Communications Satellites

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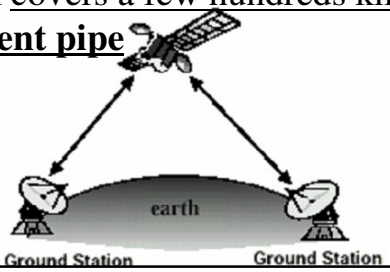
Introduction

- A communications satellite is a microwave repeater in space
  - Receive at one frequency and transmit at some other frequency in some direction,
    - Broad beam covers a broad fraction of earth's surface
    - Narrow beam covers a few hundreds km. Also called **bent pipe**

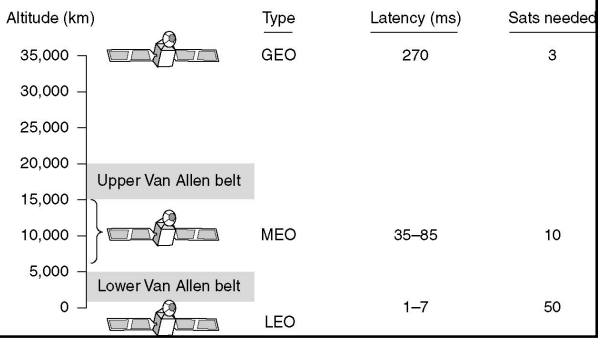


Issues

- Propagation delay: 270 msec, twice that in case of VSAT
- Broadcast media: inherently broadcast
- Security: easy to intercept
- Cost: equal cost regardless of the distance between sender and receiver
- Errors: low error rate
- Deployment: easy ?

Satellite Placement

- $T^2 = r^3$
  - Near the surfaces of the earth the period is 90 minutes
  - At 35,800 it is 24 hours
- Also need to avoid the Van Allen belts



Geostationary Satellites

- 2 degrees of separation is required between satellites
  - Orbit allocation is done by ITU
- Station keeping is the orbit correction procedure by on-board rocket motors
  - Lifetime is approximately 10 years
- Downlink transmission can interfere with terrestrial microwave use, so ITU allocated satellite bands
  - Satellite bands: order of appearance, C, L&S,Ku&Ka

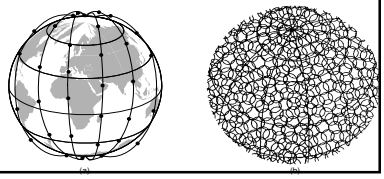
Band	Downlink	Uplink	Bandwidth	Problems
L	1.5 GHz	1.6 GHz	15 MHz	Low bandwidth; crowded
S	1.9 GHz	2.2 GHz	70 MHz	Low bandwidth; crowded
C	4.0 GHz	6.0 GHz	500 MHz	Terrestrial interference
Ku	11 GHz	14 GHz	500 MHz	Rain
Ka	20 GHz	30 GHz	3500 MHz	Rain, equipment cost

Medium Earth Orbit Satellites

- Between Van Allen belts
- 6 hours to circle earth – so must be tracked
- Smaller footprint and less power required
- Not currently used for telecommunications

Low-Earth Orbit Satellites

- Iridium
  - 77 (66) satellites at 750 km in circular polar orbits
    - Cells each satellite has a maximum of 48 cells
    - Channels each satellite has a capacity of 3840 ch.
  - Satellites relaying traffic in space
  - Nov 1998: service was launched after a decade long building
  - Aug 1999: went in Chapter 11
  - March 2001: bought by a group of private investors



Low-Earth Orbit Satellites (2)

- Globalstar
  - 48 LEOs but communication is relayed on the ground
  - Uses bent-pipes: easier to manage ground stations
- Teledesic (2005?)
  - 288 (30) LEOs originally designed with 288 low footprint satellites, it is revised to 30 larger footprint
  - High bandwidth for Internet access using a small VSAT antenna
  - Packet switched network
  - Uplink capacity 100Mbps
  - Downlink capacity 750Mbps

Satellites vs. Fiber

- Fiber wins A single optical fiber has in theory more bandwidth than all the satellites ever launched
- Satellite niches
  - High bandwidth unavailable to phone customers
  - Mobile communication while at sea or airborne
  - Broadcasting is a natural use case for satellites
  - No infrastructure required, so maybe cheaper
  - No right of way for laying fiber
  - Rapid deployment needed for military communications