Chapter 2 Solutions

1. Minimum frame size is the same as the maximum round-trip delay on the LAN.
   Maximum round-trip delay = (2 x max. I-way propagation delay) + repeater delay = (500 x 5 x 2)/200) + 25 μseconds = 50 μseconds
   At 10 Mbps, generated bytes = 50 Mbps x 10 μsec = 500 bits ~ 64 bytes, which is the minimum frame size.

2. Maximum round-trip delay is the time it takes a bit to traverse between two farthest end stations. Add to these two traversals of repeater, 1 μs each way.

   Max. R-T delay = (400 /2 x 10^8) + 2 = 4μ sec.

   Min. number of bits to detect collision = 4 x 10^{-6} x 10^9 = 4000 bits.

   Minimum bytes is the next higher 2^n bytes is 512 bytes.

3. <u>Choice 1</u>: Switched Ethernet - Replace regular hub to switched hub. This will increase the maximum capacity to about 6 times. No modifications needed to workstations. Easy to install. Switch the hub and plug the cables into the new hub.

   <u>Choice 2</u>: Full duplex - Convert NICs on the 12 workstations and replace the hub to full duplex operation. This requires hardware and configuration changes to the hub and workstations. Will double the capacity. However, this is a dead-end approach.

   <u>Choice 3</u>: Convert the network to 100Base-T Fast Ethernet. Need to replace the NICs in the workstations and replace hub for 100BaseT. Increases capacity by ten times. The speed at each workstation increases ten times. Requires 12 NICs for the workstation and a new hub.

   <u>Choice 4</u>: Split the workstation into multiple (n) LANs. Approximately increases the capacity by n times. Some hubs have the capacity to split LANs. If not, additional hubs need to be added. External bridge, or a workstation acting in the capacity of a bridge, will bridge the split LANs. This is a scalable architecture and would allow for future growth. No hardware changes need to be made to the workstations. IP address needs to be changed in the workstations that now belong to new subnets.

4. The twelve stations are divided between three subnets, with four stations in each. We need to add one 3-port bridge (in practice, a 4-port bridge), a simple version being one workstation with NICs, each connected to one of three subnets. Ports 5, 10, and 15 for the three LANs, LAN1, LAN2, and LAN3 respectively are connected to the bridge. The fourth port of the bridge is depicted as connected to the external network.

Figure for Exercise 4

The traffic in each subnet will be about 1.7 Mbps, i.e., utilization factor of 17%

5. Traffic on the hub I/O of server = 16 x 10 x 0.5 Mbps = 80 Mbps. Hence, use a 100 Mbps half-duplex mode of operation for the server as shown .

Figure for Exercise 5

6. Traffic on the server I/O of the hub = 100x 16 x 0.8
   = 128 Mbps
   In this case the server is connected to the hub using a full duplex 100 Mbps NIC.
   An alternative is to split the hub into two subnets and have two half-duplex 100 Mbps I/O's to the server, each one serving one of the two subnets.

7. (a)

IP Address	MAC Address	Port Number
145.50.50.11	00-00-ID-00-00-0B	11
145.50.50.12	00-00-ID-00-00-0C	12
145.50.50.13	00-00-ID-00-00-0D	13
145.50.60.11	00-00-ID-00-00-15	21
145.50.60.22	00-00-ID-00-00-16	22
145.50.60.23	00-00-ID-00-00-17	23

(b)

IP Address	MAC Address	Port Number
145.50.50.11	00-00-ID-00-00-0B	11
145.50.50.12	00-00-ID-00-00-0C	12
145.50.50.13	00-00-ID-00-00-0D	13
145.50.50.23	00-00-ID-00-00-17	23
145.50.60.21	00-00-ID-00-00-15	21
145.50.60.22	00-00-ID-00-00-16	22

8.

IP Address	MAC Address	Port Number
130.30.40.1	00-00-ID-00-00-64	1
145.50.50.11	00-00-ID-00-00-0B	11
145.50.50.12	00-00-ID-00-00-0C	12

145.50.50.13	00-00-ID-00-00-0D	13
145.50.60.11	00-00-ID-00-00-15	21
145.50.60.22	00-00-ID-00-00-16	22
145.50.60.23	00-00-ID-00-00-17	23

9. (a) Subnet is determined by the third decimal (bits 17-24) position of the IP address. The subnet mask is defined with the network and subnetwork bit positions being 1 and host positions zero. Thus the subnet mask is

   255.255.255.0
   or
   1111 1111 1111 1111 1111 1111 0000 0000

   (b) Packet addressed to 145.50.50.11
   145.50.50.11 XOR 255.255.255.0 = 145.50.50.0
   The subnet address table of 145.50.50.0 identifies host 11 as interface port 1. The hub, in turn, directs the packet to its port 11.

