CHAPTER 18 (corrisponde al cap. 17 italiano)

Virtual Circuit Switching: Frame Relay and ATM

Solutions to Review Questions and Exercises

Review Questions

1. ***Frame Relay*** does not use *flow* or *error control*, which means it does not use the sliding window protocol. Therefore, there is no need for ***sequence numbers***.
2. ***DLCIs*** are unique only for a particular interface. A switch assigns a DCLI to each virtual connection in an interface. This way two different connections belonging to two different interfaces may have the same DLCI.
3. ***T-lines*** provide point-to-point connections, not many-to-many. In order to connect several LANs together using T-lines, we need a mesh with many lines. Using Frame Relay we need only one line for each LAN to get connected to the Frame Relay network.
4. In a ***PVC***, two end systems are connected permanently through a virtual connection. In a ***SVC***, a virtual circuit needs to be established each time an end system wants to be connected with another end system.
5. ***Frame Relay*** does not define a specific protocol for the physical layer. Any protocol recognized by ANSI is acceptable.
6. If data packets are different sizes there might be variable delays in delivery.
7. A ***UNI*** (user network interface) connects a user access device to a switch inside the ATM network, while an ***NNI*** (network to network interface) connects two switches or two ATM networks.
8. A ***TP*** (transmission path) is the physical connection between a user and a switch or between two switches. It is divided into several ***VPs*** (virtual paths), which provide a connection or a set of connections between two switches. VPs in turn consist of several ***VCs*** (virtual circuits) that logically connect two points together.
9. An ATM virtual connection is defined by two numbers: a ***virtual path identifier (VPI)*** and a ***virtual circuit identifier (VCI).***
10. The ***Application Adaptation Layer (AAL)*** allows existing networks to connect to ATM facilities by mapping packet data into fixed-sized ATM cells. The ***ATM layer*** provides routing, traffic management, switching, and multiplexing services.

11. In an UNI, the total length of VPI+VCI is 24 bits. This means that we can define $\mathbf{2^{24}}$ virtual circuits in an UNI. In an NNI, the total length of VPI+VCI is 28 bits. This means that we can define $\mathbf{2^{28}}$ virtual circuits in an NNI.
12. We can briefly summarize the most important issues:
    a. Traditional LANs are ***connectionless*** protocols; ATM is a ***connection-oriented*** protocol.
    b. Traditional LANs define the route of a packet through ***source and destination addresses***; ATM defines the route of a cell through ***virtual connection identifiers***.
    c. Traditional LANs can do ***unicast***, ***multicast***, and ***broadcast*** transmission; ATM is designed only for ***unicast*** transmission.

Exercises

13. We first need to look at the EA bits. In each byte, the EA bit is the last bit (the eight bit from the left). If EA bit is 0, the address ends at the current byte; if it 1, the address continues to the next byte.

    Address → **10110000 00010111**

    The first EA bit is 0 and the second is 1. This means that the address is only two bytes (no address extension). DLCI is only 10 bits, bits 1 to 6 and 9 to 12 (from left).

    Address → **101100**00 **0001**0111
    DLCI → **1011000001** → **705**

14. The address field in Frame Relay is 16 bits. The address given is only 15 bits. It is **not valid**.
15. We first need to look at the EA bits. In each byte, the EA bit is the last bit (the eight bit from the left). If the EA bit is 0, the address ends at the current byte; if it 1, the address continues to the next byte.

    Address → **0x7C74E1** → **01111100 01110100 11100001**

    The first two EA bit are 0s and the last is 1. This means that the address is three bytes (address extension). DLCI is 16 bits, bits 1 to 6, 9 to 12, and 17 to 22.

    Address → **011111**00 **0111**0100 **111000**
    DLCI → **0111110111111000** → **32248**

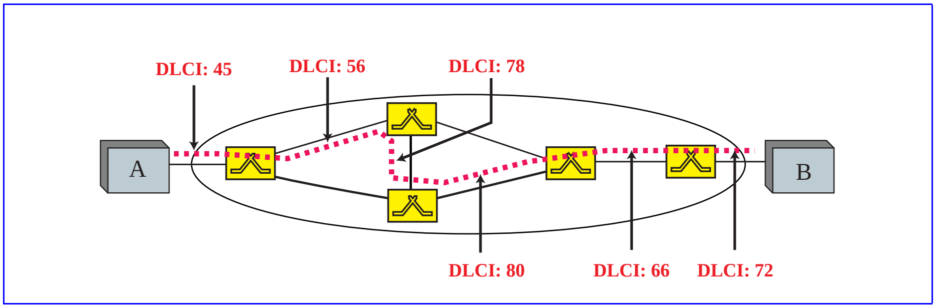
16. We first change the number 178 to 10-bit binary **0010110010**. We then add separate DLCI into a 6-bit and a 4-bit and add extra bits. Note that the first EA bit is 0; the second is 1.

