Multiple Access Concept

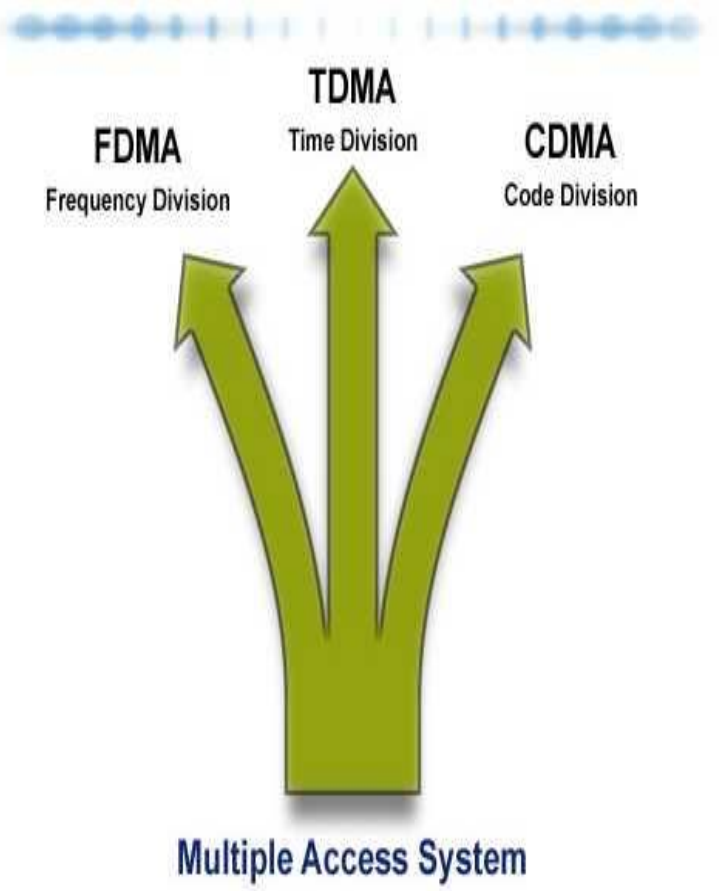
THE PROBLEM:
HOW DO WE ***SHARE*** ONE TRANSPONDER BETWEEN SEVERAL EARTH STATIONS?

MULTIPLE ACCESS

- NEED TO OPTIMIZE
  - Satellite capacity (revenue issue)
  - Spectrum utilization (coordination issue)
  - Interconnectivity (multiple coverage issue)
  - Flexibility (demand fluctuation issue)
  - Adaptability (traffic mix issue)
  - User acceptance (market share issue)
  - Satellite power
  - Cost

Multiple Access Schemes for Satellite Communications

- A multiple access scheme is expected to provide users to simultaneously access a satellite terminal efficiently
- In a satellite communications system, designing a multiple access scheme is one of the most challenging issues



HOW DO YOU SEPARATE USERS?

- LABEL THE SIGNAL IN A UNIQUE WAY AT THE TRANSMITTER
  - UNIQUE FREQUENCY SLOT ***FDMA***
  - UNIQUE TIME SLOT ***TDMA***
  - UNIQUE CODE ***CDMA***
- RECOGNIZE THE UNIQUE FEATURE OF EACH SIGNAL AT THE RECEIVER

HOW DO WE EXTRACT THE SIGNALS?

- **FDMA**
  - BAND PASS FILTER EXTRACTS SIGNAL IN THE CORRECT FREQUENCY SLOT
- **TDMA**
  - DE-MULTIPLEXER “GRABS” SIGNAL IN THE CORRECT TIME SLOT
- **CDMA**
  - DE-SPREADER EXTRACTS SIGNAL WITH THE CORRECT CODE

