vii)

9.8 SOLVED PROBLEMS

Example 9.1

Identify the address class of the following IP addresses;

i) 200. 58. 20. 165
ii) 128. 167. 23.20
iii) 16. 196. 128. 50
iv) 150. 156. 10. 10
v) 250. 10. 24. 96

Solution

i) Class C
ii) Class B
iii) Class A
iv) Class B
v) Not an IP address as this address is undefined (Class E ends with 247. 255. 255.255)

Example 9.2

Instead of using 16 bits for the network part of a class B address, 20 bits are used. How many class B networks would there be? How many hosts are possible?

Solution

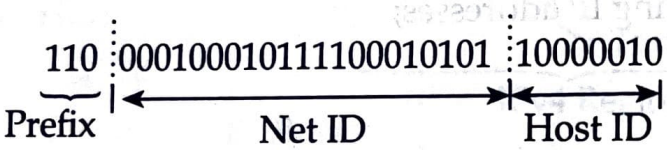
Class B address in IPv4 has 2 bits for prefix, 14 bits for net ID, and 16 bits for host ID, [Network part 16 bits and host part 16 bits].
Now, network part has 20 bits.
With two bits assigned for class B prefix, the network ID can have (20-2) = 18 bits.
Number of networks that can be accommodated = 2^{18} = 2,62,144.
Normally all 1^s and all 0^s are used for a special cases (Reserved for broadcast address).
∴ Numbers of networks = (2,62, 144 - 2) = **2,62,142**
Number of hosts = $2^{(32-20)} = 2^{12}$

Example 9.3

Convert IP address whose hexadecimal representation is C22F1582 to dotted decimal notation. To what class this address belongs to ? What is the network and host address?.

Solution

$[C22F1582]_{16}$
$= 11000010.\ 00101111.\ 00010101.\ 10000010$
$= [194.\ 47.\ 21.\ 130]_2$



110 → Prefix; This address belongs to **Class C.**
Net ID and Host ID are shown above.

Example 9.4

Write the following masks in slash notation (/n).
i) 255. 0. 0. 0 ii) 255. 255. 240. 0

Solution

i) 255. 0. 0. 0
⇒ 11111111 . 00000000. 00000000 . 00000000
Mask is a 32 bit number in which n leftmost bits are 1^s and (32-n) rightmost bits are 0^s.

Slash notation for (i); / 8

ii) 11111111 . 11111111. 11110000. 00000000
Slash notation for (ii); / 20

Example 9.5

Obtain the netid and hostid of the following IP addresses.

i) 114. 34. 2. 8
ii) 132. 56. 8. 6

Solution

i) This IP address belongs to class A addressing.
Netid → 114 , hostid → 34 .2. 8

ii) This IP address belong to class B addressing.
Netid → 132. 56, hostid → 8.6

Example 9.6

Change the following IP address from binary notation to dotted - decimal notation.

i) 10000010 00001010 01000010 10001000

ii) 11111111 00000000 00001111 10000001

Solution

Each 8 bit group is replaced by its equivalent decimal number with dots for separation.

i) 130. 10. 66. 136
ii) 255. 0. 15. 129

Example 9.7

A router outside the organization gets a packet with destination address 200. 140. 10. 81; Show how the router finds the network address to route the packet to its destination.

Solution

Various steps are,

i) The router finds the class by looking into the first byte of the address.
200 is the first byte ; the addressing class is C.

ii) Default mask for class C is 255. 255. 255. 0.

iii) ANDing operation is done for the address with the mask.

200. 140. 10. 81
225.255. 255. 0 | AND operation leads to 200. 140. 10. 0.

iv) Once the subnet is known, the router finds the route to the destination address from its routing table.

- Transition to IPv6 can be thought off in three ways; Dual stack, tunneling, and header translation.

