SATELLITE MULTIPLE ACCESS TECHNIQUES

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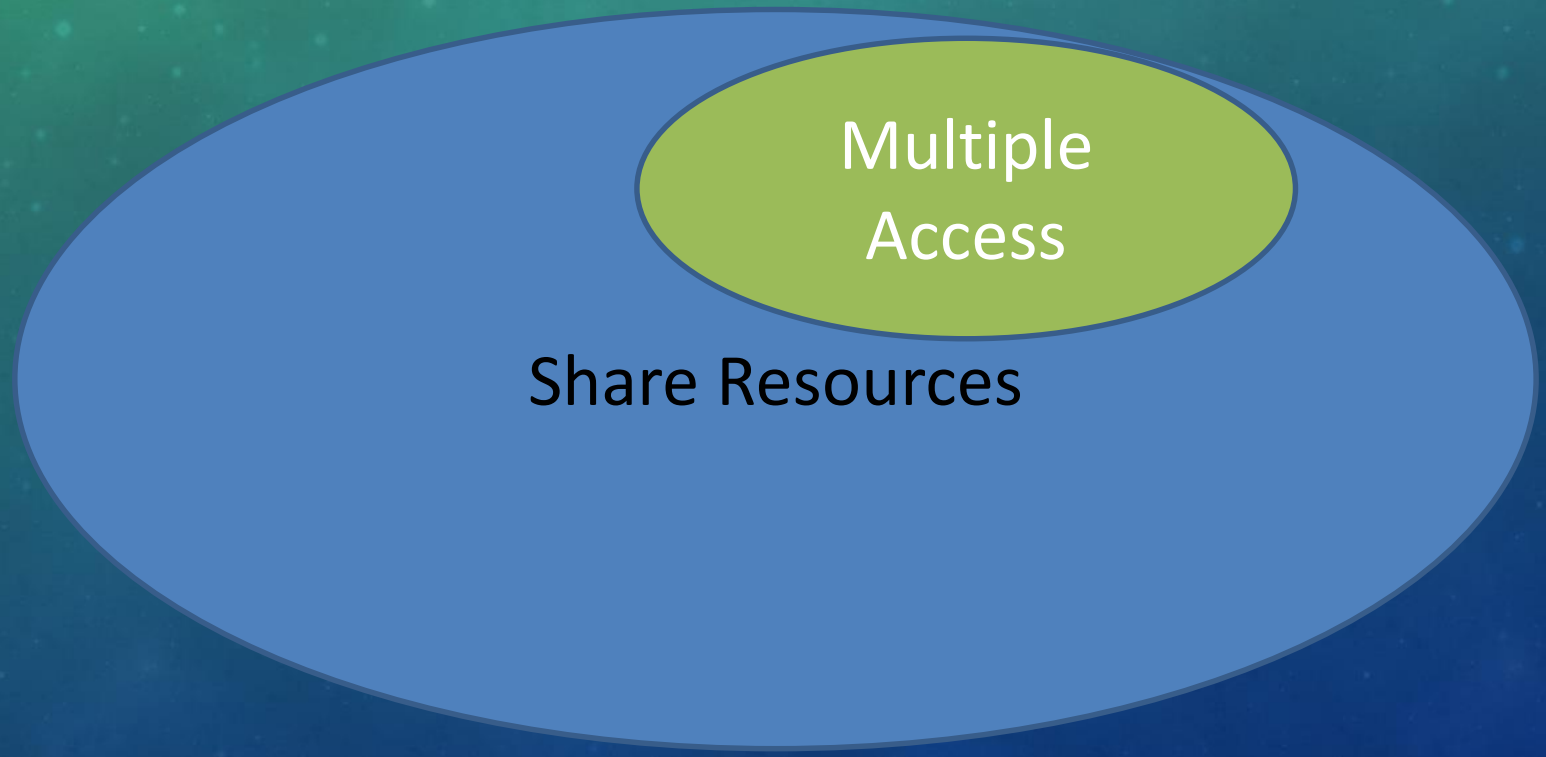
COMMUNICATION SYSTEMS

SCARCITY OF RESOURCES

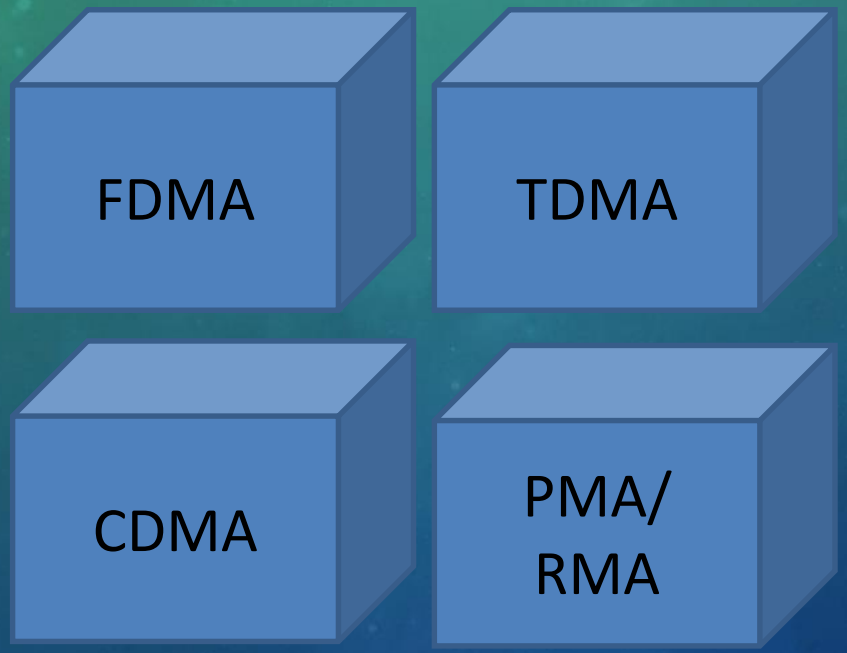
- Resources available in a satellite is limited.
  Eg: Transponders, Bandwidth, EIRP, etc.
- Services will be expensive

More Efficient way of using resources ?

SOLUTION IS TO SHARE RESOURCES



MULTIPLE ACCESS TECHNIQUES



FORMS OF RESOURCE ASSIGNMENT

- **Fixed Assignment Multiple Access (FAMA)**
- The arrangement of capacity is distributed in a fixed manner among multiple stations.
- Demand may fluctuates
- Results in the significant under use of capacity
- Suitable for broadcast satellite communication

- **Demand Assignment Multiple Access (DAMA)**

- Capacity assignment is changed as needed to respond optimally to demand changes among the multiple stations. Suitable for point to point communication.