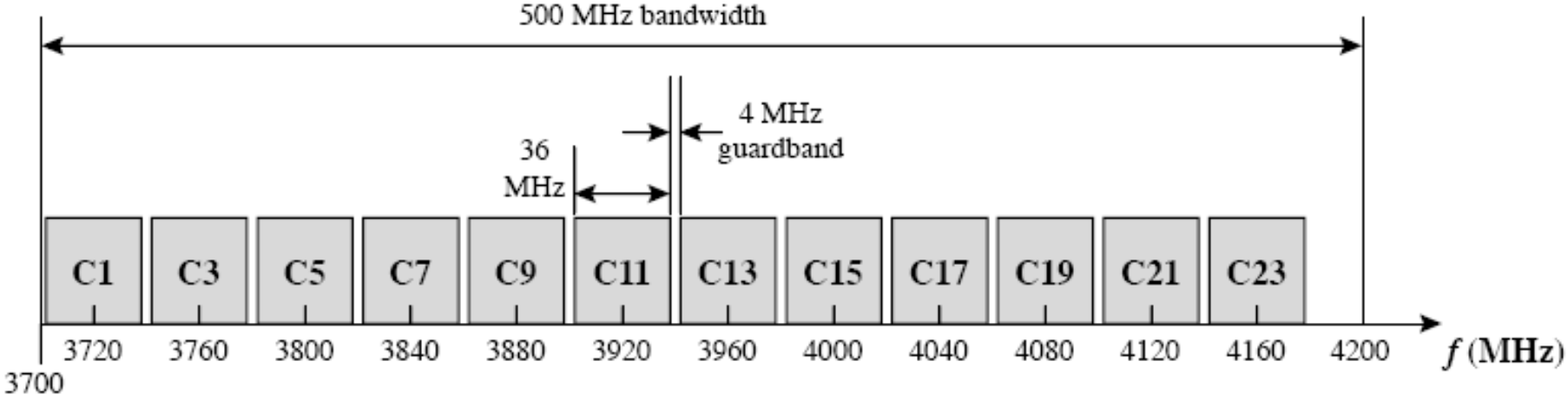
MULTIPLE ACCESS

- If the proportion of the resource (frequency, time, code) is allocated in advance, it is called ***PRE-ASSIGNED* MULTIPLE ACCESS** or ***FIXED* MULTIPLE ACCESS**
- If the proportion of the resource is allocated in response to traffic conditions in a dynamic manner it is called ***DEMAND ASSIGNED* MULTIPLE ACCESS - DAMA**

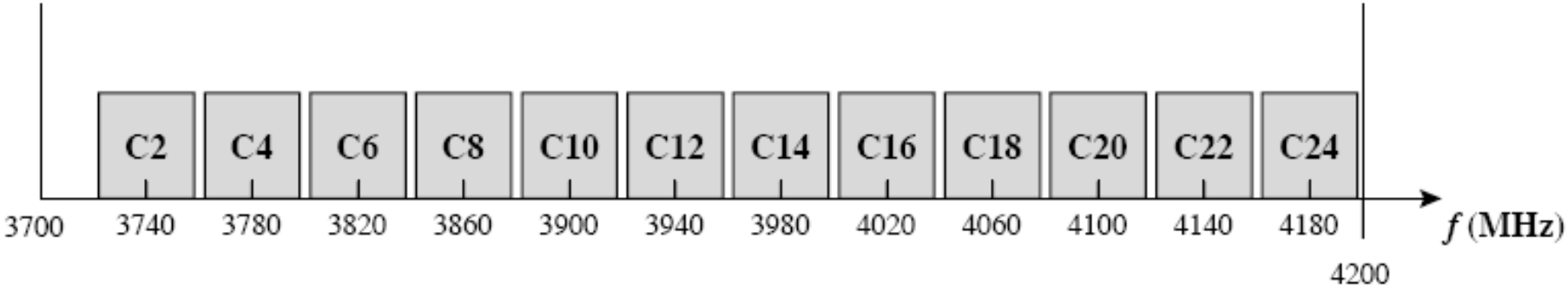
Frequency division multiple access FDMA

FDMA uses multi-destination carriers, each earth station pre-assigned carrier and bandwidth according to traffic requirements.
Channels transmitted regardless of destination.
Distant earth stations receive all carriers and select only those wanted by filtering.
Smaller channel assignments need proportionally more bandwidth. FDM/FM signals.