9.10 PRACTICE QUESTIONS

1) What is an internetwork ?
2) What are the different classes of IP addressing ? Explain subnet addressing with an example.
3) Give an IP address in decimal dotted notation; How can it's class be determined?
4) Show by calculation how many
   i) Networks ii) Hosts per network each IP address can have.
5) How is subnet mask useful in IP addressing ? Explain with an illustration.
6) What is the purpose of subnetting and how is masking related?
7) What does subnetting allow that conventional addressing does not?
8) Describe the structure of IPv4 IP packet with a diagram.
9) Identify the range of IPv4 addresses spanned by class A, B, and C.
10) Differentiate between IPv4 and IPv6.
11) Compare and contrast IPv4 and IPv6 header fields; Do they have any fields in common.
12) Describe the structure of IPv6 IP packet with a diagram.
13) How are IP addresses assigned when using classless addressing?
14) What is NAT? How can NAT help in address depletion?
15) With a diagram, explain the three level hierarchy in IPv4 addressing.

16) How are different types of addresses identified by prefixes in IPv6? Explain briefly.

17) Discuss unicast and multicast addressing in IPv6 with suitable illustrations.

18) Explain network layer functioning in an internetwork with a diagram .

19) Differentiate between connectionless and connection oriented service.

20) What do you mean by fragmentation? Explain with MTU for different networks.

21) List the advantages of IPv6.

22) Explain the fields priority and flow label in IPv6 datagram.

23) List and explain the strategies to be employed for transition from IPv4 to IPv6 with suitable diagrams.

24) Checksum field is not present in IPv6 header; Justify the statement.

25) What is the purpose of using extension headers in IPv6? Explain its usefulness as compared to IPv4 protocol.

9.11 ADDITIONAL PROBLEMS

1) Identify the class of the following IP addresses;
   i) 127. 255. 255. 250 ii) 240. 0. 10. 240
   iii) 220. 200. 15. 125 iv) 193. 0. 0. 0
   [Ans; (i) class A (ii) class E (iii) class C (iv) class C]

2) A class B network on the Internet has a subnet mask of 255. 255. 240. 0 What is the maximum number of host per subnet ?
   [Ans; 4,094]

3) Convert the following IP addresses from binary notation to dotted decimal notation
   i) 01111111. 00001111. 10000010. 11000000
   ii) 10100010. 00000001. 10000000. 11111111
   [Ans; (i) 127. 15. 130. 192,
   (ii) 162. 1. 128. 255]

4) Write the slash notation for the following masks.
   i) 255. 248. 0. 0 ii) 255. 255. 255. 128
   [Ans; (i) / 13 (ii) / 25]

5) Find the netid and hostid for the following IP addresses.
   i) 208. 34. 54. 12 ii) 10. 20. 30. 40.
   [Ans ; (i) 208. 34. 54. and 12
   (ii) 10 and 20. 30. 40]

6) Convert 11001100 00001010 10000001 01010001 to dotted decimal notation.
   [Ans; 204. 10. 129. 81]

9.12 MULTIPLE CHOICE QUESTIONS

1) Connectionless service uses _____.
(A) Datagram packet switching
(B) Circuit switching
(C) Virtual circuit switching
(D) Space division switching

2) IP address in IPv4 has _____ bits.
(A) 8
(B) 16
(C) 32
(D) 128

3) IP address in IPv6 is _____ bits long.
(A) 8
(B) 16
(C) 32
(D) 128

4) Class B addressing has the prefix_____.
(A) 0
(B) 10
(C) 110
(D) 1110

5) A subnet mask in class B has nineteen 1's; How many subnets does it define?
(A) 8
(B) 16
(C) 32
(D) 64

6) Class _____ has the highest number of networks.
(A) A
(B) B
(C) C
(D) D

7) IP address 127. 255. 255. 255 belongs to _____.
(A) class A
(B) class B
(C) class C
(D) class D

8) /16 represents _____ in dotted decimal.
(A) 255. 0. 0. 0
(B) 255. 255. 0. 0
(C) 255. 255. 255. 0
(D) 255. 255. 255. 255

9) _____ is the maximum size of the data portion of the IP datagram.
(A) 65, 535 bytes
(B) 65, 585 bytes
(C) 65, 835 bytes
(D) 65, 515 bytes

