Cellular Networks (2/2)

- 1G to B3G -

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학습에 앞서

■학습개요

- 이동통신 망 구조 및 무선 접속 프로토콜을 이해한다.

■학습목표

- 이동통신 망 구조를 이해한다.
- AMS, GSM, IS-95 표준의 무선 접속 프로토콜 동작을 학습한다.
- 위성 통신 구조를 이해한다.

IS-95

- IS-95 (Interim Standard 95)
  - One of the dominant second-generation standards in North America.
  - IS-95 is a digital cellular phone system using CDMA/DSSS and FDMA.

- Bands and Channels
  - The traditional ISM 800-MHz band or the ISM 1900-MHz band.
  - Each band is divided into 20 channels of 1.228 MHz.
  - Each IS-95 channel is equivalent 41 AMPS channels (41 x 30 kHz = 1.23MHz).

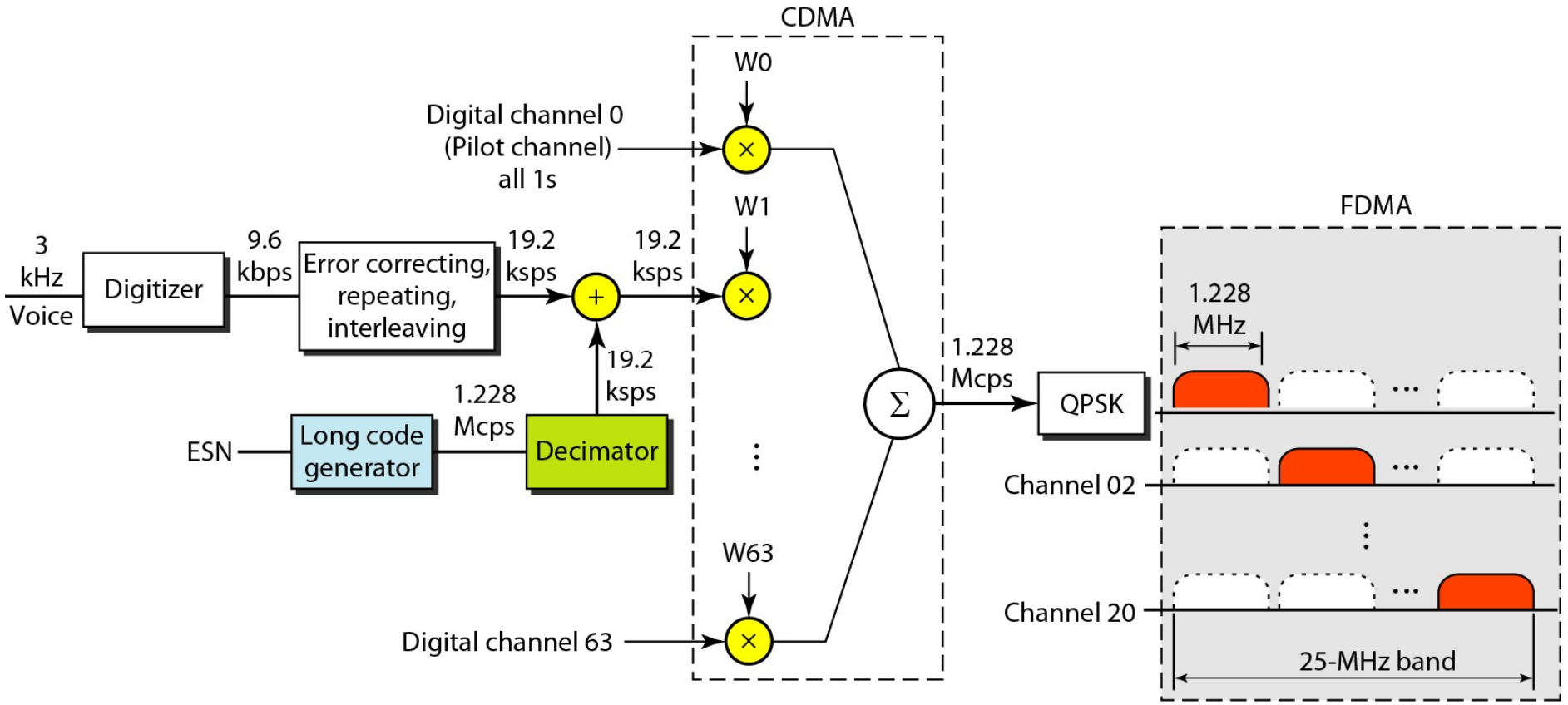
- Synchronization
  - All base channels are synchronized by using the services of GPS (Global Positioning System).

Forward Transmission

- 19.2 ksps (kilosignals per second) x 64 cps (chips per second) = 1.228 Mcps (megachips per second)

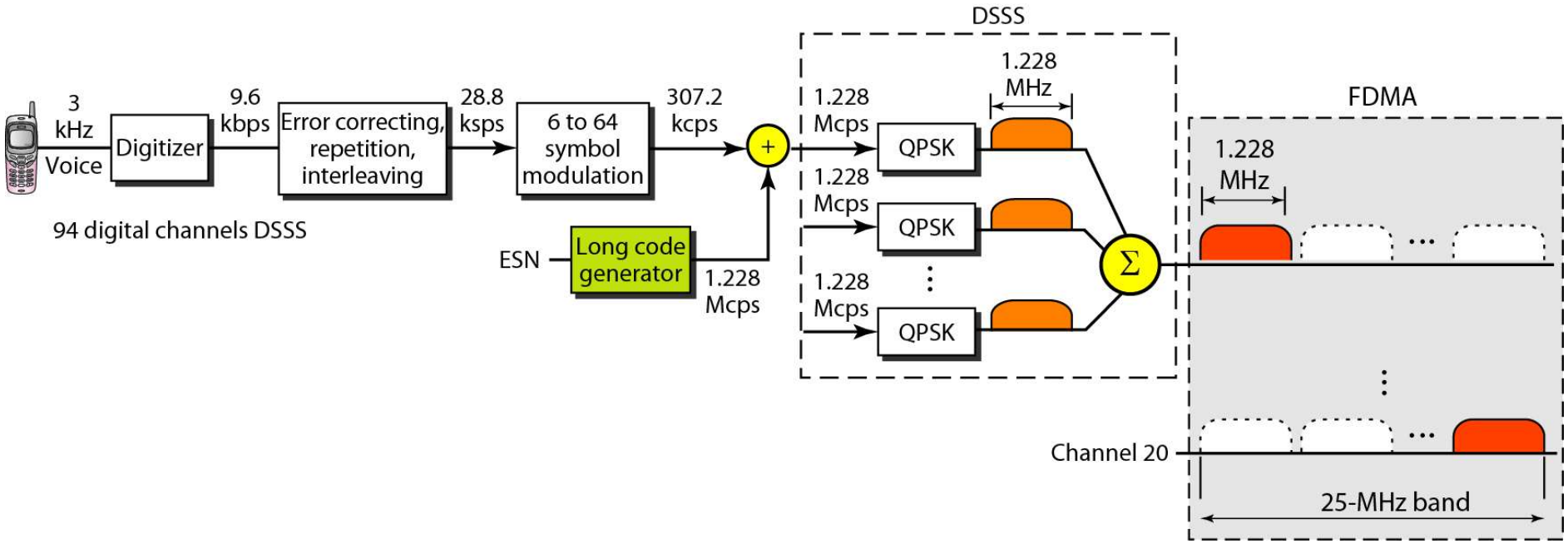
- Channel 0 for pilot channel.
  - Broadcasts a continuous stream of 1s to MSs for synchronization, a phase reference.
- Channel 32
  - Gives information about the system to the MSs.
- Channel 1 to 7
  - Used for paging.
- Channel 8 to 31 and 33 to 63
  - Traffic channel carrying digitized voice

Figure 16.10 *IS-95 forward transmission*



- Reverse Transmission

Figure 16.11 *IS-95 reverse transmission*



1. Cellular Telephony

- Two Data Rate Sets
  - 9600, 4800, 2400, 1200 bps
  - 14400, 7200, 3600, 1800 bps
- Frequency-Reuse Factor
  - Normally 1
- Soft Handoff
  - IS-95 enables an MS to do a soft handoff.

