Tutorial 3: IP Addressing and IP Routing Protocols

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Question 1

- The IP header checksum only verifies the integrity of IP header. Discuss the pros and cons of doing the checksum on the header part versus on the entire packet

Solution Question 1

- Answer
  - Error checking in the header is more important because the packet is routed according to the header information. In addition, the delivery of the data at the destination to the higher layers also requires the header information. Thus error checking of the header protects against misdelivery of the information.
  - Restricting the error checking to the header also simplifies the implementation in the notes, requires less checksum bits, and prevents unnecessary packet discard. Some higher layers can tolerate some data errors, and higher layers also the option of performing retransmission.

Question 2

- Identify the range of IPv4 addresses spanned by Class A, Class B, Class C. Class D and Class C

Solution Question 2

Network Class	Dotted-Decimel Notation Ranges	Subnet/Multicast Bitmap
A (/8 Prefixes)	1.0.0.0 through 126.255.255.255	0nnnnnnn.hhhhhhhh.hhhhhhhh.hhhhhhhh
B (/16 Prefixes)	128.0.0.0 through 191.255.255.255	10nnnnnn.nnnnnnnn.hhhhhhhh.hhhhhhhh
C (/24 Prefixes)	192.0.0.0 through 223.255.255.255	110nnnnn.nnnnnnnn.nnnnnnnn.hhhhhhhh
D (Multicast)	224.0.0.0 through 239.255.255.255	1110gggg.gggggggg.gggggggg.gggggggg
E (Experiment)	240.0.0.0 through 247.255.255.255	1111xxxx.xxxxxxxx.xxxxxxxx.xxxxxxxx

- IP Addressing Scheme (IPv4 Global Addresses).
  - Notation: ***n*** stands for network; ***h*** is host; ***g*** represents group and ***x*** denotes reserved for experiments

Question 3

- Identify the address class of the following IP addresses: 200.58.20.165;128.167.23.20; 16.196.128.50; 50.156.10.10; 250.10.24.96

Solution Question 3

- Answer

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

Class C	
200.58.20.165	**11**001000.00111010.00010100.10100101

Class B	
128.167.23.20	**1**0000000.10100111.00010111.00010100

Class A	
16.196.128.50	**0**0010000.11000100.10000000.00110010

Class B	
150.156.10.10	**10**010110.10011100.00001010.00001010

Solution Question 3

- Answer

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

Class E	
250.10.24.96	**1111**1010.00001010.00011000.01100000

Question 4

- What are all the possible subnet masks for the Class C address space? List all the subnet masks in dotted-decimal notation, and determine the number of hosts per subnet supported for each subnet mask

Solution Question 4

- Answer

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

255.255.255.128 supports 126 hosts (not including the broadcast address)
255.255.255.192 supports 62 hosts
255.255.255.224 supports 30 hosts
255.255.255.240 supports 14 hosts
255.255.255.248 supports 7 hosts
255.255.255.252 supports 3 hosts

255.255.255.254 and 255.255.255.255 are not practically usable.

Question 5

- A host in an organization has an IP address 150.32.64.34 and a subnet mask 255.255.240.0. What is the address of this subnet? What is the range of IP addresses that a host can have on this subnet?

Solution Question 5

- Answer

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

Address	**150.32.64.34**	**10010110.00100000.01000000.00100010**
Mask	255.255.240.0	11111111.11111111.11110000.00000000
Subnet	150.32.64.0	10010110.00100000.01000000.00000000

Host	**150.32.64.**	**10010110.00100000.01000000.00100010**
From	150.32.64.1	10010110.00100000.01000000.00000001
To	150.32.79.254	10010110.00100000.01001111.11111110

Question 6

- What aspect of IP addresses makes it necessary to have one address per network interface, rather than just one per host? In light of your answer, why does IP tolerate point-to-point interfaces that have nonunique addresses or no addresses?

Solution Question 6

- Answer
  - IP addresses include the network/subnet, so that interfaces on different networks must have different network portions of the address. Alternatively, addresses include location information and different interfaces are at different locations, topologically.
  - Point-to-point interfaces can be assigned a duplicate address (or no address) because the other endpoint of the link doesn't use the address to reach the interface; it just sends. Such interfaces, however, cannot be addressed by any other host in the network. See also RFC1812, section 2.2.7, page 25, on "unnumbered point-to-point links".

