PHYS 3250
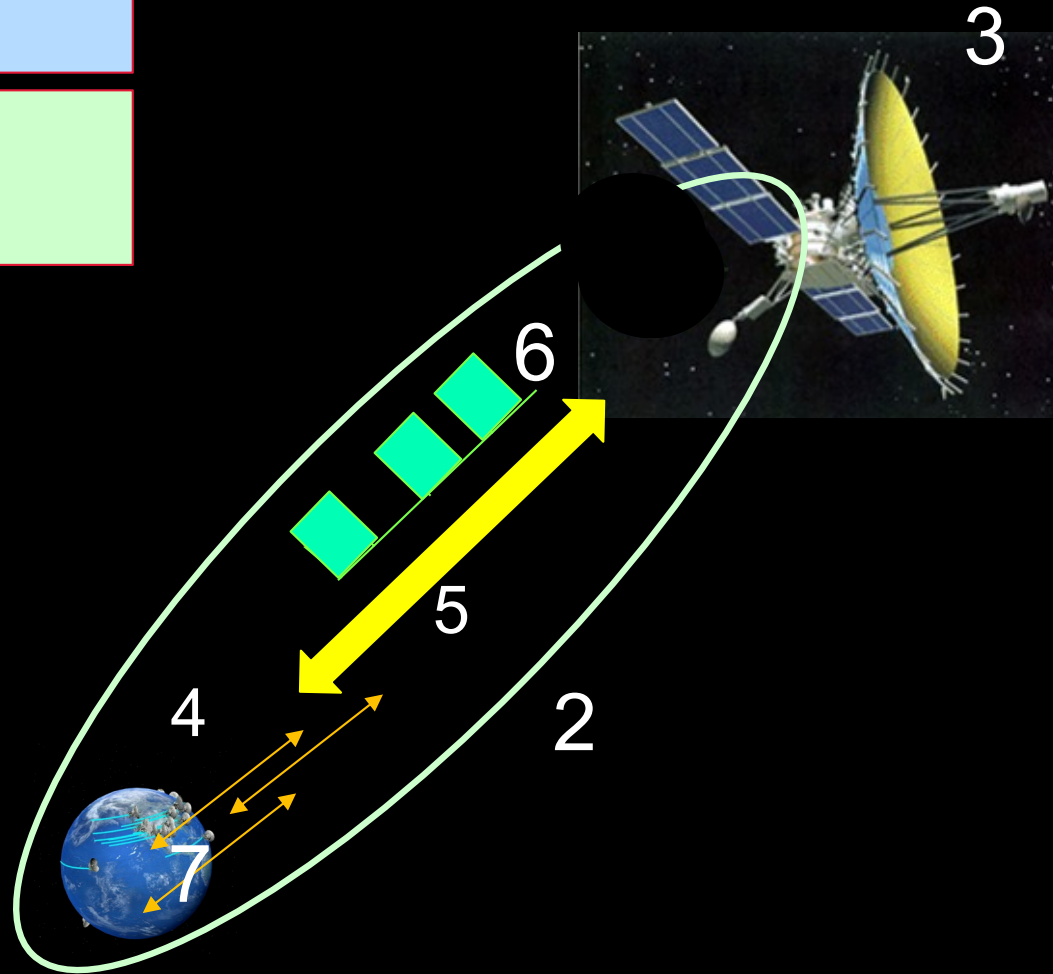# Introduction to space communications

Professor N Bartel
Sketch of the 7 chapters

2 Orbital aspects
3 Spacecraft
4 Earth station
5 Communications link
6 Modulation and
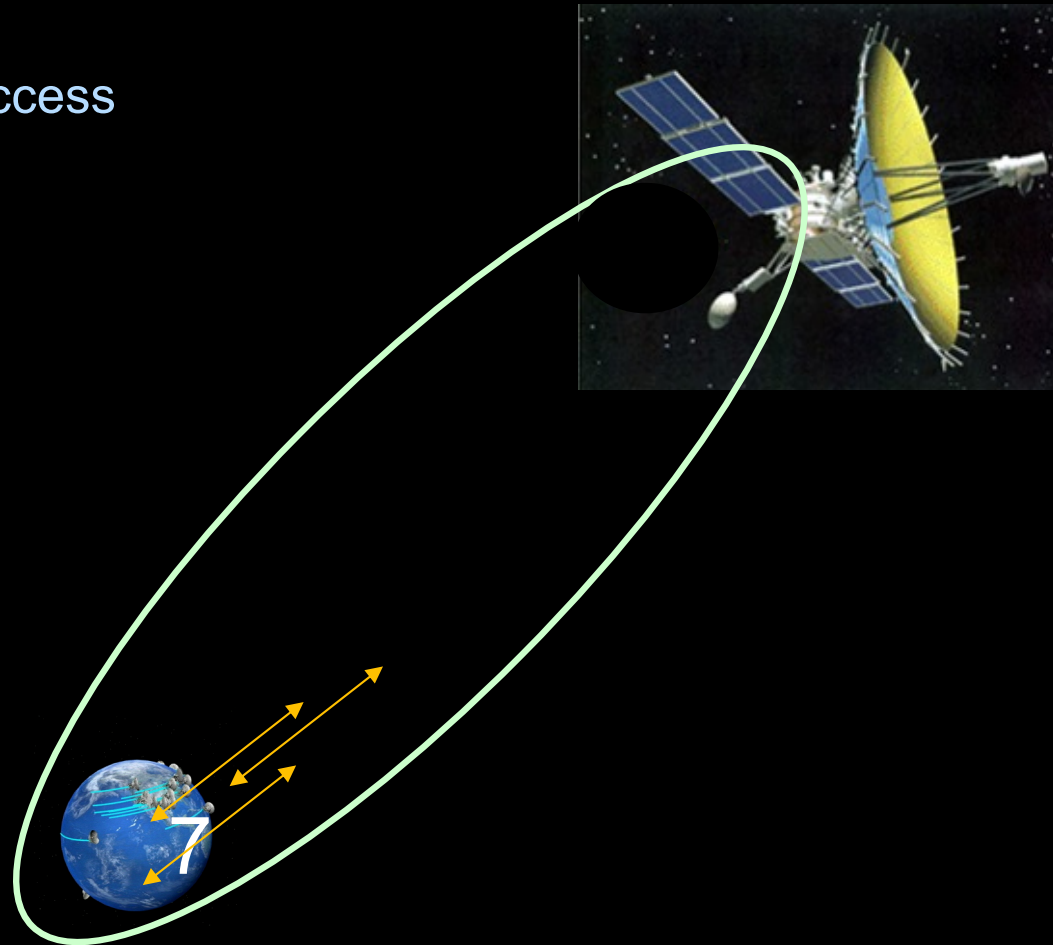   multiplexing techniques
7 Multiple access to a
   satellite