1. Cellular Telephony

PCS

- Personal communications system (PCS)
- does not refer to a single technology such as GSM, IS-136, or IS-95.

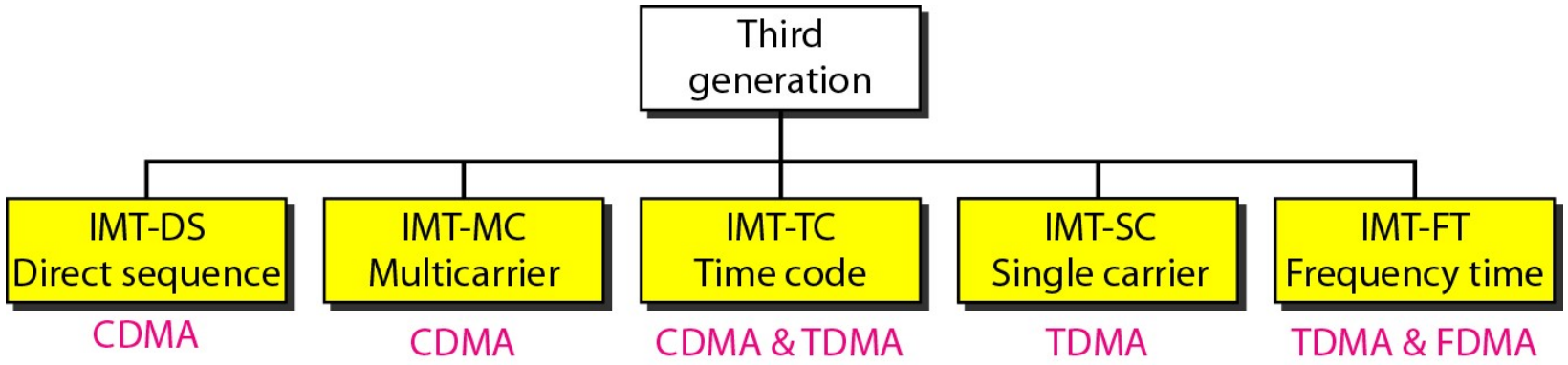
- Use any second-generation technology (GSM, IS-136, or IS-95).
- Use the 1900-MHz band
- Offer communication services such as short message service (SMS).

(3) Third Generation

- The third generation provides both digital data and voice communication.
- The third-generation concept started in 1992, when ITU issued a blueprint called the Internet Mobile Communication 2000 (IMT-2000).
  - Support for packet-switched and circuit-switched data services
  - A band of 2 GHz, Bandwidths of 2 MHz
  - Interface to the Internet

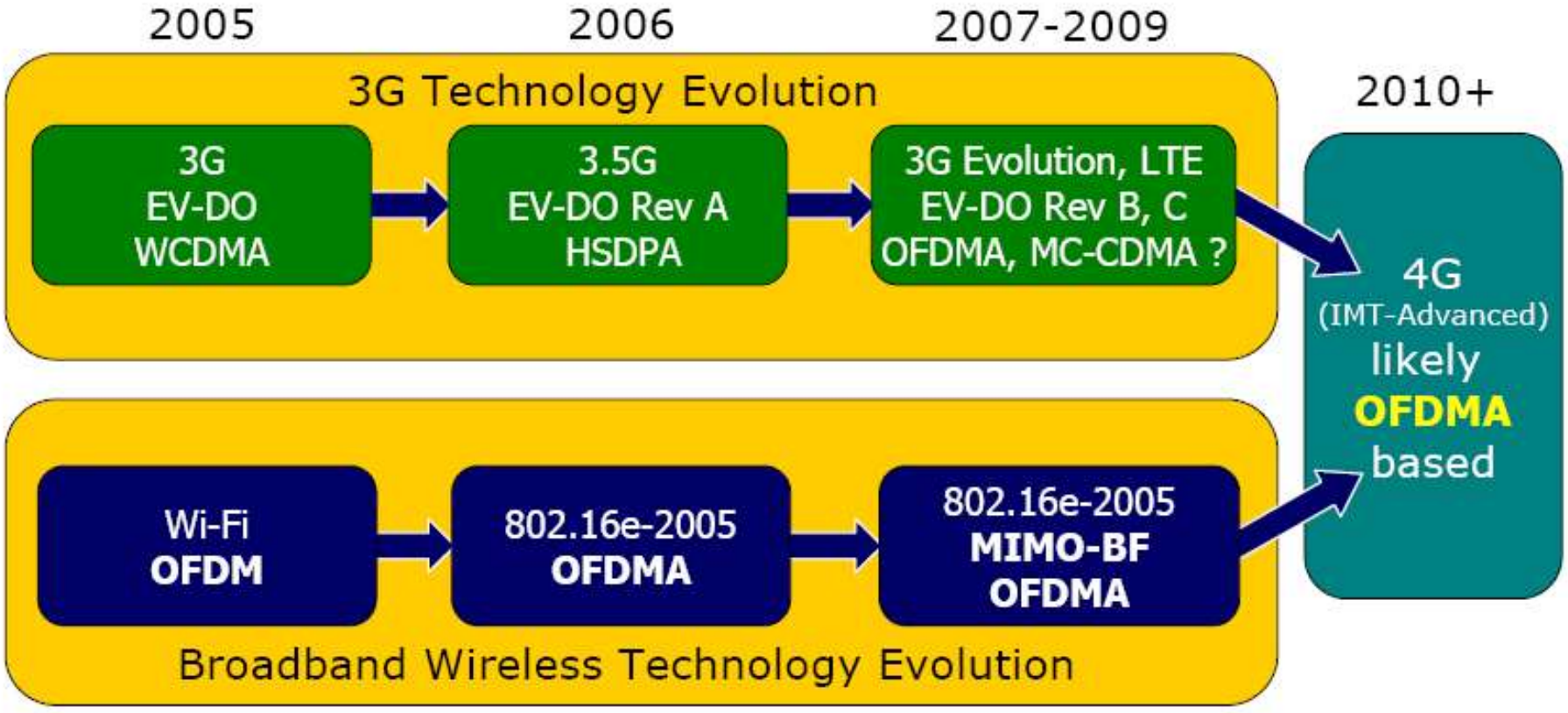
The main goal of third-generation cellular telephony is to provide universal personal communication.

