

RDMA over Ethernet - A Preliminary Study

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Outline

- Introduction
- Problem Statement
- Approach
- Performance Evaluation and Results
- Conclusions and Future Work

Introduction

- Ethernet and InfiniBand accounts for majority of interconnects in high performance distributed computing
- End users want InfiniBand like latencies with existing Ethernet infrastructure
- Can be achieved if networks converge
- Existing options have overhead or tradeoffs in terms of performance
- No solution exists that efficiently combines the ubiquitous nature of Ethernet and the high performance offered by InfiniBand
- RDMA over Ethernet (RDMAoE) seems to provide a good option as of date

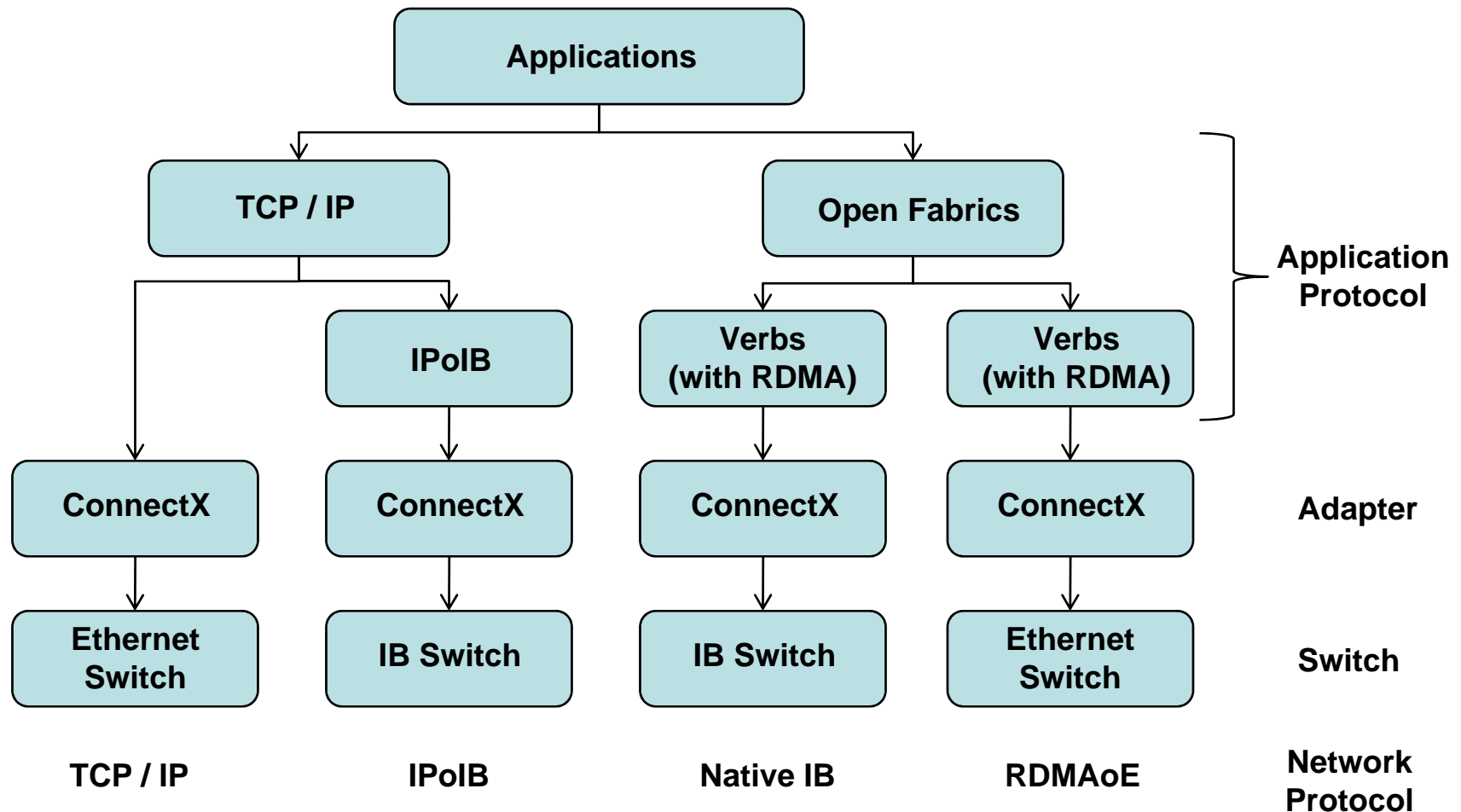
RDMAoE

- Allows running the IB transport protocol using Ethernet frames
- RDMAoE packets are standard Ethernet frames with an IEEE assigned Ethertype, a GRH, unmodified IB transport headers and payload
- InfiniBand HCA takes care of translating InfiniBand addresses to Ethernet addresses and back
- Encodes IP addresses into its GIDs and resolves MAC addresses using the host IP stack
- Use GID's for establishing connections instead of LID's
- No SM/SA, Ethernet management practices are used