    DLCI → **0010110010**

    Address → **001011**0**0** **0010**000**1** → **0x2C21**

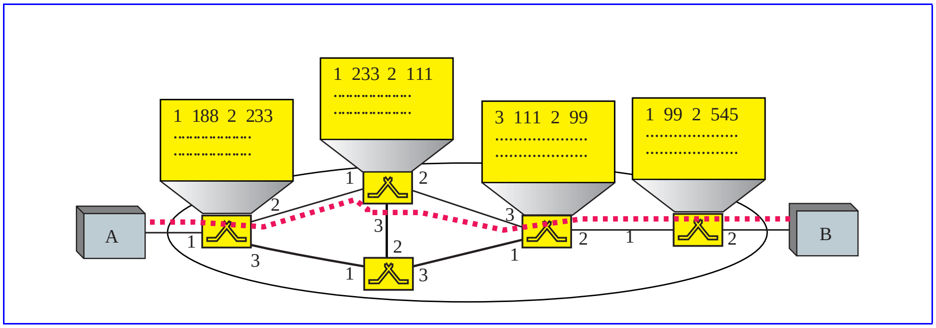
17. See Figure 18.1.

Figure 18.1 *Solution to Exercise 17*



18. See Figure 18.2.

Figure 18.2 *Solution to Exercise 18*



19. In AAL1, each cell carries only 47 bytes of user data. This means the number of cells sent per second can be calculated as [(2,000,000/8)/47] ≈ **5319.15**.

20. In AAL1, each 53-byte cell carries only 47 bytes of user data. There are 6 bytes of overhead. The efficiency can be calculated as 47/ 53 ≈ **89%**.

21.

a. In AAL3/4, the CS layer needs to pass 44-byte data units to SAR layer. This means that the total length of the packet in the CS layer should be a multiple of 44. We can find the smallest value for padding as follows:

H + Data + Padding + T = 0 mod 44
4 + 47,787 + Padding + 4 = 0 mod 44
Padding = **33 bytes**

b. The number of data unit in the SAR layer is

(4 + 47787 + 33 +4) / 44 = **1087**

c. In AAL3/4, the number of cells in the ATM layer is the same as the number of data unit in the SAR layer. This means we have **1087 cells**.

22. If we assume that there is no need for padding, the efficiency of the AAL3/4 depends on the size of the packet because of the 8 bytes of overhead in the CS layer. A larger packet is more efficient than a smaller packet. A packet of size 8 bytes has an efficiency of 8/16 = 50% while a packet of size 1000 bytes has an efficiency of 1000/1008 ≈ 99%.

23.
   a. The minimum number of cells is **1**. ***This happens when the data size ≤ 36 bytes***. Padding is added to make it exactly 36 bytes. Then 8 bytes of header creates a data unit of 44 bytes at the SAR layer.
   b. The maximum number of cells can be determined from the maximum number of data units at the CS sublayer. If we assume no padding, the maximum size of the packet is 65535 + 8 = 65543. This needs 65543 / 44 ≈ 1489.61. The maximum number of cells is **1490**. ***This happens when the data size is between 65,509 and 65,535 (inclusive) bytes.*** We need to add between 17 to 43 (inclusive) bytes of padding to make the size 65552 bytes. The 8 byte overhead at the CS layer makes the total size 65560 which means 1490 data units of size 44.

24.
   a. The minimum number of cells is **1**. ***This happens when the data size ≤ 40 bytes***. Padding is added to make it exactly 40 bytes. Then 8 bytes of header creates a data unit of 48 bytes at the SAR layer.
   b. The maximum number of cells is **1366**. It can be determined from the maximum number of data units at the CS sublayer. If we assume no padding, the maximum size of the packet is 65535 + 8 = 65543. This needs 65543 / 48 ≈ 1365.48 or 1366 cells. ***This happens when the data size is between 65,513 and 65,535 (inclusive) bytes***. We need to add between 25 to 47 (inclusive) bytes of padding to make the size 65560 bytes. The 8 byte overhead at the CS layer makes the total size 65568 which means 1366 data unit of size 48.

25. AAL1 takes a ***continuous stream*** of bits from the user without any boundaries. There are always bits to fill the data unit; there is no need for padding. The other AALs take a bounded packet from the upper layer.

26. In AAL3/4 the number of bytes in CS, after adding header, padding, and trailer must be multiple of 44.
   a. When user (**4 + user data + 4**) mod 44 = 0.
   b. When user (**4 + user data + 40 + 4**) mod 44 = 0.
   c. When user (**4 + user data + 43 + 4**) mod 44 = 0.

27. In AAL5 the number of bytes in CS, after adding padding and trailer must be multiple of 48.
   a. When user (**user data** + **8**) mod 48 = 0.
   b. When user (**user data** + **40** + **8**) mod 48 = 0.
   c. When user (**user data** + **43** + **8**) mod 48 = 0.

28. For AAL1 we can calculate the exact number of bytes; for AAL2, AAL3/4, and AAL5, we cannot calculate the portion of the overhead in CS sublayer.
   a. AAL1 → 53 – **5** – 1 = **47**

b. AAL2 $\rightarrow$ 53 – **5** – 1 – (CS header) < **47**
c. AAL3/4 $\rightarrow$ 53 – **5** – 4 – (CS header) < **44**
d. AAL3/4 $\rightarrow$ 53 – **5** – (CS header) < **48**