System Software for High-Performance Communication

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Overview

- Goal
  - —Building scalable systems software
  - —Scaling requires that we understand how resources are used and the benefits of adding resources
- Approach
  - —Modeling to understand how resources might be used
    - – Modeling protocol offload
  - —Monitoring to understand how applications use resources
    - – System call monitoring
    - – Message-centric monitoring
  - —Implementation to illustrate scaling
    - – Open MPI on Infiniband
- Faculty
  - —Bridges & Maccabe

Modeling Protocol Offload

- **Publications**
  - —"Modeling Protocol Offload for Message-oriented Communication," IEEE Cluster 2005
  - —"An Extensible Message-Oriented Offload Model for High-Performance Applications," LACSI Symposium 2005
- **Patricia Gilfeather, PhD, Fall 2005**
- **Basic Idea**
  - —Develop a model to explore the benefits of *partial* protocol offload.
    - Leave error processing on host processor
    - Minimize NIC resources while maximizing performance
  - —Specific interest in partial offload of TCP/IP (commodity protocol).
- **Highlight**
  - —Working with SeaFire to explore commercial product based on partial offload.
  - —Specific application Grid FTP at 40Gbps.

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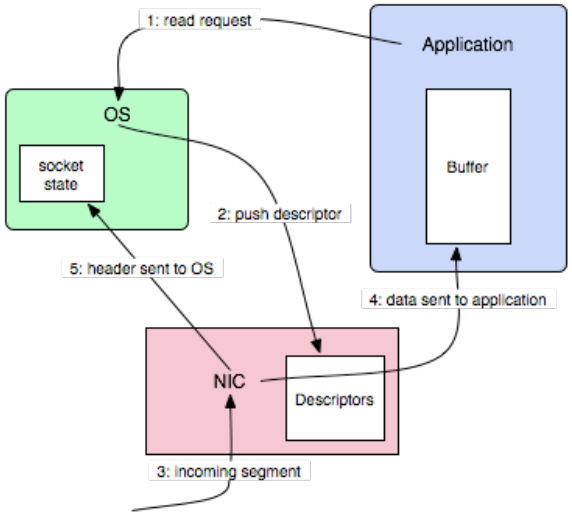
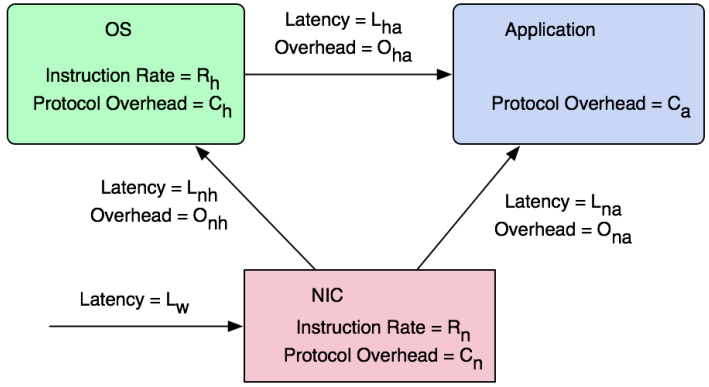
Modeling Protocol Offload

- **Partial Offload (Splintered Implementations)**
  - —Isolate functionality
  - —Distribute functionality
  - —Constrain NIC resources
- **EMO (Extensible Message-Oriented Model)**
  - —An extension of LogP
  - —Focus on NIC design – "what if designs"
    - Where to add resources
    - Benefits to additional offload
- **Comparison to LAWS and LogP**
- **Initial Validation**