InfiniBand Architecture & Adapters

- An industry standard for low latency, high bandwidth, System Area Networks
- Multiple features
 - Two communication types
 - Channel Semantics
 - Memory Semantics (RDMA mechanism)
 - Multiple virtual lanes
 - Quality of Service (QoS) support
- Double Data Rate (DDR) with 20 Gbps bandwidth has been there
- Quad Data Rate (QDR) with 40 Gbps bandwidth is available recently
- Multiple generations of InfiniBand adapters are available now
- The latest ConnectX DDR adapters provide support for both IB as well as RDMAoE modes

Modes of Communication using ConnectX DDR Adapter



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Problem Statement

- How do the different communication protocols stack up against each other as far
 - Raw sockets / verbs level performance
 - Performance for MPI applications
 - Performance for Data center applications
- Does RDMAoE bring us a step closer to the goal of network convergence

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Approach

- Protocol level benchmarks to evaluate very basic performance
- MPI level benchmarks to evaluate basic MPI performance at both point to point and collective levels
- Application level benchmarks to evaluate performance of real world applications
- Evaluation using common data center applications

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Experimental Testbed

- Compute Platform
 - Intel Nehalem
 - Intel Xeon E5530 Dual quad-core processors operating at 2.40 GHz
 - 12GB RAM, 8MB cache
 - PCIe 2.0 interface
- Host Channel Adapter
 - Dual port ConnectX DDR adapter
 - Configured in either RDMAoE mode or IB mode
- Network Switches
 - 24 port Mellanox IB DDR switch
 - 24 port Fulcrum Focalpoint 10GigE switch
- OFED version
 - OFED-1.4.1 for IB and IPoIB
 - Pre-release version of OFED-1.5 for RDMAoE and TCP / IP
- MPI version – MVAPICH-1.1 and MPICH-1.2.7p1

