Networking over next-generation satellites

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Introduction

On-board processing (OBP) satellites are changing satellite network architectures

- Networks of interconnected low earth orbit (LEO) satellites
- Antenna arrays provide “hopping” beams for better power utilization
- Improvements in electronics enabling low-power/low-weight processing payloads, allowing on-board switching (OBS)
- Advances in FEC eliminating transmission errors on many links

Introduction (cont.)

General research questions:

1. How do next-generation "OBS" systems fit into evolving Internet and broadcast-media architecture?
2. How do advanced Internet protocols and applications perform over asymmetric/high-latency channels?

GEO vs. LEO satellites

- GEO advantages:
  - Much cheaper to deploy
  - Do not require tracking antennas, handoff control procedures
- LEO advantages:
  - Reduced latency and terminal power
  - Higher availability
- We must consider both
  - Several proposed systems use both

Network architecture

1. How do next-generation OBP systems fit into evolving Internet architecture?

Our emphasis is on exploiting the *broadcast* capabilities of satellites

Network architecture

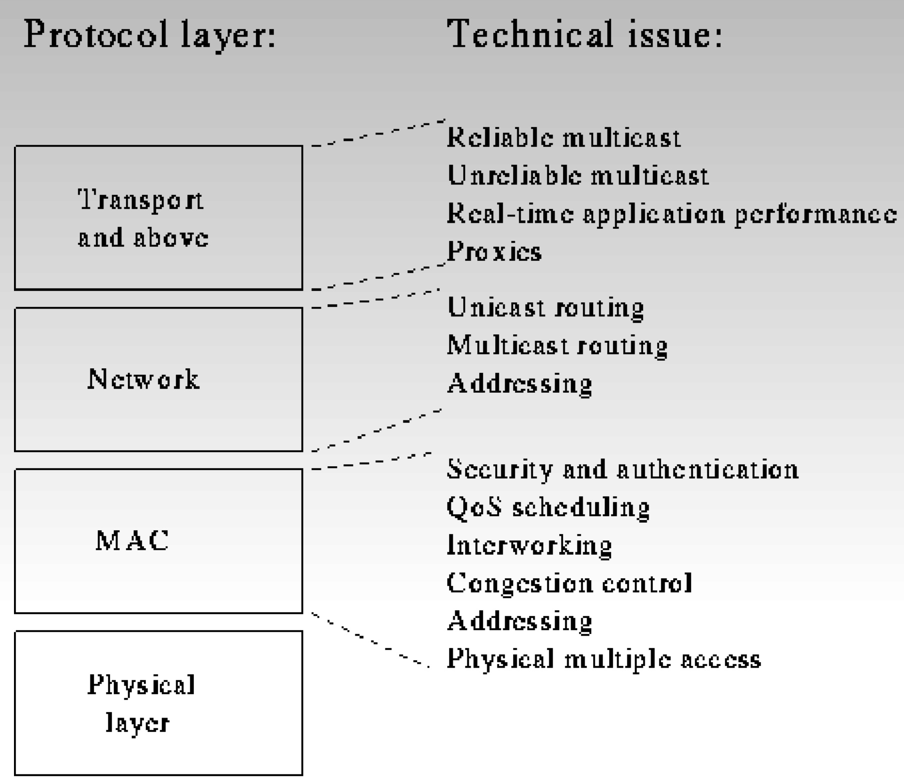
Communications system architectures should be *application/service driven*:

Wide area communication services (and satellite examples):

- IP access-- DirecPC
- multimedia broadcast-- DBS
- LAN/WAN interconnection-- Advanced VSAT
- ISP interconnection-- Teledesic

Network architecture

- We first focus on MAC and Network layer



Network architecture: MAC

- Many proposed systems based on ATM
- Does ATM make sense in this architecture?
  - IP: broadcast friendly network layer (nice indirection for multicast)
  - ATM: a point-to-point, connection oriented technology
  - Physical layer: Broadcast medium, with multicast capable switching

Network architecture: MAC

Why might ATM be poor for satellites?

- Support for multipoint-multipoint connections is poor, does not match IP well
- Multiple access protocol is limited
- Bandwidth inefficient (10% overhead without cell header compression)
- QoS granularity not well suited to wireless networks
- Why manage two large address spaces?

Network architecture: MAC

- A better alternative: a simpler MAC, matched to IP/MPEG-2 traffic
  - MAC address space only as large as needed to route in the satellite network
  - Enable high QoS (low delay variation) in scheduling mechanism
  - Interwork with ATM (handle resequencing)
  - Use IP address space for end-system routing

Network architecture: MAC

- Potential research issues:
  - MAC design; physical multiple access + MAC framing + addressing + scheduling
  - QoS scheduling in high-latency environment
  - Interworking with various network technologies; primarily ATM
  - Congestion control

Network architecture: Routing

- Datagram routing in LEO and mixed LEO/GEO systems
  - Overall routing strategy (what is messaging overhead required for different protocols?)
  - Rapid response to dynamic topology changes
  - Handoff of QoS reserved flows (which drift to a suboptimal route)
  - Load balancing and routing around temporary hot spots
  - Enabling policy based routing
  - Handling asymmetry and mobility

Network architecture: Routing

- Multicast routing
  - How well do current and proposed multicast routing protocols handle asymmetry?
  - How can we force fast convergence of multicast routing in a rapidly changing network topology (LEO systems)?
  - Routing hierarchy: Can dense mode traffic be preferentially routed over satellites
  - Delay-based routing metrics
  - Scalability of IGMP

Network architecture: Addressing

- Global satellite addressing based on IPv6 or compressed IPv6?
  - 16 bytes/address expensive in overhead but adds flexibility in assignment
- Routing hierarchy should assign addresses based on geographical location
- Hosts must filter based on IP address
  - enables scalability of system to “unlimited” number of nodes

Network architecture: Security

- Security (key distribution) and authentication at IP layer
  - MAC addresses not globally unique
  - complicates TCP spoofing, splitting strategies

Protocols

2. How do advanced Internet protocols and applications perform over asymmetric/high-latency channels?

This question pertains to end-to-end protocols and applications, both for GEO and LEO systems

Protocols: Transport

- Unicast transport already well studied (TCP over satellites)
- Reliable multicast is interesting
  - e.g., how does the broadcast asymmetric link affect how error recovery is performed?
- Even unreliable multicast protocols are of interest
  - Receiver-driven layered multicast (RLM) may have bias against long round trip times

Protocols: Applications

How does latency affect popular multicast applications?

- Experimental evaluation of popular applications, such as the MASH tools
- Subjective evaluation by experienced users, (such as the VINT meeting)
- Split-session routing: Should some multimedia components be routed differently?

Protocols: Proxies

- Web caching and prefetching
  - e.g., broadcast disk strategies
- TCP spoofing or connection splitting

Simulator status

- ns-2 simulator appropriate for studies
  - several advanced Internet technologies (latest TCP, RED queueing, PIM routing, etc.) already supported
  - abstraction techniques for scalability anticipated (but not there yet)
- To do:
  - Extend Giao Nguyen’s MAC work
  - Support (and routing protocol) for dynamically changing topologies

Conclusions

- Datagram networking (particularly multicast) over on-board-switching satellites is a promising research area
- Two general research areas involve:
  1. Network architectures
  2. Protocol and application performance
- We invite your feedback on this future work effort