Question 7

- Path MTU is the smallest MTU of any link on the current path (route) between two hosts. Assume we could discover the path MTU of the path used in the previous exercise, and that we use this value as the MTU for all the path segments. Give the sizes and offsets of the sequence of fragments delivered to the network layer at the destination host

Solution Question 7

- Answer
  - By definition, path MTU is 576 bytes.
  - Maximum IP payload size is 576-20 = 556 bytes. We need to transfer 1024+20 = 1044 bytes in the IP payload.
  - This would be fragmented into 2 fragments, the first of size 552 bytes (because the fragment needs to be a multiple of 8 bytes, so it can't be exactly 556) and the second of size 1044 - 552 = 492 bytes.
  - There are 2 packets in total if we use path MTU. In the previous setting we needed 3 packets.

Question 8

- A small organization has a Class C address for seven networks each with 24 hosts. What is an appropriate subnet mask?

Solution Question 8

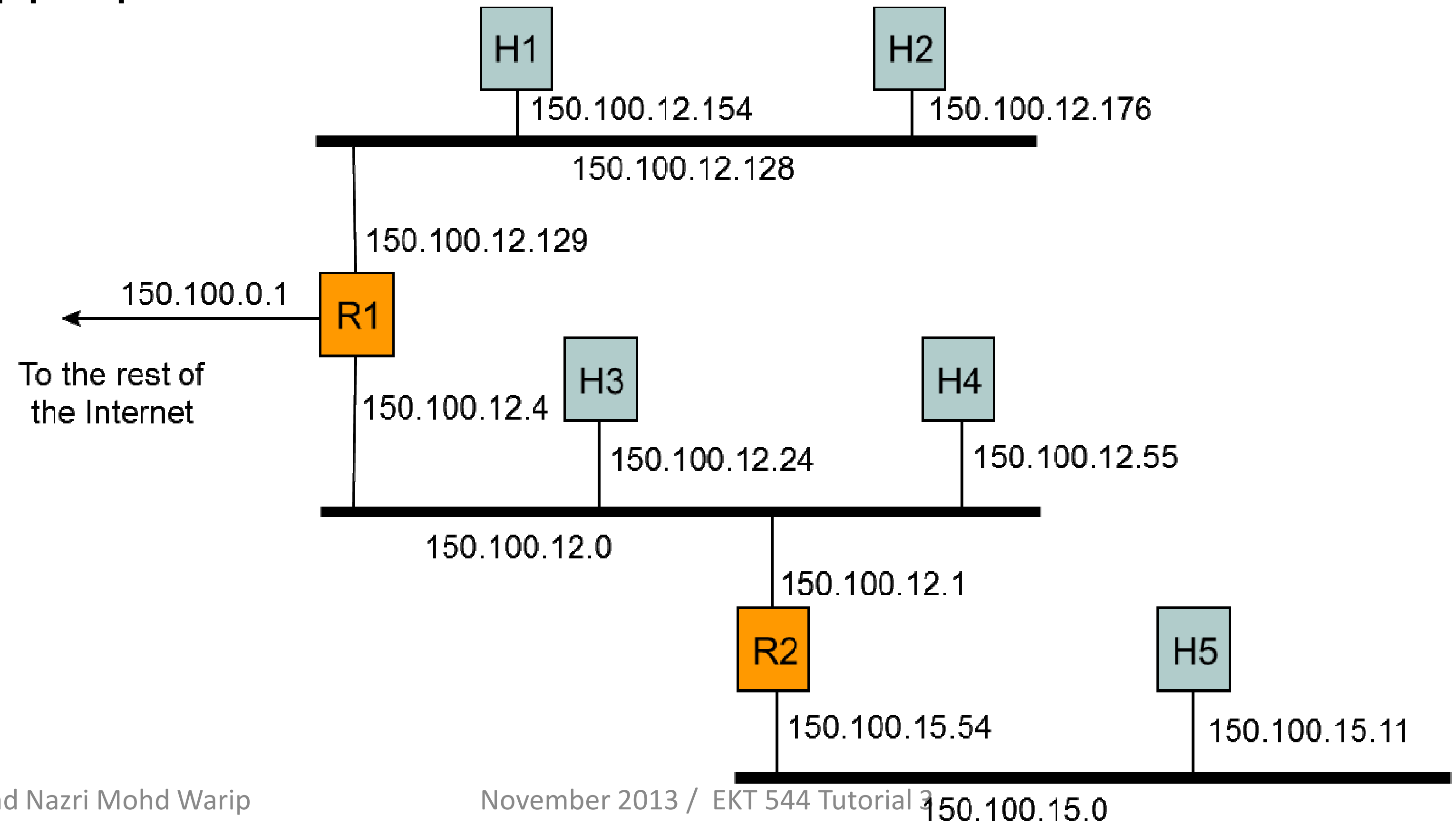
- Answer
  - A Class C address requires 21 bits for its network ID, leaving 8 bits for the host ID and subnet ID to share. One possible scheme would assign 4 bits to the host and 4 to the subnet ID, as shown below. The number of bits assigned to the host can be increased to 5 as well
  - Subnet mask: 255.255.255.224