MVAPICH / MVAPICH2 Software

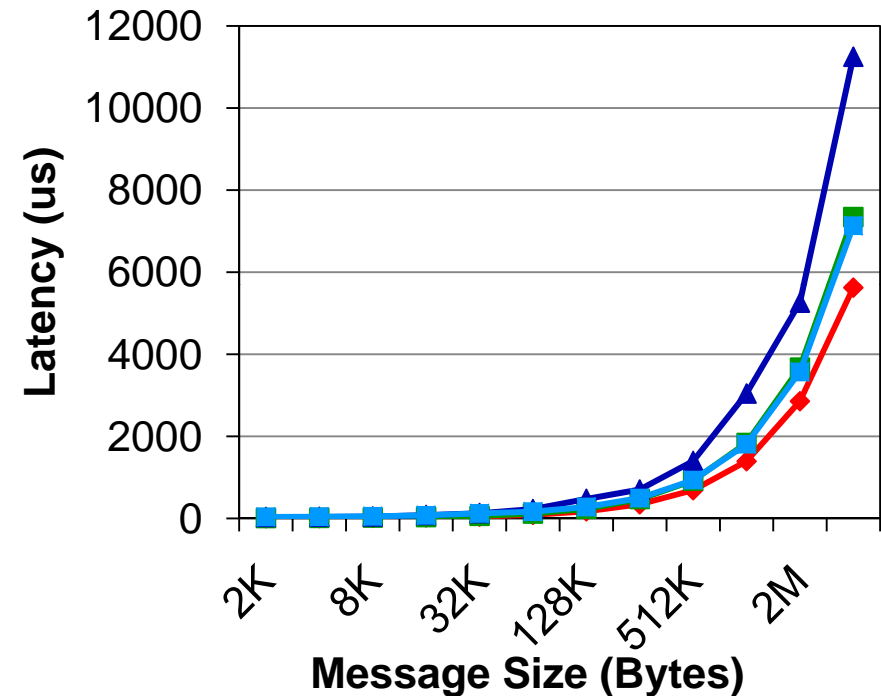
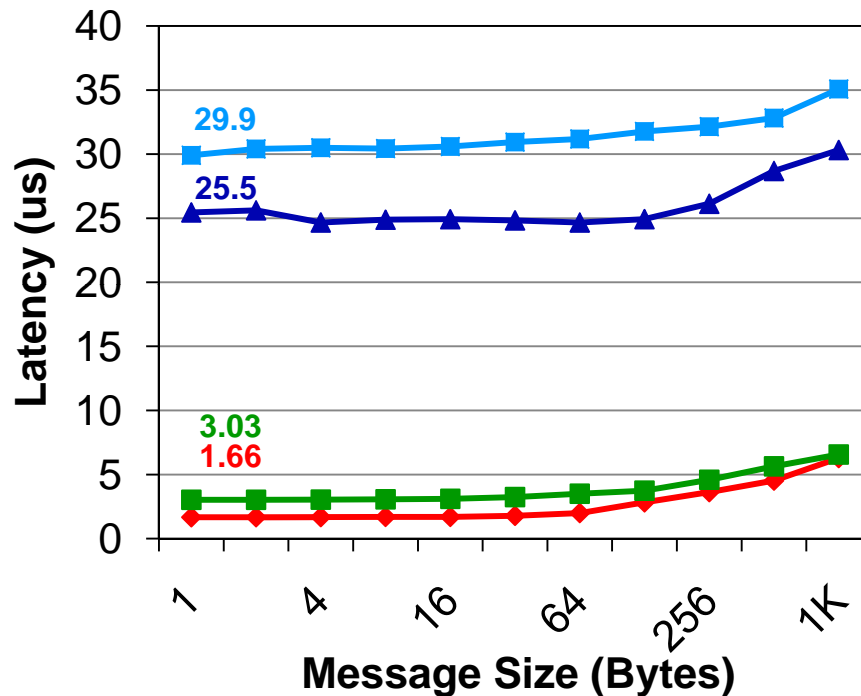
- High Performance MPI Library for IB and 10GE
 - MVAPICH (MPI-1) and MVAPICH2 (MPI-2)
 - Used by more than 960 organizations in 51 countries
 - More than 32,000 downloads from OSU site directly
 - Empowering many TOP500 clusters
 - 8th ranked 62,976-core cluster (Ranger) at TACC
 - Available with software stacks of many IB, 10GE and server vendors including Open Fabrics Enterprise Distribution (OFED)
 - Also supports uDAPL device to work with any network supporting uDAPL
 - <http://mvapich.cse.ohio-state.edu/>

List of Benchmarks

- OSU Microbenchmarks (OMB)
 - Version 3.1.1
 - <http://mvapich.cse.ohio-state.edu/benchmarks/>
- Intel Collective Microbenchmarks (IMB)
 - Version 3.2
 - <http://software.intel.com/en-us/articles/intel-mpi-benchmarks/>
- NAS Parallel Benchmarks (NPB)
 - Version 3.3
 - <http://www.nas.nasa.gov/>

