Asymmetric Bandwidth Channels

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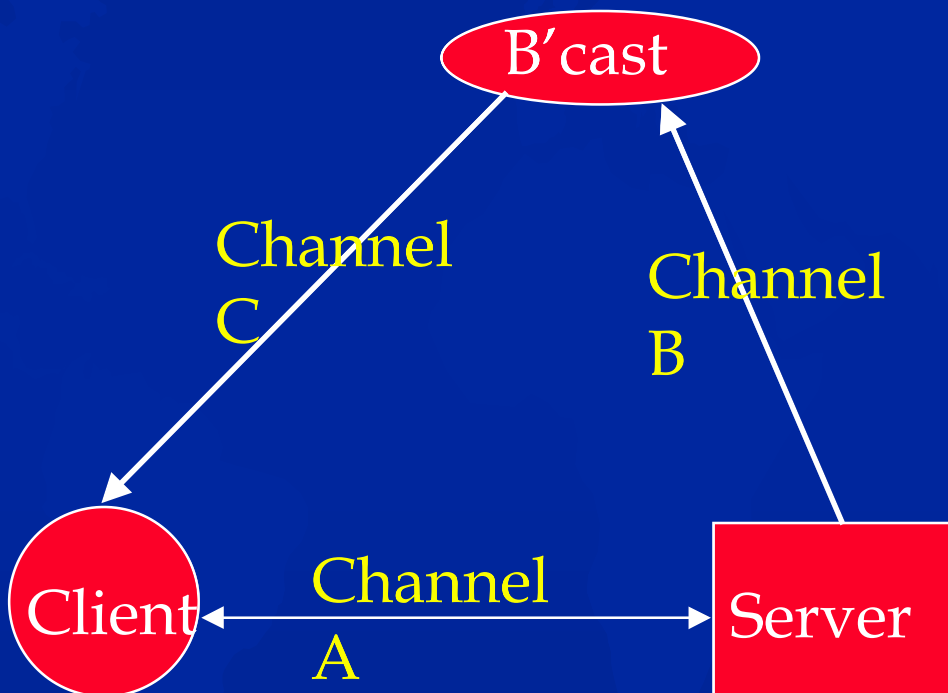
The ABC Model



Channels A, B and C

- A is low latency and B/W, duplex
- B is hi latency and B/W, simplex
- C is hi latency and B/W, simplex
- B is unicast and C is multicast
- A *may* be real-time (POTS, ATM)

Opportunity for Basic Research

- CATV and DBS penetration; ADSL also!
- Cost advantage for multicast
- Bidirectional channels WRONG!

Applications

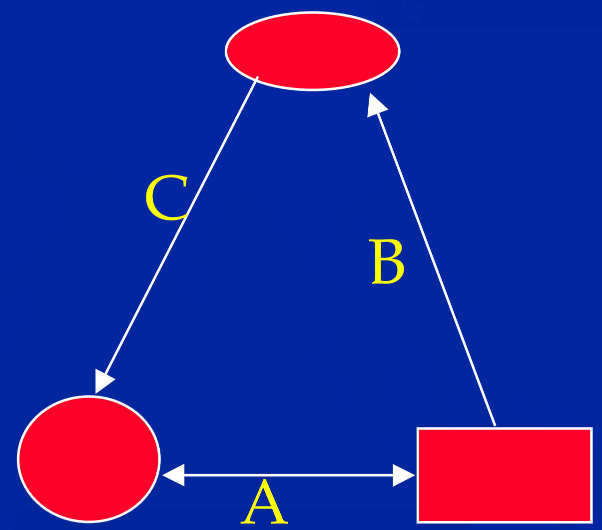
- World-Wide Web (R/W>10)
- Telerobotics
- ``Snowcrash'' shared VR
- Mobile computers

Challenges

- Real-time/interactivity
- Integration with existing protocols (IP)
- Routing algorithms
- Application Transparency?
- Resource multiplexing