Figure 16.12 *IMT-2000 radio interfaces*



(4) Beyond 3rd Generation

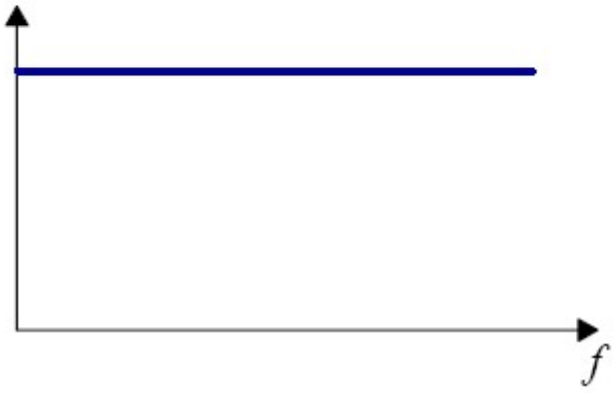
- OFDM: Orthogonal Frequency Division Multiplexing
- OFDMA: Orthogonal Frequency Division Multiple Access

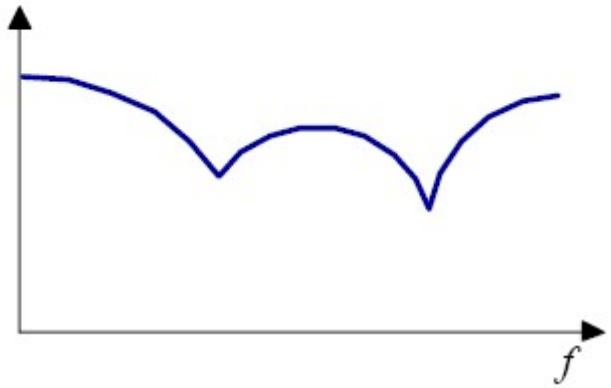


Source: Rysavy Research

Mutipath Fading

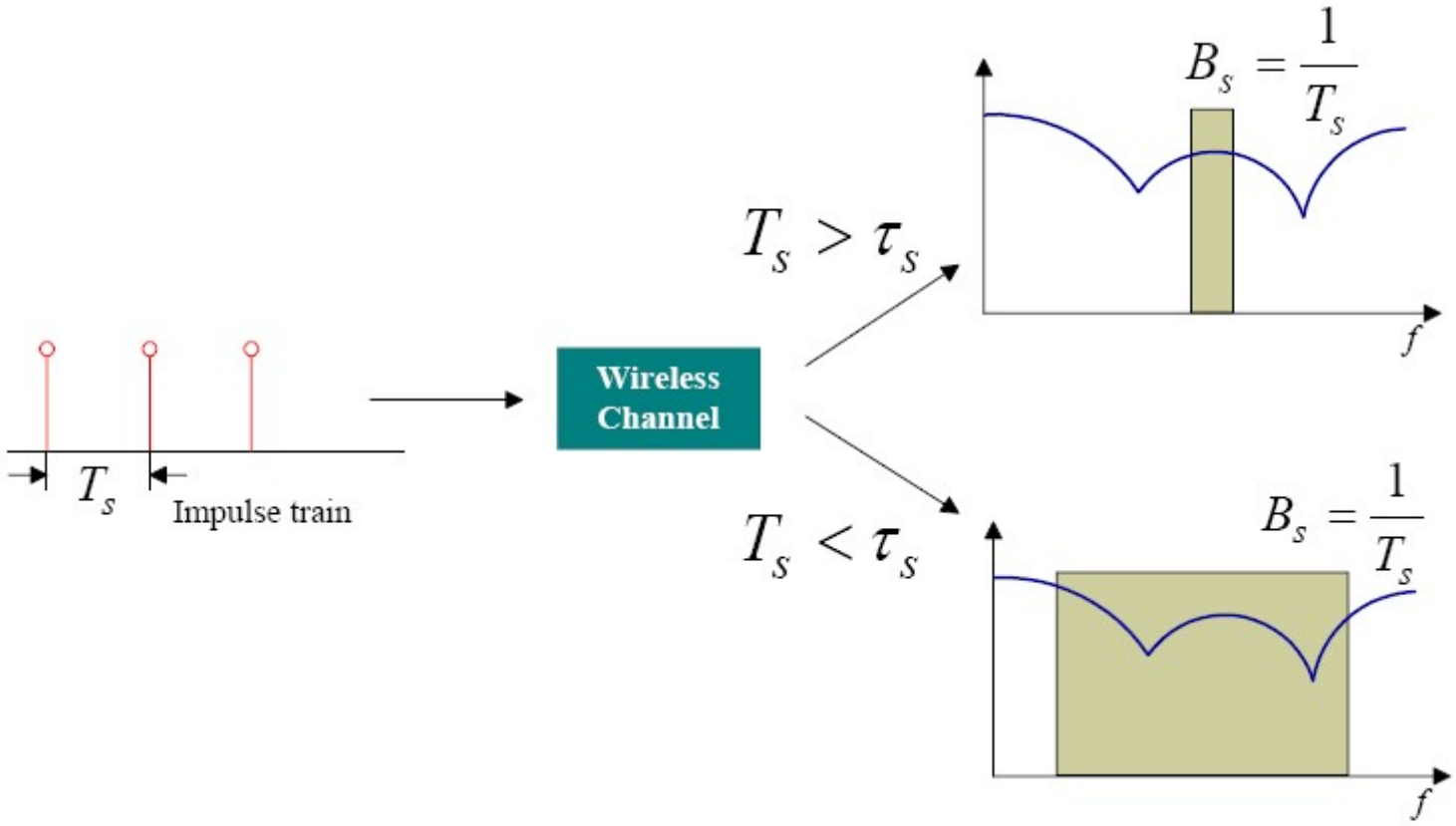