Verbs Level Evaluation

Inter-Node Latency



◆ Native IB ◆ RDMAoE ◆ TCP/IP ◆ IPoIB

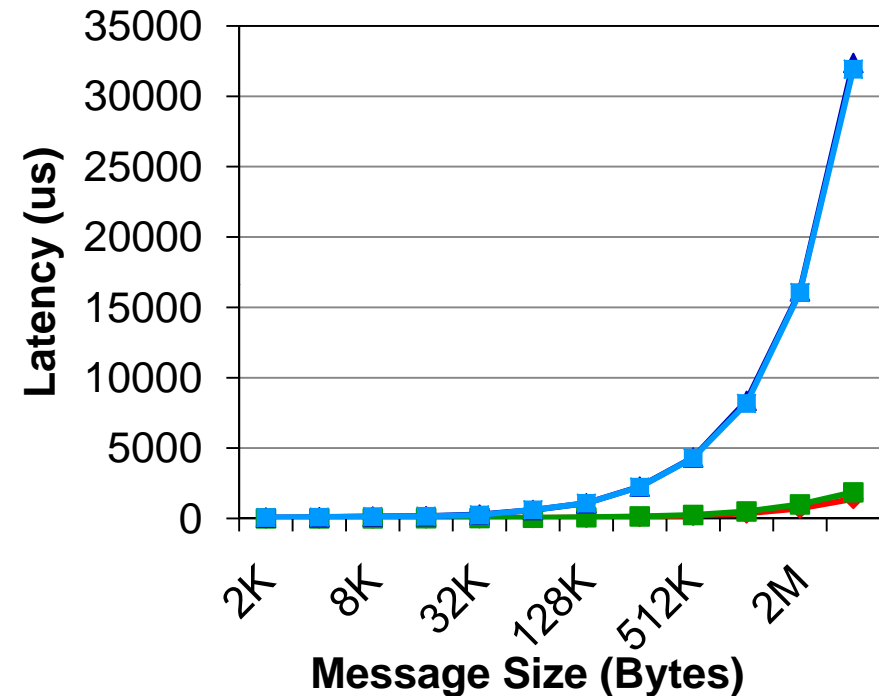
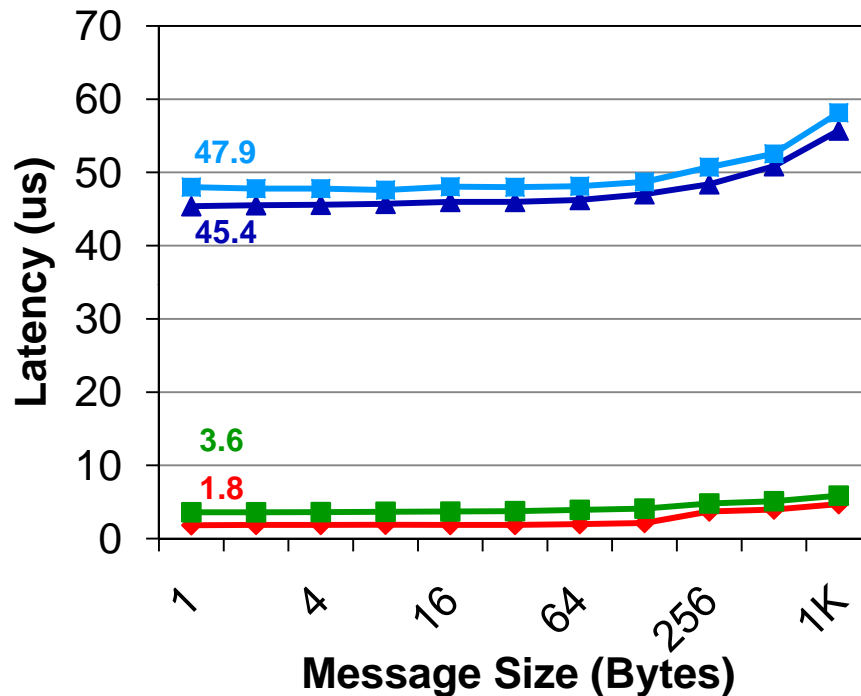
◆ Native IB ◆ RDMAoE ◆ TCP/IP ◆ IPoIB

- **For small messages**

- Native IB verbs offers best latency of **1.66 us**
- RDMAoE comes very close to this at **3.03 us**

