Networking Using Direct Broadcast Satellite

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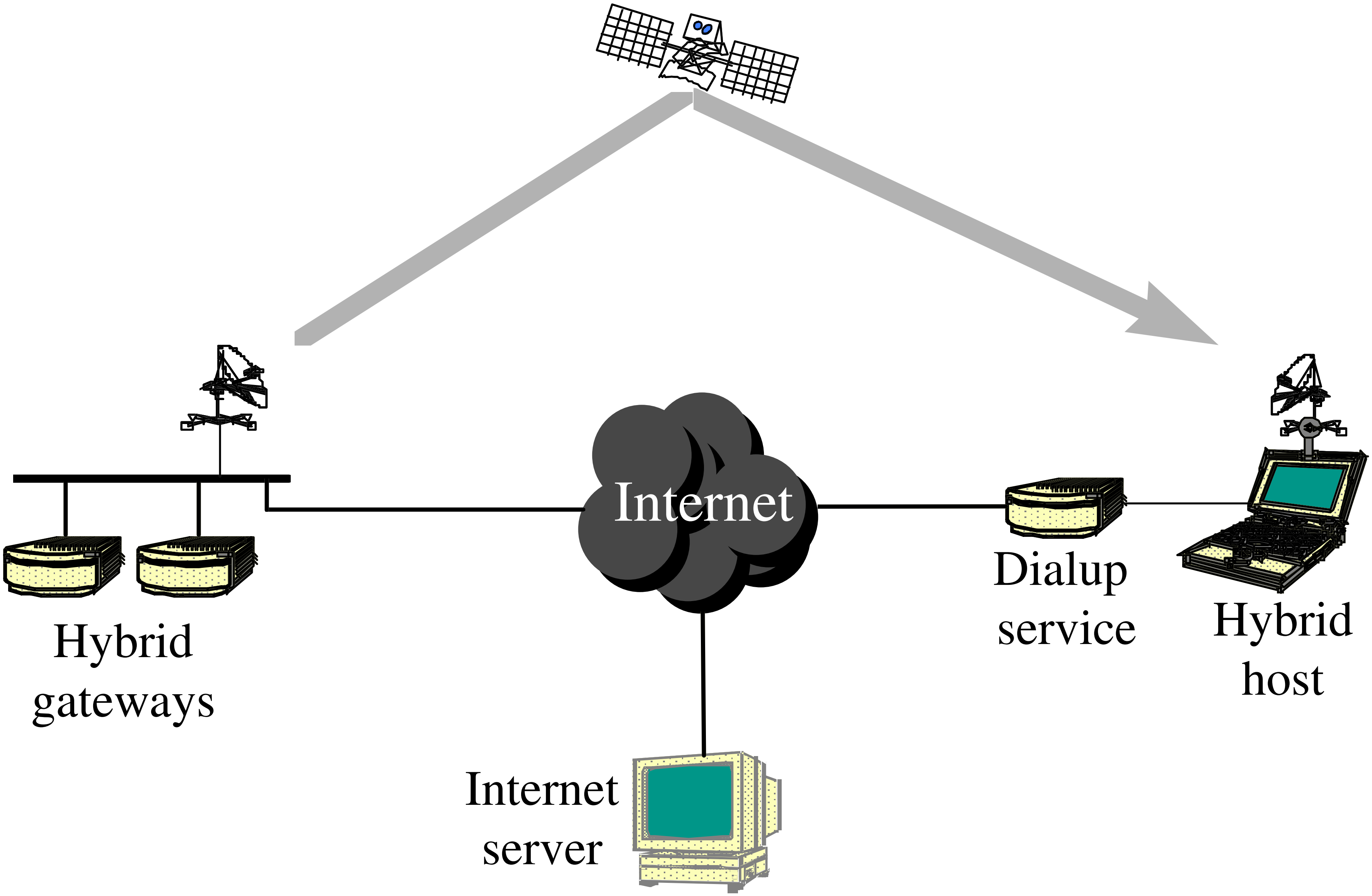
Outline

- The Hughes DirecPC system
- Easy relocation: “LAN-in-a-van”
- Routing issues
- Data transport issues and performance
- Application issues
- Summary and future work