3

6

5

4

2

7

7. Multiple access to a satellite

7.1Single and multiple access
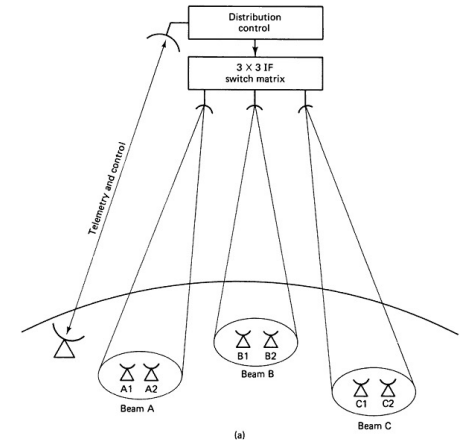7.2 FDMA and TDMA
7.3 CDMA

For heavy traffic the whole of the available bandwidth of a transponder may be used. Telesat Canada uses 30 m antennas of Class A to provide 960 voice circuits for each transponder channel for dedicated communication between two Earth stations. This is referred to as a *single access* mode of operation.
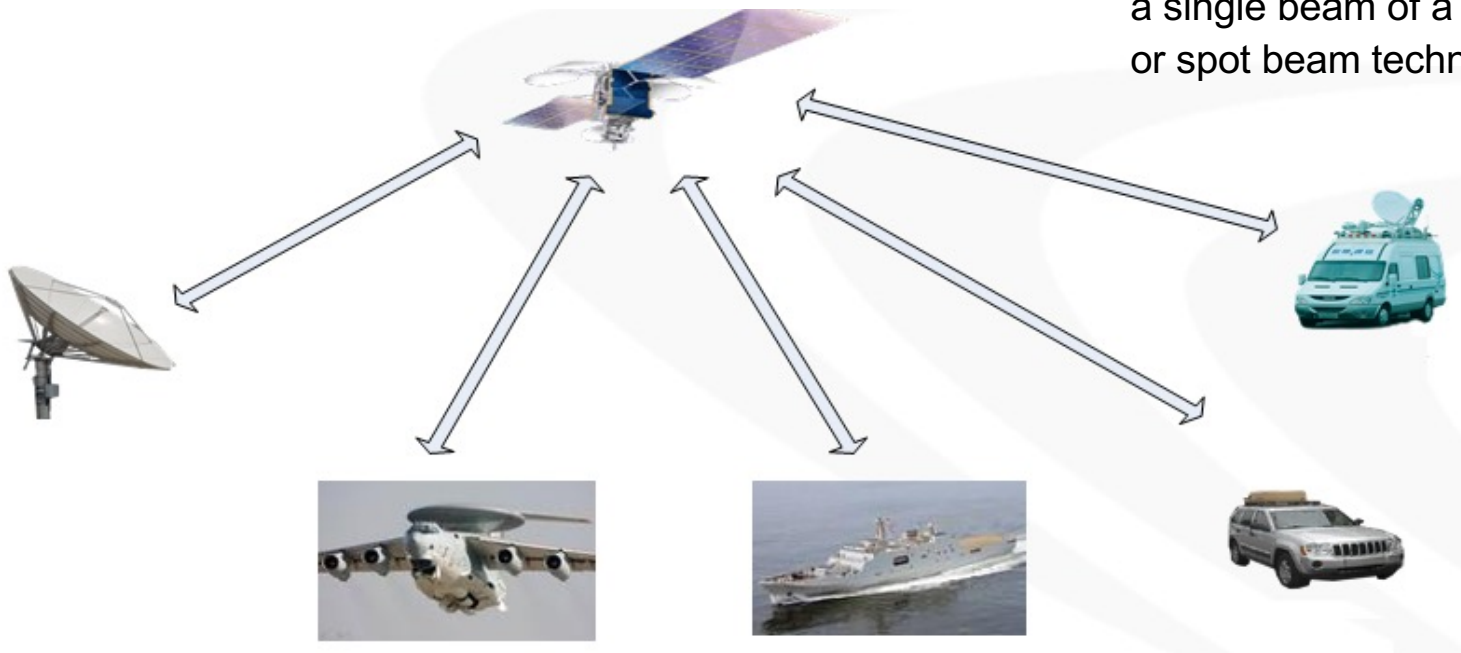

