Data Communications and Networking Fourth Edition

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Chapter 16

Wireless WANs: Cellular Telephone and Satellite Networks

16-1 CELLULAR TELEPHONY

Cellular telephony *is designed to provide communications between two moving units, called mobile stations (MSs), or between one mobile unit and one stationary unit, often called a land unit.*

Topics discussed in this section:

Frequency-Reuse Principle
Transmitting
Receiving
Roaming
First Generation
Second Generation
Third Generation

Figure 16.1 *Cellular system*

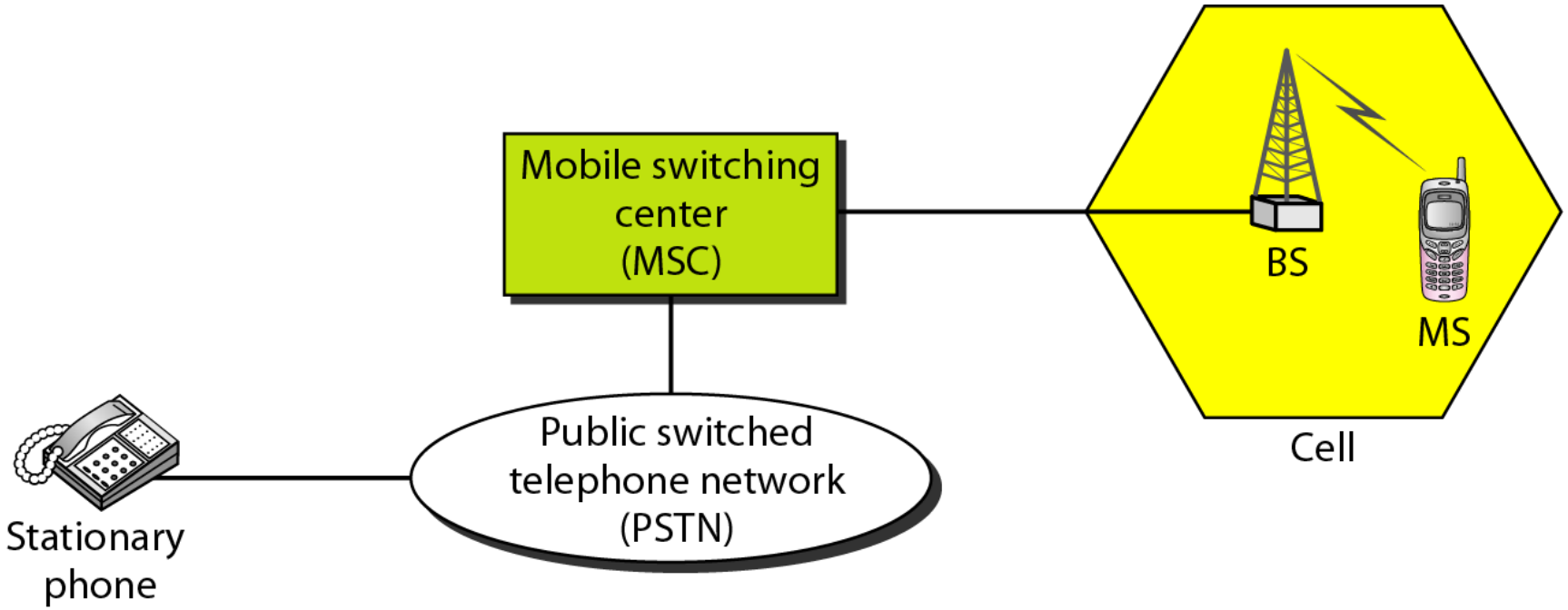
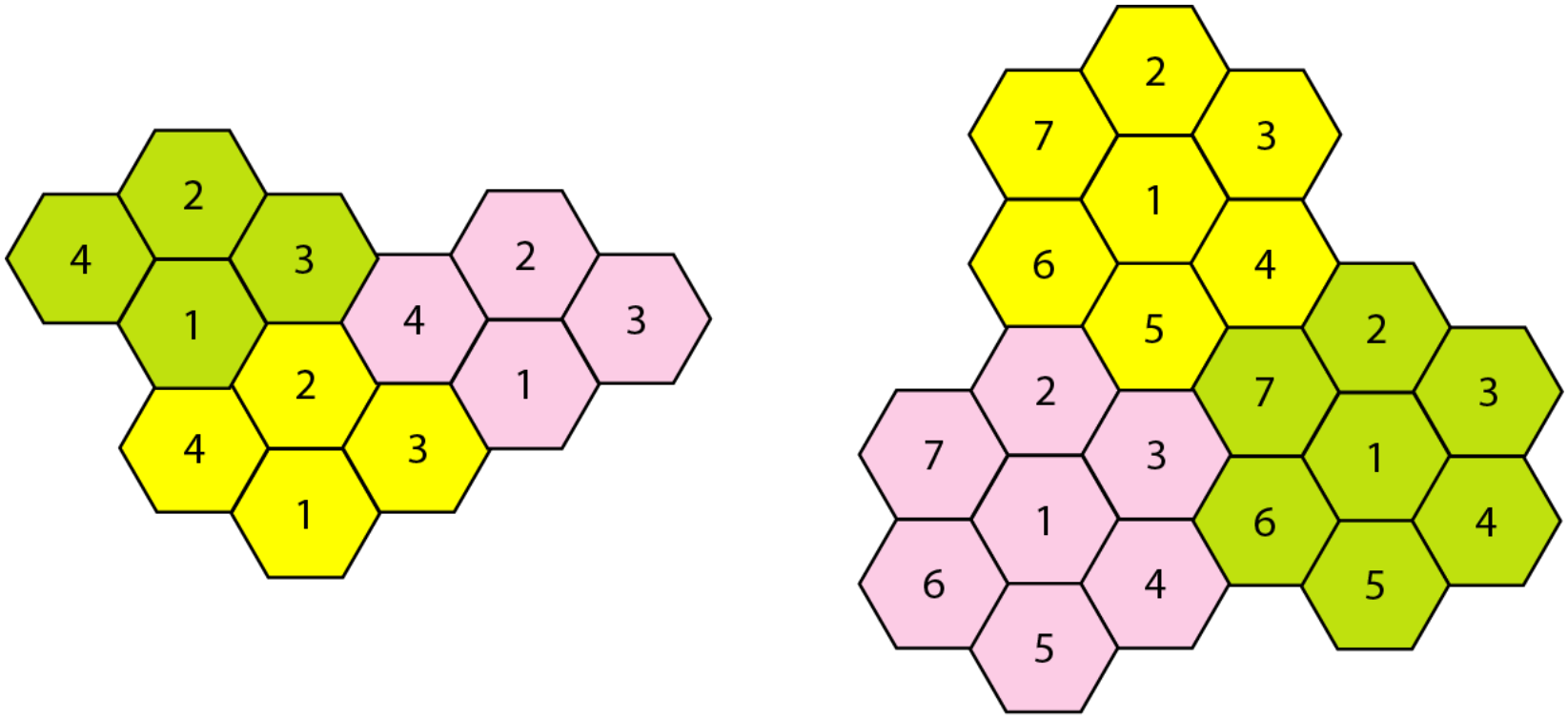


Figure 16.2 *Frequency reuse patterns*



a. Reuse factor of 4

b. Reuse factor of 7

Note

AMPS is an analog cellular phone system using FDMA.