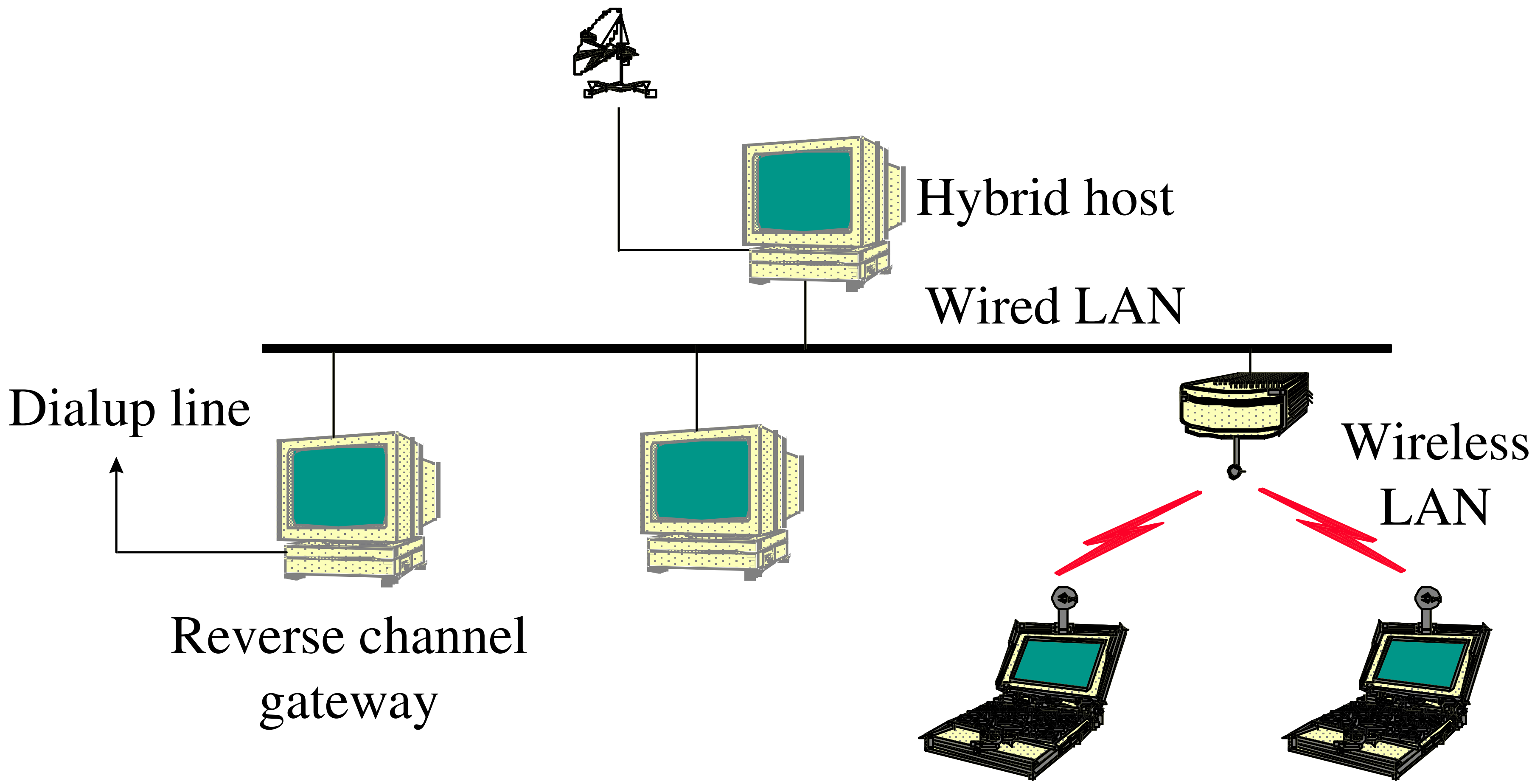
The Hughes DirecPC System

- Geostationary satellite broadcasts data over a large geographical area
- Asymmetric access to the Internet
  - 12 Mbps aggregate downlink; target rate of 400 Kbps per user
  - reverse channel usually slow (e.g., dialup line)
- Simple equipment at user premises
  - 24-inch dish antenna, special network adapter
- Easy to deploy

