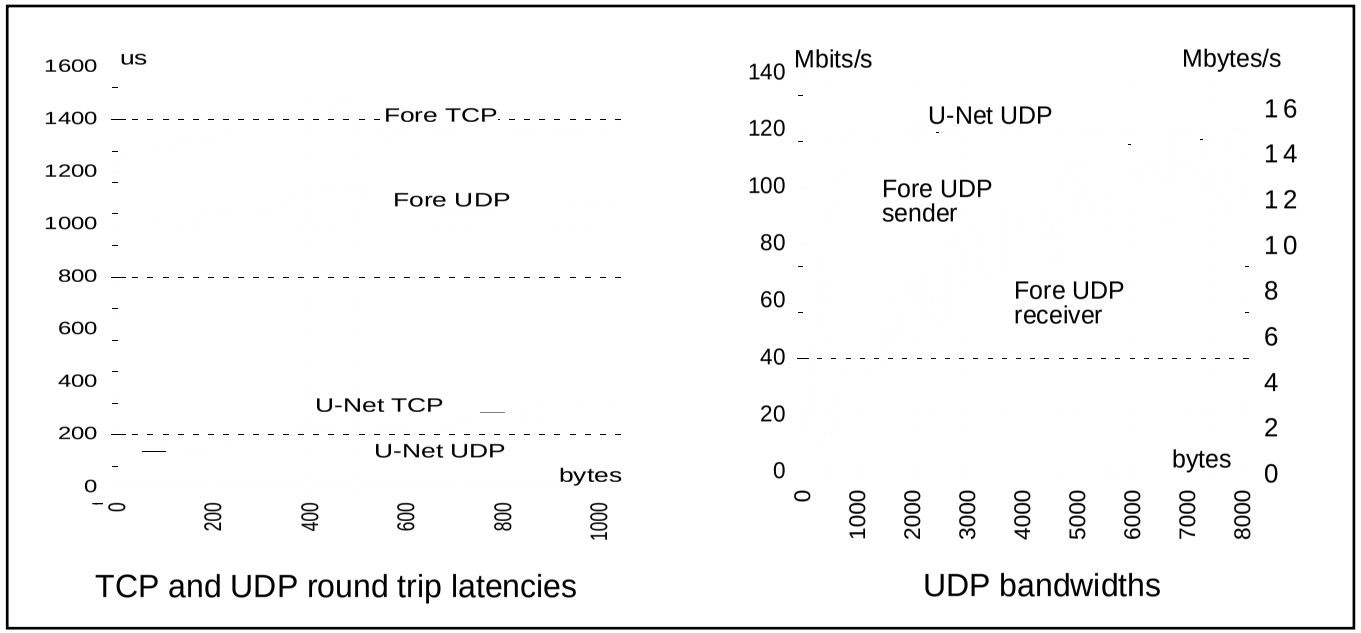
Summary

- User level network interface works and performs well!
  - supports legacy protocols (TCP/IP) as well as novel ones (UNAM).
  - need better resource management.
- UNAM adds very little overhead.
  - need to investigate flow control further.
- Split-C performance comparable to MPPs like CM-5 and Meiko CS-2.
  - need to make it robust enough to be usable by others.
- TCP/IP performance order of magnitude better than traditional architectures.
  - need to figure out what user-level IP means.