FREQUENCY DIVISION MULTIPLE ACCESS (FDMA)

- The available transponder bandwidth is divided into channels and then assigned to users. The users are separated in the frequency domain.
- Factors which limit the number of subchannels provided within a satellite channel via FDMA
  - - Thermal noise
  - - Intermodulation noise
  - - Crosstalk

FAMA - FDMA

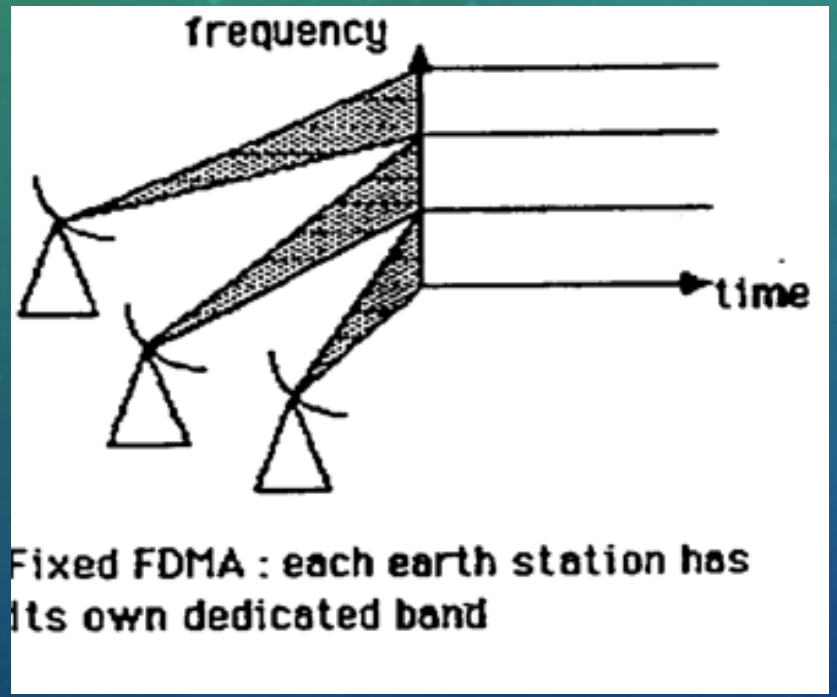
- FAMA – Logical links between stations are preassigned. . Each station is allocated a dedicated logical link or channel that remains constant over time.
- specific communication channels or capacity are dedicated to each station or user in advance.
- FDMA – Multiple stations access the satellite by using different frequency bands.
- Uses considerable amount of bandwidth.
- Relatively inflexible system and if there are changes in the required capacity, then the RF plan has to change.

DAMA FDMA

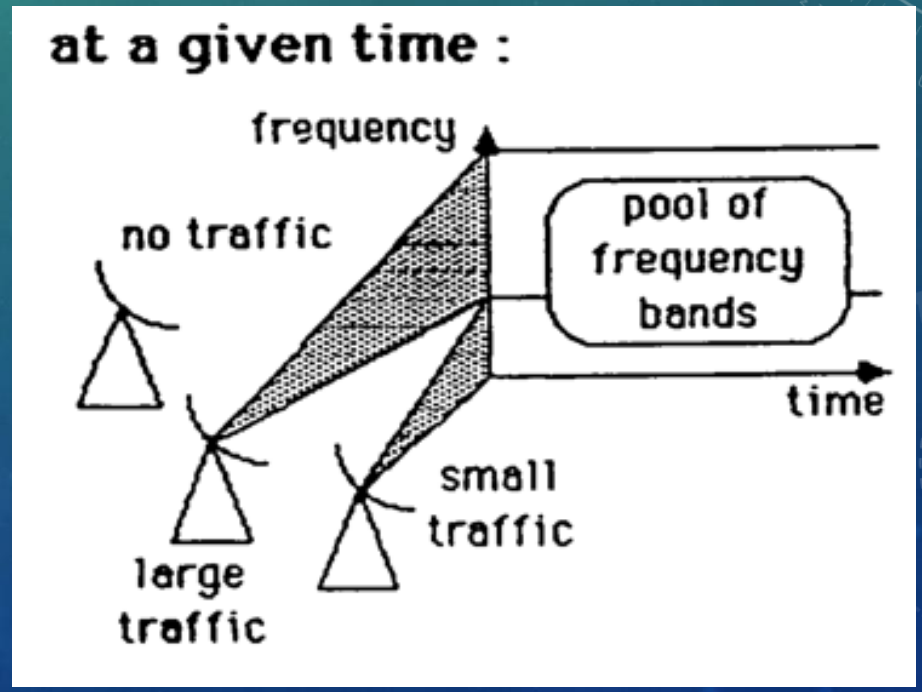
- Single channel per carrier (SCPC) – bandwidth divided into individual channels
  - - Attractive for remote areas with few user stations near each site.with each channel dedicated to a specific communication link between two stations. Each SCPC link operates on a separate carrier frequency, and the bandwidth for each link remains fixed.
  - - Suffers from inefficiency of fixed assignment.

- DAMA – A set of subchannels in a channel is treated as a pool of available links
- dynamic allocation of subchannels based on demand
  - - 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. DAMA does not require a centralized control entity for channel allocation. Instead, each earth station can independently request and receive subchannels as needed, allowing for more flexible and efficient resource utilization.

FREQUENCY DIVISION MULTIPLE ACCESS (FDMA)



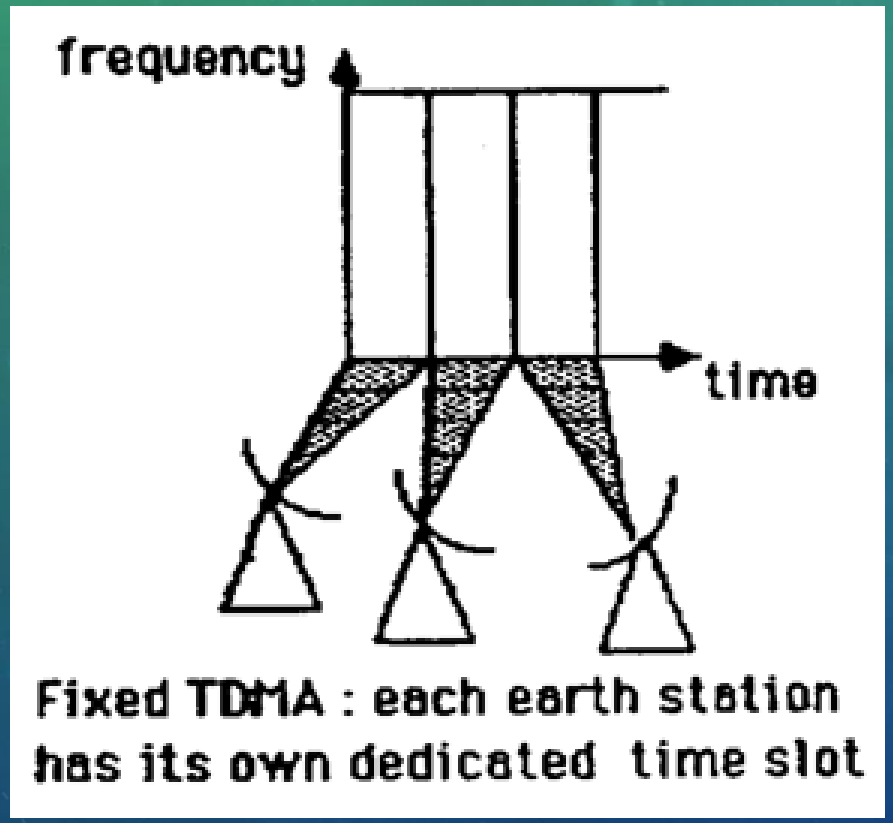
Fixed FDMA : each earth station has its own dedicated band