MPI Level Evaluation

Inter-Node Latency



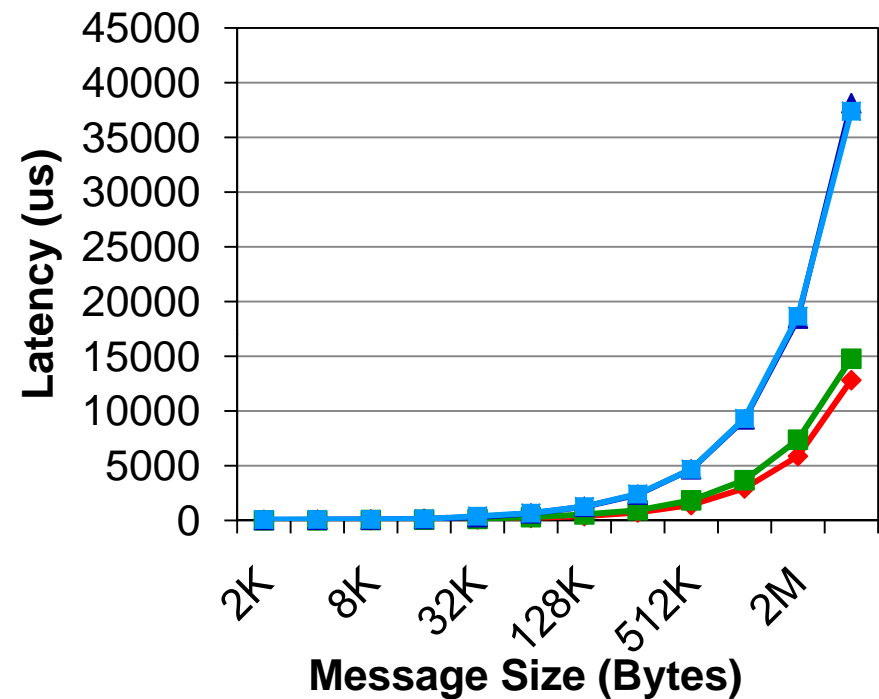
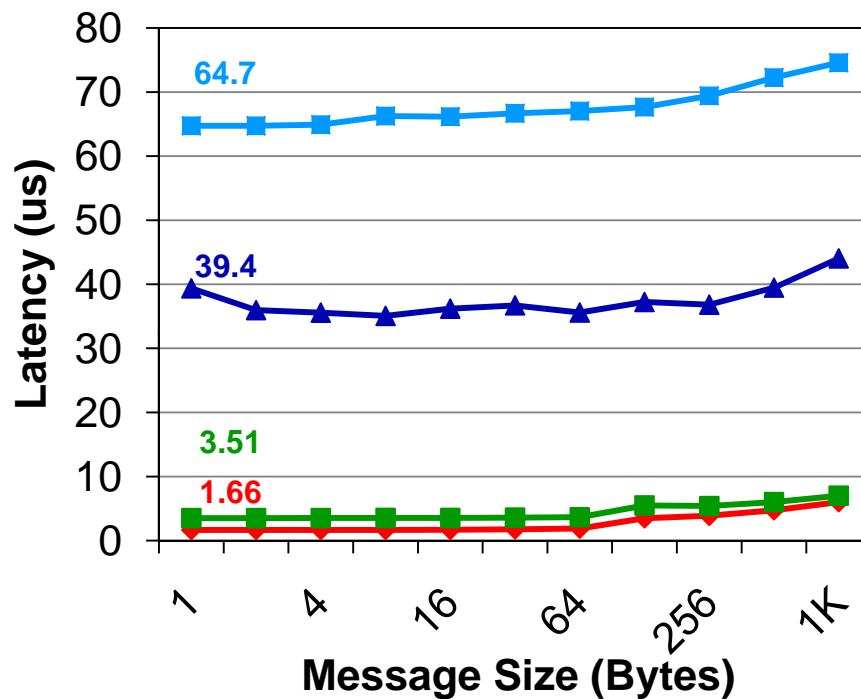
◆ Native IB ◆ RDMAoE ◆ TCP/IP ◆ IPoIB

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- **For small messages**

- Native IB verbs offers best latency of **1.8 us**
- RDMAoE comes very close to this at **3.6 us**

