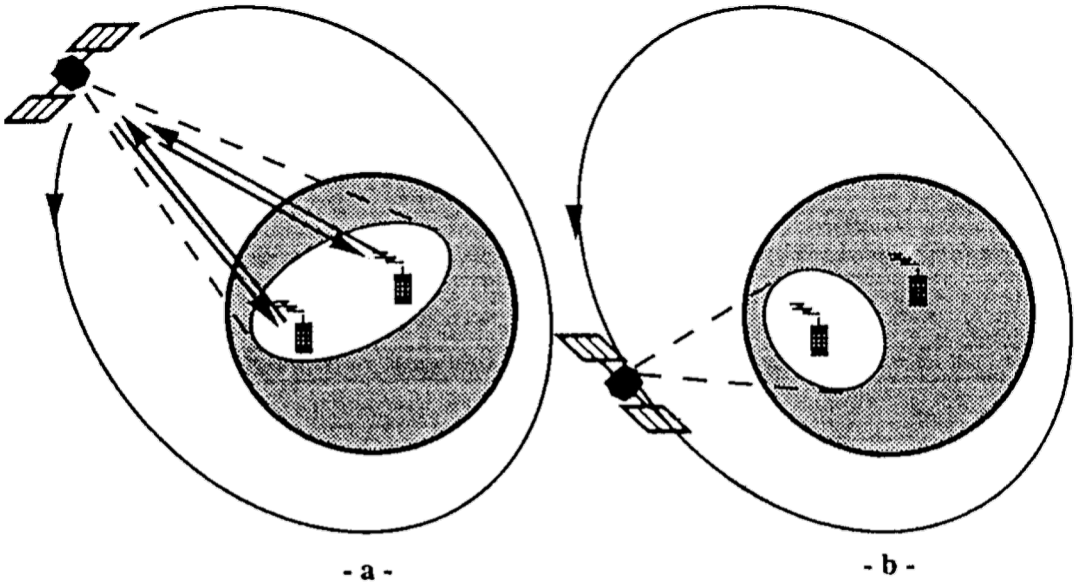
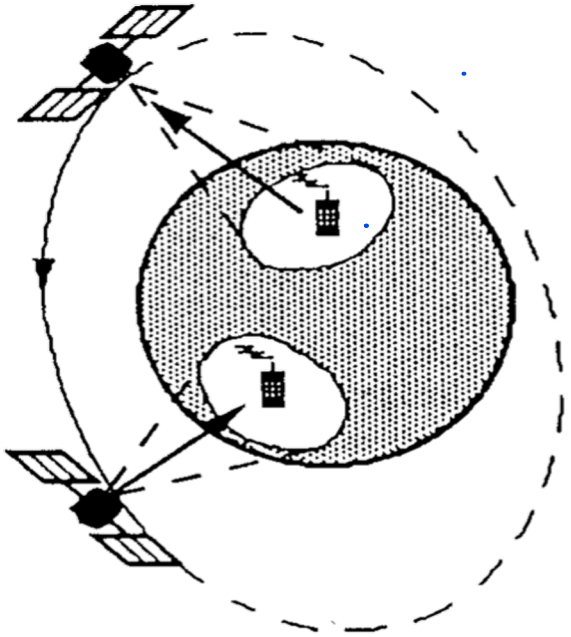
SPACE NETWORK ARCHITECTURE

Application	Application
Presentation	
Session	
Transport	Transport
Network	Internet
Data Link	Network Interface
Physical Layer	Physical
Architecture	

Communication scenarios with LEOs (1)

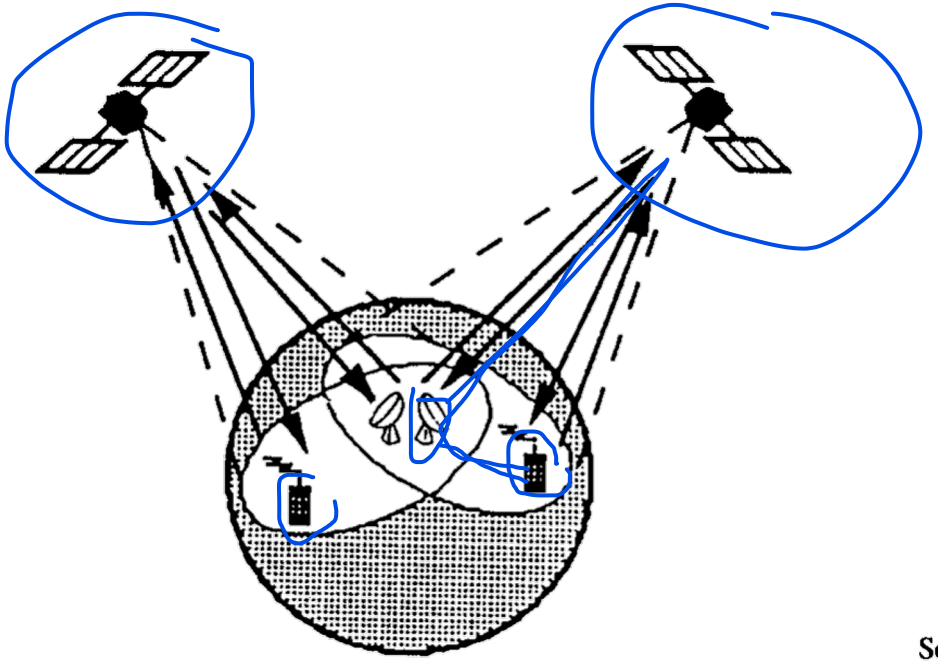


Scenario 1: (a) real time communication is possible only if the users are located in the satellite coverage area simultaneously;
(b) as the satellite moves on its orbit, the users do not remain continuously in the satellite coverage area simultaneously