Class A earth station
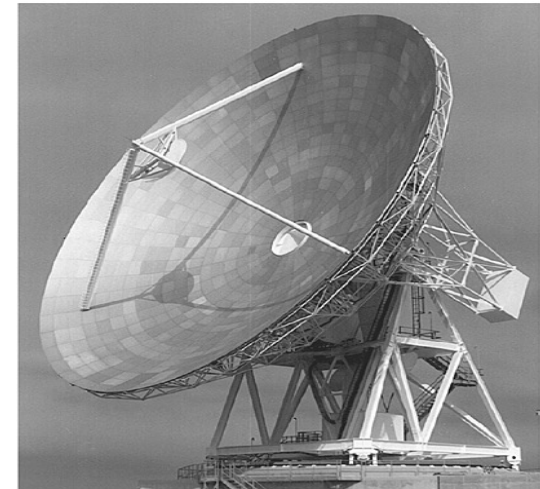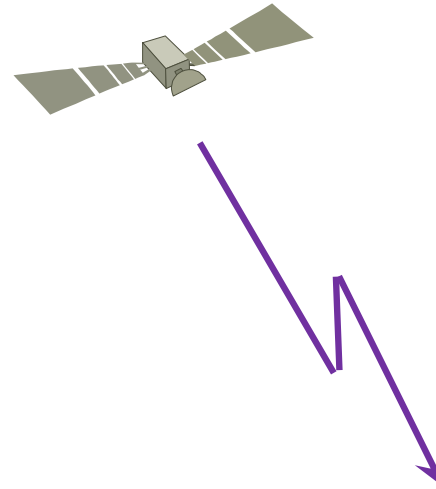
It is more common, however, if a transponder is loaded by a number of carriers originating from several earth stations which are geographically separate from each other. Each earth station could transmit one or more carriers. This is referred to as a *multiple access* mode of operation.

The earth stations could be in a single beam of a satellite antenna or spot beam technology could be used.

There are three most commonly used methods of multiple access: FDMA, TDMA and CDMA

Multiple access is the ability of a large number of earth stations to simultaneously interconnect their respective voice, data, fax, and TV links through a satellite.

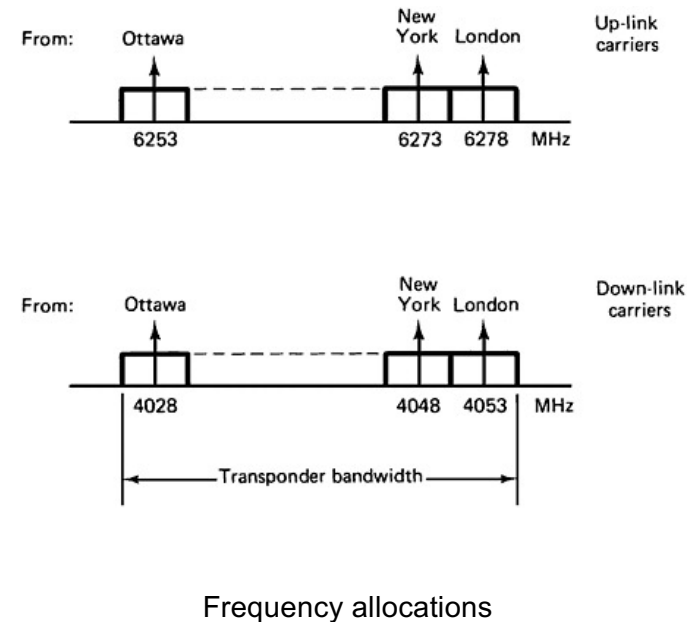There are three different multiple access techniques:

- FDMA: frequency division multiple access
- TDMA: time division multiple access
- CDMA: code division multiple access