Original address	1	0	Net ID	Host ID

Subnetted address	1	0	Net ID	Subnet ID	Host ID

Question 9

- A packet with IP address 150.100.12.55 arrives at router R1 in Figure 1. Explain how the packet is delivered to the appropriate host.

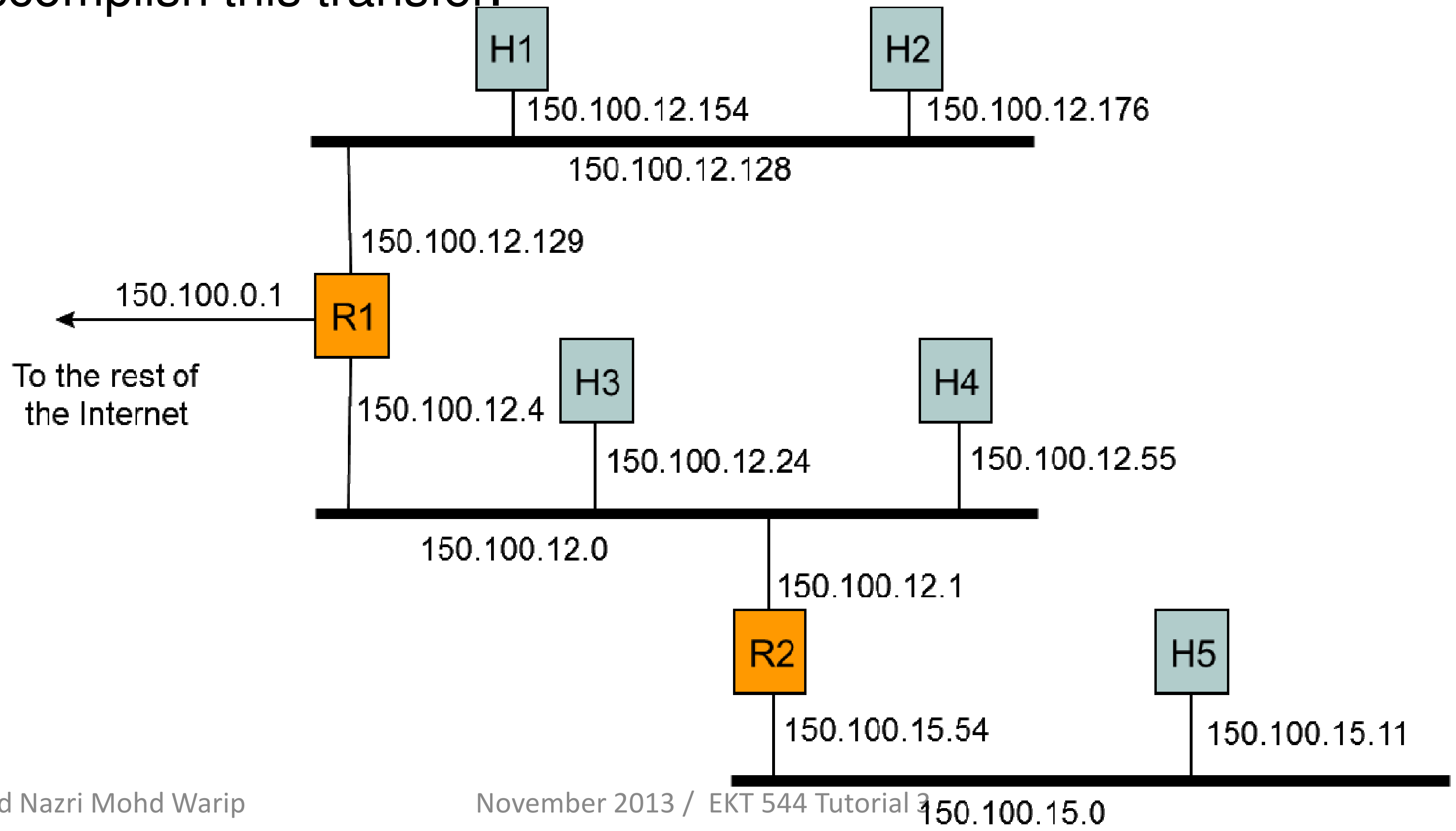


Solution Question 9

- Answer
  - The packet with IP address 150.100.12.55 arrives from the outside network. R1 has to know the next-hop router or host to send the packet to.
  - The address corresponds to the binary string 10010110.01100100.00001100.00110111. R1 knows that a 9 bit subnet field is in use so it applies the following mask to extract the subnetwork address from the IP address.11111111.11111111.11111111.10000000
  - The resulting IP address is 10010110.01100100.00001100.00000000 and corresponds 150.100.12.0. This indicates that the host is in subnet 150.100.12.0, so the router transmits the IP packet on this (attached) LAN.

Question 10

- In Figure 1 assign a physical layer address 1, 2, … to each physical interface starting from the top row, moving right to left, and then moving down. Suppose H4 sends an IP packet to H1. Show the sequence of IP packets and Ethernet frames exchanged to accomplish this transfer.



Solution Question 10

- Answer
  - Send IP packet from H4 to R1:
  - Source address 150.100.12.55 to destination IP address 150.100.12.176
  - Source Ethernet 4 to Receive Ethernet 6
  - Forward IP packet from R1 to H1
  - Source address 150.100.12.55 to destination IP address 150.100.12.176
  - Source Ethernet 3 to Receive Ethernet 2

Question 11

- Perform CIDR aggregation on the following /24 IP addresses: 200.96.86.0/24; 200.96.87.0/24; 200.96.88.0/24; 200.96.89.0/24.