10) Transition from IPv4 to IPv6 can use _____ strategy.
(A) Dual stack
(B) Tunneling
(C) Header translation
(D) All the three strategies given in (A), (B), and (C)

11) A value of Internet header length 20 bytes correspond to IHL _____.
(A) 5
(B) 10
(C) 15
(D) 6

12) Maximum size of IP header in IPv4 = _____.
(A) 20 bytes (B) 40 bytes
(C) 60 bytes (D) 10 bytes

13) Minimum size of IP header in IPv6 = _____.
(A) 20 bytes (B) 40 bytes
(C) 60 bytes (D) 10 bytes

14) In IPv4, the header is 20 bytes long and the data field is 200 bytes long. Then the total length in bytes = _____.
(A) 20 bytes (B) 200 bytes
(C) 180 bytes (D) 220 bytes

15) One-to-one communication is done by _____addressing.
(A) Multicast (B) Broadcast
(C) Anycast (D) Unicast

16) Address depletion in IPv4 can be overcome by _____.
(A) Classless addressing (B) DHCP
(C) NAT (D) All the solutions listed in a (A), (B), and (C)

17) IPv4 protocol provides _____ service.
(A) Flow control (B) Error control
(C) Guaranteed (d) Unreliable connectionless

18) Checksum in IPv4 covers _____.
(A) Data (B) Header
(C) Data and Header (D) None

ANSWERS TO MULTIPLE CHOICE QUESTIONS

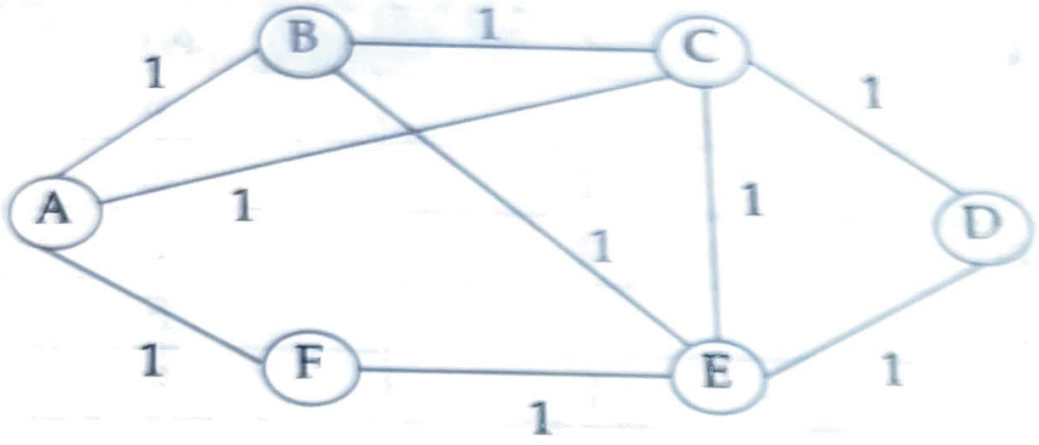
1	A	2	C	3	D	4	B
5	C	6	C	7	A	8	B
9	A	10	D	11	A	12	B
13	B	14	D	15	D	16	D
17	D	18	B				

10.10 SOLVED PROBLEMS

Example 10.1

In a 6 node network having nodes A, B, C, D, E, F, there are nine paths AB, BC, CD, DE, EF, AF, AC, BE, and CE each of cost 1. Construct the network and find the routing table at node A by distant vector routing.

Solution



Network

Routing Table at node A

Initially A sees that it has direct paths to B, C, and F and cannot reach D, E directly.

Table 1

Initial table prepared by A		
Destination (D)	**Cost (C)**	**Next hop (NH)**
B	1	B
C	1	C
D	∞	-
E	∞	-
F	1	F

Table 2

Table updated by A after hearing from B		
D	**C**	**NH**
B	1	B
C	1	C
D	∞	-
E	2	B
F	1	F

Table 3

Table updated by A after hearing from C		
D	**C**	**NH**
B	1	B
C	1	C
D	2	C
E	2 2	B C
F	1	F

Final Table

Table updated by A after hearing from F		
D	**C**	**NH**
B	1	B
C	1	C
D	2	C
E	2	F
F	1	F

Final table is prepared for the routing of packets from A to all other nodes in the network.