DirecPC Hybrid Network



LAN-in-a-Van


Hybrid host
Wired LAN
Dialup line
Wireless
LAN
Reverse channel
gateway

LAN-in-a-Van

- Enables easy relocation of networking infrastructure
- Hybrid subnet can integrate *heterogeneous* technologies
  - wireless LANs enable further mobility in the vicinity
- Several practical applications
  - mobile command and control center
  - medical emergency vehicles

Challenges

- Asymmetric routing
  - send data via the reverse channel, receive data via the DBS downlink
  - extend routing support to all hosts in the LAN
- Asymmetric bandwidth characteristics
  - reverse channel typically has a much smaller bandwidth than the DBS downlink
- Long fat data pipe
  - large delay-bandwidth product of connections

Asymmetric Routing

- DirecPC solution
  - hybrid host has IP addresses for 2 interfaces: DBS downlink and reverse channel
  - use DBS address as IP source address of outgoing packets
  - replies to DBS address routed via satellite downlink
- Limitations
  - works only for a stand-alone hybrid host
  - problems if IP-spoofing protection employed by reverse-channel service provider

Asymmetric Routing

- Our solution: home agent-based routing
  - based on IETF Mobile IP to extend routing to entire hybrid subnet.
    - well-connected home agent for each host.
    - hybrid host acts as a foreign agent.
  - outgoing packets are tunneled to the hybrid gateway which forwards them to the Internet server
  - incoming packets are routed via the home agent which tunnels them to the hybrid host.
- Limitations
  - tunneling overhead, routing via home agent

Asymmetric Routing

- DirecPC solution:
  - DBS address as source for outgoing packets
  - replies arrive via DBS downlink
  - Limitations:
    - works only for stand-alone hybrid host
    - problems with IP-spoofing protection
- Our solution: home agent-based routing
  - home address as source for outgoing packets
  - tunneled to hybrid gateway
  - replies routed via home agent
  - Limitations:
    - tunneling overhead, routing via home agent

Data Transport Performance

- Testbed
  - hybrid host at UCB
  - reverse channels:
    - 14.4 Kbps dialup SLIP return
    - 10 Mbps Ethernet
- Experiments
  - UDP transfers
  - TCP bulk transfers
  - Web-like transfers