Inter-Node Multipair Latency



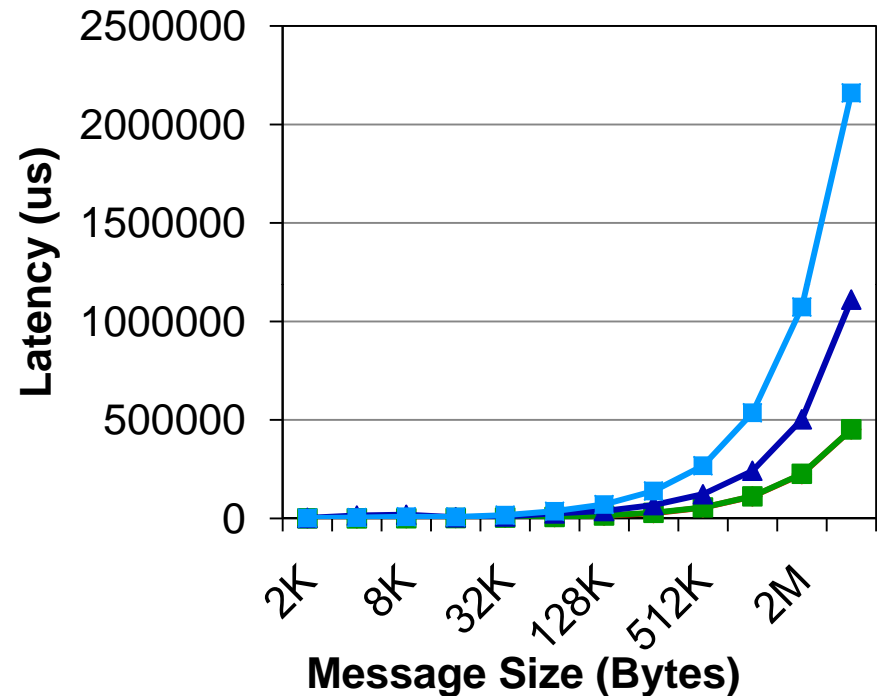
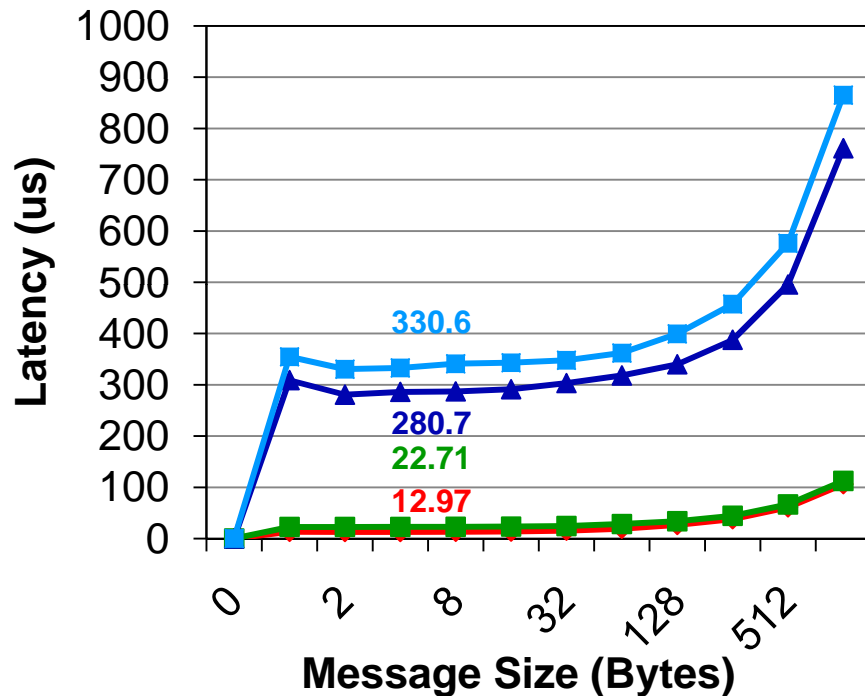
◆ Native IB ■ RDMAoE ▲ TCP/IP ■ IPoIB

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- 4 pairs of processes communicating simultaneously
- For small messages
 - Native IB verbs offers best latency of **1.66 us**
 - RDMAoE comes very close to this at **3.51 us**

Collective Performance

Allgather Latency (32-cores)