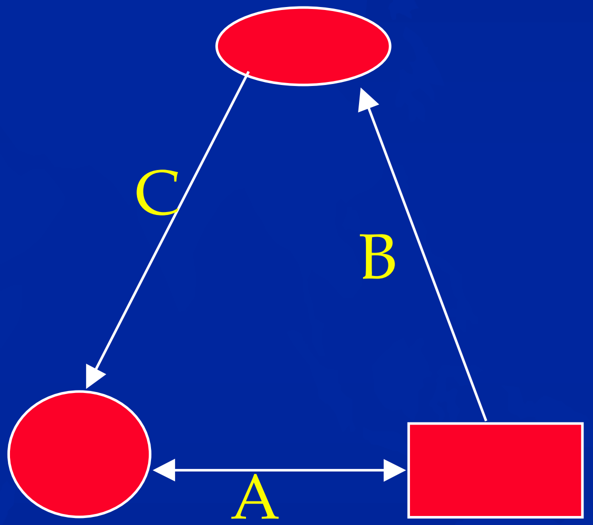
Approach highlights

- Half-duplex use of multiple paths
- Resource scheduling at multicast server
- Multipath routing at multicast server
- Use of new ‘‘protocol boosters’’ ideas



Half-duplex Paths

- ABC model: two paths
- Fast multicast (w/delay)
- Slow dedicated unicast
- Client: Fast path R/O
- Server: Fast path W/O



Scheduling

- Server uplink is shared
- Service reflects application QoS
- R/T: R/T server + R/T unicast
- Integrated N/W, Appl. and O.S.

Multipath Routing

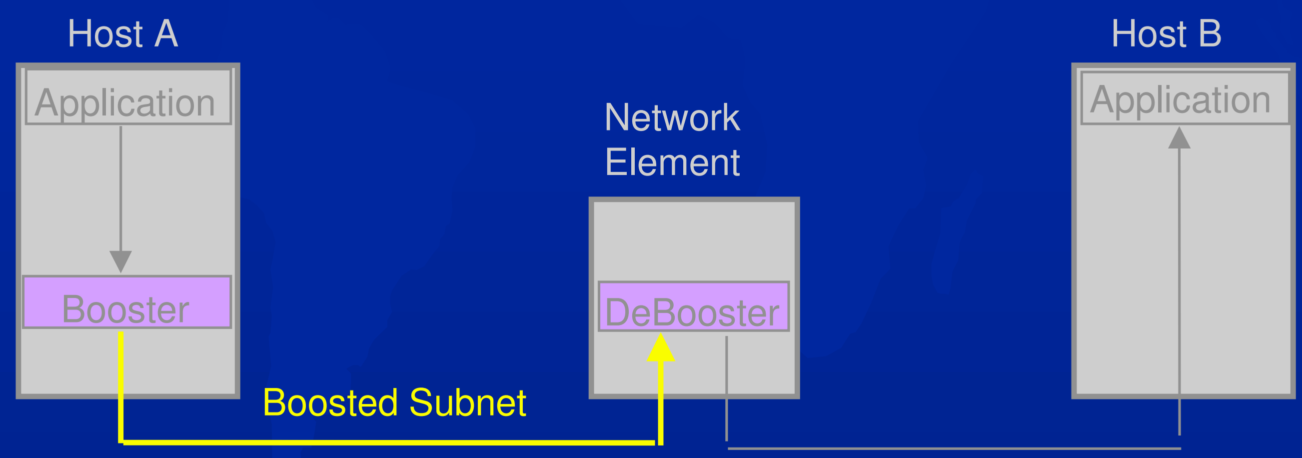
- Classifying packets by path
- Size (Control vs. Data bimodal)
- Transparency to TCP, browsers, etc.
- Flow control and RTT algorithms
- Path differences: B/W, delay, prob(error)

A new design methodology: Protocol Boosters

- Assume things are working well
- Detect when they are not (policy)
- Add functions (mechanism) to fix
- Functions are called “protocol boosters”
- An optimistic approach to transparently achieving high end-to-end performance or new capabilities

Protocol Boosters

- Protocol Elements added ‘‘as-needed’’
- Example of “optimistic” design method
- Useful to maintain common case