Solution Question 11

- Answer

200.96.86.0/20	11001000.01100000.01010110.00000000
200.96.87.0/20	11001000.01100000.01010111.00000000
200.96.88.0/20	11001000.01100000.01011000.00000000
200.96.89.0/20	11001000.01100000.01011001.00000000
255.255.240.0	11111111.11111111.11110000.00000000

  – The resulting prefix is 200.96.80.0/20

Question 12

- A university has 150 LANs with 100 hosts in each LAN.
    a) Suppose the university has one Class B address. Design an appropriate subnet addressing scheme.
    b) Design an appropriate CIDR addressing scheme.

Solution Question 12

- Answer 12(a)
  - Defining the subnet mask / Extended prefix length.
  - Defining the subnet number.
  - The all-zeros (0s) subnet and all-ones (1s) subnet.
  - Defining host addresses for each subnet
  - Defining the broadcast address for each subnet
  - If we allocate 8 bits for to identify the host, as shown below, then there are sufficient subnet-id bits to cover up to 28=256 LANs and enough host-id bits to cover up to 256 hosts for each LAN. The subnet mask in this case is 255.255.255.0

Solution Question 12

- Answer 12(a)
  - If we allocate 7 bits for to identify the host, as shown below, then there are sufficient subnet-id bits to cover up to 29=512 LANs and enough host-id bits to cover up to 128 hosts for each LAN. The subnet mask in this case is 255.255.255.128
  - The choice between 7 or 8 bits to represent the hosts depends on which is likely to grow more, the number of subnets or the number of hosts in a LAN. Alternatively a variable-length prefix scheme using 7-bit host addresses, and grouping these form larger subnets provides greater flexibility in accommodating future changes.