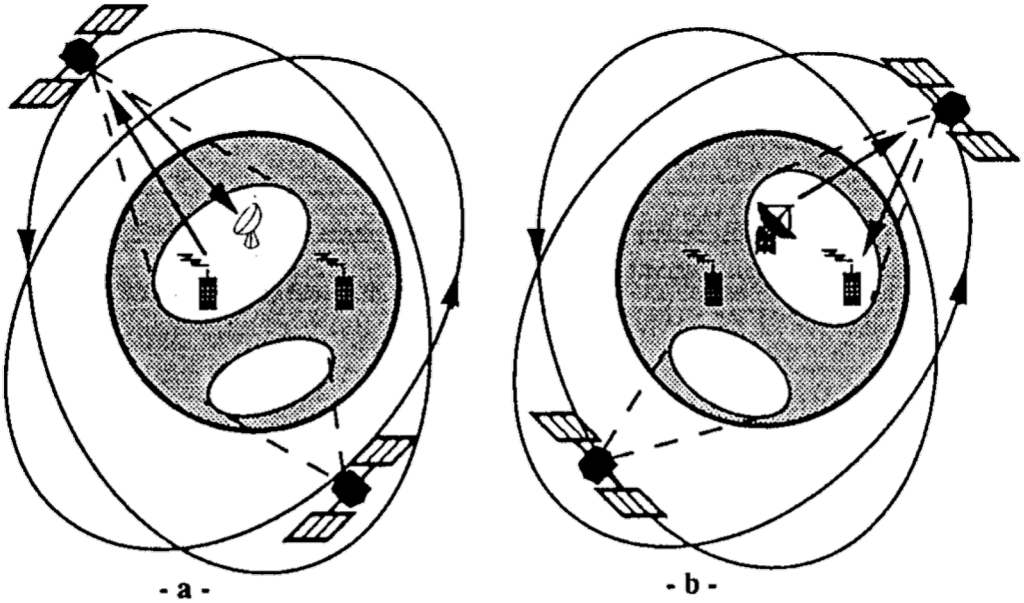


Scenario 1: delayed data transmission system using on-board storage

Communication scenarios with LEOs (2)

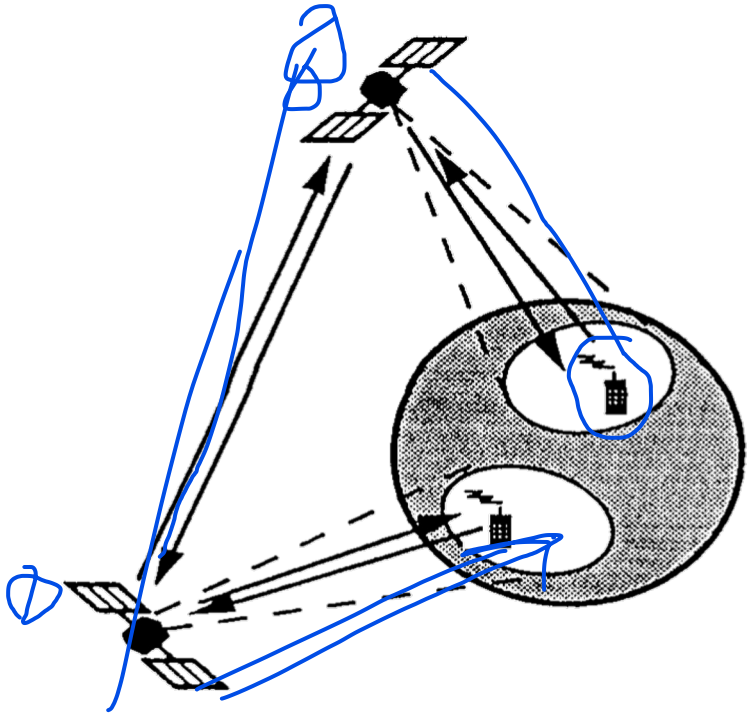


Scenario 2: real-time communications are provided via relay ground stations distributed all over the service zone

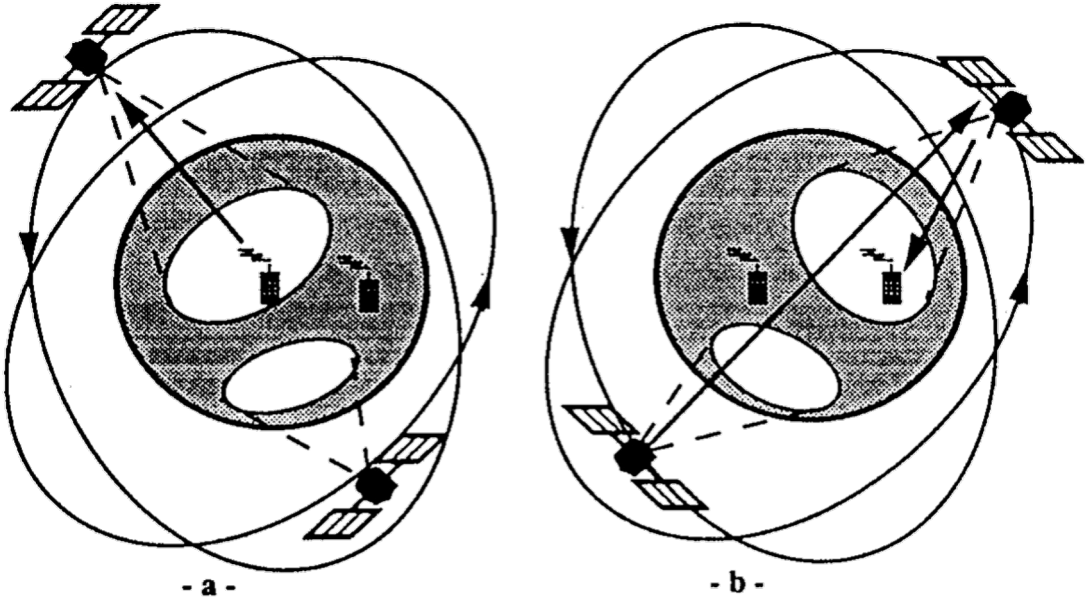


Scenario 2: delayed data transmission using relay satellites and ground stations. The user sends its message via a relay satellite to the ground station where it is stored (a). When a satellite is in view of the end user and of the ground station simultaneously, the message is delivered (b)

