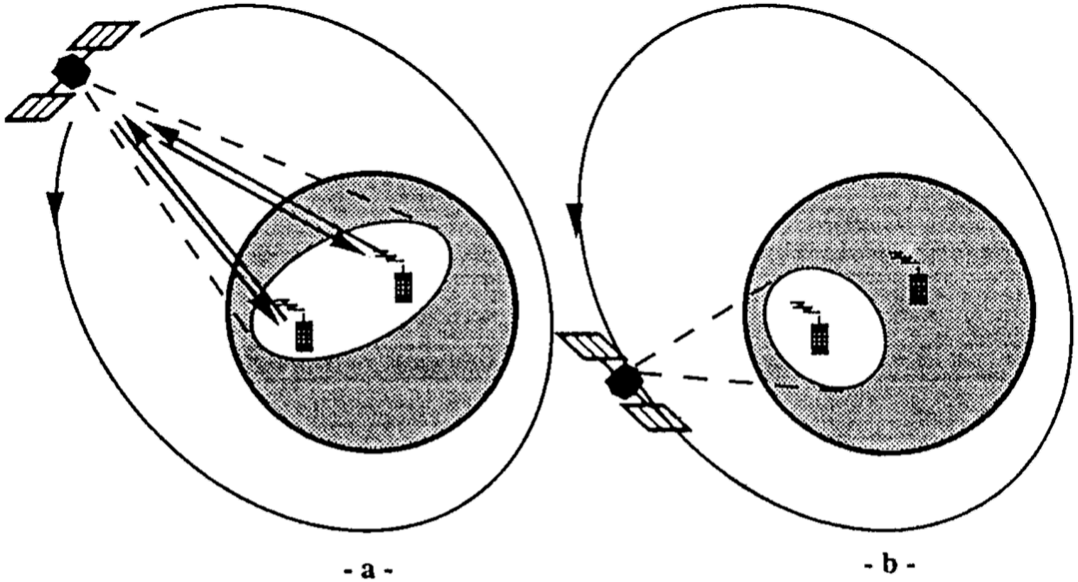
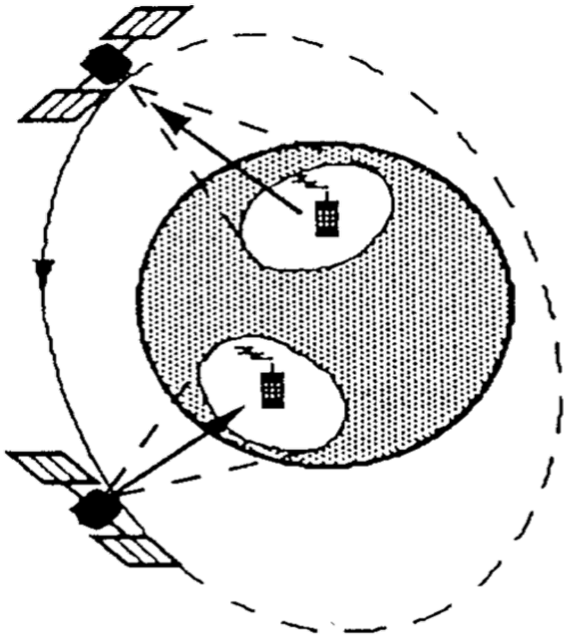
SPACE NETWORK ARCHITECTURE

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

Communication scenarios with LEOs (1)

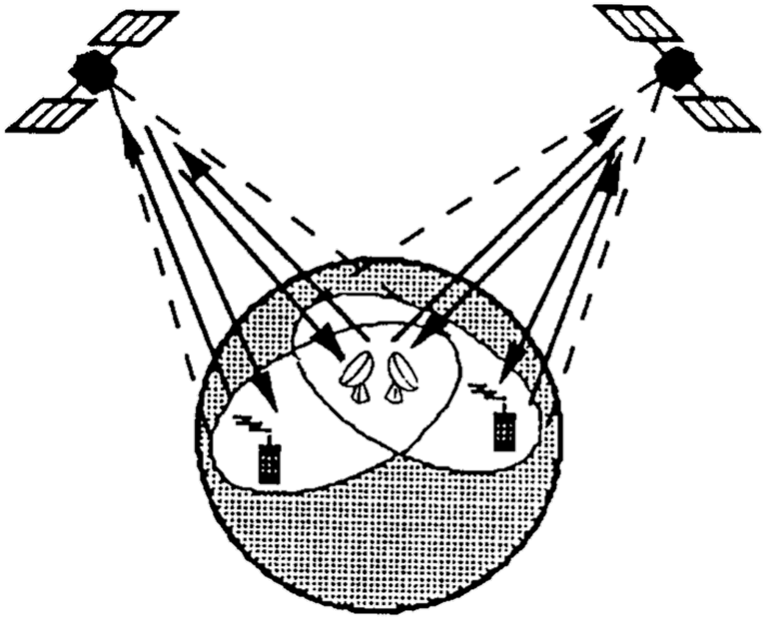


Scenario 1: (a) real time communication is possible only if the users are located in the satellite coverage area simultaneously;
(b) as the satellite moves on its orbit, the users do not remain continuously in the satellite coverage area simultaneously

