

Wireless Communication

Lecture 8

Satellite Communications

Satellite-Related Terms

- Earth Stations – antenna systems on or near earth
- Uplink – transmission from an earth station to a satellite
- Downlink – transmission from a satellite to an earth station
- Transponder – electronics in the satellite that convert uplink signals to downlink signals

Ways to Categorize Communications Satellites

- Coverage area
 - Global, regional, national
- Service type
 - Fixed service satellite (FSS)
 - Broadcast service satellite (BSS)
 - Mobile service satellite (MSS)
- General usage
 - Commercial, military, amateur, experimental

Classification of Satellite Orbits

- Circular or elliptical orbit
 - Circular with center at earth's center
 - Elliptical with one foci at earth's center
- Orbit around earth in different planes
 - Equatorial orbit above earth's equator
 - Polar orbit passes over both poles
 - Other orbits referred to as inclined orbits
- Altitude of satellites
 - Geostationary orbit (GEO)
 - Medium earth orbit (MEO)
 - Low earth orbit (LEO)

Geometry Terms

- Elevation angle - the angle from the horizontal to the point on the center of the main beam of the antenna when the antenna is pointed directly at the satellite
- Minimum elevation angle
- Coverage angle - the measure of the portion of the earth's surface visible to the satellite

Minimum Elevation Angle

- Reasons affecting minimum elevation angle of earth station's antenna ($>0^\circ$)
 - Buildings, trees, and other terrestrial objects block the line of sight
 - Atmospheric attenuation is greater at low elevation angles
 - Electrical noise generated by the earth's heat near its surface adversely affects reception

GEO Orbit

- Advantages of the the GEO orbit
 - No problem with frequency changes
 - Tracking of the satellite is simplified
 - High coverage area
- Disadvantages of the GEO orbit
 - Weak signal after traveling over 35,000 km
 - Polar regions are poorly served
 - Signal sending delay is substantial

LEO Satellite Characteristics

- Circular/slightly elliptical orbit under 2000 km
- Orbit period ranges from 1.5 to 2 hours
- Diameter of coverage is about 8000 km
- Round-trip signal propagation delay less than 20 ms
- Maximum satellite visible time up to 20 min
- System must cope with large Doppler shifts
- Atmospheric drag results in orbital deterioration

LEO Categories

- Little LEOs

- Frequencies below 1 GHz
- 5MHz of bandwidth
- Data rates up to 10 kbps
- Aimed at paging, tracking, and low-rate messaging

- Big LEOs

- Frequencies above 1 GHz
- Support data rates up to a few megabits per sec
- Offer same services as little LEOs in addition to voice and positioning services

MEO Satellite Characteristics

- Circular orbit at an altitude in the range of 5000 to 12,000 km
- Orbit period of 6 hours
- Diameter of coverage is 10,000 to 15,000 km
- Round trip signal propagation delay less than 50 ms
- Maximum satellite visible time is a few hours

Frequency Bands Available for Satellite Communications

Band	Frequency Range	Total Bandwidth	General Application
L	1 to 2 GHz	1 GHz	Mobile satellite service (MSS)
S	2 to 4 GHz	2 GHz	MSS, NASA, deep space research
C	4 to 8 GHz	4 GHz	Fixed satellite service (FSS)
X	8 to 12.5 GHz	4.5 GHz	FSS military, terrestrial earth exploration, and meteorological satellites
Ku	12.5 to 18 GHz	5.5 GHz	FSS, broadcast satellite service (BSS)
K	18 to 26.5 GHz	8.5 GHz	BSS, FSS
Ka	26.5 to 40 GHz	13.5 GHz	FSS

Satellite Link Performance Factors

- Distance between earth station antenna and satellite antenna
- For downlink, terrestrial distance between earth station antenna and “aim point” of satellite
 - Displayed as a satellite footprint (Figure 9.6)
- Atmospheric attenuation
 - Affected by oxygen, water, angle of elevation, and higher frequencies