Communication scenarios with LEOs (3)



Scenario 3: real-time communications are provided via inter-satellite links

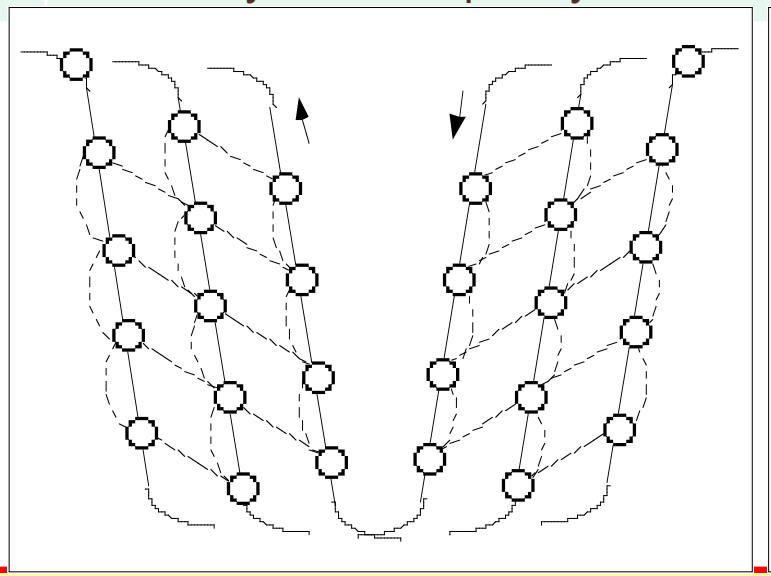


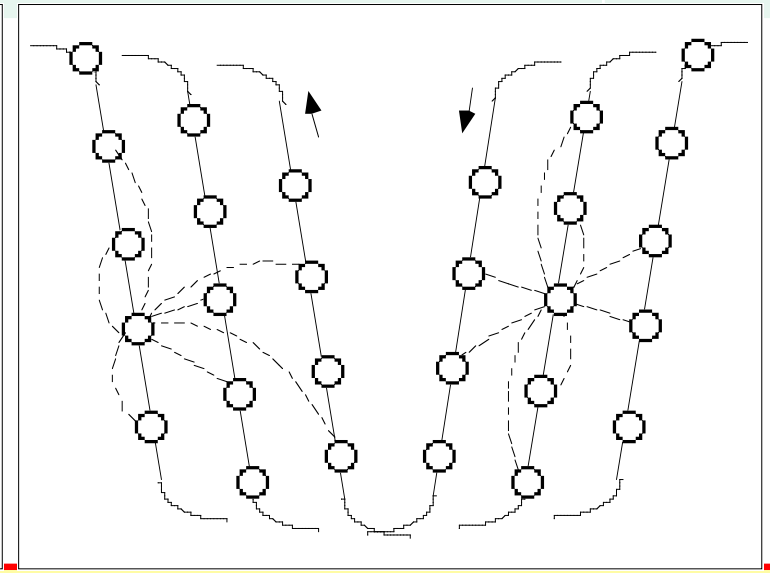
Scenario 3: delayed data transmission using on-board storage and inter-satellite links. The user sends its message to the satellite in view (a). The message is stored on board the satellite until an inter-satellite link is possible with a satellite in view of the end user (b)

Interconnection function: Inter Satellite Link (ISL)

	LEO	GEO
With ISL	Larger flexibility Reduced use of terrestrial networks (in theory only one Earth station is needed). Quasi polar constellations: (a) Iridium type, (b) Teledesic type	Requirements of Earth-satellite link decrease
Without ISL	Required visibility of at least one Gateway Earth Station (GES) at all times (for continuous-time services only) Lower system complexity and cost	Lower system complexity and cost

(a)



