Broadband to the Home by Satellite

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Topics

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Background – Today's Satellite Networks
Broadband Satellite Networks
TCP/IP over Satellite
Satellite Personal Broadband

Background – Today's Satellite Networks

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Today's satellite networks set the stage

- DBS – broadcast video to the home
  - –DIRECTV®
  - –Echostar
  - –Primestar
- DIRECPC® – asymmetric Internet access
  - –DirecDuo™
  - –Up to 1.5 Mbps download rate
- VSAT networks – corporate data communications
  - –Hughes Network Systems
  - –STM
  - –Scientific-Atlanta
  - –Stanford Telecommunications Laboratories

Commercial Satellite On-Orbit History

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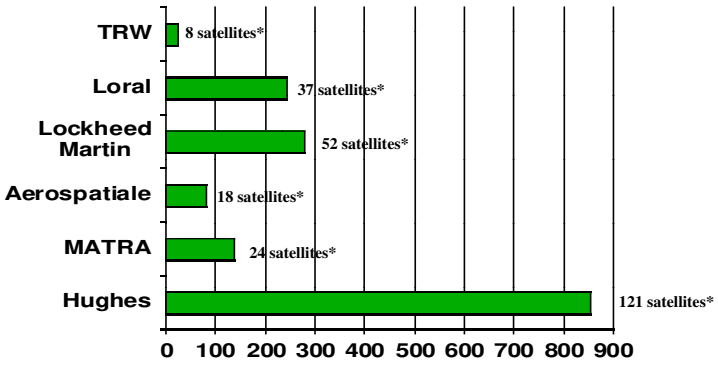

*Commercial satellites launched

Satellite Network Advantages

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Distance Insensitive

- Same cost to connect NYC to LA as Manhattan to Long Island

Ubiquitous access

- Cover USA, for example, from one GSO satellite

Immediate installation

- Buy terminal, set it up, operate
- Supports portable and temporary applications (e.g. disaster recovery, remote location job-sites)

Shared resource

- Suits low-duty-cycle access
- Low cost for low usage

Natural broadcast support

- 'Push' applications – multicast data (e.g., DSS-PC)
- Webcast video (MBONE)

Satellite Disadvantages

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Finite power resource –> throughput limits

- Uplink power drives terminal cost
- Power of satellite limited by launch mass
- Spectrum limitations (as with all wireless comm systems)

Deployment schedule requires long-term plan

- Multi-year deployment
  - –Manufacture satellites
  - –Purchase launch commitments

Shared resource

- High cost for full-time point-to-point usage

When to Use Satellite?

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Use the technology that is best for the application

	Fiber	Satellite
	Full-time link from A to B	Part-time home use
	Inter-exchange trunking	Remote office
	Internet backbone	Small business
		Video distribution
Connections:	Point-to-point	Multi-destination
Site:	Near POP	Anywhere

Broadband Satellite Networks

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Future broadband satellite systems

- SPACEWAY™ – GSO
- CyberStar – similar to SPACEWAY concept
- Astrolink – similar to SPACEWAY concept
- Other GSO systems – similar to SPACEWAY concept
- SkyBridge – LEO/GSO combination
- Teledesic – LEO
- Celestri – LEO/GSO combination

SPACEWAY™ System Concept

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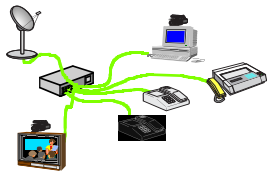
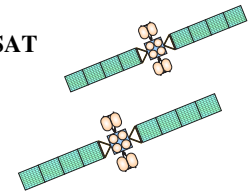
Terminals

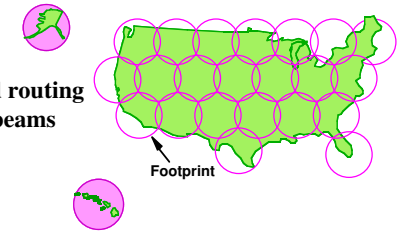
- Low cost, easy to install USAT terminals
  - 66 cm, 384 kbps uplink
  - 1.2 m, 1.5 Mbps uplink
  - 2.5 m, 6 Mbps uplink burst
  - 108 Mbps downlink
- Standard interfaces
- Bursty and constant bit rate applications