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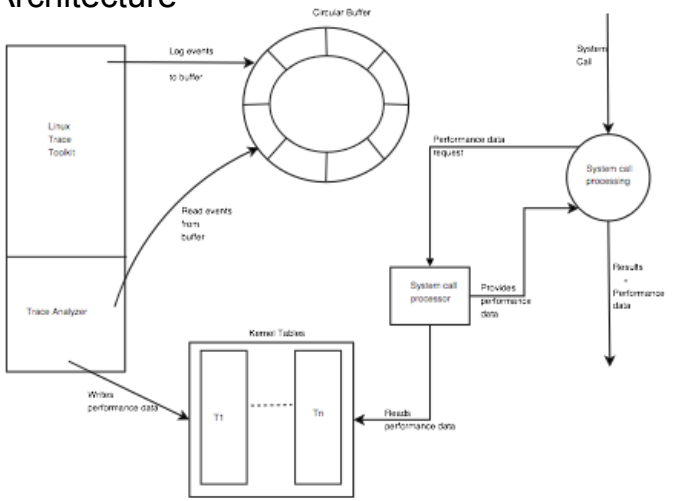
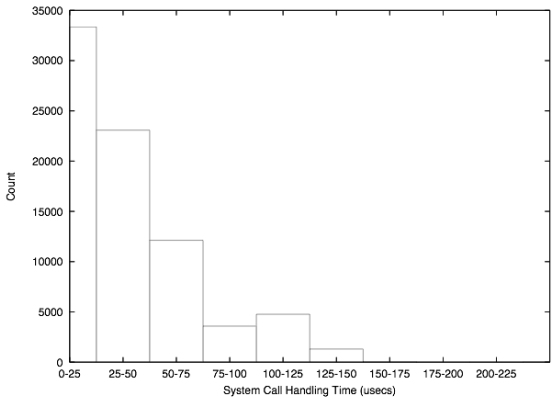
System Call Monitoring

- **Publication**
  - **—"A Framework for Analyzing Linux System Overheads on HPC Applications," LACSI Symposium 2005**
- **Sushant Sharma, MS Summer 2005, now in CCS1**
- **Basic idea**
  - **—Need to monitor system calls to better understand the interaction between operating system implementation and application performance**
  - **—Extend LTT (Linux Tracing Toolkit)**
- **Highlight**
  - **—Monitoring overhead is minimal (~3-6%)**

Architecture



Distribution of time spent in recvfrom syscall (NAS CG-B)



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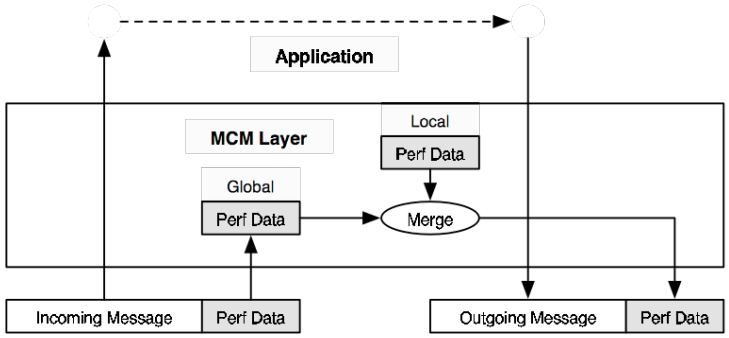
Message-Centric Monitoring

- **Publications**
  - —"Online Critical Path Profiling for Parallel Applications," IEEE Cluster 2005
- **Wenbin Zhu, PhD student**
- **Basic idea**
  - —Tag local information into application messages
  - —Merge local data with data from incoming messages to provide global view (critical path)
- **Highlight**
  - —<3% overhead
  - —Able to detect injected overhead
  - —Online analysis



