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

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

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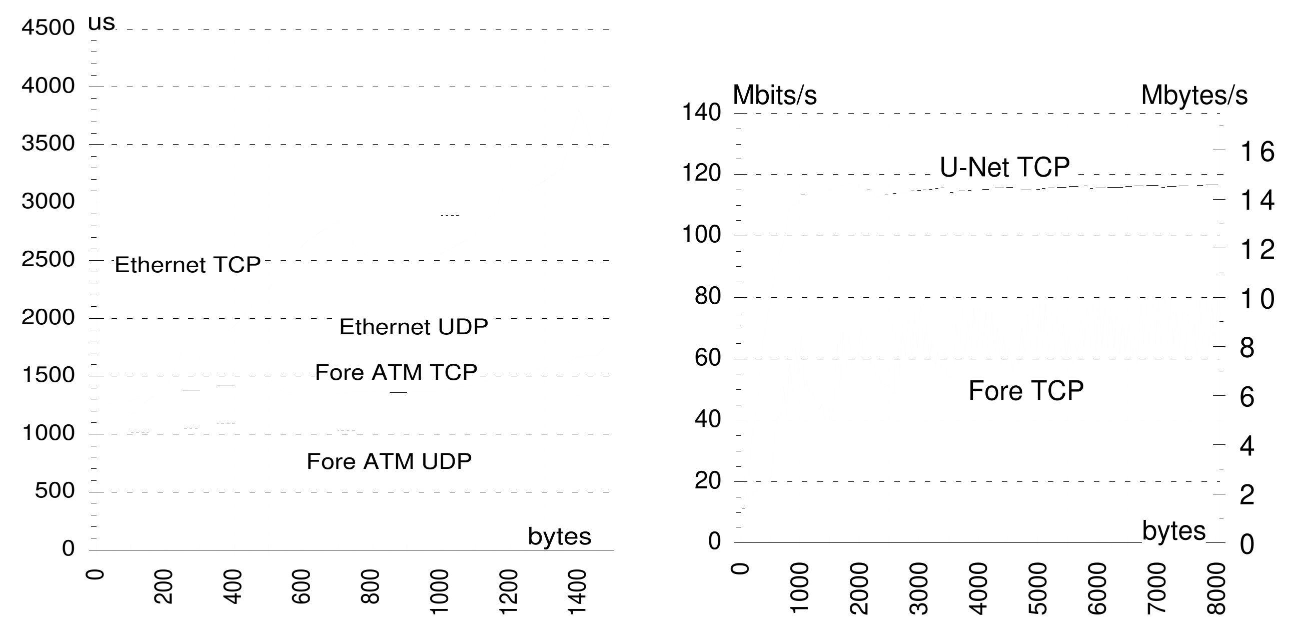
# TCP/IP performance on ATMs: a brief look

