Satellite Communication(EC0723)
Unit-IV
B.Tech (Electronics and Communication)
Semester-VII

Prof. Divyangna Gandhi

Multiple Access Techniques

Definition of Multiple Access

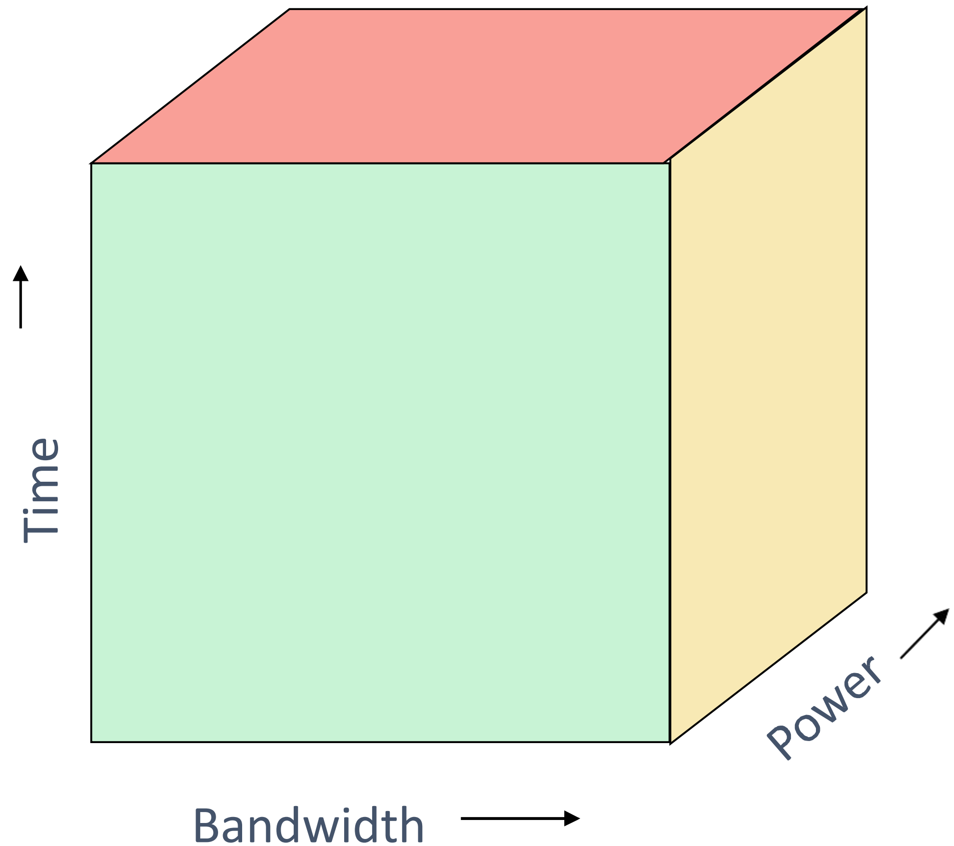
- In satellite communications, the capability of a communications satellite to function as a portion of a communications link between more than one pair of satellite terminals concurrently
- In computer networking, a scheme that allows temporary access to the network by individual users, on a demand basis, for the purpose of transmitting information