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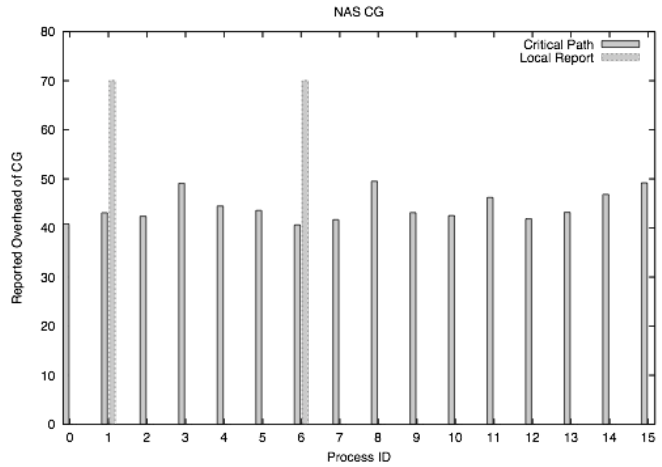
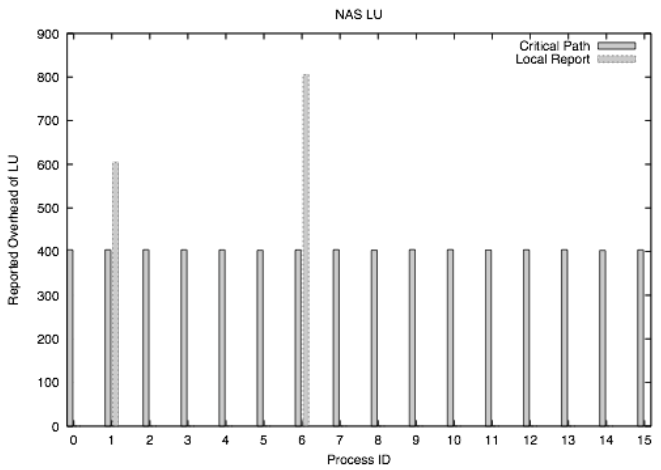
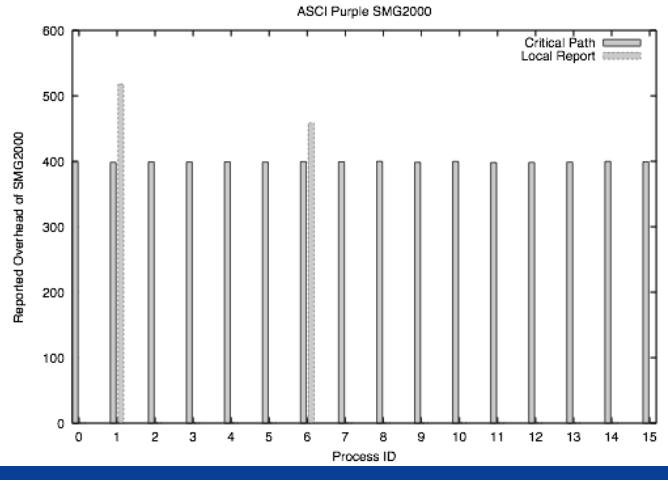
Message-Centric Monitoring

- **Online analysis**







Nodes 1 & 6 detect additional overhead

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Open MPI on Infiniband

- **Publication**
  - —"Infiniband Scalability in OpenMPI," IPDPS 2006
- **Galen Shipman, MS Fall 2005, now in CCS1**
- **Basic idea**
  - —Develop and Open MPI implementation for Infiniband
- **Highlight**
  - —Compared to MVAPICH
    - Small message latency improved by 10%
    - Per host memory usage decreased by 300%
    - Latency is highly predictable

Open MPI on Infiniband

- Approach
  - —MVAPICH
    - Uses pure RDMA protocol
    - Allocates a buffer per peer
      - Memory use
      - Latency depends on node index
        - good latency for node 0 or 1 :)
  - —Open MPI
    - Uses send/receive for small messages
    - Uses a Shared Request Queue (SRQ) for completions
      - Issue: no flow control when using SRQ!
    - Dynamic allocation of communication buffers reflects actual use of communication resources by application