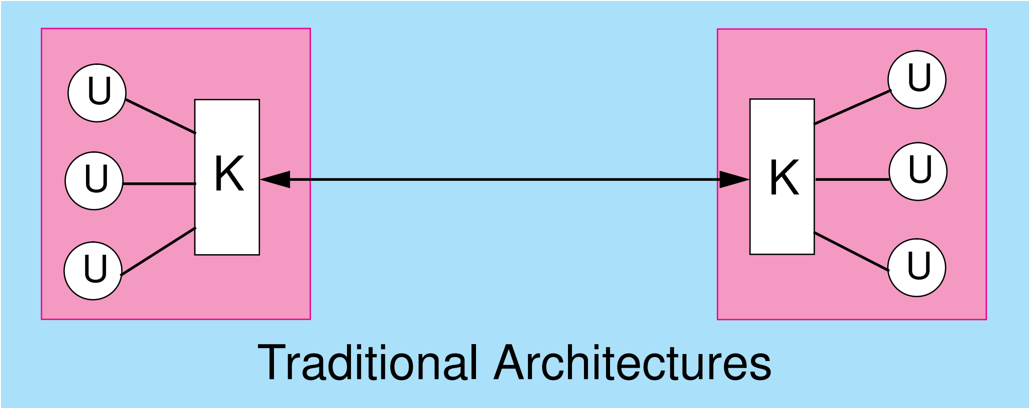



TCP and UDP roundtrip latencies

TCP bandwidths

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

# Motivation for U-Net

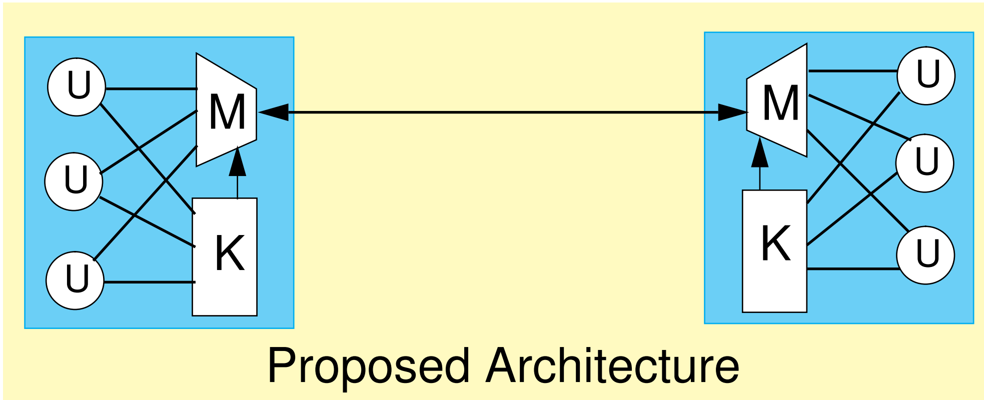



- End-to-end high-bandwidths and low latencies not observed even when network fabric is capable.
- Generalized buffering strategies in kernel (e.g. *mbufs*) at the core of problems.
- So what is the solution?

# Outline of the talk

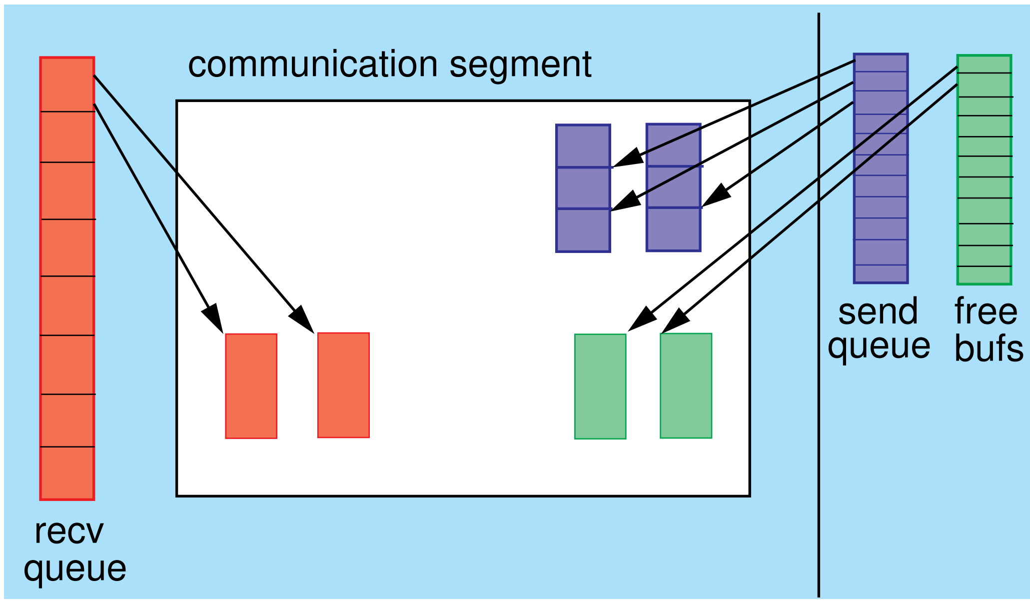
- U-Net solution: architecture, implementation and performance.
- UNAM: an active message implementation over U-net.
- Split-C over UNAM.
- Performance of TCP/IP over U-Net
- Summary