Multiple Access - Meaning

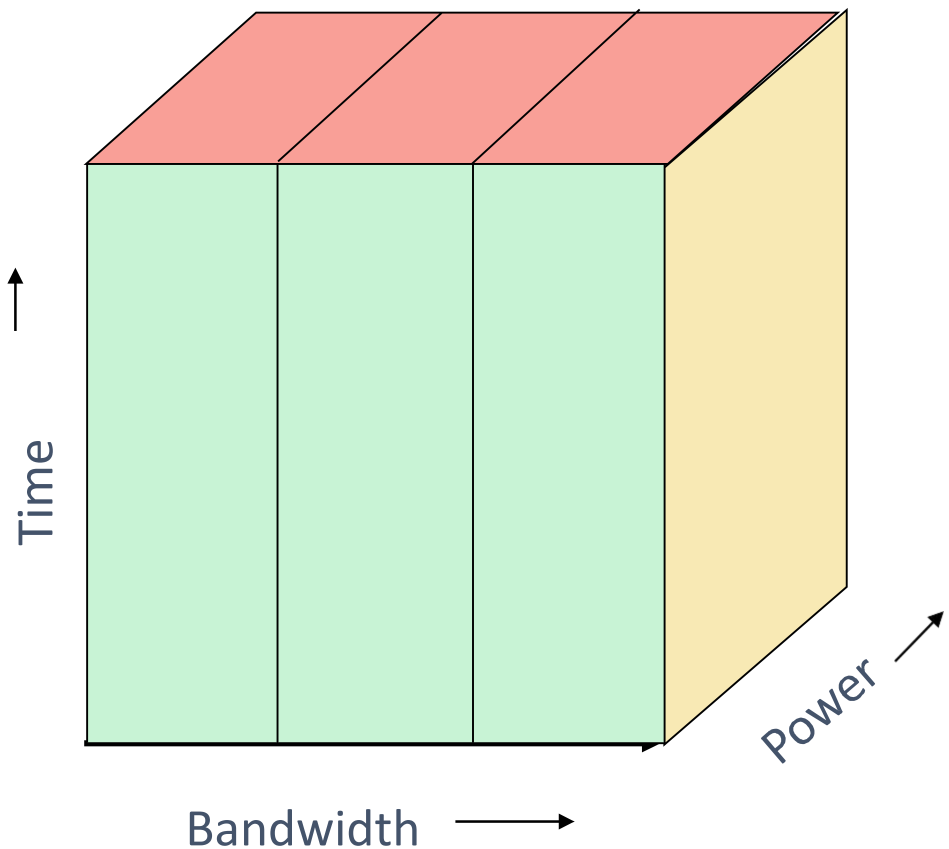
- A method of accessing a transmission medium by different users by sharing the resources of the medium

- Resources
  - Bandwidth – FDMA   Frequency Division
  - Time – TDMA   Time Division
  - Power – CDMA   Code Division