- Collocated satellites
- Spot beams enable small, low-cost terminals
- Spot beams give high capacity via frequency reuse

- On-board routing between beams



SPACEWAY™ Internet Access

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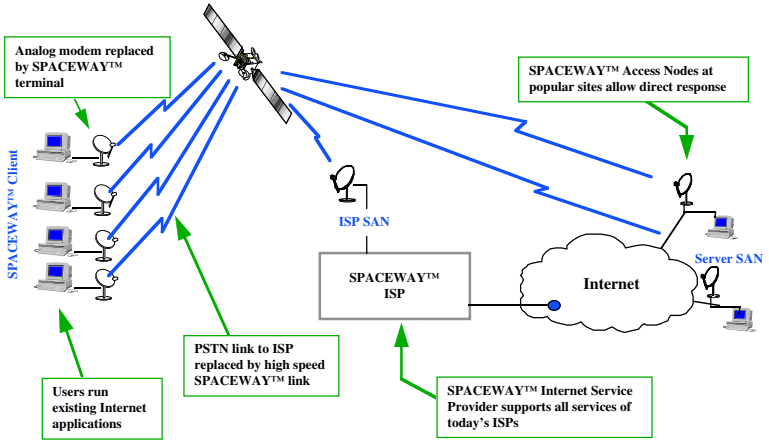

LEO Constellation Concept

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Low orbit

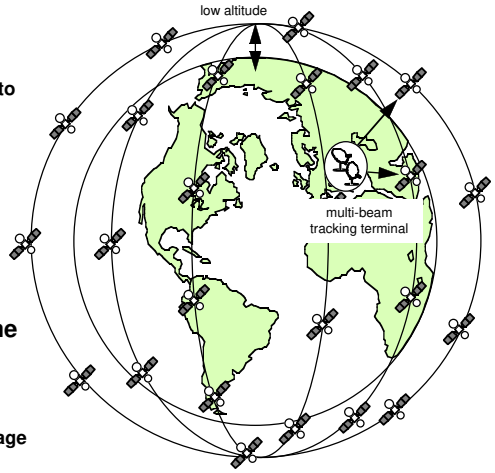
- 700 to 1500 km altitude
- 5 to 7 year satellite lifetime (due to drag of atmosphere)

Satellites in rapid motion

- Terminal tracks satellite
- 5 to 15 minutes in view
- Terminal tracks next satellite coming into view for handover
- Dual (possibly triple) tracking antenna beams

40 to 60 satellites give full-time coverage

- Narrow field of view from each satellite covers small area
- More satellites give better coverage



TCP/IP over GSO Satellite

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GSO satellites support TCP/IP networks today

- HNS builds VSAT networks with 1,000's of sites running TCP/IP
- E.G., WalMart - 2,500 sites, Holiday Inn - 2,200 sites

Link performance is influenced by application and data rate

- Application: Some protocols are unaffected by delay, e.g., UDP/IP for video
- Data rate: Speed of the link
  - –Full TCP/IP throughput requires sufficient buffer for acknowledgment
  - –Buffer size for full throughput = (data rate * delay), e.g.,
    - GSO satellite case: 6 Mbps * 750 ms = 4.5 Mbits = 0.56 Mbytes
    - Cross-continent fiber: 155 Mbps * 60 ms = 9.3 Mbits = 1.16 Mbytes

Internet community is extending TCP/IP and defining new protocols to support broadband links, e.g., 622 Mbps fiber

- TCP/IP was first designed when 9.6 Kbps was fast
- Asserting that 'protocols cannot change' and be backwards compatible is misleading
- BBN, NASA, UC Berkeley, other universities, Sun, HP, DEC, other vendors, are working on improved protocols
  - –Internet Engineering Task Force (IETF) issues new standards (RFC's)

GSO satellite systems will naturally benefit from this work

Satellite Personal Broadband

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Hope, Hype, and Expectations

- Hope for satellite broadband needs realism
  - –Remote hope of inexpensive satellite OC-3 to the home
- Beware of “Hype”
  - –It takes more than press releases to build a network
- Practical expectations
  - –Bulk of traffic will be terrestrial

Satellites may be the best technology for personal broadband

- Ubiquitous access
- Low-cost part-time usage
- ‘Push’ applications delivery
- MBONE video delivery