Figure 16.3 *Cellular bands for AMPS*

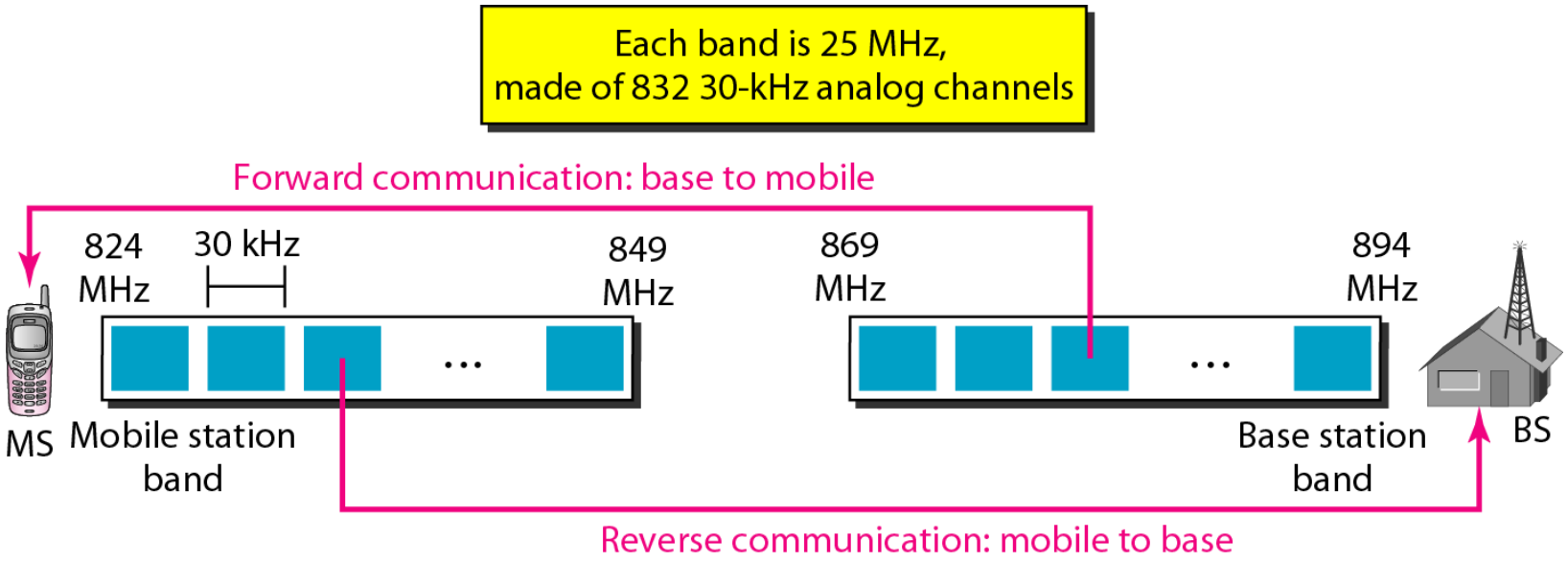


Figure 16.4 *AMPS reverse communication band*

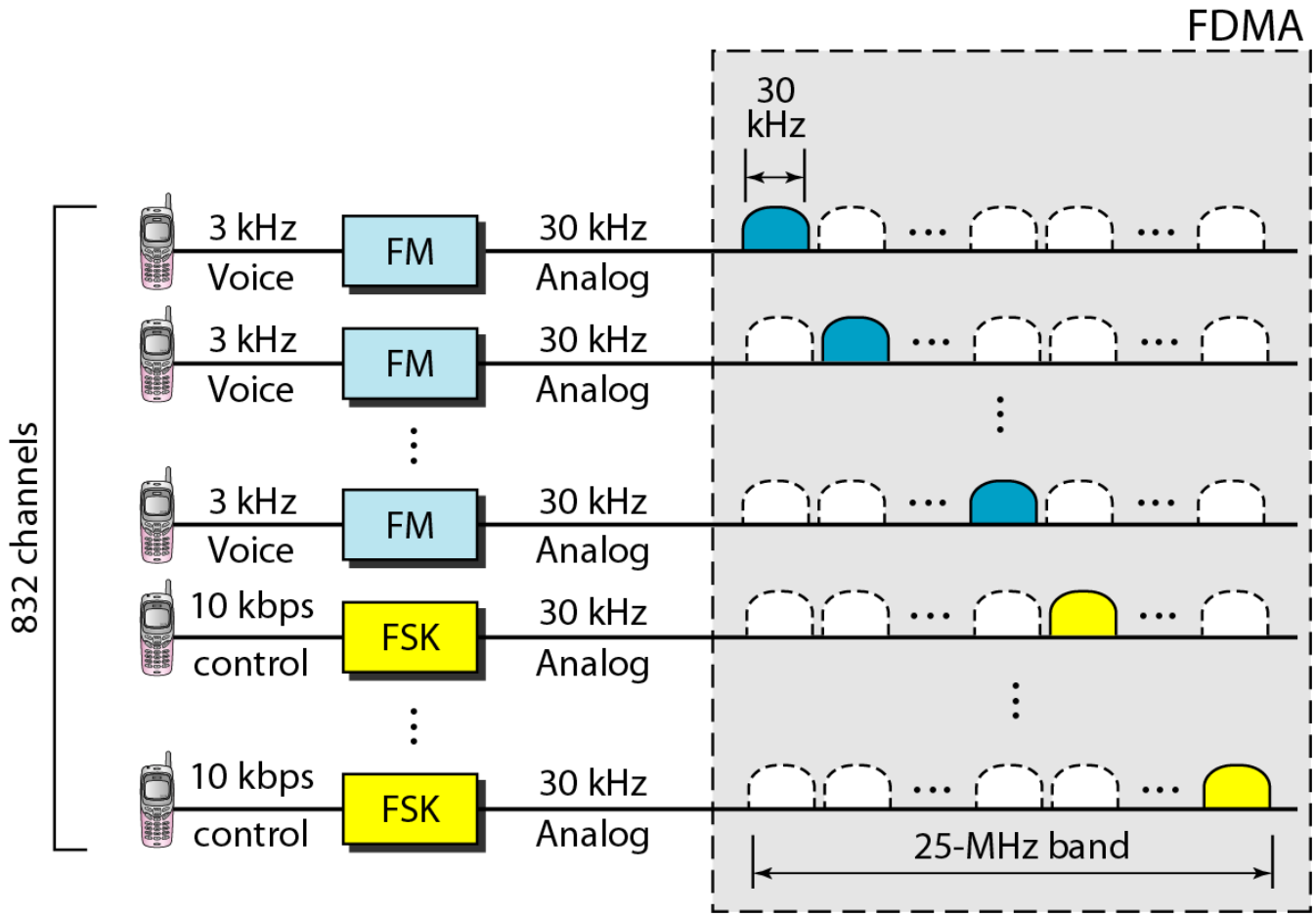


Figure 16.5 *Second-generation cellular phone systems*