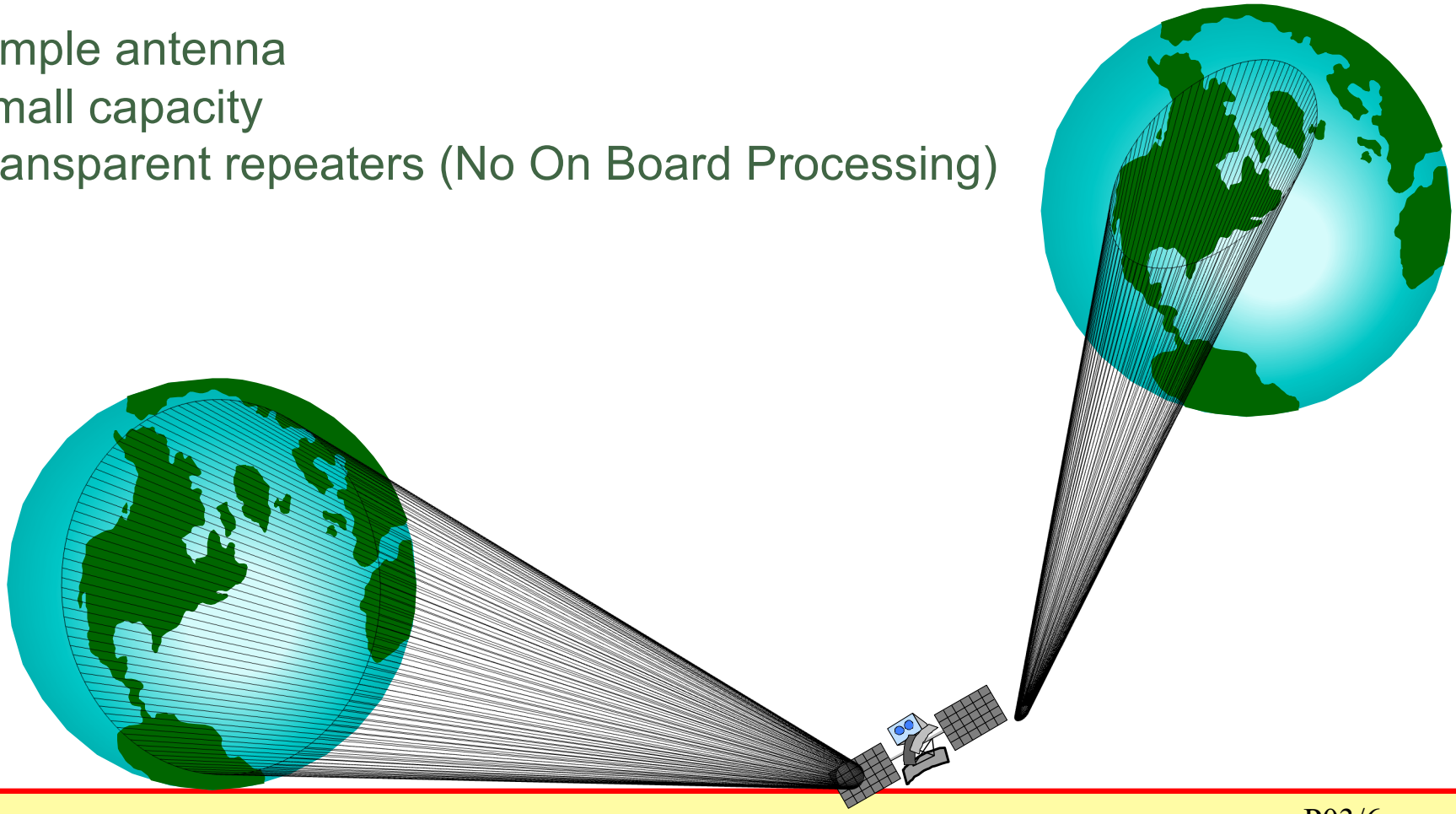


(b)

Global coverage (one beam)

One beam over the **target area** (even regional/national coverages)

Simple antenna
Small capacity
Transparent repeaters (No On Board Processing)



Multispot coverage (not contiguous)

Single reflector and multiple feeds to provide multiple spots.

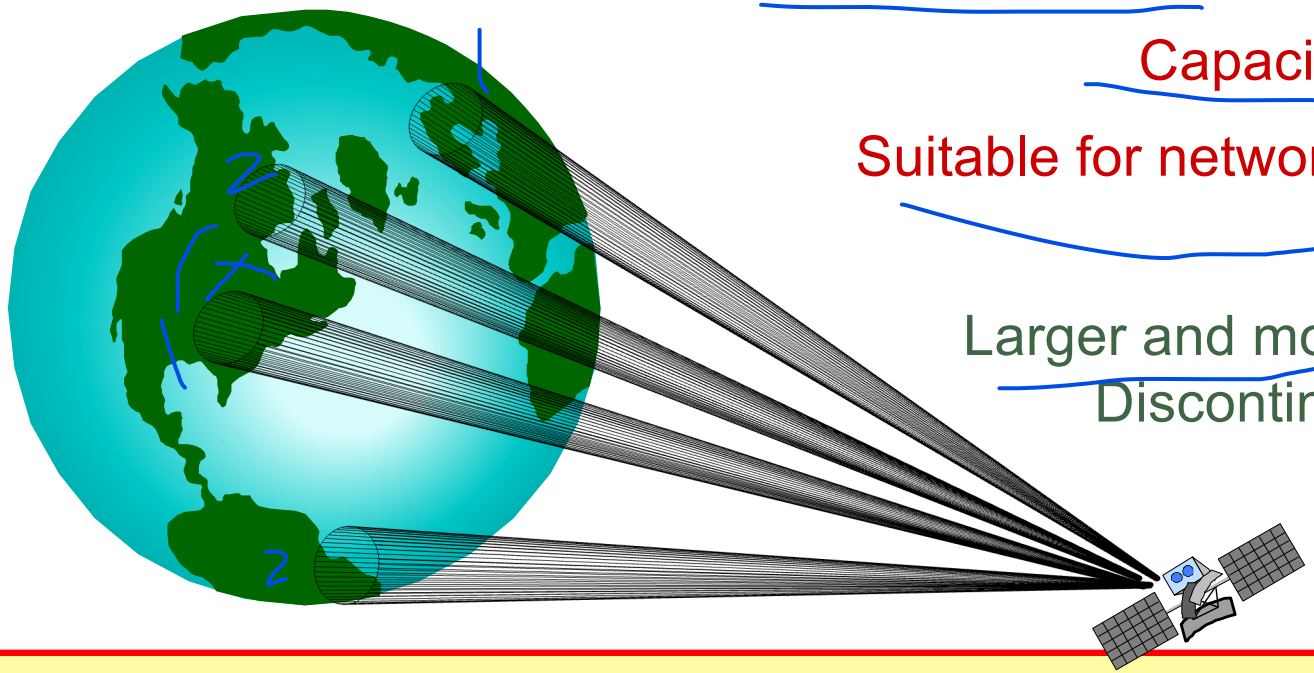
Advantages

If spots are widely separated and/or orthogonal polarizations are used the same frequency can be reused.