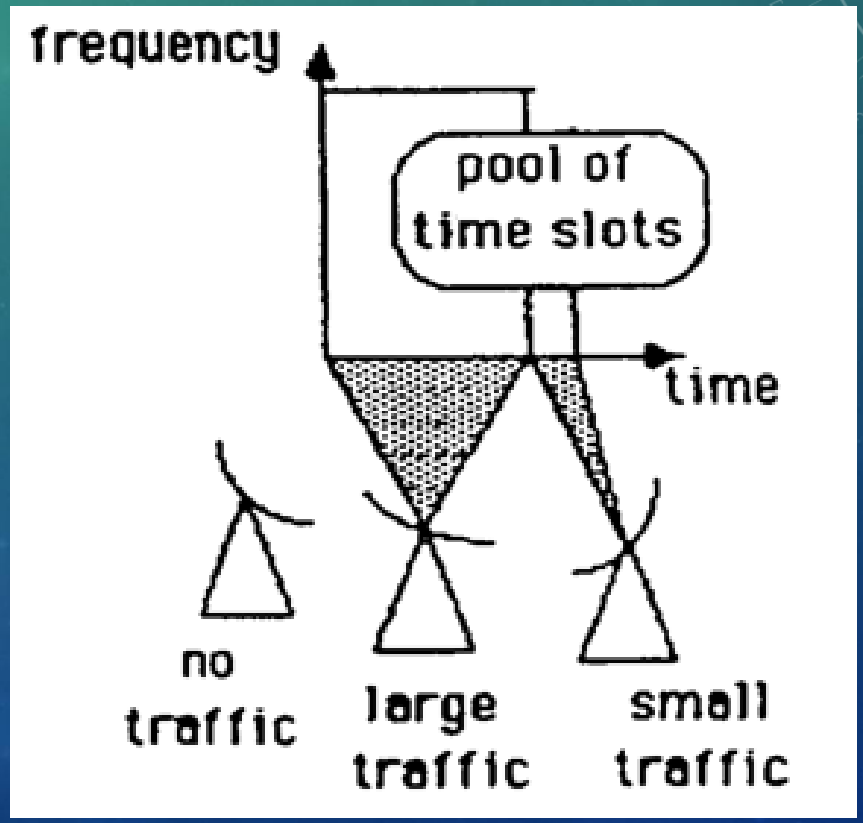


REASONS FOR INCREASING USE OF TDMA TECHNIQUES

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

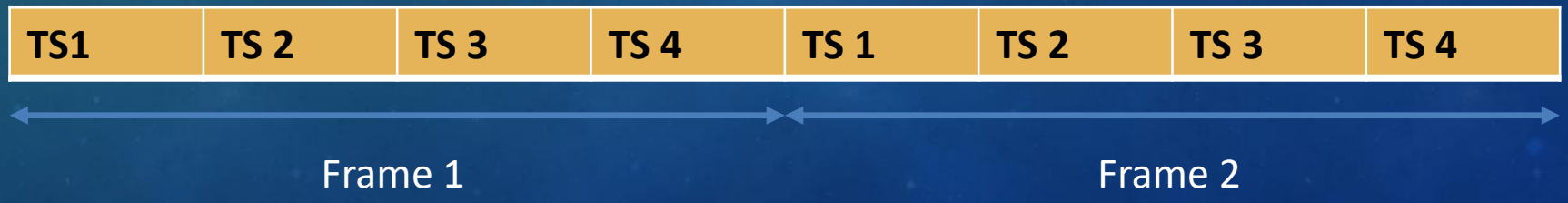
TIME DIVISION MULTIPLE ACCESS (TDMA)