Dimensions of a Channel



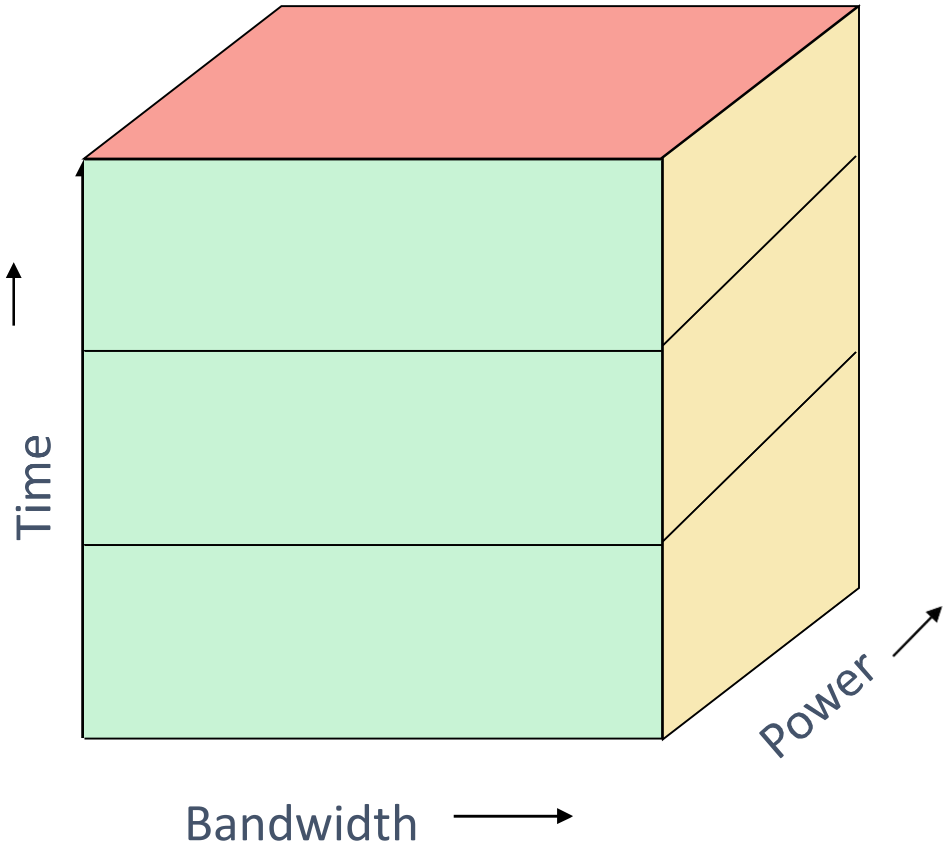
FDMA - Sharing the Bandwidth



Share BW &Time and Power

Transmit all time

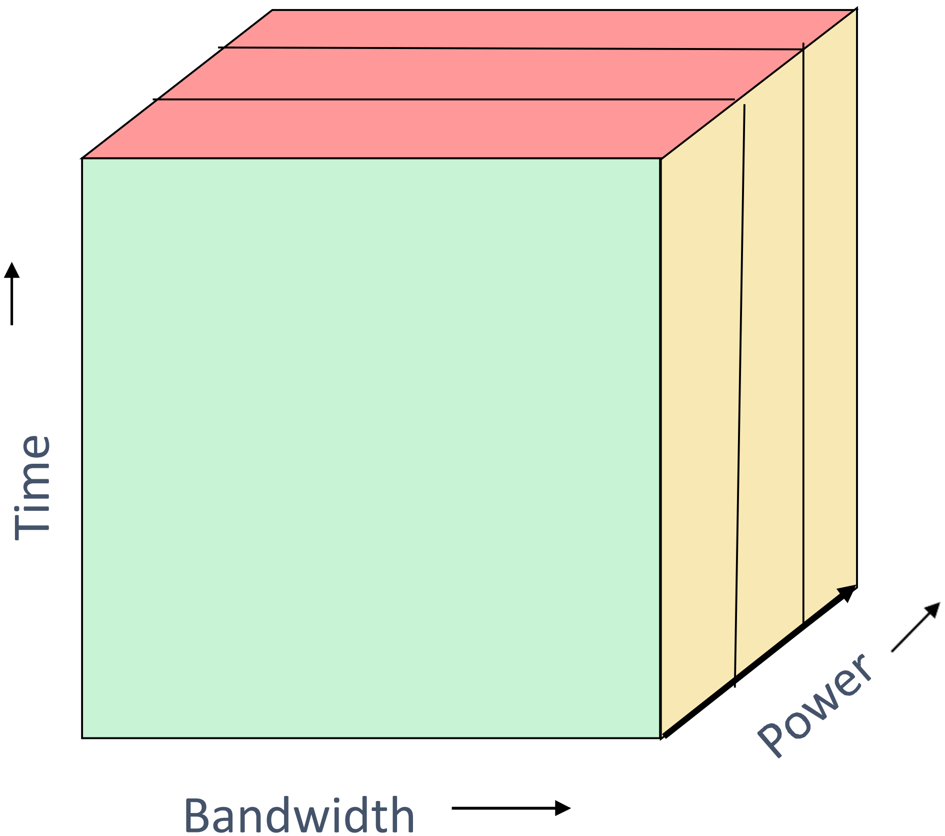
TDMA - Sharing the Time



Share Time

Use full BW & Power

CDMA - Sharing the Power

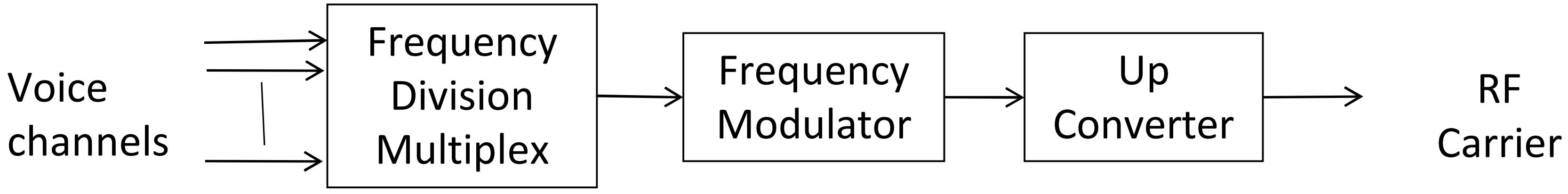


Share Power

Use full BW & Power

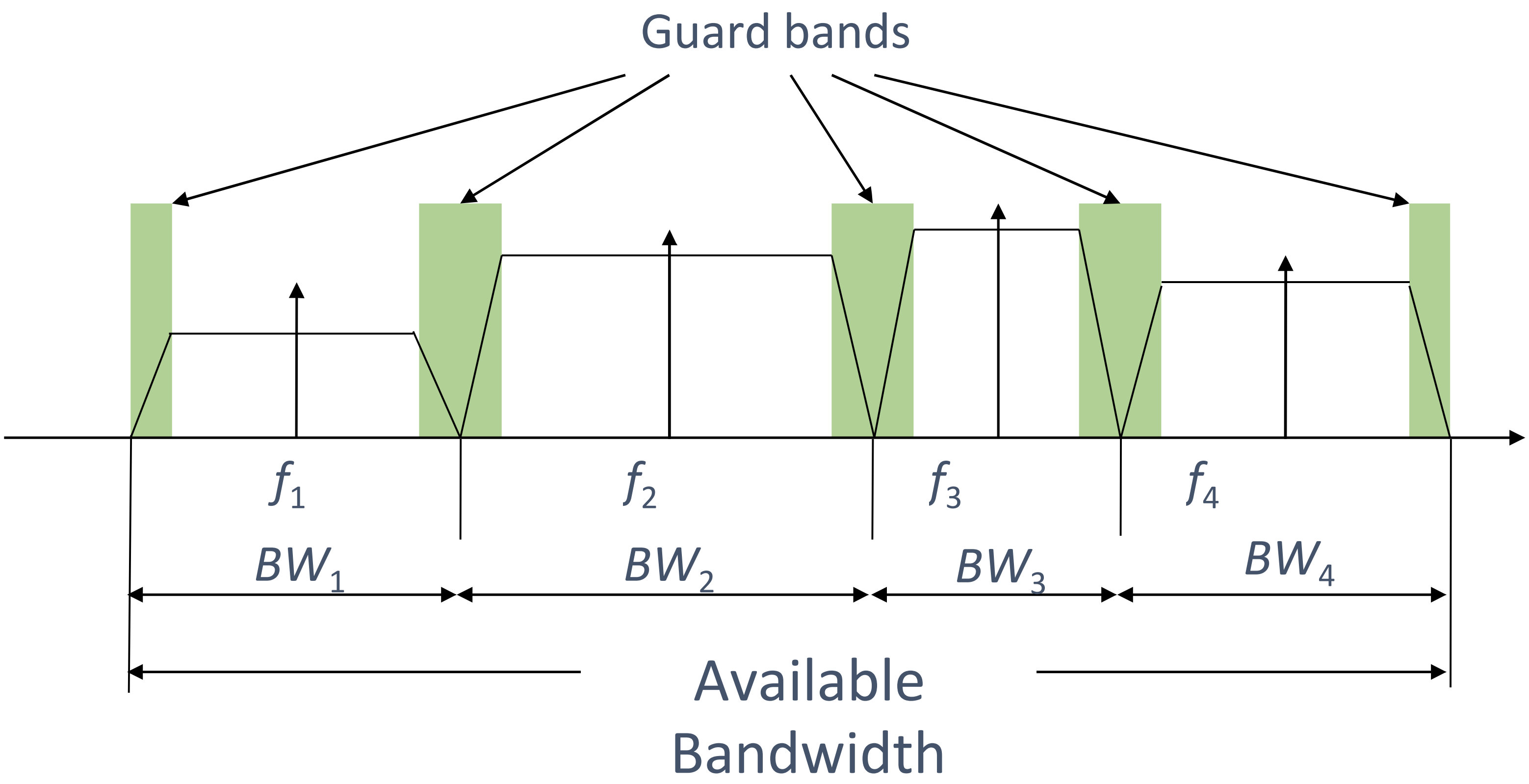
Frequency Division Multiple Access

- Multi Channel Per Carrier (MCPC) transmission
  - FDM/FM/FDMA (Analog carrier)
  - PCM-TDM/PSK/FDMA (Digital carrier)



- Single Channel Per Carrier (SCPC) transmission
  - PCM/PSK/FDMA (Digital carrier)
