UNIVERSITY OF MARYLAND

CENTER FOR SATELLITE AND HYBRID COMMUNICATION NETWORKS

PROTOCOL SUPPORT FOR A NEW SATELLITE-BASED AIRSPACE COMMUNICATION NETWORK

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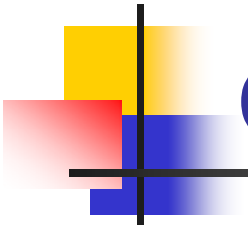

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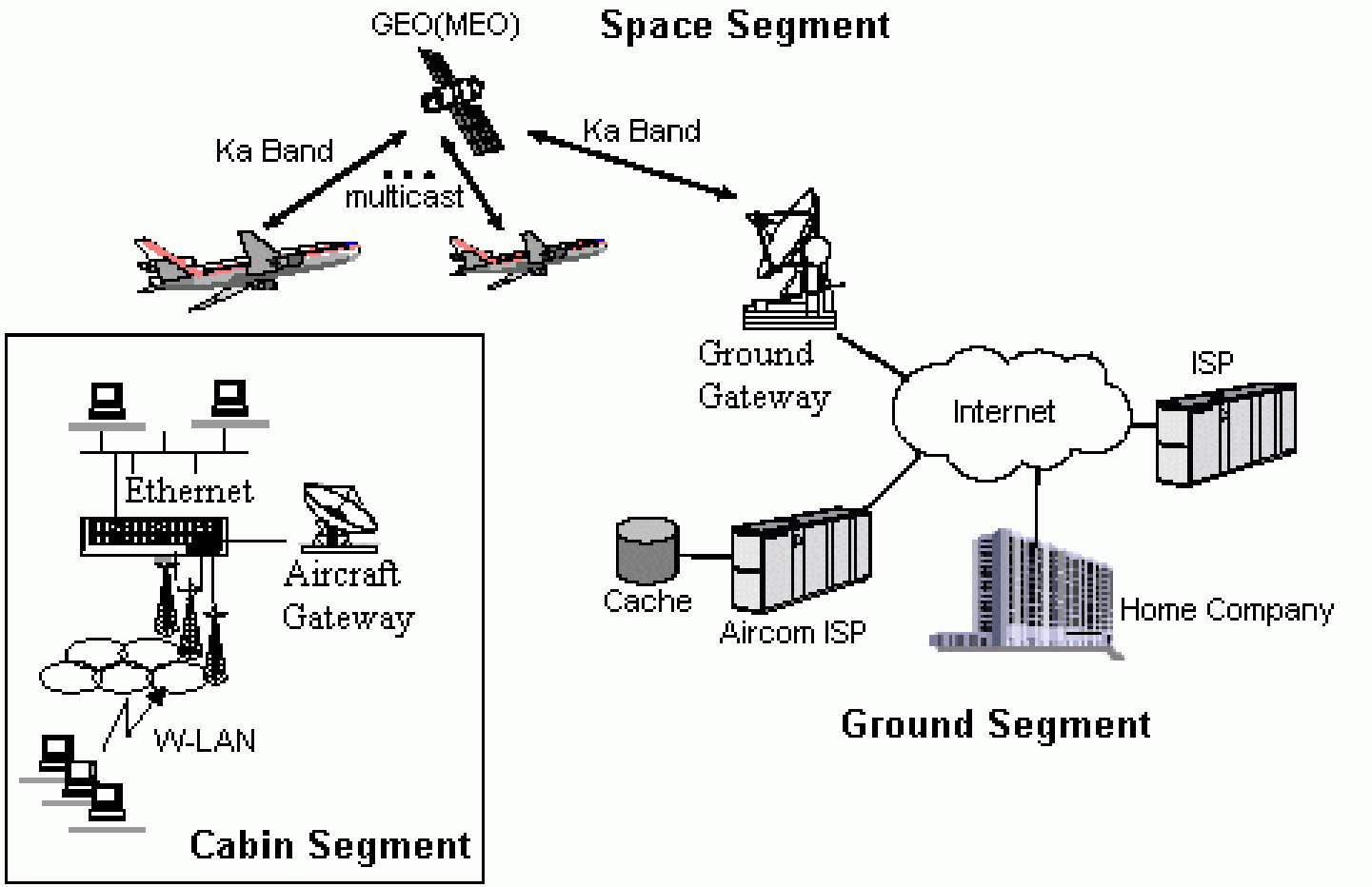
Introduction