Solution Question 12

- Answer 12(b)
  - CIDR addressing scheme involves devising a prefix length that indicates the length of the network mask.
  - In this case, 8 bits are required to identify each LAN (since 127 < 150 < 255) and 7 bits are required to identify each host in each LAN (since 63 < 100 < 127).
  - Therefore a CIDR address would use a 17-bit prefix, and thus have an address of the form address/17.

Question 13

- Suppose that host A is connected to a router R 1, R 1 is connected to another router, R 2, and R 2 is connected to host B. Suppose that a TCP message that contains 900 bytes of data and 20 bytes of TCP header is passed to the IP code at host A for delivery to B. Show the Total length, Identification, DF, MF, and Fragment offset fields of the IP header in each packet transmitted over the three links. Assume that link A-R1can support a maximum frame size of 1024 bytes including a 14-byte frame header, link R1-R2 can support a maximum frame size of 512 bytes, including an 8-byte frame header, and link R2-B can support a maximum frame size of 512 bytes including a 12-byte frame header.

Solution Question 13

- Answer
  - We have an IP payload of 920 bytes to send. Assume a 20 byte IPv4 header. The first link can carry IP packets up to 1010 bytes, so there will be no fragmentation.
  - The second link can carry IP packets up to 504 bytes, so there will be fragmentation. There may be up to 484 bytes of data, but fragments must carry a multiple of 8 bytes of data (except the last fragment).
  - So the first fragment will carry 480 bytes of data, and the second fragment will carry 440 bytes. The third link can carry IP packets up to 500 bytes, so both fragments will fit and no other fragmentation will occur. The value of the fields is:

Solution Question 13

- Answer
  - Link A-R1:
    1) Length = 940; ID = x; DF = 0; MF = 0; Offset = 0
  - Link R1-R2:
    1) Length = 500; ID = x; DF = 0; MF = 1; Offset = 0
    2) Length = 460; ID = x; DF = 0; MF = 0; Offset = 60
  - Link R2-B:
    1) Length = 500; ID = x; DF = 0; MF = 1; Offset = 0
    2) Length = 460; ID = x; DF = 0; MF = 0; Offset = 60

Question 14

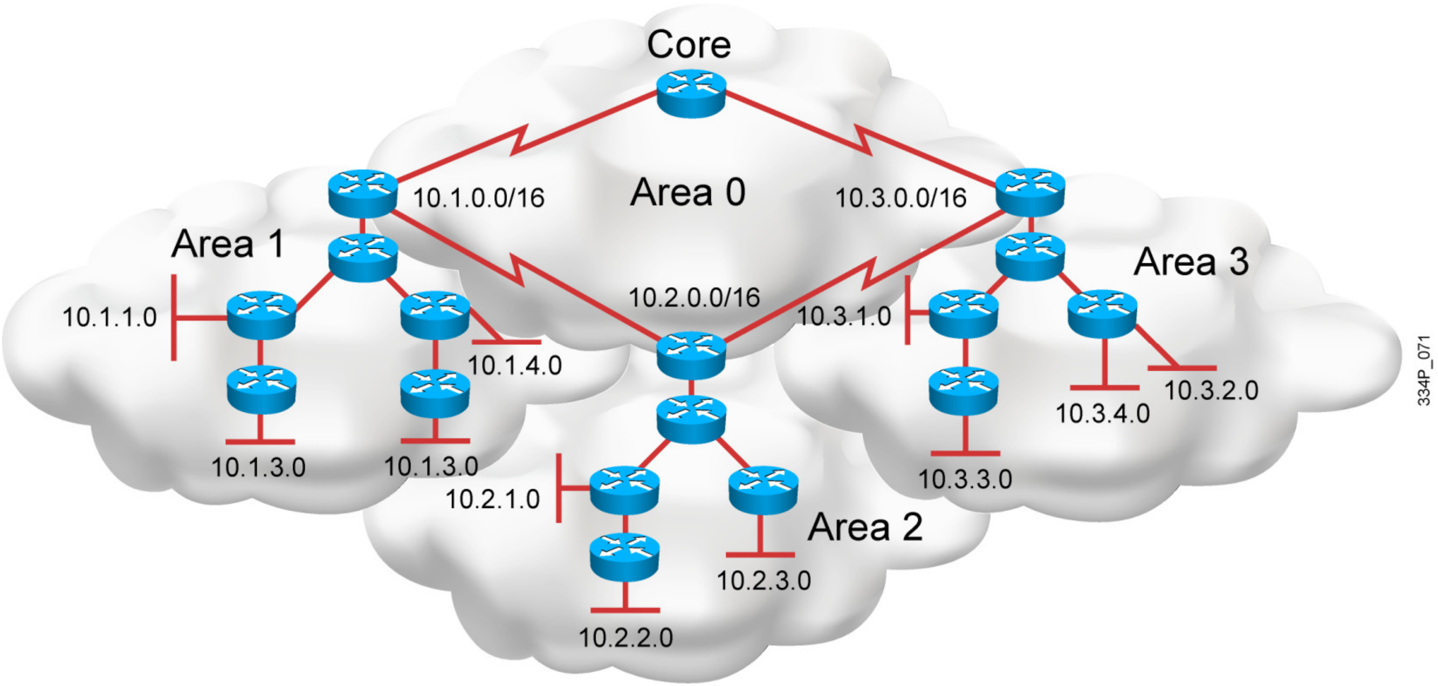
- IP Routing protocols include link-state and distance vector mechanisms.
  a) Compare between static and dynamic routing.
  b) Explain how to plan the OSPF design consideration
  c) Explain benefits and drawbacks of Link-State Routing

