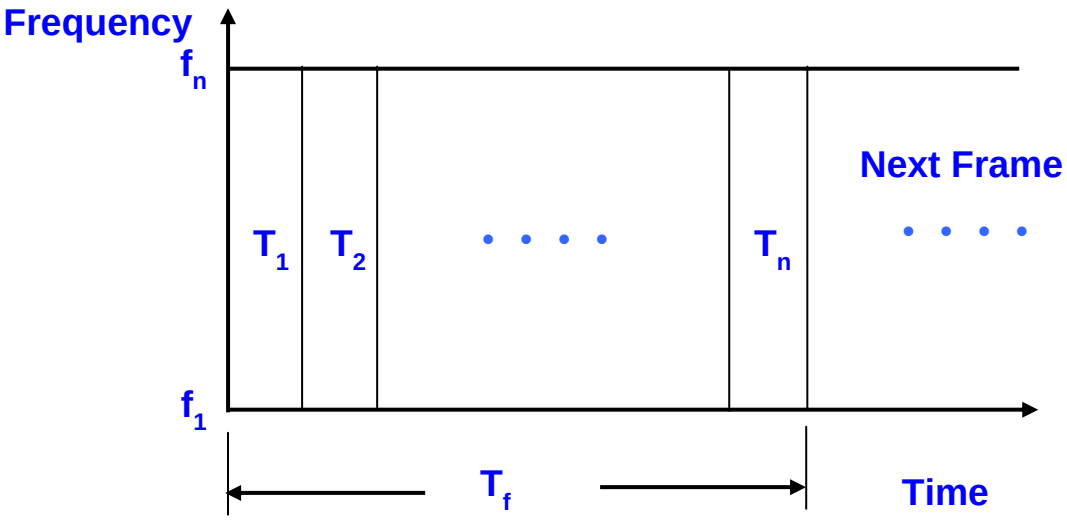
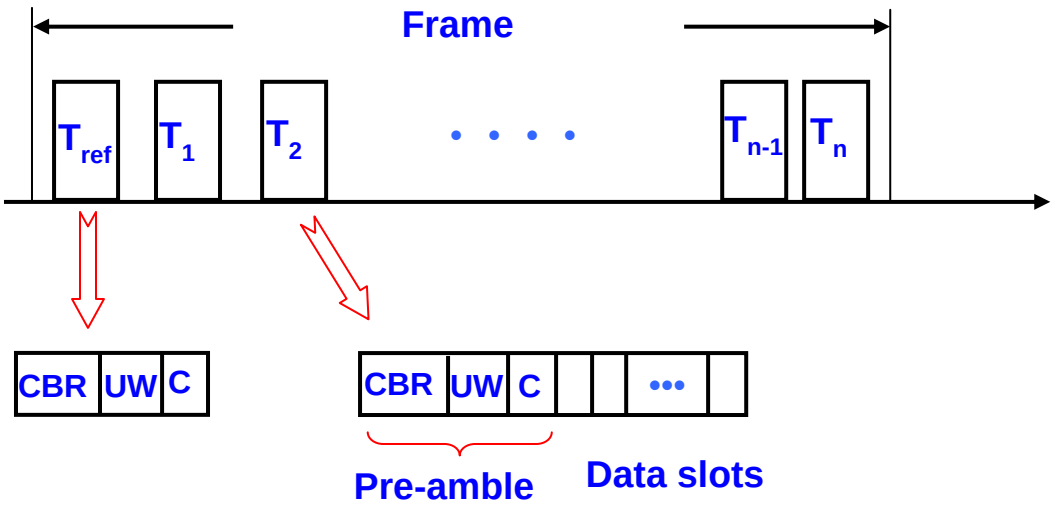
Multiple Access Techniques