  - FM/FDMA (Analog carrier)

Bandwidth utilization in satellite FDMA system



FDMA Capacity – BW limited case

Assuming equal bandwidth per channel the total number of carriers is

$$\text{Number of carriers } K = \frac{\text{Effective Bandwidth}}{\text{Carrier bandwidth}}$$

$$= \frac{\text{Total bandwidth} - \text{Total gaurdband}}{\text{Carrier bandwidth}}$$

$$= \frac{B_t - B_g}{B_c}$$

Limitations of FDMA

- **Inefficient use of spectrum**
  - Wastage of spectrum due to guard bands
  - In power-limited case full spectrum cannot be used
- **With multi-carriers the system must operate in linear mode, requiring lower power transmission**
  - Intermode products generated when operated in non-linear region
  - Power back-off reduces system capacity
- **Linear operation implies strict power control of each user**
- **Equipment complexity**
  - Separate transmitter and receiver are required for each carrier
- **System is not flexible with dynamic traffic**
  - The capacity of carriers cannot be modified easily. Filters need to be changed to accommodate varying bandwidth

FDMA Applications

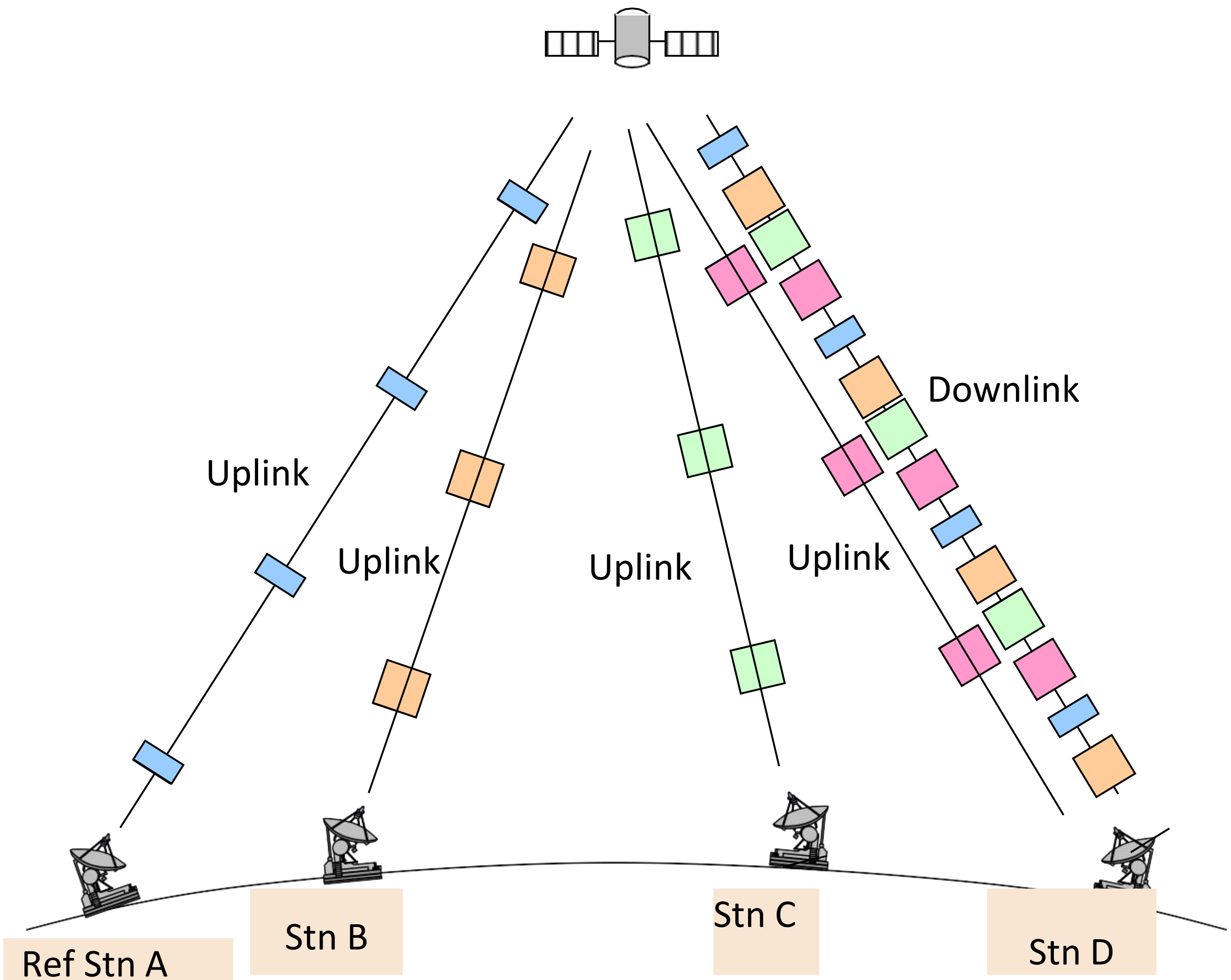
- FM/SCPC/FDMA in early Intelsat SCPC systems
  - Individual FM carriers carrying single voice channels and accessing satellite in FDMA mode