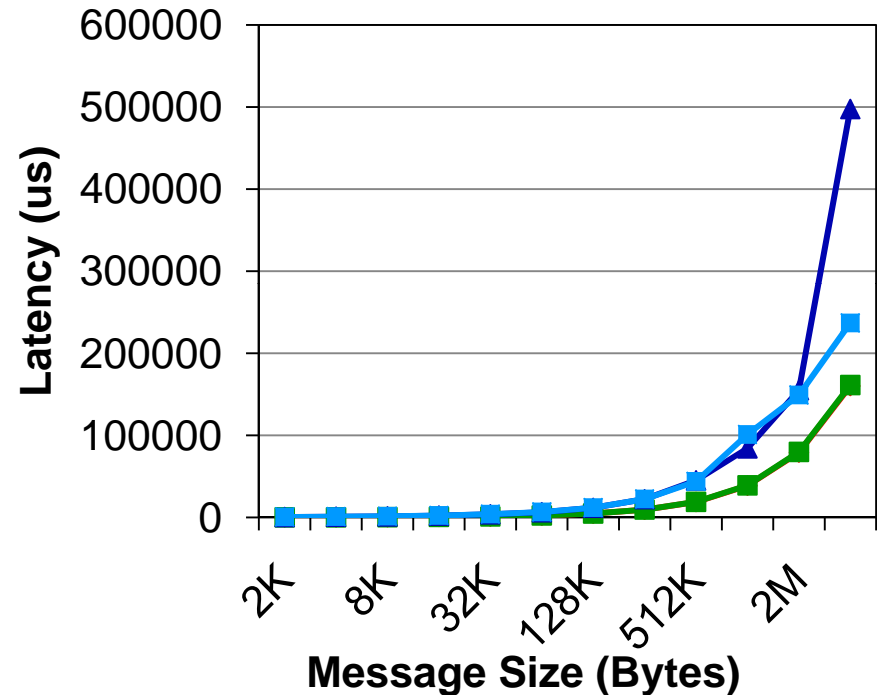
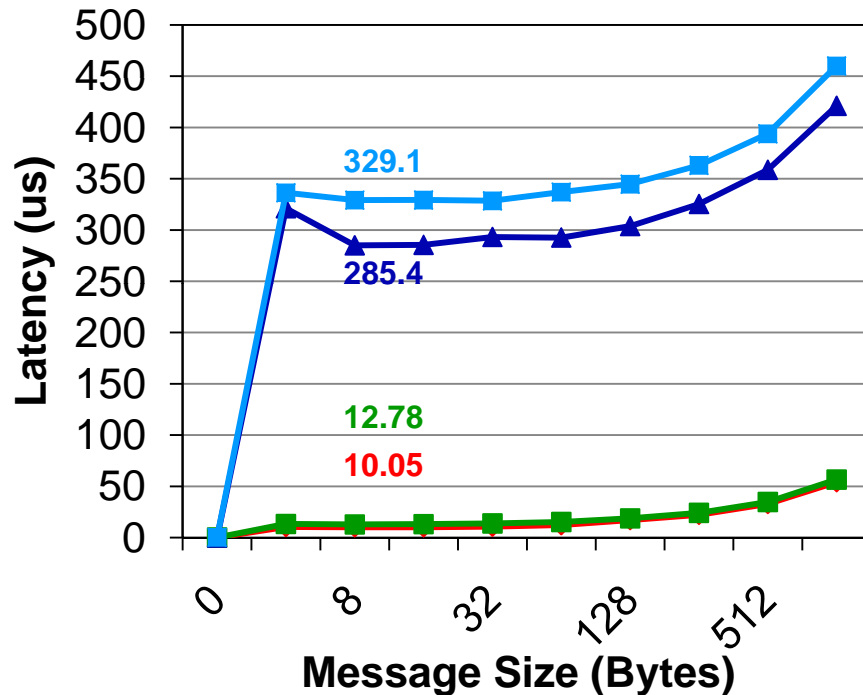
◆ Native IB ■ RDMAoE ▲ TCP/IP ■ IPoIB

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- For small messages
 - Native IB verbs offers best latency of **12.97 us**
 - RDMAoE comes very close to this at **22.71 us**

Collective Performance

Allreduce Latency (32-cores)