UDP Transfers

Goal: to estimate bottleneck link characteristics

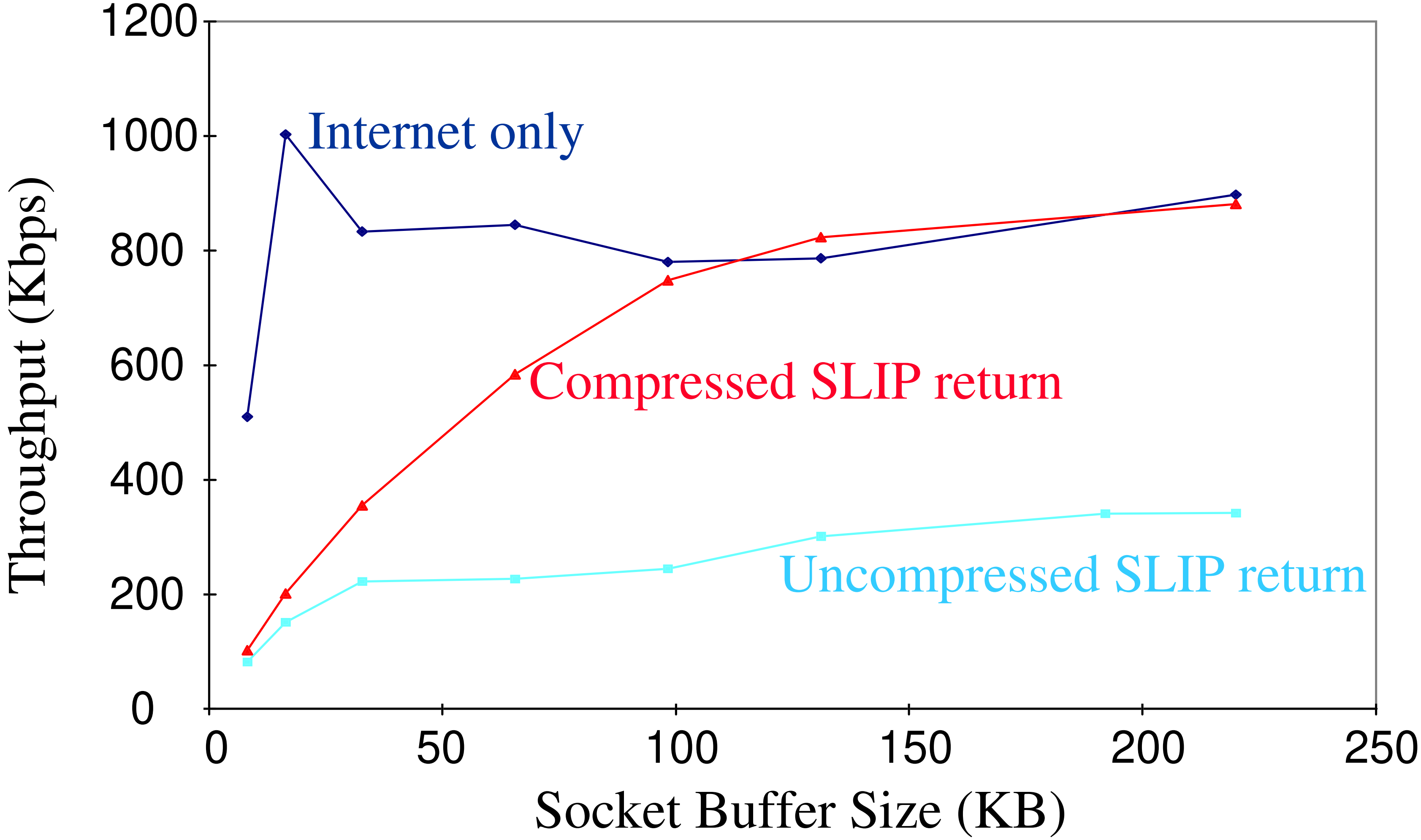
- Sent a constant rate UDP stream via DBS earth station and downlink
  - a total of 16 Internet hops
  - experiments done late at night to minimize chances of interfering traffic
- Bottleneck link characteristics
  - bandwidth: ~ 1.4 Mbps (close to T1 speed)
  - bottleneck buffer size: ~ 56-64 KB

TCP Bulk Transfers

Asymmetric bandwidth characteristics

- Without SLIP header compression
  - ACKs place an upper bound of 460 Kbps on throughput
  - observed throughput was 350 Kbps
- With SLIP header compression
  - upper bound on throughput is 3.1 Mbps
  - observed maximum throughput was 880 Kbps
- Failure of TCP MSS negotiation