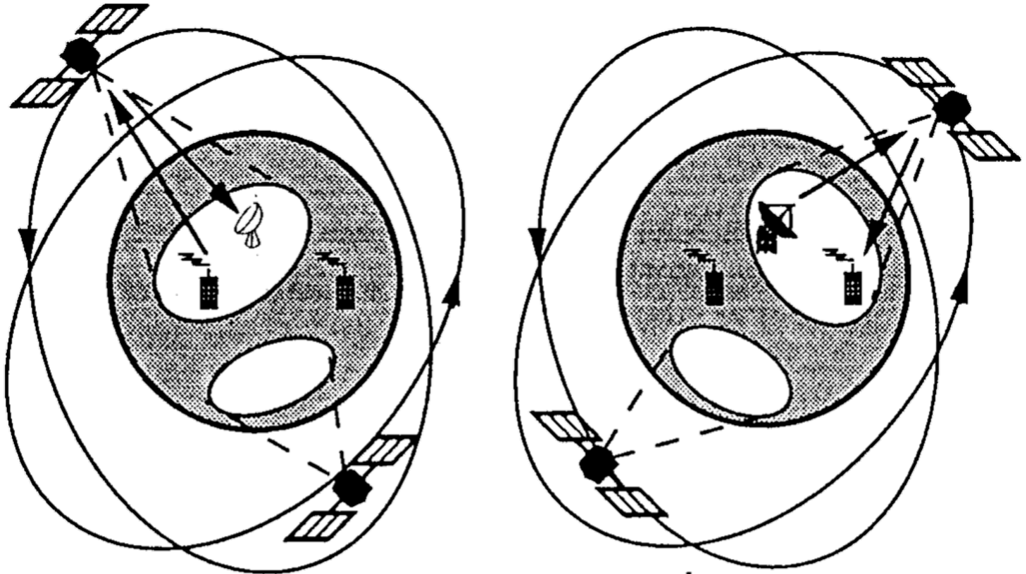


Scenario 1: delayed data transmission system using on-board storage

Communication scenarios with LEOs (2)



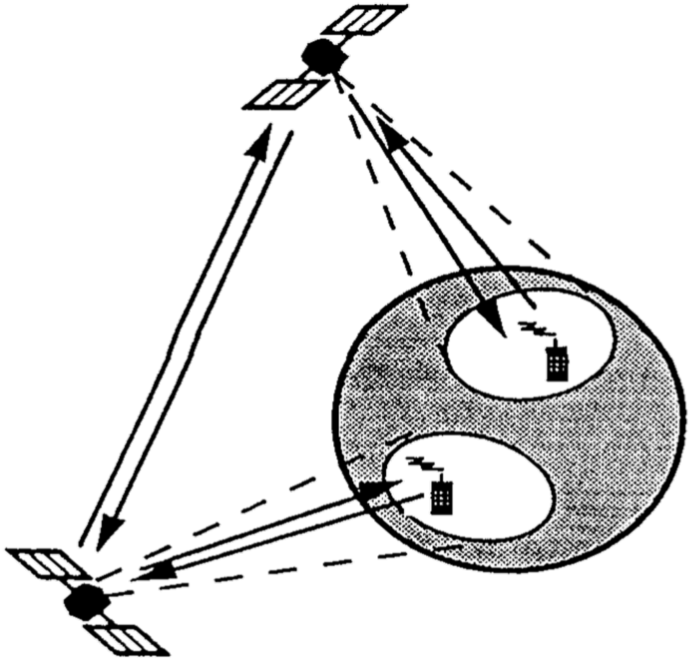
Scenario 2: real-time communications are provided via relay ground stations distributed all over the service zone



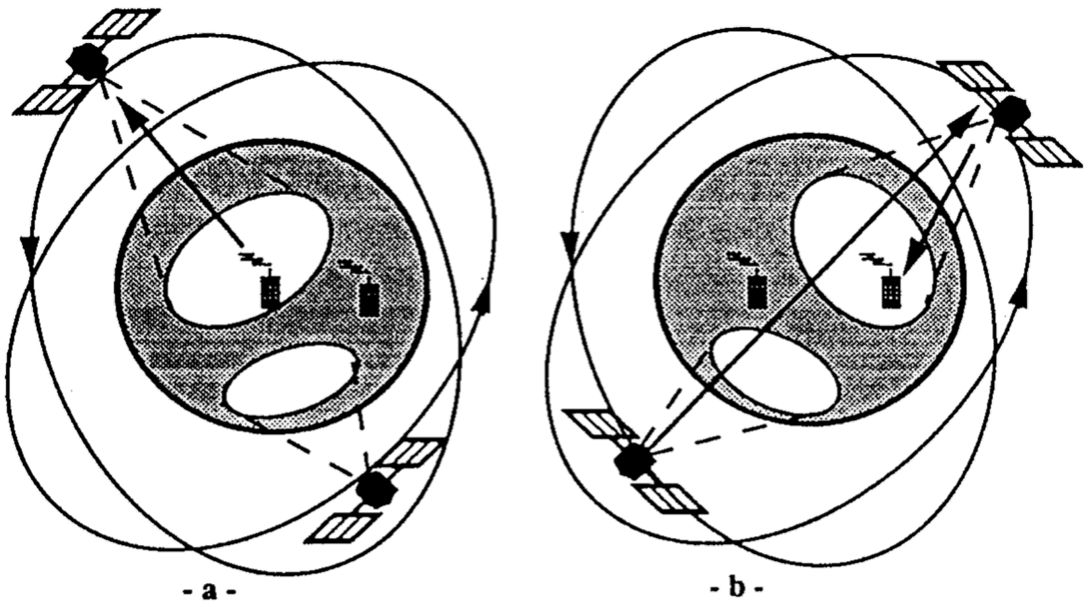
- a - - b -

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)