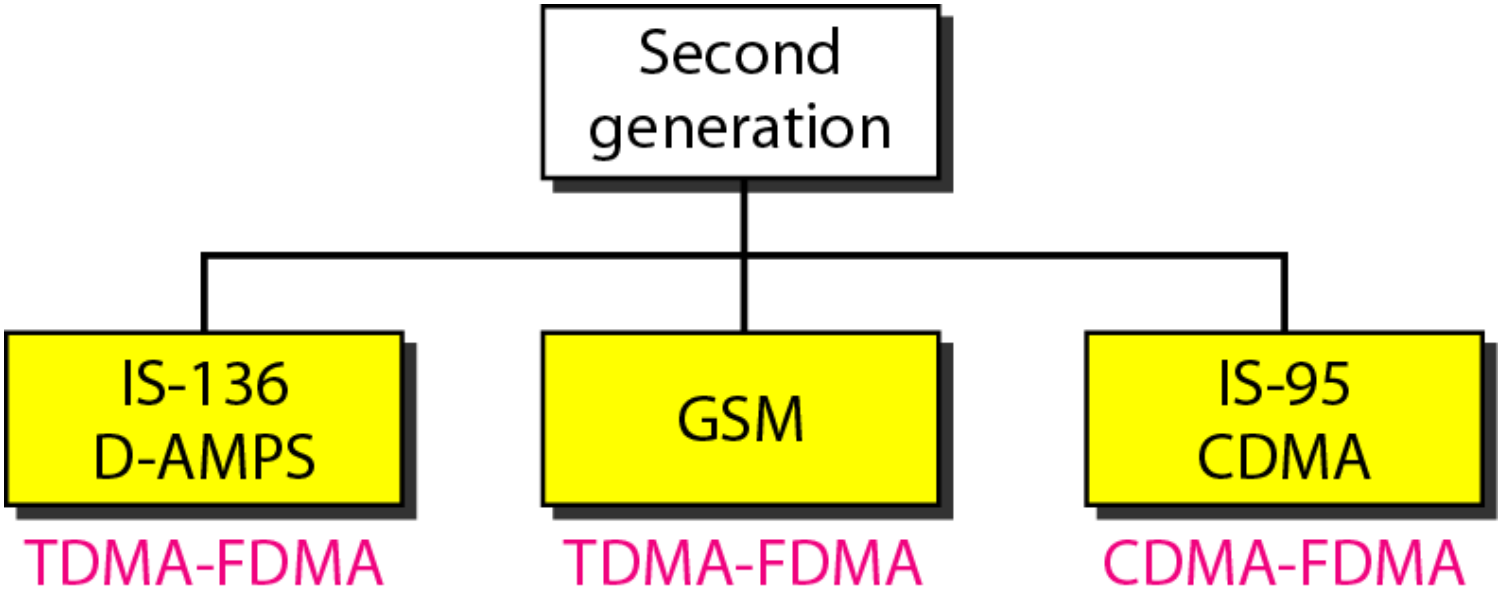
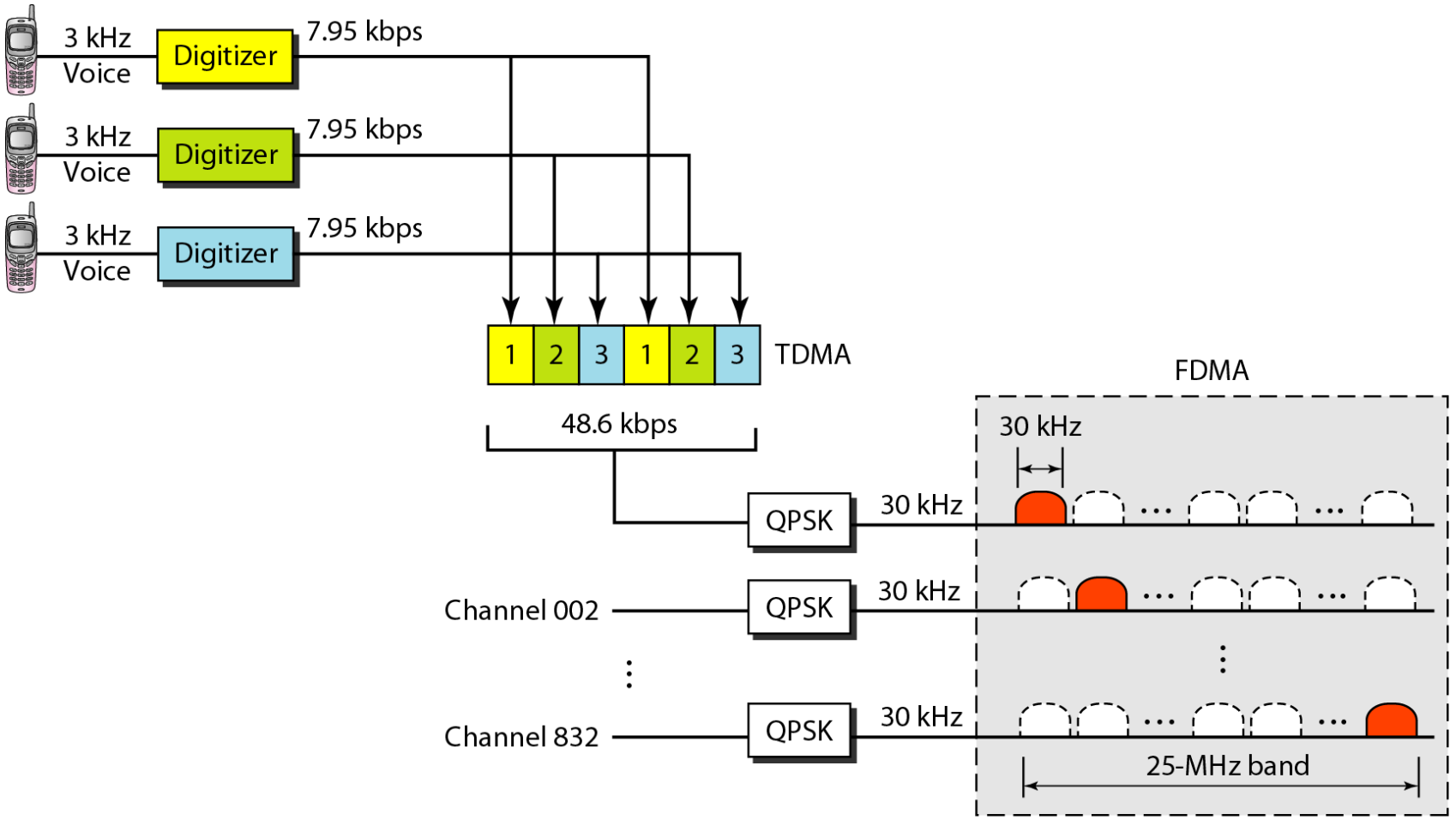


Figure 16.6 *D-AMPS*



Note

D-AMPS, or IS-136, is a digital cellular phone system using TDMA and FDMA.