- Significance
  - Increased air traffic volume vs. old communication system
  - Use Satellite technology for aeronautical communication
  - Internet data services for passengers on flight
  - TCP/IP protocol support
- Objectives
  - Evaluate TCP performance on aeronautical network
  - Design a better transport protocol

Aeronautical Satellite Network



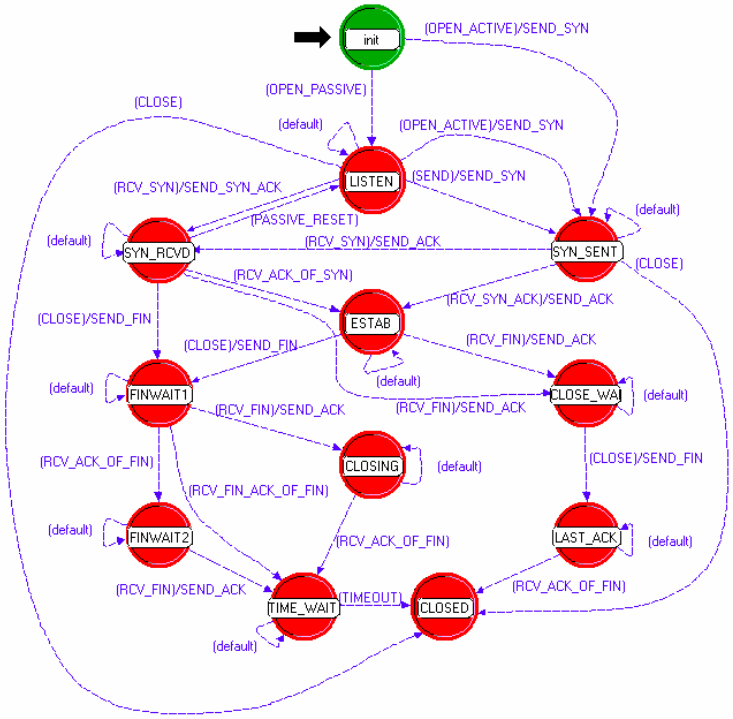
Network Characteristics

- Satellite Channel Characteristics
  - long propagation delay,
  - large bandwidth delay product,
  - occasional high bit error rate,
  - bandwidth asymmetry
- Aeronautical network
  - Mobile Aircraft
  - En-route Low BER
  - FIFO Satellite Channel
  - Intermittent connectivity
  - Variable Round Trip Time

TCP Operation

- Flow Control: Sliding window

  Received window=receiver Buffer size
- Congestion Control: Congestion window
  - Slow start
  - Congestion avoidance
  - fast retransmission
  - fast recovery
- Error Control: acknowledgement, timer, and retransmission