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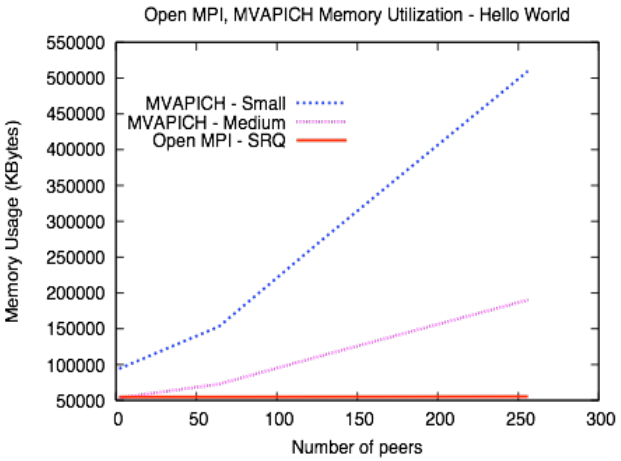
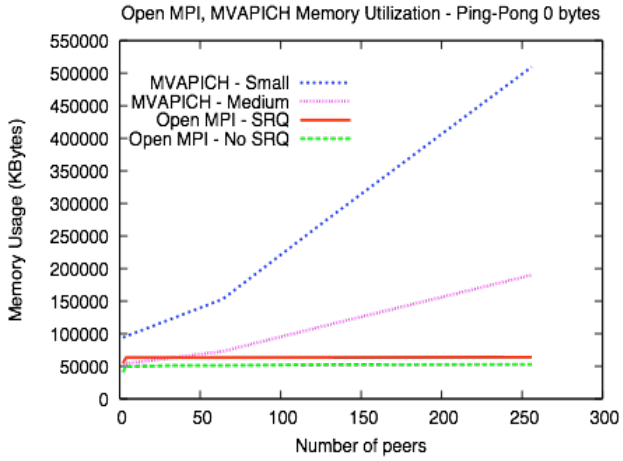
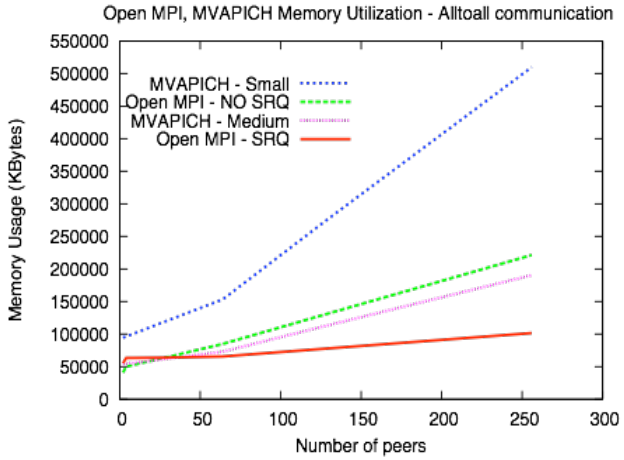
Open MPI on Infiniband



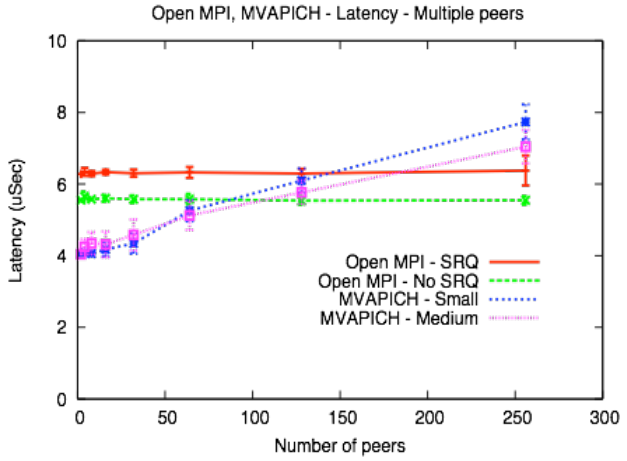
Hello world Memory Usage



Pairwise Ping-pong Memory Latency



All-to-all Memory Usage



Multi-node Zero Byte Latency

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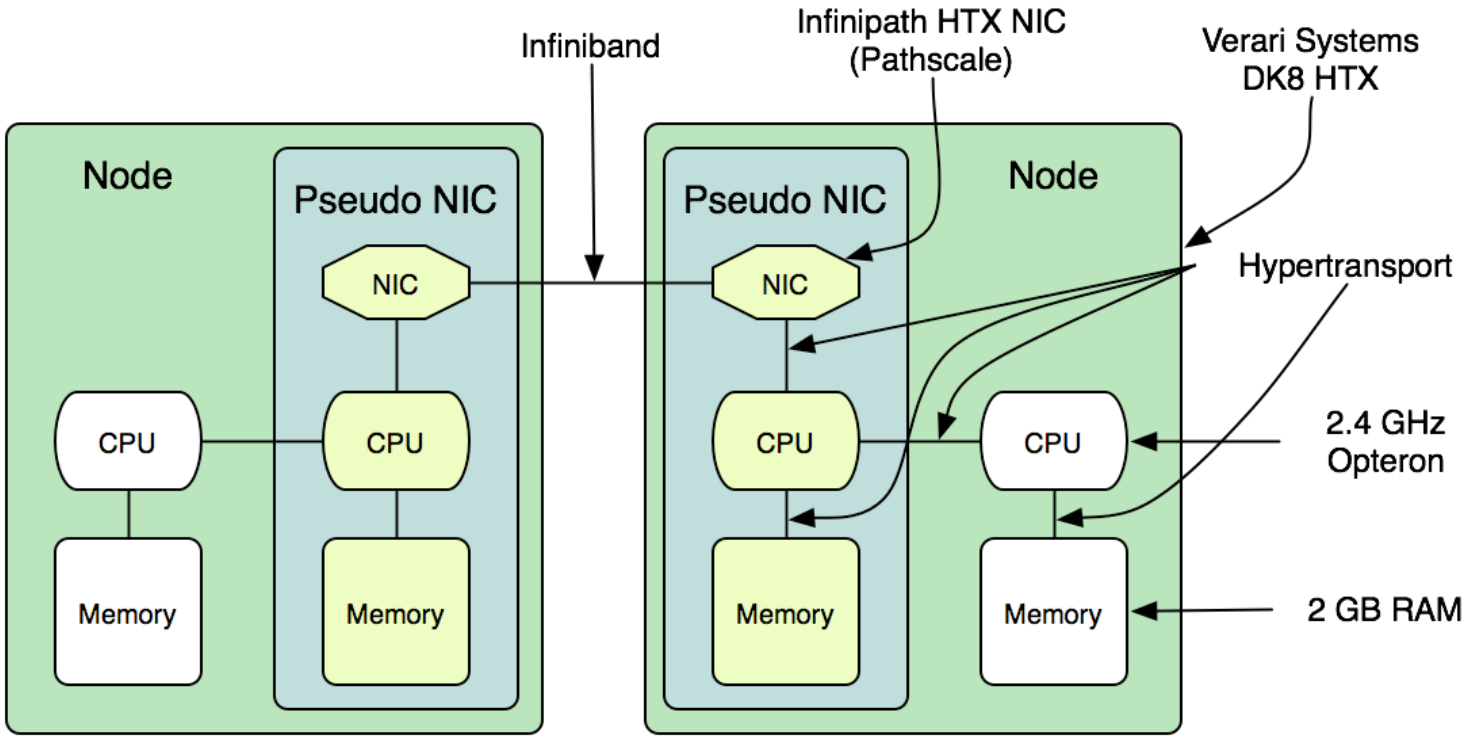
Future

- **Offload Testbed – beyond modeling, implement and measure**



Summary

- Focus on
  - —Improving communication performance
  - —Measuring performance
- Degrees
  - —Two MS degrees
    - – Sushant started working for Wu Feng and is now working for Ron Minnich
    - – Galen is working for David Daniel
  - —One PhD
    - – Patricia is currently working as a postdoc at UNM
- Relevance to WSR
  - —Need to understand and manage resource usage
    - – Monitor to understand
    - – Manage resources to build scalable systems