   Packet addressed to 145.50.60.11, similarly yields the subnet 145.50.60.0 and addresses the host 21 to same port 1 of the router. The hub, in turn, switches it to its port 21.

10.

Figure for Exercise 10

   Limitations:
   1) Maximum distance to a server from the hub = 100 m; 4 pairs half-duplex mode (100Base-T4).
   Maximum distance to a client from the hub = 150 m with CAT-5 cable, half-duplex mode(100Base-T).

   2) at 30% utilization, the LAN data rate is 30 Mbps.
   At 10 Mbps - clients, only three clients can be accommodated for satisfactory performance.

11. (c) is the correct answer. Four pairs of conversations can simultaneously occur with 8 ports.

12. For a 12-port hub at 50% utilization, maximum data rate is 5 Mbps.
    For a switched hub, the twelve ports can carry 6 simultaneous conversations with a data rate capacity of 60 Mbps.
    Thus, the percentage utilization improvement is 1200%.

13. (a) A bit occupies $\frac{200 \times 10^6 \text{ m/sec}}{16 \times 10^6 \text{ bits / sec}} = 12.5$ meters/bit

For the token of 3 bytes or 24 bits, the minimum length of the ring is 12.5 m/bit x 24 bits = 300 meters

(b) Additional length per bit = 12.5 meters

14. (a) Minimum length = $\frac{300 \times 10^6 \times 24}{100 \times 10^6} = 72$ meters

(b) Additional length per bit = $\frac{300 \times 10^6 \text{ m/sec}}{100 \times 10^6} = 3$ meters

15. In Ethernet configuration, as number of stations increase, collision increases and stations have to abort transmission and try again. Thus utilization / performance decreases.

In Token Ring configuration, when token is passed from one station to the next, the time it takes to travel is simply overhead. As number of stations increase, time to travel between adjacent stations is less, thus improving the utilization / performance of the LAN.

16.

Figure for Exercise 16

17. (a) The packet that takes the longest path in the message takes 10x5= 50 milliseconds and the message will be assembled only after that. This implies a latency of 50 milliseconds.

(b) Virtual circuit path delay is the shortest path, which traverses through 5 switches, producing a latency of 25 milliseconds.

18. (a) Number of E1 channels in STM-1 = 3 STS-1 x 7 VT Groups x 3 E1 = 63 channels

(b) Number of DS1 channels in STM-1 = 3 STS-1 x 7 VT Groups x 4 DS1 = 84 channels

19.