Results: TCP Throughput

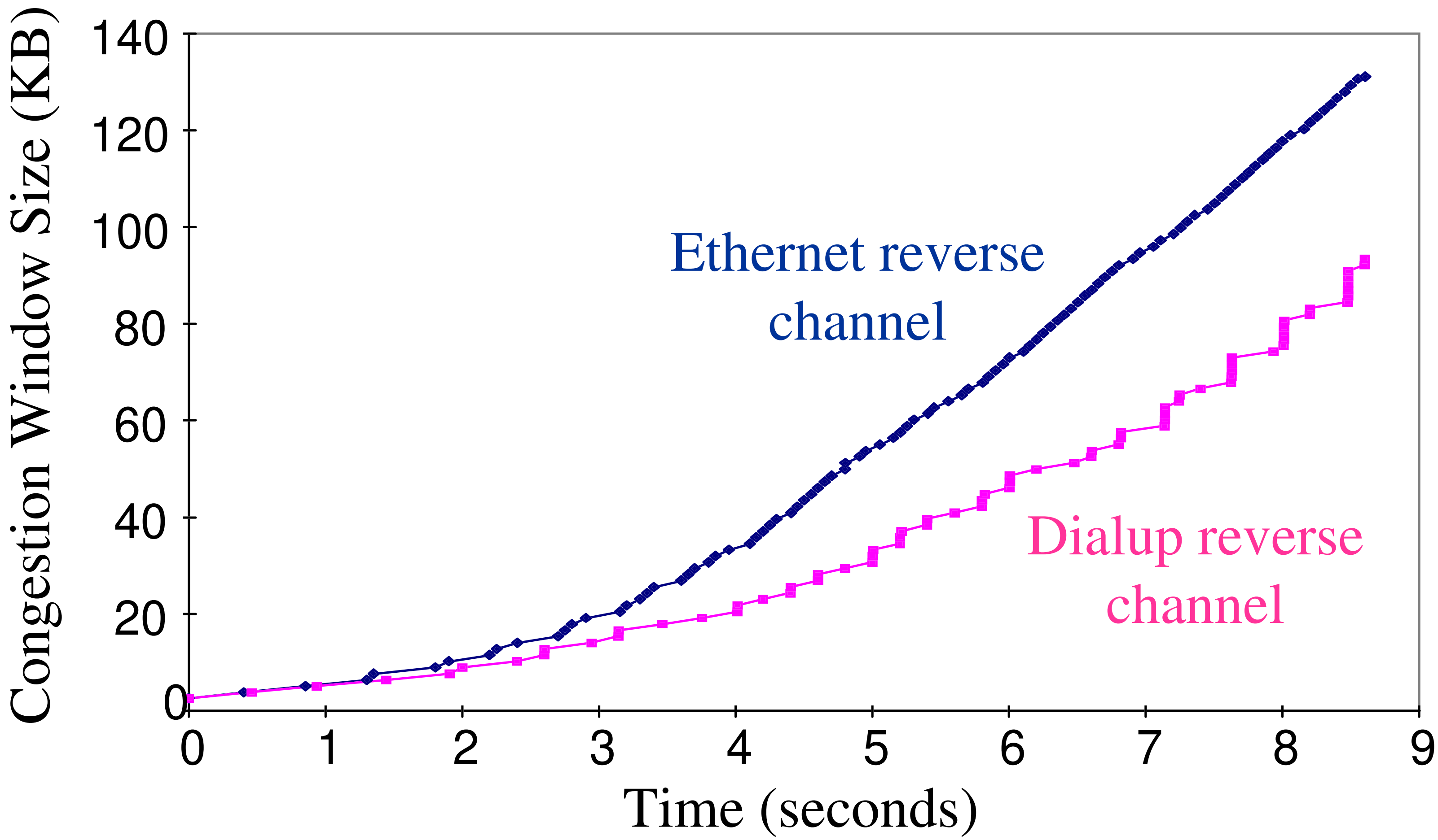


Summary of TCP Bulk Transfers

Large bandwidth-delay product

- Large delays
  - 270 ms for satellite hop, 180 ms for dialup line
- Large socket buffers help improve throughput
  - levels off beyond ~ 130 KB
  - but large buffer sizes hurt Internet-only transfers
- TCP SACKs help in the presence of losses
  - preliminary experiments indicate 20-50% improvement in throughput