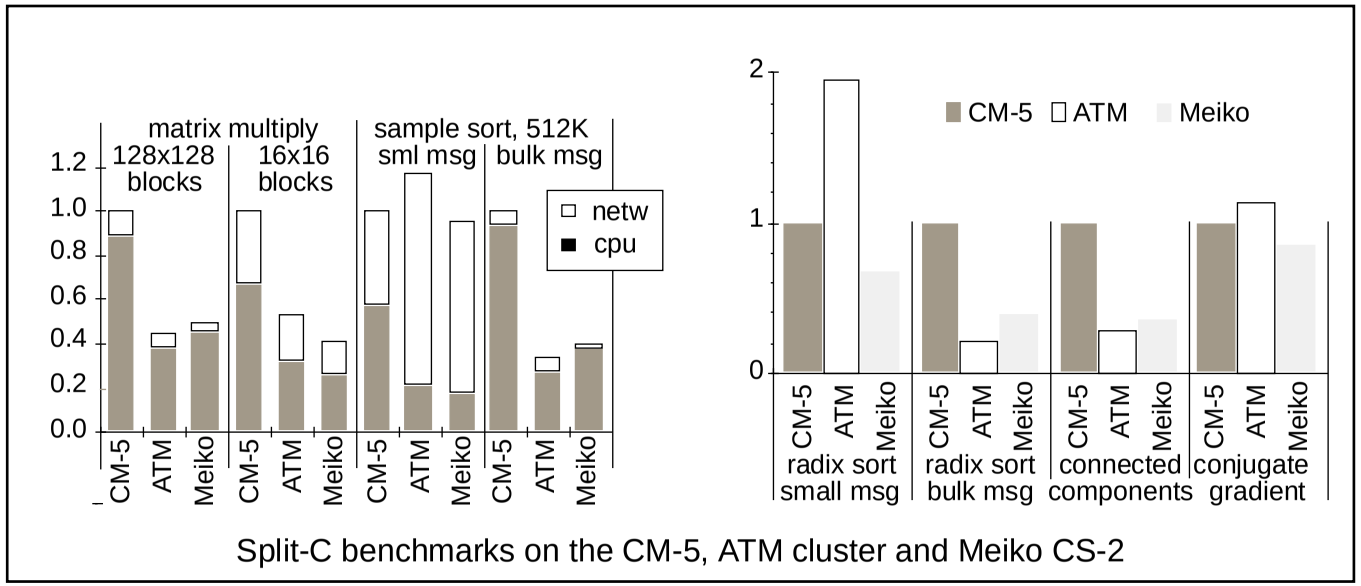
TCP/IP: Performance over U-Net



- TCP round trip latency:
  U-Net: 200 - 300µs vs Fore ATM: 1200 - 1400µs — order of magnitude better.

- TCP bandwidth:
  — U-Net: full 15.2 Mbytes/sec for 2Kbyte message size with 8Kbyte window.
  — Fore ATM: 7Mbytes/sec for 8Kbyte message size with 64Kbyte window.

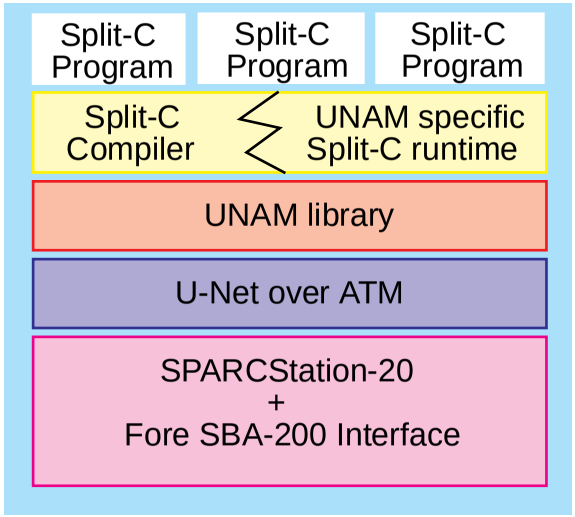
Split-C: Application benchmarks



Split-C benchmarks on the CM-5, ATM cluster and Meiko CS-2

- executions on 8 processors, normalized to the CM-5.
- ATM cluster beats Meiko CS-2 on CPU but is slightly worse in bandwidth.
- ATM cluster and Meiko CS-2 better than CM-5 in bulk message case.
- ATM cluster worse than CM-5 in the small message case.