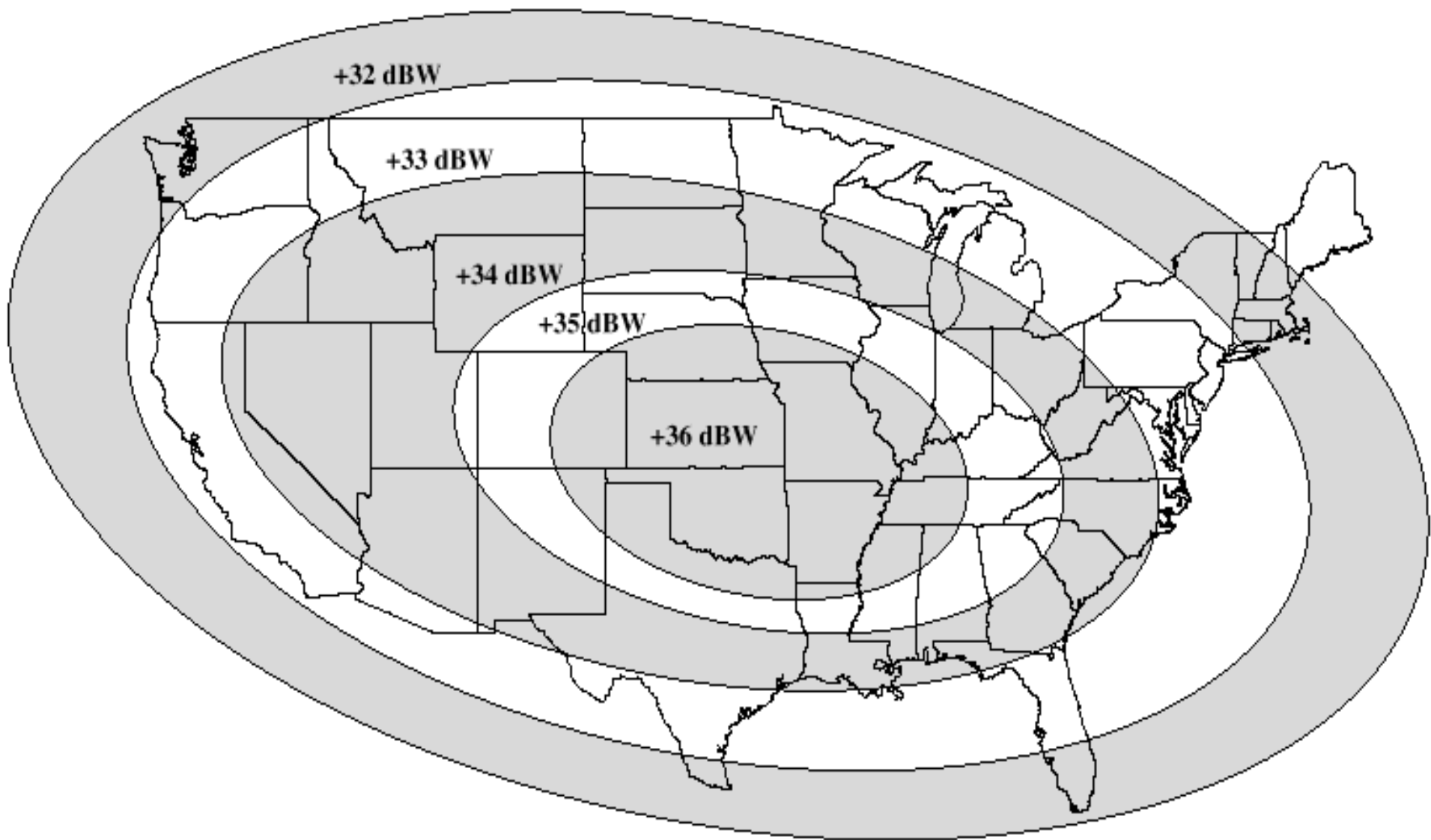
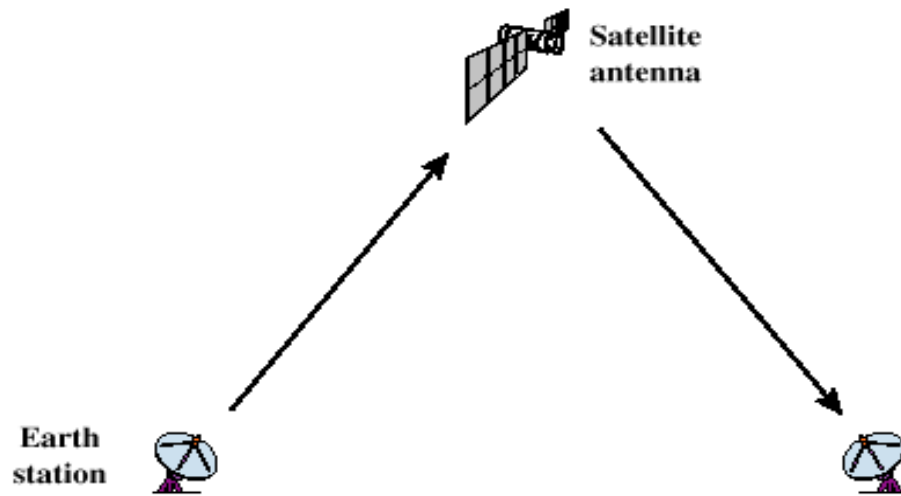
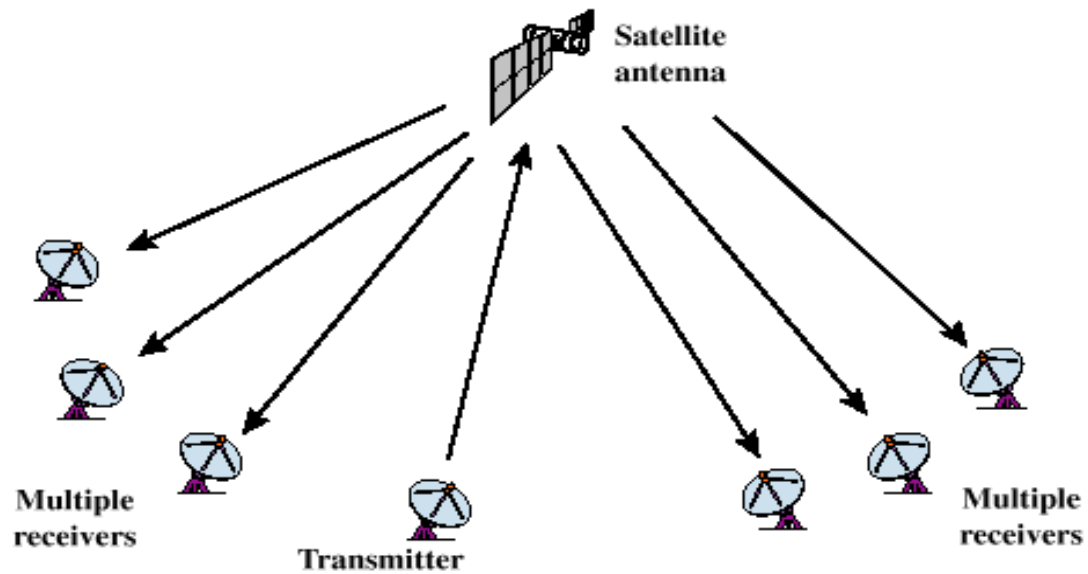