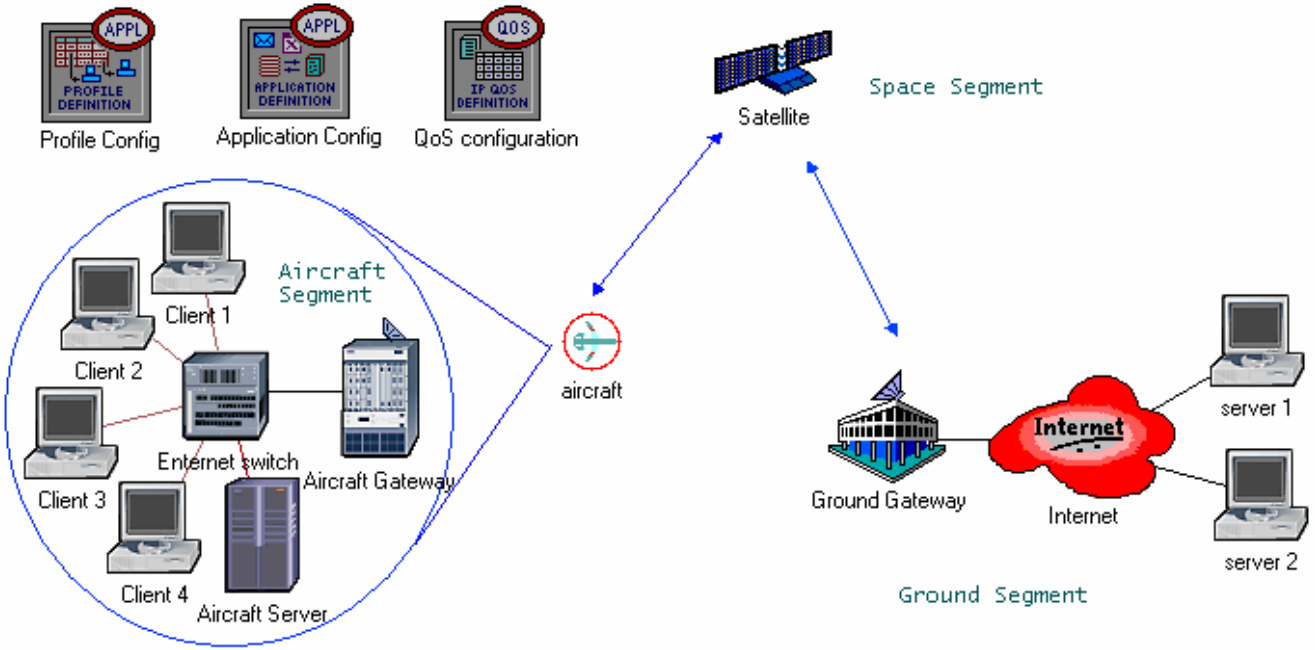


End-to-End TCP solution

Satellite Hybrid Network	*TCP Problems*	*End-to-End TCP Solution (Flavors and Extensions)*
Long propagation delay	Spend long time in Slow Start	Large Initial Window (4 MSS)
Large bandwidth-delay product	16bits Window	Window Scaling (multiple losses in one window)
High bit error rate	Drop its congestion window to a small size	Can not use fix window, TCP SACK for recovery
Bandwidth asymmetry	Increase ACKs delay	Priority Queue

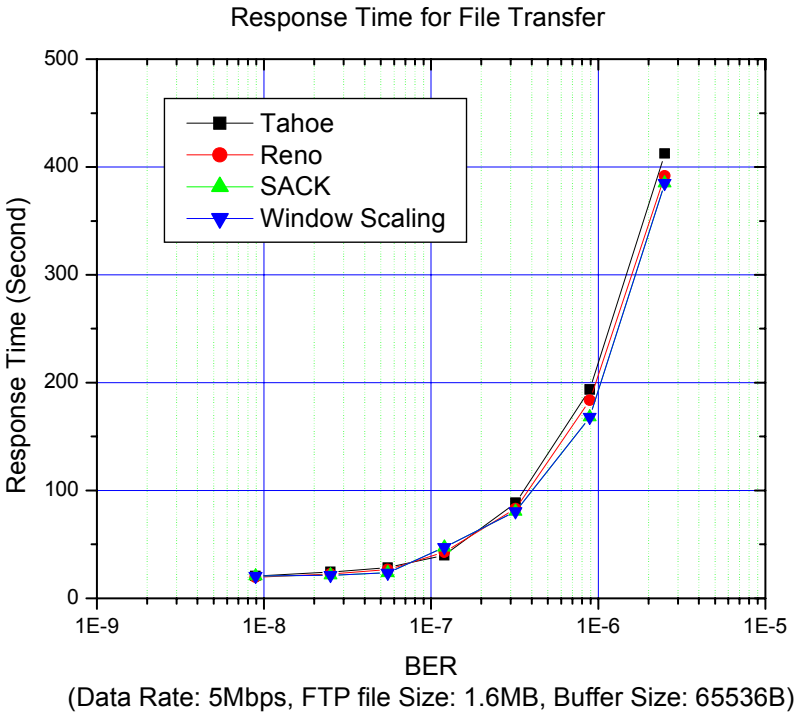
Other mechanisms: Path MTU discovery, Forward Error Correction, Ack filtering.