Example 10.2

Consider a 200 nodes network in which the delays are recorded as 8 bit numbers. If the delay vectors are exchanged twice a second, what is the bandwidth consumed per line for the distributed routing algorithm? Assume each node has three lines to other routes.

Solution

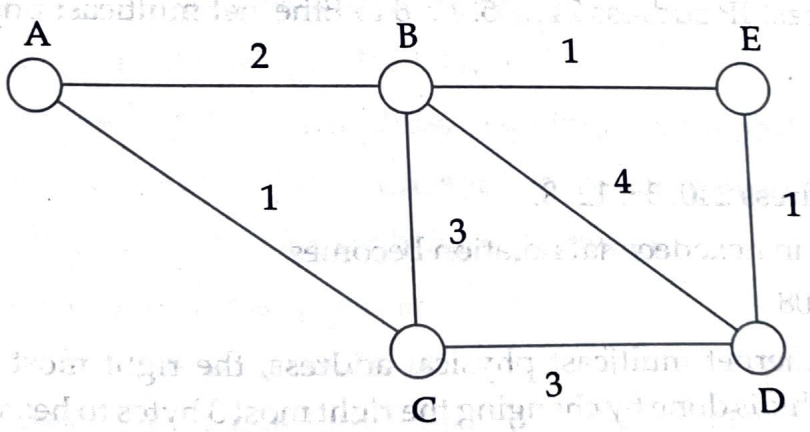
$(8 \times 200) = 1600$ bits are needed for each routing table. This table is changed twice per second and written on to the line.

$\therefore 2 \times 1600 =$ **3200 bps** data rate is required on each line.

Assuming a bandwidth efficiency of **1** bit/Hz, the bandwidth consumed per line = **3,200 Hz.**