Sketch for FDMA and TDMA

f_1 f_2 f_3 f_4

t_1 t_2 t_3 t_4

Reference station for TDMA

1   2   3   4
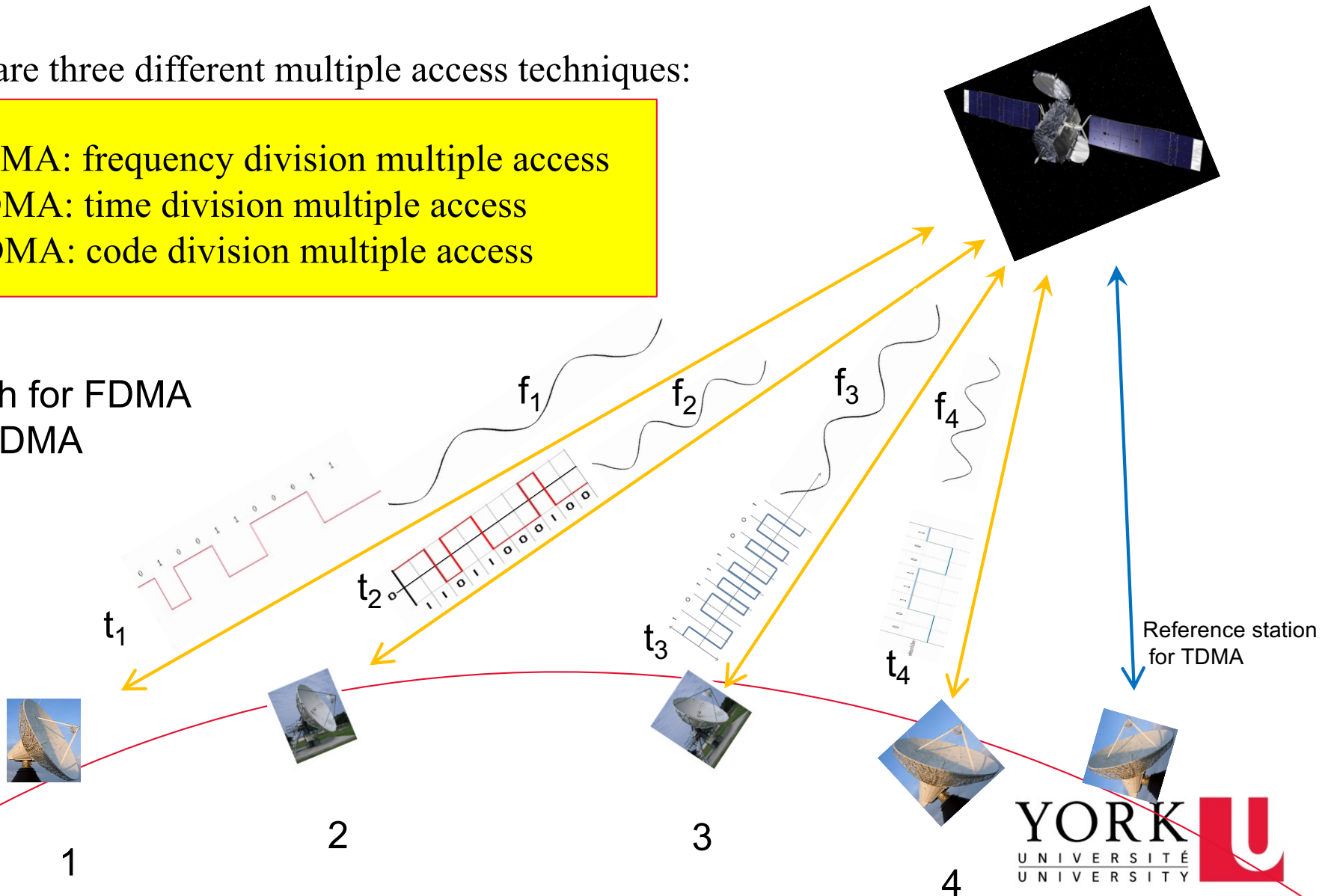
Typical FDMA structure

Three earth stations are involved in transmitting and receiving simultaneously using the same satellite transponder. Frequency channels are pre-assigned

Frequency allocations

D. Roddy
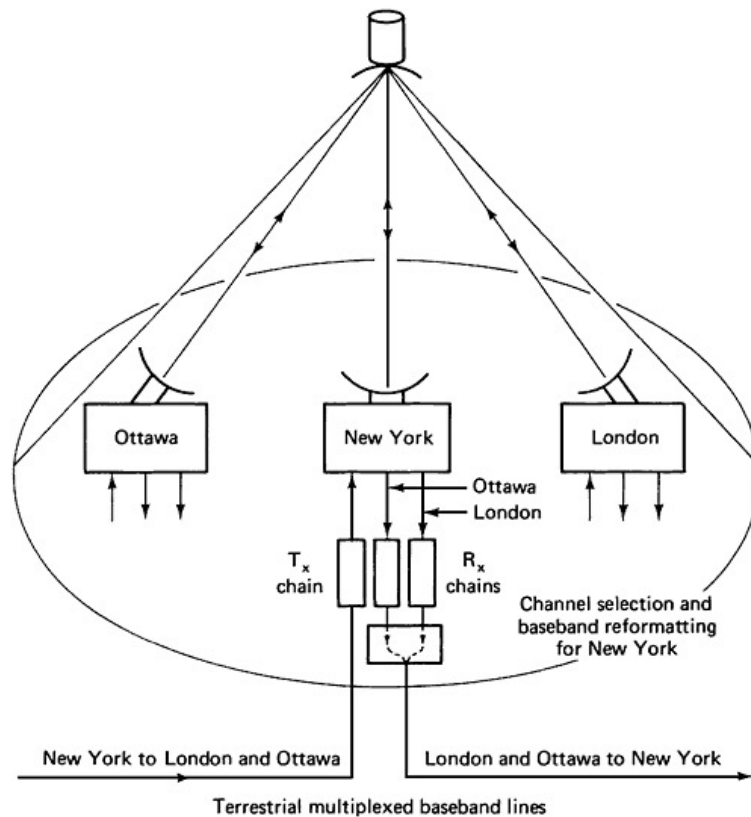
Remember Chapter 3:
Spot beam technology

Spot beams can be arranged to cover particular areas on Earth.

Multifeed array

Gain [dB]