- Frequency selective fading





Flat fading vs Freq. selective fading

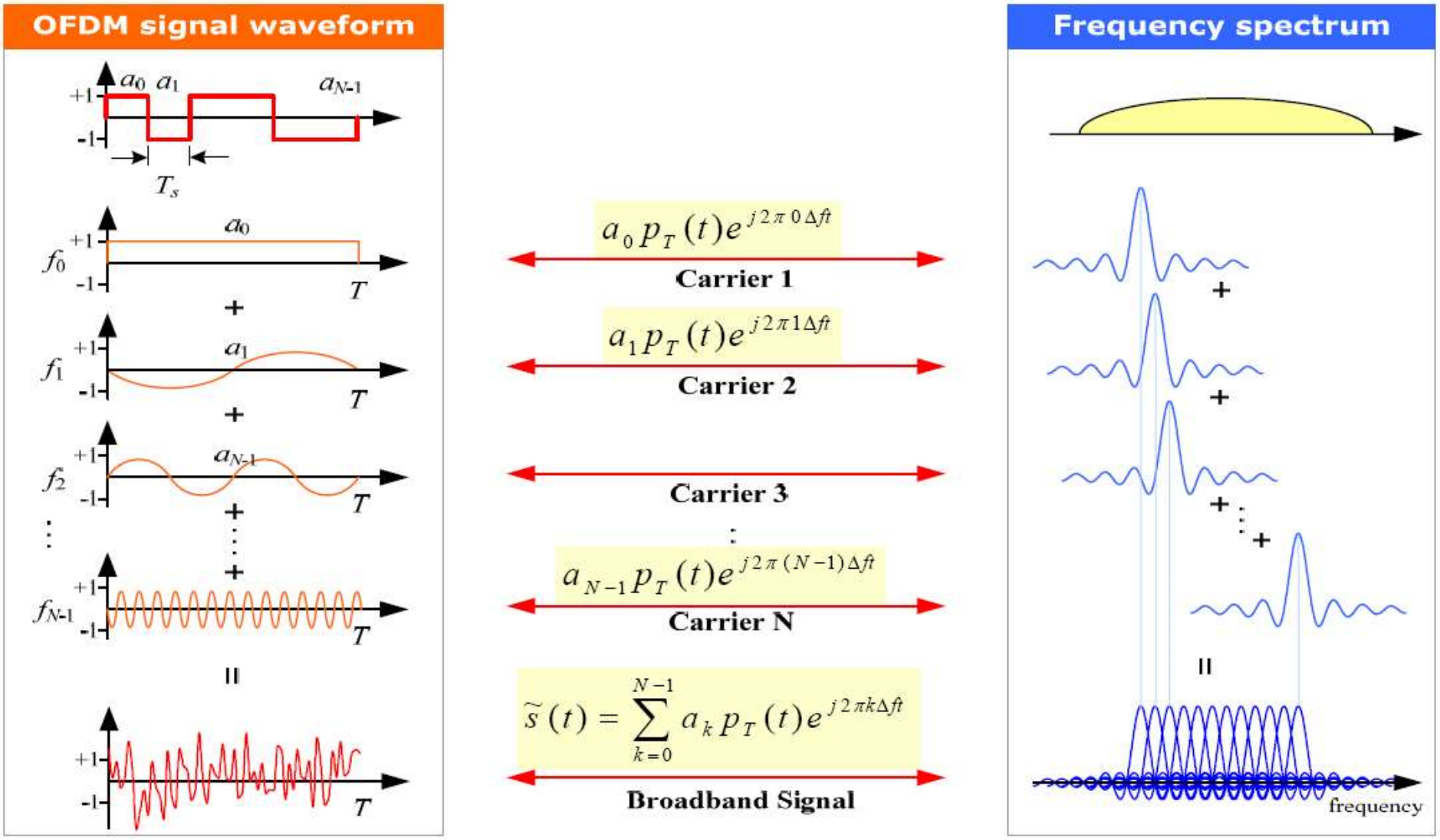
- T_s: sampling period, τ_s: delay spread



$T_s > \tau_s$: no intersymbol interference $\Rightarrow$ *flat fading*

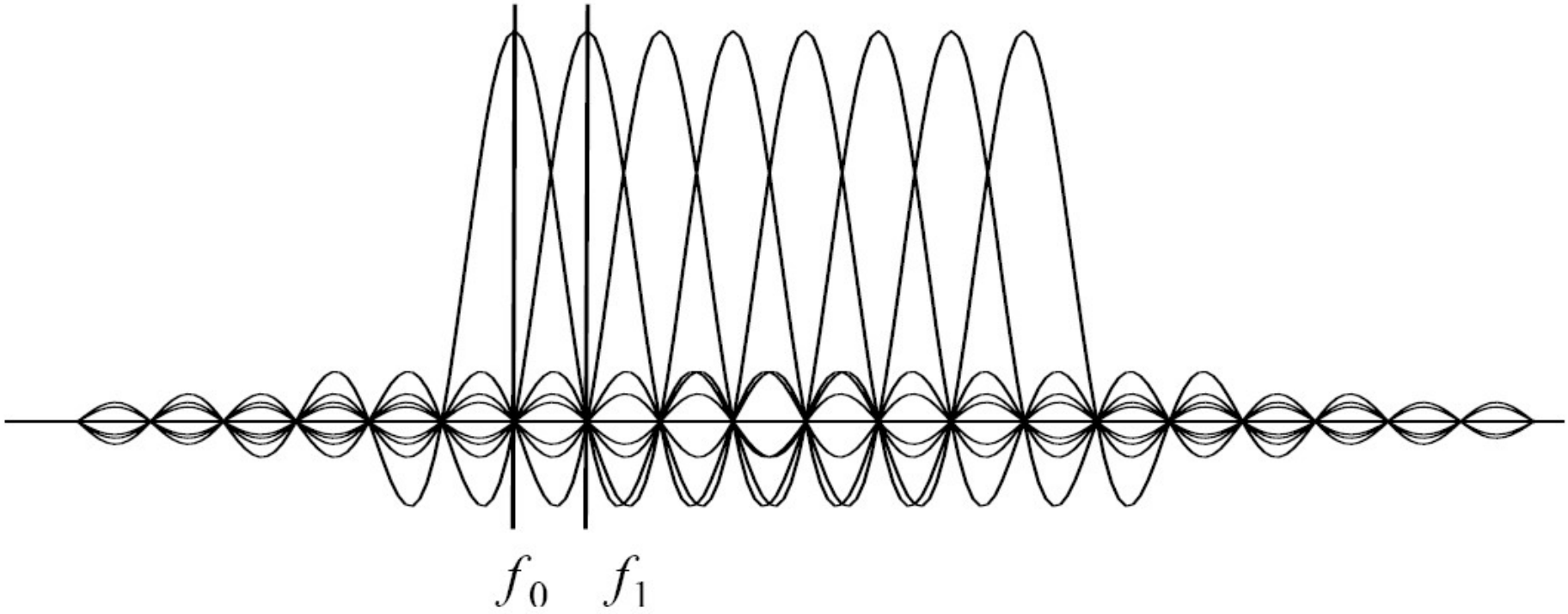
$T_s < \tau_s$: intersymbol interference $\Rightarrow$ *frequency – selective fading*