# U-Net: The Architecture



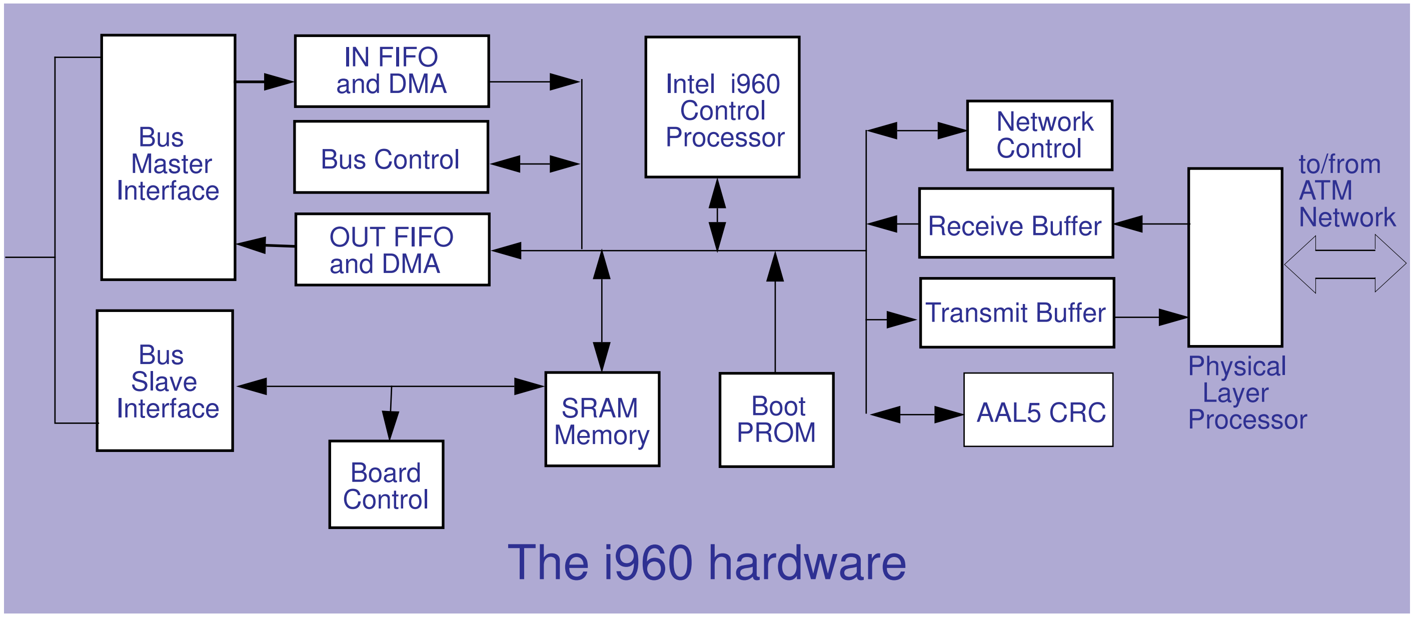

- Remove kernel from the critical path.
- Virtualize network using a message mux/demux mechanism.
- Simplify buffering strategies.
- Queue-based send and receive models.
- Concept of endpoint as unit of addressing and protection.