Frequency-Division Multiplexing



(a) Horizontal Polarization



(b) Vertical Polarization

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 Reuse – overlapping channels use orthogonal polarization (vertical/horizontal) to add channel separation

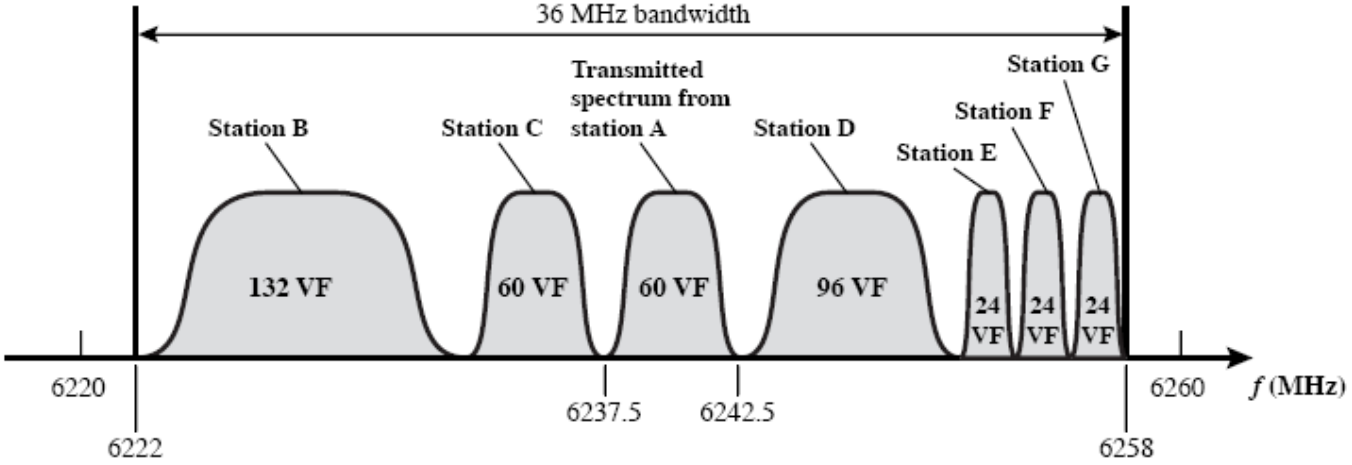
Frequency-Division Multiple Access

- Factors which limit the number of subchannels provided within a satellite channel via FDMA
  - Intermodulation noise – TWTs must be backed off reducing efficiency
  - Crosstalk

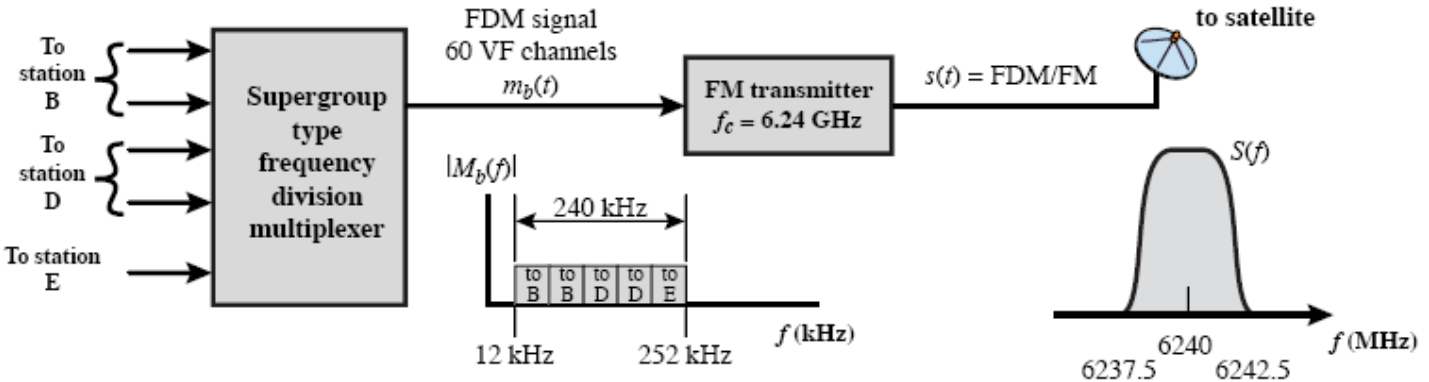
Forms of FDMA

- Fixed-assignment multiple access (FAMA)
  - Capacity 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
  - **Pool of channels is used**

FAMA-FDMA



(a) Transponder uplink frequency allocation



(b) Station A ground transmitting equipment

Time division multiple access TDMA

Different stations assigned different time slots – digital – uses entire transponder bandwidth – operation and control complex – global clocks needed for synchronisation – only 1 carrier at transponder at any time – no IM products – TWT operates at saturation maximising C/N and efficiency.

