2025 Computer Networks
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Chapter 4 Problems

Problem 5. 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 **11100000 00**111111 11111111 11111111	0
11100000 01000000 00000000 00000000 **11100000 01000000** 11111111 11111111	1
11100000 01000001 00000000 00000000 **11100001** 01111111 11111111 11111111	2
otherwise	3

a. Provide a forwarding table that has five entries, uses longest prefix matching, and forwards packets to the correct link interfaces.
[Answer]

Prefix Match	Link Interface
11100000 00	0
11100000 01000000	1
11100000	2
11100001 1	3
Otherwise	4

b. Describe how your forwarding table determines the appropriate link interface for datagrams with destination addresses:

11001000 10010001 01010001 01010101
11100001 01000000 11000011 00111100
11100001 10000000 00010001 01110111

[Answer]
Prefix match for first address is 5th entry: link interface 3
Prefix match for second address is 3rd entry: link interface 2
Prefix match for third address is 4th entry: link interface 3

Problem 12. Consider the topology shown in Figure 4.20. Denote the three subnets with hosts (starting clockwise at 12:00) as Networks A, B, and C. Denote the subnets without hosts as Networks D, E, and F.

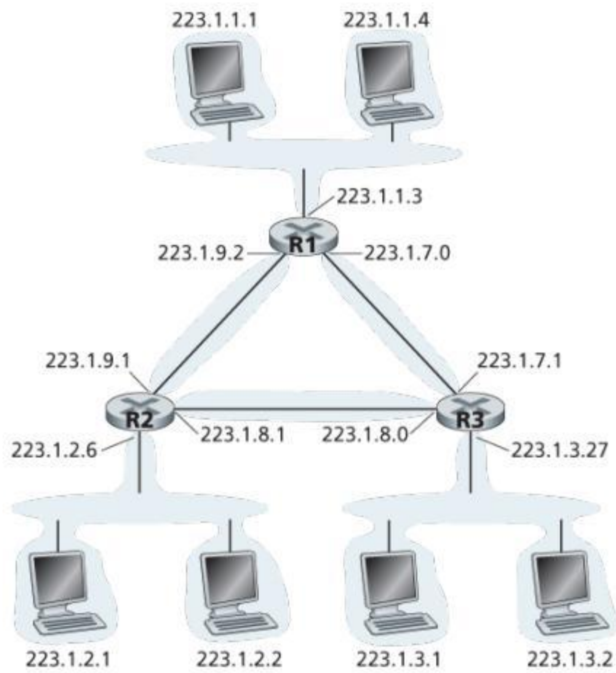


Figure 4.20 Three routers interconnecting six subnets

a. Assign network addresses to each of these six subnets, with the following constraints: All addresses must be allocated from 214.97.254/23; Subnet A should have enough addresses to support 250 interfaces; Subnet B should have enough addresses to support 120 interfaces; and Subnet C should have enough addresses to support 120 interfaces. Of course, subnets D, E and F should each be able to support two interfaces. For each subnet, the assignment should take the form a.b.c.d/x or a.b.c.d/x – e.f.g.h/y.
[Answer]
Subnet A: 214.97.255/24 (256 >= 250)
Subnet B: 214.97.254.0/25 – 214.97.254.0/29 (128 – 8 >= 120)
Subnet C: 214.97.254.128/25 (128 >= 120)

Subnet D: 214.97.254.0/31 (2 >= 2)
Subnet E: 214.97.254.2/31 (2 >= 2)
Subnet F: 214.07.254.4/30 (4 >= 2)

b. Using your answer to part (a), provide the forwarding tables (using longest prefix matching) for each of the three routers.

[Answer]

Router 1

Longest Prefix Match	**Outgoing Interface**
11010110 01100001 11111111	A
11010110 01100001 11111110 0000000	D
11010110 01100001 11111110 000001	F

Router 2

Longest Prefix Match	**Outgoing Interface**
11010110 01100001 11111110 1	C
11010110 01100001 11111110 0000001	E
11010110 01100001 11111110 000001	F

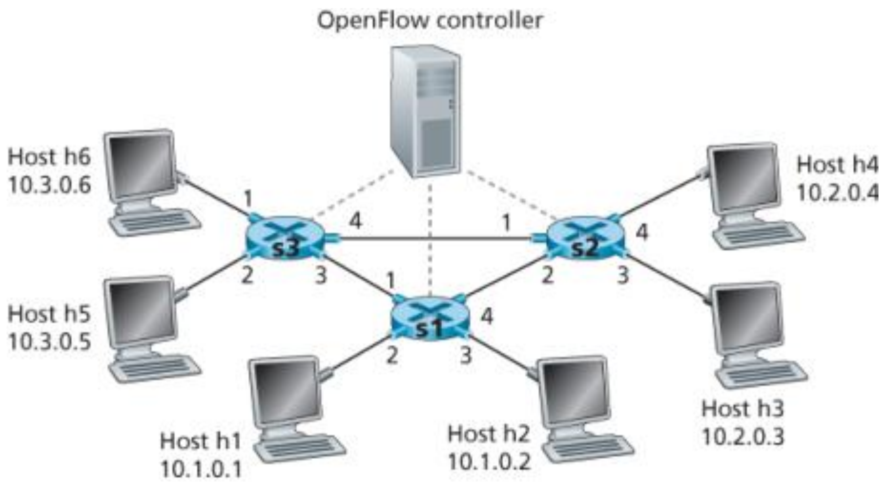
Router 3

Longest Prefix Match	**Outgoing Interface**
11010110 01100001 11111110 0	B
11010110 01100001 11111110 0000000	D
11010110 01100001 11111110 0000001	E

Problem 17. Suppose you are interested in detecting the number of hosts behind a NAT. You observe that the IP layer stamps an identification number sequentially on each IP packet. The identification number of the first IP packet generated by a host is a random number, and the identification numbers of the subsequent IP packets are sequentially assigned. Assume all IP packets generated by hosts behind the NAT are sent to the outside world.

a. Based on this observation, and assuming you can sniff all packets sent by the NAT to the outside, can you outline a simple technique that detects the number of unique hosts behind a NAT? Justify your answer.
   [Answer]
   Yes. If each IP packet has its own id and sequential sequences for each id, the number of different hosts beyond NAT can be estimated by sniffing out the number of independent sequences.
b. If the identification numbers are not sequentially assigned but randomly assigned, would your technique work? Justify your answer.
   [Answer]
   No. Detecting the number of hosts inside NAT is difficult because if all id in an ip packet is randomly allocated, sniffing outside NAT will not find any association between id.

Problem 19. Consider the SDN OpenFlow network shown in Figure 4.30. Suppose that the desired forwarding behavior for datagrams arriving at s2 is as follows:



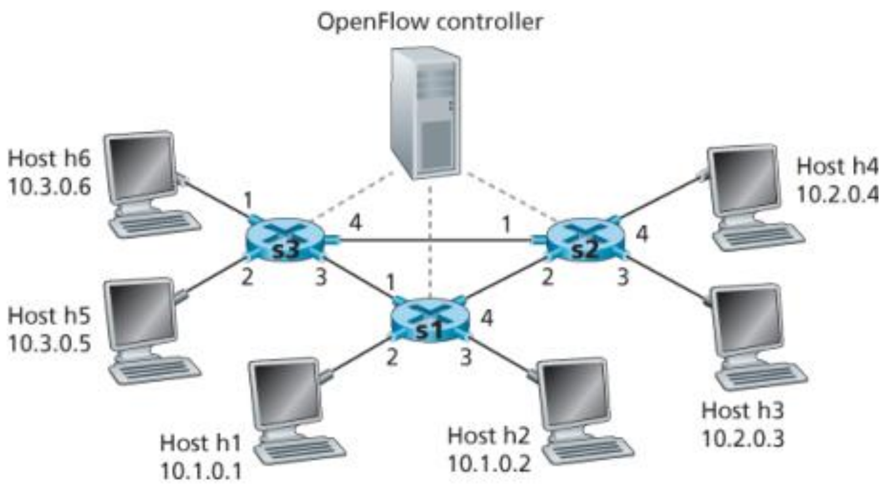
- any datagrams arriving on input port 1 from hosts h5 or h6 that are destined to hosts h1 or h2 should be forwarded over output port 2;
- any datagrams arriving on input port 2 from hosts h1 or h2 that are destined to hosts h5 or h6 should be forwarded over output port 1;
- any arriving datagrams on input ports 1 or 2 and destined to hosts h3 or h4 should be delivered to the host specified;
- hosts h3 and h4 should be able to send datagrams to each other.

Specify the flow table entries in s2 that implement this forwarding behavior.

[Answer]

Rule	Action
input_port: 1 ip_src: 10.3.0.* ip_dst: 10.1.0.*	output_port: 2
input_port: 2 ip_src: 10.1.0.* ip_dst: 10.3.0.*	output_port: 1
input_port: 1 or 2 ip_dst: 10.2.0.3	output_port: 3
input_port: 1 or 2 ip_dst: 10.2.0.4	output_port: 4
input_port: 3 ip_src: 10.2.0.3 ip_dst: 10.2.0.4	output_port: 4
input_port: 4 ip_src: 10.2.0.4 ip_dst: 10.2.0.3	output_port: 3

Problem 20. Consider again the SDN OpenFlow network shown in Figure 4.30. Suppose that the desired forwarding behavior for datagrams arriving from hosts h3 or h4 at s2 is as follows:



- any datagrams arriving from host h3 and destined for h1, h2, h5 or h6 should be forwarded in a clockwise direction in the network;
- any datagrams arriving from host h4 and destined for h1, h2, h5 or h6 should be forwarded in a counter-clockwise direction in the network.

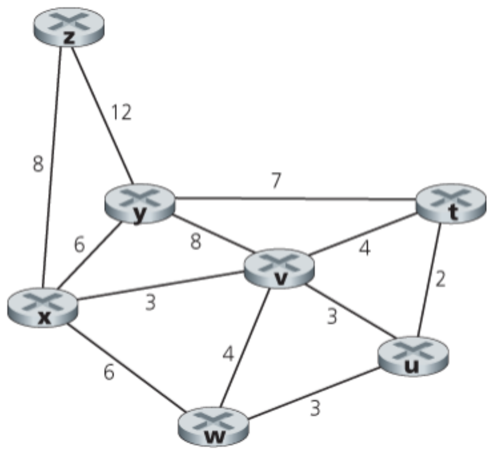
Specify the flow table entries in s2 that implement this forwarding behavior

[Answer]

Rule	Action
input_port: 3 ip_src: 10.2.0.3 ip_dst: 10.3.0.* & 10.1.0.*	output_port: 2
input_port: 4 ip_src: 10.2.0.4 ip_dst: 10.3.0.* & 10.1.0.*	output_port: 1

Chapter 5 Problems

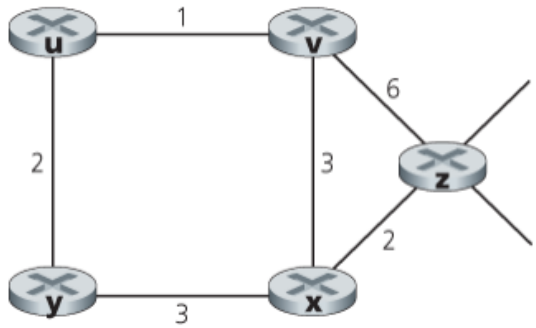
Problem 3. Consider the following network. With the indicated link costs, use Dijkstra's shortest-path algorithm to compute the shortest path from x to all network nodes. Show how the algorithm works by computing a table similar to Table 5.1.



[Answer]

Step	N'	D(y), p(y)	D(z), p(z)	D(v), p(v)	D(w), p(w)	D(u), p(u)	D(t), p(t)
0	x	6, x	8, x	3, x	6, x	∞	∞
1	xv	6, x	8, x		6, x	6, v	7, v
2	xvu	6, x	8, x		6, x		7, v
3	xvut	6, x	8, x		6, x		
4	xvuty		8, x		6, x		
5	xvutyz				6, x		
6	xvutyzw						

Problem 5. Consider the network shown below and assume that each node initially knows the costs to each of its neighbors. Consider the distance-vector algorithm and show the distance table entries at node z.



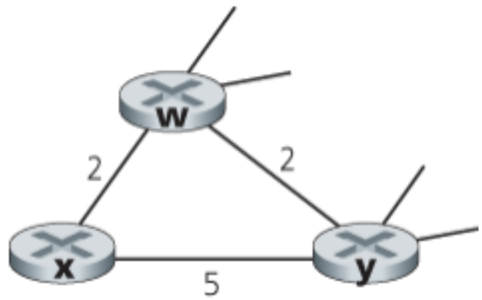
[Answer]

		Cost to				
		u	v	x	y	z
from	v	∞	∞	∞	∞	∞
	x	∞	∞	∞	∞	∞
	z	∞	6	2	∞	0

		Cost to				
		u	v	x	y	z
from	v	1	0	3	∞	6
	x	∞	3	0	3	2
	z	7	5	2	5	0

		Cost to				
		u	v	x	y	z
from	v	1	0	3	3	5
	x	4	3	0	3	2
	z	6	5	2	5	0

Problem 7. Consider the network fragment shown below. x has only two attached neighbors, w and y. w has a minimum-cost path to destination u (not shown) of 5, and y has a minimum-cost path to u of 6. The complete paths from w and y to u (and between w and y) are not shown. All link costs in the network have strictly positive integer values.



a. Give x's distance vector for destinations w, y, and u.
   [Answer]
   Dx(w) = 2, Dx(y) = 4, Dx(u) = 7

b. Give a link-cost change for either c(x, w) or c(x, y) such that x will inform its neighbors of a new minimum-cost path to u as a result of executing the distance-vector algorithm.
   [Answer]
   If c(x, y) is changed to be bigger or smaller, it cannot affect the shortest path from x to u. So, x does not need to advertise a link-cost change.

   (c(x, w) = 1), if c(x, w) is equal to 1, the cost shortest path from x to u is changed to 1 + 5. As a result, x should broadcast the modified data to its neighbors.
   (c(x, w) > 6), if c(x, w) is become bigger than 6, shortest path from x to u is via only y (x - y - u). In this case, x should flood the information about updated distance vector.

c. Give a link-cost change for either c(x, w) or c(x, y) such that x will not inform its neighbors of a new minimum-cost path to u as a result of executing the distance-vector algorithm.
   [Answer]
   If cost of link (x - y) is changed to 6, c(x, y) is still 4 and Dx(u) is never changed. So, in that case x does need to advertise nothing.

Problem 11. Consider Figure 5.7. Suppose there is another router w, connected to router y and z. The costs of all links are given as follows: c(x, y)=4, c(x, z)=50, c(y, w)=1, c(z, w)=1, c(y, z)=3. Suppose that poisoned reverse is used in the distance-vector routing algorithm.

a. When the distance vector routing is stabilized, router w, y, and z inform their distances to x to each other. What distance values do they tell each other?
[Answer]

w	inform y, Dw(x) = ∞ inform z, Dw(x) = 5
y	inform w, Dy(x) = 4 inform z, Dy(x) = 4
z	inform w, Dz(x) = ∞ inform y, Dz(x) = 6

b. Now suppose that the link cost between x and y increases to 60. Will there be a count-to-infinity problem even if poisoned reverse is used? Why or why not? If there is a count-to-infinity problem, then how many iterations are needed for the distance-vector routing to reach a stable state again? Justify your answer.
[Answer]
Yes, it is possible to have count-to-infinity problem.

	0	1	2	3	4
w	y, Dw(x) = ∞ z, Dw(x) = 5		y, Dw(x) = ∞ z, Dw(x) = 10		
y	w, Dy(x) = 4 z, Dy(x) = 4	w, Dy(x) = 9 z, Dy(x) = ∞			w, Dy(x) = 14 z, Dy(x) = ∞
z	w, Dz(x) = ∞ y, Dz(x) = 6			w, Dz(x) = ∞ y, Dz(x) = 11	

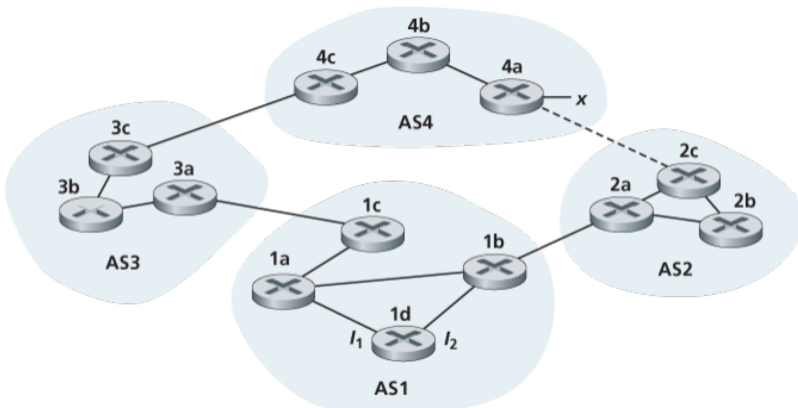
We see that w, y, z forms a loop in their computation of the costs to router x.

	27	28	29	30	31
w		y, Dw(x) = ∞ z, Dw(x) = 50	y, Dw(x) = 51 z, Dw(x) = ∞		Via z, 51
y		w, Dy(x) = 53 z, Dy(x) = ∞			Via z, 52
z	w, Dz(x) = 50 y, Dz(x) = 50			w, Dz(x) = ∞ y, Dz(x) = 52	Via z, 50

At t27, z detects that its least cost to x is 50, via its direct link with x. At t29, w learns its least cost to x is 51 via z. At t30, y updates its least cost to x to be 52 (via w). Finally, at time t31, no updating, and the routing is stabilized.

c. How do you modify c(y, z) such that there is no count-to-infinity problem at all if c(y, x) changes from 4 to 60?
   [Answer]
   If c(y, z) >= 54, then y cannot think it can reach x via z.

Problem 14. 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.



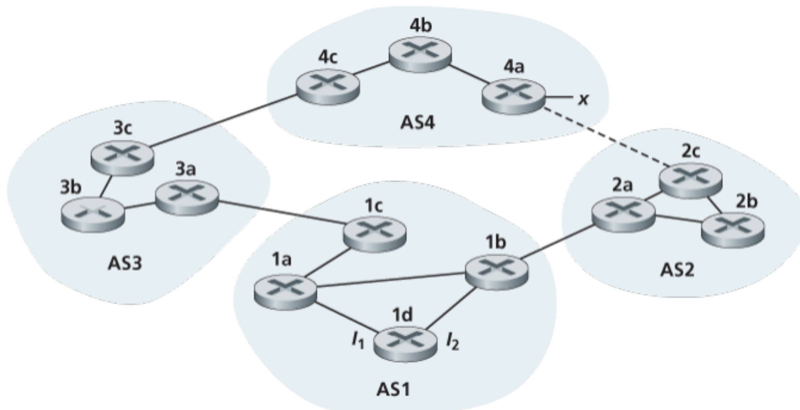
a. Router 3c learns about prefix x from which routing protocol: OSPF, RIP, eBGP, or iBGP?
   [Answer]
   eBGP

b. Router 3a learns about x from which routing protocol?
   [Answer]
   iBGP

c. Router 1c learns about x from which routing protocol?
   [Answer]
   eBGP

d. Router 1d learns about x from which routing protocol?
   [Answer]
   iBGP

Problem 15. Referring to the previous problem, once router 1d learns about x it will put an entry (x, I) in its forwarding table.

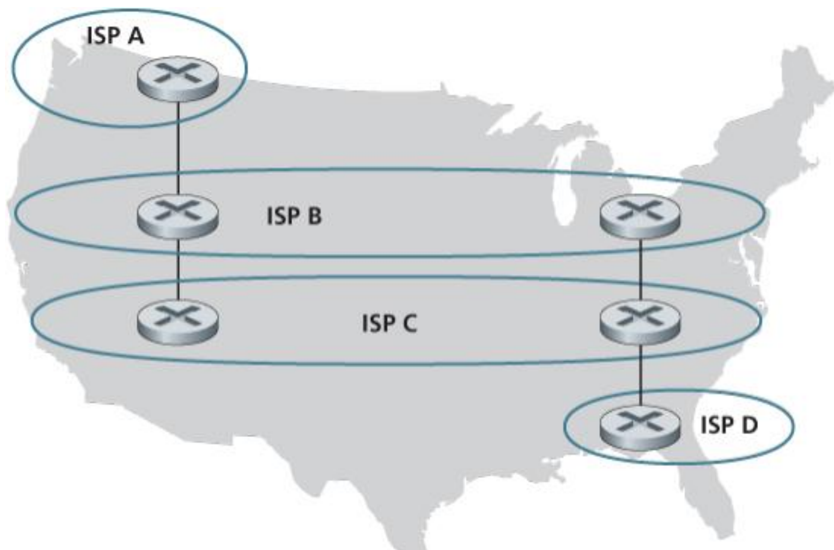


a. Will I be equal to I1 or I2 for this entry? Explain why in one sentence.
   [Answer]
   I = I1, because router 1d uses RIP to forward packets, and the least-cost path (minimum hop count) to the BGP gateway router 1c begins via interface I1.

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 I1 or I2? Explain why in one sentence.
   [Answer]
   I2 will be set for I because both routes have equal AS path length, but I2 begins the path that has the closest next hop router.

c. Now suppose there is another AS, called AS5, which lies on the path between AS2 and AS4 (not shown in diagram). Suppose router 1d learns that x is accessible via AS2 AS5 AS4 as well as via AS3 AS4. Will I be set to I1 or I2? Explain why in one sentence.
   [Answer]
   I1 begins the path that has the shortest AS path just via AS3, AS4.

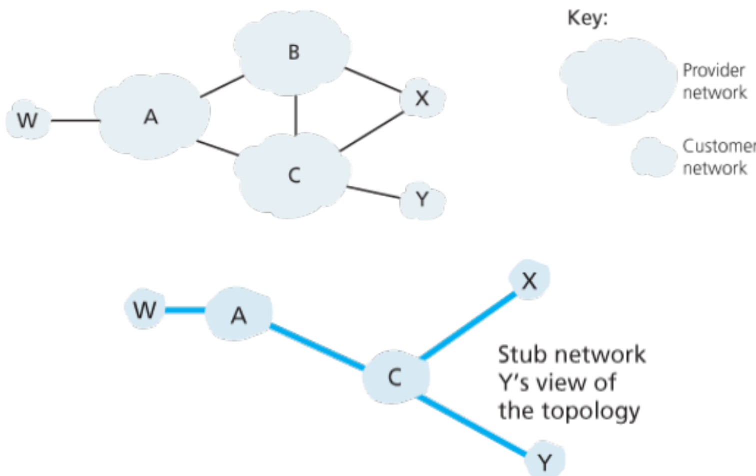
Problem 16. Consider the following network. ISP B provides national backbone service to regional ISP A. ISP C provides national backbone service to regional ISP D. Each ISP consists of one AS. B and C peer with each other in two places using BGP. Consider traffic going from A to D. B would prefer to hand that traffic over to C on the West Coast (so that C would have to absorb the cost of carrying the traffic cross-country), while C would prefer to get the traffic via its East Coast peering point with B (so that B would have carried the traffic across the country). What BGP mechanism might C use, so that B would hand over A-to-D traffic at its East Coast peering point? To answer this question, you will need to dig into the BGP -specification.



[Answer]

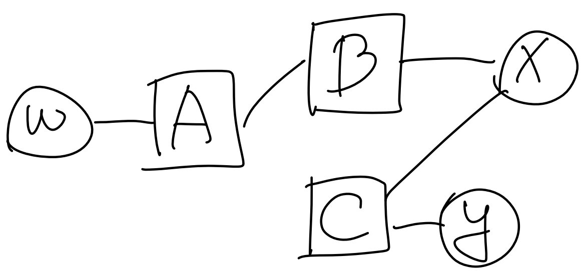
If ISP C advertises a shorter AS path to ISP D at east coast peering point and broadcasts a much longer AS path to ISP D at west coast peering point. Then, ISP B would decide to transfer traffic at east coast peering point because ISP B should service fast and stable internet service to its client, ISP A.

Problem 17. In Figure 5.13, consider the path information that reaches stub networks W, X, and Y. Based on the information available at W and X, what are their respective views of the network topology? Justify your answer. The topology view at Y is shown below.

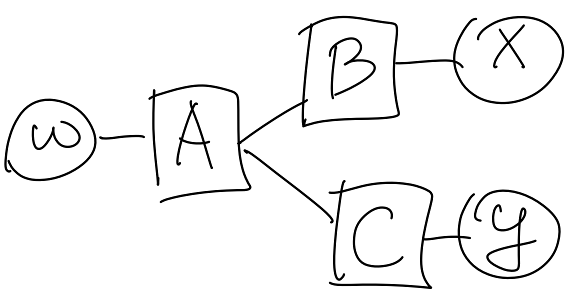


[Answer]

X does not know about the AC link since X does not receive an advertised route to w or to y that contains the AC link (i.e., X receives no advertisement containing both AS A and AS C on the path to a destination.

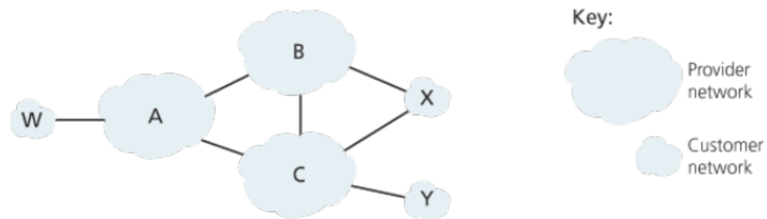


view of X



view of W

Problem 19. In Figure 5.13, suppose that there is another stub network V that is a customer of ISP A. Suppose that B and C have a peering relationship, and A is a customer of both B and C. Suppose that A would like to have the traffic destined to W to come from B only, and the traffic destined to V from either B or C. How should A advertise its routes to B and C? What AS routes does C receive?



[Answer]

A should advise B two routes, AS-paths A-W and A-V.

A should advise C only one route, A-V.

C receives AS paths: B-A-W, B-A-V, A-V.