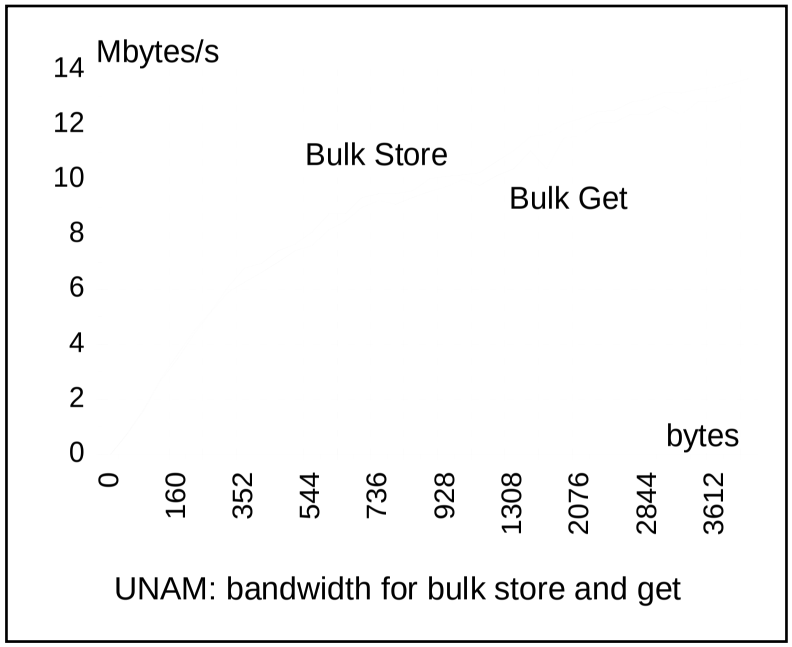
Split-C: the Model and Implementation



- Split-C programs consist of:
  — one thread/processor.
  — global pointers.
  — communication among threads via shared data.

- implementation:
  — dereferencing global pointers generate appropriate active message calls.

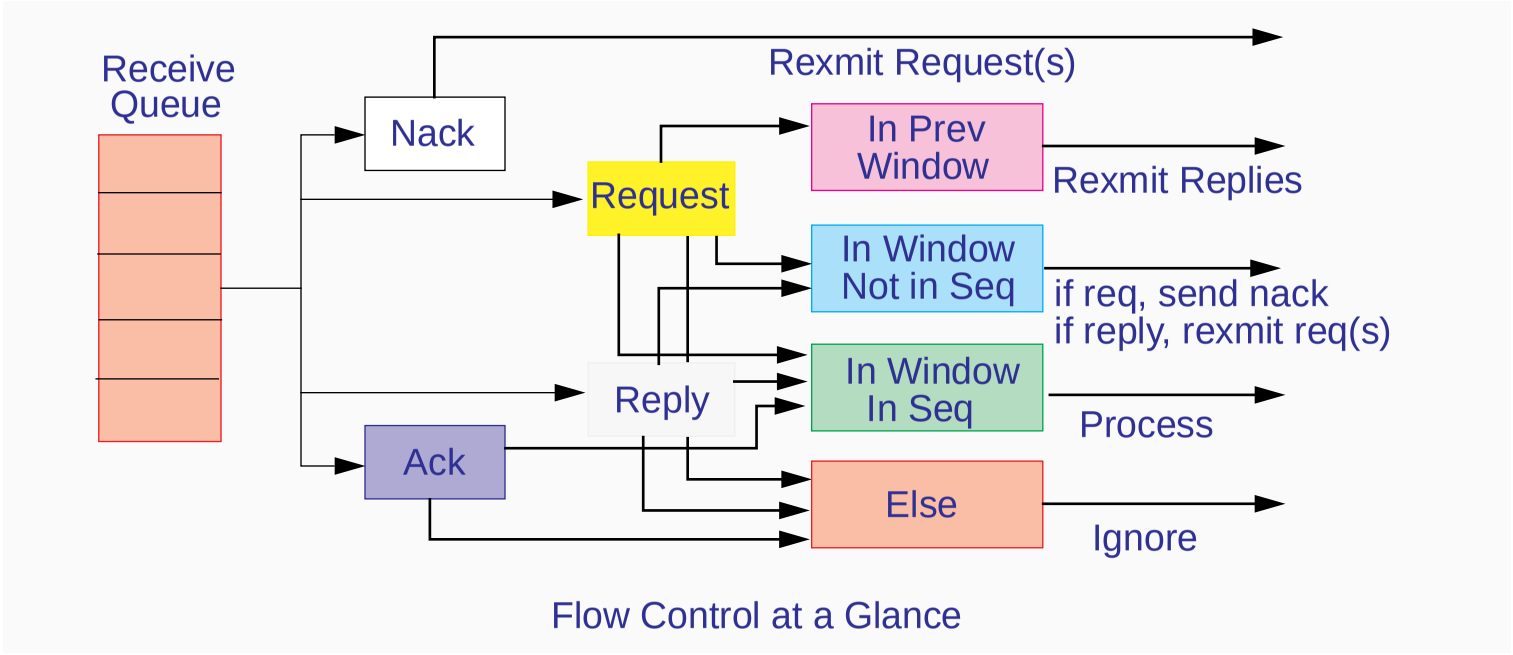
UNAM: Micro-benchmarks



UNAM: bandwidth for bulk store and get

- round trip time for small messages: 66µs.
- maximum bandwidth achieved: 13.6 MB/sec using 3Kbyte messages.
- working on getting full bandwidth.