Figure 16.7 *GSM bands*

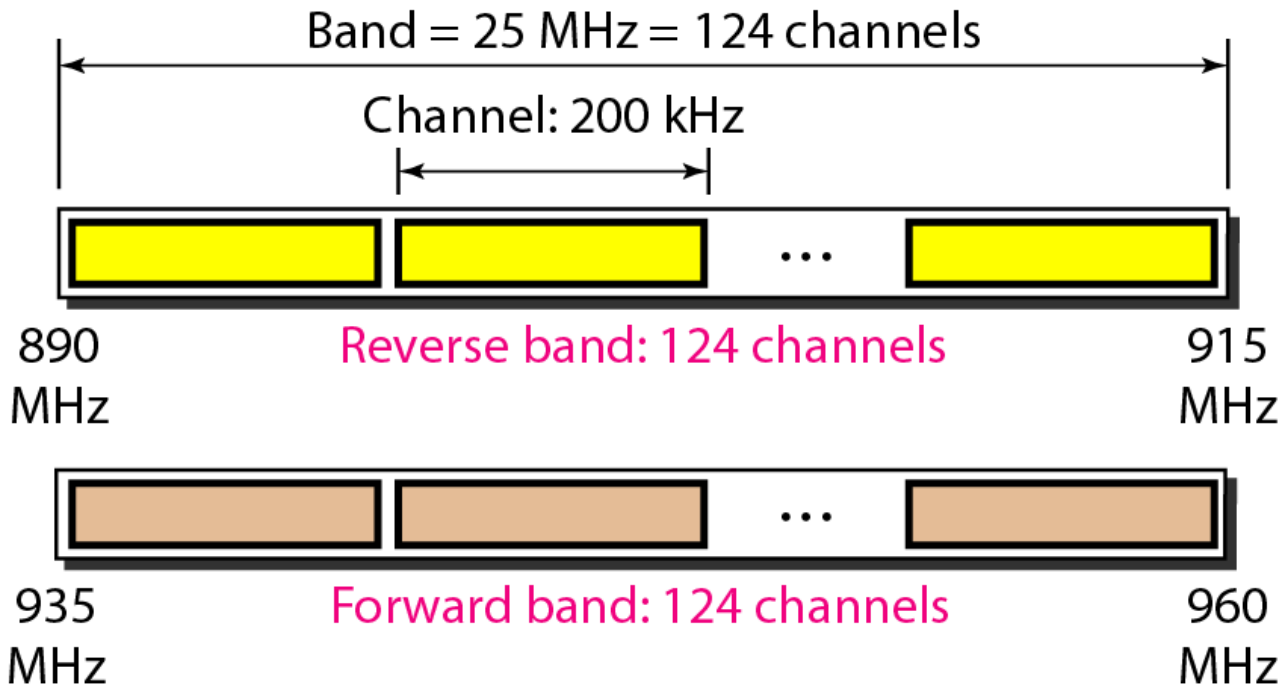


Figure 16.8 *GSM*

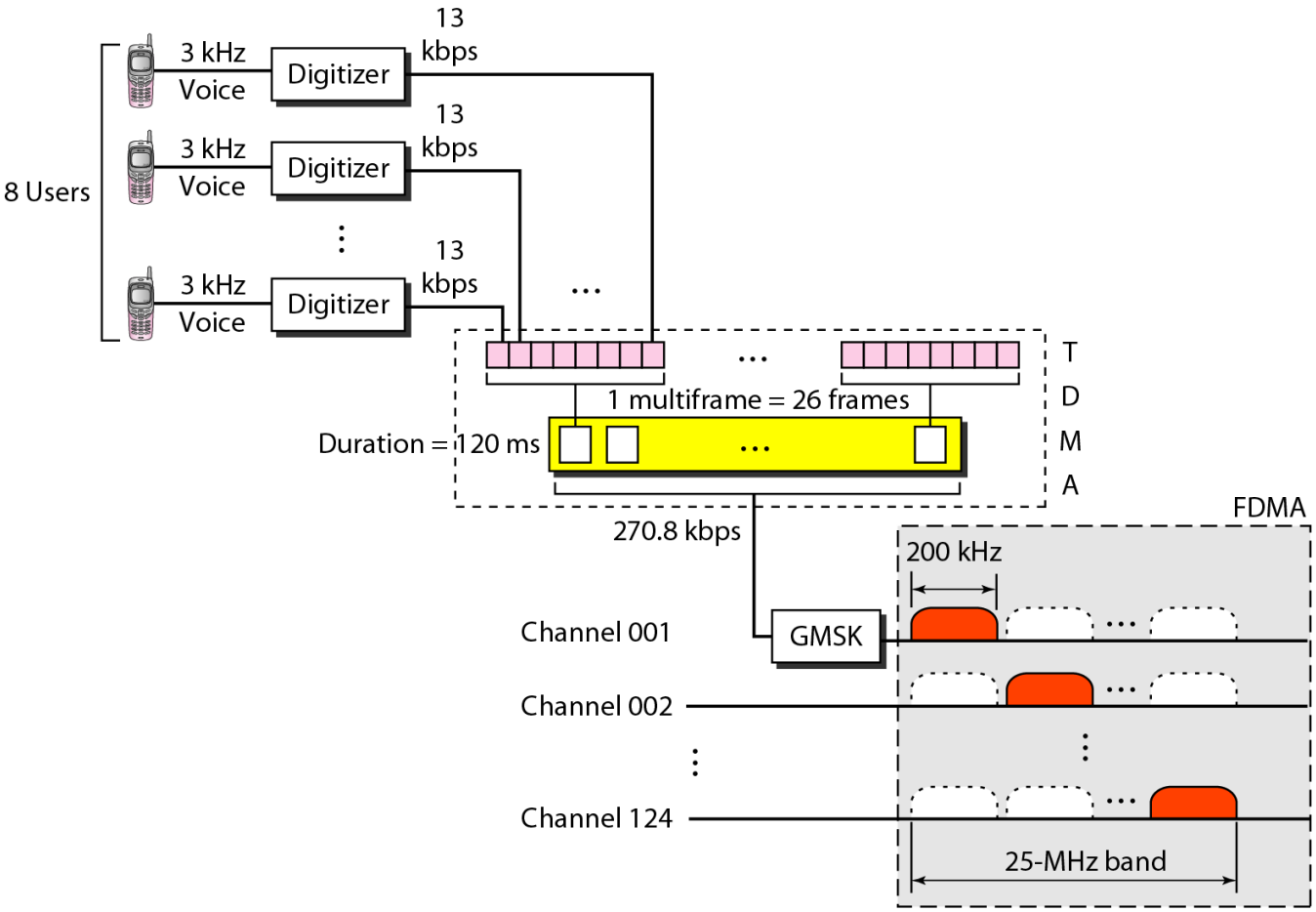
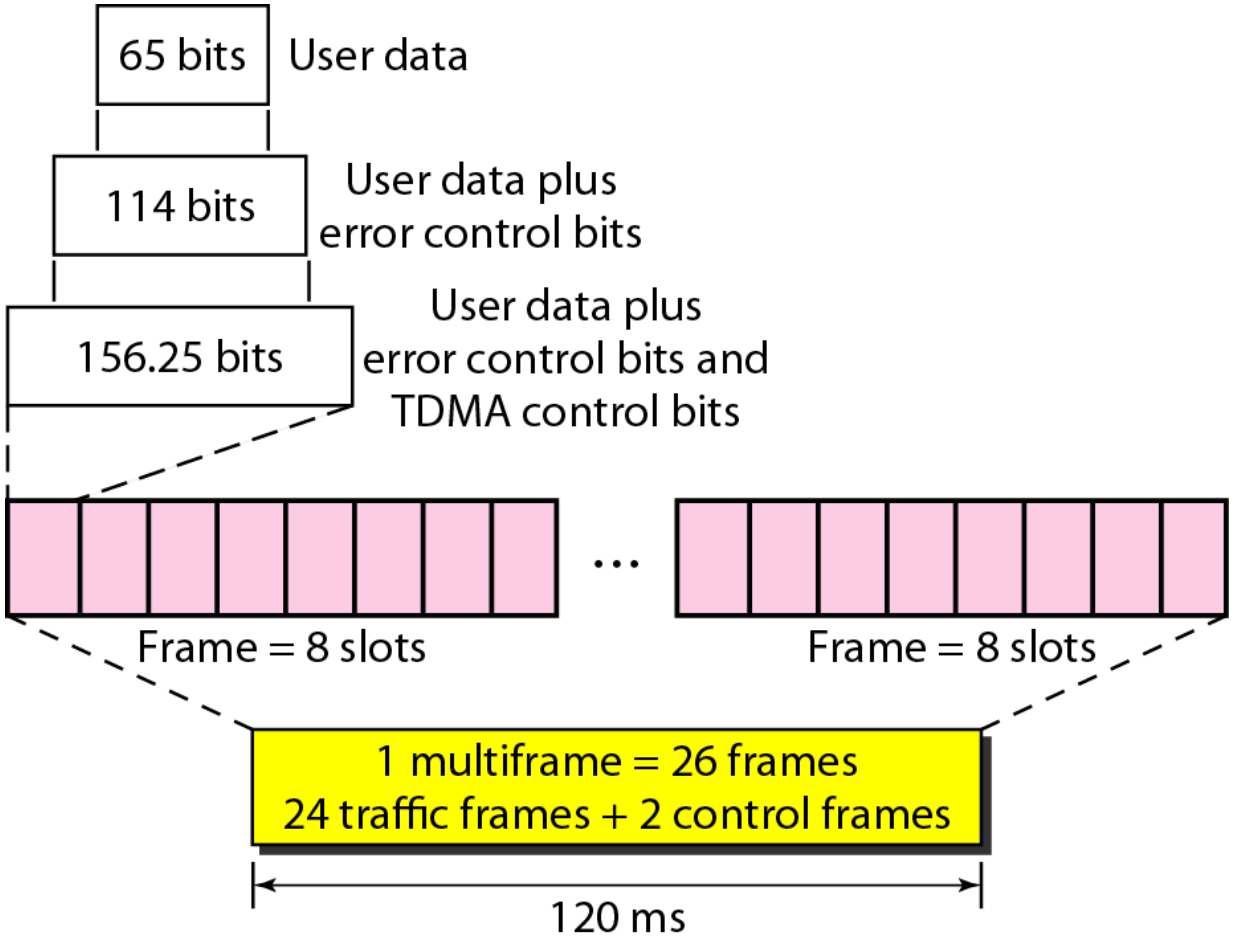


Figure 16.9 *Multiframe components*



Note

GSM is a digital cellular phone system using TDMA and FDMA.