Experiment setup

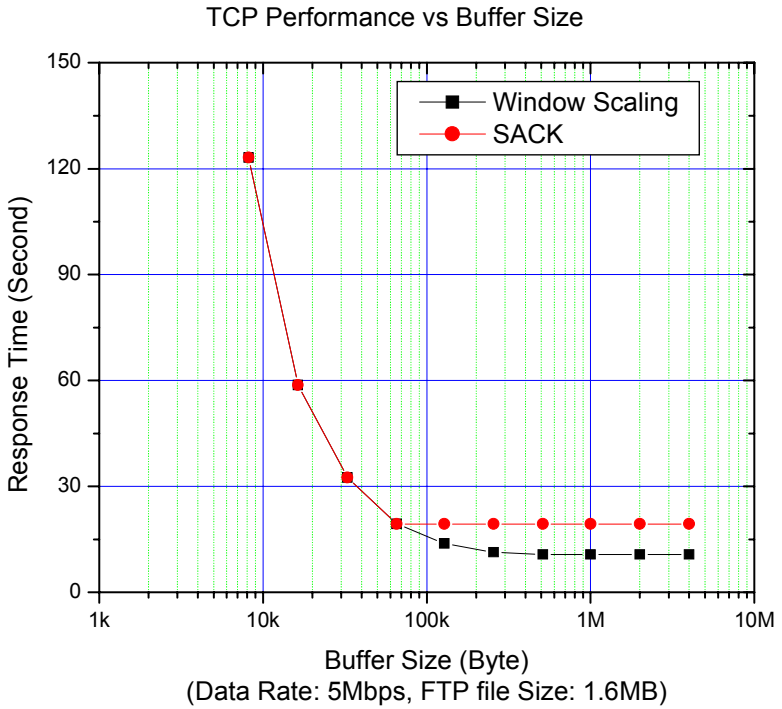


Tahoe	Fast Retransmit
Reno	Fast Retransmit and Fast Recovery
SACK	Selective Acknowledge
Window Scaling	SACK and Window Scaling

End-to-End TCP Performance



(Data Rate: 5Mbps, FTP file Size: 1.6MB, Buffer Size: 65536B)



(Data Rate: 5Mbps, FTP file Size: 1.6MB)

Unsolved problems

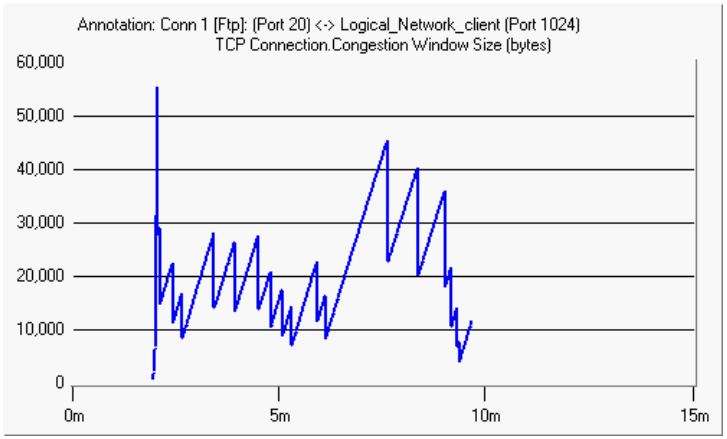
- Small operational window

  Large propagation, slow start and link layer corruption

  RecvWin / GndRTT = SatWin / SatRTT

  Throughput=min (SatBW, Buff / (SatRTT + GndRTT))

  Backlog packets=max(o,Buff–SatBW*(SatRTT+TerrRTT))



BER=1E-7

DS1=1,544,000bps

RTT=580ms

Unsolved problems (cont.)

