP
C. eBGP
D. iBGP

Problem 3

Referring to the previous problem, once router 1d learns about x will put an entry (x, I) in its forwarding table:

(a) Will I be equal to I_1 or I_2 for this entry? Explain why in one sentence.

(b) Now suppose that there is a physical link between AS2 and AS4, shown by the dotted line. Suppose router 1d learns that x is accessible via AS2 as well as via AS3. Will I be set to I_1 or I_2? Explain why in one sentence.

(c) Now suppose there is another AS, called AS5, which lies on the path between AS2 and AS4 (not shown in the figure). Suppose router 1d learns that x is accessible via AS2 AS5 AS4 as well as via AS3 AS4. Will I be set to I_1 or I_2? Explain why in one sentence.

Write your solution to Problem 3 in this box

3.

A. It will be equal to I_1 because it has shorter path from X to I_1 instead of I_2.

B. Even though now, the cost will be equal via I_1 or I_2, but if it uses I2 then it has the closest NEXT-HOP router. Thus, it will choose I_2 instead of I_1.

C. It will be equal to I_1 because it has shorter path from X to I_1, it will only use AS3, and AS4.

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.

Problem 4 continued on next page. . .

Write your solution to Problem 4 in this box

4. 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
204.79.197.200:80	131.179.176.1:8005

B.

10.0.0.6:5000 sends a message to 172.217.11.78:80:
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>

10.0.0.10:6000 sends a message to 204.79.197.200:80
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.

Problem 5 continued on next page. . .

Write your solution to Problem 5 in this box

5a let's assume $\alpha = NP(1-P)^{N-1}$

α: probability of successive slots.

let m be an integer

$P[\text{Success} = m] = \alpha(1-\alpha)^{m-1}$

Efficiency of channel $= \frac{k}{k+x}$,

x is expected number of consecutive non-productive slots,

$x = E(\text{Success}) - 1$

$= \frac{1-\alpha}{\alpha}$

$$x = \frac{1 - NP(1-P)^{N-1}}{NP(1-P)^{N-1}} \quad \text{bcs } \alpha = NP(1-P)^{N-1}$$

Sub x to efficiency of channel.

$$\text{eff} = \frac{k}{k + \frac{1-NP(1-P)^{N-1}}{NP(1-P)^{N-1}}}$$

b) Max eff → take 1st derivative, set equal to 0, thus:

$$\frac{\partial(NP(1-P)^{N-1})}{\partial P} = 0$$

From lecture & text book, we will get

$$P = \frac{1}{N}$$