- PCM/PSK/FDMA in Intelsat SPADE system
  - Voice channels are PCM coded and modulated on PSK carriers accessing satellite in FDMA mode

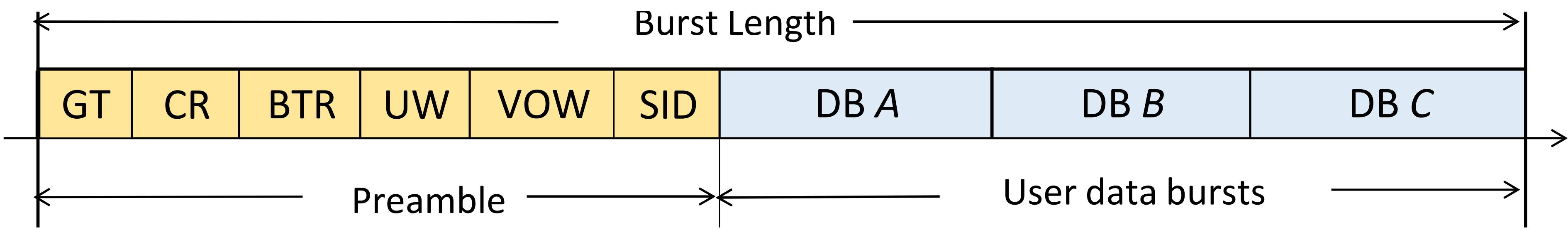
Time Division Multiple Access

- An all digital baseband system
- All users employ same carrier
- All users can use full bandwidth
- All users can use full power
- Each users transmits at different times in burst mode
- Efficient use of system power and spectrum