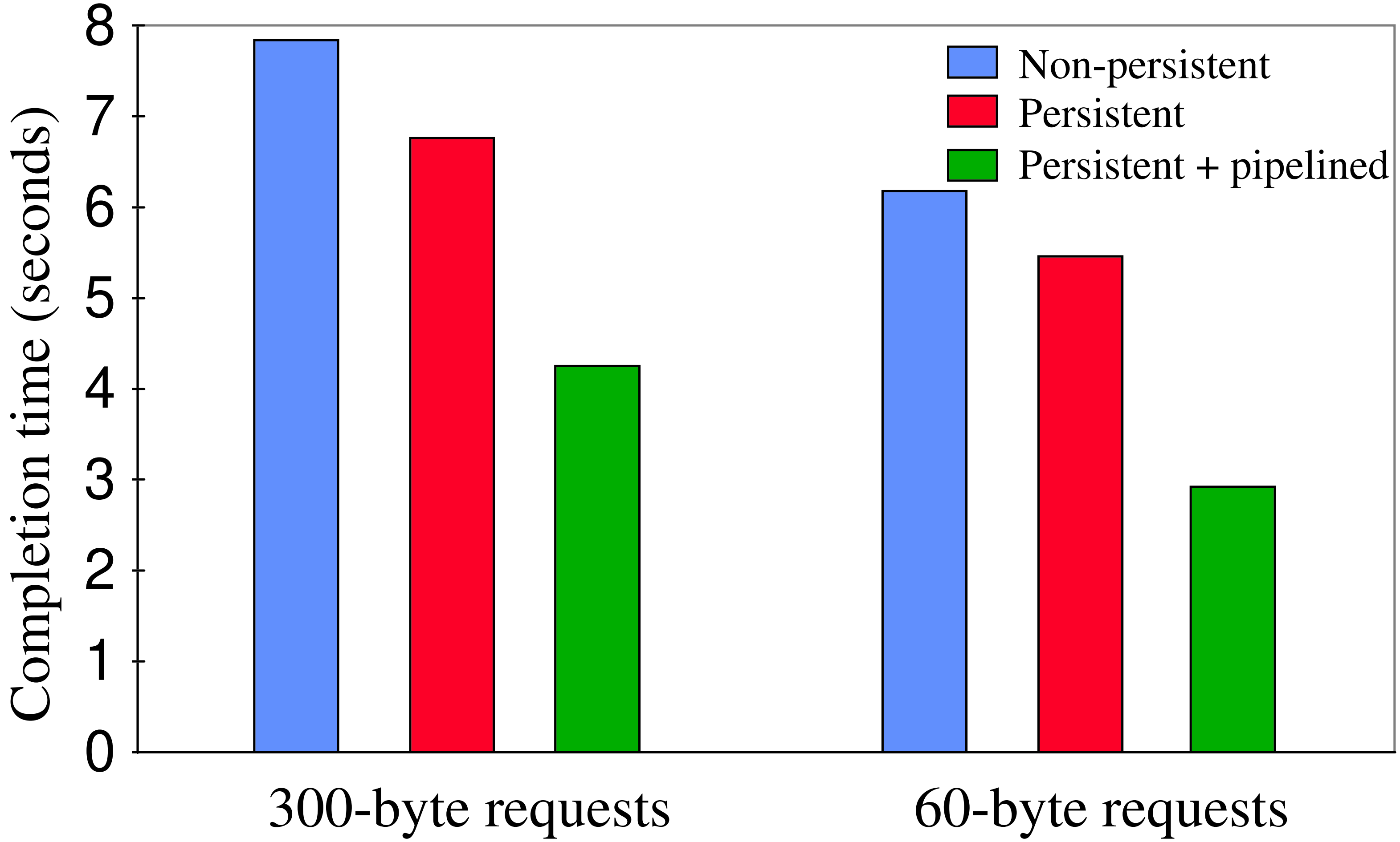
Results: TCP Window Growth



Web-like Transfers

- Hyper Text Transfer Protocol
  – separate TCP connection for each short transfer
  – dominance of round-trip time increases latency
- Persistent-connection HTTP [PM94]
  – persistent connection between client and server
  – pipelined requests
- Other optimizations
  – coalesce multiple HTTP requests into one packet because large portions remain unchanged
  – helps when reverse channel bandwidth is limited

Results: Web-like Transfer



Four 5-KB transfers between simulated server and client

Audio/Video Dissemination

- Heterogeneity
  - network bandwidth
  - multicast capability
  - end-system capability
- Real-time conferencing by proxy
  - RTP-aware transcoding agents
  - control agent (*proxy*) adaptive rate control
  - example transcoder: video gateway [AMZ95]
    - real-time transcoding
    - address translation

Summary

- Relocatable networking using DirecPC
  - LAN-in-a-van for instant infrastructure
- Asymmetric routing
  - Mobile IP-like solution
- Asymmetric bandwidth
  - SLIP header compression helps overcome bandwidth asymmetry (T1 bottleneck)
- Large bandwidth-delay product
  - large socket buffers and SACKs
  - persistent-connection HTTP
- Real-time audio/video dissemination

Future Work

- General study of implications of asymmetry for data transport
  - bandwidth, delay, round-trip variability, loss characteristics
  - other networks: e.g., wireless cable modems
- Adaptive proxy architecture
  - real-time audio/video conferencing
  - Web access