# U-Net: The Send and Receive Model



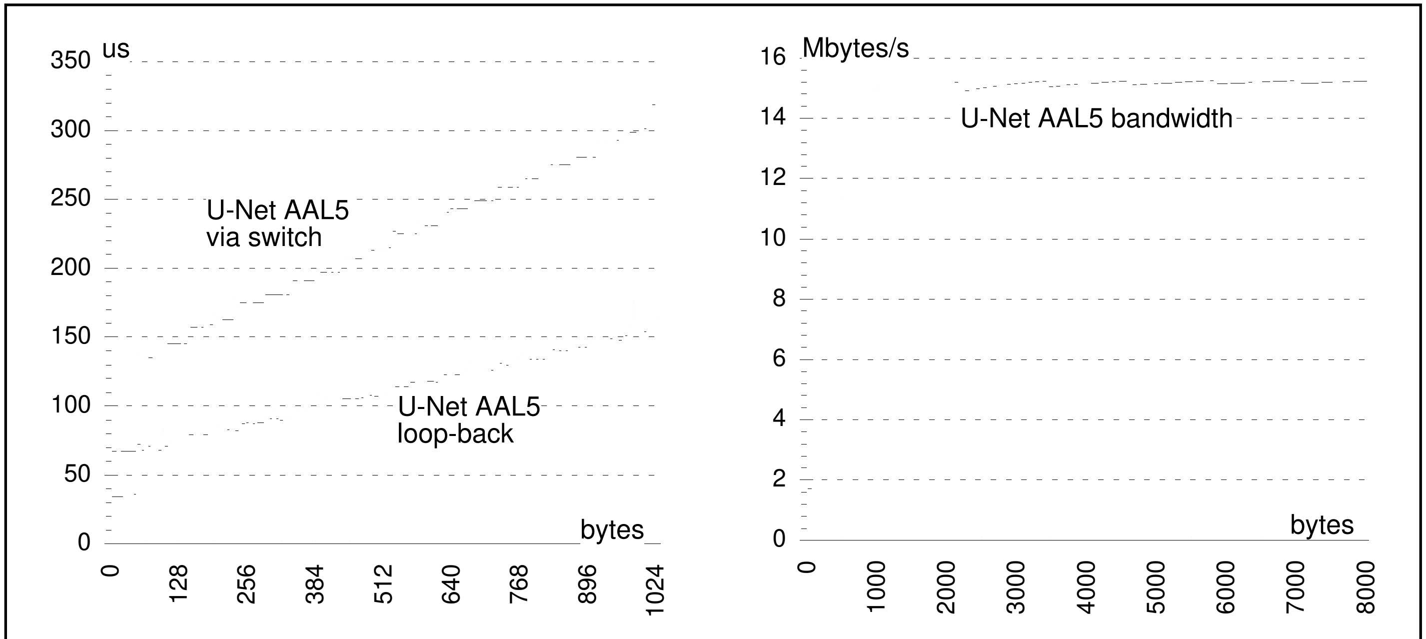

- push pointers to transmit data buffers onto send queue (out fifo) for sending.
- receive queue (in fifo) entries contain small msgs or pointers to large msgs.
- connections opened via kernel.
- U-Net checks incoming endpoint addresses and demuxes.