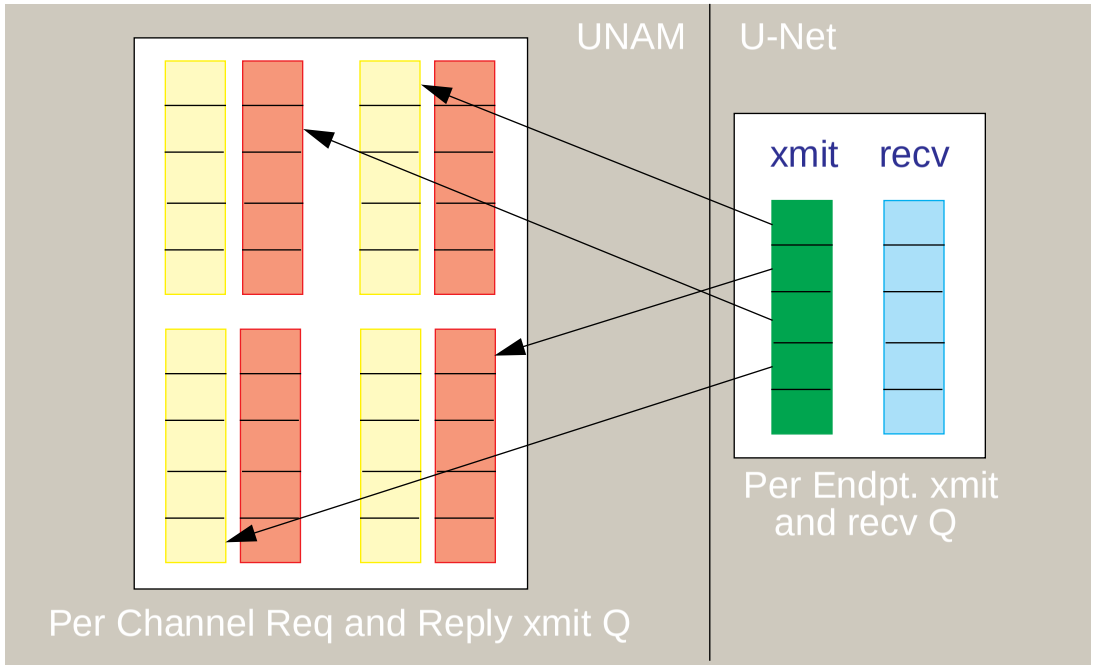
UNAM: the Flow Control



Flow Control at a Glance

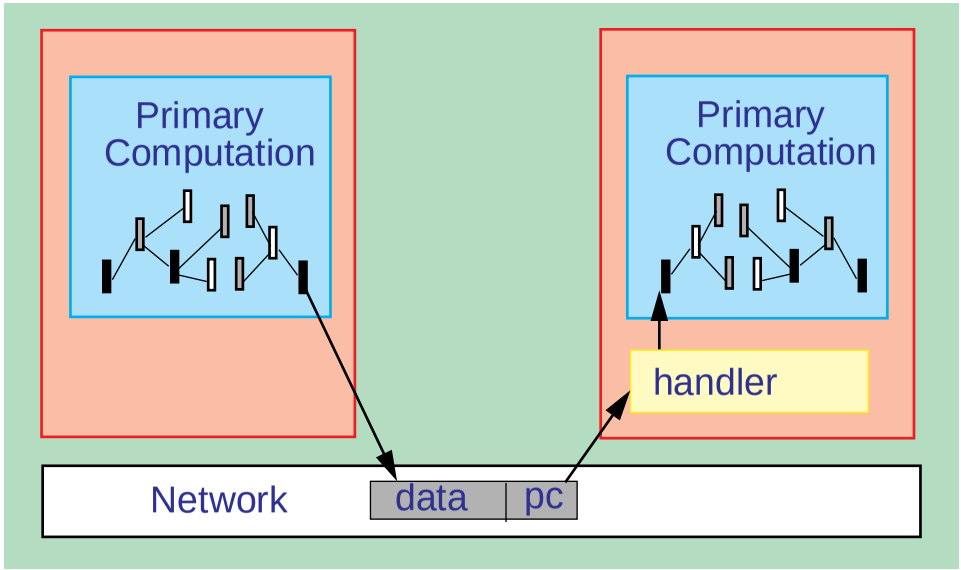
- window based flow control.
- four types of messages: request, reply, ack and nack.
- acknowledgements piggybacked whenever possible.