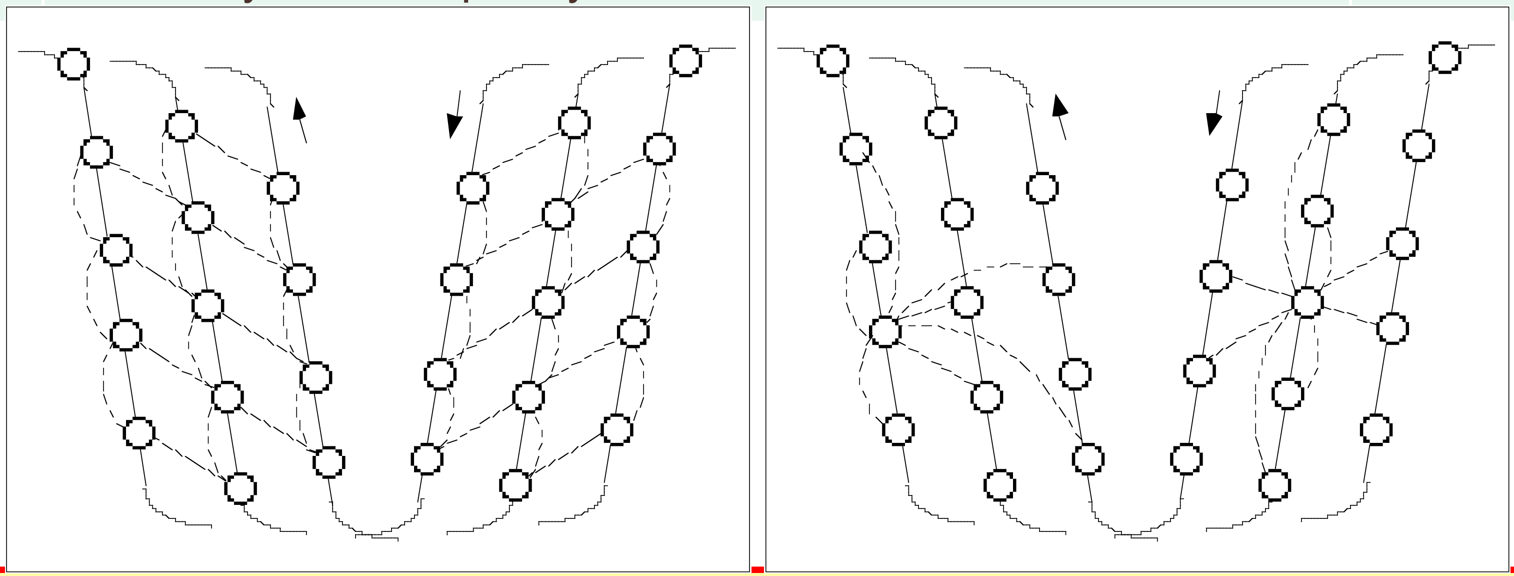
Scenario 3: real-time communications are provided via inter-satellite links



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)

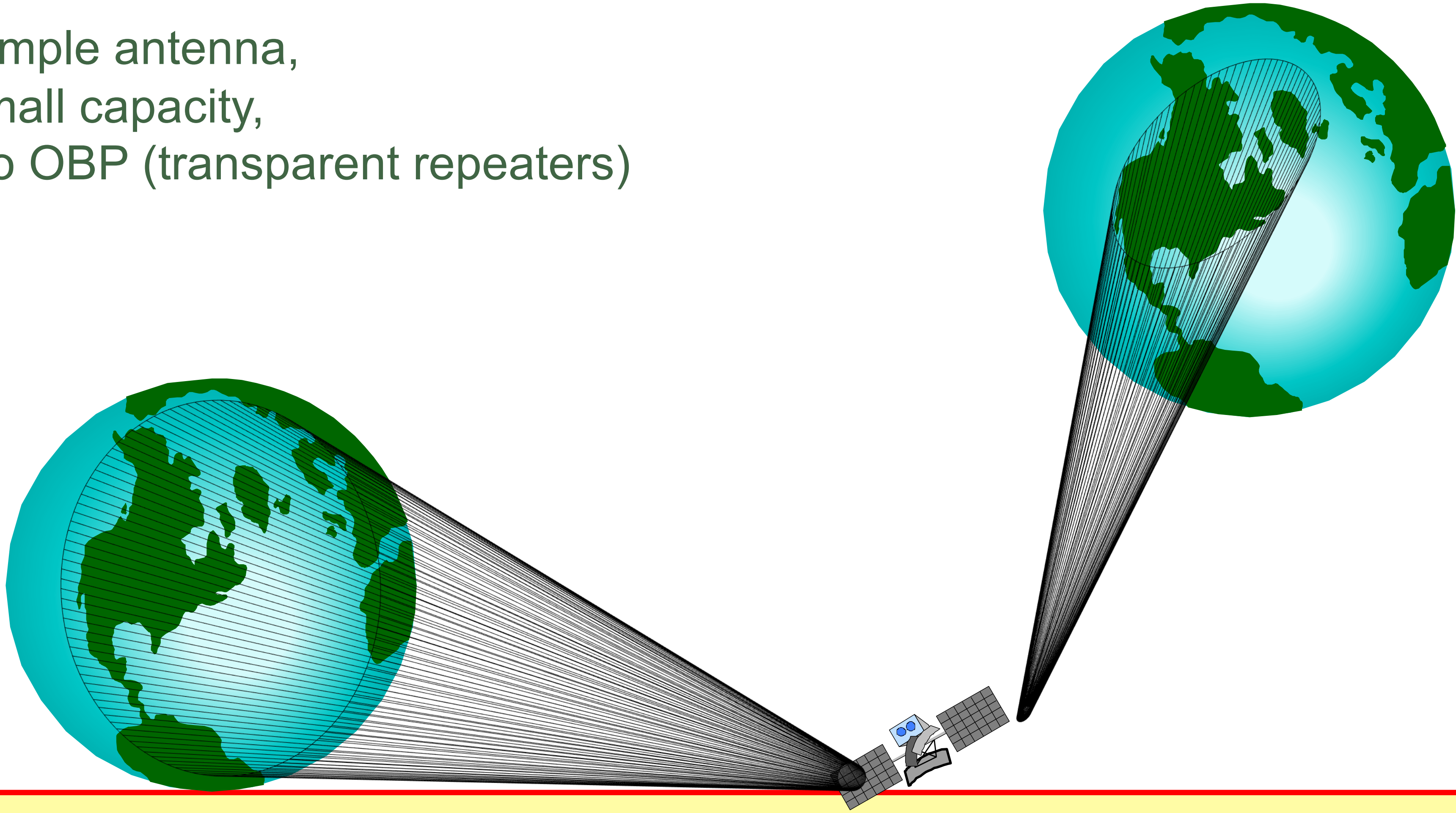
	LEO	GEO
With ISL	Larger flexibility Reduced use of terrestrial networks (in theory only one Earth station is needed). Quasi polar constellations: (a) Iridium type, (b) Teledesic type	Requirements of earth-satellite link decrease
Without ISL	Required visibility of at least one GES at all times (for continuous-time 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,
No OBP (transparent repeaters)