TDMA Transmission to Satellite

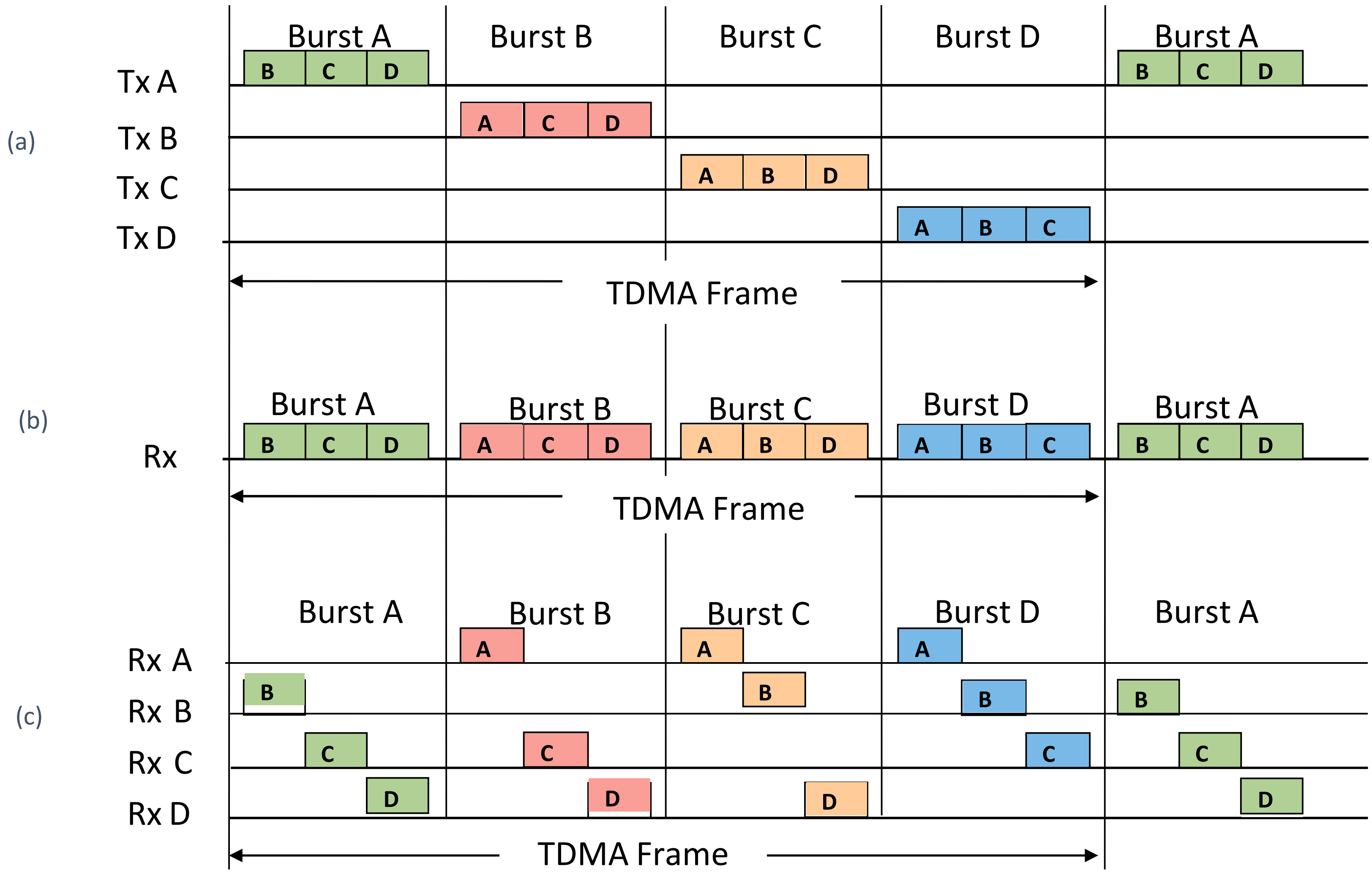


TDMA Burst format



GT: Guard Time
CR: Carrier Recovery bits
BTR: Bit Timing Recovery
UW: Unique Word
VOW: Voice Order Wire
SID: Station ID
DB *N*: Data Burst (Destination N)

TDMA Concept (a) Transmit Frames (b) Received Frame (c) Decoded Frames



TDMA Frame Efficiency

- A measure of what percent of the transmitted data is actually utilized by the user
- Frame efficiency = (User data bits/Total bits in the frame)