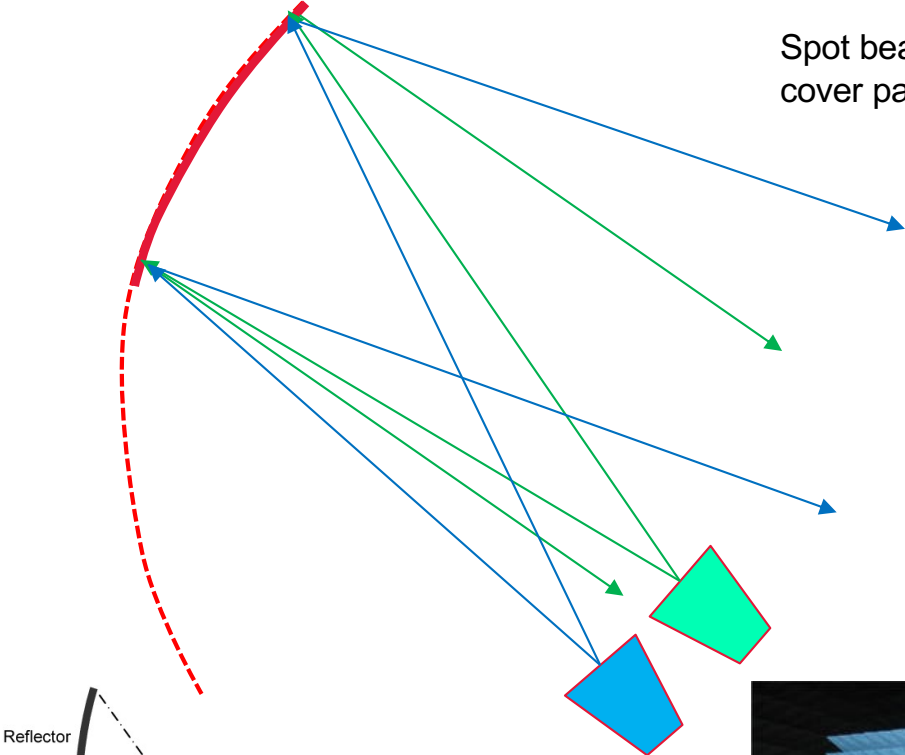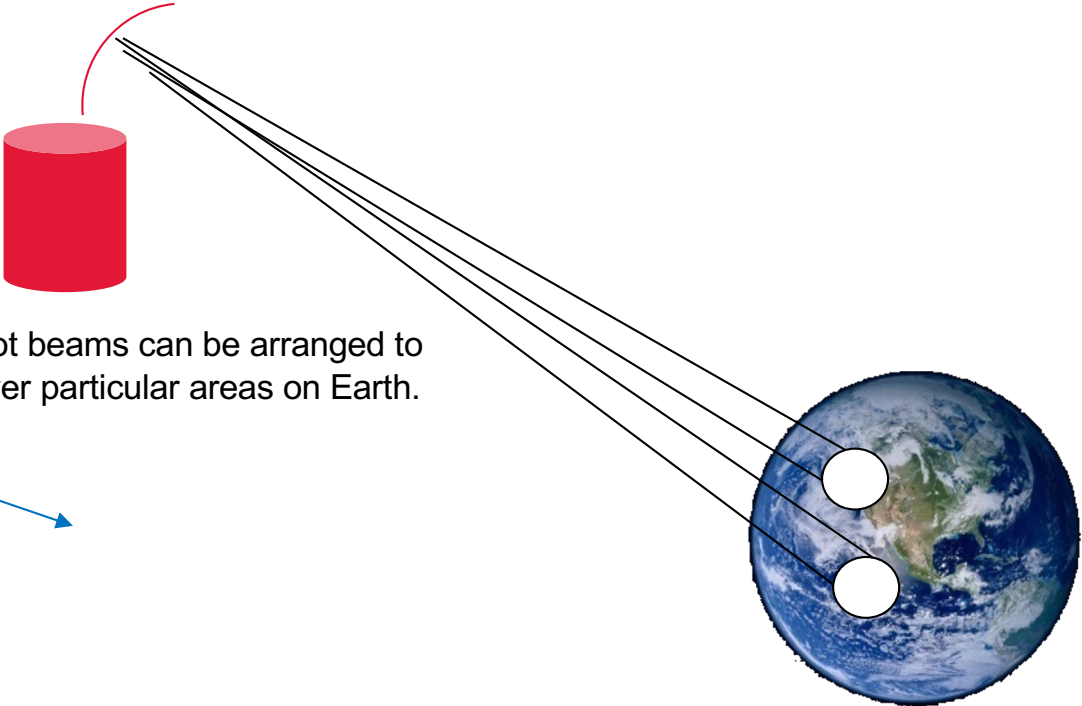|	
Horn #1	Gen. 1
Horn #2	Gen. 2
Horn #3	Gen. 3
Horn #4	Gen. 4
Horn #5	Gen. 5
Horn #6	Gen. 6

Spot beam pattern

Reflector

Wiring harness

Switch matrix

Patches

Outputs to transponders and feeder downlink
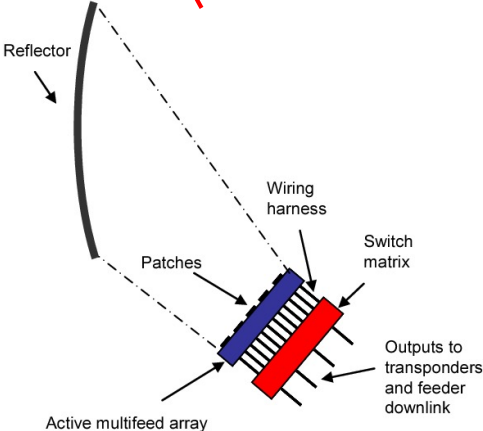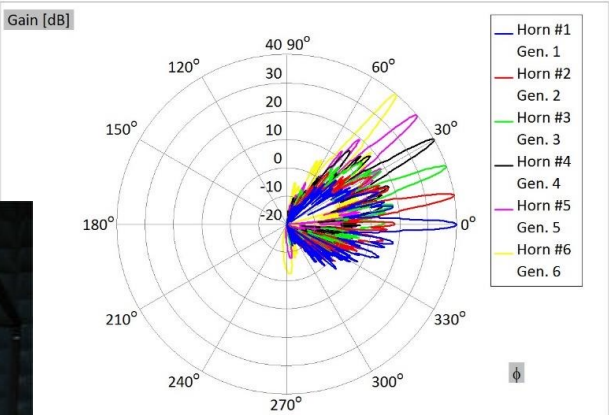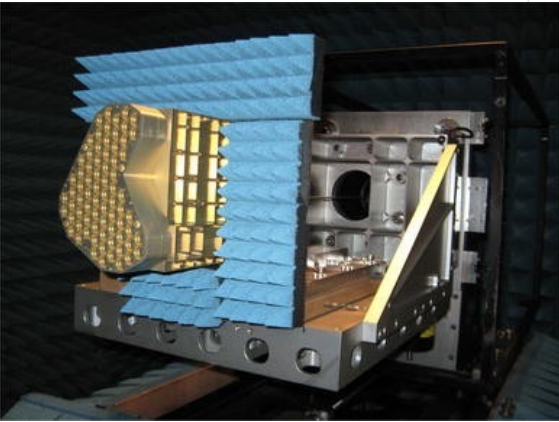
Active multifeed array