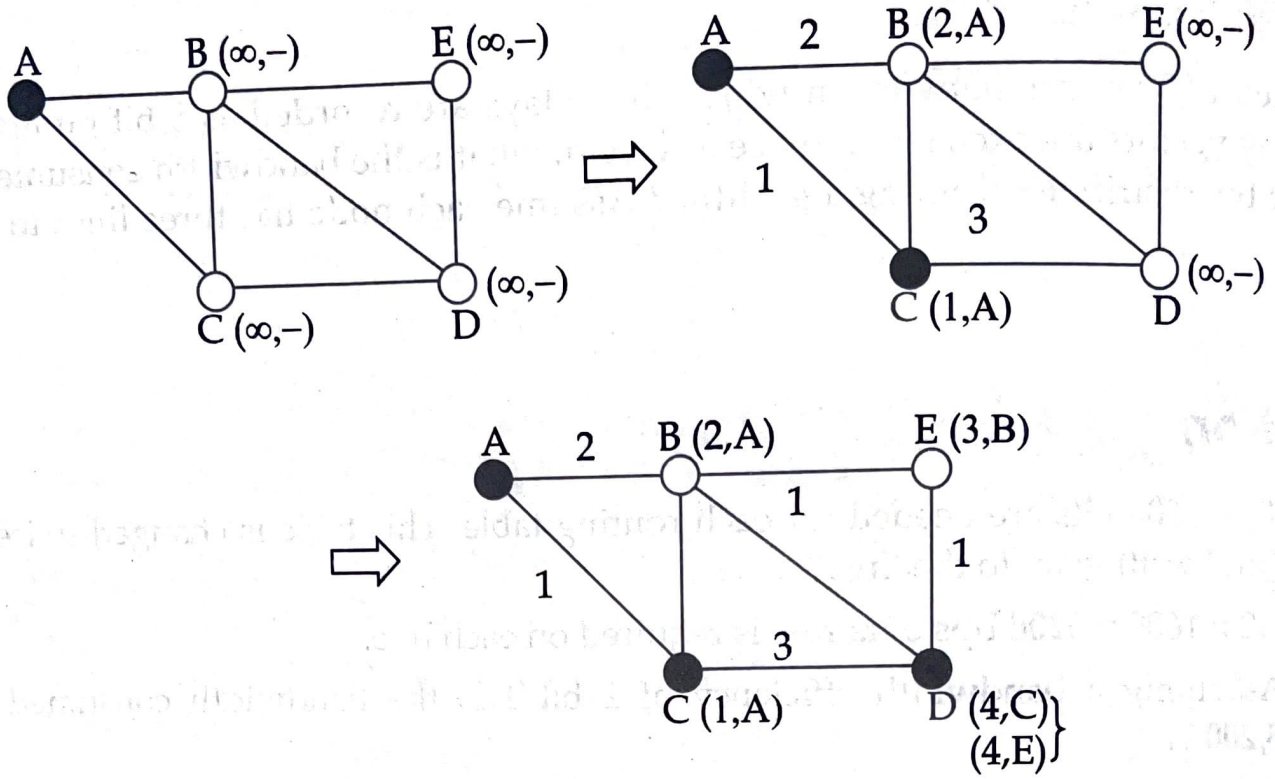
Example 10.3

Find the shortest path from A to D for the network shown.



Solution

Various steps are shown to find the shortest path from A to D.



The paths are ACD with 2 hops and ABED with 3 hops with weighing factor 4. Path **ACD** is selected as it has only 2 hops.

Example 10.4

Change the multicast IP address 240. 35. 12. 8 to Ethernet multicast physical address.

Solution

Given IP address 240. 35. 12. 8.

This address in hexadecimal notation becomes

F0 · 23 · 0C · 08

To get the Ethernet multicast physical address, the right most 23 bits are to be considered. This is done by changing the right most 3 bytes to hexadecimal notation and subtract 8 from the left most digit if it is greater or equal to 8.

For the example given the right most 3 bytes are 23. 0C. 08. As the left most digit is < 8, the result is 23. 0C. 08.

Starting Ethernet multicast address; 01. 00. 5E. 00. 00. 00

Add; 23. 0C. 08

Ethernet multicast Physical address; **01. 00. 5E. 23. 0C. 08**

Example 10.5

Obtain the multicast Ethernet address for the multicast IP address 200. 210. 15. 5.

Solution

200. 210. 15. 5 in hexadecimal notation is C8. D2. 0F. 05

Right most 23 bits are considered to get the Ethernet multicast address.

Right most 3 bytes of IP address; D2. 0F. 05.

As the left most digit is D, it is subtracted by 8 to get 5 → 0101.

The resulting right most 3 bytes = 52. 0F. 05

Starting Ethernet multicast address; 01. 00. 5E. 00. 00. 00

Add 52. 0F. 05 ; 52. 0F. 05

Ethernet multicast address; **01. 00. 5E. 52. 0F. 05**

10.12 PRACTICE QUESTIONS

1) What are the objectives and desirable features of routing algorithms?
2) How are routing techniques classified?
3) Explain the shortest path routing with suitable illustrations?
4) Discuss the following non-adaptive routing techniques with an example.
   i) Shortest path routing.
   ii) Flow based routing.
5) Why is adaptive routing superior to non-adaptive routing?
6) What are the advantages of adaptive algorithms? Explain link state ro
   an example.

7) Compare and contrast link state and distant vector routing algorithms.

8) What is the need of hierarchical routing? Explain how such networks are organized with an example.

9) Differentiate between
   i) ARP and RARP.
   ii) IGP and EGP.
   iii) Unicasting and multicasting.

10) What do you mean by address mapping? Discuss ARP operation with a diagram.

11) Draw the format of an ARP packet and explain the function of each field.

12) Explain the encapsulation of an ARP packet with a diagram.

13) List and explain the four cases of ARP.

14) Define a proxy ARP; Explain its operation with an illustration.

15) Discuss the salient features of BOOTP with a diagram.

16) List and explain the various error reporting messages in ICMP.

17) What is a query message? Explain the different types.

18) What is the function of Ping and traceroute?

19) Where is IGMP used? Discuss the various message types with a diagram.