Examples

- Implemented over IP on FreeBSD
  - Encryption Booster
  - Compression Booster
- FEC Booster at Bellcore
- Hardware Support: The P4*

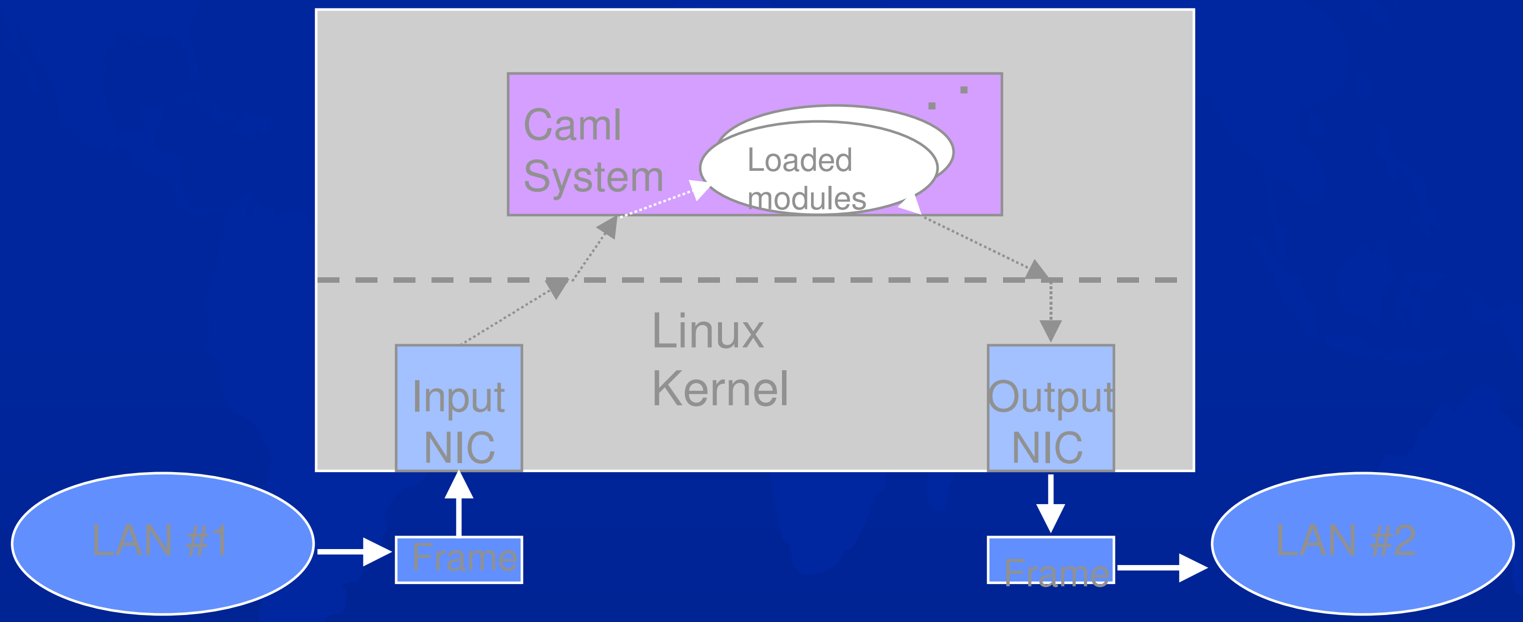
*see http://www.cis.upenn.edu/~boosters/boosters.html

Performance Potential:

- Thruput: TCP, TCP/FEC, Hybrid

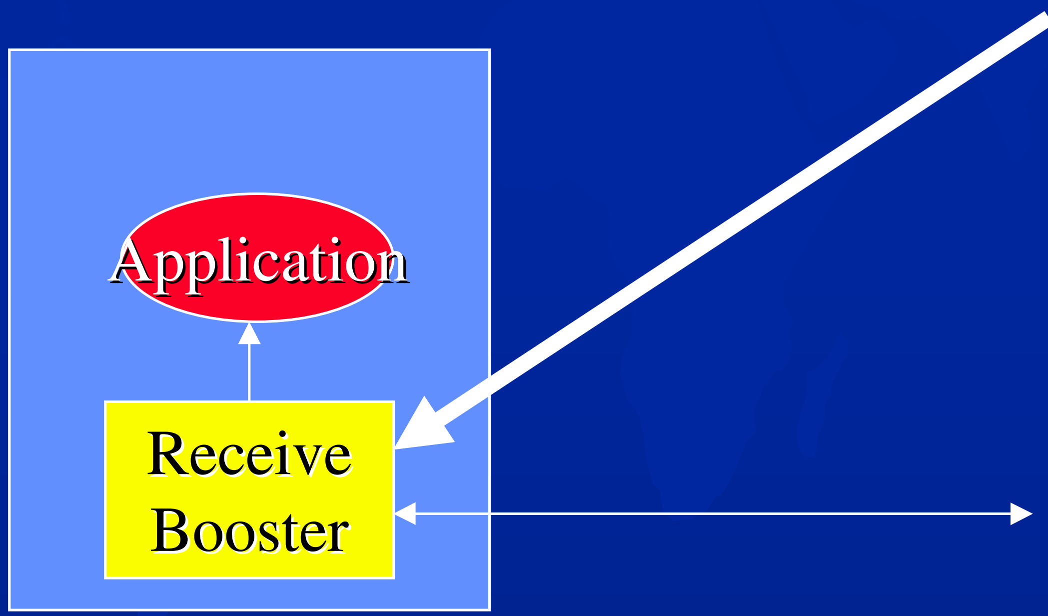
SwitchWare Module Loader

- Active Bridging



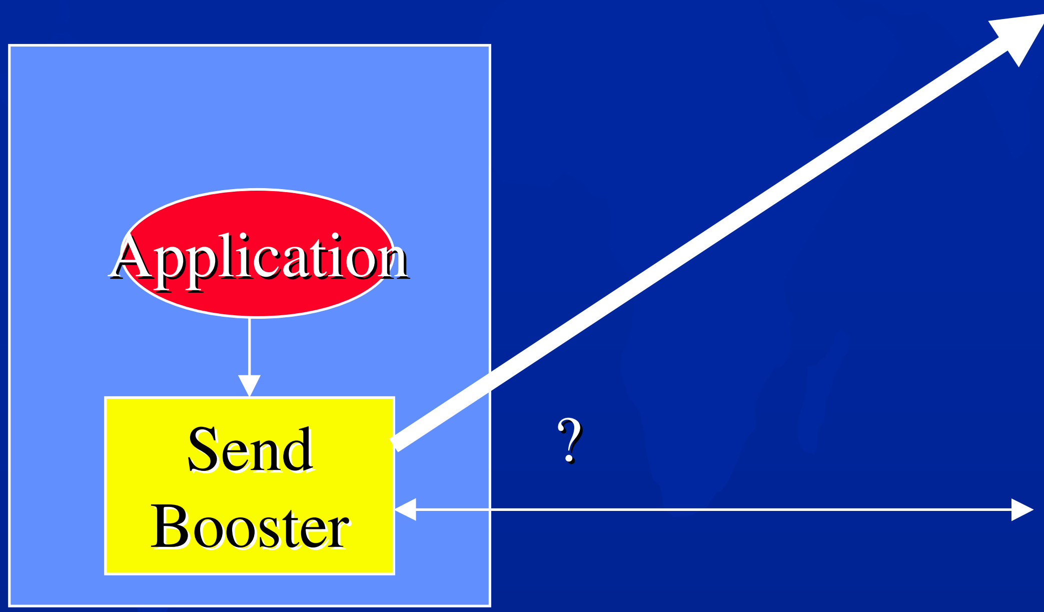
Multipath Boosting: Receiver

- Merge two streams into one:



Multipath Boosting: Sender

- Create two streams from one:



Summary

- This architecture is coming
  - ADSL (Asymmetric Digital Subscriber Line)
  - CATV (Cable Television/Cable Modem)
  - DBS (Digital Broadcast Satellite)
- Current Approaches
  - Multipath Routing with Protocol Boosters
  - Apply to Real-time telerobotics