Figure 16.10 *IS-95 forward transmission*

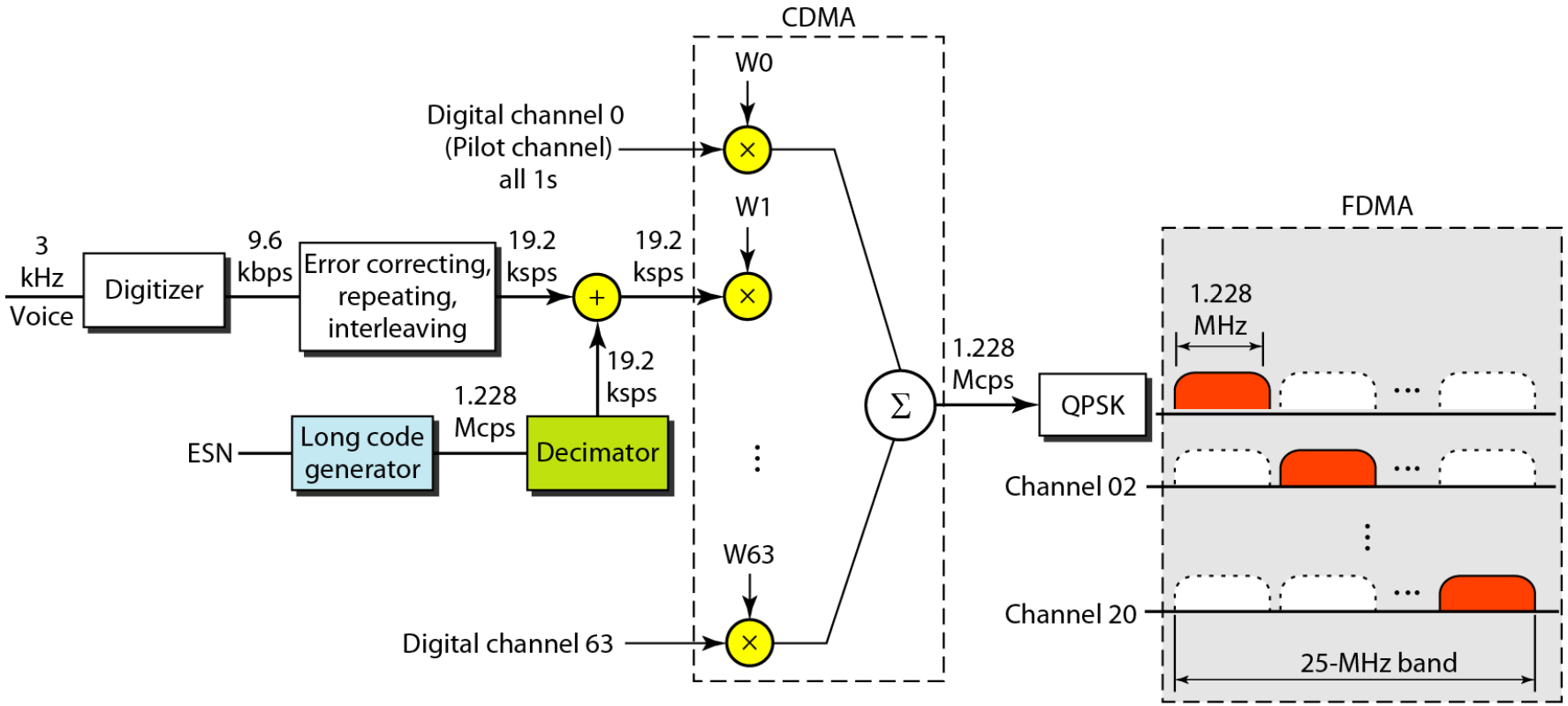
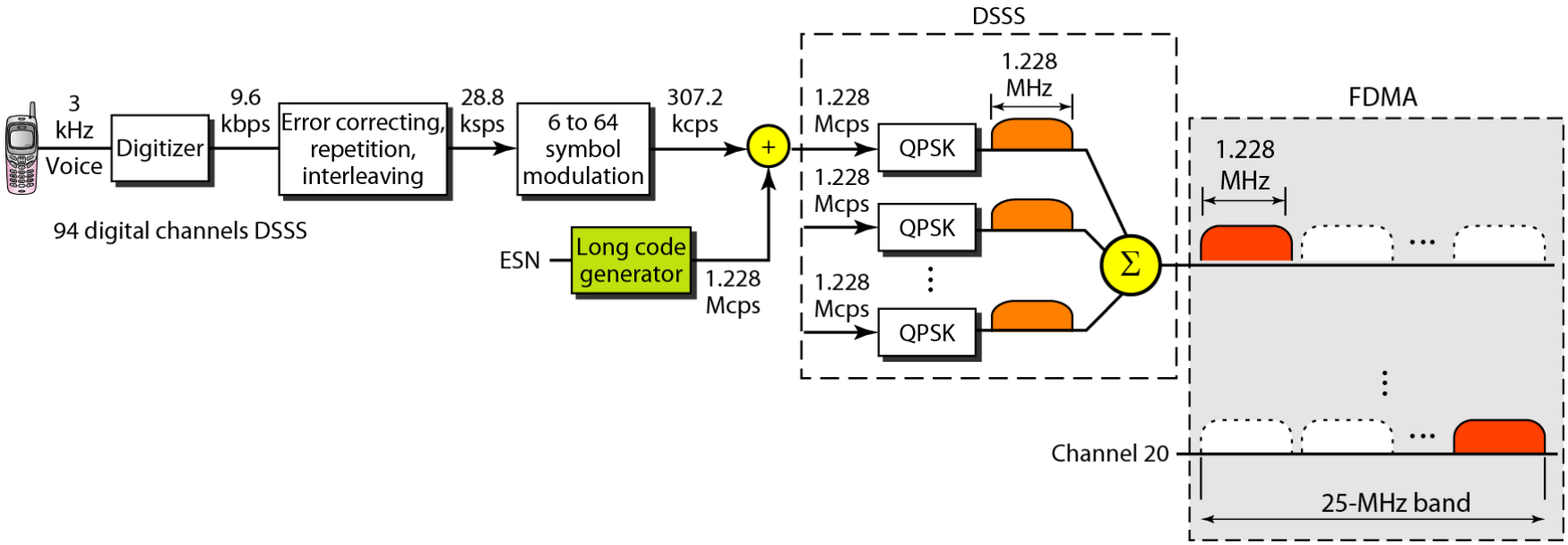


Figure 16.11 *IS-95 reverse transmission*



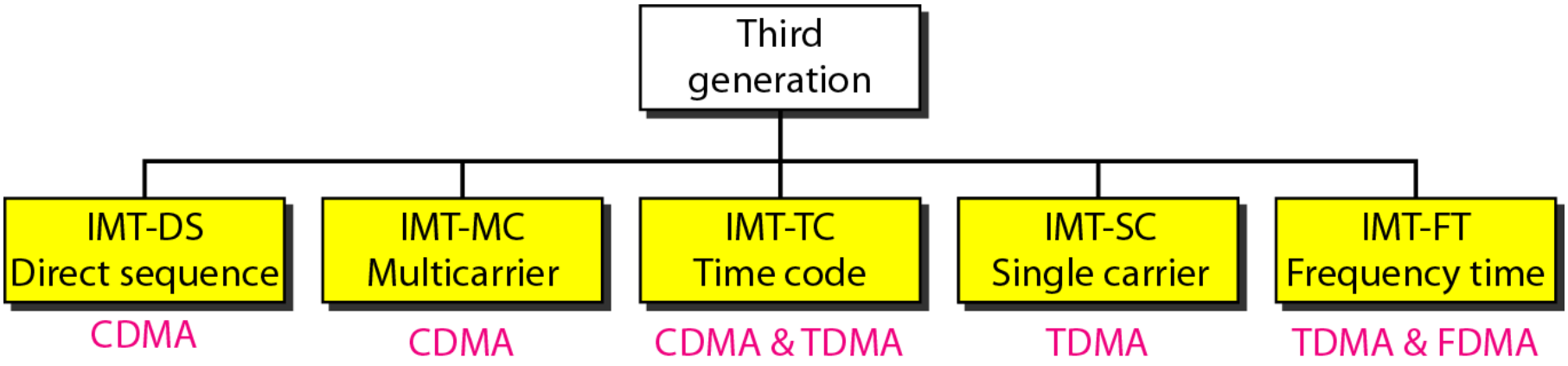
Note

IS-95 is a digital cellular phone system using CDMA/DSSS and FDMA.

Note

The main goal of third-generation cellular telephony is to provide universal personal communication.