Figure 9.6 Typical Satellite Footprint



(a) Point-to-point link



(b) Broadcast link

Figure 9.8 Satellite Communication Configurations

Capacity Allocation Strategies

- Frequency division multiple access (FDMA)
- Time division multiple access (TDMA)
- Code division multiple access (CDMA)

Frequency-Division Multiplexing

- Alternative uses of channels in point-to-point configuration
 - 1200 voice-frequency (VF) voice channels
 - One 50-Mbps data stream
 - 16 channels of 1.544 Mbps each
 - 400 channels of 64 kbps each
 - 600 channels of 40 kbps each
 - One analog video signal
 - Six to nine digital video signals

Frequency-Division Multiple Access

- Factors which limit the number of subchannels provided within a satellite channel via FDMA
 - Thermal noise
 - Intermodulation noise
 - Crosstalk

Forms of FDMA

- Fixed-assignment multiple access (FAMA)
 - The assignment of capacity is distributed in a fixed manner among multiple stations
 - Demand may fluctuate
 - Results in the significant underuse of capacity
- Demand-assignment multiple access (DAMA)
 - Capacity assignment is changed as needed to respond optimally to demand changes among the multiple stations

FAMA-FDMA

- FAMA – logical links between stations are preassigned
- FAMA – multiple stations access the satellite by using different frequency bands
- Uses considerable bandwidth