# U-Net: The 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: Performance




Raw U-Net AAL5 roundtrip times

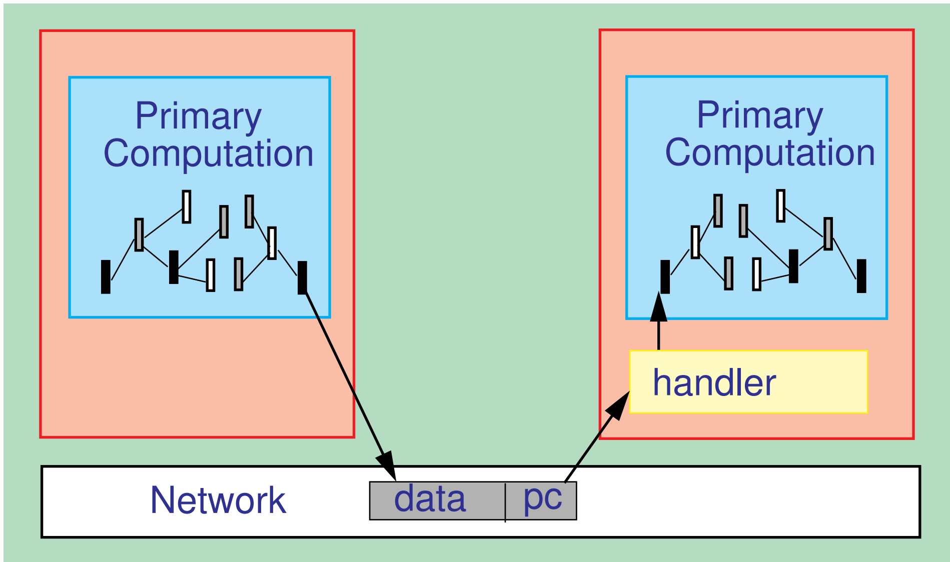
Raw U-Net AAL5 bandwidth

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

## U-Net: Memory Requirements

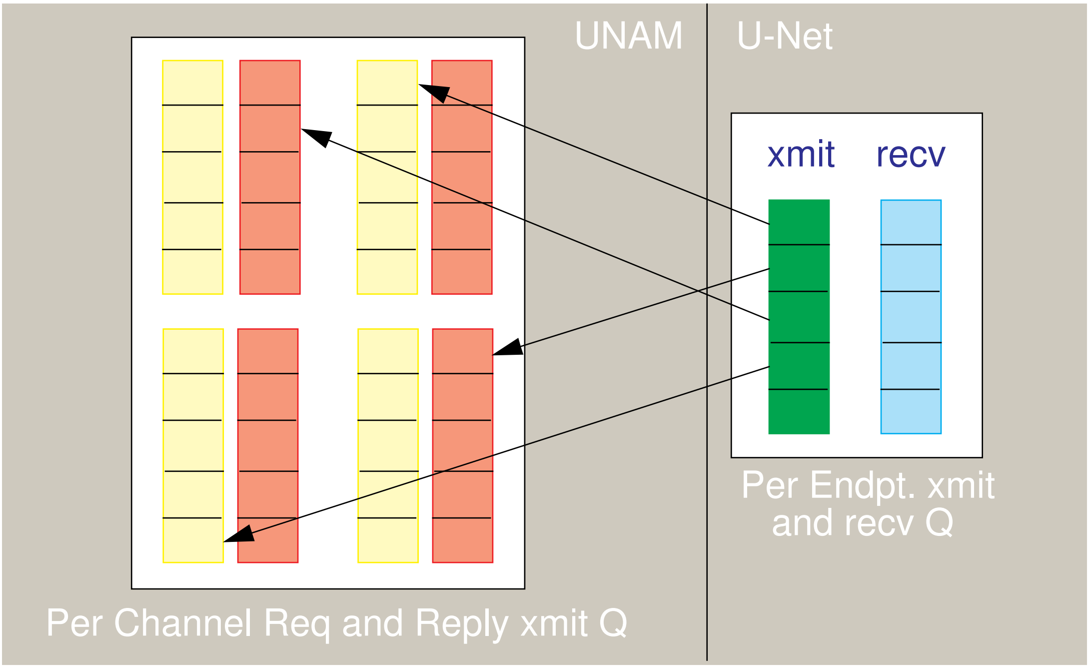
- currently: fixed number of pages pinned to physical memory for all endpoints.
- pages for communication segments and queues all mapped to DMA space.
- size of DMA space limits number of distinct applications running at one time.
- how to get around this?