Solution Question 14 (a)

Static Routing	Dynamic Routing
Set up manually, do not change; requires administration	Adapt to changes in network conditions
Works when traffic predictable & network is simple	Uses a route that a network routing protocol adjusts automatically for topology or traffic changes
Used to override some routes set by dynamic algorithm	Calculates routes based on received updated network state information
Used to provide default router	

Solution Question 14 (b)

- Assess the requirements and options:
  - IP addressing plan
  - Network topology
    - Primary vs. backup links
    - WAN bandwidth utilization
- Define hierarchical network design and areas
- Evaluate OSPF scaling options
  - Summarization - where necessary
  - Define stub areas

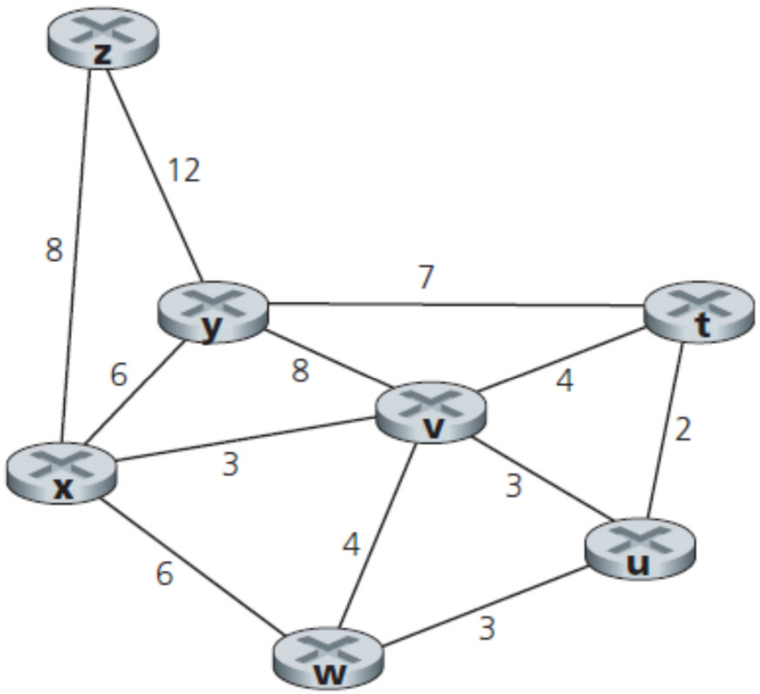


Solution Question 14 (c)

Benefits	Drawbacks
▪ Fast convergence: – Changes are reported immediately by the affected source. ▪ Robustness against routing loops: – Routers know the topology. – Link-state packets are sequenced and acknowledged. ▪ Hierarchical network design enables optimization of resources.	▪ Significant demands for resources: – Memory (three tables: adjacency, topology, forwarding). – CPU (Dijkstra's algorithm can be intensive, especially when there are many instabilities). ▪ Requires very strict network design. ▪ Configuration can be complex when tuning various parameters and when design is complex.