DAMA-FDMA

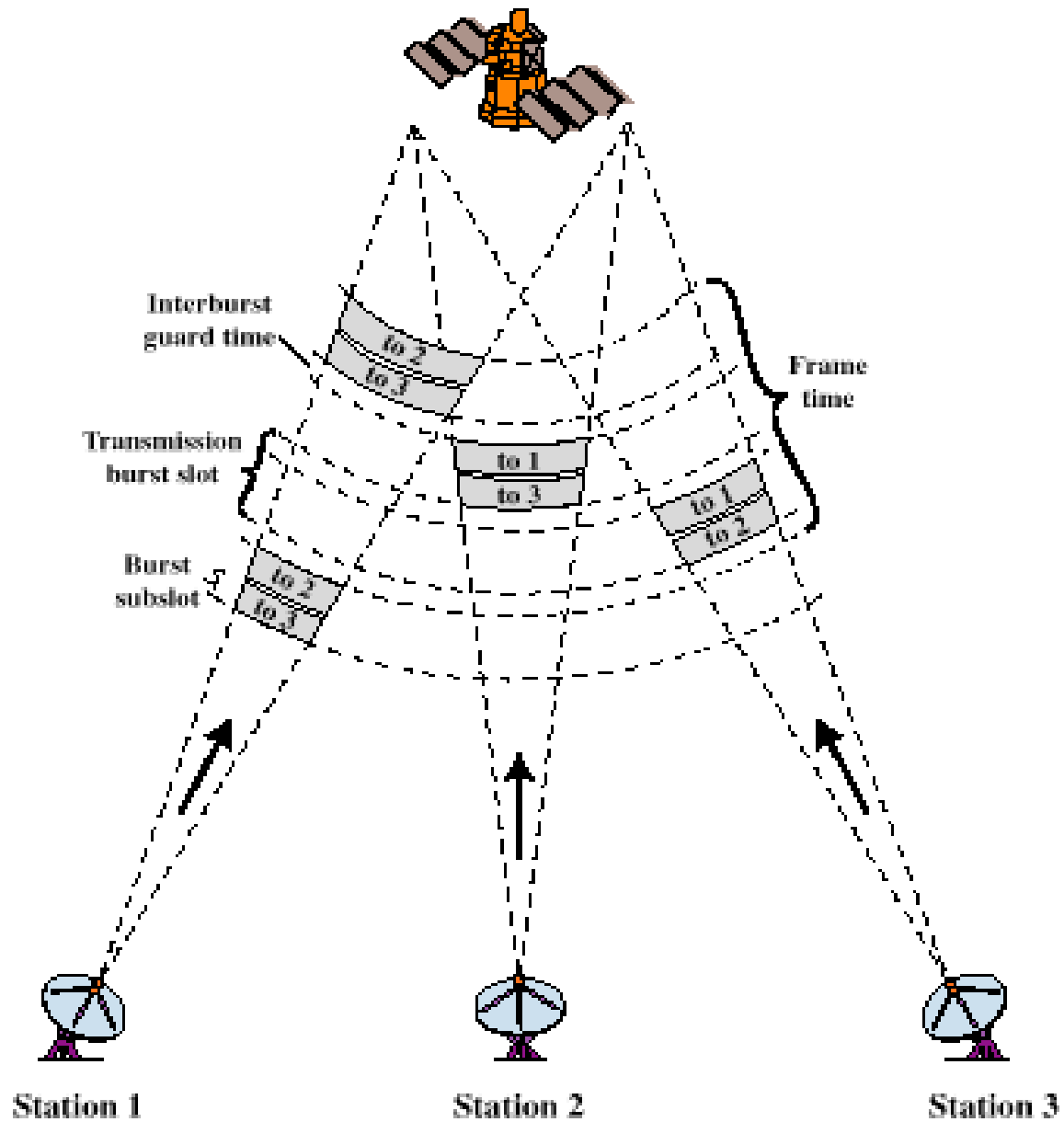
- Single channel per carrier (SCPC) – bandwidth divided into individual VF channels
 - Attractive for remote areas with few user stations near each site
 - Suffers from inefficiency of fixed assignment
- DAMA – set of subchannels in a channel is treated as a pool of available links
 - For full-duplex between two earth stations, a pair of subchannels is dynamically assigned on demand
 - Demand assignment performed in a distributed fashion by earth station using CSC

Reasons for Increasing Use of TDM Techniques

- Cost of digital components continues to drop
- Advantages of digital components
 - Use of error correction
- Increased efficiency of TDM
 - Lack of intermodulation noise