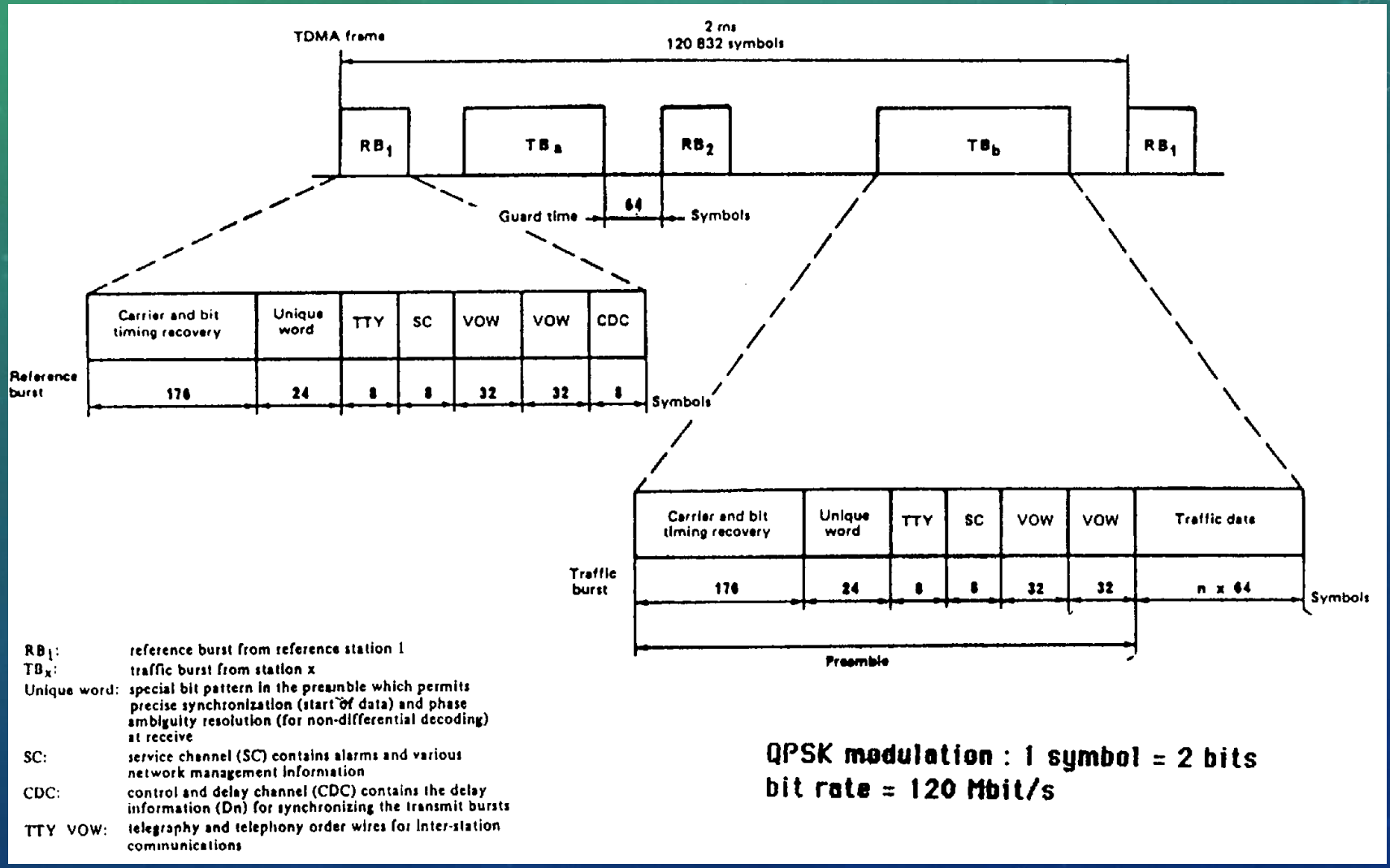


TIME DIVISION MULTIPLE ACCESS (TDMA)

- Consider a single carrier frequency. It's transmission is divided into Time Slots (TS)
- Within each time slot a burst transmission of one communication channel. : A burst is a short period of time during which a communication channel sends its data. It is the active transmission within a time slot, where the data is modulated onto the carrier frequency for transmission.
- After N slots the frame repeats.



A TDMA FRAME


TDMA frame
2 ms
120 832 symbols
RB1
TBa
RB2
TBb
RB1
Guard time
64
Symbols
Carrier and bit timing recovery
Unique word
TTY
SC
VOW
VOW
CDC
Reference burst
176
24
8
8
32
32
8
Symbols
Carrier and bit timing recovery
Unique word
TTY
SC
VOW
VOW
Traffic data
Traffic burst
176
24
8
8
32
32
n x 64
Symbols
Preamble
RB1: reference burst from reference station 1
TBx: traffic burst from station x
Unique word: special bit pattern in the preamble which permits precise synchronization (start of data) and phase ambiguity resolution (for non-differential decoding) at receive
SC: service channel (SC) contains alarms and various network management information
CDC: control and delay channel (CDC) contains the delay information (Dn) for synchronizing the transmit bursts
TTY VOW: telegraphy and telephony order wires for inter-station communications
QPSK modulation : 1 symbol = 2 bits
bit rate = 120 Mbit/s