# GAM: the Architecture



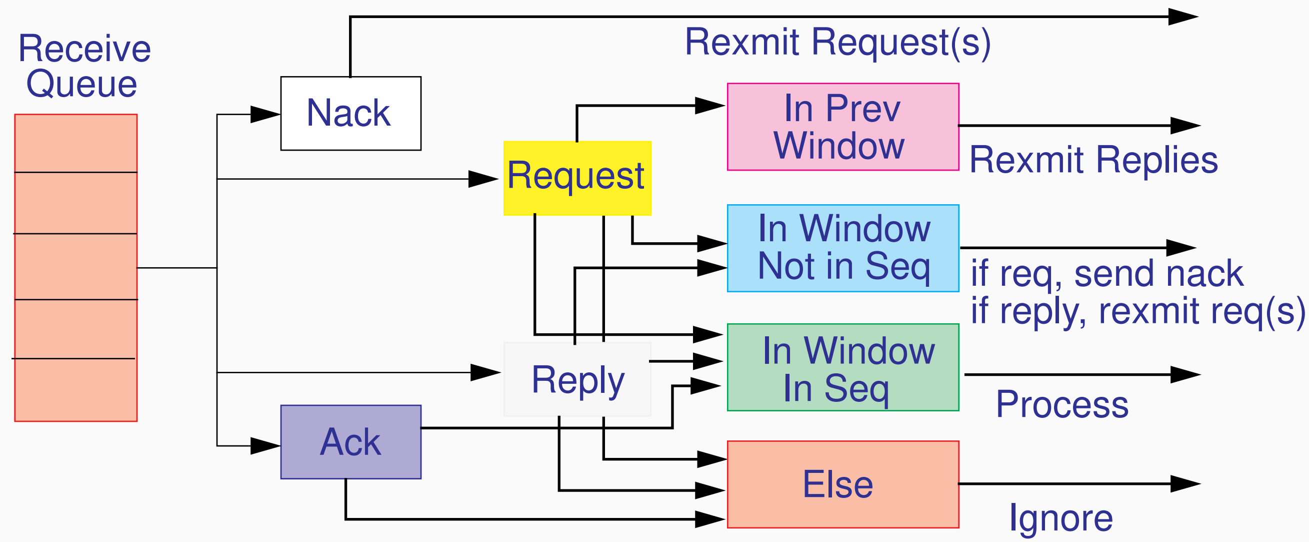

- assumes SPMD model.
- small messages — upto 4 words of data + handler.
  bulk xfers — store and get.
- request and reply messages distinct.
- best-effort delivery.

# 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.

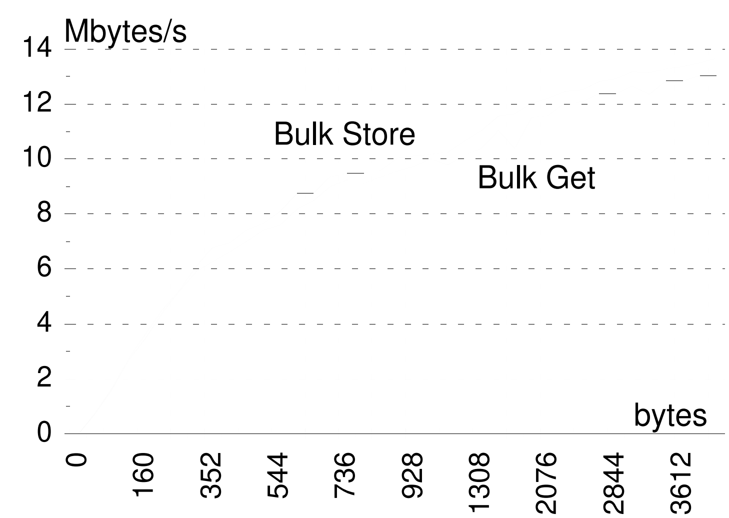
# UNAM: the Flow Control




Flow Control at a Glance

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

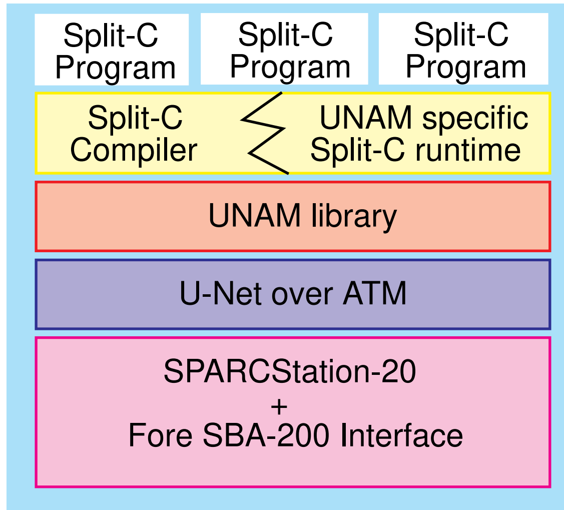
# UNAM: Micro-benchmarks




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.