Figure 16.12 *IMT-2000 radio interfaces*



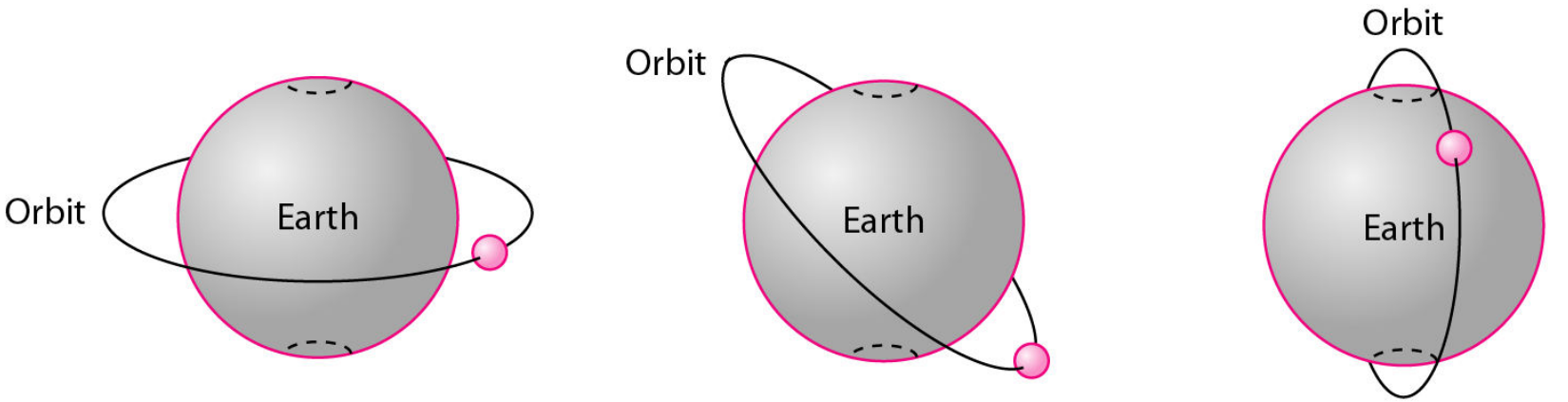
16-2 SATELLITE NETWORKS

A satellite network is a combination of nodes, some of which are satellites, that provides communication from one point on the Earth to another. A node in the network can be a satellite, an Earth station, or an end-user terminal or telephone.

Topics discussed in this section:

Orbits
Footprint
Three Categories of Satellites
GEO Satellites
MEO Satellites
LEO Satellites

Figure 16.13 *Satellite orbits*



a. Equatorial-orbit satellite

b. Inclined-orbit satellite

c. Polar-orbit satellite

Example 16.1

What is the period of the Moon, according to Kepler's law?

$$\text{Period} = C \times \text{distance}^{1.5}$$

Here C is a constant approximately equal to 1/100. The period is in seconds and the distance in kilometers.

Example 16.1 (continued)

Solution

The Moon is located approximately 384,000 km above the Earth. The radius of the Earth is 6378 km. Applying the formula, we get.

$$\text{Period} = \frac{1}{100}(384{,}000 + 6378)^{1.5} = 2{,}439{,}090 \text{ s} = 1 \text{ month}$$

Example 16.2

According to Kepler's law, what is the period of a satellite that is located at an orbit approximately 35,786 km above the Earth?

Solution

Applying the formula, we get

$$\text{Period} = \frac{1}{100}(35{,}786 + 6378)^{1.5} = 86{,}579 \text{ s} = 24 \text{ h}$$

Example 16.2 (continued)

This means that a satellite located at 35,786 km has a period of 24 h, which is the same as the rotation period of the Earth. A satellite like this is said to be stationary to the Earth. The orbit, as we will see, is called a geosynchronous orbit.

Figure 16.14 *Satellite categories*

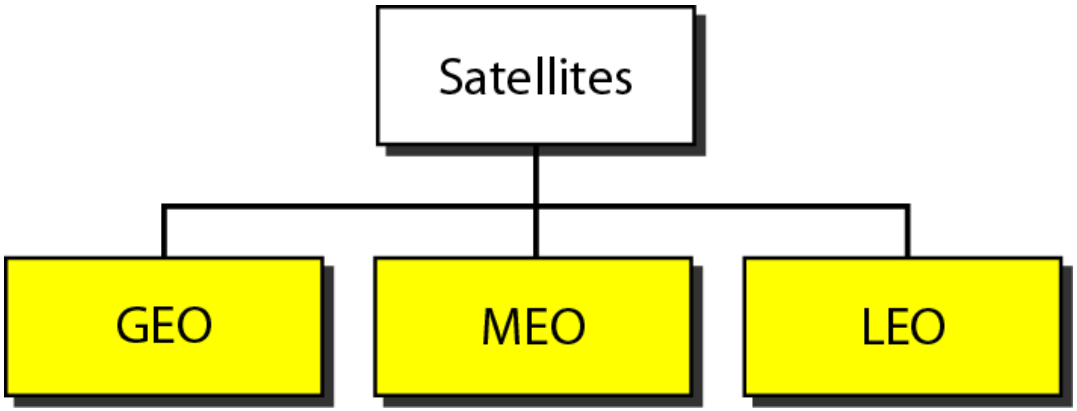


Figure 16.15 *Satellite orbit altitudes*

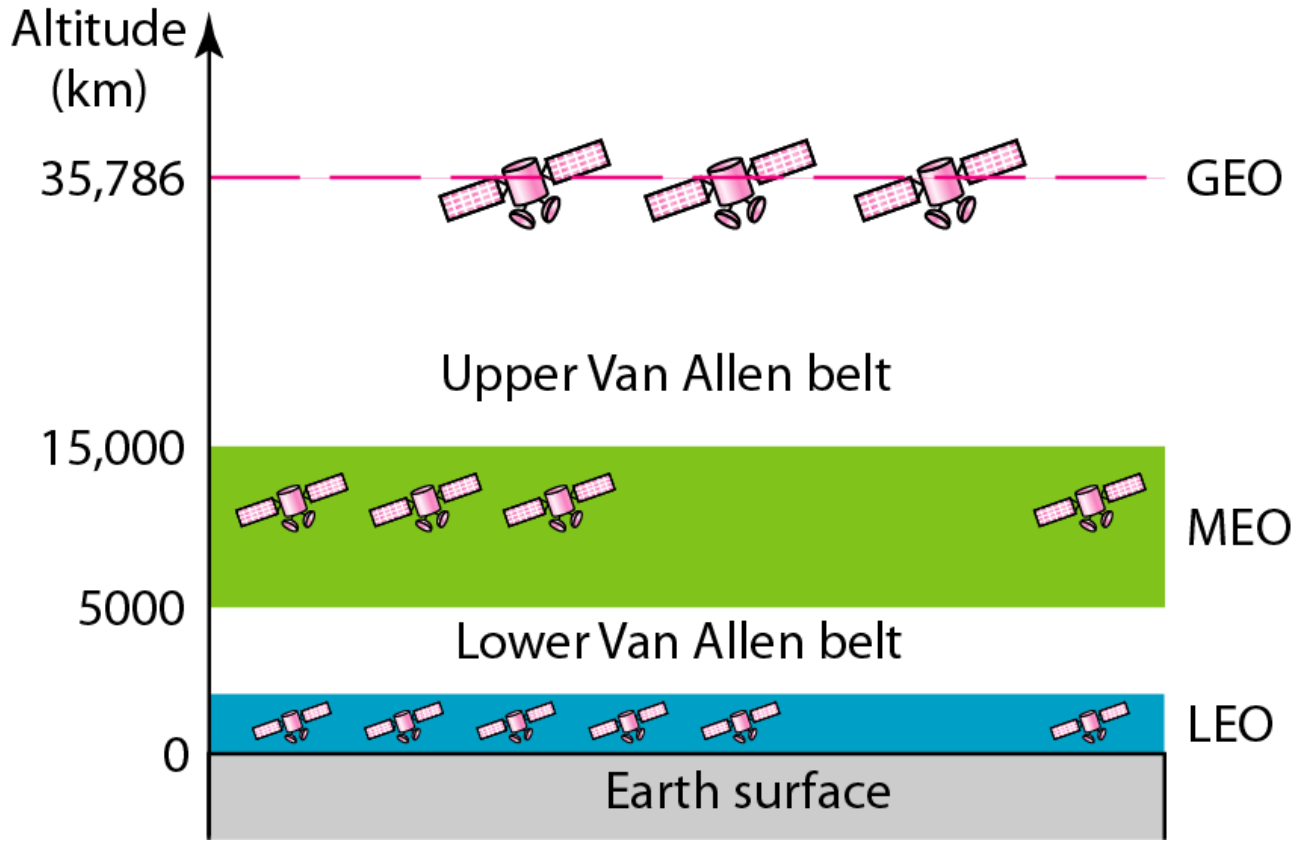


Table 16.1 *Satellite frequency bands*

Band	*Downlink, GHz*	*Uplink, GHz*	*Bandwidth, MHz*
L	1.5	1.6	15
S	1.9	2.2	70
C	4.0	6.0	500
Ku	11.0	14.0	500
Ka	20.0	30.0	3500