OFDM transmitter



1. Cellular Telephony

- OFDM increases the spectral efficiency by allowing subchannels to overlap



- The *n*th subcarrier signal

$$s_n(t) = b_n \exp(j2\pi f_n t), \quad 0 \le t \le T \quad (7.54)$$

- The multi-carrier signal

$$s(t) = \sum_{n=0}^{N-1} s_n(t)$$

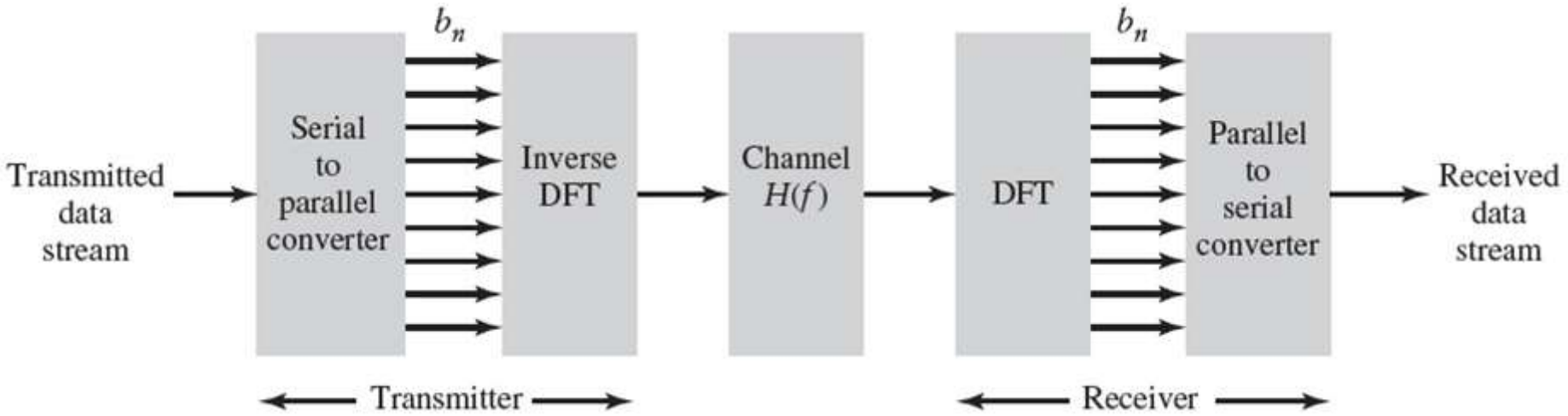
$$= \sum_{n=0}^{N-1} b_n \exp(j2\pi f_n t) \quad 0 \le t \le T \quad (7.55)$$

  - We sample this multicarrier signal at interval of T_s where $T_s = T/N$.
  - We choose the subcarrier frequencies to be spaced at intervals of $f_n = n/T$.
  - Then, $t = kT_s$,

→ Inverse discrete Fourier transform (DFT)

$$s(kT_s) = \sum_{n=0}^{N-1} b_k \exp\left(j2\pi \frac{kn}{N}\right) \quad (7.56)$$

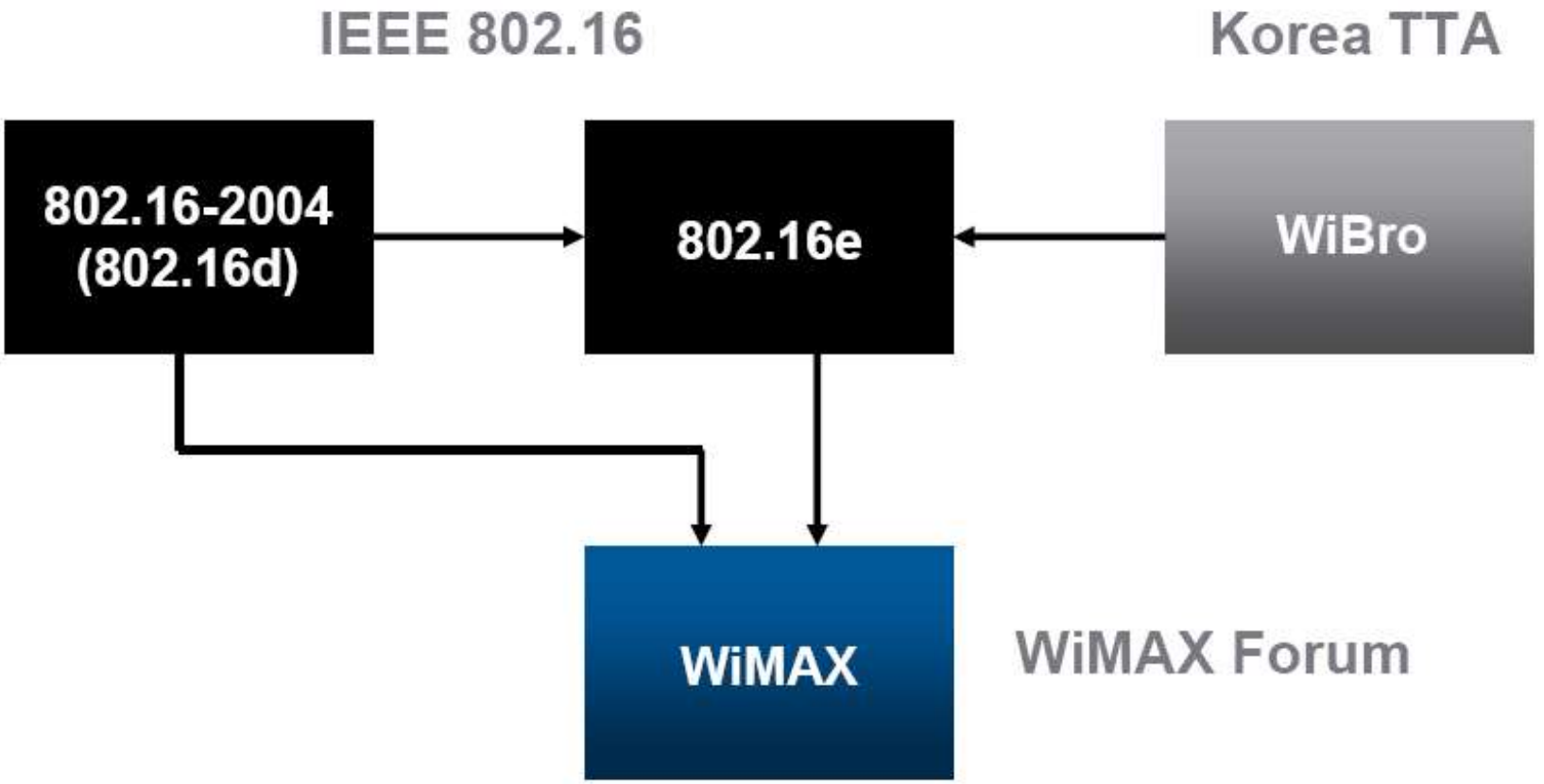
1. Cellular Telephony



What is WiMAX, IEEE 802.16, WiBro?

- **IEEE 802.16**
  - A work group developing WirelessMAN®Standards for Wireless Metropolitan Area Networks
  - Originally focused on fixed, point-to-point data transmission. Published IEEE 802.16-2004 for fixed applications (e.g. backhaul). 802.16e introduces mobility to the standard.
- **WiBro**
  - Developed by the Korean telecoms industry. WiBro stands for “Wireless Broadband”.
  - WiBro provides high data rate wireless internet access with Personal Subscriber Stations in a stationary or mobile environment.
- **WiMAX**
  - An industry group, promoting and certifying products based on standards developed by IEEE 802.16.
  - WiMAX cleans up and streamlines the implementation of IEEE 802.16 standards, although it is not a standard body.
  - WiMAX stands for “Worldwide Interoperability for Microwave Access”.