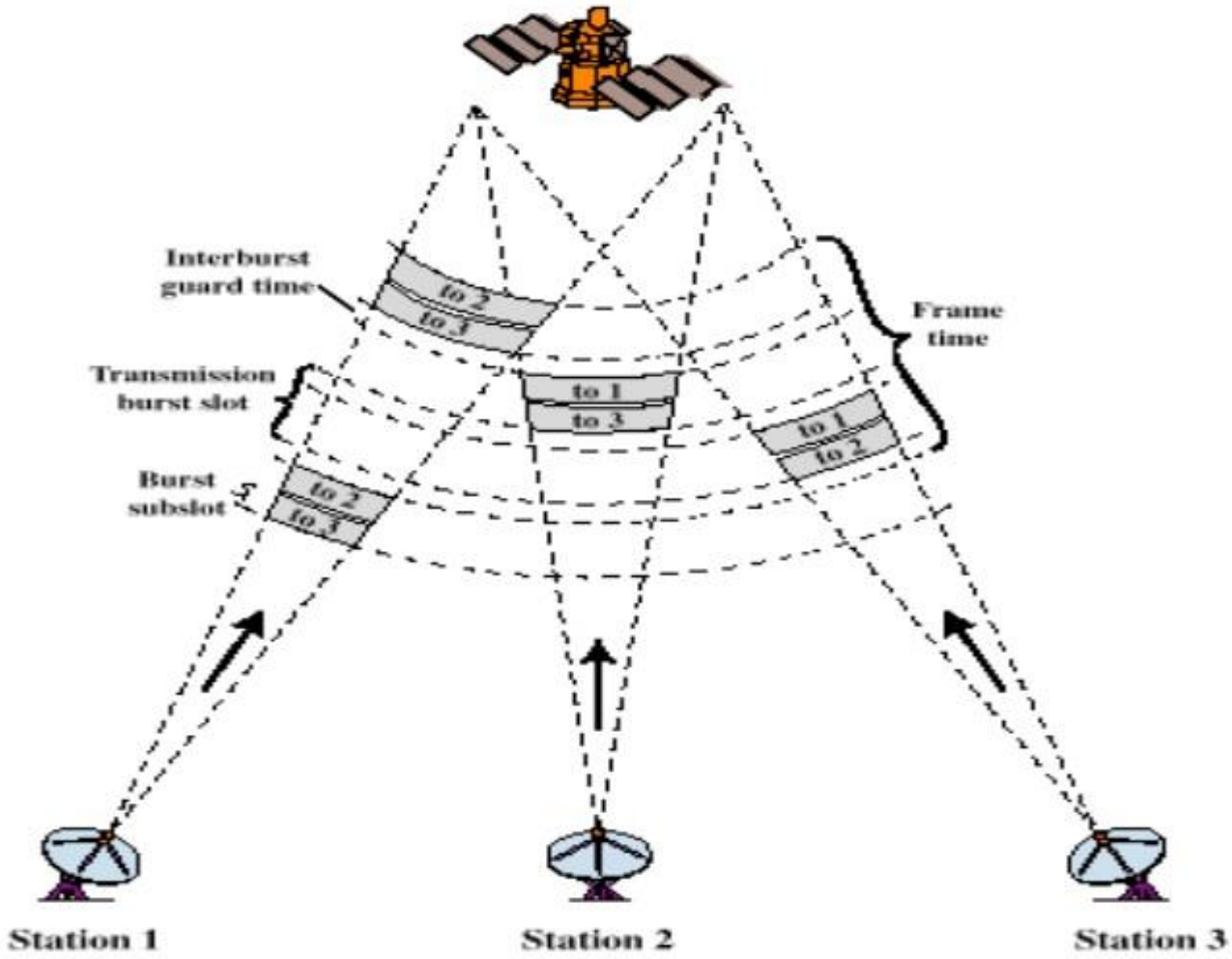
FAMA TDMA OPERATION

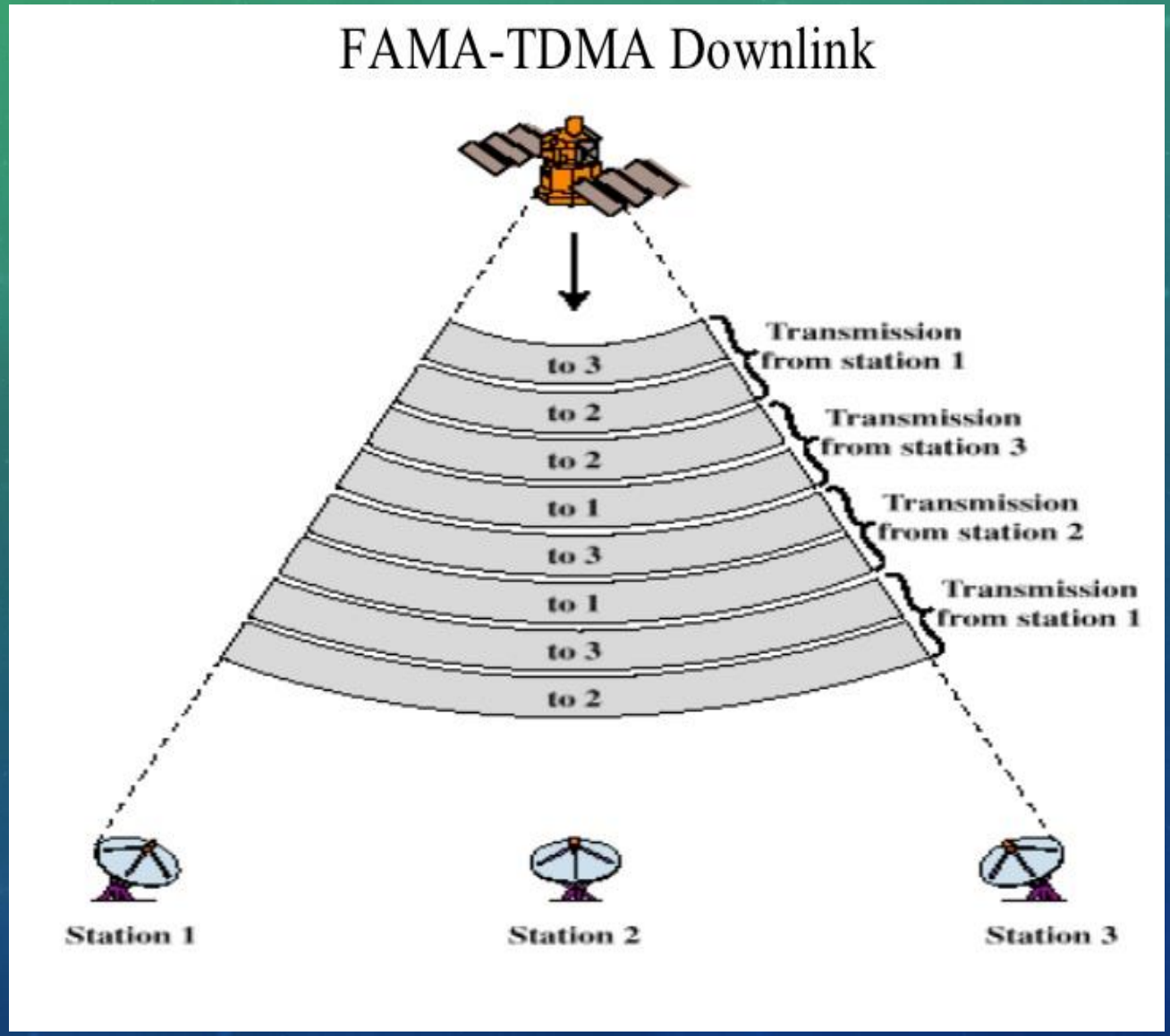
- Transmission in the form of repetitive sequence of frame
  - Each frame is divided into a number of time slots.
  - Each slot is dedicated to a particular transmitter.
- Earth stations take turns using uplink channel
  - Sends data in assigned time slot.
- Satellite repeats incoming transmissions
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

FAMA TDMA

- This method avoids collusion entirely but imposes high delay unless number of users are low.
- Fixed TDMA is wasteful of resources unless most of the users have data to transmit in their assigned time slot.

FAMA-TDMA Uplink




FAMA-TDMA Downlink
Transmission from station 1
Transmission from station 3
Transmission from station 2
Transmission from station 1
to 3
to 2
to 2
to 1
to 3
to 1
to 3
to 2
Station 1
Station 2
Station 3

TDMA

- Advantages
  - - Digital signalling provides easy interfacing with developing digital networks on ground.
  - - Digital circuitry has decreasing cost.
  - - Higher throughput compared to FDMA when number of accesses is large.
- Disadvantages
  - - Stations transmit high bit rate bursts, requiring large peak power
  - - Network control is required,
    - Generation and distribution of burst time plans to all traffic stations.
    - Protocols to establish how stations enter the network.
    - Provision of redundant reference stations with automatic switchover to control the traffic stations.
    - Means for monitoring the network.

SATELLITE SWITCHED MULTIPLE ACCESS

- Satellite is capable of switching the traffic between earth stations

efficiently share the satellite's transponder capacity among multiple users or earth stations

