CHAPTER 17 (corrisponde al cap. 16 italiano)

SONET/SDH

Solutions to Review Questions and Exercises

Review Questions

1. The ANSI standard is called ***SONET*** and the ITU-T standard is called ***SDH***. The standards are nearly identical.
2. SONET defines a hierarchy of electrical signaling levels called ***synchronous transport signals (STSs)***. SDH specifies a similar system called a ***synchronous transport module (STM).***
3. ***STS multiplexers/demultiplexers*** mark the beginning points and endpoints of a SONET link. An STS multiplexer multiplexes signals from multiple electrical sources and creates the corresponding optical signal. An STS demultiplexer demultiplexes an optical signal into corresponding electric signals. ***Add/drop multiplexers*** allow insertion and extraction of signals in an STS. An add/drop multiplexer can add an electrical signals into a given path or can remove a desired signal from a path.
4. ***STSs*** are the hierarchy of electrical signals defined by the SONET standards. ***OCs*** are the corresponding optical signals.
5. ***Pointers*** are used to show the ***offset*** of the SPE in the frame or for ***justification***. SONET uses two pointers show the position of an SPE with respect to an STS. SONET use the third pointer for rate adjustment between SPE and STS.
6. A ***single clock*** handles the timing of transmission and equipment across the entire network.
7. A ***regenerator*** takes a received optical signal and regenerates it. The SONET regenerator also replaces some of the existing overhead information with new information.
8. SONET defines four layers: ***path***, ***line***, ***section***, and ***photonic***.
9. The ***path layer*** is responsible for the movement of a signal from its source to its destination. The ***line layer*** is responsible for the movement of a signal across a physical line. The ***section layer*** is responsible for the movement of a signal across a physical section. The ***photonic layer*** corresponds to the physical layer of the OSI model. It includes physical specifications for the optical fiber channel. SONET

uses NRZ encoding with the presence of light representing 1 and the absence of light representing 0.

10. ***A virtual tributary*** is a partial payload that can be inserted into an STS-1 and combined with other partial payloads to fill out the frame. Instead of using all 86 payload columns of an STS-1 frame for data from one source, we can subdivide the SPE and call each component a VT.

Exercises

11. Each STS-n frame carries $(9 \times \boldsymbol{n} \times 86)$ bytes of bytes. SONET sends 8000 frames in each second. We can then calculate the user data rate as follows:

$$\begin{array}{llllll} \text{STS-}\mathbf{3} & \rightarrow & 8000 \times & (9 \times \mathbf{3} \times 86) & \times 8 & = \mathbf{148.608\ Mbps} \\ \text{STS-}\mathbf{9} & \rightarrow & 8000 \times & (9 \times \mathbf{9} \times 86) & \times 8 & = \mathbf{445.824\ Mbps} \\ \text{STS-}\mathbf{12} & \rightarrow & 8000 \times & (9 \times \mathbf{12} \times 86) & \times 8 & = \mathbf{594.432\ Mbps} \end{array}$$

12. To create one STS-36 from four STS-9s, we first need to demultiplex each STS-9 into nine STS-1s. We can then multiplex thirty-six STS-1s into one STS-36. However, there is no extra overhead involved in the process of demultiplexing or multiplexing. Demultiplexing is done byte by byte; multiplexing is also done byte by byte.
13. The user data rate of STS-1 is $(8000 \times 9 \times 86 \times 8) = 49.536$ Mbps. To carry a load with a data rate 49.540, we need another 4 kbps. This means that we need to insert 4000 / 8 = 500 bytes into every 8000 frames. In other words, ***500 out of every 8000*** frames need to allow the H3 byte to carry data. For example, we can have sequences of 16 frames in which the first frame is an overloaded frame and then 15 frames are normal.
14. The user data rate of STS-1 is $(8000 \times 9 \times 86 \times 8) = 49.536$ Mbps. To carry a load with a data rate 49.526, we need 10 kbps worth of dummy data. This means that we need 10000 / 8 = 750 bytes of dummy data in 8000 frames. In other words, ***750 out of every 8000*** frames need to allow the next byte after H3 to be empty (dummy). For example, we can have sequences of 32 frames in which the first three frames are underloaded and the next 29 are normal.
15. In answering this question, we need to think about the three upper layers in SONET. The path layer is responsible for end-to-end communication. The line layer is responsible between multiplexers. The section layer is responsible between devices.
    a. ***A1*** and ***A2*** are used as ***aligners*** (synchronizers). They perform the same job as a preamble or flag field in other networks. We can call them ***framing bytes***. These bytes are set and renewed at each device to synchronize the two adjacent devices. There is no need for these bytes at the line or path layer.
    b. ***C1*** is used at the section layer to identify multiplexed STSs. This idea can be compared to statistical TDM in which each slot needs an address. In other words, C1 is the address of each STS-1 in an STS-n. C2 is like the port numbers in other protocols. When different processes need to communicate over the

same network, we need port addresses to distinguish between them. There is no need for C byte at the line layer.

c. ***D*** bytes are used for SONET administration. SONET requires two separate channels at the section (device-to-device) and line (multiplexer-to-multiplexer) layers.No administration is provided at the line layer.

d. ***E*** byte creates a voice communication channel between two devices at the ends of a section.

e. ***F*** bytes also create a voice communication. F1 is used between two devices at the end of a section; F2 is used between two ends. No bytes are assigned at the line layer.

f. The only ***G*** bytes are used for status reporting. A device at the end of the path reports its status to a device at the beginning of the path. No other layer needs this byte.

g. ***H*** bytes are the pointers. H1 and H2 are used to show the offsetting of the SPE with respect to STS-1. H3 is used to compensate for a faster or slower user data. All three are used in the line layer because add/drop multiplexing is done at this layer. H4 is used at the path layer to show a multiframe payload. Obviously we do not need an H byte in the section layer because no multiplexing or demultiplexing happens at this layer.

h. The only ***J*** byte is at the path layer to show the continuous stream of data at the path layer (end-to-end). The user uses a pattern that must be repeated to show the stream is going at the right destination. There is no need for this byte at the other layers.

i. As we discussed, ***K*** bytes are used for automatic protection switching, which happens at the line layer (multiplexing). Other layers do not need these bytes.

j. Z bytes are unused bytes. All of the bytes in SOH are assigned, but in LOH and POH some bytes are still unused.

16. The ***B*** bytes are ***error-detection*** bytes. They are used at all layers. B1 is used at the section layer (over the whole frame). Each bit of this byte is calculated over the corresponding bit of all bytes in the previous frame. B2 is used at the line layer. B3 is used at the path layer calculated over all bits of previous SPE.