# CHAPTER 24 (corrisponde al cap. 23 italiano)

# *Congestion Control and Quality of Service*

## *Solutions to Review Questions and Exercises*

### Review Questions

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.
2. A ***traffic descriptor*** is a qualitative value that describes a data flow.
3. The ***average data rate*** is always less than or equal to the ***peak data rate***.
4. The data rate of ***bursty data*** changes suddenly in a very short period of time.
5. ***Open-loop*** congestion control policies try to prevent congestion. ***Closed-loop*** congestion control policies try to alleviate the effects of 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***.
7. Congestion can be alleviated by ***back pressure***, ***a choke point***, and ***explicit signaling***.
8. The TCP send window size is determined by the ***receiver*** and by the ***congestion on the network***.
9. Frame Relay uses the ***BECN*** bit and the ***FECN*** bit to control congestion.
10. A flow of data can be described by its ***reliability***, ***delay***, ***jitter***, and ***bandwidth***.
11. ***Scheduling***, ***traffic shaping***, ***admission control***, and ***resource reservation*** can improve QoS.
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.
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***.
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.

15. The attributes are ***access rate***, ***committed burst size***, ***committed information rate***, and ***excess burst size***.
16. ***User-related*** attributes define how fast the user wants to send data. ***Network-related attributes*** define network characteristics.

## Exercises

17. The bit pattern is 10110000 00010**1**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.
18. Both ***FECN*** and ***BECN*** bits are set (they are both **1s**).
19. Input: $(100/60) \times 12 + 0 \times 48 = \mathbf{20}$ gallons
    Output: **5** gallons
    Left in the bucket: $20 - 5 = \mathbf{15}$
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. 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. 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 $B_c$.

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**

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**.