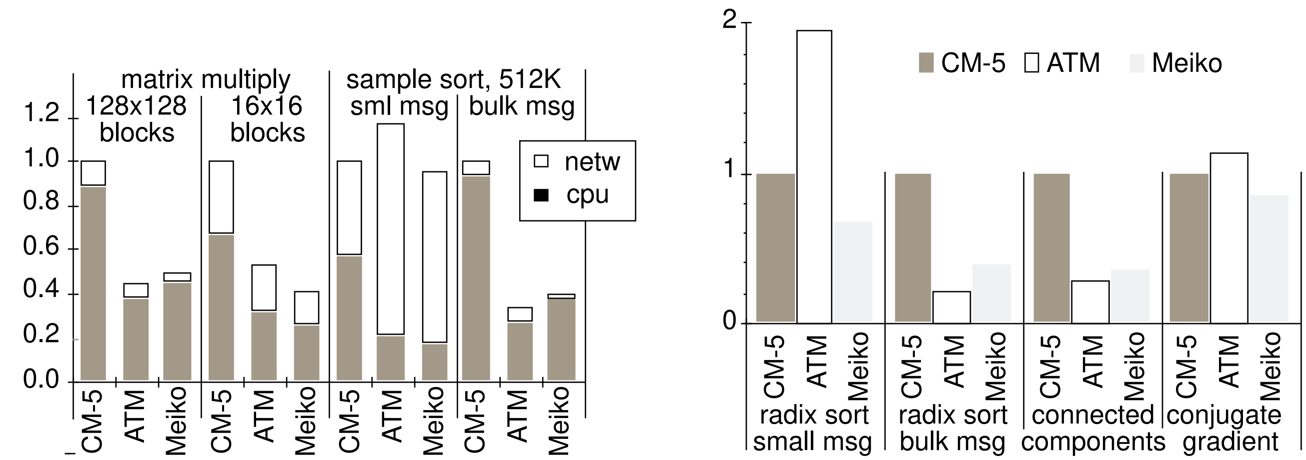
# Split-C: the Model and Implementation




- 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.

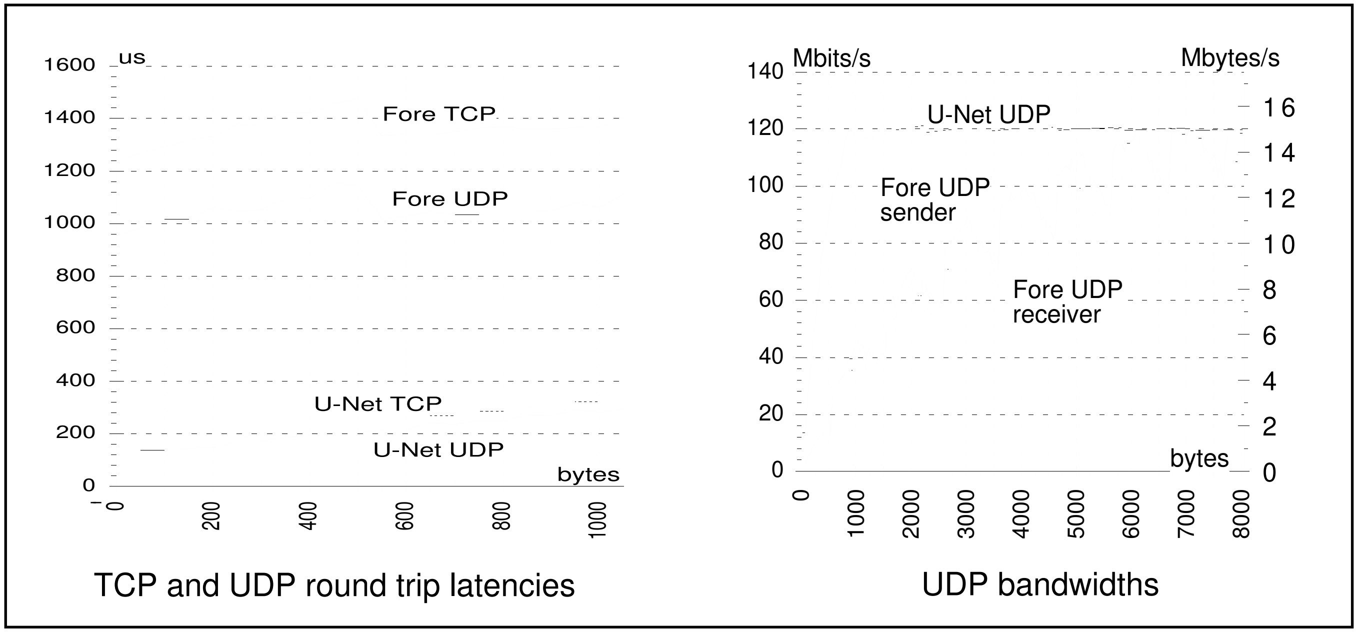
# Split-C: Application benchmarks




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.

# 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.

# 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.