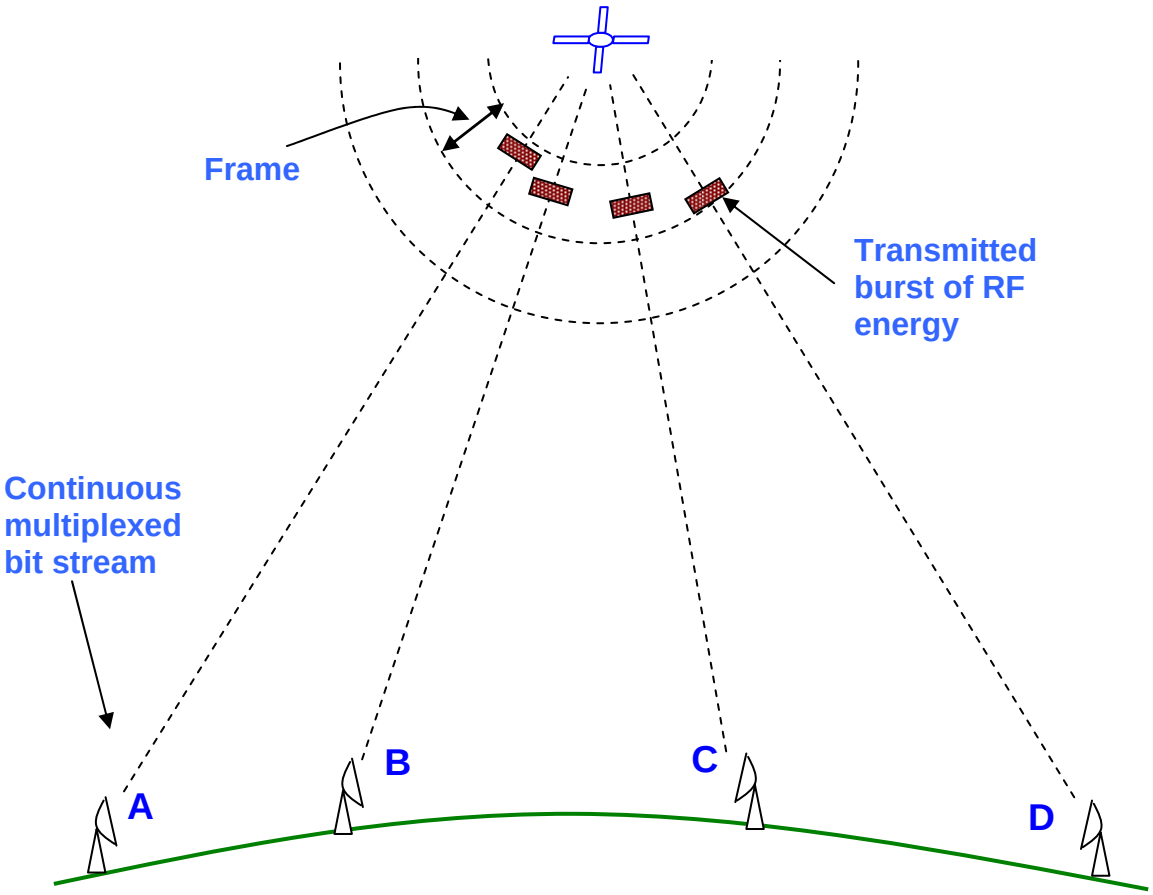
Time Division Multiple Access (TDMA)

- In TDMA, only one carrier is allowed access to the transponder at any given time.
- The transponder is time shared between the different users.
- Each user is allocated a certain time slot for transmission.
- Transmission is arrived at the satellite in a sequence of non-overlapping bursts.
- All the transmissions must be synchronized in order to avoid collision between the different bursts.
- The time frequency plot of the scheme is shown below.





CBR → Carrier and bit time recovery.
UW → The unique word, used for burst synchronization.
C → Control bits, such as station identification.



TDMA Advantages

- Easy to reconfigure for changing traffic demands.
- More robust against noise and interference.
- Mixes voice and data easily.
- One main advantage, unique to satellite communications permits the transponder's travelling wave tube (TWT) to operate at or near saturation. ∴It maximizes the down link C/N because only one carrier is in the TWT at any given time.

TDMA Synchronization

Successful operation of TDMA system depends on network wide synchronization.