Figure 16.16 *Satellites in geostationary orbit*

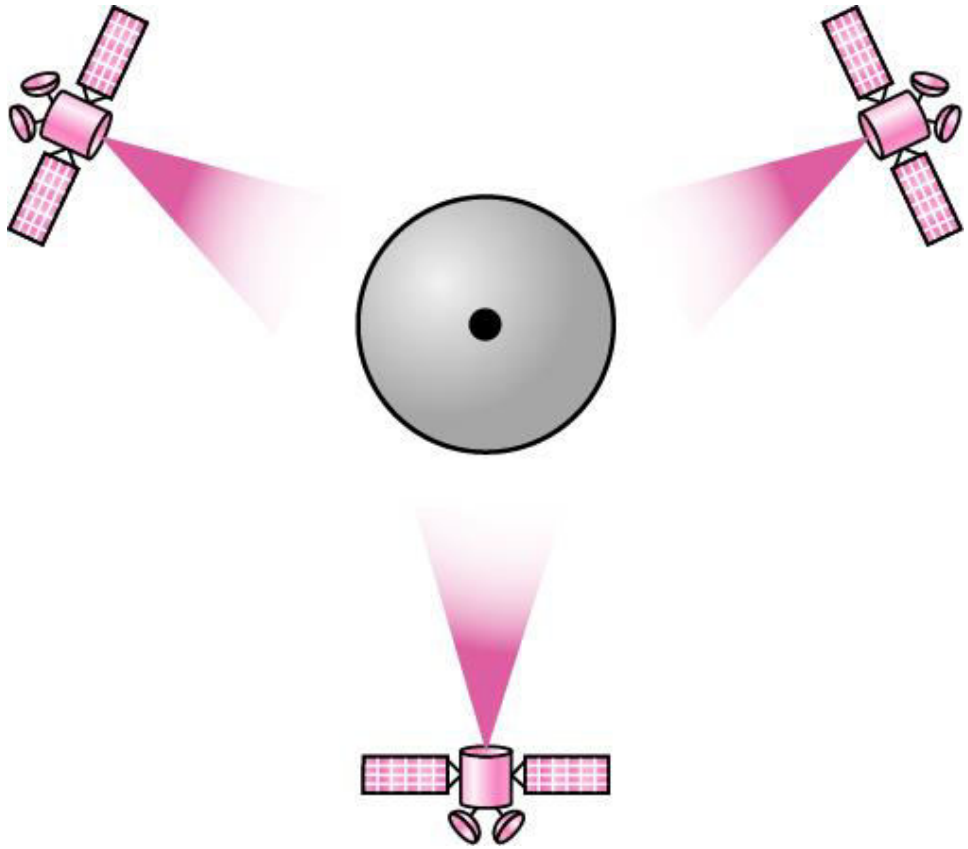


Figure 16.17 *Orbits for global positioning system (GPS) satellites*

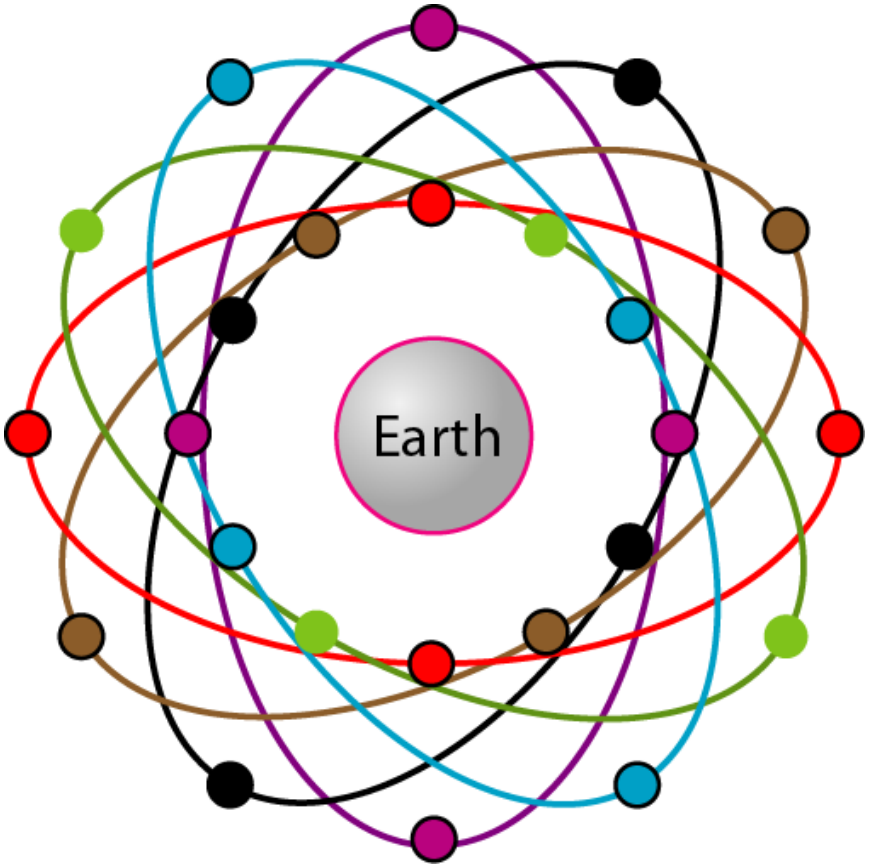
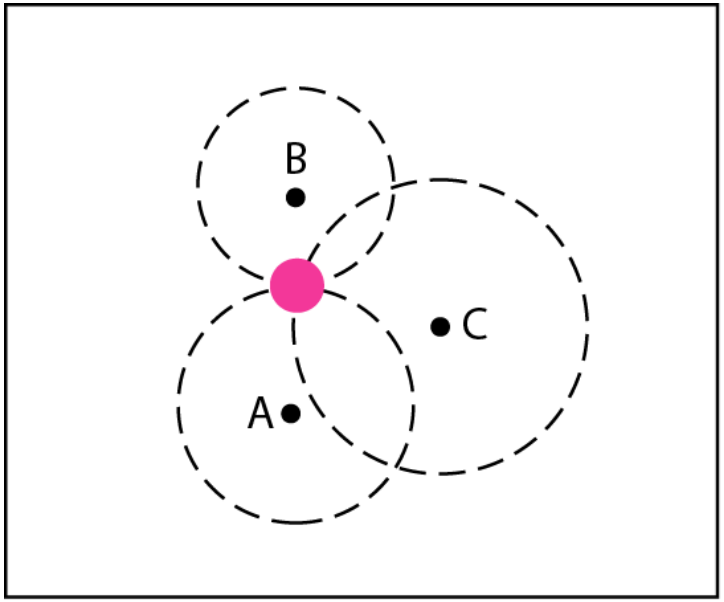
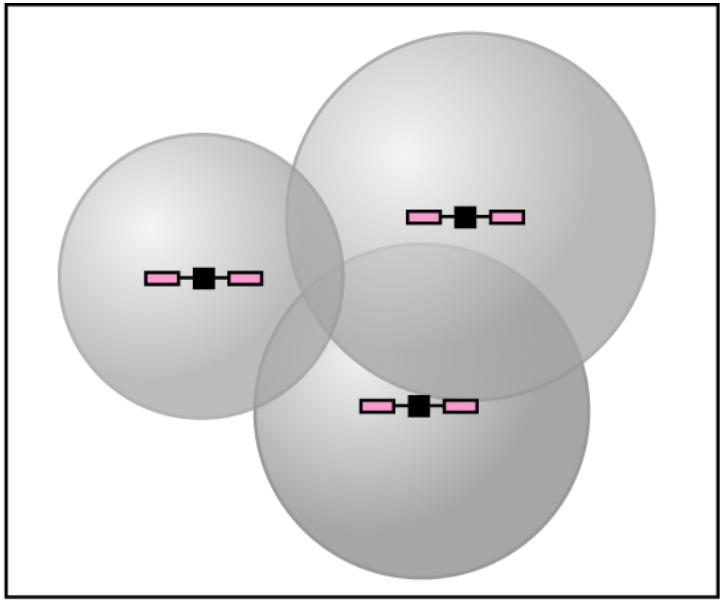