Fig. 1 Schematic view of a single offset reflector antenna with multih

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Footprint

-3dB   -12dB   -27dB
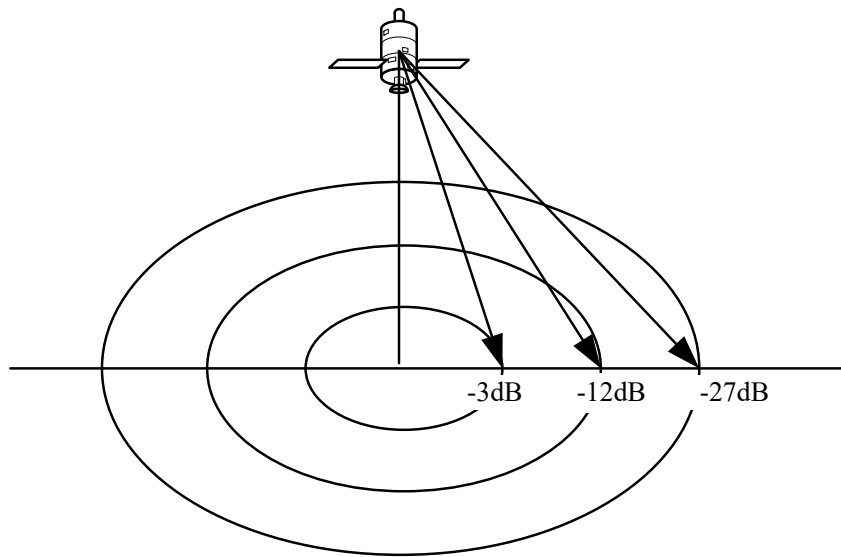
Footprint of one beam

Beamforming with spot-beam technology

波束
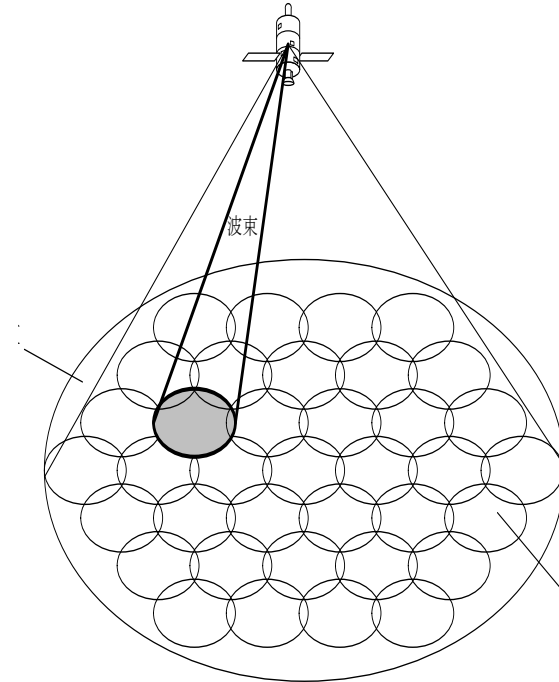
Footprint of many beams arranged in a pattern

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FDMA and TDMA should not be confused with FDM and TDM.

FDMA and TDMA are traffic features.
FDM and TDM are transmission features

FDMA is used at all participating stations each using different frequency slots all the time.
TDMA is used at all participating stations each using the total frequency band only within short time slots.

FDMA usually comes with FDM/FM. ➔ FDM/FM/FDMA
TDMA usually comes with TDM/QPSK. ➔ TDM/QPSK/TDMA

FDM is hardware controlled
TDM is software controlled

Advantage of TDMA
In TDMA only one carrier is used ➔ TWTA can be operated near saturation:
- Max C/N possible
- No BO
- No intermodulation interference noise

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Mode mixtures

FDMA/TDM with e.g. QPSK
There is an advantage in terms of power requirement for small earth stations. These stations often carry digital data with continuously low data rates.
➔ TDM with e.g. QPSK for digital data transmission
➔ FDMA because of relatively low power requirements
Why?

$$[C/N_0] = [E_b/N_0] + [R_b]$$

fixed for required BER

For earth station, maximum $[R_b]$ is lower for FDMA than for TDMA, since TDMA requires drastically increased data rate, R_b, in bursts.

➔ FDMA/TDA allows operation with lower C/N_0 than TDMA/TDM for same long-term averaged R_b and same BER.

But TDMA offers flexible burst time and better use of transponder by operating close to the saturation point.
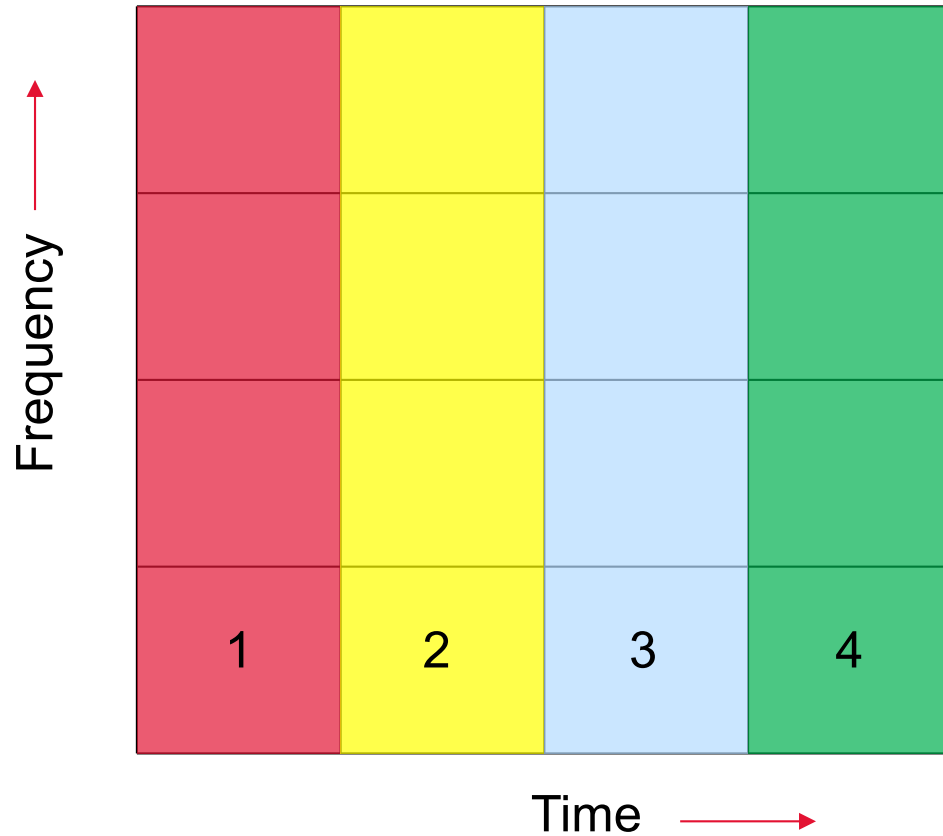
FDMA