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.

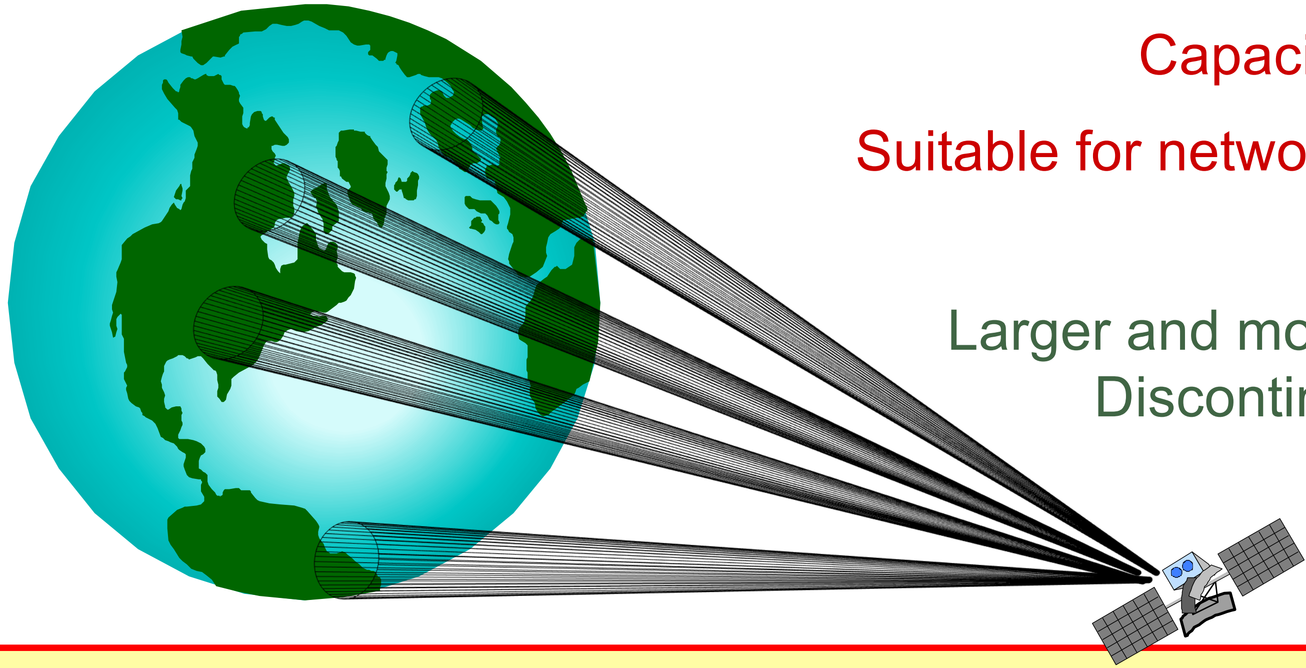
Higher power efficiency (better addressed)

Capacity better addressed

Suitable for network oriented services

Disadvantages:

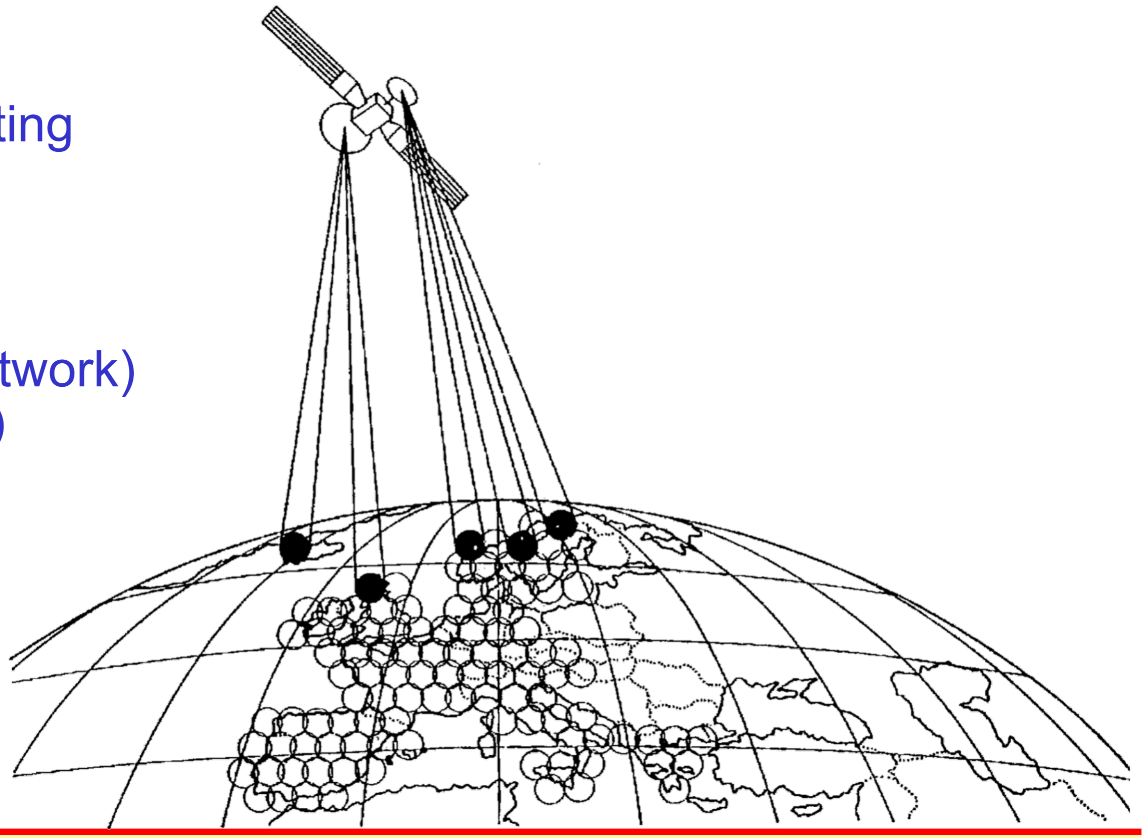
Larger and more complex antenna.
Discontinuous area coverage
No mobile services



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

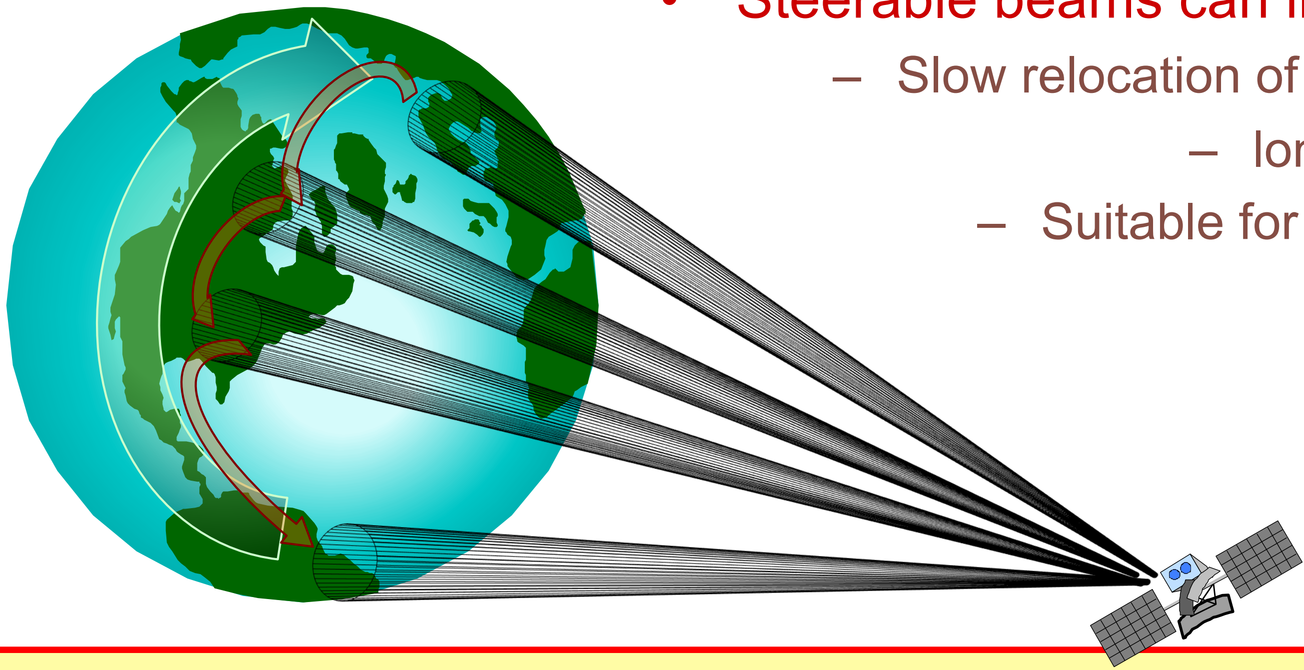


Disadvantages:

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 or 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