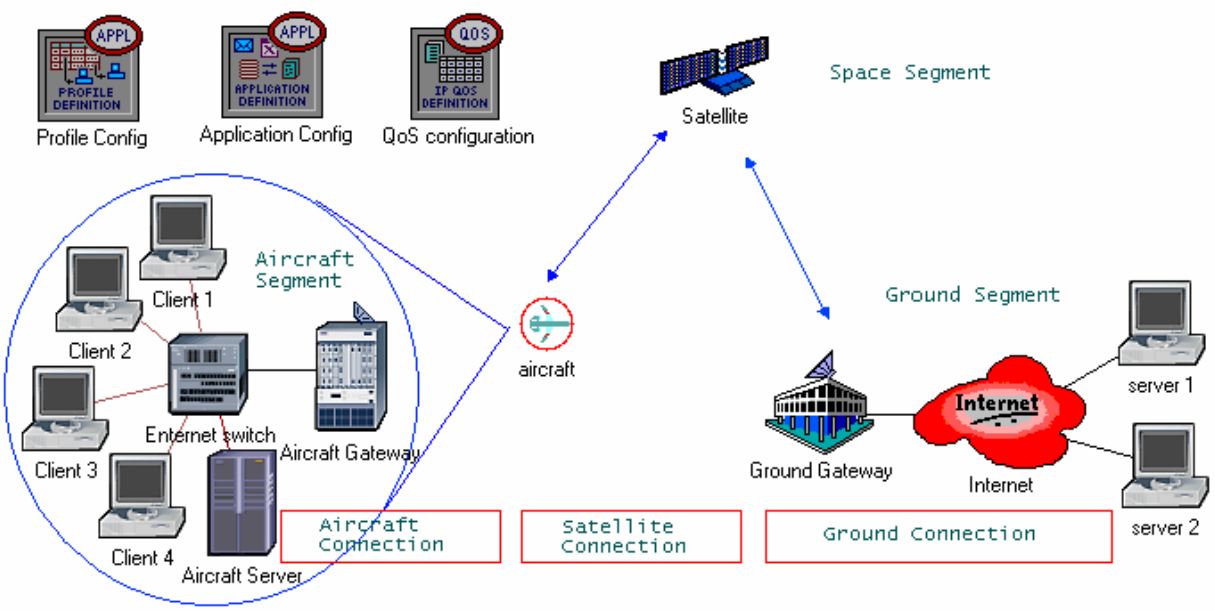
- Asymmetric link

  Congestion in reverse link: ACK filtering, Priority Queue

- TCP Fairness

  TCP throughput is inverse proportional to RTT, so TCP connection with large RTT does not get its fair share of the bandwidth when it competes with the connections with shorter RTT