Higher power efficiency (better addressed)

Capacity better addressed

Suitable for network oriented services



Disadvantages:

Larger and more complex antenna

Discontinuous area coverage

No mobile services

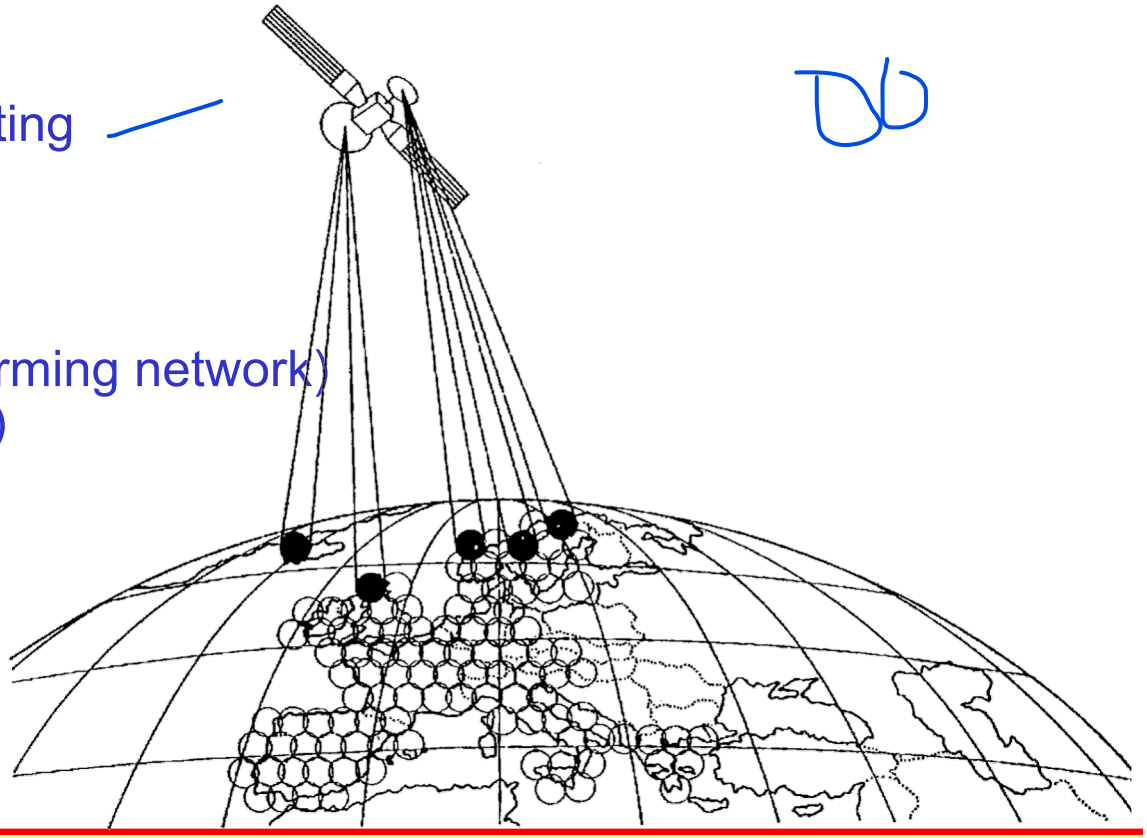
Multibeam Satellite Coverage (contiguous)

Advantages:

- Spectrum efficiency (frequency reuse)
- Less severe requirements for the ground segment
- High capacity
- High power efficiency
- On board processing and routing

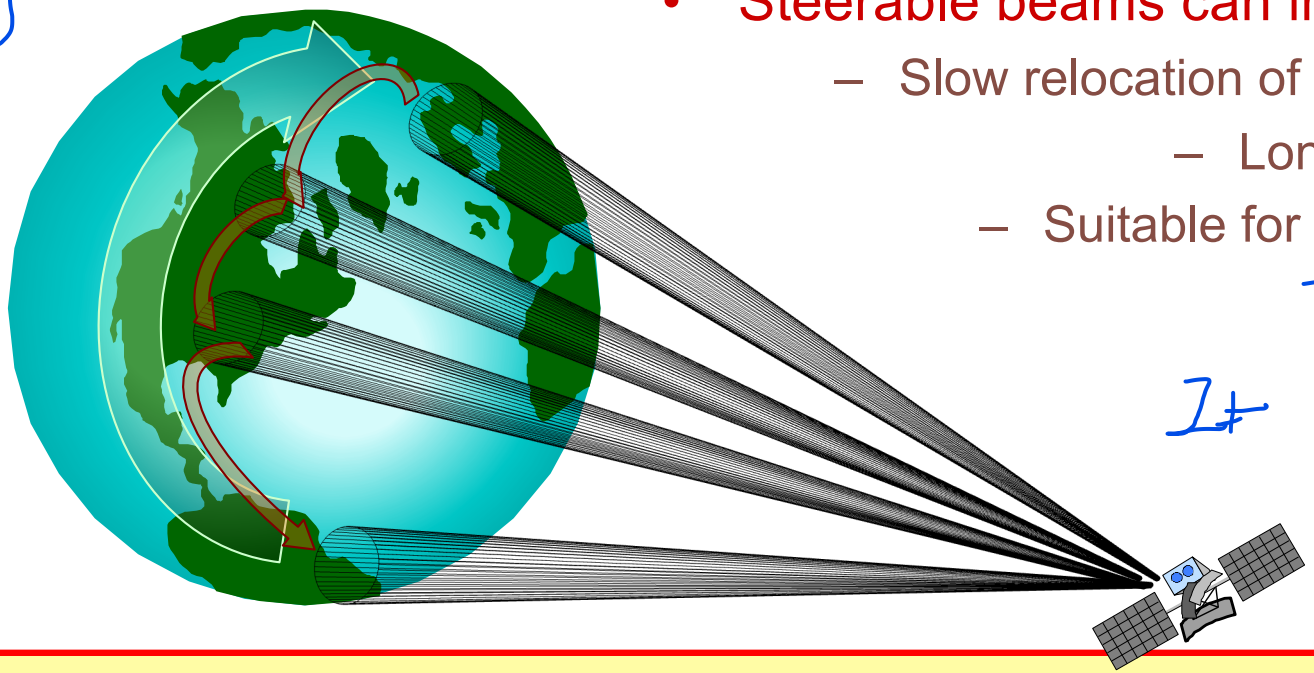
Disadvantages:

- Antenna complexity (beam forming network)
- Handover (in case of mobility)
- Cochannel interference
- Costs of satellite segment