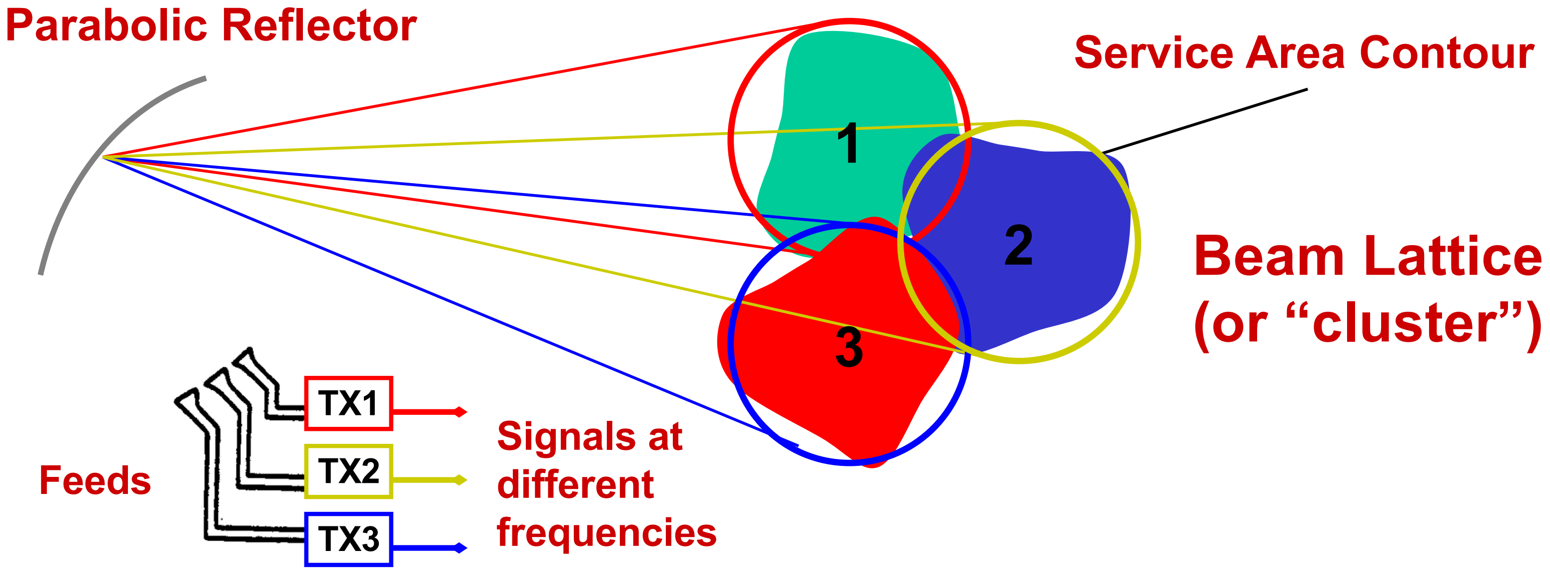
Non GEO satellites: types of local area coverage

- 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

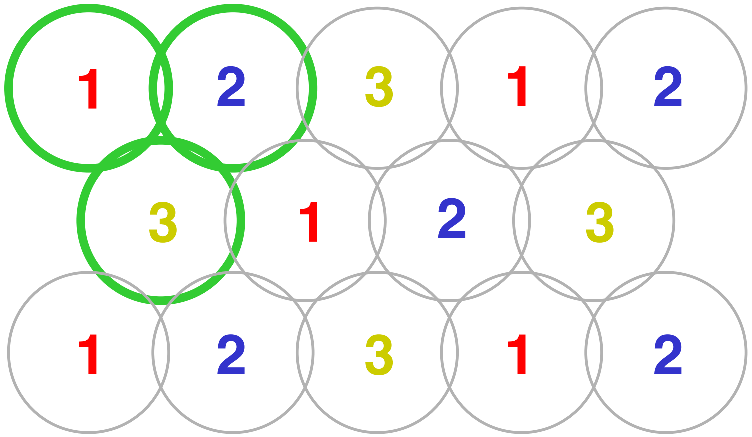
  b) Solidal with footprint (e.g. Teledesic, HEO)
     - Fixed spots with respect to a fixed point on the Earth

