Review Question 8.1

Multiplexing is cost-effective because, higher the data rate, the more cost-effective the transmission facility.

Review Question 8.4

Downstream: from the carrier's central office to the customer's site
Upstream: from customer to carrier's central office.

Review Question 8.5

A synchronous time division multiplexer interleaves bits from each signal and takes turns transmitting bits from each of the signals in a round-robin fashion.

Review Question 8.6

A statistical time division multiplexer is more efficient than a synchronous time division multiplexer because it allocates time slots dynamically on demand and does not dedicate channel capacity to inactive low speed lines.

Problem 8.9

Assuming 4 kHz per voice signal, the required bandwidth for FDM is $24 \times 4 = 96$ kHz. With PCM, each voice signal requires a data rate of 64 kbps, for a total data rate of $24 \times 64 = 1.536$ Mbps. At 1 bps/Hz, this requires a bandwidth of 1.536 MHz.

Problem 8.10

The structure is that of Figure 8.8, with one analog signal and four digital signals. The 500 Hz analog signal is converted into a PAM signal at 1 kHz; with 4-bit encoding, this becomes a 4-kbps PCM digital bit stream. A simple multiplexing technique is to use a 260-bit frame, with 200 bits for the analog signal and 15 bits for each digital signal, transmitted at a rate of 5.2 kbps or 20 frames per second. Thus the PCM source transmits at (20 frames/sec) $\times$ (200 bits/frame) = 4000 bps. Each digital source transmits at (20 frames/sec) $\times$ (15 bits/frame) = 300 bps.

Problem 8.12

The capacity of the T1 line is 1.544 Mbps. The available capacity is 1.544×0.99 = 1.52856 Mbps = AC.

a. AC/110 = 13,896
b. AC/300 = 5,095
c. AC/1200 = 1273
d. AC/9600 = 159
e. AC/64000 = 23

If the sources were active only 10% of the time, a statistical multiplexer could be used to boost the number of devices by a factor of about seven or eight in each case. This is a practical limit based on the performance characteristics of a statistical multiplexer.

Problem 8.13

Synchronous TDM: 9600 bps $\times$ 10 = 96 kbps
Statistical TDM: 9600 bps $\times$ 10 $\times$ 0.5/0.8 = 60 kbps