24.12 SUMMARY

- The average data rate, peak data rate, maximum burst size, and effective band width are qualitative values that describe a data flow.
- A data flow can have a constant bit rate, a variable bit rate, or traffic that is bursty.
- Congestion control refers to the mechanisms and techniques to control congestion and keep the load below capacity.
- Delay and throughput measure the performance of a network.
- Open-loop congestion control prevents congestion; closed-loop congestion control removes congestion.

- TCP avoids congestion through the use of two strategies: the combination of slow start and additive increase, and multiplicative decrease.
- Frame Relay avoids congestion through the use of two strategies: backward explicit congestion notification (BECN) and forward explicit congestion notification (FECN).
- A flow can be characterized by its reliability, delay, jitter, and bandwidth.
- Scheduling, traffic shaping, resource reservation, and admission control are techniques to improve quality of service (QoS).
- FIFO queuing, priority queuing, and weighted fair queuing are scheduling techniques.
- Leaky bucket and token bucket are traffic shaping techniques.
- Integrated Services is a flow-based QoS model designed for IP.
- The Resource Reservation Protocol (RSVP) is a signaling protocol that helps IP create a flow and makes a resource reservation.
- Differential Services is a class-based QoS model designed for IP.
- Access rate, committed burst size, committed information rate, and excess burst size are attributes to control traffic in Frame Relay.
- Quality of service in ATM is based on service classes, user-related attributes, and network-related attributes.

24.13 PRACTICE SET

Review Questions

I. How are congestion control and quality of service related?

1. In ***congestion control***, the load on a network is prevented from exceeding the capacity. ***Quality of service*** refers to the characteristics that a flow of data seeks to attain. If there is good congestion control, then the QoS is also good and vice versa.

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2. What is a traffic descriptor?

2. A ***traffic descriptor*** is a qualitative value that describes a data flow.

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3. What is the relationship between the average data rate and the peak data rate?

3. The ***average data rate*** is always less than or equal to the ***peak data rate***.

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4. What is the definition of bursty data?

4. The data rate of ***bursty data*** changes suddenly in a very short period of time.

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5. What is the difference between open-loop congestion control and closed-loop congestion control?

5. ***Open-loop*** congestion control policies try to prevent congestion. ***Closed-loop*** congestion control policies try to alleviate the effects of congestion.

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6. Name the policies that can prevent congestion.

6. The following policies can help to prevent congestion: ***a good retransmission policy***, ***use of the selective-repeat window***, ***a good acknowledgment policy***, ***a good discard policy***, and ***a good admissions policy***.

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7. Name the mechanisms that can alleviate congestion.

7. Congestion can be alleviated by ***back pressure***, ***a choke point***, and ***explicit signaling***.

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8. What determines the sender window size in TCP?

8. The TCP send window size is determined by the ***receiver*** and by the ***congestion on the network***.

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9. How does Frame Relay control congestion?

9. Frame Relay uses the ***BECN*** bit and the ***FECN*** bit to control congestion.

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10. What attributes can be used to describe a flow of data?

10. A flow of data can be described by its ***reliability***, ***delay***, ***jitter***, and ***bandwidth***.

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11. What are four general techniques to improve quality of service?

11. ***Scheduling***, ***traffic shaping***, ***admission control***, and ***resource reservation*** can improve QoS.

12. What is traffic shaping? Name two methods to shape traffic.

12. ***Traffic shaping*** is a mechanism to control the amount and rate of traffic sent to the network. The ***leaky bucket*** method and the ***token bucket*** method can shape traffic.

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13. What is the major difference between Integrated Services and Differentiated Services?

13. ***Differentiated Services*** was developed to handle the shortcomings of IntServ. The main processing was moved from the core of the network to the edge of the network. Also, the ***per-flow service*** was changed to ***per-class service***.

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14. How is Resource Reservation Protocol related to Integrated Services?

14. When ***IntServ*** is used at the IP level, a signaling system is needed to set up the needed virtual circuit. The ***Resource Reservation Protocol*** is this signaling system.

IS. What attributes are used for traffic control in Frame Relay?

15. The attributes are ***access rate***, ***committed burst size***, ***committed information rate***, and ***excess burst size***.

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16. In regard to quality of service, how do user-related attributes differ from network-related attributes in ATM?

16. ***User-related*** attributes define how fast the user wants to send data. ***Network-related attributes*** define network characteristics.

Exercises

17. The address field of a Frame Relay frame is 1011000000010111. Is there any congestion in the forward direction? Is there any congestion in the backward direction?

17. The bit pattern is 10110000 0001**01**1. The ***FECN*** bit is **0** and the ***BECN*** bit is **1**. There is no congestion in the forward direction, but there is congestion in the backward direction.

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18. A frame goes from A to B. There is congestion in both directions. Is the PECN bit set? Is the BECN bit set?

18. Both ***FECN*** and ***BECN*** bits are set (they are both **1s**).

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19. In a leaky bucket used to control liquid flow, how many gallons of liquid are left in the bucket if the output rate is 5 gal/min, there is an input burst of 100 gal/min for 12 s, and there is no input for 48 s?