1. Cellular Telephony



IEEE 802.16 defines air interface standards
WiMAX Forum fills gaps (above MAC layer) and certifies product

2. Satellite Networks

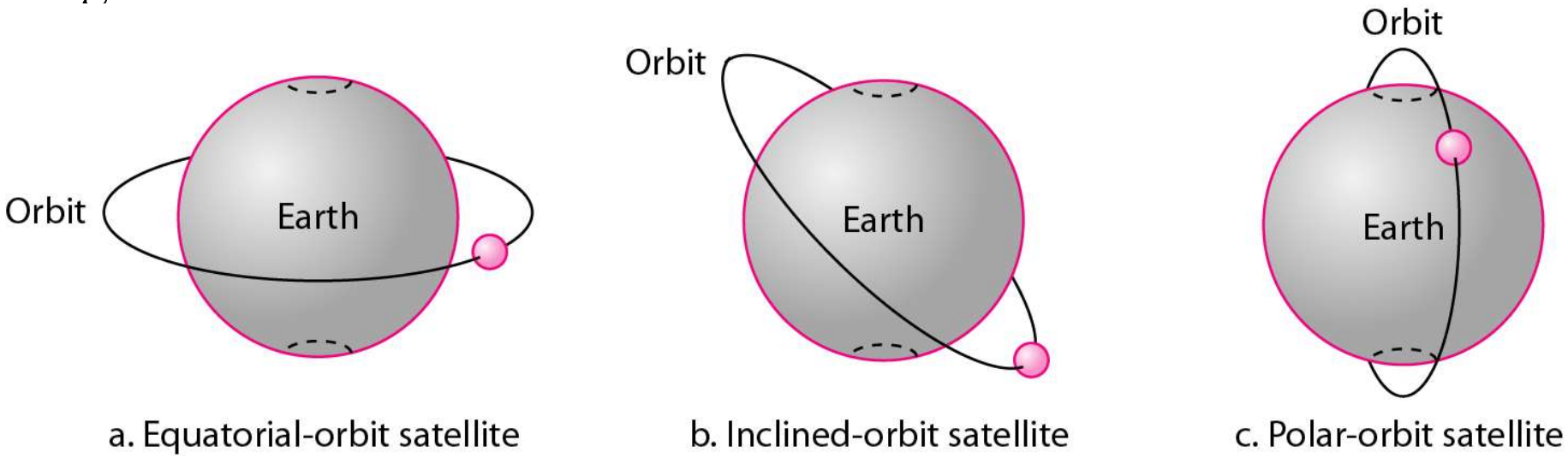
A satellite network is a combination of nodes, some of which are satellites, that provides communication from one point on the Earth to another. A node in the network can be a satellite, an Earth station, or an end-user terminal or telephone.

Topics discussed in this section:

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

Orbits

Figure 16.13 *Satellite orbits*



a. Equatorial-orbit satellite

b. Inclined-orbit satellite

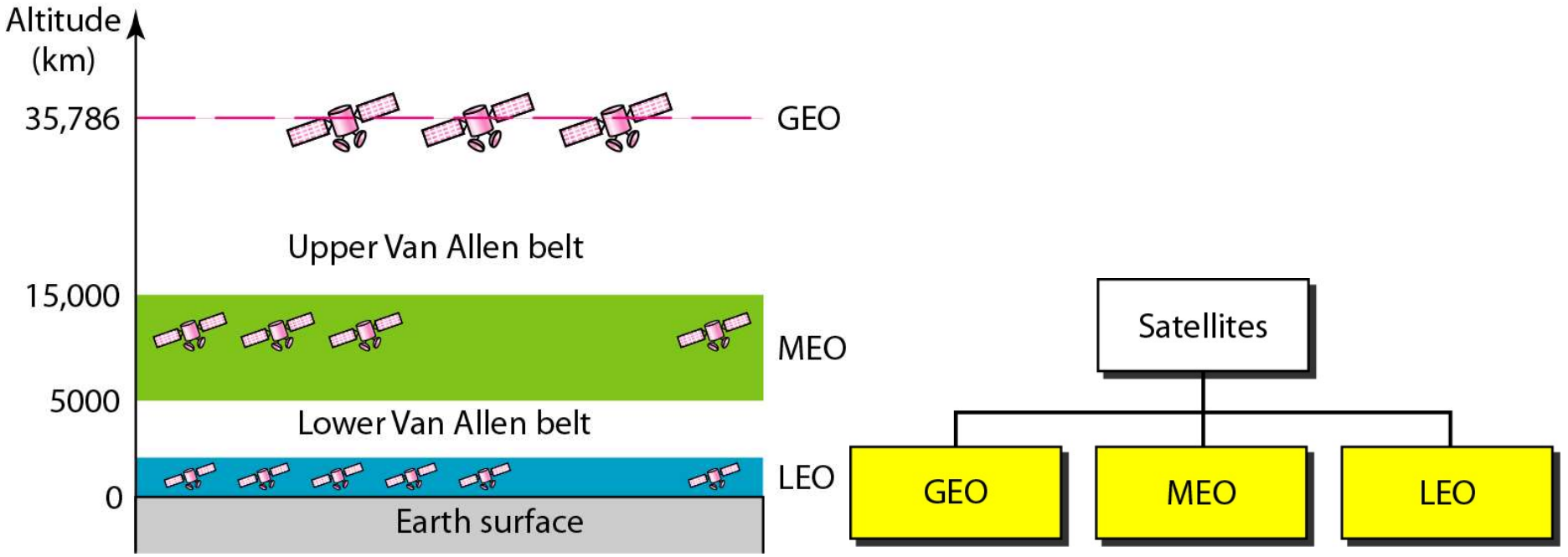
c. Polar-orbit satellite

- Kepler's law
  - Period = C x distance$^{1.5}$
    - C: a constant approximately equal to 1/100
    - distance in kilometer
  - 384,000 km (Moon), the radius of the Earth is 6378 km
    - Period = 0.01 x (384,000 + 6378)$^{1.5}$ = 1 month
  - 35,786 km → 24 h
    - Period = 0.01 x (35,786 + 6378)$^{1.5}$ = 86,579 s = 24 h

Three Categories of Satellites

- Based on the location of the orbit, satellites can be divided into three categories.

Figure 16.14 *Satellite categories and orbit altitudes*



- Frequency Bands for Satellite Communication

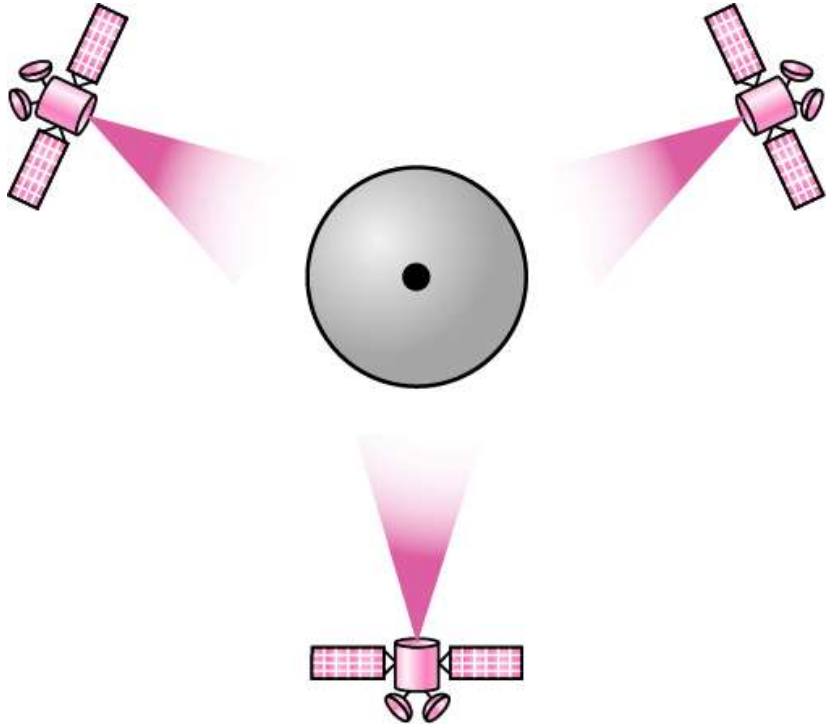
Table 16.1 *Satellite frequency bands*

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

GEO Satellites

- The satellite moves at the same speed as the Earth so that it seems to remain fixed above a certain spot.
- Such satellite are called *geostationary*.
- This orbit occurs at the equatorial plane and is approximately 22,000 mi from the surface of the Earth.