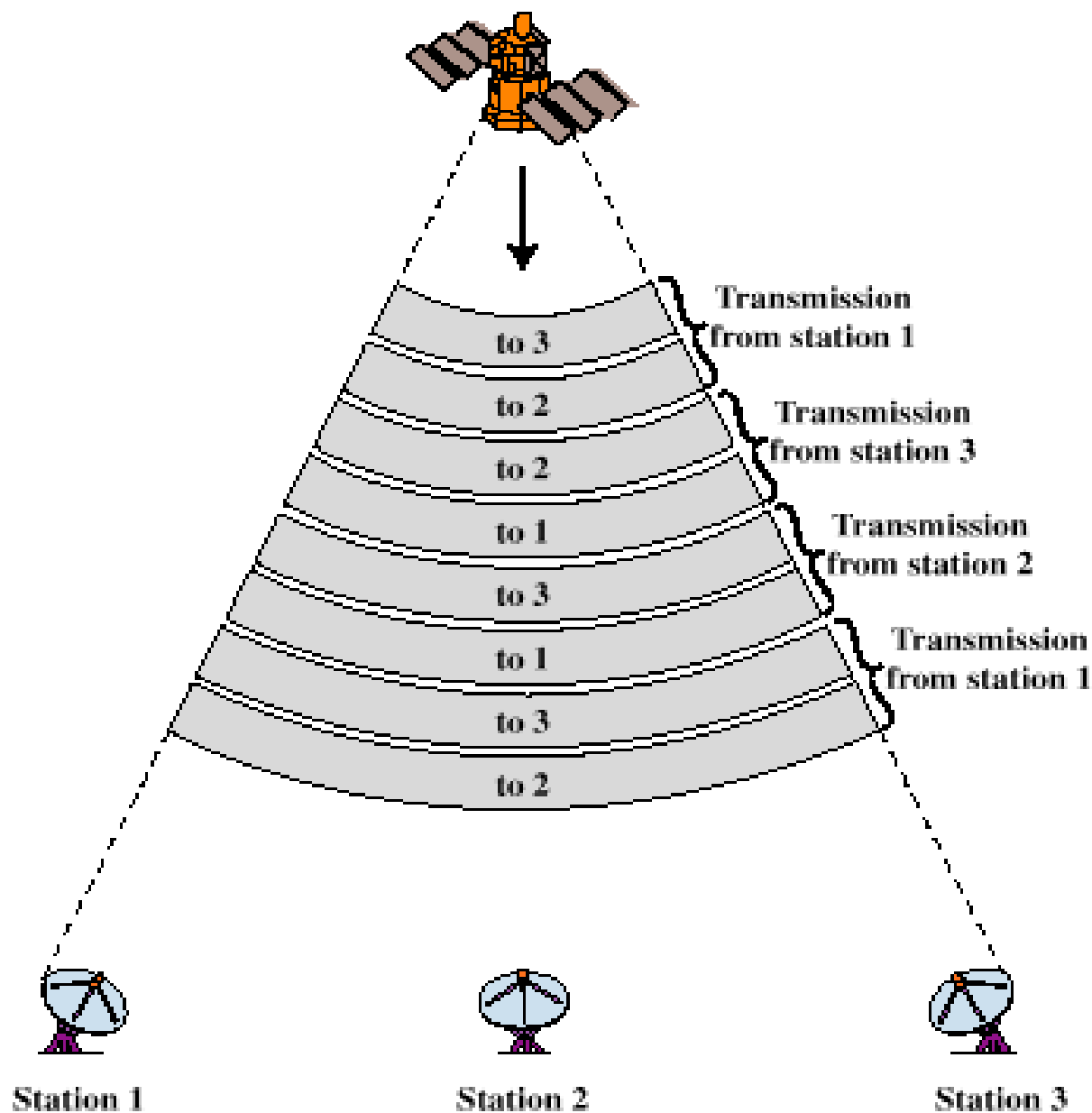
FAMA-TDMA Operation

- Transmission in the form of repetitive sequence of frames
 - Each frame is divided into a number of time slots
 - Each slot is dedicated to a particular transmitter
- Earth stations take turns using uplink channel
 - Sends data in assigned time slot
- Satellite repeats incoming transmissions
 - Broadcast to all stations
- Stations must know which slot to use for transmission and which to use for reception



(a) Uplink

Figure 9.14 FAMA-TDMA Operation



(b) Downlink

Figure 9.14 FAMA-TDMA Operation