- 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

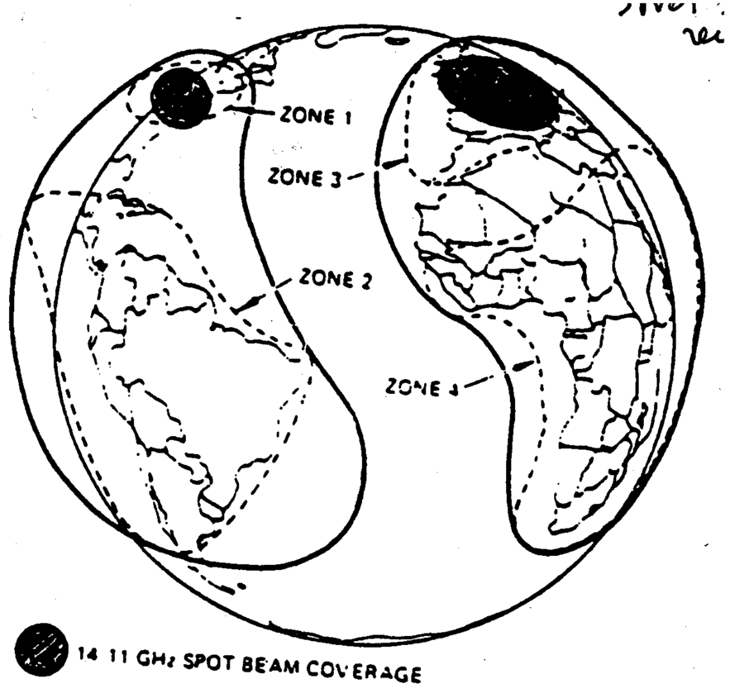


Contoured beam coverage

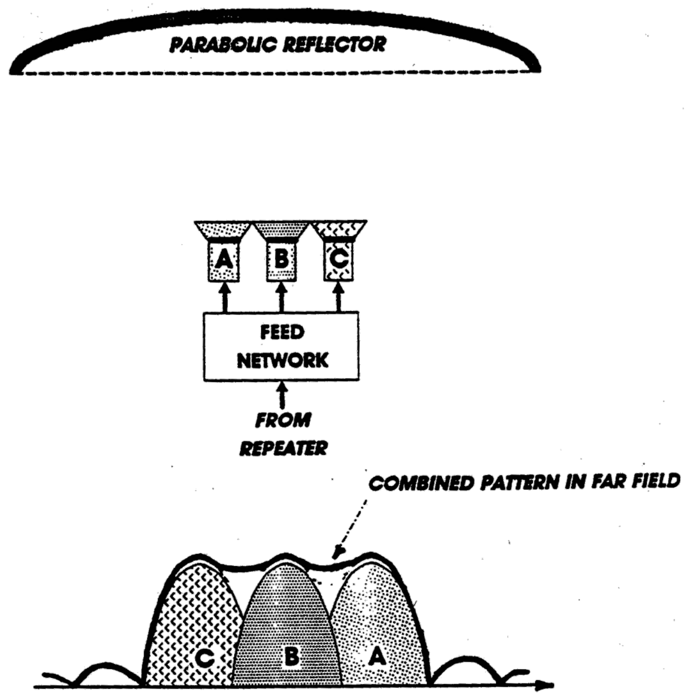
Shaped-beam antenna

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 in a given area.



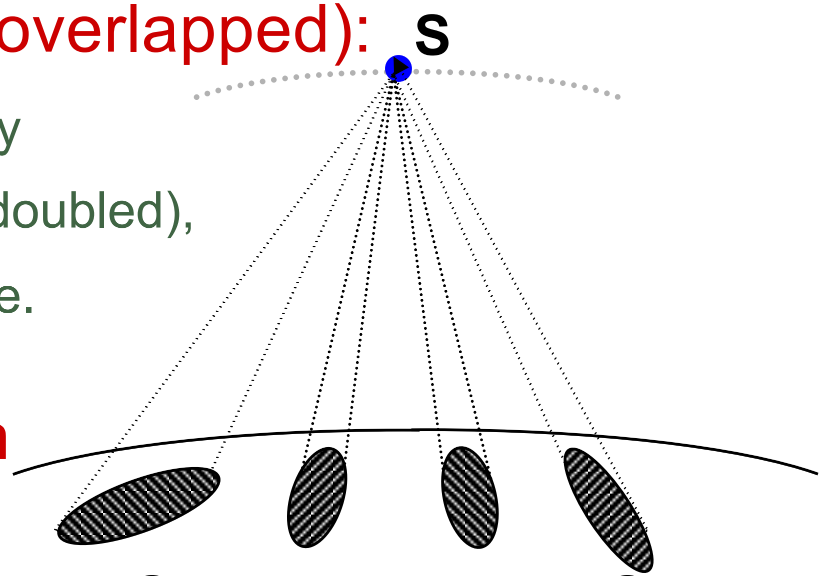
Example of contoured beam coverages



Concept of contoured beam forming

Discrimination by polarization

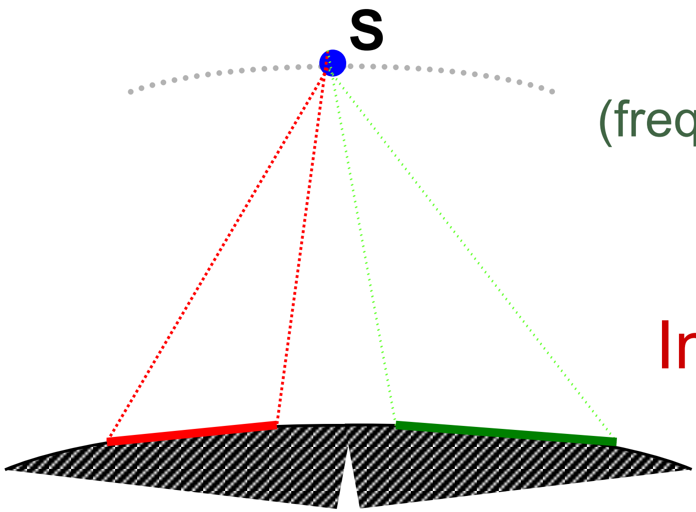
Use of dual polarization (overlapped):



