CS 525M – Mobile and Ubiquitous Computing Seminar

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Satellite-Based Internet: A Tutorial

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Satellite-Based Internet: Introduction

- Internet!!!
- Why new technologies?
  - Growth (applications & hosts)
  - New QoS requirements
  - Mobility
- Why satellite?
  - Global coverage
  - Broadcast capability
  - Bandwidth on demand flexibility
  - Mobility support
- Satellite networks can be: Broadband access networks, high-speed backbone networks, communication links.
- Challenges of interoperation of satellite systems and terrestrial Internet infrastructure

Satellite-Based Internet: Fundamentals

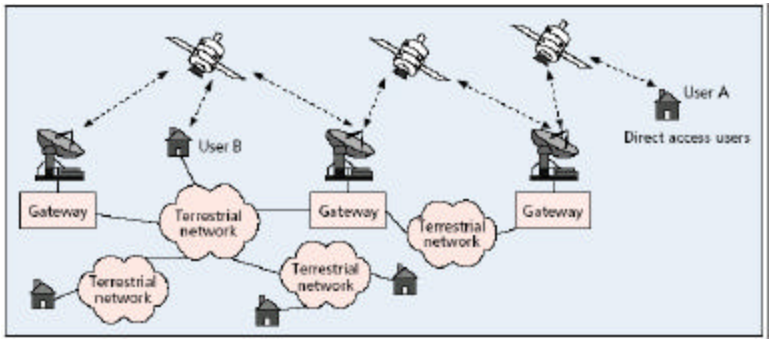
- Satellite system: Gateway Stations (GS), Network Control Center (NCC), Operation Control Center (OCC)
- Satellite types:
  - Geostationary Orbit (GSO): 35’786 km above equator synchronized with Earth’s rotation, covers 1/3 of Earth, RTD of 250-280ms
  - Medium Earth Orbit (MEO): 3’000 km above Earth, RTD of 110-130ms
  - Low Earth Orbit (LEO): 200 – 3’000km above Earth, RTD of 20-25ms
  - MEOs and LEOs require smaller antennas and less transmission power than GSOs but more satellites are needed to cover Earth.

Satellite-Based Internet: Fundamentals

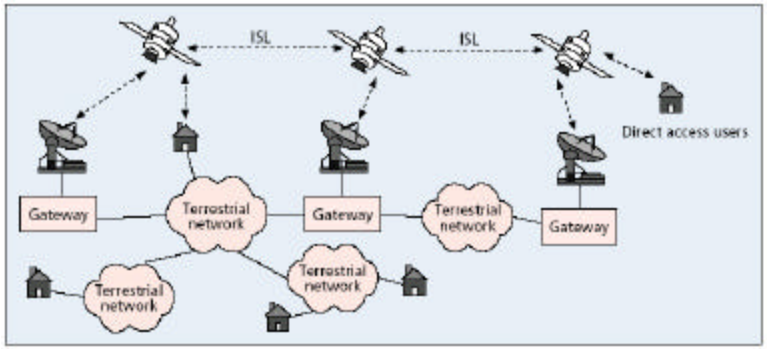
- Satellite Payload:
  - Simple and robust
  - Bent pipes: No onboard processing (OBP)
  - OBP payloads: Demodulation/redemodulation, decoding/recording etc
  - High-capacity intersatellite links (ISLs)
- Frequency Bands:
  - C band (4-8GHz)
  - Ku band (10-18GHz)
  - Ka band (18-31GHz)

Satellite-Based Internet: Architectures

- Many options due to various satellite systems, orbit and payload types.
- Bent-pipe architecture



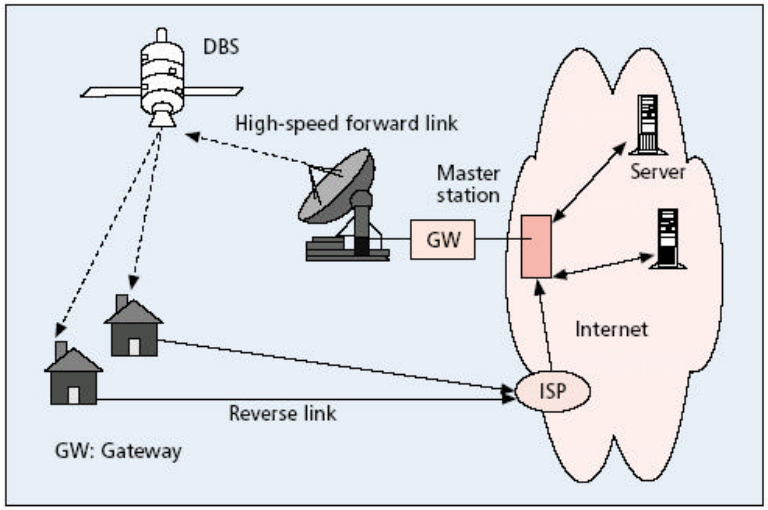
  - Low spectrum efficiency and long delay
- Inter-satellite links



  - Routing issues

Satellite-Based Internet: Architectures

- Two previous architectures used interactive terminals which are expensive in satellite systems.
- Asymmetric architecture



  - Unidirectional routing

Satellite-Based Internet: Technical Challenges

Multiple Access Control (MAC)