Hopping or steerable beams

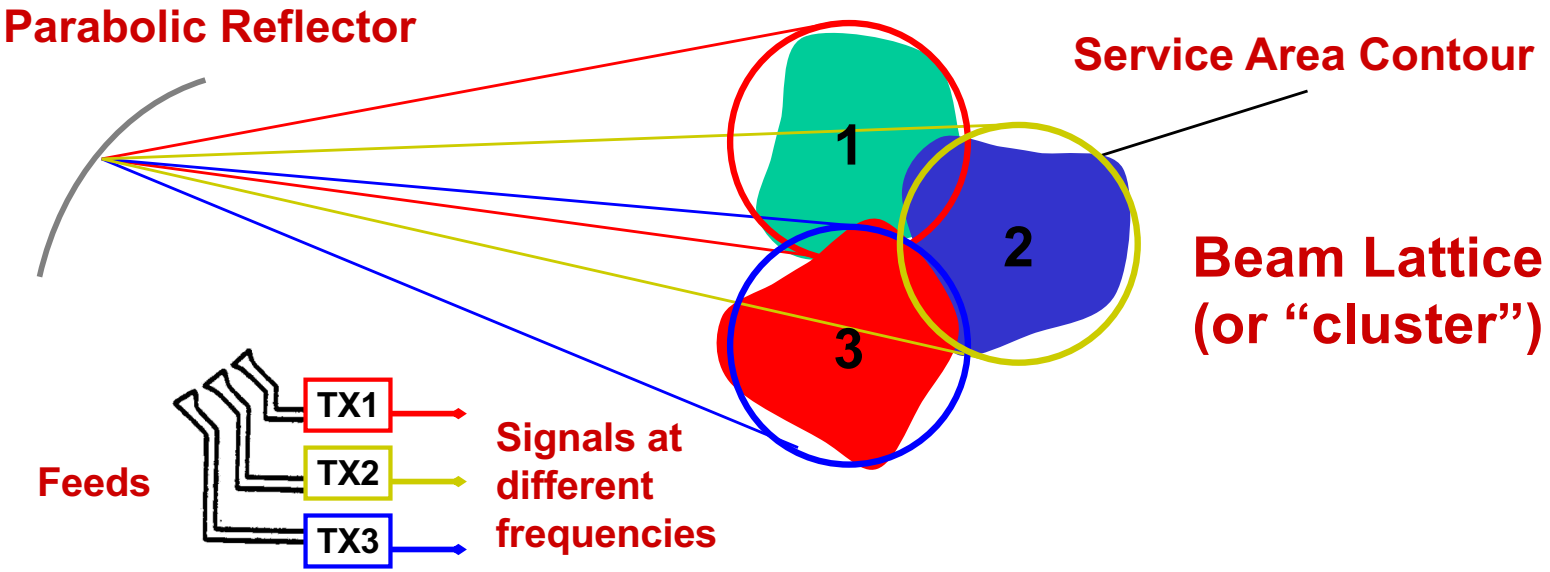
- Hopping beams introduce dynamicity in spatial coverage
  - Fast or very fast hopping among several locations
    - Automatically steerable for short term operation
      - Suitable for traffic coming from sparse population
        - Switching even in the order of ms
- Steerable beams can improve flexibility
  - Slow relocation of the beam pointing
    - Long term operations
      - Suitable for occasional events



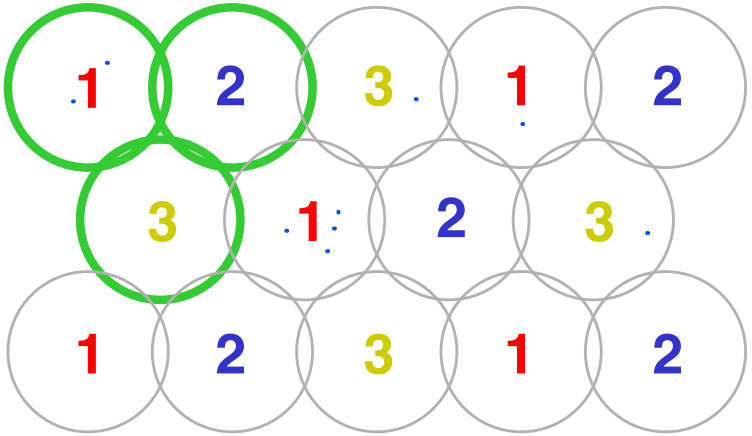
Non GEO satellites: types of local area coverage

- Coverage of local area with multiple spots:
  - a) Solidal with satellites (e.g. Iridium, Globalstar)
    - Moving spots with respect to a fixed point on the Earth
  - b) Solidal with footprint (HEO)
    - Fixed spots with respect to a fixed point on the Earth
- Coverage with electronic scanning antennas:
  - Larger dimension of constellation
  - Scanning angle should be low for feasibility (e.g., < 10°)
  - Scanning angle correlated with spot handover rate

Concept of "Beam Lattice" ...