UNAM: Implementing GAM over U-Net



- user-level library, implements the GAM 1.1 specification from Berkeley.
- per channel request and reply queues.
- flow control and reliable message delivery using a windowing protocol.

GAM: the Architecture

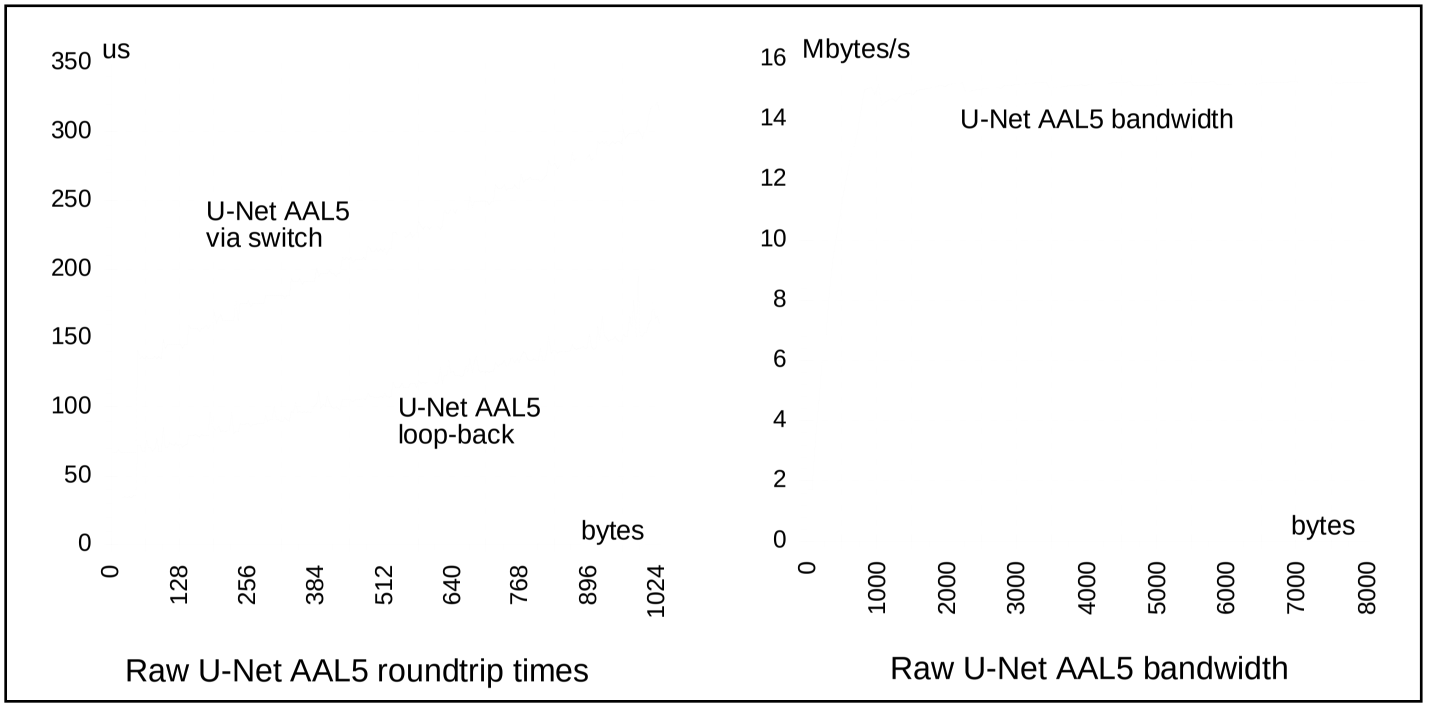


- assumes SPMD model.
- small messages — upto 4 words of data + handler.
  bulk xfers — store and get.
- request and reply messages distinct.
- best-effort delivery.