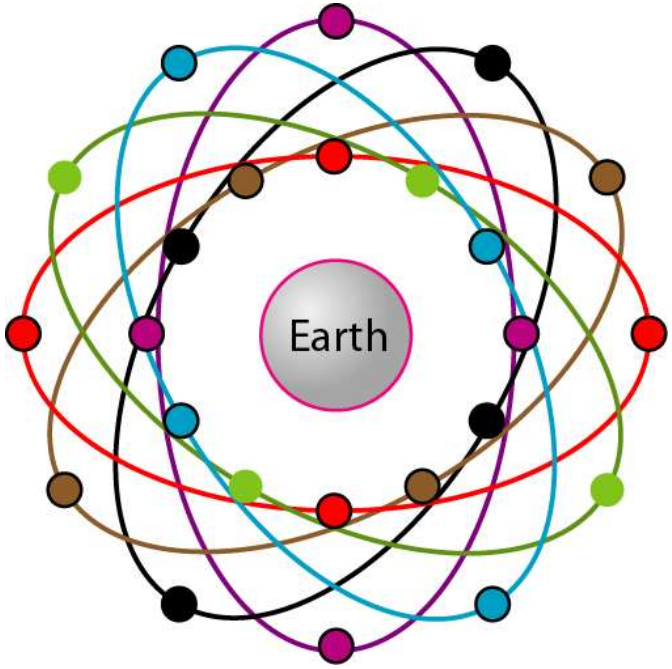
Figure 16.16 *Satellites in geostationary orbit*



MEO Satellites

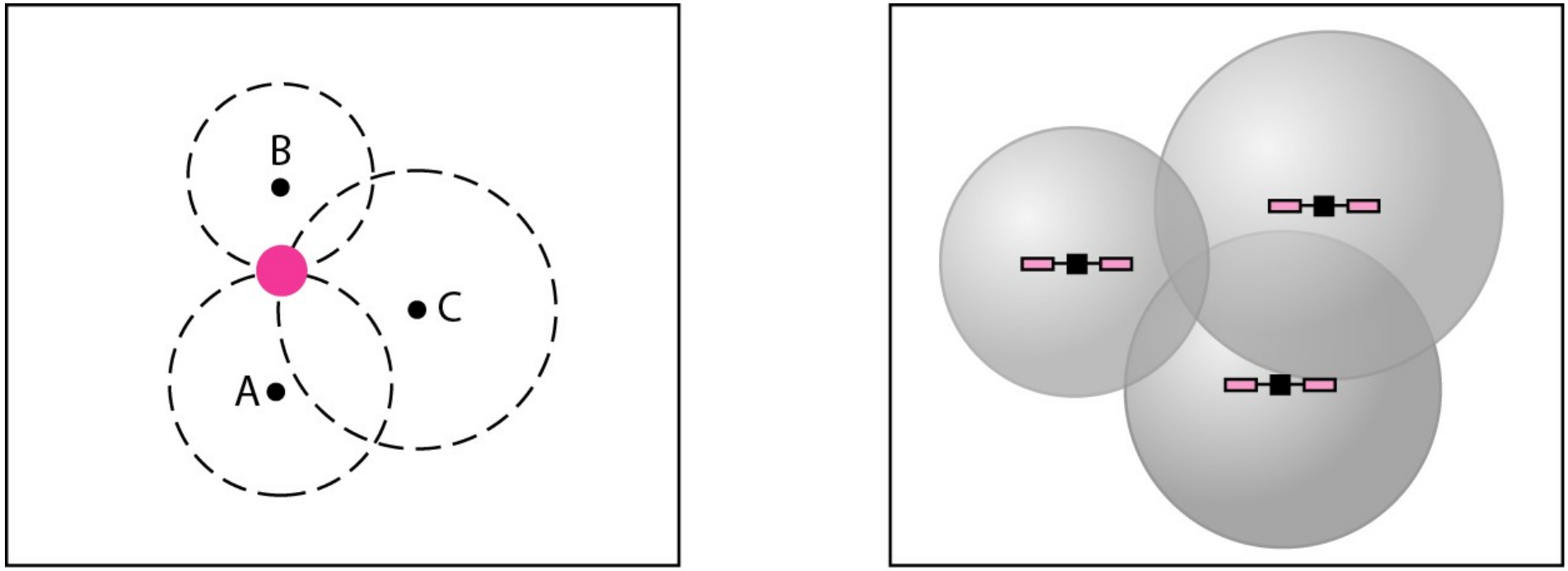
- Positioned between the two Van Allen belts.
- Global Positioning System (GPS)
  - One example of a MEO satellite system
  - Orbiting at an altitude about 18,000 km (11,000 mi) above the Earth.
  - The system consists of 24 satellites is used for land, sea, and air navigation to provide time and locations for vehicles and ships.

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



- Trilateration
  - GPS is based on a principle called trilateration.
  - On a plane, if we know our distance from three points, we know exactly where we are.