… and frequency reuse among different lattices

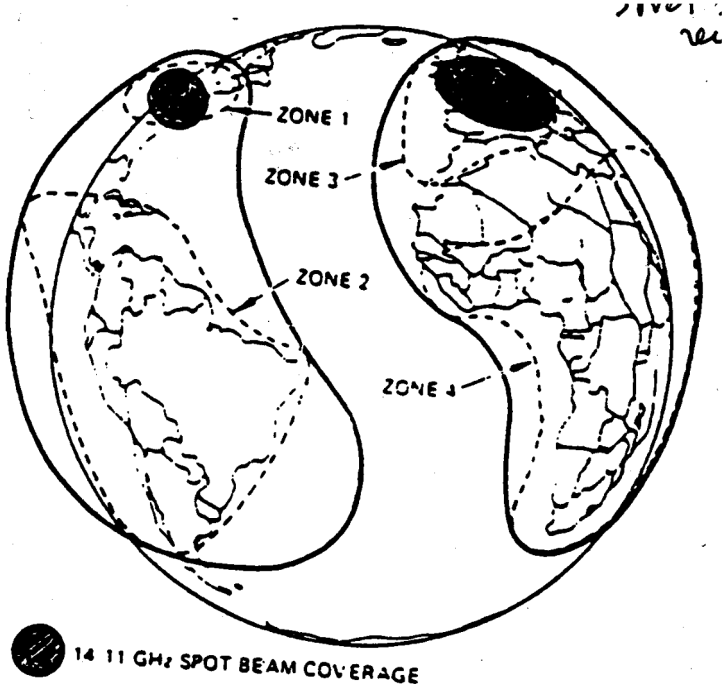


Contoured beam coverage

Shaped-beam antenna

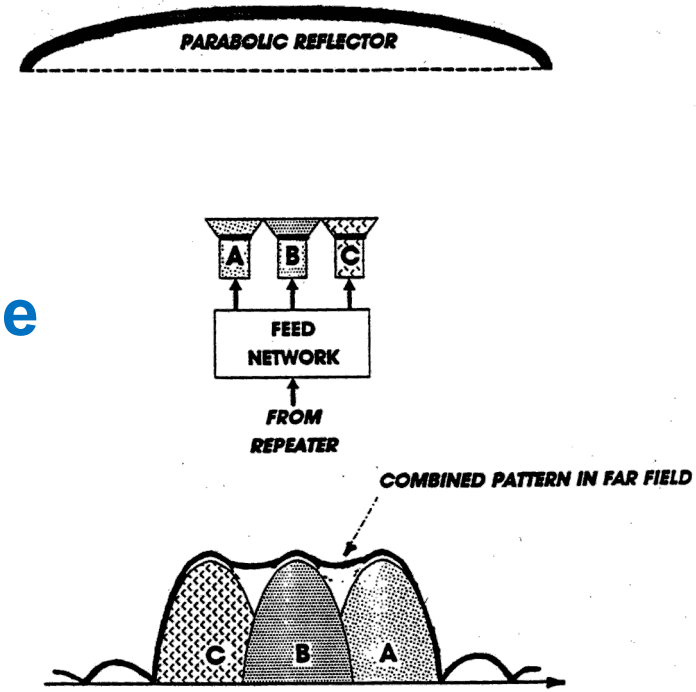
The coverage of the service area is provided with a single beam.

The beam forming network (BFN) that drives the feed subsystem allows power to be concentrated on a given area.



Example of contoured beam coverages

Antenna
Very expensive
Not reusable



Concept of contoured beam forming

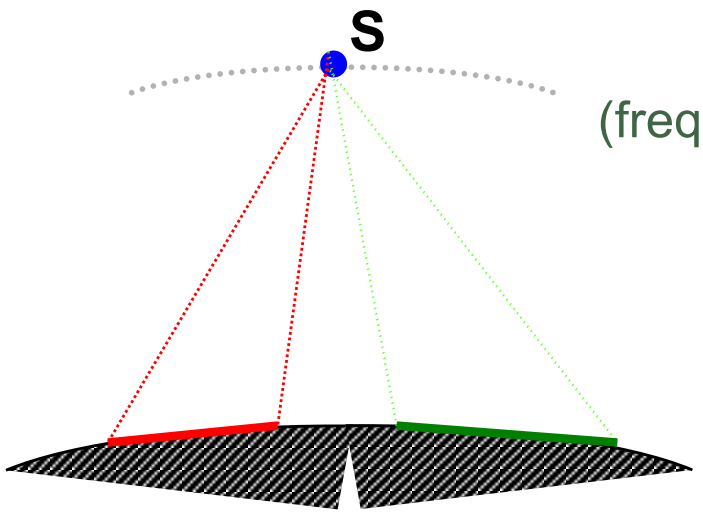
Discrimination by polarization

Use of dual polarization (overlapped):

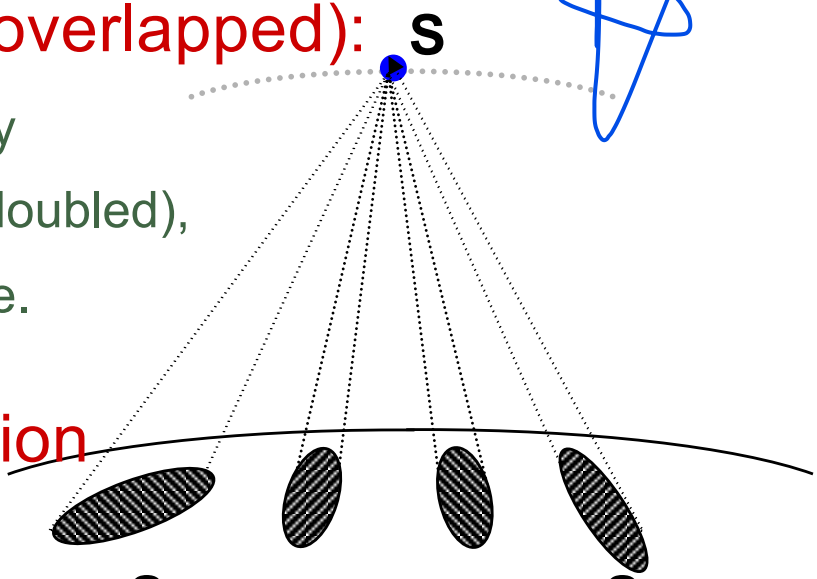
Increased capacity

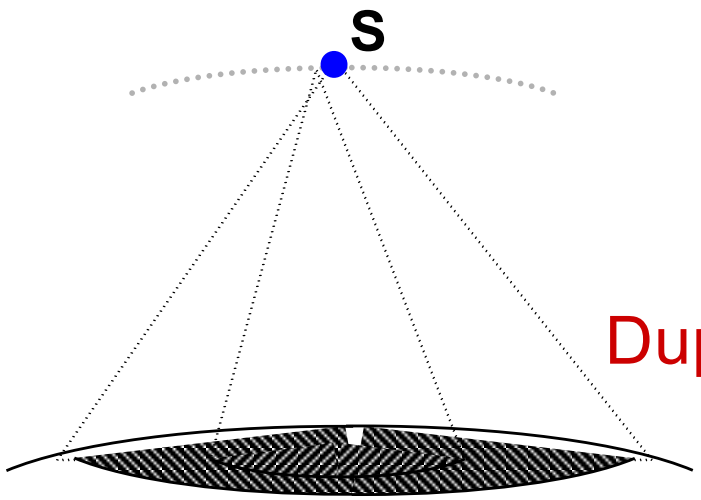
(frequency reuse almost doubled),

higher interference.