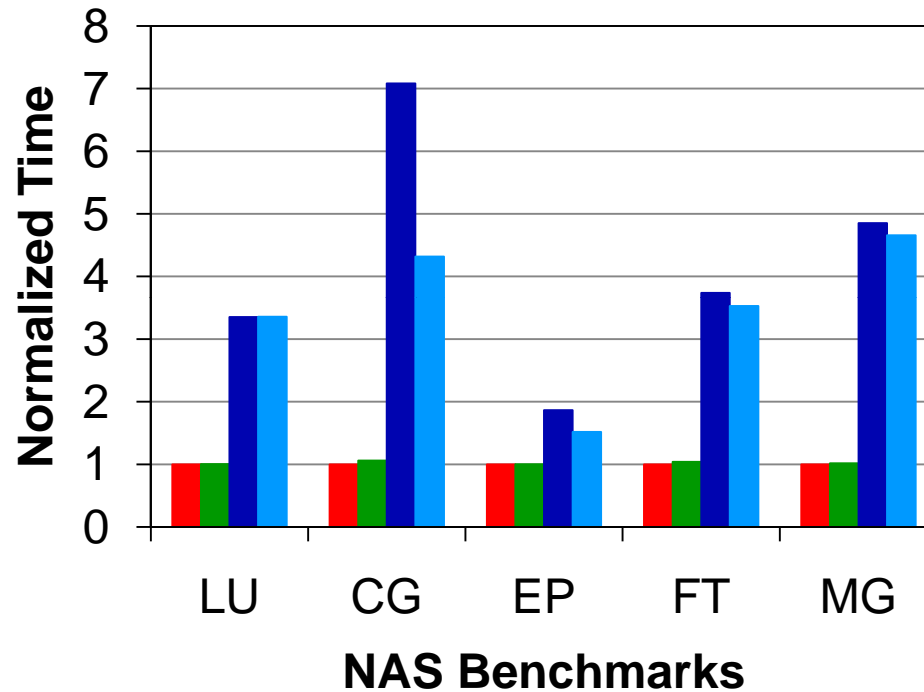
◆ Native IB ◆ RDMAoE ◆ TCP/IP ◆ IPoIB

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- For small messages

- Native IB verbs offers best latency of **10.05 us**
- RDMAoE comes very close to this at **12.78 us**

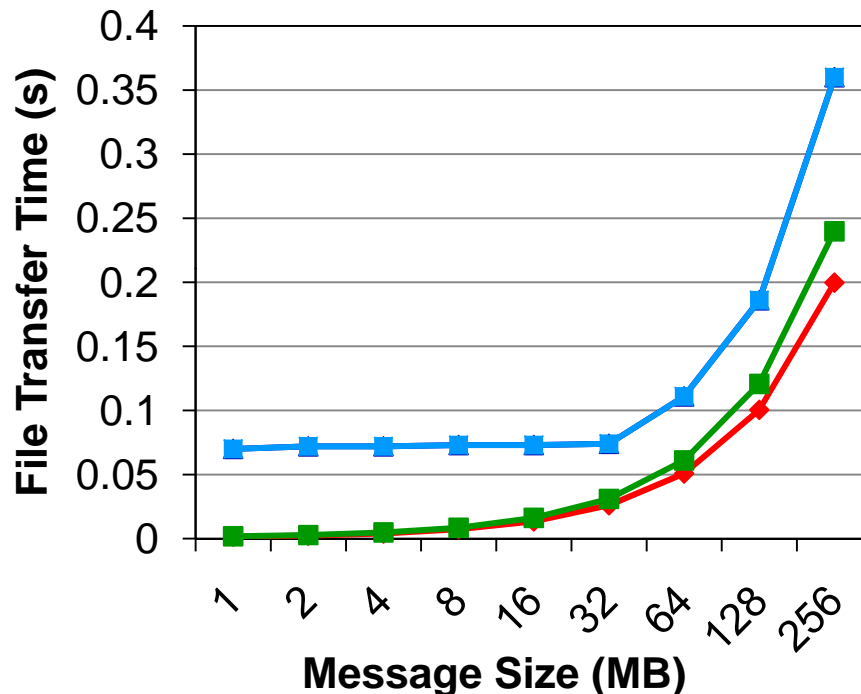
Performance of NAS Benchmarks



- 32 process, Class C
- Numbers normalized to Native-IB
- Performance of Native IB and RDMAoE are very close with Native IB giving the best performance

■ Native-IB ■ RDMAoE ■ TCP/IP ■ IP over IB

Evaluation of Data Center Applications



◆ Native IB ◆ RDMAoE ◆ TCP/IP ◆ IPoIB

- We evaluate FTP, a common data center application
- We use our own version of FTP over native IB verbs (FTP-ADTS [2]) to evaluate RDMAoE and Native IB
- GridFTP [1] is used to evaluate performance of TCP/IP and IPoIB
- RDMAoE shows performance comparable to Native IB

[1] http://www.globus.org/grid_software/data/gridftp.php

[2] FTP Mechanisms for High Performance Data-Transfer over InfiniBand. Ping Lai, Hari Subramoni, Sundeep Narravula, Amith Mamidala, D K. Panda. ICPP '09.

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Conclusions & Future Work

- Perform comprehensive evaluation of all possible modes of communication (Native IB, RDMAoE, TCP/IP, IPoIB) using
 - Verbs
 - MPI
 - Application and,
 - Data center level experiments
- Native IB gives the best performance followed by RDMAoE
- RDMAoE provides a high performance solution to the problem of network convergence
- As part of future work, we plan to
 - Perform large scale evaluations including studies into the effect of network contention on the performance of these protocols
 - Study these protocols in a comprehensive manner for file systems

Thank you !

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Network-Based Computing Laboratory

<http://mvapich.cse.ohio-state.edu/>