Time Division Multiple Access

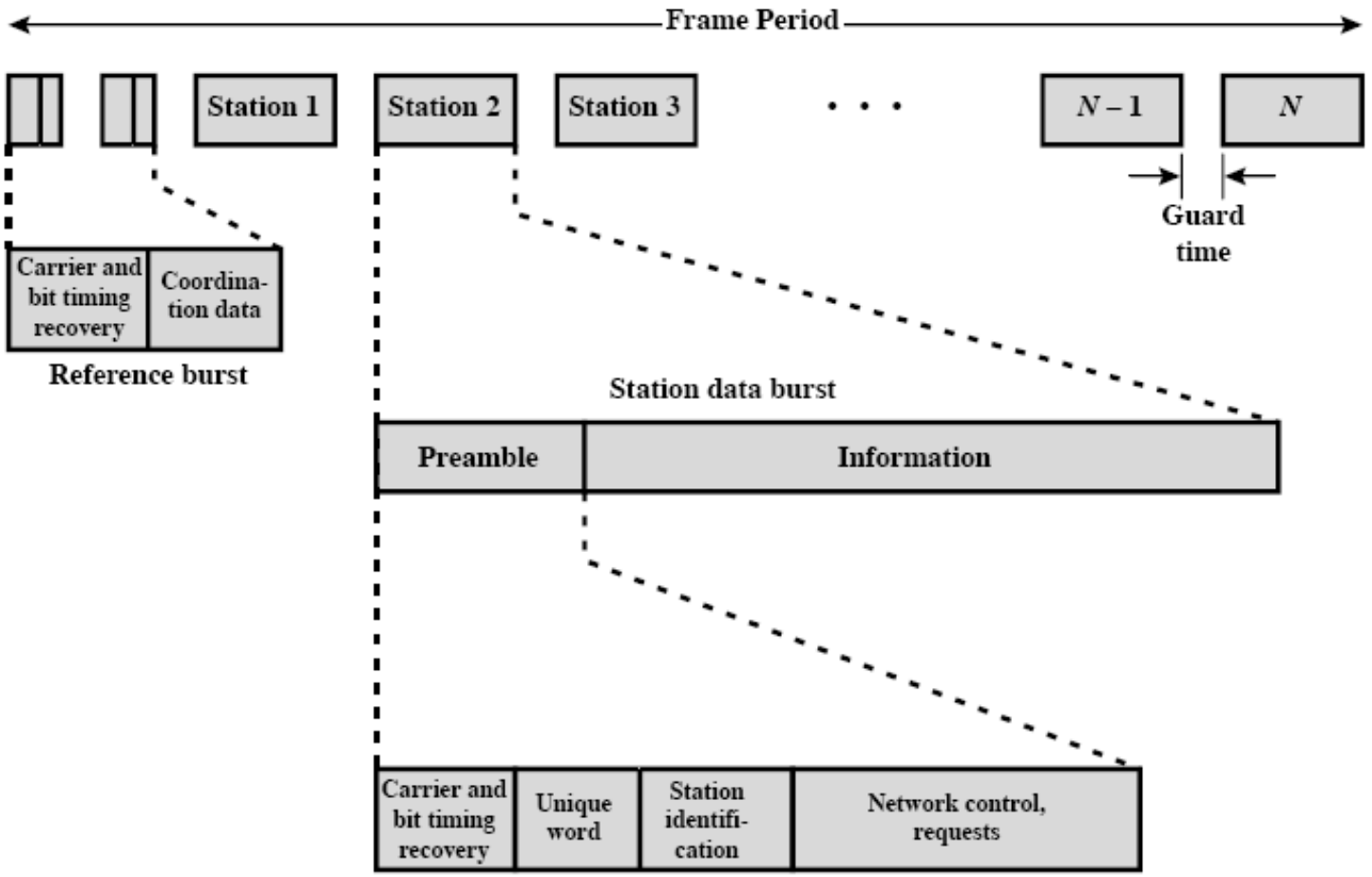


Figure 9.13 Example of TDMA Frame Format

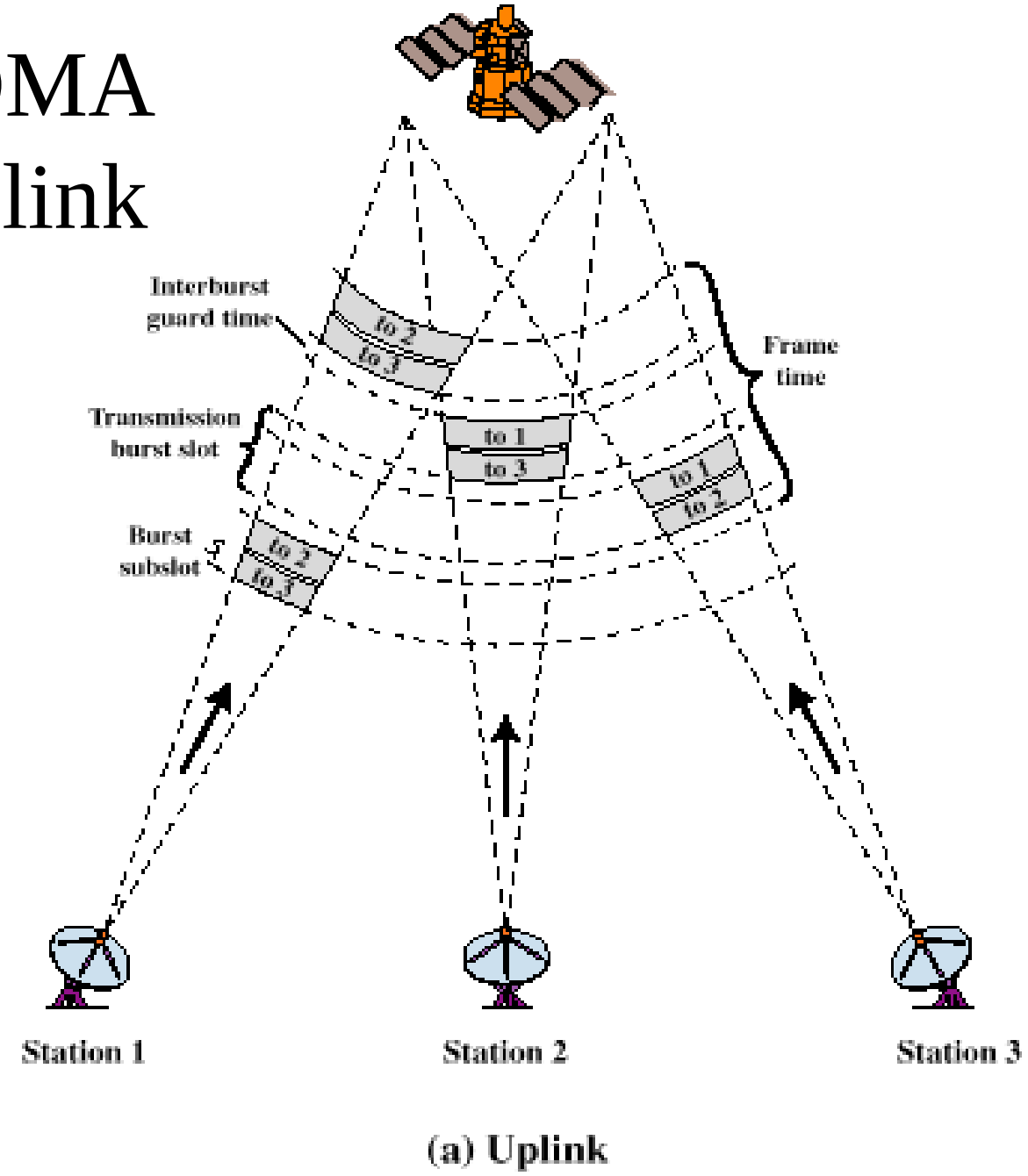
Reasons for Increasing use of TDM Techniques

- Advantages of digital components
  - Use of error correction
- Increased efficiency of TDM
  - Lack of intermodulation noise