U-Net: Memory Requirements

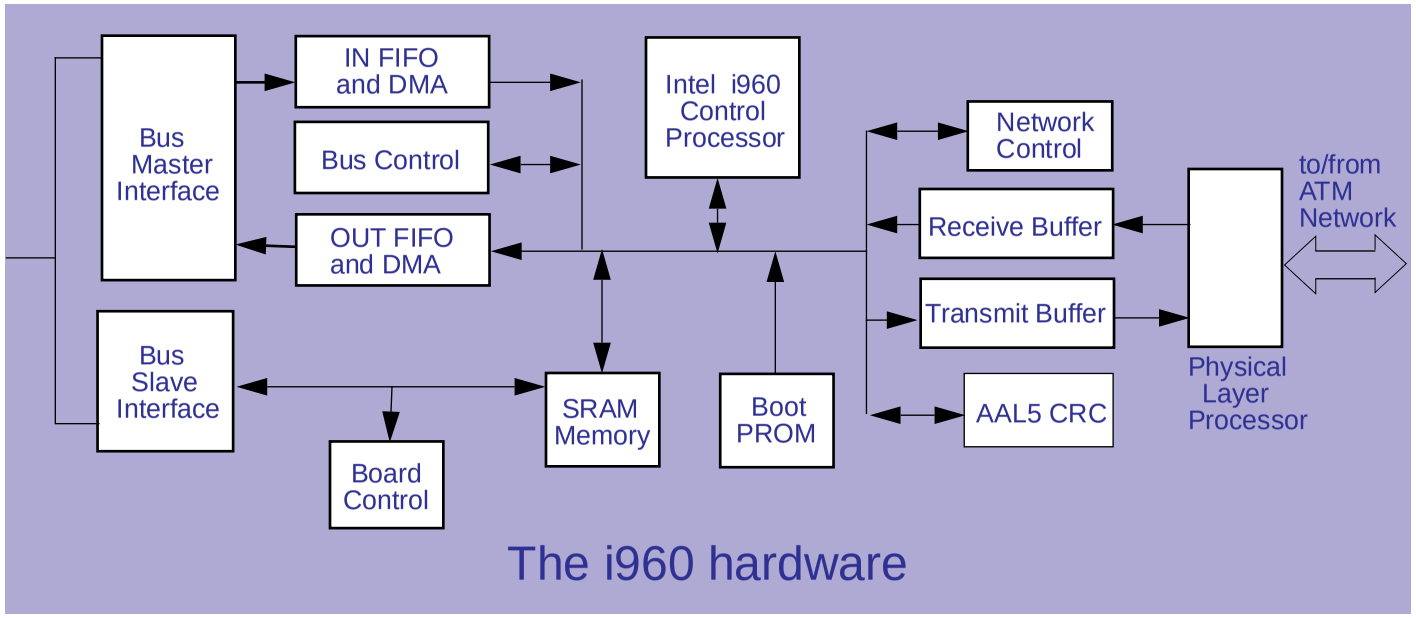
- currently: fixed number of pages pinned to physical memory for all endpoints.
- pages for communication segments and queues all mapped to DMA space.
- size of DMA space limits number of distinct applications running at one time.
- how to get around this?

U-Net: Performance



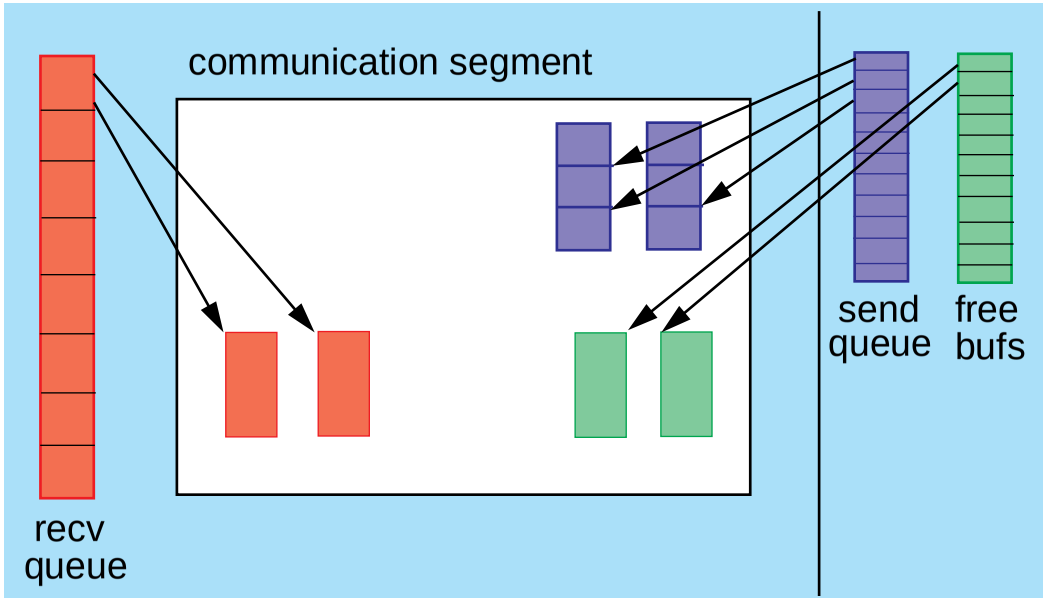
- roundtrip time: 60µs across the switch.
- full bandwidth (~15.2MB/sec) achieved for PDU sizes as low as 1Kbytes.