Figure 16.18 *Trilateration*



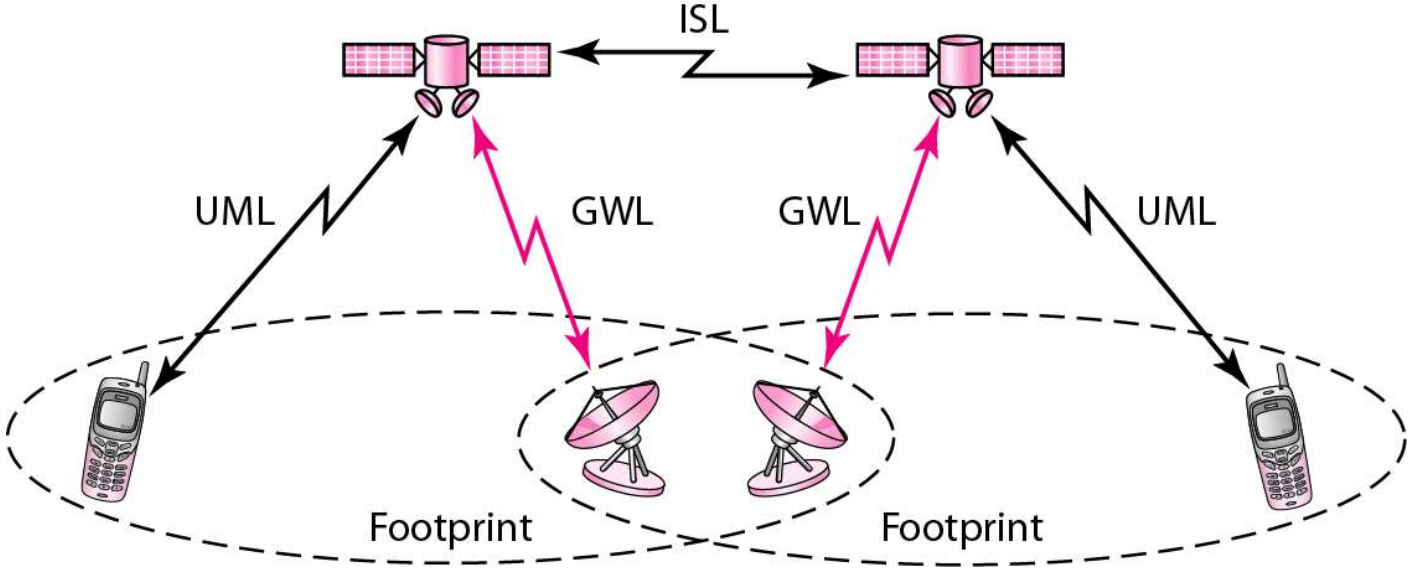
a. Two-dimensional trilateration

b. Three-dimensional trilateration

LEO Satellites

- Low-Earth-orbit (LEO) satellites have polar orbits.
  - The altitude: 500 ~ 2000 km
  - A rotation period: 90 ~ 120 min
  - A speed: 20,000 ~ 25,000 km/h

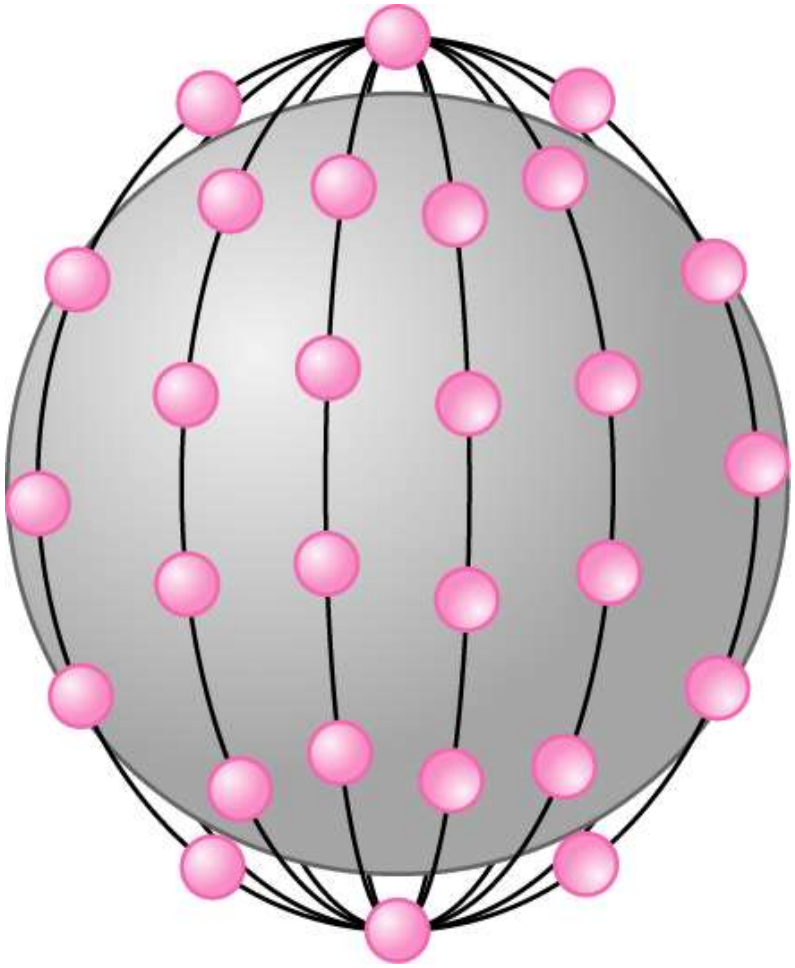
Figure 16.19 *LEO satellite system*



- ISL: intersatellite Links
- UMC: User Mobile Link
- GWL: Gateway Link

- Iridium System
  - Started by Motorola in 1990 with an object of a 77-satellite network
  - finally, in 1998, the service was started with 66 satellites.

Figure 16.20 *Iridium constellation*



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

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.

2. Satellite Networks

- Globalstar
  - Uses 48 satellites in six polar orbits.
  - An altitude: almost 1,400 km

- Difference between the Iridium system and the Globalstar
  - The main difference is the relaying mechanism.
  - Communication between two distant users
    - Iridium system: requires relaying between several satellites
    - Globalstar: requires both satellites and Earth stations, which means that ground stations can create more powerful signals.

- Teledesic
  - A system of satellites that provides fiber-optic-like (broadband channels, low error rate, and low delay) communication.
  - Internet in the sky
  - Started in 1990 by Craig McCaw and Bill Gates.
  - 288 satellites in 12 polar orbits
  - Altitude: 1350 km

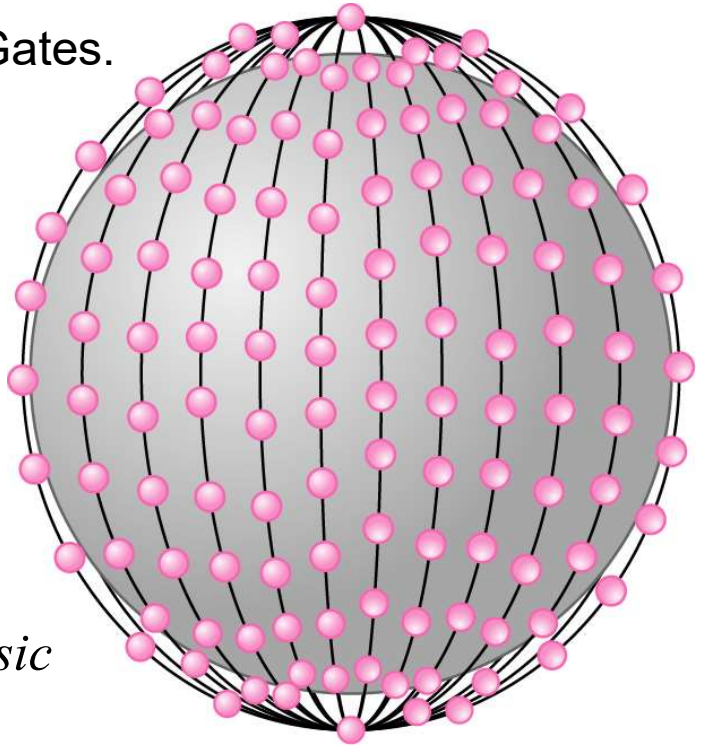


Figure 16.20 *Teledesic*

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

Summary

- Cellular telephony provides communication between two devices. One or both may be mobile.
- Advanced Mobile Phone System (AMPS) is a first-generation cellular phone system.
- Digital AMPS (D-AMPS) is a second-generation cellular phone system that is a digital version of AMPS.
- Global System for Mobile Communication (GSM) is a second-generation cellular phone system used in Europe.
- Interim Standard 95 (IS-95) is a second-generation cellular phone system based on CDMA and DSSS.
- The third-generation cellular phone system will provide universal personal communication.
- A satellite network uses satellites to provide communication between any points on earth.