- Known as SS- Multiple Access
  - SS FDMA
  - SS TDMA

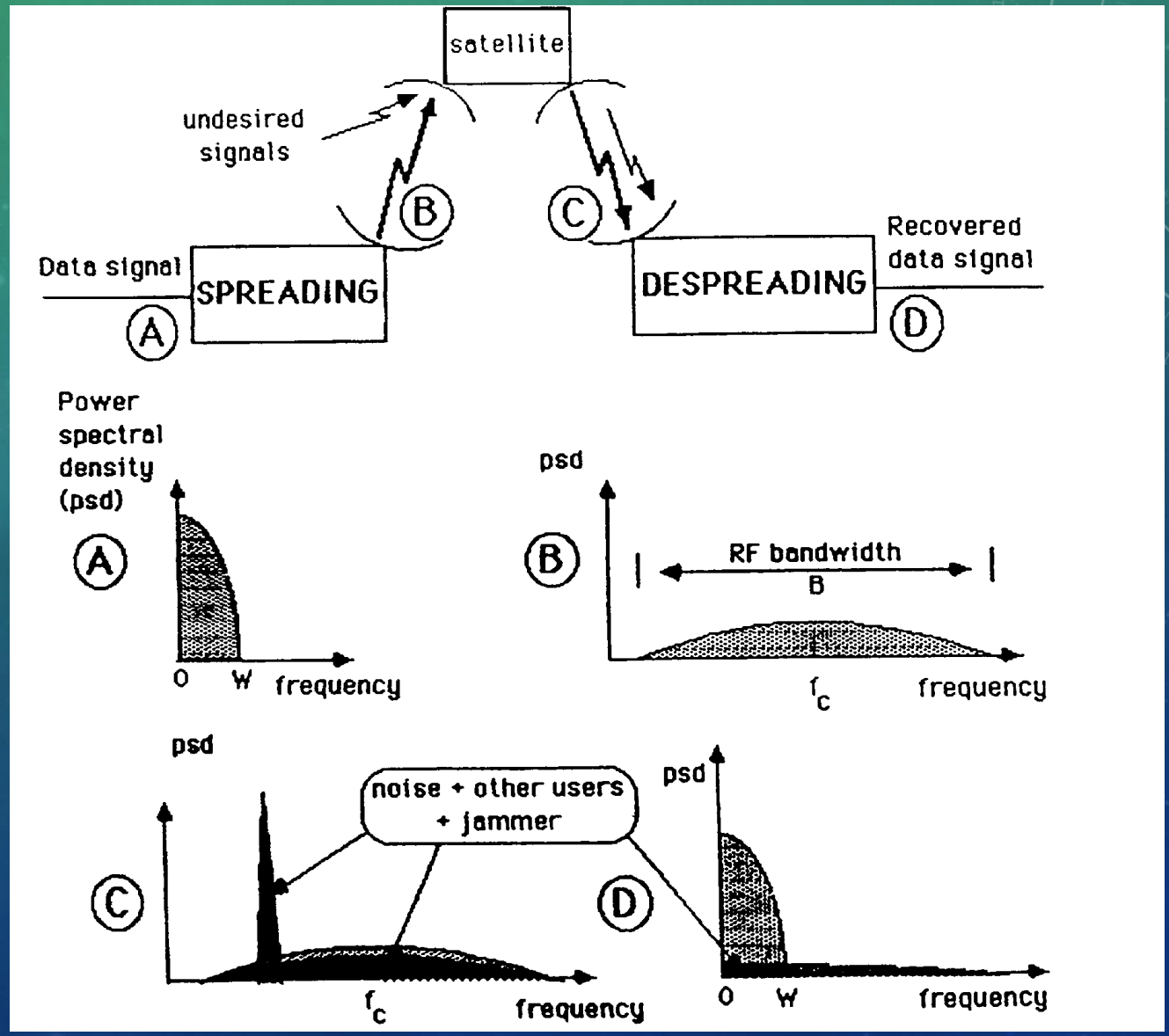
SS - TDMA

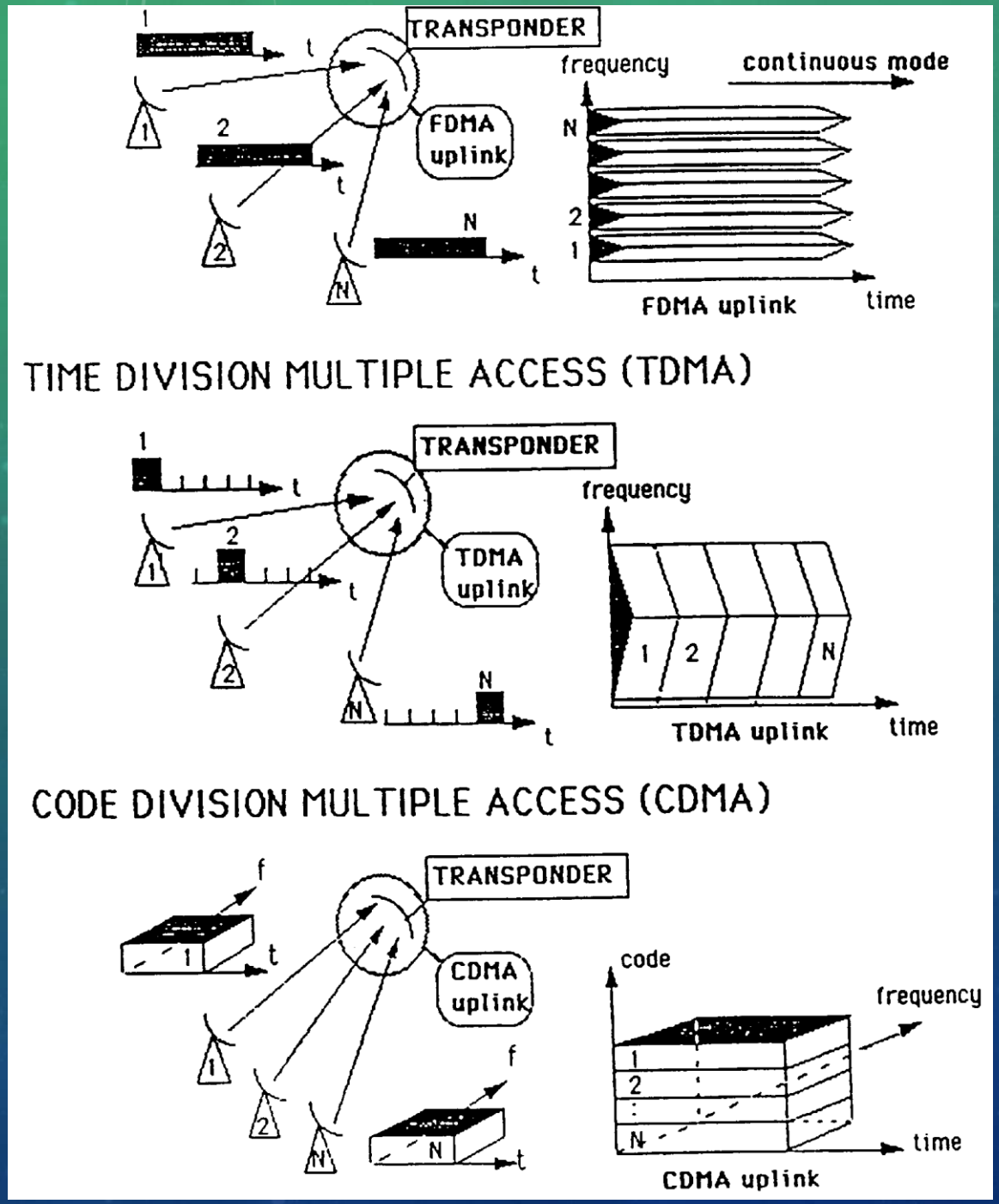
- Spatial isolation between beams
- each spot beam is focused on a particular region and doesn't overlap significantly with adjacent beams. This isolation is important to reduce interference between beams and to maximize the efficiency of communication.
- Beam switching employed
- to reconfigure its coverage area dynamically based on user demand or traffic patterns.
- Switching time slots from one beam to another the satellite can dynamically change the assignment of time slots to users in different spot beams
- Greater traffic carrying capability The spatial isolation between beams minimizes interference, and the ability to switch time slots dynamically between beams allows the satellite to efficiently allocate resources based on deman

CDMA

- CDMA is based on spread spectrum communication techniques.
- Different signals may use the same frequency range and they may be transmitted simultaneously.
- The receiver can still differentiate between them using digital code used to modulate the signal.