Increased isolation

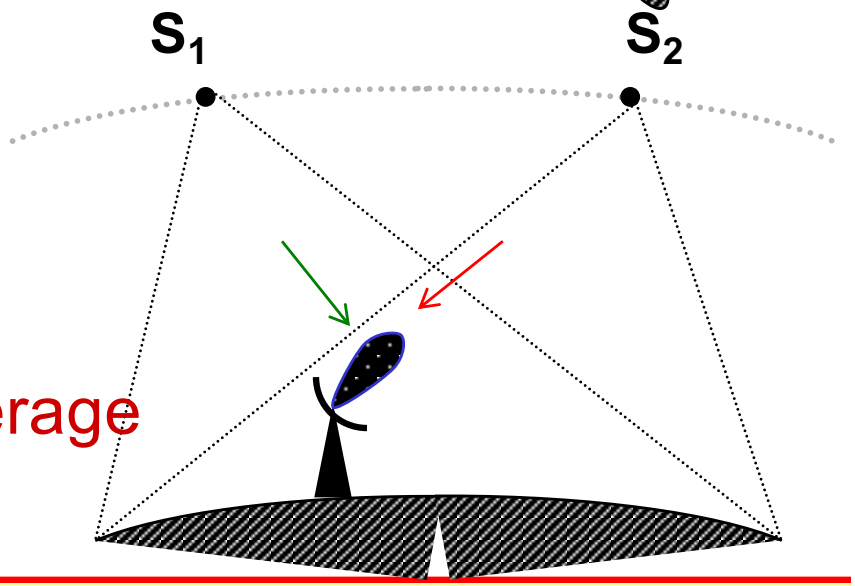




Pol. X

Pol. Y

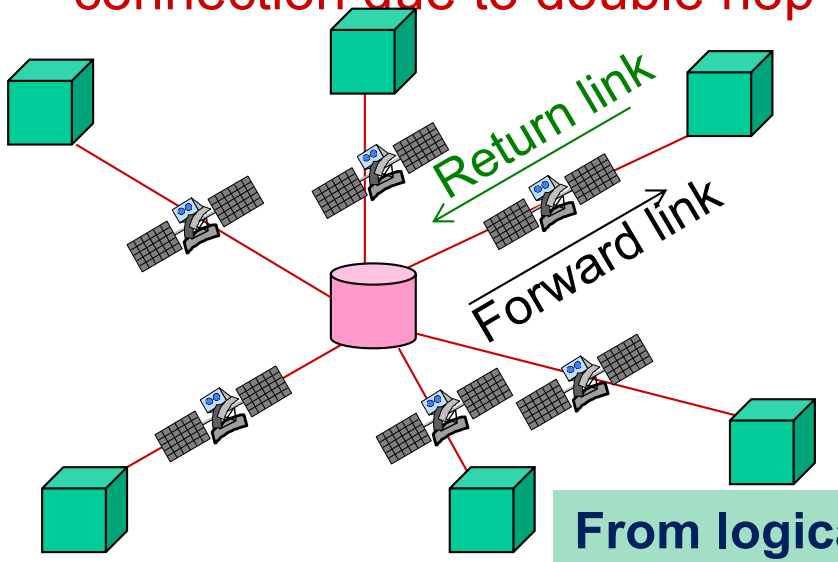
Duplicated coverage



Physical Topology

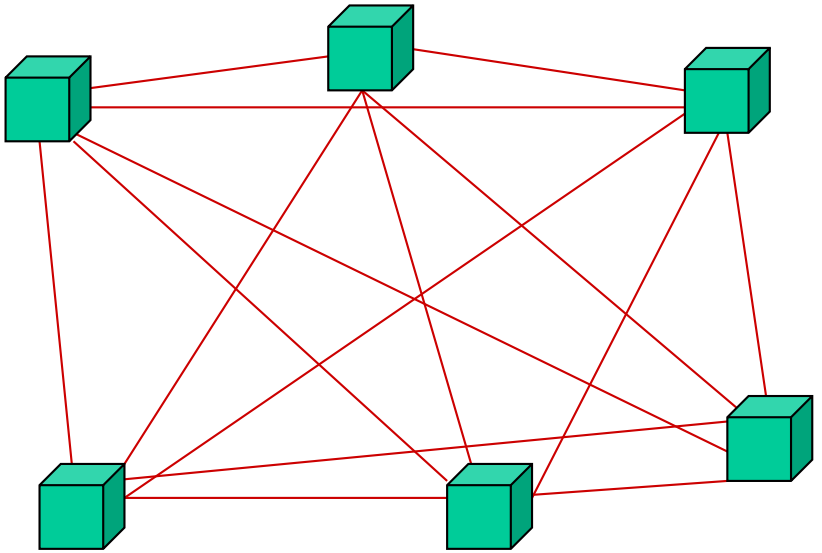
Star network

- Each sat-terminal must be connected to a hub
- The connection sat-terminal to sat-terminal needs a double hop
- User ground segment: simplest architecture
- High delay for satT-satT connection due to double hop



Full Mesh

- Each sat-user is directly connected to any sat-user
- Single hop needed
- User ground segment: complex architecture
- Lowest delay



From logical point of view both topologies are full mesh

Virtual Star

- Trade off between the previous configurations
- Some stations works as a hub
- Every user is connected to at least one hub
- High complexity
- Double hop needed in some case