Question 15

- 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.



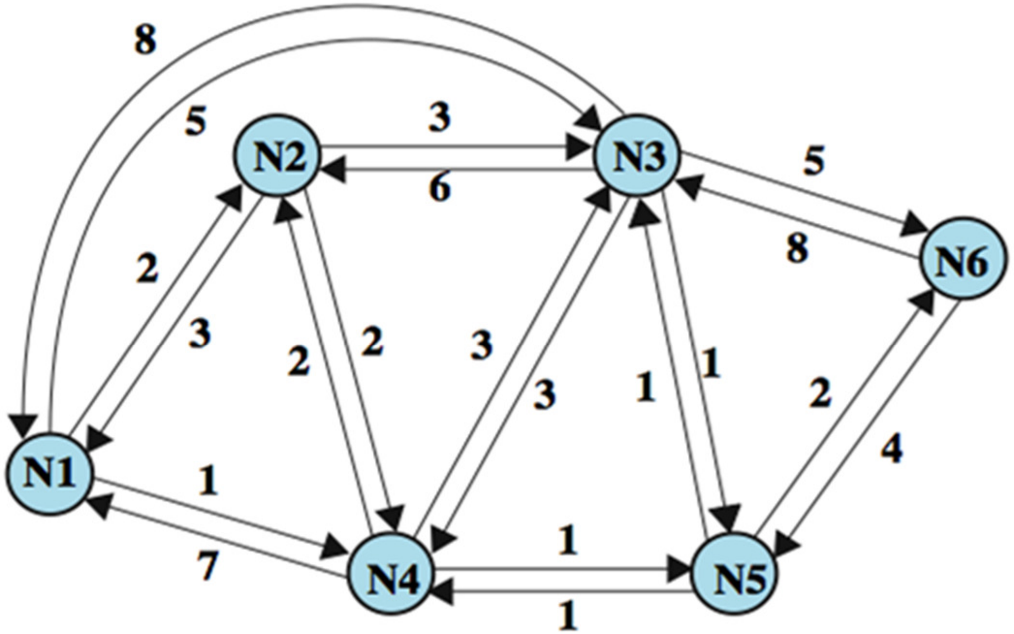
Solution Question 15

- Answer

Step	*N'*	*D(t),p(t)*	*D(u),p(u)*	*D(v),p(v)*	*D(w),p(w)*	*D(y),p(y)*	*D(z),p(z)*
0	x	∞	∞	3,x	6,x	6,x	8,x
1	xv	7,v	6,v	3,x	6,x	6,x	8,x
2	xvu	7,v	6,v	3,x	6,x	6,x	8,x
3	xvuw	7,v	6,v	3,x	6,x	6,x	8,x
4	xvuwy	7,v	6,v	3,x	6,x	6,x	8,x
5	xvuwyt	7,v	6,v	3,x	6,x	6,x	8,x
6	xvuwytz	7,v	6,v	3,x	6,x	6,x	8,x

Question 16

- Using Dijktra's algorithm, generate a least-cost route to all other nodes for nodes 2 through 6 of Figure 2. Illustrate your answer in term of Execution Table.



Solution Question 16

- Answer
  - We show the results for starting from node 2

	M	L(1)	Path	L(3)	Path	L(4)	Path	L(5)	Path	L(6)	Path
1	{2}	3	2-1	3	2-3	2	2-4	∞	—	∞	—
2	{2, 4}	3	2-1	3	2-3	2	2-4	3	2-4-5	∞	—
3	{2, 4, 1}	3	2-1	3	2-3	2	2-4	3	2-4-5	∞	—
4	{2, 4, 1, 3}	3	2-1	3	2-3	2	2-4	3	2-4-5	8	2-3-6
5	{2, 4, 1, 3, 5}	3	2-1	3	2-3	2	2-4	3	2-4-5	5	2-4-5-6
6	{2, 4, 1, 3, 5, 6}	3	2-1	3	2-3	2	2-4	3	2-4-5	5	2-4-5-6