CDMA CONCEPT




TRANSPONDER
FDMA uplink
frequency
continuous mode
N
2
1
FDMA uplink
time
TIME DIVISION MULTIPLE ACCESS (TDMA)
TRANSPONDER
TDMA uplink
frequency
1
2
N
TDMA uplink
time
CODE DIVISION MULTIPLE ACCESS (CDMA)
TRANSPONDER
CDMA uplink
code
frequency
time
CDMA uplink

SPREAD SPECTRUM SIGNALS

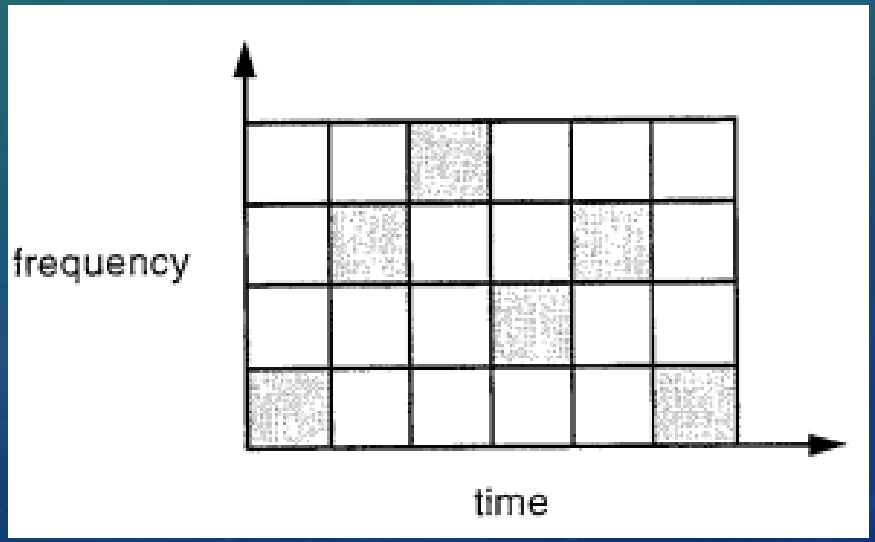
- Wide band, noise like signals-difficult to detect or distinguish from background noise,
- Hard to intercept or demodulate : Low Probability of Intercept (LPI) making it challenging for unauthorized users to decode the transmitted information.
- Hard to jam. jam because they use a wider bandwidth and lower power spectral density. Jamming a spread spectrum signal effectively would require transmitting a high-power jamming signal across a wide frequency range, which is not practical for jammers.
- Transmission a much lower spectral power density.
- SS and narrow band signals can coexist.
- Random access probability
- Immune to multipath effects.

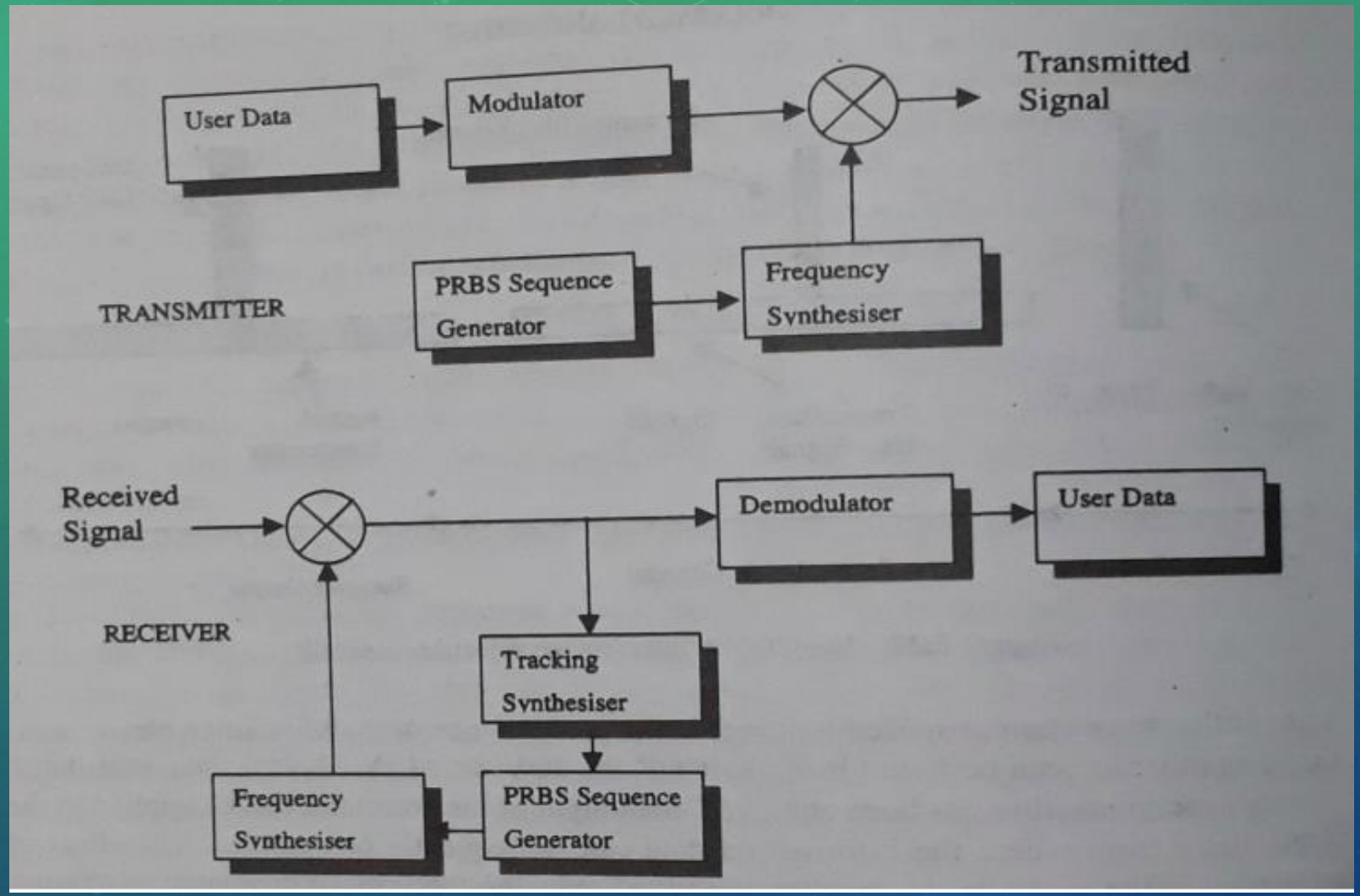
DIFFERENT WAYS TO SPREAD THE SPECTRUM

- Frequency Hopping (FHSS)
- Direct Sequence (DSSS)
- Chirp Modulation (CM)
- Time Hopping (TH)

FREQUENCY HOPPING (FHSS)

- Hop the carrier frequency over the spread spectrum bandwidth.
- Short period of time with one frequency.hop duration/dwell time
- Hopping pattern is determined by the code.