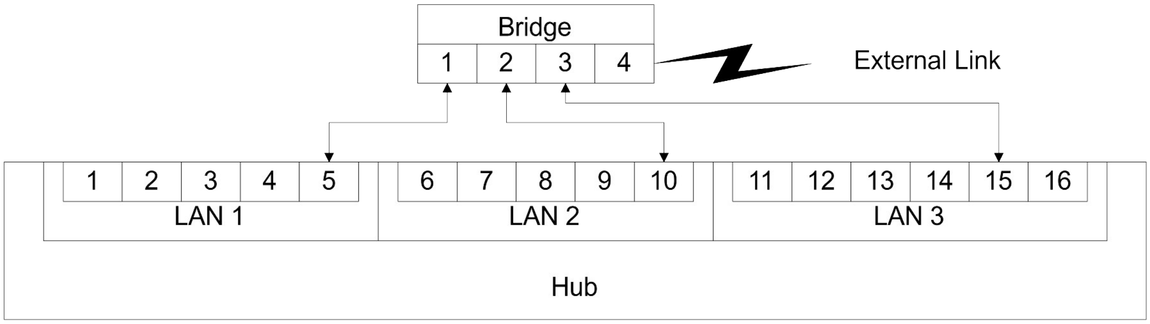

Figure for Exercise 4

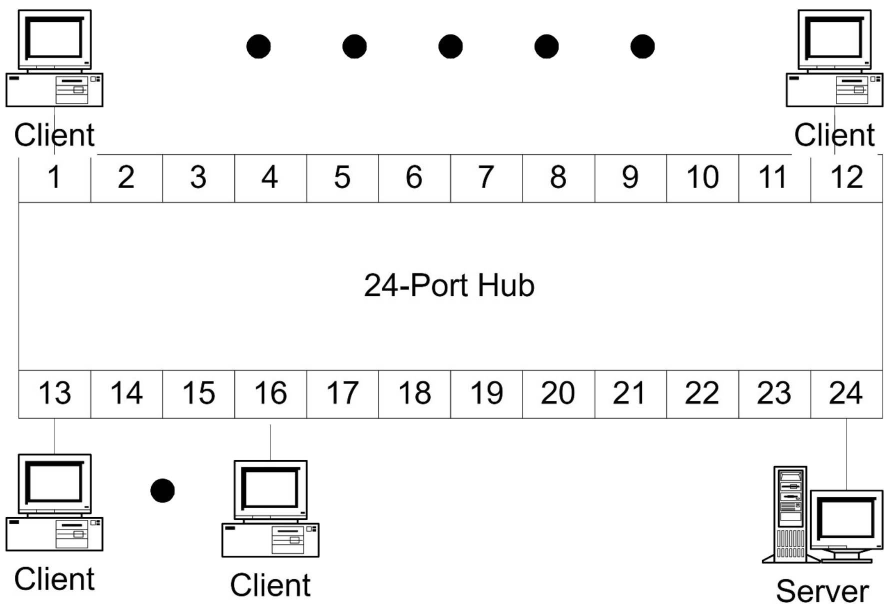

Figure for Exercise 5

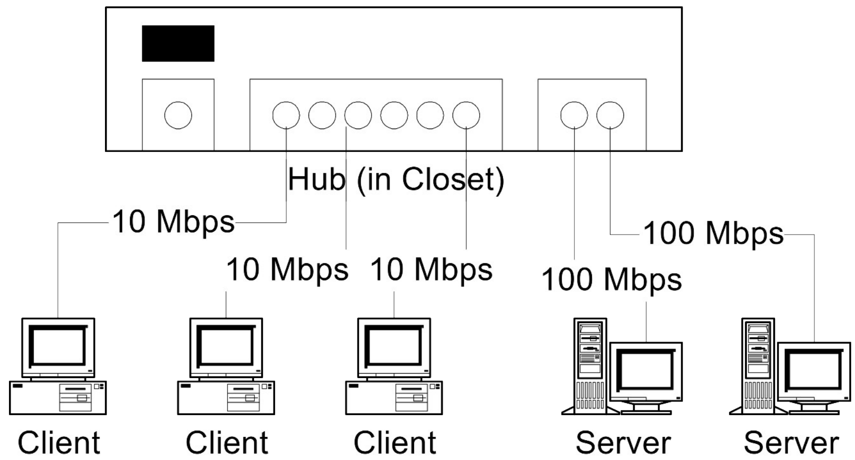

Figure for Exercise 10

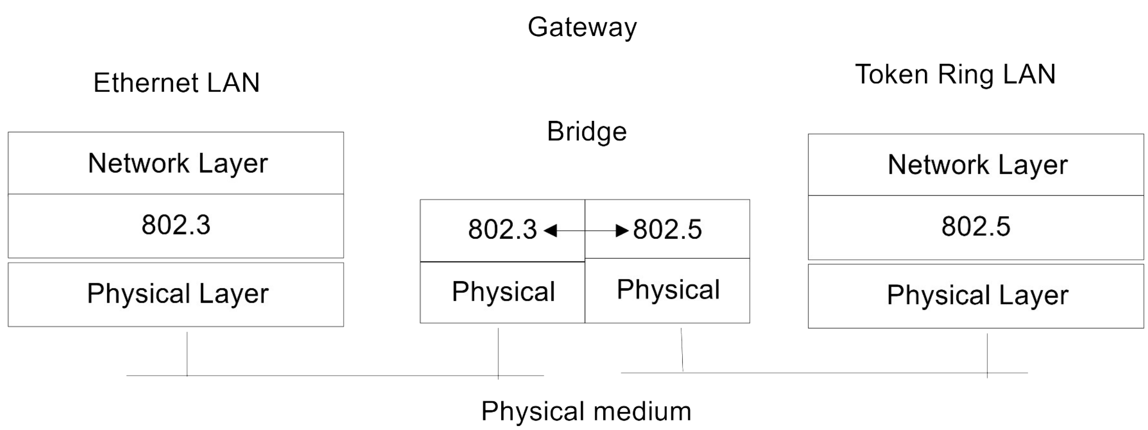

Figure for Exercise 16