TDMA Operation

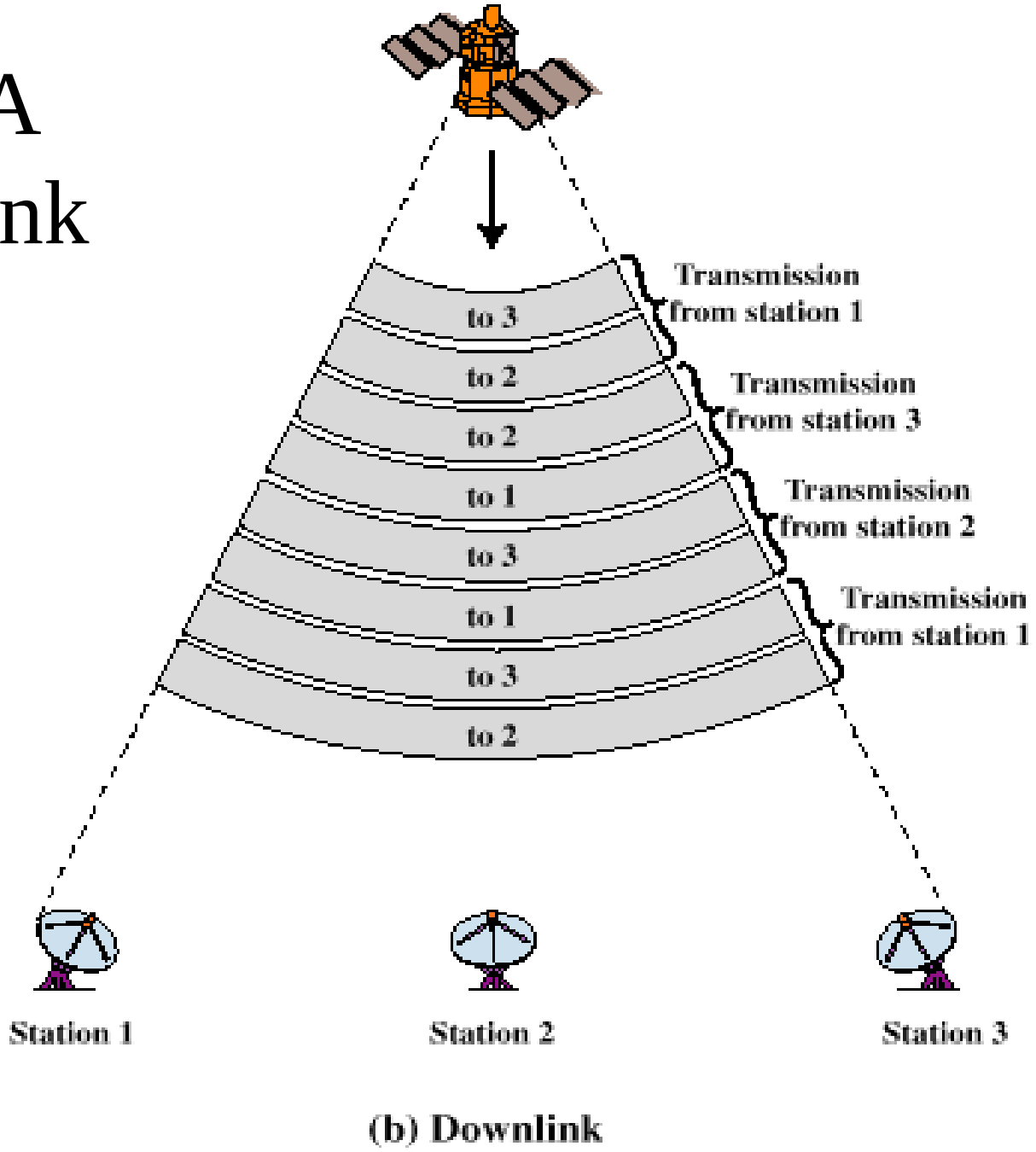
- Transmission in the form of repetitive sequence of frames
  - Each frame is divided into a number of time slots
  - Each slot is dedicated to a particular station
- Earth stations take turns using uplink channel
  - Sends data in assigned time slot
- Satellite repeats incoming transmissions
  - Broadcast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