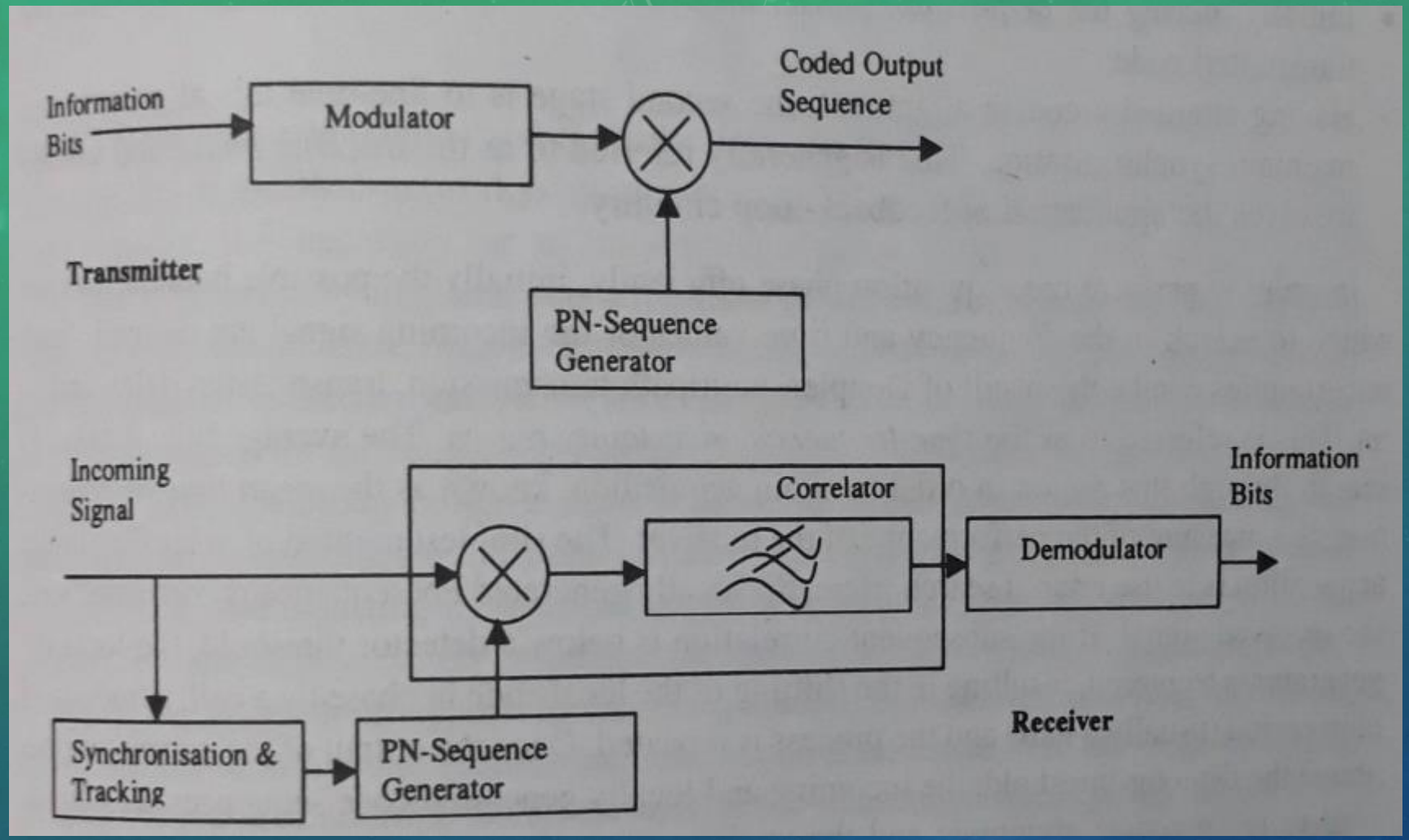




The modulated signal is then passed to the frequency synthesizer. The frequency synthesizer generates a carrier frequency that is determined by the PRBS generator. The PRBS generator produces a sequence of pseudorandom bits that are used to select the carrier frequency. The PRBS generator is used to synchronize the transmitter and receiver. The PRBS sequence is known to both the transmitter and receiver, so they can both use it to generate the same hopping carrier frequencies. This ensures that the transmitter and receiver are always communicating on the same frequency.

DIRECT SEQUENCE (DSSS)

- The digtal data is directly coded at a much higher frequency. The code is generated pseudo randomly. The receiver knows how to generate the same code, and correlates the received signal with that code to extract data. The receiver correlates (multiplies and integrates) the received signal with the spreading code to extract the original data. The correlation process effectively removes the spreading effect and recovers the original data signal.



The PN sequence generator produces a sequence of pseudorandom bits that are used to spread the user data. The synchronization & tracking block ensures that the receiver is synchronized with the transmitter's PN sequence. This is important because it allows the receiver to correctly demodulate the signal.

Type of multiple access	Advantages	Disadvantages
FDMA	-Network timing not required	Intermodulation products cause degradation and poor power utilisation
	-Compatible to existing hardware	-Uplink control power required
TDMA	-No mutual interference between accesses	-Network control required
	-Uplink power control not needed	Large peak power transmission for earth station
	Maximum use of satellite transponder power, most efficient	-Being digital in nature interface with analogue system is expensive
CDMA	-Network timing not required	Wide bandwidth per user required
	-Anti-jamming capability	-Strict code sync.needed

RANDOM ACCESS MAC PROTOCOLS

- Collision detection multiple access protocols cannot be used.
- Either pure ALOHA or selective reject ALOHA or slotted ALOHA is used.
- Reservation R ALOHA a combination of random access with reservation access protocols can be used.
- Reservation ALOHA that is being used when the number of ground stations is larger than the number of channels.
- The reservation is done by directly trying to send in different slots. This is called reservation ALOHA.

1.Pure ALOHA: Pure ALOHA is an early multiple access protocol used in packet-switched networks. In Pure ALOHA
2.Selective Reject ALOHA: Selective Reject ALOHA is an improvement over Pure ALOHA, where a device that exp
3.Slotted ALOHA: In Slotted ALOHA, the time is divided into discrete time slots, and devices are only allowed to tra
4.Reservation R ALOHA: Reservation R ALOHA is a combination of random access with reservation access protoc
5.Reservation ALOHA: Reservation ALOHA is used when the number of ground stations (devices) is larger than the
Meaning of the overall concept:
In a scenario where the number of ground stations (devices) is larger than the number of available channels, reserv
Selecting the appropriate multiple access protocol depends on factors such as the number of devices, available cha