- Long latency and limited power resource in satellites constrain choices of MAC protocol.
- Protocol must be: simple, robust, support priorities, flexible, achieve high throughput, maintain channel stability, low overhead, small delays
- Fixed assignment protocols:
  - Frequency division multiple access (FDMA)
  - Time division multiple access (TDMA):
    - Like FDMA, each station has dedicated channel, contention free, provide QoS
    - No interference (one user accesses transporter)
  - Code division multiple access (CDMA):
    - Code sequence assigned to users
    - Use of whole bandwidth (flexibility for system expansion)

Satellite-Based Internet: Technical Challenges

Multiple Access Control (MAC) 2

- Random access protocols:
  - Due to increased number of users and bursty traffic fixed assignment replaced by random access
  - Random transmissions ignoring other stations
  - Collisions and retransmissions increase delays and decrease throughput
- Demand assignment protocols:
  - Random access makes no QoS guarantees
  - Dynamically allocate bandwidth based on requests
  - Reservation can have centralized or distributed control, can made explicitly or implicitly
  - Some mechanisms: PODA, FODA (implicit and explicit reservations), CFDAMA, CRRMA, RRR (unreserved resources assigned to other stations after reservation)

Satellite-Based Internet: Routing Issues

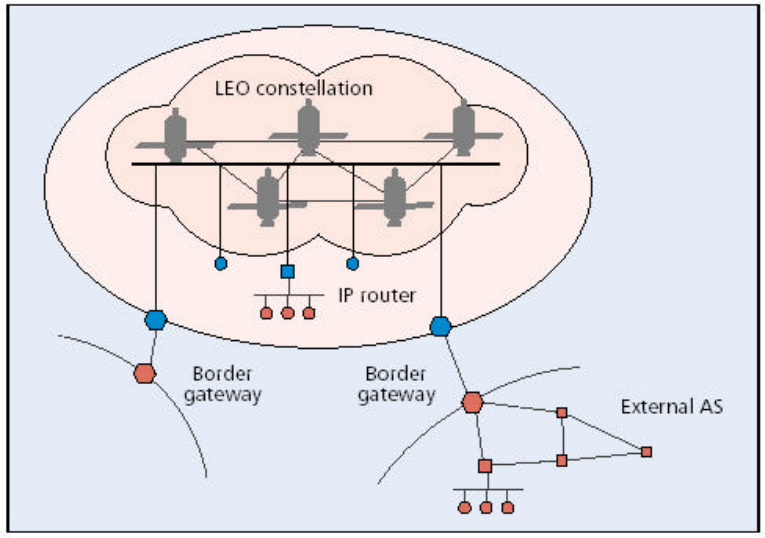
- Dynamic topology:
  - Two handover types (intersatellite, interbeam)
  - Two ISL types (intraplane, interplane may change)
- Discrete-time Dynamic Virtual Topology Routing
  - Period time divided into time intervals
  - Topology remains the same within one interval
  - Routing tables retrieved when topology changes
- Virtual Node Routing
  - Hide topology changes from protocols
  - VNs keep state info of users
  - VNs represented by different satellites as topology changes
  - Routing decisions based on virtual topology

Satellite-Based Internet: Routing Issues (2)

- IP Routing
  - Based on VN routing
  - Variable –length packets, scalability of routing tables, computational & processing capacity limitations
- ATM Switching
  - ATM version of DT-DVTR
  - All virtual channel connections between satellites grouped into a VPC
  - Onboard switching according to VPC labels

Satellite-Based Internet: Routing Issues (3)

- External Routing Issues
  - Terrestrial Internet should not know details of satellite system: Satellite system is an AS



  - Space-based BGs: Too much computational load and storage requirements for satellites
  - Terrestrial BGs: Extra round trip delay but more realistic

Satellite-Based Internet: Routing Issues (4)

- Unidirectional Routing
  - Static routing
  - Routing Modification
    - Send-only interface: feeder
    - Receive –only interface: receiver
    - Receivers filter update messages to identify potential feeders and vice versa
  - Tunneling
    - Virtual bidirectional tunnel set up between user and DBS
    - Packets are encapsulated/decapsulated at end-points

Satellite-Based Internet: Satellite Transport

- TCP/IP and UDP/IP affected by delays and errors
- TCP performance
  - Slow feedback, false timeouts and retransmissions
  - Very slow start!
  - TCP can’t differentiate between corrupted data and packet loss due to congestion
  - Network asymmetry affects ACK transmissions
  - Fairness issue
- Performance Enhancements
  - TCP selective acknowledgment
  - TCP for transaction
  - Persistent TCP
  - Path maximum transfer unit
  - FEC

Satellite-Based Internet: Satellite Transport (2)

- TCP extensions can’t solve problems like long end-to-end delays and asymmetry
- Split TCP connections at the GSs
  - TCP spoofing
    - GS isolate divided connections and send spoofing ack’s
  - TCP splitting
  - Web caching
    - Web cache splits connection
    - Users connected to cache don’t need to set up TCP connections if required data are cached
- Satellite Transport Protocol
  - NACK

Satellite-Based Internet: Conclusion

- Possible architectures
- Technical issues
- Research issues:
  - IP QoS:
    - ATM based QoS
    - MPLS
  - Traffic and congestion control