TDMA Uplink



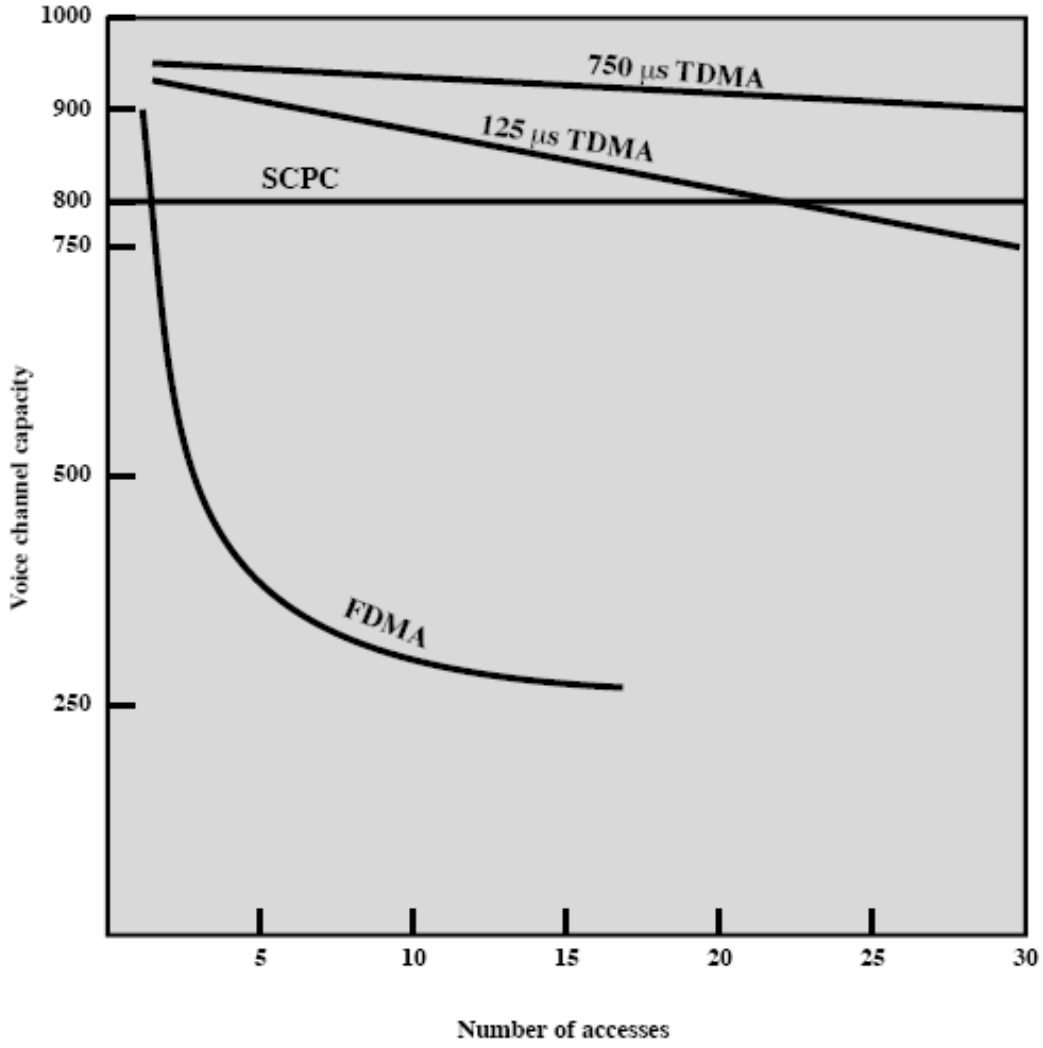
(a) Uplink

TDMA Downlink



(b) Downlink

Efficiency



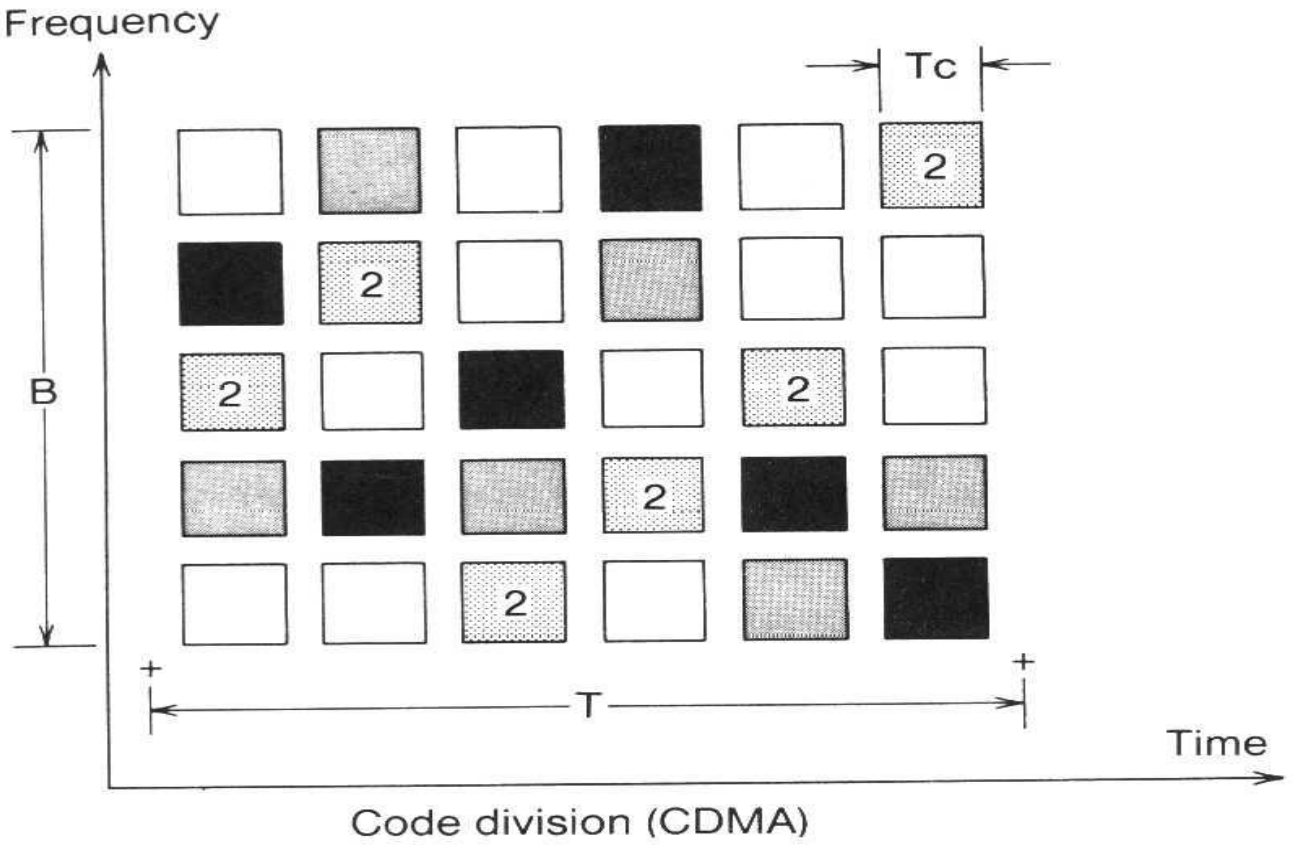
SCPC
Single
Channel per
Carrier –
Radio broadcast

Code division multiple access CDMA

- SHARE TIME **AND** FREQUENCY
  - separation of signals is through the use of unique codes
- EACH USER IS ASSIGNED A CODE
- RECEIVER SEARCHES FOR CODES
- CODE RATE >> DATA RATE

- Used in mobile satellite communications

CDMA



- SYSTEM OPERATOR - OR INDIVIDUAL PAIRS OF USERS - ASSIGN UNIQUE SPREADING OR HOPPING CODES TO EACH DUPLEX LINK
- CDMA IS A SOLUTION FOR SEVERE INTERFERENCE ENVIRONMENTS, USUALLY AT A CAPACITY LOSS COMPARED WITH TDMA AND FDMA
- ALL USERS SHARE THE **SAME TIME *AND* FREQUENCY**
- SIGNALS ARE SEPARATED BY USING A UNIQUE CODE
  - Codes must be “orthogonal” so that ***User A*** does not respond to a code intended for ***User B***
  - Codes are usually **very long** : PN sequence, Gold, or Kasami codes