19.

Input: $(100/60) \times 12 + 0 \times 48 =$ **20** gallons
Output: **5** gallons
Left in the bucket: $20 - 5 =$ **15**

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20. An output interface in a switch is designed using the leaky bucket algorithm to send 8000 bytes/s (tick). If the following frames are received in sequence, show the frames that are sent during each second.

Frames 1, 2, 3,4: 4000 bytes each

Frames 5, 6, 7: 3200 bytes each

Frames 8, 9: 400 bytes each

Frames 10, 11, 12: 2000 bytes each

20.

Second 1:

Initial:	→	n = 8000	
Frame **1** is sent	→	n = 4000	
Frame **2** is sent	→	n = 0	**Stop: n < Frame 3**

Second 2:

Initial:	→	n = 8000	
Frame **3** is sent	→	n = 4000	
Frame **4** is sent	→	n = 0	**Stop: n < Frame 5**

Second 3:

Initial:	→	n = 8000	
Frame **5** is sent	→	n = 4800	
Frame **6** is sent	→	n = 1600	**Stop: n < Frame 7**

Second 4:

Initial:	→	n = 8000	
Frame **7** is sent	→	n = 4800	
Frame **8** is sent	→	n = 4400	
Frame **9** is sent	→	n = 4000	
Frame **10** is sent	→	n = 2000	
Frame **11** is sent	→	n = 0	**Stop: n < Frame 12**

Second 5:

Initial:	→	n = 8000	
Frame **12** is sent	→	n = 6000	**Stop: no more frames**

21. A user is connected to a Frame Relay network through a T-1 line. The granted CIR is 1 Mbps with a *Be* of 5 million bits/5 s and *Be* of 1 million bits/5 s.

a. What is the access rate?

b. Can the user send data at 1.6 Mbps?

c. Can the user send data at 1 Mbps all the time? Is it guaranteed that frames are never discarded in this case?

d. Can the user send data at 1.2 Mbps all the time? Is it guaranteed that frames are never discarded in this case? If the answer is no, is it guaranteed that frames are discarded only if there is congestion?

e. Repeat the question in part (d) for a constant rate of 1.4 Mbps.

f. What is the maximum data rate the user can use all the time without worrying about the frames being discarded?

g. If the user wants to take a risk, what is the maximum data rate that can be used with no chance of discarding if there is no congestion?

21.

a. The access rate is the rate of T-1 line (**1.544 Mbps**) that connects the user to the network. Obviously, the user cannot exceed this rate.

b. The user data rate cannot exceed the access rate, the rate of the T-1 line that connects the user to the network. The user should stay below this rate (**1.544 Mbps**).

c. The CIR is **1 Mbps**. This means that the user can send data at this rate all the time without worrying about the discarding of data.

d. The user can send data at the rate of **1.2 Mbps** because it is below the access rate. However, the user sends 6 million bits per 5 seconds, which is above B_c (5 million per 5 seconds), but below B_c+B_e (6 million per 5 seconds). The network will discard no data if there is no congestion, but it may discard data if there is congestion.

e. The user can send data at the rate of **1.4 Mbps** because it is below the access rate. However, the user sends 7 million bits per 5 seconds, which is above B_c and above B_c+B_e (6 million per 5 seconds). In other words, the user rate is beyond its share. The network will discard some data to limit the data rate.

f. To be sure that the network never discard her data, the user should stay at or below CIR rate all the time, which means below or at **1 Mbps**.

g. If the user can accept possible data discarding in case of congestion, she can send at a higher rate if the number of bits is below B_c+B_e (6 million per 5 seconds in this case). This mans that the user can send at **1.2 Mbps** all the time if she accepts this risk.

22. In Exercise 21 the user sends data at 1.4 Mbps for 2 s and nothing for the next 3 s. Is there a danger of discarded data if there is no congestion? Is there a danger of discarded data if there is congestion?

22. There is no risk of discarding at all because in 5 seconds, the user has sends

$$1.4 \text{ Mbps} \times 2 + 0 \times 3 = \mathbf{2.8} \text{ million bits in 5 seconds,}$$

which is below the B_c.

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23. In ATM, if each cell takes 10 μs to reach the destination, what is the CTD?

23. CTD is the average *cell transfer delay*. If each cell takes 10 μs to reach the destination, we can say that CTD = [(10 μs × *n*) / *n*] in which *n* is the total number of cells transmitted in a period of time. This means that CTD = **10 μs**

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24. An ATM network has lost 5 cells out of 10,000 and 2 are in error. What is the CLR? What is the CER?

24.

a. CLR is the average *cell loss ratio*. If the network has lost 5 cells out of 10,000, then CLR = **5 /10,000** = **1/2000**.

b. CER is the average *cell error ratio*. If two cells out of 10,000 are in error, then CLR = **2 /10,000** = **1/5000**.