Satellite perturbations → $\pm 0.1^{o}$ in longitude, $2\text{-}3^{o}$ in inclination. This leads to uncertainty of $\pm$ 75 km in range (equivalent to uncertainty of 500 μsec in time).

∴ a guard time of 500 μsec is necessary to avoidadjacent burst collision.

To minimize guard bands, synchronization must be used.

Two types of TDMA synchronization can be used:

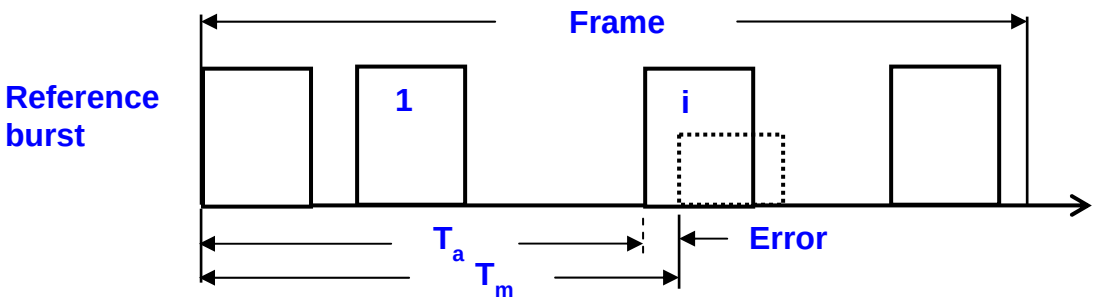
1. Open loop.
2. Closed loop.

Open Loop:

Each earth station maintains an accurate clock, independent of other earth stations. Open loop synchronization is easy to implement. Guard band in the order of 100 μsec is achieved.

Closed Loop:

Synchronization is achieved through continuous adjustment of the burst position (in time), based on real time measurements. Received burst is compared with desired T_a, and a correction ($T_a - T_m$) is applied to the initial estimate in the next transmission.



In another synchronization scheme, a reference station is used that observes the burst time slots and provides feed back to each station to apply the necessary correction.

Frame Efficiency

The ratio of time used for useful transmission to the total frame width.

$$\eta_f = 1 - \frac{\Sigma t_i}{T_f}$$

Σt_i = all guard times and pre-amble including the reference burst.

T_f = Frame time.

Frame efficiency increases with frame time. Typical frame efficiencies in the range of 0.9 are possible.

Transponder Utilization

Transponder utilization depends on sat. EIRP, G/T ratio of the receiving earth station, and the efficiency of the modulation scheme. Utilization expressed as transmission bit rate can be either EIRP limited or bandwidth limited.

$$C / N_o = EIRP - L_{pd} - L_{md} + G/T - k \text{ dB}$$

but $C = E_b R$

where E_b is energy / bit, and R is the bit rate.

Or $C = 10\log E_b + 10\log R$

$\therefore$ The bit rate for a power limited link is:

$$R_p = EIRP - L_{pd} - L_{md} + G/T - k - E_b / N_o \text{ dB}$$

Or $R = 10^{R_p/10}$ bits/s

This is the bit rate in a power limited case for a given G/T and E_b/N_o.

When the satellite EIRP is sufficiently high, the maximum permissible bit rate (R) is governed by the transponder bandwidth.

More spectrally efficient modulation scheme provides higher bit rate. In such case:

$$R_b = B\eta$$

R_b → max. bit rate in a bandwidth limited case.
B → transponder bandwidth.
η → modulation efficiency (bits/Hz)

The last two equations for R and R_b can be used to determine if a system is power limited or bandwidth limited.

Advantages of TDMA

1. Maximum use of the available sat. power (no back-off is needed).
2. Uplink power control is not required.
3. Easy transmission plans. Capacity management is simple and flexible.
4. Advantages of digital techniques (e.g. source and channel coding) are easily incorporated.

Disadvantages

1. Requires network-wide timing synchronization.
2. Analog signals must be converted to digital.
3. Interface with analog terrestrial plants is expensive.