CHAPTER 17

SONET/SDH

Solutions to Odd-Numbered 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.
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.
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.
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.
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.

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:

$$\text{STS-}\mathbf{3} \quad \rightarrow \quad 8000 \times (9 \times \mathbf{3} \times 86) \times 8 = \mathbf{148.608\ Mbps}$$

STS-**9** → 8000 × (9 × **9** × 86) × 8 = **445.824 Mbps**
STS-**12** → 8000 × (9 × **12** × 86) × 8 = **594.432 Mbps**

13. The user data rate of STS-1 is (8000 × 9 × 86 × 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.

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.