20) Draw and explain IGMP message format.

21) Explain the tunneling process with a diagram.

22) Compare network layer in versions 4 and 6.

23) Explain the functions of delivery, forwarding, and routing of IP packets.

24) Explain direct and indirect delivery of packets with suitable diagrams.

25) Discuss the various methods of forwarding with illustrations.

26) What is interdomain routing? Explain OSPF protocol with a diagram.

27) Differentiate between multicasting and multiple unicasting with diagrams. Which is more useful for multicasting and why?

28) Explain:
   (i) RPF
   (ii) RPB
   (iii) RPM with suitable diagrams.

29) What CBT? How is it useful for multicasting.

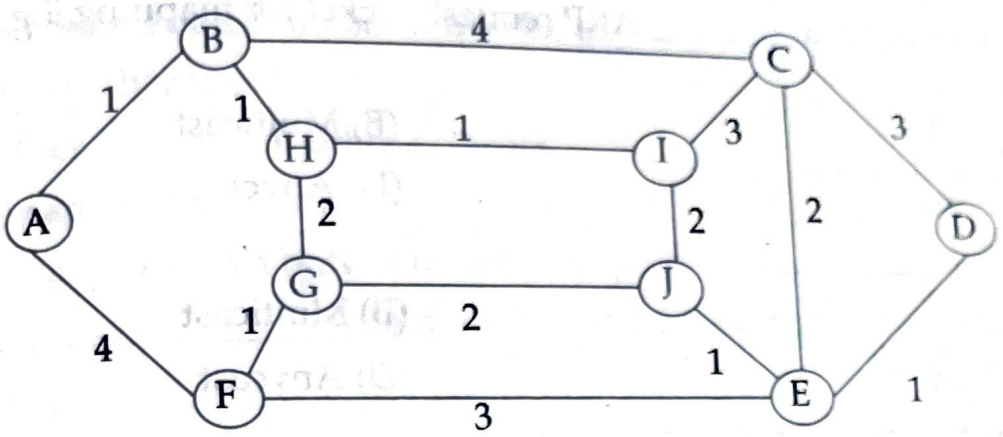
30) What is logical tunneling? How it is useful for MBONE Explain with suitable diagrams.

10.13 ADDITIONAL PROBLEMS

1) Consider a network with 720 nodes. Assuming a three layers hierarchy, find the region and cluster sizes to minimize the size of the routing table.

[**Ans:** 8 clusters,9 regions and 10 nodes].

2) Find the shortest path from node A to D using shortest path algorithm for the network shown.

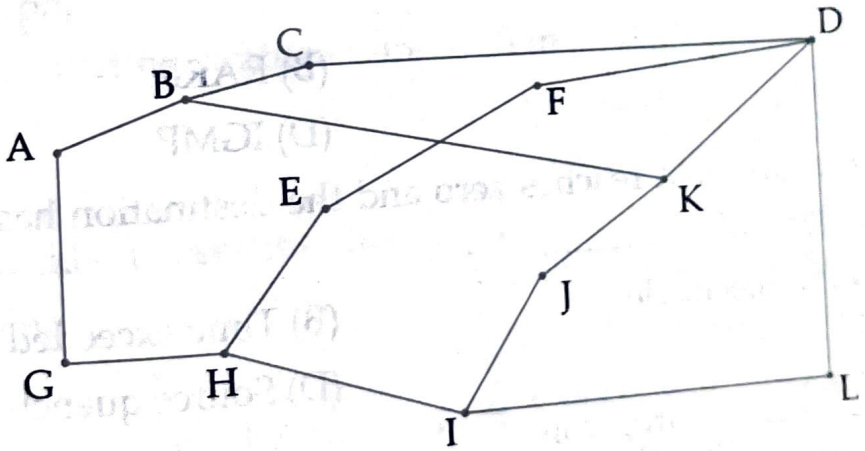


[**Ans:** ABHIJED with weighing factor 7 and 6 hops]