U-Net: The Implementation



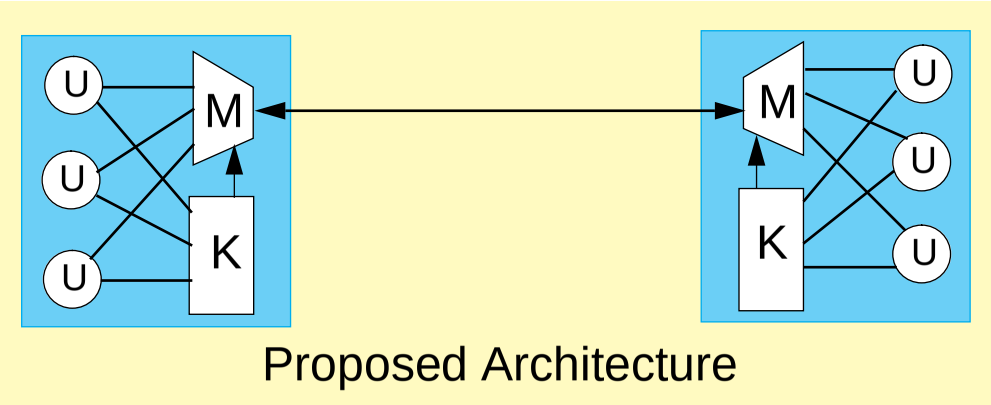
- send and free buffer queues on i960, receive queue on host.
- all queues and communication segment mapped to DMA-space.
- DMA done using the “fly-by” feature.
- optimized for single cell messages.

U-Net: The Send and Receive Model



- push pointers to transmit data buffers onto send queue (out fifo) for sending.
- receive queue (in fifo) entries contain small msgs or pointers to large msgs.
- connections opened via kernel.
- U-Net checks incoming endpoint addresses and demuxes.

U-Net: The Architecture



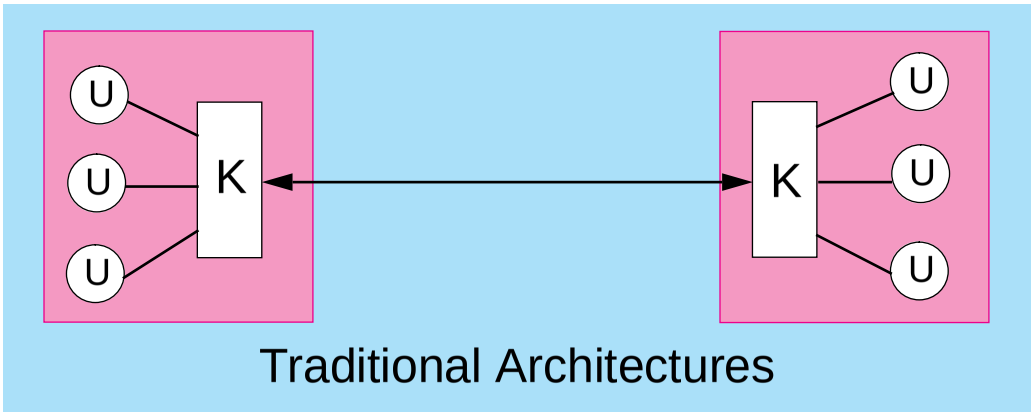
Proposed Architecture

- Remove kernel from the critical path.
- Virtualize network using a message mux/demux mechanism.
- Simplify buffering strategies.
- Queue-based send and receive models.
- Concept of endpoint as unit of addressing and protection.