  = (1 – Overhead bits/Total bits in the frame)

$$\eta_F = \left(1 - \frac{N.b_P + b_C}{b_F}\right) 100\%$$

N = number of data bursts,

b_p =bits in the preamble,

b_C =bits in the control burst and

b_F =total bits in the frame

TDMA : Example

- A TDMA network has six users each transmitting an E1 carrier PCM multiplexed data of 32 channels (PCM sampling rate is 8 kHz and coding of 8 bits/sample).
- TDMA frame is 2ms long and each data burst has a preamble of 128 bits including the guard time.
- The control channel contains just the preamble.

- Find
  - compression ratio for the data in the TDMA frame
  - transmit data rate
  - frame efficiency

Solution to TDMA Example

- PCM sampling period $T_s = 125\ \mu s$
- Number of PCM samples/channel in the TDMA frame

  =TDMA frame length/PCM frame length = 2ms/125 μs = 16
- Total number of bits in the data burst per user $= B_{DB} = 16 \times 32 \times 8 = 4096$ *bits*
- Total bits in the frame $= b_F = 128 + 6 \times (128 + 4096) = 25{,}472$ bits
- Compression ratio for the data = 2 *ms* / 125 μs = 16
- Transmission rate R = bits per frame x frame rate

  $= 25{,}472 \times (1/.002) = 12{,}736{,}000 = 12.736\ Mb/s$
- $\eta_F = [1 - (128+6 \times 128)/25{,}472] \times 100\% = 96.5\ \%$

Code Division Multiple Access

- Also called Spread Spectrum Multiple Access (SSMA)
- All users can use compete bandwidth
- All users can transmit full time
- All users share the system power
- Each user uses a unique code to make the signal orthogonal to other user's signal
- The unique code serves as an address of the transmitter enabling the receiver to select the correct transmitter

TDMA : Example

- A TDMA network has ten users each transmitting an E1 carrier PCM multiplexed data of 64 channels (PCM sampling rate is 8 kHz and coding of 8 bits/sample).
- TDMA frame is 10ms long and each data burst has a preamble of 64 bits including the guard time.
- The control channel contains just the preamble.

- Find
  - compression ratio for the data in the TDMA frame
  - transmit data rate
  - frame efficiency

Types of CDMA

- **Direct Sequence CDMA** (DS-CDMA)
  - The PN code is combined directly with data before modulation
- **Frequency Hopping CDMA** (FH-CDMA)
  - The PN code controls the carrier frequency of transmission

VSATs

VSAT stands for very small aperture terminal system. This is the distinguishing feature of a VSAT system, the earth station antennas being typically less than 2.4 m in diameter. The trend is toward even smaller dishes, not more than 1.5 m in diameter. In this sense, the small TVRO terminals for direct broadcast satellites could be labeled as VSATs, but the appellation is usually reserved for private networks, mostly providing two-way communications facilities. Typical user groups include banking and financial institutions, airline and hotel booking agencies, and large retail stores with geographically dispersed outlets.

The basic structure of a VSAT network consists of a hub station which provides a broadcast facility to all the VSATs in the network and the VSATs themselves which access the satellite in some form of multiple access mode. The hub station is operated by the service provider, and it may be shared among a number of users, but of course, each user organization has exclusive access to its own VSAT network. Time- division multiplex is the normal downlink mode of transmission from hub to the VSATs, and the transmission can be broadcast for reception by all the VSATs in a network, or address coding can be used to direct messages to selected VSATs.

VSAT systems operate in a star configuration, which means that connection of one VSAT to another must be made through the hub. This requires a double-hop circuit with a consequent increase in propagation delay, and twice the necessary satellite capacity is required compared with a single-hop circuit. In Hughes, a proposal is presented for a VSAT system which provides for mesh connection, where the VSATs can connect with one another through the satellite in a single hop.

Most VSAT systems operate in the Ku band, although there are some C-band systems in existence

Reference

Dennis Roddy, “Satellite Communication”, 4th Ed., McGraw Hill, 2008