Figure 16.18 *Trilateration*



a. Two-dimensional trilateration



b. Three-dimensional trilateration

Figure 16.19 *LEO satellite system*

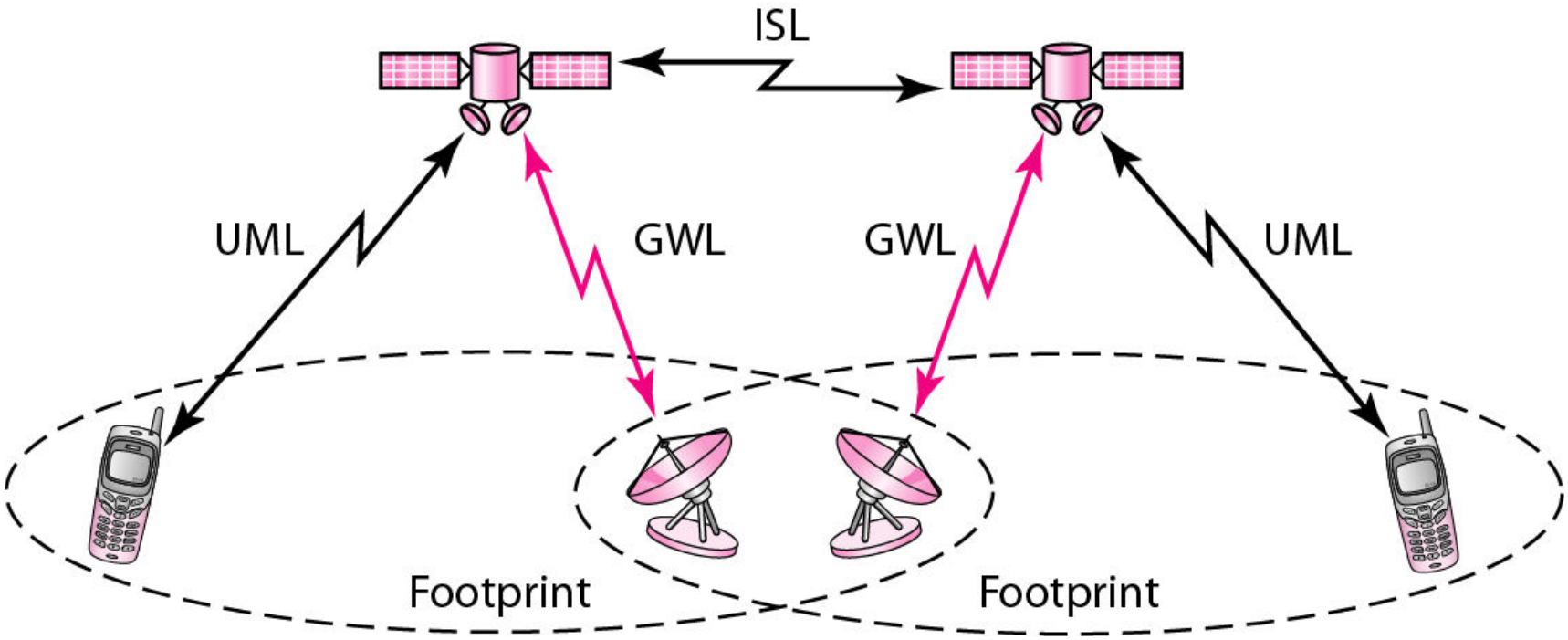
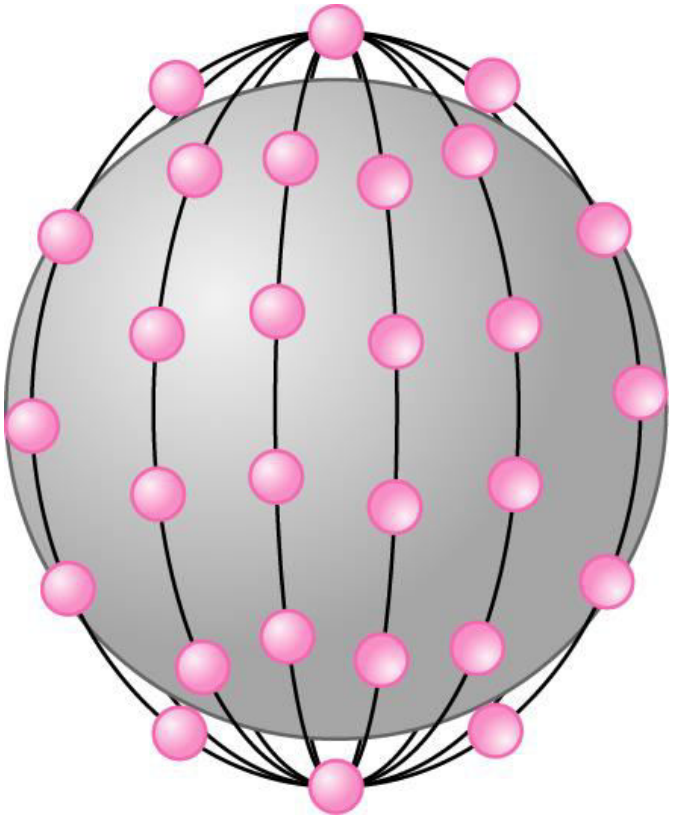


Figure 16.20 *Iridium constellation*



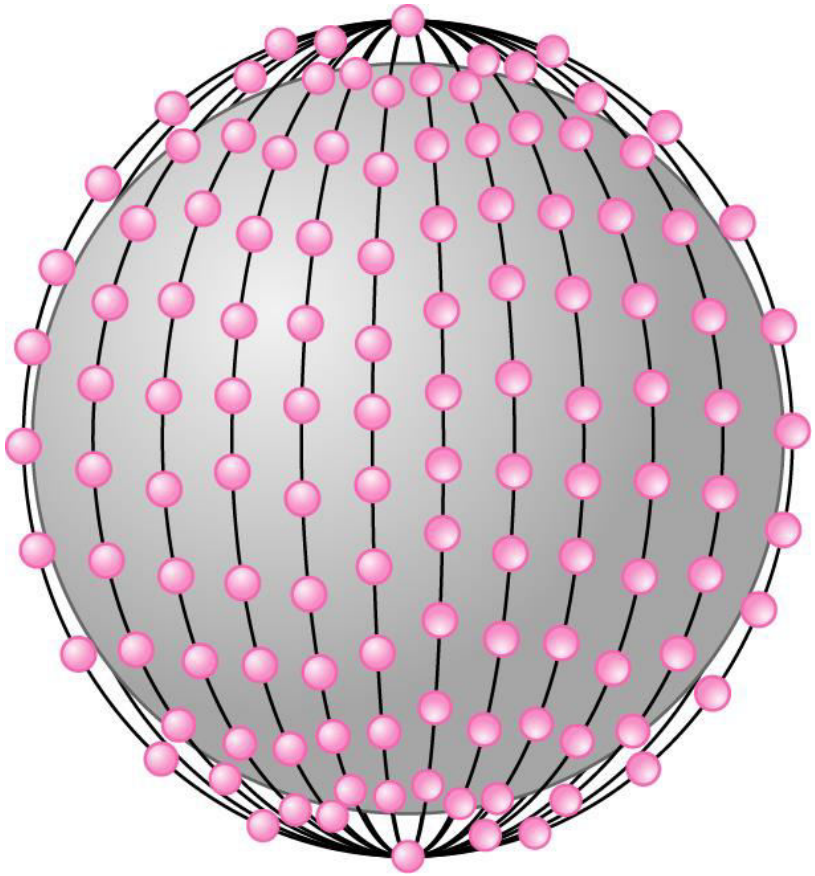
Note

The Iridium system has 66 satellites in six LEO orbits, each at an altitude of 750 km.

Note

Iridium is designed to provide direct worldwide voice and data communication using handheld terminals, a service similar to cellular telephony but on a global scale.

Figure 16.20 *Teledesic*



Note

Teledesic has 288 satellites in 12 LEO orbits, each at an altitude of 1350 km.