Supporting iWARP Compatibility and Features for Regular Network Adapters

P. Balaji H. –W. Jin K. