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Review Questions & Answers
Problems & Answer

Chapter 4

Network layer

Chapter 4: Network layer

1 Let's review some of the terminology used in this textbook. Recall that the name of a transport-layer packet is segment and that the name of a link-layer packet is frame. What is the name of a network-layer packet? Recall that both routers and link-layer switches are called packet switches. What is the fundamental difference between a router and link-layer switch? Recall that we use the term routers for both datagram networks and VC networks.

ANSWER

Let's review some of the terminology used in this textbook. Recall that the name of a transport-layer packet is segment and that the name of a link-layer packet is frame. What is the name of a network-layer packet? Recall that both routers and link-layer switches are called packet switches. What is the fundamental difference between a router and link-layer switch? Recall that we use the term routers for both datagram networks and VC networks.

2 What are the two most important network-layer functions in a datagram net- work? What are the three most important network-layer functions in a virtual- circuit network?

ANSWER

The two most important network-layer functions in a datagram network are

1. Forwarding
2. Routing

3 What is the difference between routing and forwarding?

ANSWER

The difference between routing and forwarding as follows:

- Forwarding is about moving a packet from a router's input link to the appropriate output link.
- Routing is about determining the end-to-routes between sources and destinations.

4 Do the routers in both datagram networks and virtual-circuit networks use for- warding tables? If so, describe the forwarding tables for both classes of networks.

ANSWER:

Yes, both datagram networks and virtual-circuit networks use forwarding tables.

5 Describe some hypothetical services that the network layer can provide to a single packet. Do the same for a flow of packets. Are any of your hypothetical services provided by the Internet's network layer? Are any provided by ATM's CBR service model? Are any provided by ATM's ABR service model?

ANSWER:
The following network layers can be provide hypothetical services are:

- Guaranteed delivery
- Guaranteed delivery with bounded delay

The following network layers can be provide flow of packets are:

- In-order packet delivery
- Guaranteed minimal bandwidth
- Guaranteed maximum jitter
- Security services

The following ATM's CBR(Constant Bit Rate) service model provides:

- Guaranteed delivery of video and audio traffic at a constant bit rate

The following ATM's ABR(Available Bit Rate) service model provides:

- In-order delivery of packets.

6 List some applications that would benefit from ATM's CBR service model.

ANSWER

List some applications that would benefit from ATM's CBR service model.

- Interactive live multimedia applications
- Video conference

7 Discuss why each input port in a high-speed router stores a shadow copy of the forwarding table.

ANSWER:

With the shadow copy, the forwarding decision is made locally, at each input port, without invoking the centralized routing processor. Such decentralized forwarding avoids creating a forwarding processing bottleneck at a single point within the router.

8Three types of switching fabrics are discussed in Section 4.3. List and briefly describe each type. Which, if any, can send multiple packets across the fabric in parallel?

ANSWER

- Switching via memory
- Switching via a bus
- Switching via an interconnection network

9. Describe how packet loss can occur at input ports. Describe how packet loss at input ports can be eliminated (without using infinite buffers).

ANSWER:

The following steps are packet loss can occur at input ports:

- Routers contains input ports. It is using to move packets through forwarding table.
- The forwarding table maintain each router as well as a duplicate copy in the routing process with each input port.
- If the size of the queue is large or slow speed, then the packet loss can occur at input ports.

The following steps are eliminating the packet loss:

- Need to increase the speed at least by number of input ports times.
- Need to reduce the queue size.

10. Describe how packet loss can occur at output ports. Can this loss be prevented by increasing the switch fabric speed?

ANSWER:

Packet loss can occur if the queue size at the output port grows large because of slow outgoing line-speed.

11. What is HOL blocking? Does it occur in input ports or output ports?

ANSWER:

A queued packet in an input queue must wait for transfer through the fabric is called HOL blocking. It is blocked by another packet at the head of the line. It occurs at the input port.

12. Do routers have IP addresses? If so, how many?

Yes.

They have only one address for each interface in router.

13. What is the 32-bit binary equivalent of the IP address 223.1.3.27?

Convert each decimal number to binary in given IP address:
223=11011111
1=00000001
3=00000011
27=00011100

So, the 32-bit binary equivalent of the IP addresses 223.1.3.27:
11011111 00000001 00000011 00011100

14. Visit a host that uses DHCP to obtain its IP address, network mask, default router, and IP address of its local DNS server. List these values.

NOTE: The solution may vary for different hosts that use DHCP.

IP address: 192.168.1.17
Subnet mask: 255.255.255.0
Default router: 192.168.1.254
Local DNS server: 192.168.1.2

15. Suppose there are three routers between a source host and a destination host. Ignoring fragmentation, an IP datagram sent from the source host to the desti- nation host will travel over how many interfaces? How many forwarding tables will be indexed to move the datagram from the source to the destination?

- An IP datagram sent from the source host to the destination host will travel over 8 interfaces.
- 3 forwarding tables will be indexed to move the datagram from the source to the destination

16. Suppose an application generates chunks of 40 bytes of data every 20 msec, and each chunk gets encapsulated in a TCP segment and then an IP datagram. What percentage of each datagram will be overhead, and what percentage will be application data?
Given data:
Suppose an application generates chunks of 40 bytes of data every 20 msec, and each chunk gets encapsulated in a TCP segment and then an IP datagram
That means, TCP segment and IP datagram are 20 bytes each.
Assume to added to the 40 byte to each chunk makes 2*40=80 total bytes.
The overhead is 40 of the 80 total, that means 50%.
So, the percentage will be application data 50%

17. Suppose Host A sends Host B a TCP segment encapsulated in an IP datagram. When Host B receives the datagram, how does the network layer in Host B know it should pass the segment (that is, the payload of the datagram) to TCP rather than to UDP or to something else?

Consider data:

- Suppose Host A Sends Host B a TCP segment encapsulated in an IP datagram. That means, 8-bit field.
- If Host B receives the datagram, then encapsulated Host A sends a TCP segment. Then network layer transfers the data to TCP in the Host B.

18. Suppose you purchase a wireless router and connect it to your cable modem. Also suppose that your ISP dynamically assigns your connected device (that is, your wireless router) one IP address. Also suppose that you have five Pcs at home that use 802.11 to wirelessly connect to your wireless router. How are IP addresses assigned to the five PCs? Does the wireless router use NAT? Why or why not?

Typically, the wireless router includes a DHCP server. DHCP is used to assign IP addresses to the 5 PCs and to the router interface. Yes, the wireless router also uses NAT as it obtains only one IP address from the ISP.

19. Compare and contrast the IPv4 and the IPv6 header fields. Do they have any fields in common?

IPv6 has a fixed length header, which does not include most of the options an IPv4 header can include. Even though the IPv6 header contains two 128 bit addresses (source and destination IP address) the whole header has a fixed length of 40 bytes only. Several of the fields are similar in spirit. Traffic class, payload length, next header and hop limit in IPv6 are respectively similar to type of service, datagram length, upper-layer protocol and time to live in IPv4.

20. It has been said that when IPv6 tunnels through IPv4 routers, IPv6 treats theIPv4 tunnels as link-layer protocols. Do you agree with this statement? Why or why not?

Yes.
The entire IPv6 datagram (including header fields) is encapsulated in an IPv4 datagram

Chapter 4: Network layer

21. Compare and contrast link-state and distance-vector routing algorithms.
ANSWER:

Link state algorithms: Computes the least-cost path between source and destination using complete, global knowledge about the network. Distance-vector routing: The calculation of the least-cost path is carried out in an iterative, distributed manner. A node only knows the neighbor to which it should forward a packet in order to reach given destination along the least-cost path, and the cost of that path from itself to the destination.

22. Discuss how a hierarchical organization of the Internet has made it possible to scale to millions of users.

Routers are organized into autonomous systems (ASs). Within an AS, all routers run the same intra-AS routing protocol. The problem of scale is solved since an router in an AS need only know about routers within its AS and the subnets that attach to the AS. To route across ASes, the inter-AS protocol is based on the AS graph and does not take individual routers into account.

23. Is it necessary that every autonomous system use the same intra-AS routing algorithm? Why or why not?

No. it is not necessary that every autonomous system use the same intra-AS routing algorithm. Because each autonomous system routing has administrative autonomy for routing within an AS.

24. Consider Figure 4.37. Starting with the original table in D, suppose that D receives from A the following advertisement:

Destination Subnet	Next Router	Number of Hops to Destination
z	C	10
w	—	1
x	—	1
....	....	....

Will the table in D change? If so how?

ANSWER:
Consider A sends an advertisement to D, and D receives the advertisement. The table given in Figure 4.37 is at D. After receiving the advertisement from A, the table at D has no impact. The reasons for no impact are listed below:

- Observing the table at A, D can reach Z in (10+1) 11 hops using A.
- But, D can reach Z using path through B in 7 hops. So, D has a path with shorter distance to Z when compared to path through A. **So, there is no need to modify the entry of Z in table of D.**

25. Compare and contrast the advertisements used by RIP and OSPF.

With OSPF, a router periodically broadcasts routing information to all other routers in the AS, not just to its neighbouring routers. This routing information sent by a router has one entry for each of the router's neighbours; the entry gives the distance from the router to the neighbour. A RIP advertisement sent by a router contains information about all the networks in the AS, although this information is only sent to its neighbouring routers.

26. Fill in the blank: RIP advertisements typically announce the number of hops to various destinations. BGP updates, on the other hand, announce the __________ to the various destinations.

RIP advertisements typically announce the number of hops to various destinations. BGP updates, on the other hand, announce the **<u>sequence of ASs on the routes</u>** to the various destinations.

27. Why are different inter-AS and intra-AS protocols used in the Internet?

- Border Gateway Protocol(**BGP**) is used for inter-AS(Autonomous System (AS)) protocols. But, Router Information Protocol(**RIP**) and Open Shortest Path First(**OSPF**) protocol are used for intra-AS protocols.
- Inter-AS protocol provides for the controlled distribution of routing information, but Intra-As protocol are the policy issues play a much less important role in choosing routes
- Inter-AS protocol provides is dominates the quality and the performance, but Intra-As protocol focuses on the performance.

28. Why are policy considerations as important for intra-AS protocols, such as OSPF and RIP, as they are for an inter-AS routing protocol like BGP?

The policy considerations as important for intra-AS protocols, such as OSPF and RIP.
Reasons are as follows:
The OSPF (Open Shortest path First) routing algorithm which is an Intra-AS routing algorithm. It is used to the weights of the links in routing paths that minimize the overall cost. Link weights is used to flow of routing in a network. The goal the maximum link utilization or minimize link utilization is depends on the set of link weight by the router.

29. Define and contrast the following terms: subnet, prefix, and BGP route.

The definition and differences of mentioned terms are

- A **Subnet** is a logical subdivision of an IP network. It does not contain a router.
- A **Prefix** is the portion of the network CIDR address. It does contain a router. One or more subnets are covered.
- The **BGP** messages along with the TCP connection sent over a link.It does contain a router.

30. How does BGP use the NEXT-HOP attribute? How does it use the AS-PATH attribute?

***BGP* protocol:** *BGP* (Border Gateway Protocol) is an Inter-AS routing protocol. The two most important attributes are *AS-PATH* and *NEXT-HOP*.

- The advertisement passed for the prefix values contains the *AS's* in the *AS-PATH*.
- The NEXT-HOP is the router interface that initiates the AS-PATH.
- The routers also uses the *AS-PATH* attribute for multiple paths.
- The first router is configured in the forward table, the router uses the *NEXT-HOP* attribute.

31. Describe how a network administrator of an upper-tier ISP can implement policy when configuring BGP.

The below steps are to network administrator of an upper-tier ISP can implement policy when configuring BGP:

- Let us assume the three *ISPs* such as *ISP A*, *ISP B* and *ISP C*.
- Take *ISP B* does not carry between *ISP A* and *ISP C*.
- Then *ISP A* and *ISP C* have *ISP B* as their *BGP peers*
- *ISP B* does not promote to *ISP A*, which authorization through *ISP C*.

32. What is an important difference between implementing the broadcast abstraction via multiple unicasts, and a single network- (router-) supported broadcast?

Differences between the broadcast abstraction via multiple unicasts and single network router supported broadcast:

- multi-way unicast generates multiple copies from the source node. It is used to find the address of the all the destination nodes.
- Single network router generates duplicate copies to send destinations at same time. It is used to find all the destination addresses. Using unicast routing, the source node then transmits N copies to N destinations.

33. For each of the three general approaches we studied for broadcast communication (uncontrolled flooding, controlled flooding, and spanning-tree broad- cast), are the following statements true or false? You may assume that no packets are lost due to buffer overflow and all packets are delivered on a link in the order in which they were sent.

a. A node may receive multiple copies of the same packet.

b. A node may forward multiple copies of a packet over the same outgoing link.

a)
Uncontrolled Flooding: A node may receive multiple copies of the same packet is TRUE.
Reason: The packet has no end point if broadcasting in an under uncontrolled flooding.
Controlled Flooding: A node may receive multiple copies of the same packet is TRUE.
Reason: The same packet may be forwarded by different links each time
Spanning tree: A node may receive multiple copies of the same packet is FALSE.
Reason: Spanning tree forms a loop if a node receives multiple copies of packet.
b)
Uncontrolled Flooding: A node may forward multiple copies of a packet over the same outgoing link is TRUE.
Reason: The
Controlled Flooding: A node may forward multiple copies of a packet over the same outgoing link is FALSE.
Reason: The traversed link is dropped from the list in controlled flooding.
Spanning tree: A node may forward multiple copies of a packet over the same outgoing link is FALSE.

Reason: Spanning tree forms a loop.

34. When a host joins a multicast group, must it change its IP address to that of the multicast group it is joining?

No, if a host joins a multicast group, must it change its IP address to that of the multicast group it is joining.
Reasons:

- A unique IP address have in each host. By using single source node to transfer packet to subnet in the multicast routing process.
- If host add with multicast routing, then has an own IP address.

35. What are the roles played by the IGMP protocol and a wide-area multicast routing protocol?

IGMP is a protocol run only between the host and its first-hop multicast router. IGMP allows a host to specify (to the first-hop multicast router) the multicast group it wants to join. It is then up to the multicast router to work with other multicast routers (i.e., run a multicast routing protocol) to ensure that the data for the host-joined multicast group is routed to the appropriate last-hop router and from there to the host.

36. What is the difference between a group-shared tree and a source-based tree in the context of multicast routing?
Differences between the Group-shared tree and Source-based tree:

- Group-shared tree is a multicast group includes all the edge routers and hosts.
- Group-shared tree shares a single tree for all the hosts and initiate the multicast join.

- Source based tree is maintaining all these trees to a multicast group. It contains multiple individual trees.
- Source based tree is used multicast packets without hosts.

PROBLEMS

1. In this question, we consider some of the pros and cons of virtual-circuit and datagram networks.
a. Suppose that routers were subjected to conditions that might cause them to fail fairly often. Would this argue in favour of a VC or datagram architecture? Why?
b. Suppose that a source node and a destination require that a fixed amount of capacity always be available at all routers on the path between the source and destination node, for the exclusive use of traffic flowing between this source and destination node. Would this argue in favour of a VC or datagram architecture? Why?
c. Suppose that the links and routers in the network never fail and that rout- ing paths used between all source/destination pairs remains constant. In this scenario, does a VC or datagram architecture have more control traffic overhead? Why?

a)
Assume that routers were subjected to conditions that might cause them to fail fairly often.
I Prefer the data gram architecture. The reasons are:

- VC means virtual circuit network. It is a connection oriented network through router. If network problems occurred by the router failed.
- Data gram architecture is a connection less network. It can handle between the nodes in a network in hectic circumstances.

b)
Assume that a source node and a destination require that a fixed amount of capacity always be available at all routers on the path between the source and destination node, for the exclusive use of traffic flowing between this source and destination node.
In this time, i prefer VC. The reason is that the VC router handles the path between source and destination nodes through a link. It is not possible in data gram architecture.

c)
Assume that the links and routers in the network never fail and that rout- ing paths used between all source/destination pairs remains constant. In this case VC more control traffic overhead in datagram architecture. The reason is that VC is connection -oriented network and not possible to change the network till the transmission of all the packets is completed.

2. Consider a virtual-circuit network. Suppose the VC number is an 8-bit field.

a) **What is the maximum number of virtual circuits that can be carried over a link?**

b) **Suppose a central node determines paths and VC numbers at connection setup. Suppose the same VC number is used on each link along the VC's path. Describe how the central node might determine the VC number at connection setup. Is it possible that there are fewer VCs in progress than the maximum as determined in part (a) yet there is no common free VC number?**

c) **Suppose that different VC numbers are permitted in each link along a VC's path. During connection setup, after an end-to-end path is determined, describe how the links can choose their VC numbers and configure their forwarding tables in a decentralized manner, without reliance on a central node**.

ANSWER

a) Suppose the VC number bit field(n)=8.

The maximum number of virtual circuits that can be carried over a link is $2^n=2^8=256$

b)

- Suppose a central node determines paths and VC numbers at connection setup.
- Suppose the same VC number is used on each link along the VC's path. So, as there are 256 VCs, it is not possible that there are fewer VCs in progress than the maximum length.

c)

During connection setup, each link contains the VC number from 0 to 255. It does not contain same number link for path. Replace VC path instead of packet link.

3. Consider a virtual-circuit network. Suppose the VC number is an 8-bit field.

a) **What is the maximum number of virtual circuits that can be carried over a link?**

b) **Suppose a central node determines paths and VC numbers at connection setup. Suppose the same VC number is used on each link along the VC's path. Describe how the central node might determine the VC number at connection setup. Is it possible that there are fewer VCs in progress than the maximum as determined in part (a) yet there is no common free VC number? c. Suppose that different VC numbers are permitted in each link along a VC's path. During connection setup, after an end-to-end path is determined, describe how the links can choose their VC numbers and configure their forwarding tables in a decentralized manner, without reliance on a central node.**

ANSWER

a)

Suppose the VC number n=8.

The maximum number of virtual circuits that can be carried over a link is $2^n=2^8=256$

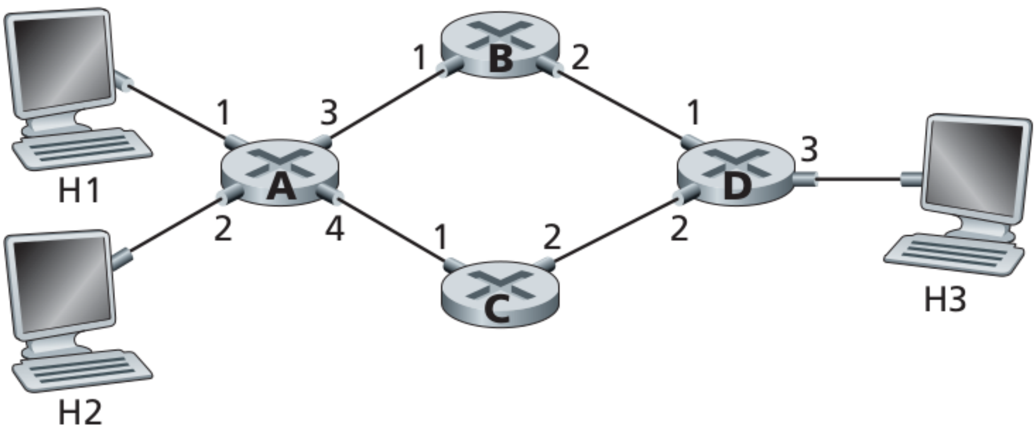
b)

Chapter 4: Network layer

Suppose a central node determines paths and VC numbers at connection setup. Suppose the same VC number is used on each link along the VC's path. So, as there are 256 VCs, it is not possible that there are fewer VCs in progress than the maximum length.

4 Consider the network below.

a) **Suppose that this network is a datagram network. Show the forwarding table in router A, such that all traffic destined to host H3 is forwarded through interface 3.**
b) **Suppose that this network is a datagram network. Can you write down a forwarding table in router A, such that all traffic from H1 destined to host H3 is forwarded through interface 3, while all traffic from H2 destined to host H3 is forwarded through interface 4? (Hint: this is a trick question.)**
c) **Now suppose that this network is a virtual circuit network and that there is one ongoing call between H1 and H3, and another ongoing call between H2 and H3. Write down a forwarding table in router A, such that all traffic from H1 destined to host H3 is forwarded through interface 3, while all traffic from H2 destined to host H3 is forwarded through interface 4.**
d) **Assuming the same scenario as (c), write down the forwarding tables in nodes B, C, and D**



ANSWER
a)

Taken the given data and figure:
Suppose that the forwarding table in router A, such that all traffic destined to host H3 is forwarded through interface 3 in datagram network.
It contains,

- Destination address
- Link Interface

The destination address is H3 and link interface is 3.
b)
No.

It is not possible for a forwarding table in router A, such that all traffic from H1 destined to host H3 is forwarded through interface 3, while all traffic from H2 destined to host H3 is forwarded through interface 4.

c)

Suppose that this network is a virtual circuit network and that there is one ongoing call between H1 and H3, and another ongoing call between H2 and H3.

After clear observations, the forwarding table in router A, such that all traffic from H1 destined to host H3 is forwarded through interface 3, while all traffic from H2 destined to host H3 is forwarded through interface 4 is as follows:

Incoming Interface	Incoming VC#	Outgoing Interface	Outgoing VC#
1	12	3	22
2	63	4	18

5. Consider a VC network with a 2-bit field for the VC number. Suppose that the network wants to set up a virtual circuit over four links: link A, link B, link C, and link D. Suppose that each of these links is currently carrying two other virtual circuits, and the VC numbers of these other VCs are as follows:

Link A	Link B	Link C	Link D
00	01	10	11
01	10	11	00

In answering the following questions, keep in mind that each of the existing VCs may only be traversing one of the four links.

- **a) If each VC is required to use the same VC number on all links along its path, what VC number could be assigned to the new VC?**
- **b) If each VC is permitted to have different VC numbers in the different links along its path (so that forwarding tables must perform VC number translation), how many different combinations of four VC numbers (one for each of the four links) could be used?**

ANSWER:

The VC (virtual circuit) number contains two digits. So, the size of VC number is 2 bits. To step the network, the VC uses four links A, B, C and D respectively. Each link carries two links.

a.

It is not possible to establish a new VC over the network. The VC is using a number with 2 bits size.

Only four numbers can be created using 2 bits number. **There are four links in total and there is no room for the new VC.**

b.

The number of links is 4, and size of VC numbers is 2.

The number of combinations can be calculated as 2^4=16.

Therefore, each VC can have one of these combinations.

Example combination is (00,10,00,01).

Chapter 4: Network layer

6. In the text we have used the term connection-oriented service to describe a transport-layer service and connection service for a network-layer service. Why the subtle shades in terminology?

ANSWER:

- The term connection-oriented service for a transport-layer service as communication session between the nodes terminology is used for virtual circuit in Transport layer.
- The term connection service for a network-layer service as an end-to-end terminology connection service is used for virtual circuit in network layer.

7. Suppose two packets arrive to two different input ports of a router at exactly the same time. Also suppose there are no other packets anywhere in the router.

a) **Suppose the two packets are to be forwarded to two different output ports. Is it possible to forward the two packets through the switch fabric at the same time when the fabric uses a shared bus?**
b) **Suppose the two packets are to be forwarded to two different output ports. Is it possible to forward the two packets through the switch fabric at the same time when the fabric uses a crossbar?**
c) **Suppose the two packets are to be forwarded to the same output port. Is it possible to forward the two packets through the switch fabric at the same time when the fabric uses a crossbar?**

ANSWER:

a) No
b) No
c) Yes

8. In Section 4.3, we noted that the maximum queuing delay is (n–1) D if the switching fabric is n times faster than the input line rates. Suppose that all packets are of the same length, n packets arrive at the same time to the n input ports, and all n packets want to be forwarded to different output ports. What is the maximum delay for a packet for the (a) memory, (b) bus, and (c) crossbar switching fabrics?

ANSWER:

Consider the given data:
Assume packet length=n
Maximum queuing delay= (n–1)D

All packets are of the same length, n packets arrive at the same time to the n input ports, and all n packets want to be forwarded to different output ports.

a)

The maximum delay for a packet for the memory = (n-1)D

b)

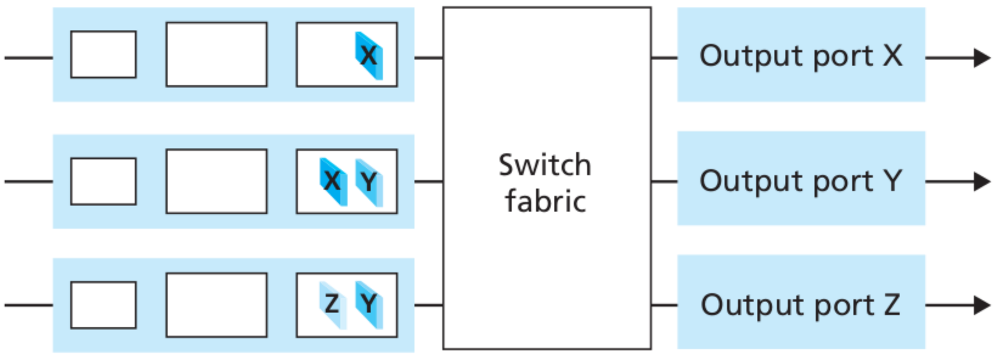
The maximum delay for a packet for the bus = (n-1)D

c)

The maximum delay for a packet for the crossbar switching fabrics= 0

9. Consider the switch shown below. Suppose that all datagrams have the same fixed length, that the switch operates in a slotted, synchronous manner, and that in one time slot a datagram can be transferred from an input port to an output port. The switch fabric is a crossbar so that at most one datagram can

be transferred to a given output port in a time slot, but different output ports can receive datagrams from different input ports in a single time slot. What is the minimal number of time slots needed to transfer the packets shown from input ports to their output ports, assuming any input queue scheduling order you want (i.e., it need not have HOL blocking)? What is the largest number of slots needed, assuming the worst-case scheduling order you can devise, assuming that a non-empty input queue is never idle?



Answer

The minimal number of time slots needed is 3. The scheduling is as follows.

Slot 1: send X in top input queue, send Y in middle input queue.

Slot 2: send X in middle input queue, send Y in bottom input queue

Slot 3: send Z in bottom input queue.

Largest number of slots is still 3. Actually, based on the assumption that a non-empty input queue is never idle, we see that the first time slot always consists of sending X in the top input queue and Y in either middle or bottom input queue, and in the second time slot, we can always send two more datagram, and the last datagram can be sent in third time slot. NOTE: Actually, if the first datagram in the bottom input queue is X, then the worst case would require 4 time slots

Chapter 4: Network layer

10: 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 has five entries, uses longest prefix matching, and forwards packets to the correct link interfaces.

b) Describe how your forwarding table determines the appropriate link inter- face for datagrams with destination addresses:

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

ANSWER:

Prefix Match Link Interface
11100000 0
11100001 00000000 1
11100001 2
otherwise 3

b) Prefix match for first address is 4th entry: link interface 3
Prefix match for second address is 2nd entry: link interface 1
Prefix match for first address is 3rd entry: link interface 2

11. Consider a datagram network using 8-bit host addresses. Suppose a router uses longest prefix matching and has the following forwarding table:

Prefix Match	Interface
00	0
010	1
011	2
10	2
11	3

For each of the four interfaces, give the associated range of destination host addresses and the number of addresses in the range.

ANSWER:

Destination Address Range Link Interface

00000000
through 0
00111111

01000000
through 1
01111111

10000000
through 2
10111111

11000000
through 3
11111111

Number of addresses in each range = $2^6 = 64$

12. Consider a datagram network using 8-bit host addresses. Suppose a router uses longest prefix matching and has the following forwarding table:

Prefix Match	Interface
1	0
10	1
111	2
otherwise	3

For each of the four interfaces, give the associated range of destination host addresses and the number of addresses in the range.

ANSWER:

Destination Address Range Link Interface
--

10000000
through (64 addresses) 0
10111111

11000000
through(32 addresses) 1
11011111

11100000
through (32 addresses) 2
11111111

00000000
through (128 addresses) 3
01111111

13. Consider a router that interconnects three subnets: Subnet 1, Subnet 2, and Subnet 3. Suppose all of the interfaces in each of these three subnets are required to have the prefix 223.1.17/24. Also suppose that Subnet 1 is required to support at least 60 interfaces, Subnet 2 is to support at least 90 interfaces, and Subnet 3 is to support at least 12 interfaces. Provide three net- work addresses (of the form a.b.c.d/x) that satisfy these constraints.

ANSWER:

Three network addresses (of the form a.b.c.d/x) that satisfy given constraints as follows:

- 223.1.17.0/25
- 223.1.17.128/26
- 223.1.17.192/26

14: In the below forwarding table (using longest prefix matching) is given. Rewrite this forwarding table using the a.b.c.d/x notation instead of the binary string notation.

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

ANSWER:

Destination Address Link Interface

200.23.16/21 0
200.23.24/24 1
200.23.24/21 2
otherwise 3

15. **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

Rewrite this forwarding table using the a.b.c.d/x notation instead of the binary string notation.

ANSWER:

Take the forwarding table (using longest prefix matching) in problem 10.

Range of Destination address	Link interface
11100000 00000000 00000000 00000000 through 11100000 00111111 11111111 1111111	0
11100000 01000000 00000000 00000000 through 11100000 01000000 11111111 11111111	1
11100000 01000001 00000000 00000000 through 11100001 01111111 11111111 11111111	2
Otherwise	3

Now the following steps are used for the above forwarding table convert the *a.b.c.d/x* notation:

- The number of significant bits used to identify a network.
- Identify hosts are remaining 32-n bits
- The network prefix defined is \x

Range of Destination address	**Link interface**
224.0.0.0/10	0
224.64.0.0/16	1
224.65.0.0/7	2
Otherwise	3

16. Consider a subnet with prefix 128.119.40.128/26. Give an example of one IP address (of form xxx.xxx.xxx.xxx) that can be assigned to this network. Suppose an ISP owns the

block of addresses of the form 128.119.40.64/26. Suppose it wants to create four subnets from this block, with each block having the same number of IP addresses. What are the prefixes (of form a.b.c.d/x) for the four subnets?

ANSWER:

he prefixes (of form a.b.c.d/x) for the four subnets as follows:

Destination Address Link Interface
200.23.16/21 0
200.23.24/24 1
200.23.24/21 2
otherwise 3

17. Consider the topology shown in Figure 4.17. Denote the three subnets with hosts (starting clockwise at 12:00) as Networks A, B, and C. Denote the sub- nets without hosts as Networks D, E, and F.

a) **Assign network addresses to each of these six subnets, with the follow- ing constraints: All addresses must be allocated from 214.97.254/23; Subnet A should have enough addresses to support 250 interfaces; Sub- net 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.**
b) **Using your answer to part (a), provide the forwarding tables (using longest prefix matching) for each of the three routers.**

ANSWER:

a)

Subnet A: 214.97.255/24 (256 addresses)

Subnet B: 214.97.254.0/25 - 214.97.254.0/29 (128-8 = 120 addresses)

Subnet C: 214.97.254.128/25 (128 addresses)

Subnet D: 214.97.254.0/31 (2 addresses)

Subnet E: 214.97.254.2/31 (2 addresses)

Subnet F: 214.97.254.4/30 (4 addresses)

b)

To simplify the solution, assume that no data grams have router interfaces as ultimate destinations. Also, label D, E, F for the upper-right, bottom, and upper-left interior subnets, respectively.

Router 1:

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

Router 2:

Longest Prefix Match Outgoing Interface
11010110 01100001 11111111 0000000 Subnet D
11010110 01100001 11111110 0 Subnet B
11010110 01100001 11111110 0000001 Subnet E

Router 3:

Longest Prefix Match Outgoing Interface
11010110 01100001 11111111 000001 Subnet F
11010110 01100001 11111110 0000001 Subnet E
11010110 01100001 11111110 1 Subnet C

18. Use the whois service at the American Registry for Internet Numbers (http://www.arin.net/whois) to determine the IP address blocks for three universities. Can the whois services be used to determine with certainty the geographical location of a specific IP address? Use www.maxmind.com to determine the locations of the Web servers at each of these universities.

ANSWER:

Let us assume the three universities:

1. "Stanford University",
2. "New York University" and
3. "Chicago University"

Consider the website "www.maxmind.com" and "http://www.arin.net/whois" to find the above university IP addresses.

The specific IP address of Stanford University: 140.142.0.0-140.142.255.255

It is denoted by the notation: 140.142.0.0/16.

The specific IP address of New York University: 128.238.0.0 -128.238.255.255

It is denoted by the notation:128.238.0.0/16

The specific IP address of Chicago University: 171.64.0.0-171.67.255.255

It is denoted by the notation: 128.64.0.0/24

19. Consider sending a 2400-byte datagram into a link that has an MTU of 700 bytes. Suppose the original datagram is stamped with the identification number 422. How many fragments are generated? What are the values in the various fields in the IP datagram(s) generated related to fragmentation?

ANSWER:

Given data:

Datagram = 2400 bytes

IP header =20

MTU (Maximum Transmission Unit)=700

The original datagram is stamped with the identification number= 422.

Formula:

$$\text{The required number of fragments} = \left\lceil \frac{\text{Datagram} - \text{IP header}}{\text{MTU} - \text{IP header}} \right\rceil.$$

$$= \left\lceil \frac{2400 - 20}{700 - 20} \right\rceil$$

$$= \left\lceil \frac{2380}{680} \right\rceil$$

$$= \lceil 3.5 \rceil$$

$$\approx 4$$

So, the number of fragments generated is 4.

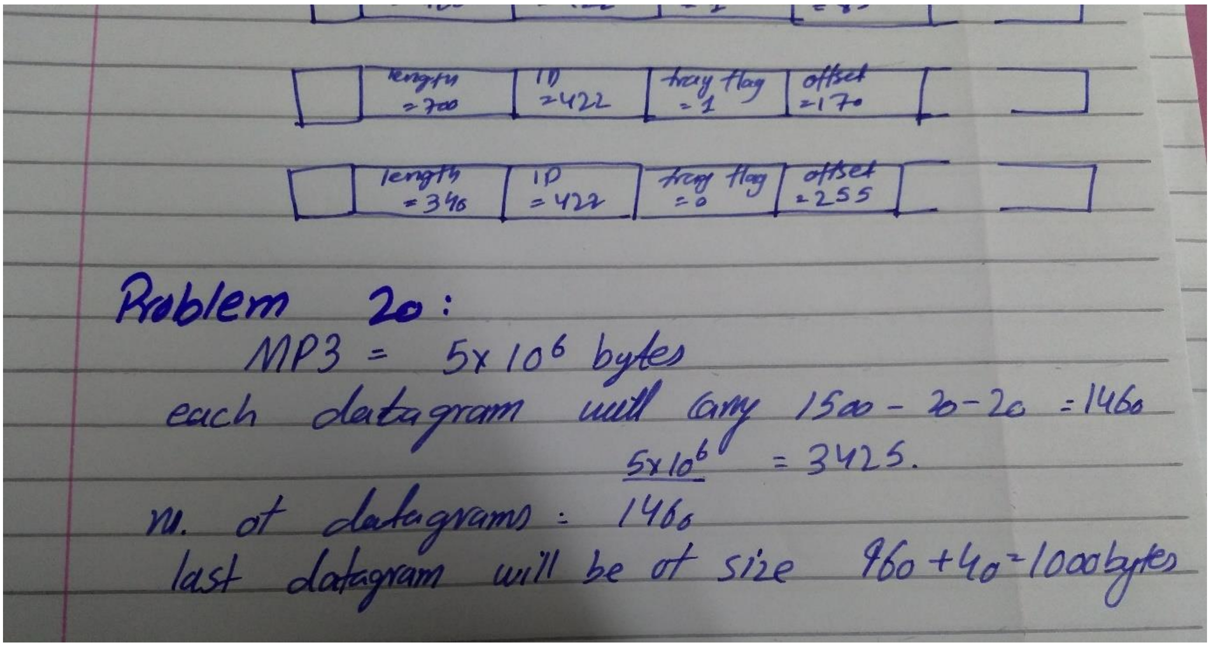
The following table displays the values in the various fields in the IP datagrams for the 4 fragments:

Fragment Value	*Bytes in Data field of Datagram*	*Identification number*	*Fragmentation Offset*	*Flag*
1	700-20=**680**	422	**0**	**Flag=1**
2	700-20=**680**	422	**85** (85×8=6ชบ byte)	**Flag=1**
3	700-20=**680**	422	**170** ($170 \times 8 = 1360$ byte)	**Flag=1**
4	2380-3(680)=**340**	422	**255** ($255 \times 8 = 2040$ byte)	**Flag= 0**

NOTE: If fragments more than represents Flag=1, otherwise Flag=0

20. Suppose datagrams are limited to 1,500 bytes (including header) between source Host A and destination Host B. Assuming a 20-byte IP header, how many datagrams would be required to send an MP3 consisting of 5 million bytes? Explain how you computed your answer.

ANSWER:



length =700 | ID =422 | frag flag =1 | offset =170

length =346 | ID =422 | frag flag =0 | offset =255

Problem 20:

MP3 = 5×10^6 bytes

each datagram will carry 1500 - 20 - 20 = 1460

no. of datagrams = $\frac{5 \times 10^6}{1460}$ = 3425.

last datagram will be of size 960 + 40 = 1000 bytes

21. Consider the network setup in Figure 4.22. Suppose that the ISP instead assigns the router the address 24.34.112.235 and that the network address of the home network is 192.168.1/24.

a. Assign addresses to all interfaces in the home network.

b. Suppose each host has two ongoing TCP connections, all to port 80 at host 128.119.40.86. Provide the six corresponding entries in the NAT translation table.

ANSWER:

a) Home address : 192.168.1.1, 192.168.1.2, 192.168.1.3, 192.168.1.4
b) NAT Translation table

WAN side	LAN side
24.34.112.235.4000	192.168.1.1.3345
24.34.112.235.4001	192.168.1.1.3346
24.34.112.235.4002	192.168.1.1.3345
24.34.112.235.4003	192.168.1.1.3346
24.34.112.235.4004	192.168.1.1.3345
24.34.112.235.4005	192.168.1.1.3346

22: 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.**

b) **If the identification numbers are not sequentially assigned but randomly assigned, would your technique work? Justify your answer.**

ANSWER:

a) Since all IP packets are sent outside, so we can use a packet sniffer to record all IP packets generated by the hosts behind a NAT. As each host generates a sequence of IP packets with sequential numbers and a distinct (very likely, as they are randomly chosen from a large space) initial identification number (ID), we can group IP packets with consecutive IDs into a cluster. The number of clusters is the number of hosts behind the NAT.

For more practical algorithms, see the following papers.

"A Technique for Counting NATted Hosts", by Steven M. Bellovin, appeared in IMW'02, Nov. 6-8, 2002, Marseille, France.
"Exploiting the IPID field to infer network path and end-system characteristics."
Weifeng Chen, Yong Huang, Bruno F. Ribeiro, Kyoungwon Suh, Honggang Zhang, Edmundo de Souza e Silva, Jim Kurose, and Don Towsley.
PAM'05 Workshop, March 31 - April 01, 2005. Boston, MA, USA.

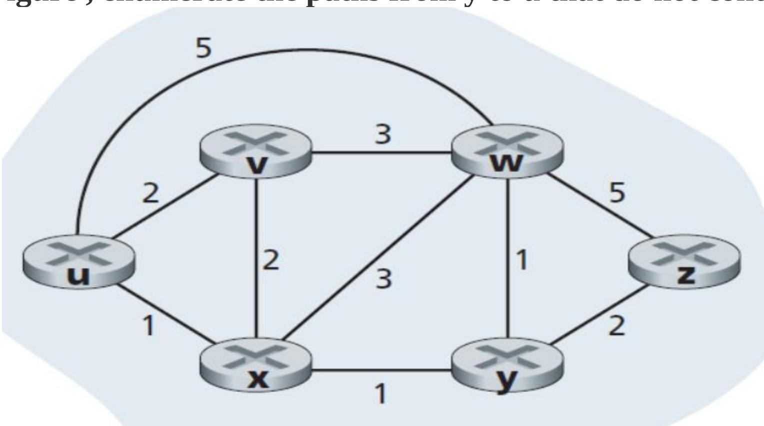
b) However, if those identification numbers are not sequentially assigned but randomly assigned, the technique suggested in part (a) won't work, as there won't be clusters in sniffed data.

23. In this problem we'll explore the impact of NATs on P2P applications. Suppose a peer with username Arnold discovers through querying that a peer with username Bernard has a file it wants to download. Also suppose that Bernard and Arnold are both behind a NAT. Try to devise a technique that will allow Arnold to establish a TCP connection with Bernard without application-specific NAT configuration. If you have difficulty devising such a technique, discuss why.

Answer:

It is not possible to devise such a technique. In order to establish a direct TCP connection between Arnold and Bernard, either Arnold or Bob must initiate a connection to the other. But the NATs covering Arnold and Bob drop SYN packets arriving from the WAN side. Thus neither Arnold nor Bob can initiate a TCP connection to the other if they are both behind NATs.

24. Looking at Figure , enumerate the paths from y to u that do not contain any loops.



ANSWER:

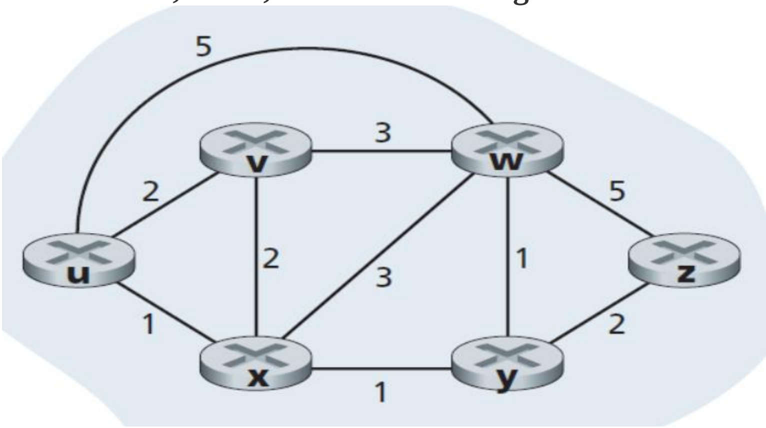
The following paths from 'y' to 'u' that do not contain any loops:

1. y-x-u
2. y-w-u
3. y-x-v-u
4. y-w-v-u
5. y-w-x-u
6. y-x-w-u
7. y-z-w-u
8. y-x-w-v-u
9. y-z-w-v-u
10. y-w-v-x-u
11. y-x-v-w-u
12. y-z-w-x-u
13. y-w-x-v-u
14. y-z-w-v-x-u
15. y-z-w-x-v-u

So, there are total 15 paths that do not form cycles from path "y" to path "u".

Chapter 4: Network layer

25: **Find the path from x to z, z to u, and z to w in the given network.**



ANSWER:

There are 11 paths found that do not form cycles from "x" to "z". Those 11 paths are as follows:

1. **x-y-z**
2. **x-w-z**
3. **x-y-w-z**
4. **x-w-y-z**
5. **x-v-w-z**
6. **x-u-w-z**
7. **x-v-w-y-z**
8. **x-u-v-w-z**
9. **x-u-w-y-z**
10. **x-u-v-w-y-z**
11. **x-v-u-w-y-z**

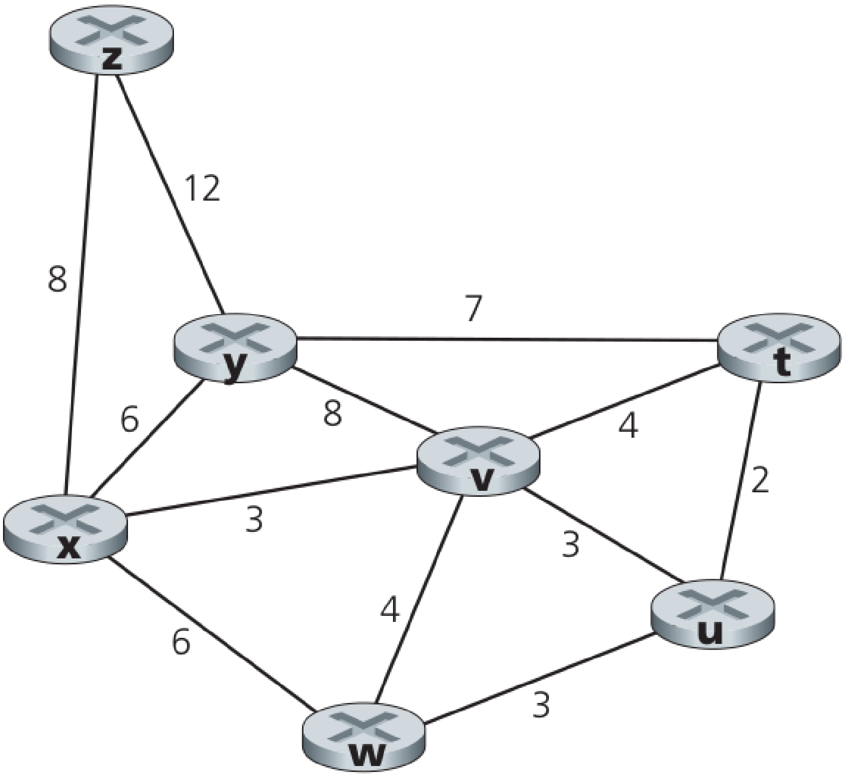
There are 18 paths found that do not form cycles from "z" to "u". Those 18 paths are as follows:

1. **z-w-u**
2. **z-y-w-u**
3. **z-w-v-u**
4. **z-y-x-u**
5. **z-y-w-u**
6. **z-w-x-u**
7. **z-y-w-x-u**
8. **z-w-y-x-u**
9. **z-w-x-v-u**
10. **z-w-v-x-u**
11. **z-y-x-w-u**
12. **z-y-x-v-u**
13. **z-y-w-v-u**
14. **z-y-x-w-v-u**
15. **z-y-x-v-w-u**
16. **z-y-w-x-v-u**
17. **z-y-w-v-x-u**
18. **z-w-y-x-v-u**

There are 7 paths found that do not form cycles from "z" to "w". Those 7 paths are as follows:

1. **z-w**
2. **z-y-w**
3. **z-y-x-w**
4. **z-y-x-v-w**
5. **z-y-x-u-w**
6. **z-y-x-u-v-w**
7. **z-y-x-v-u-w**

26. **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.**



ANSWER:

Given diagram contains nodes t, u,v,w,x,y, and z.

The below table is the computation of shortest path from source x to all the nodes by using Dijkstra's algorithm:

S'	*l(t),c(t)*	*l(u),c(u)*	*l(v),c(v)*	*l(w),c(w)*	*l(y),c(y)*	*l(z),c(z)*
x	∞	∞	3,x	6,x	6,x	8,x
x**v**	7,v	6,v	**3,x**	6,x	6,x	8,x
xv**u**	7,v	**6,v**	3,x	6,x	6,x	8,x
xvuw	7,v	6,v	3,x	**6,x**	6,x	8,x
xvuwy	7,v	6,v	3,x	6,x	**6,x**	8,x
xvuwy**t**	**7,v**	6,v	3,x	6,x	6,x	8,x
xvuwy**tz**	7,v	6,v	3,x	6,x	6,x	**8,x**

Here,
S' = subset of nodes.
c(v) = Current path of node v
l(v) = Least cost path of node v

So, the following are shortest paths from **x** along with their costs:

t: xvt = **7;**

u: xvu = **6;**

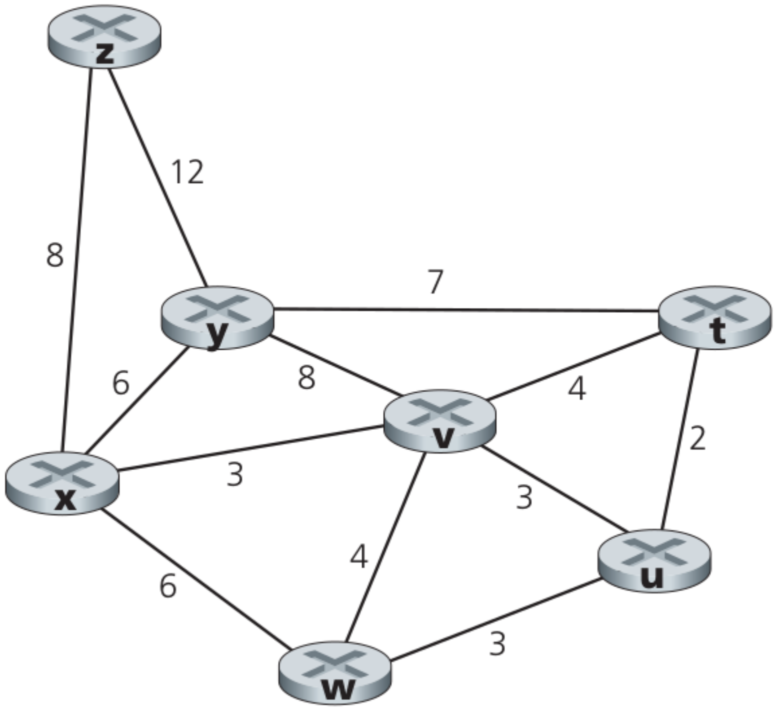
v: xv = **3;**

w: xw = **6;**

y: xy = **6;**

z: xz = **8**

27. Consider the network shown below. Using Dijkstra's algorithm, and showing your work using a table similar to Table 4.3, do the following:
a. Compute the shortest path from t to all network nodes.
b. Compute the shortest path from u to all network nodes.
c. Compute the shortest path from v to all network nodes.
d. Compute the shortest path from w to all network nodes.
e. Compute the shortest path from y to all network nodes.
f. Compute the shortest path from z to all network nodes.



ANSWER:

Refer the Dijkstra's algorithm and the problem 26 in the text book.

a)

The shortest path from t to all network nodes:

Num	***N'***	***D(u),p(u)***	***D(v),p(v)***	***D(w),p(w)***	***D(x),p(x)***	***D(y),p(y)***	***D(z),p(z)***
0	**t**	2,t	4,t	∞	∞	7,t	∞
1	t**u**	**2,t**	4,t	5,u	∞	7,t	∞
2	tu**v**	2,t	**4,t**	5,u	7,v	7,t	∞
3	tuv**w**	2,t	4,t	**5,u**	7,v	7,t	∞
4	tuvw**x**	2,t	4,t	5,u	**7,v**	7,t	15,x
5	tuvwx**y**	2,t	4,t	5,u	7,v	**7,t**	15,x
6	tuvwxy**z**	2,t	4,t	5,u	7,v	7,t	**15,x**

Here, assume N'=subset of nodes, D(v)= The path from the source to the destination for the node,v. p(v)=The path with least cost from source to node, ***v.***

b)

The shortest path from u to all network nodes:

Num	***N'***	***D(t),p(t)***	***D(v),p(v)***	***D(w),p(w)***	***D(x),p(x)***	***D(y),p(y)***	***D(z),p(z)***
0	**u**	2,u	3,u	3,u	∞	∞	∞
1	u**t**	**2,u**	3,u	3,u	∞	9,t	∞
2	ut**v**	2,u	**3,u**	3,u	6,v	9,t	∞
3	utv**w**	2,u	3,u	**3,u**	6,v	9,t	∞
4	utvw**x**	2,u	3,u	3,u	**6,v**	9,t	14,x
5	utvwx**y**	2,u	3,u	3,u	6,v	**9,t**	14,x
6	utvwxy**z**	2,u	3,u	3,u	6,v	9,t	**14,x**

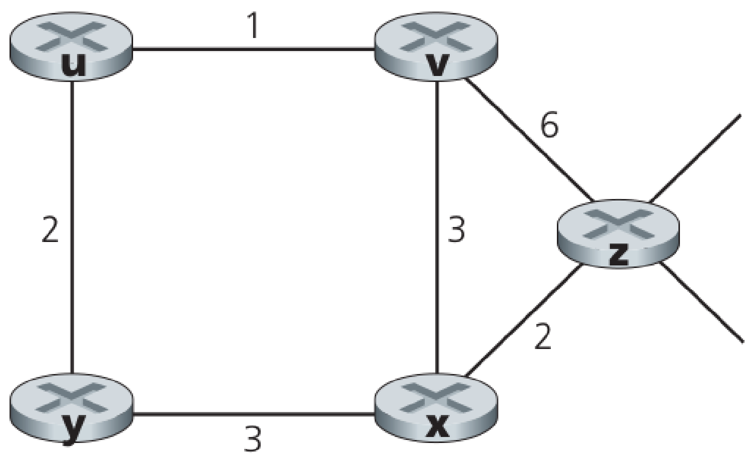
c)
The shortest path from v to all network nodes:

Num	*N'*	*D(t),p(t)*	*D(u),p(u)*	*D(w),p(w)*	*D(x),p(x)*	*D(y),p(y)*	*D(z),p(z)*
0	**v**	4,v	3,v	4,v	3,v	8,v	∞
1	v**x**	4,v	3,v	4,v	**3,v**	8,v	11,x
2	vx**u**	4,v	**3,v**	4,v	3,v	8,v	11,x
3	vxu**t**	**4,v**	3,v	4,v	3,v	8,v	11,x
4	vxut**w**	4,v	3,v	**4,v**	3,v	8,v	11,x
5	vxutw**y**	4,v	3,v	4,v	3,v	**8,v**	11,x
6	vxutwy**z**	4,v	3,v	4,v	3,v	8,v	**11,x**

d)
The shortest path from w to all network nodes:

Step	*N'*	*D(t),p(t)*	*D(u),p(u)*	*D(v),p(v)*	*D(x),p(x)*	*D(y),p(y)*	*D(z),p(z)*
0	**w**		3,w	4,w	6,w	∞	∞
1	w**u**	5,u	**3,w**	4,w	6,w	∞	∞
2	wu**v**	5,u	3,w	**4,w**	6,w	12,v	∞
3	wuv**t**	**5,u**	3,w	4,w	6,w	12,v	∞
4	wuvt**x**	5,u	3,w	4,w	**6,w**	12,v	14,x
5	wuvtx**y**	5,u	3,w	4,w	6,w	**12,v**	14,x
6	wuvtxy**z**	5,u	3,w	4,w	6,w	12,v	**14,x**

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



ANSWER:

Distance vector routing algorithm exchanges the information with the neighbours and works asynchronously.

According to the distance vector algorithm, any node *m* computes the distance vector using the following formulas:

$$D_m(m) = 0$$
$$D_m(n) = \min\{c(m,n) + D_n(n), c(m,n) + D_o(n)\}$$
$$D_m(o) = \min\{c(m,n) + D_n(o), c(m,o) + D_o(o)\}$$

Note: NA is used when there is no distance value.

Construct the distance vector table for node *z* from the network diagram:

	u	*v*	*x*	*y*	*z*
v	*NA*	*NA*	*NA*	*NA*	*NA*
x	*NA*	*NA*	*NA*	*NA*	*NA*
z	*NA*	6	2	*NA*	0

Now update the table with costs of all the neighboring nodes.

	u	*v*	*x*	*y*	*z*
v	1	0	3	*NA*	6
x	*NA*	3	0	3	2
z	*NA*	6	2	*NA*	0

Update the table with minimum costs using the distance vector routing algorithm:

Example: *v* to *y*, two paths are available. *v-u-y* and *v-x-y* with costs 3 and 6 respectively. So, *v-u-y* is the path with minimum cost. Hence update the table with this value.

	u	*v*	*x*	*y*	*z*
v	1	0	3	3	5
x	4	3	0	3	2
z	6	5	2	5	0

Therefore, at node *z*, the above table will be computed by the distance vector routing algorithm.

29. Consider a general topology (that is, not the specific network shown above) and a synchronous version of the distance-vector algorithm. Suppose that at each iteration, a node exchanges its distance vectors with its neighbors and receives their distance vectors. Assuming that the algorithm begins with each node knowing only the costs to its immediate neighbors, what is the maximum number of iterations required before the distributed algorithm converges? Justify your answer.

ANSWER:

The general topology is considered.

- The distance table entries are computed using the distance-vector algorithm synchronous version.
- The nodes in the network has limited knowledge about their neighbors.
- They know only their neighbors costs.

The maximum number of iterations required for the algorithm convergence can be calculated as follows:

In each iteration, the nodes in the network will exchange information of distance tables with their neighbors.

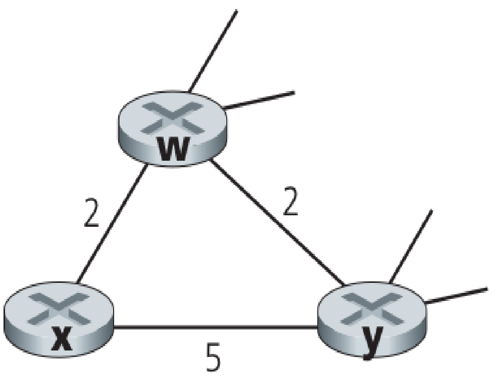
After the first iteration, all the neighboring nodes to the current node will be aware of shortest path cost to current node. For example, let X and Y represent two nodes and they are neighbors. Then after first iteration, all the neighbors of Y will be aware of shortest path cost to node X.

- Assume that *d* (the networks diameter) is the length of the longest path and without loops between any two nodes in the network.
- From the above analogy, after performing *d*-1 iterations, all nodes will have the knowledge about the shortest path cost of *d* to all other nodes.
- If the path length is greater than *d* hops, then the path contains loops. The removal of loops converges the algorithm result to at most *d*-1 iterations.
- Any path with greater than *d* hops consists of loops which leads the result of the algorithm to converge in at most *d*-1 iterations.

Therefore, the result of the distance vector algorithm converges in at most *d*-1 iterations.

30. Consider the network fragment shown below. x has only two attached neighbours, 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.

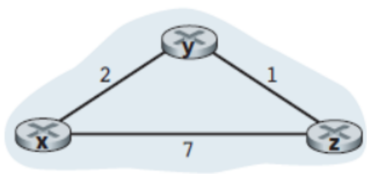
a) Give x's distance vector for destinations w, y, and u.
b) Give a link-cost change for either c(x,w) or c(x,y) such that x will inform its neighbours of a new minimum-cost path to u as a result of executing the distance-vector algorithm.
c) Give a link-cost change for either c(x,w) or c(x,y) such that x will not inform its neighbours of a new minimum-cost path to u as a result of executing the distance-vector algorithm.



ANSWER:

a)
Consider the diagram:
Minimum cost path from node w to node u= 5.
Minimum cost path from node w to node y =6.
Distance-vectors from node x are as follows:
$V_x(w)=2$
$V_x(y)=5$
$V_x(u)=\infty$
Considering the neighbors of node y and node w from x in the first iteration completed
$V_x(w)=2$
$V_x(y)=4$
$V_x(u)=7$
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.
The result of executing the distance-vector algorithm is node *x* again informs its neighbors of the new cost.
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.
The result of executing the
distance-vector algorithm is not cause *x* to inform its neighbors of a new minimum-cost path to *u*.

31: Consider the three-node topology shown in Figure . Rather than having the link costs shown in Figure, the link costs are c(x,y) = 3, c(y,z) = 6, c(z,x) = 4. Compute the distance tables after the initialization step and after each iteration of a synchronous version of the distance-vector algorithm



ANSWER:

Consider the cost of the links as follows:

$c(x,y)=3$
$c(y,z)=6$
$c(z,x)=4$

Construct the matrix as follows:

	x	y	z
x	0	3	4
y	3	0	6
z	4	6	0

According to the distance vector algorithm, any node *m* computes the distance vector using the following formulas:

$D_m(m) = 0$

$D_m(n) = \min\{c(m,n) + D_n(n), c(m,n) + D_o(n)\}$

$D_m(o) = \min\{c(m,n) + D_n(o), c(m,o) + D_o(o)\}$

Note: NA is used when there is no distance.

The distance tables at the node *x* after initialization step are as follows:

	x	*y*	*z*
x	0	3	4
y	*NA*	*NA*	*NA*
z	*NA*	*NA*	*NA*

The distance tables at the node *y* after initialization step are as follows:

	x	*y*	*z*
x	*NA*	*NA*	*NA*
y	3	0	6
z	*NA*	*NA*	*NA*

The distance tables at the node *y* after initialization step are as follows:

	x	*y*	*z*
x	*NA*	*NA*	*NA*
y	*NA*	*NA*	*NA*
z	4	6	0

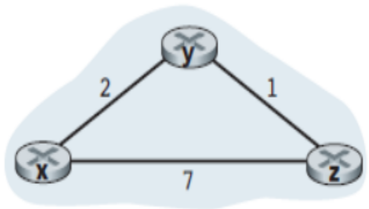
32: Consider the count-to-infinity problem in the distance vector routing. Will the count-to-infinity problem occur if we decrease the cost of a link? Why? How about if we connect two nodes which do not have a link?

ANSWER:

- No, the count-to-infinity problem occur if we decrease the cost of a link as according to the updates received the nodes find their new least costs and in turn send their updates for distance vector.

- if we connect two nodes, the data cannot be propagated properly as face to cost-to-infinity problem and the find the minimum cost paths results in errors.

33. Argue that for the distance-vector algorithm in Figure , each value in the distance vector D(x) is non-increasing and will eventually stabilize in a finite number of steps.



ANSWER:

Chapter 4: Network layer

- A Distance Vector algorithm is asynchronous and distributed.
- Node x to node y represented by $d(x)$ can be calculated using the formula to The cost of the least-cost path:

$$d_x(y) = \min_v \{c(x,v) + d_v(y)\}$$

- Every node computes the minimum cost paths from the updated routing tables.

So, $d(x)$ will eventually stabilize the finite number of steps in Distance-Vector routing algorithm.

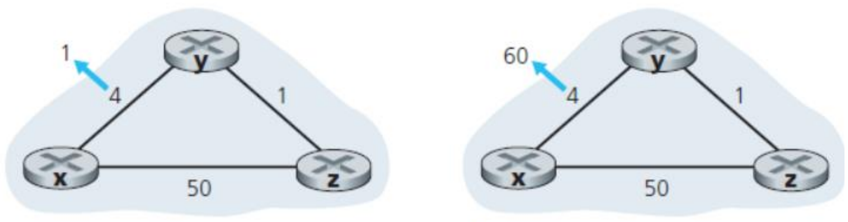
34. Consider Figure 4.31. Suppose there is another router w, connected to router y and z. The costs of all links are given as follows: c(x,y) = 4, c(x,z) = 50, c(y,w) = 1, c(z,w) = 1, c(y,z) = 3. Suppose that poisoned reverse is used in the distance-vector routing algorithm.

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?

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.

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?

a) The cost of the network links from the given Figure :



a. **b.**

n(x,z)=50
n(x,y)=4
n(y,z)=3
n(y,w)=1
n(z,w)=1

The distance values(D) do they tell each other as:

Router z	Connect w, $D_z(x) = \infty$
	Connect y, $D_z(x) = 4+1+1 = 6$
Router w	Connect y, $D_w(x) = \infty$
	Connect z, $D_w(x) = 5$
Router y	Connect w, $D_y(x) = 4$
	Connect z, $D_y(x) = 4$

b)

Consider that the link cost between x and y increases to 60. Then there be a count-to-infinity problem even if poisoned reverse is used as routing converging process.
The routing converging process table follows:

Time	t_0	t_1	t_2	t_3	t_4
z	Connect w, $D_z(x)=\infty$ Connect y, $D_z(x)=6$			Connect w, $D_z(x)=\infty$ y, $D_z(x)=11$	
w	Connect y, $D_w(x)=\infty$ Connect z, $D_w(x)=5$		y, $D_w(x)=\infty$ z, $D_w(x)=10$		No change
y	Connect w, $D_y(x)=4$ Connect z, $D_y(x)=4$	Connect w, $D_y(x)=9$ z, $D_y(x)=\infty$			Connect w, $D_y(x)=14$ Connect z, $D_y(x)=\infty$

c)
If the link between router at all if c(y,x) changes is removed then there is no count-to-infinity problem even if the cost of link changes from 4 to 60.

35. Describe how loops in paths can be detected in BGP.

ANSWER:

The loops in the BGP (Border Gateway Protocol) can be detected as follows:

- The BGP protocol propagates and obtains reachability of all the neighboring AS (Autonomous Systems).
- The attributes AS-PATH and NEXT-HOP are used for routing.
- The router verifies all the AS numbers. If it finds its own number, it will discard the advertisement to prevent the looping. In this way BGP detects the loops and prevents them.

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

ANSWER:

BGP stands for *Border Gateway Protocol.* It contains the subnet reachability data from AS and maintain the data to reach all routers in AS. So, it is an Inter-AS routing protocol.
The following reasons are the BGP router always choose the loop-free route with the shortest AS- path length:

- Generally, the router may contain more than one path to any one prefix.
- In this case, the BGP can apply some elimination rules to catch the one route.

- These elimination rules obtained from the AS_PATH. It is an inter domain routing. Then choose the loop-free route with the shortest AS- path length.

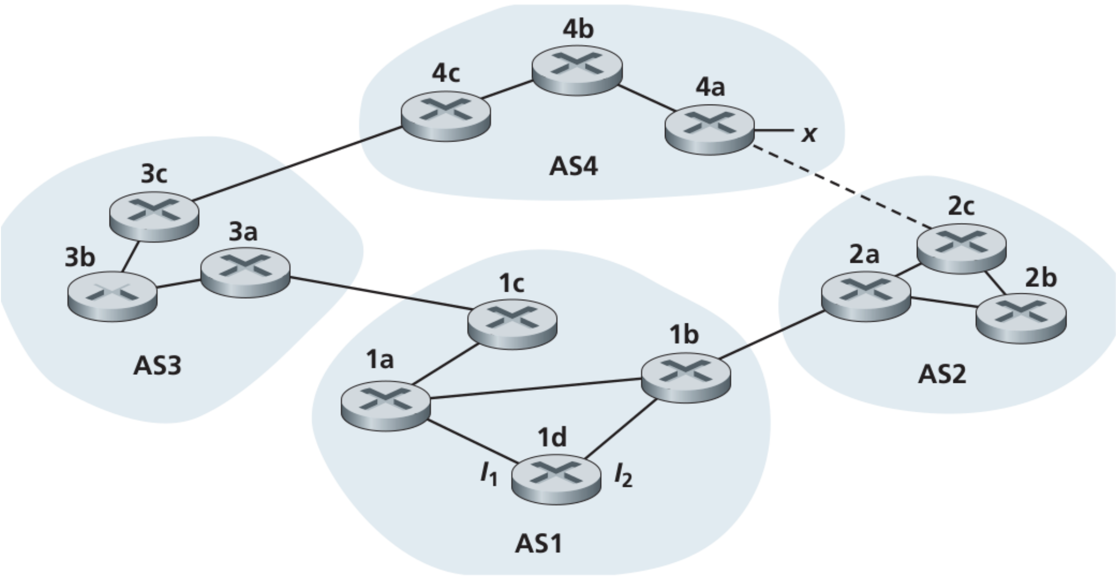
37, Consider the network shown below. Suppose AS3 and AS2 are running OSPF for their intra-AS routing protocol. Suppose AS1 and AS4 are running RIP for their intra-AS routing protocol. Suppose eBGP and iBGP are used for the inter- S routing protocol. Initially suppose there is no physical link between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

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

b. Router 3a learns about x from which routing protocol?

c. Router 1c learns about x from which routing protocol?

d. Router 1d learns about x from which routing protocol?



ANSWER:

EBGP: external BGP runs between routers in different ASs
IBGP: internal BGP runs between routers in the same AS
a. eBGP: **Router 3c learns about x from eBGP**
b. iBGP: **Router 3a learns about x from iBGP**
c. eBGP: **Router 1c learns about x from eBGP**
d. iBGP: **Router 1d learns about x from iBGP**

38. 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 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 diagram). 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 I2? Explain why in one sentence.

ANSWER:

a)

Consider the data: The router "1d" learns about "x" it will put an entry (x, I) in its forwarding table.

- The interface starts the least-cost path "1d" towards the router "1c".
- The path "I_1" is the least-cost path with 2 hops from the Router "1d" through the router "1c".
- The path "I_2" is the least-cost path with 3 hops from the Router "1d" through the router "1c".

So, the value of "I" will be equal to "I_1" or "I_2".

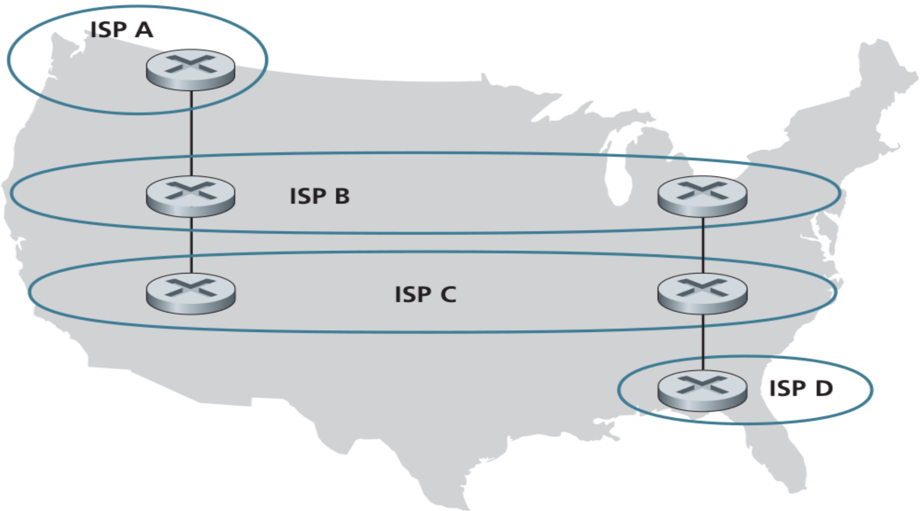
b)

Assume there is a physical link between AS2 and AS4, shown by the dotted line.
Assume the router "1d" learns that "x" is accessible through AS2 as well as via AS3.
Then, both the routers have equal *AS-PATH* length is 2 hops. **So, the value of "I" will be set to "I_2".**

c)

Assume there is another AS, called AS5, which lies on the path between AS2 and AS4.
Assume the router"1d" learns that "x" is accessible via AS2 AS5 AS4 as well as through AS3 AS4.
Then, the path "I_1" handle the shortest *AS-PATH* than it takes place through the path "I_2". **So, the value of "I" will be set to "I_1".**

39: 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:

One way for C to force B to hand over all of B's traffic to D on the east coast is for C to only advertise its route to D via its east coast peering point with C.

40 In Figure a, 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 figure b.

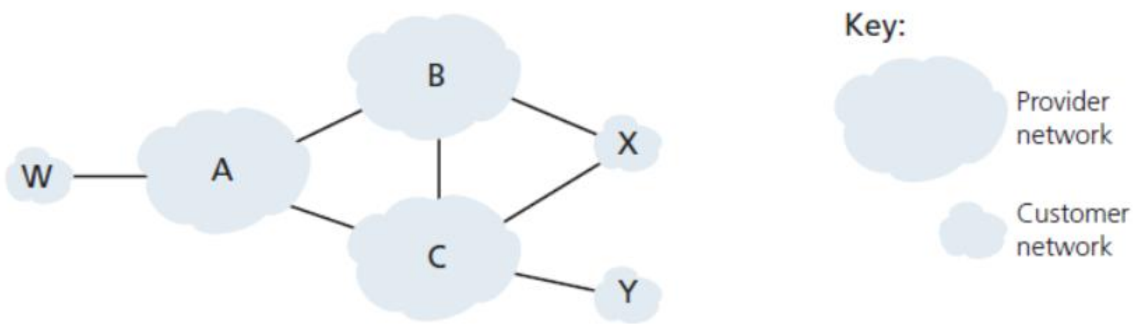


Figure a

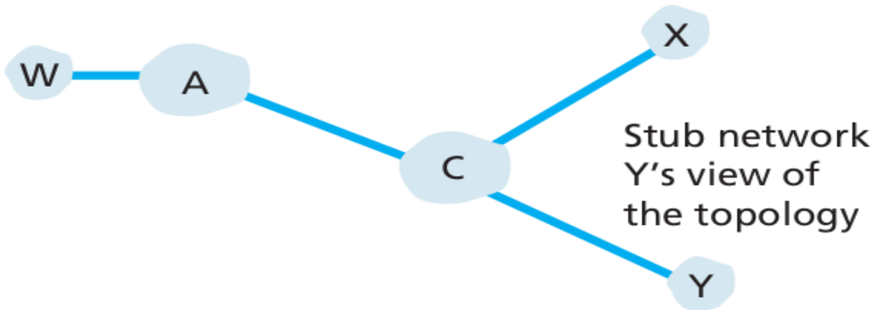
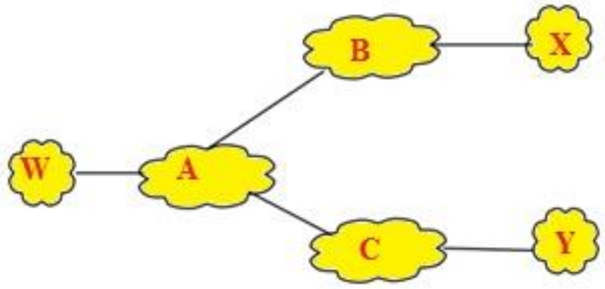


Figure b

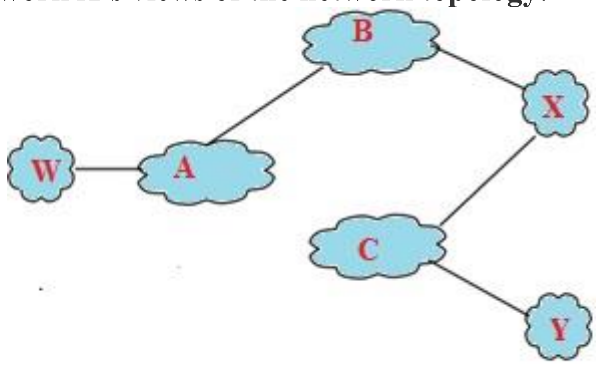
ANSWER:

Chapter 4: Network layer

Consider data:
The path information that reaches stub networks W, X, and Y. Based on the information available at W and X.
Given diagram is the topology view at sub network Y:
The respective sub network W's views of the network topology:

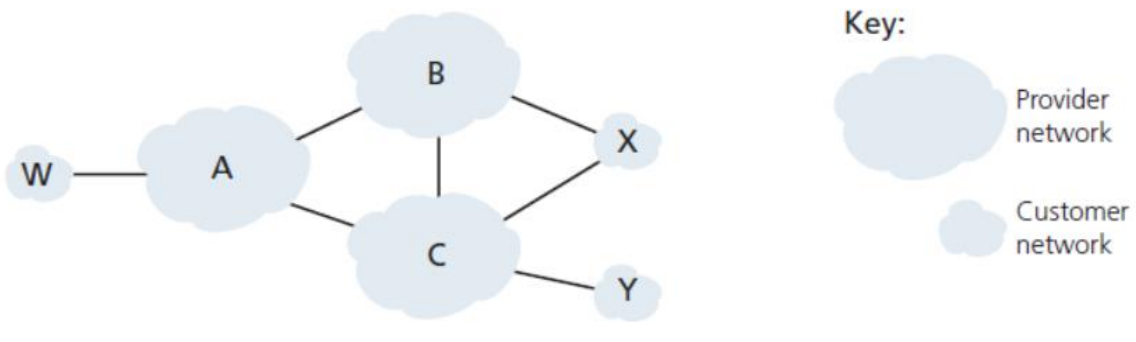


Here the sub network W contains a single path to AS A, then next AS A forwards packets to intermediate networks B and C. Simply, w receives the links AC, AB respectively.
The respective stb network X's views of the network topology:



No connection between A and C. So, the Autonomous system X has no knowledge of the link AC. Therefore, the destination path has no data about the paths AS A and AS C.

41. Consider Figure . B would never forward traffic destined to Y via X based on BGP routing. But there are some very popular applications for which data packets go to X first and then flow to Y. Identify one such application, and describe how data packets follow a path not given by BGP routing.



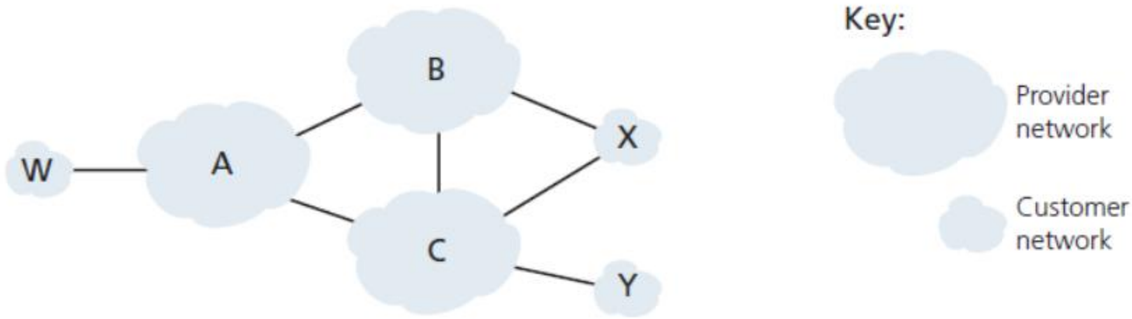
Chapter 4: Network layer

ANSWER:

Assume some very popular applications for which data packets go to "X" first and then flow to "Y" on BGP routing. Then, the Identify one such application is ***Skype P2P* and *Bit Torrent file sharing* application.**

- This application consists of the peer 1,peer 2, and peer 3 in customer networks respectively W, X, and Y by using BGP routing.
- This application is used to peer 2 receives the data from peer 1.
- Then, next send those data to peer 3.
- Finally, the data destined to customer network Y. It is only a default route to non-local destinations.

42 .In Figure , 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:

Consider the data from the Figure 4.42:

Number of provider networks=3 (A, B and C).

Number of customer networks=4 (W, V, X and Y).

Autonomous system AS A collect the information only from AS B.

Autonomous system AS V A collect the information only from AS B and AS C.

To decide the information as AS W, need to transfer from AS A to AS B at the AS-PATH. The peering relationship contains AS B and AS C. Then AS C route the packets to AS B to AS A. Thus, AS C follows the AS-PATH CBAW.

So, the route to be advertised by A for B to reach A is *AS-PATH* AW. The path used by C to reach W is *AS-PATH* CBAW.

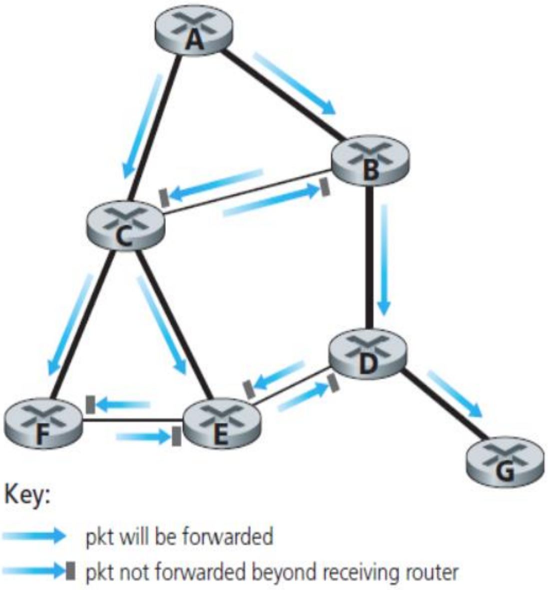
43. Suppose ASs X and Z are not directly connected but instead are connected by AS Y. Further suppose that X has a peering agreement with Y, and that Y has a peering agreement with Z. Finally, suppose that Z wants to transit all of Y's traffic but does not want to transit X's traffic. Does BGP allow Z to implement this policy?

ANSWER:

Yes, BGP allows Z to implement the given policy.
Given data:
The network contains Autonomous Systems AS X, AS Y and AS Z.
BGP means *Border Gateway Protocol*. It is an Inter-AS routing protocol.

- It takes the subnet reachability data from neighboring AS.
- AS X has an agreement of peering with AS Y.
- AS Y has an agreement of peering with AS Z.
- This protocol permits AS Z to develop the policy.
- The *BGP* route trailers are held by each AS.
- AS Y should present AS X that, it has no path to Z.
- The system AS X is ignorant that AS Y has path to AS Z.
- AS X never forward the traffic.
- AS Z can transfer all of Y's traffic.

44. Consider the topology shown in Figure. Suppose that all links have unit cost and that node E is the broadcast source. Using arrows like those shown in Figure 4.44 indicate links over which packets will be forwarded using RPF, and links over which packets will not be forwarded, given that node E is the source.



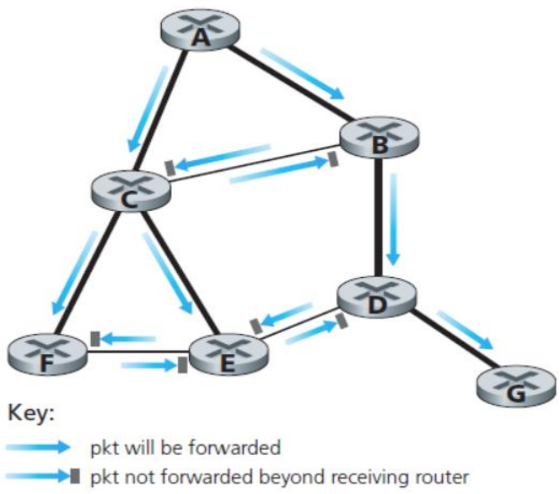
ANSWER:

Refer the Figure 4.44 in the text book.
Assume all links have unit cost and that node E is the broadcast source.

- Using RPF(Reverse Path Forwarding , the router receives a broadcast packet from a source address and it transfer to all links through the router.
- Then, the packets F and D ill be forwarded in the figure 4.44 as the path from E to C is least-cost than from E to C trhoug F. So, the link is blocked from C to F.
- The packets A through C and B will not be forwarded in the figure 4.44 as not have the least-cost path.

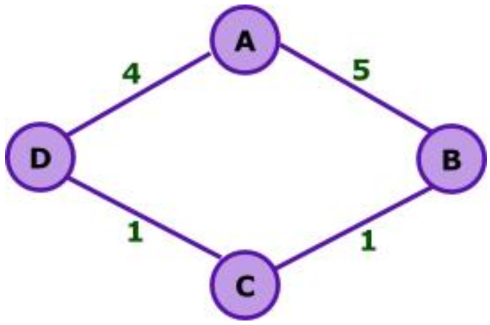
45. In figure , Assume all links have unit cost and that node E is the broadcast source.

- Using RPF(Reverse Path Forwarding , the router receives a broadcast packet from a source address and it transfer to all links through the router.
- Then, the packets F and D ill be forwarded in the figure 4.44 as the path from E to C is least-cost than from E to C trhoug F. So, the link is blocked from C to F.
- The packets A through C and B will not be forwarded in the figure 4.44 as not have the least-cost path.



ANSWER:

Consider the following graph:



Find the minimum spanning tree from node A using Dijkstra's algorithm.
The minimum spanning from node A is AD, DC, CB.

The cost of minimum spanning tree can be calculated as 4+1+1 = 6.

Now calculate the least cost path with source node A.

Source Node	Neighbor Nodes
A(-,∞)	B(5,A) **D(4,A)**
D(4,A)	**C(5,B)**
C(5,B)	**B(6,C)**
B(6,C)	-----

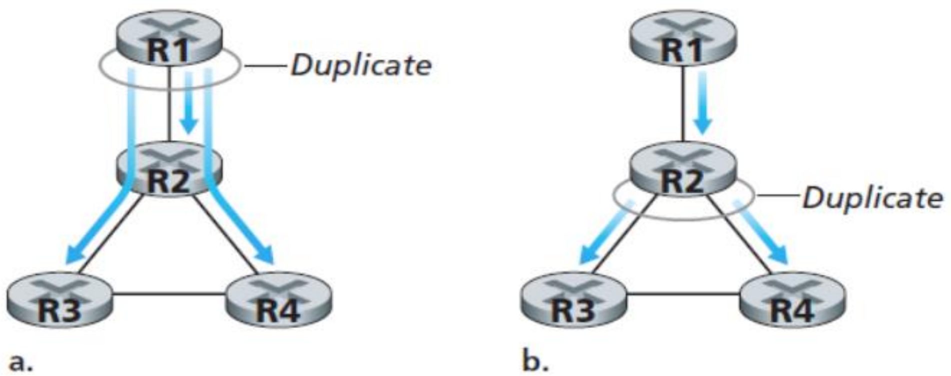
The unicast paths according Dijkstra's algorithm are individually least cost paths. The paths from source A are as follows:

- Node A unicast path to nodes B and D with costs 5 and 4 respectively.
- Node D has unicast to node C with cost 1.
- Node C has unicast to node B with cost 1.
- Node B to node A unicast is ignored as already exists.

The least unicast cost is the union of all the unicasts paths. The cost is calculated as 4+5+6=15.

Therefore, the least unicast path cost tree and minimum spanning tree are not always same.

46 We saw in Section 4.7 that there is no network-layer protocol that can be used to identify the hosts participating in a multicast group. Given this, how can multicast applications learn the identities of the hosts that are participating in a multicast group?



ANSWER:

Assume there is no network-layer protocol that can be used to identify the hosts participating in a multicast group.
Then, the following stes are multicast applications learn the identities of the hosts that are participating in a multicast group:

- The *End-system multicast* process is used to apply the peer-to-peer systems for the distribution of the application.
- The internet network consists a unicast path between two end-systems instead of routers.
- Then, the multicast applications are identify to distribute the multicast data to all the other nodes in the multicast group.