Frequency →

1			
2			
3			
4			
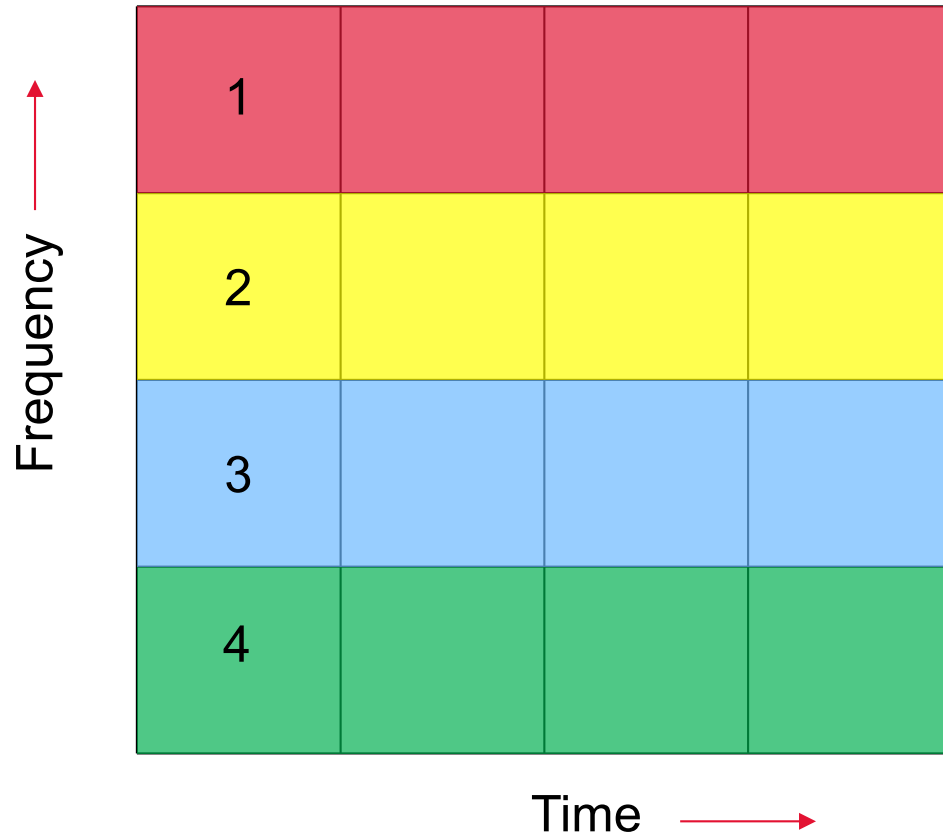
Time →

Bandwidth is divided among users. All transmit simultaneously, each in their assigned frequency slots
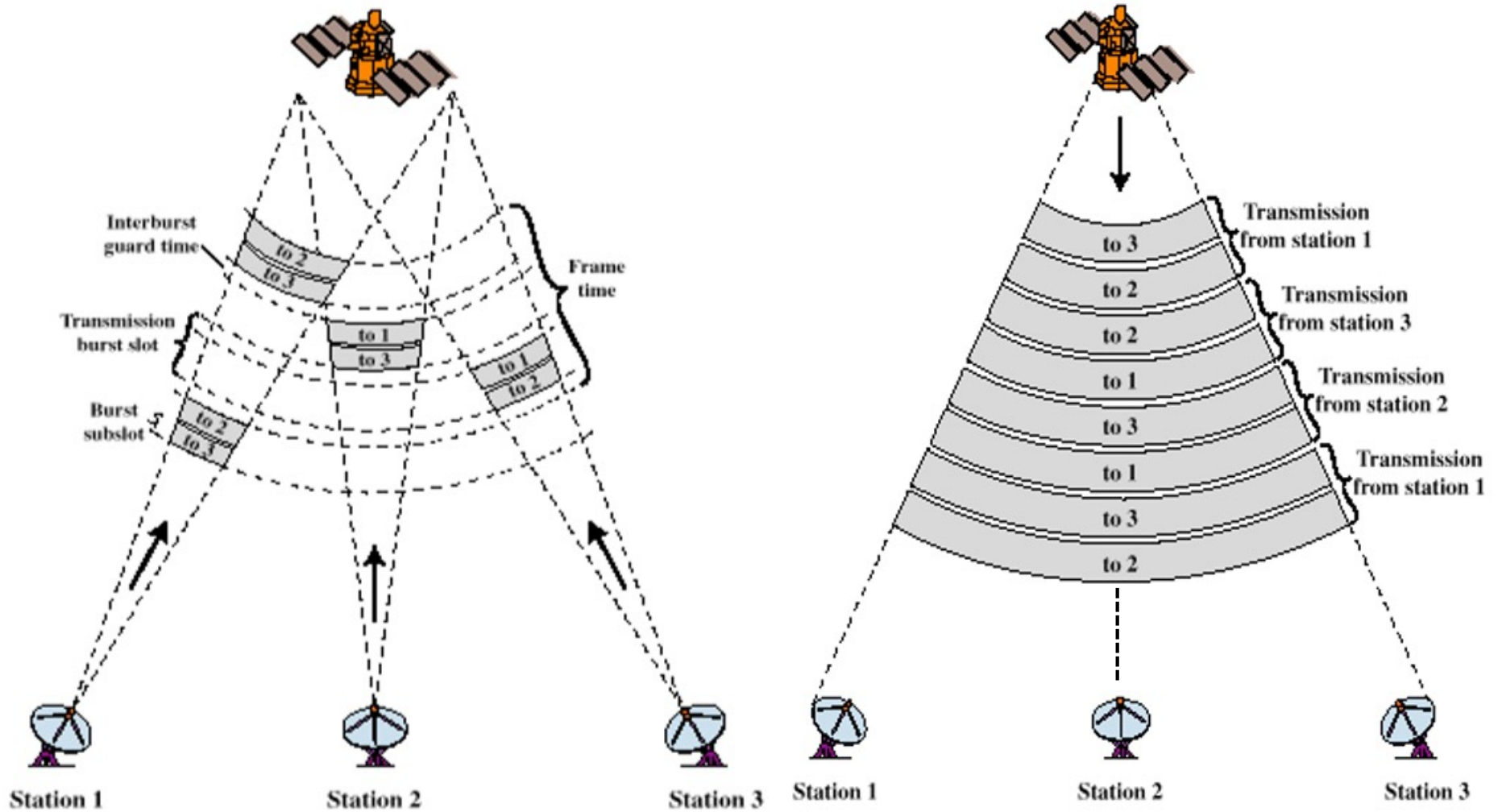
For analogue data