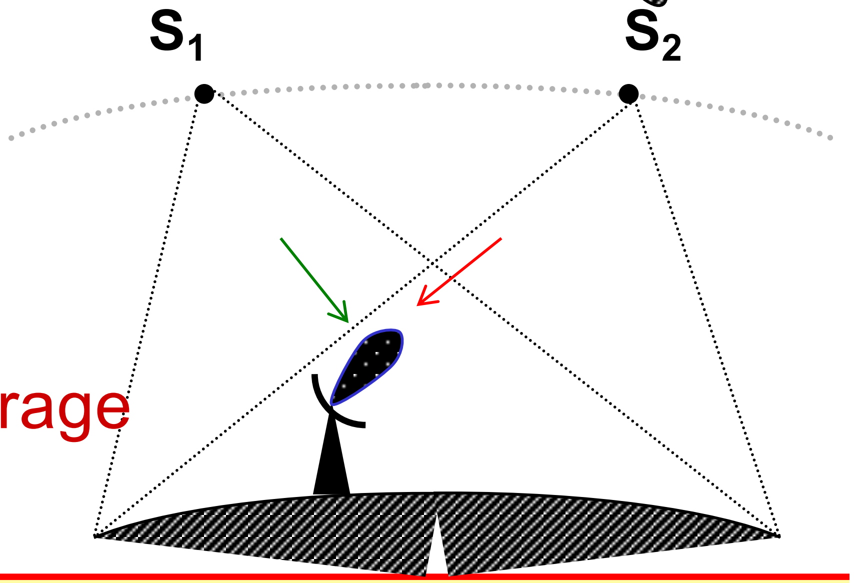
Increased capacity

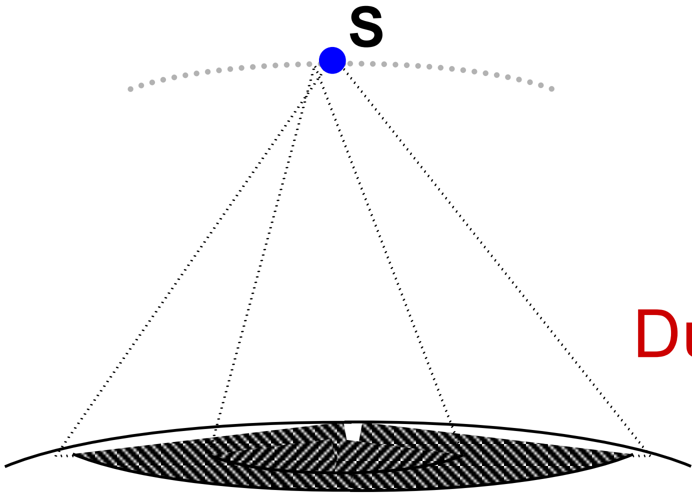
(frequency reuse almost doubled),

higher interference.



Increase isolation



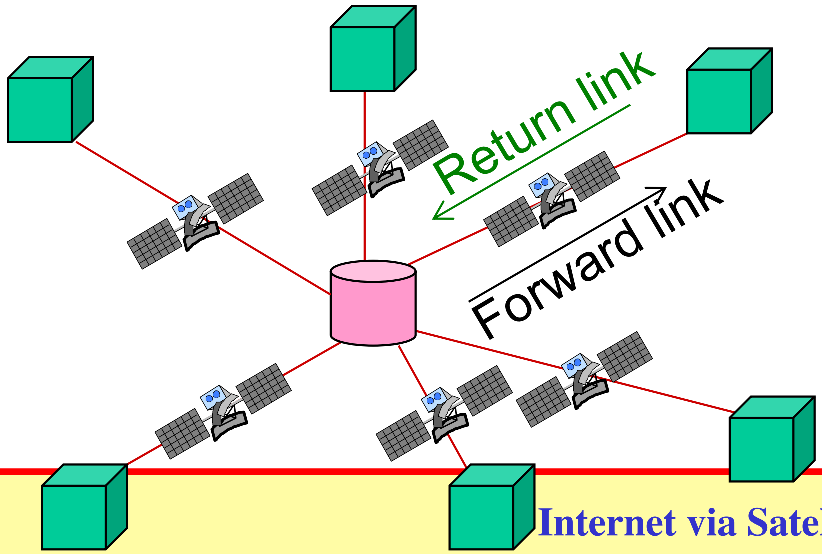


Duplicate coverage

Physical Topology

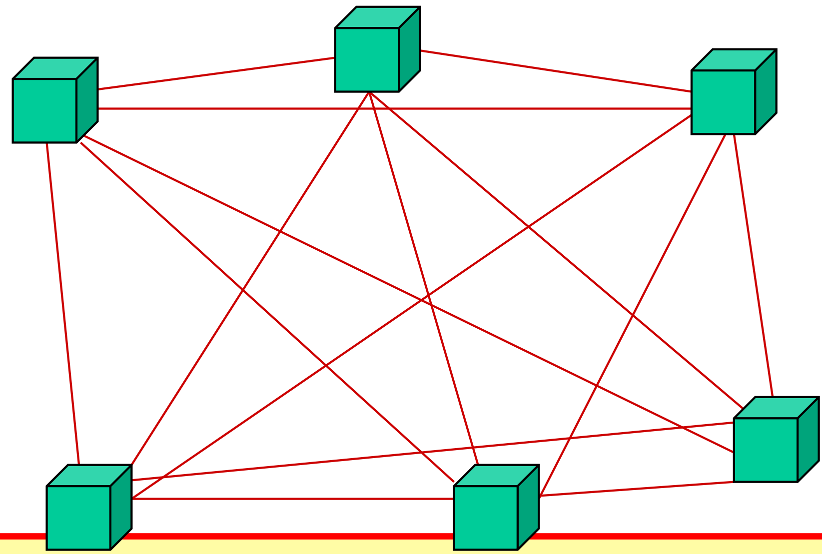
Star network

- Each user must be connected to a hub
- The connection sat-user to sat-user needs a double hop
- User ground segment: simplest architecture
- High delay (due to double hop)



Full Mesh

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



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