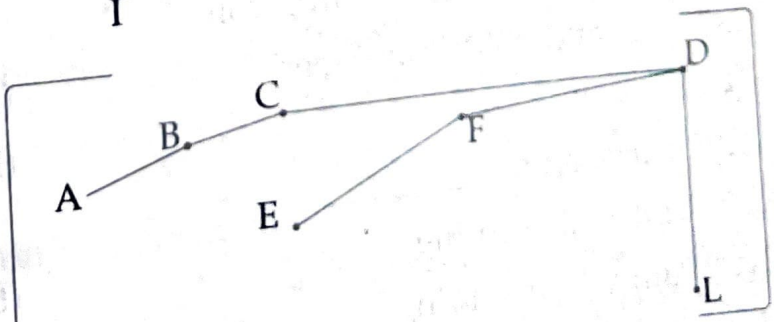
3) For hierarchal routing with 4800 nodes, what region and cluster sizes should be chosen to minimize the size of the routing table for a 3 layer hierarchy?

[**Ans:** 20 nodes, 16 regions and 15 clusters]

4) Compute a multicast spanning tree for the router C in the following subnet for a group with members at routers A, B, C, D, E, F, and L.



[**Ans:**



]

5) Obtain the Ethernet multicast physical address for the multicast IP address 230. 212. 14. 9.

[Ans: 01. 00. 5E. 54. 0E. 09]

10.14 MULTIPLE CHOICE QUESTIONS

1) ARP protocol uses a _____ ARP request packet for mapping logical to physical address.

(A) Unicast
(B) Multicast
(C) Broadcast
(D) Anycast

2) ARP reply is _____.

(A) Unicast
(B) Multicast
(C) Broadcast
(D) Anycast

3) ICMP reports error messages to_____.

(A) Original source
(B) Receiver
(C) Router
(D) None of (A), (B) or (C)

4) IGMP is a companion to _____.

(A) ARP
(B) ICMP
(C) RARP
(D) IP protocol

5) _____ is a dynamic mapping protocol in which a physical address is found for a given IP address.

(A) ARP
(B) RARP
(C) ICMP
(D) IGMP

6) When the hop count field reaches zero and the destination has not been reached the error message sent is_____.

(A) Destination unreachable
(B) Time exceeded
(C) Redirection
(D) Source quench

7) ICMPv6 has _____ protocols.

(A) ARP and IGMP combined
(B) RARP
(C) BOOTP
(D) IGMP

8) RIP is based on _____.

(A) Link state routing
(B) Shortest path routing
(C) Path vector routing
(D) Distance vector routing

9) BGP is based on _____.
(A) Link state routing
(B) Shortest path routing
(C) Path vector routing
(D) Distance vector routing

10) OSPF is _____protocol.
(A) BGP
(B) IGP
(C) RARP
(D) IGMP

11) An area border router can be connected to _____.
(A) Only another router
(B) Another router or another network
(C) Only another network
(D) Only another area border router

12) The _____ field of the IGMP message is all zeros in a query message.
(A) Version
(B) Type
(C) Checksum
(D) Group address

13) One-to-all communication is called _____ communication.
(A) Unicast
(B) Multicast
(C) Broadcast
(D) Anycast

14) The _____is a IGMP message.
(A) Query message
(B) Membership report
(C) Leave report
(D) All (A), (B) and (C)

15) Pruning and grafting strategies are used in _____.
(A) RPF
(B) RPB
(C) RPM
(D) Flooding

16) Multicast backbone uses the concept of _____.
(A) Tunneling
(B) Pruning
(C) Grafting
(D) Spanning tree

17) A system uses group shared trees for multicasting. If there are 100 sources and 10 groups, there is a maximum of _____ different trees.
(A) 10
(B) 100
(C) 1000
(D)1

18) _____ is a multicasting application.
(A) Distance learning
(B) Teleconferencing
(C) Information dissemination
(D) All (A), (B) and (C)

ANSWERS TO MULTIPLE CHOICE QUESTIONS

1	C	2	A	3	A	4	D
5	B	6	B	7	A	8	D
9	C	10	B	11	B	12	D
13	C	14	D	15	C	16	A
17	A	18	D				