TDMA

Time is divided among users. Users transmit in rapid succession, one after the other each at specific times
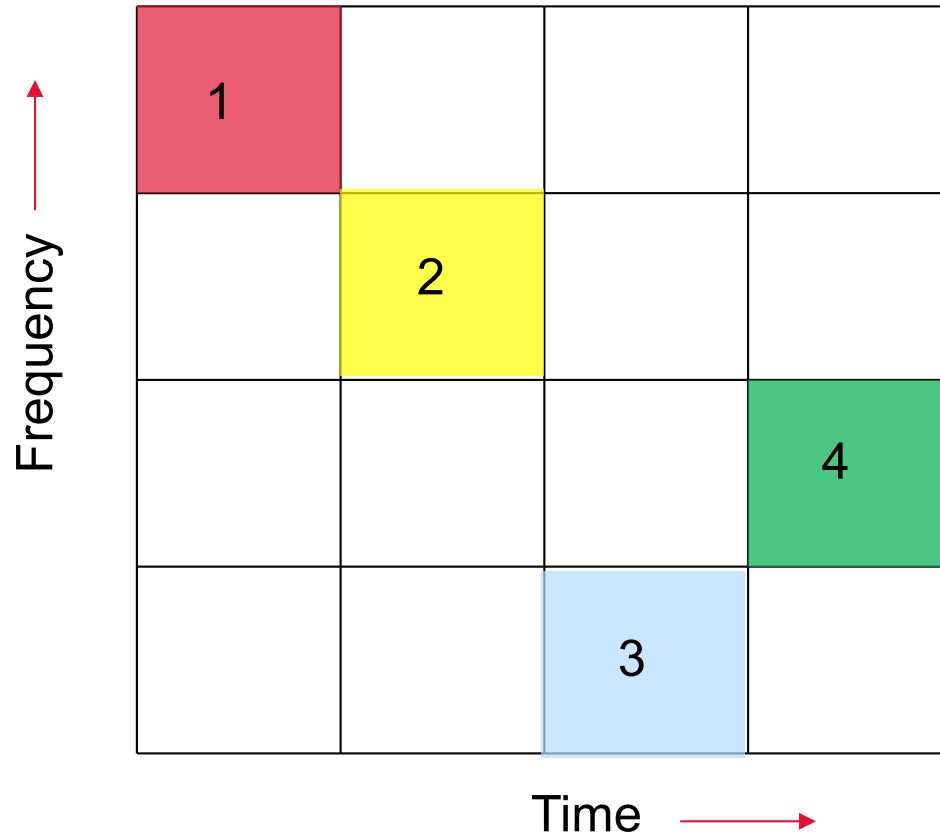
For digital data

TDMA
fixed assignment

Uplink

Downlink

CDMA

Frequency →

1

2

4

3

Time →

Time and frequency slots are divided among users. Users transmit in rapid succession,
one after the other each at specific Times and frequencies.

A code key is necessary to correspond to the correct carrier

Originally only for military data, now widely used.

For digital data.

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Advantage of CDMA:
- Transmission of classified messages possible
- Uncoordinated access possible

CDMA has been heavily used in military applications for decades. It has now also been used in commercial applications for some years.

CDMA
Code Division Multiple Access (CDMA) is a scheme in which, on average, a number of earth stations occupy all of a transponder bandwith all of the time. Their signal is coded and needs to be decoded by the receiving station in order to be recovered.

In CDMA, the transponder can be accessed on demand without coordination of frequency or time slot by central agency.

Each receiving station has "address." The transmitting station modulates transmission with address of intended receiver.

CDMA is also called Spread Spectrum Multiple Access (SSMA).

The techniques used are:
- PN : direct sequence pseudo noise
- FH : frequency hopping
- TH : time hopping
- Chirp: continuous sweep in frequency