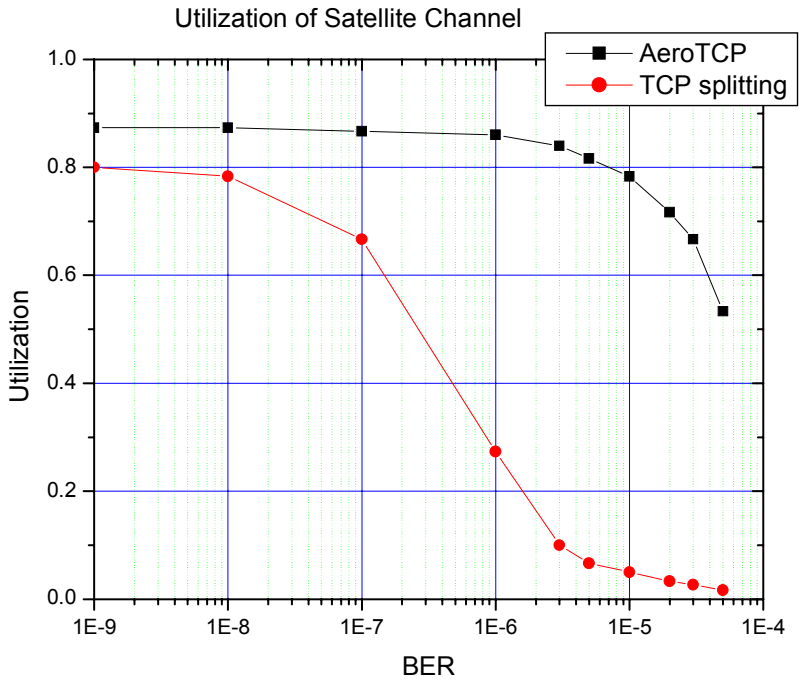
TCP Splitting Protocol

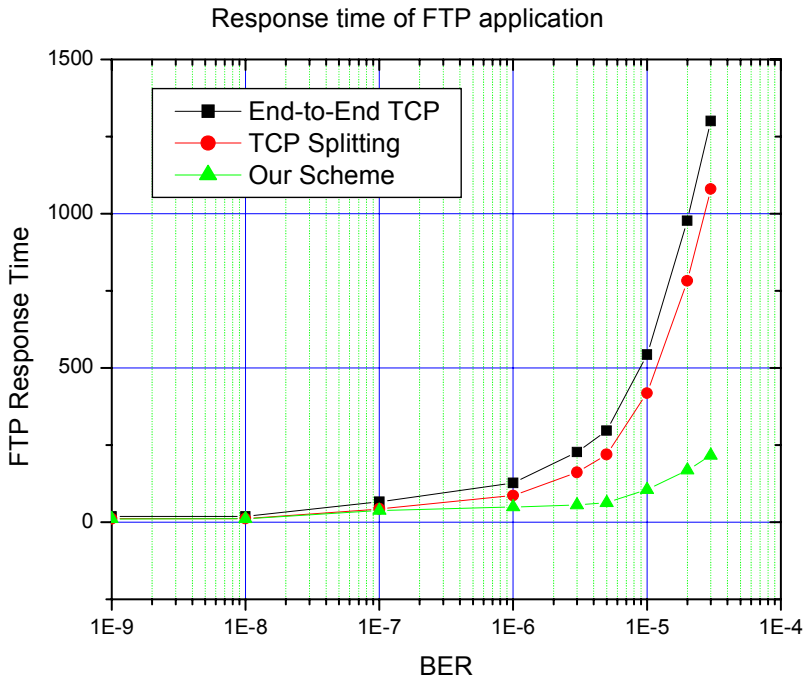


AeroTCP

- Flow Control: Fixed window for each connection
- Congestion Control: FIFO Channel, No congestion
- Error Control: One duplicated ACK for fast retransmission and partial ACK for burst loss recovery

TCP splitting protocol performance





Study Scenario: 2 Connections, TCP/IP/PPP, FTP application, File size=1.6MB, DS1=1,544,000bps, RTT=580ms (500ms for satellite link and 80ms for terrestrial link)

AeroTCP (Our scheme), TCP splitting (TCP SACK for both connections), and End-to-End TCP

Conclusion

- We observed degradation in TCP performance for large bandwidth-delay product networks such as aeronautical satellite systems. If the right TCP options are used and congestion is light, TCP can work well for large file transfers even over GEO links.
- It is difficult for an end-to-end TCP solution to solve the problems in the aeronautical satellite networks, our connection splitting based solution, AeroTCP, can maintain high utilization of the satellite link and has better performance than end-to-end solutions.

Future Work

- Modeling the realistic Ka-band satellite channel (Uniform BER in OPNET, burst error)
- Support other applications and services (FTP, HTTP, TELNET, Email, Telephone, Video)
- Support more aircraft and global coverage (MAC layer protocol, spot beam handover, ISI)