Outline of the talk

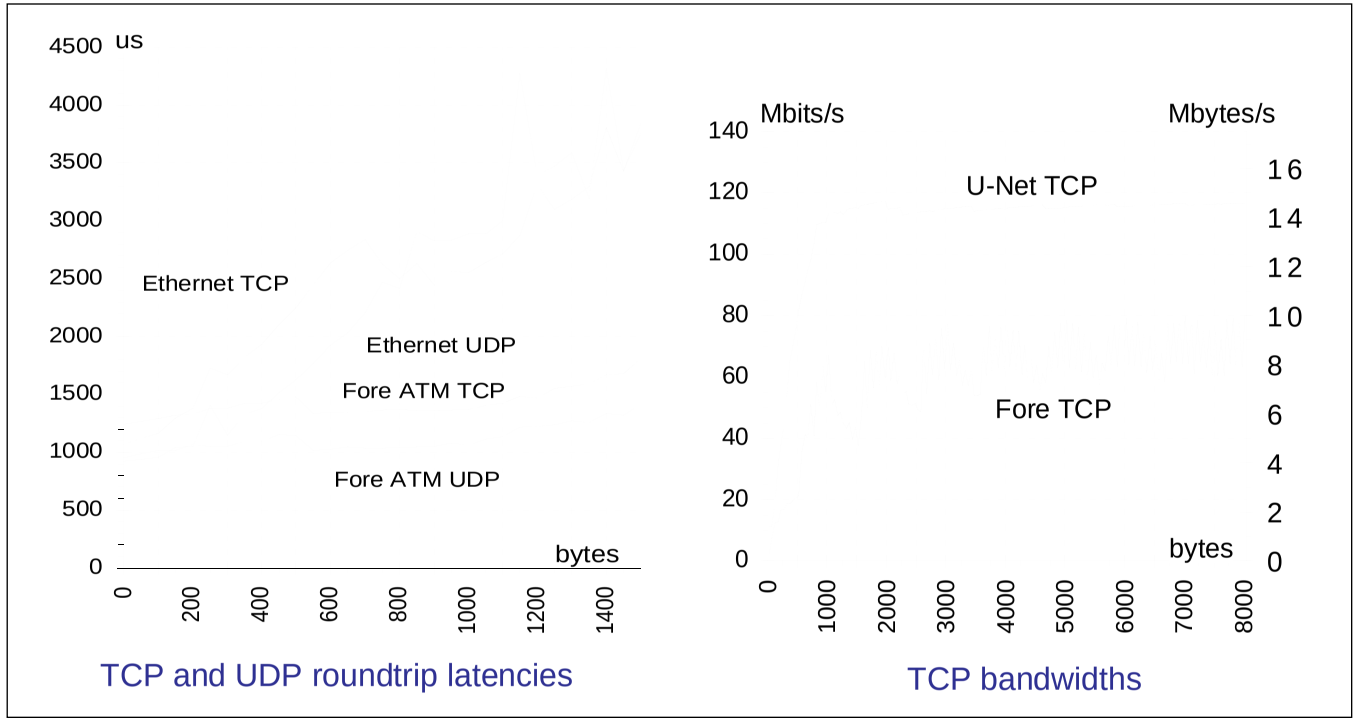
- U-Net solution: architecture, implementation and performance.
- UNAM: an active message implementation over U-net.
- Split-C over UNAM.
- Performance of TCP/IP over U-Net
- Summary

Motivation for U-Net



- End-to-end high-bandwidths and low latencies not observed even when network fabric is capable.
- Generalized buffering strategies in kernel (e.g. *mbufs*) at the core of problems.
- So what is the solution?

TCP/IP performance on ATMs: a brief look



- no significant improvement in latencies in spite of faster network fabric.
- full bandwidth not achieved even at packet sizes of 8Kbytes.

U-Net and UNAM: bringing parallel and distributed computing closer

Anindya Basu

Joint work with Vineet Buch, Werner Vogels, and Thorsten Von Eicken

http://www.cs.cornell.edu/Info/Projects/ATM

April 12, 1995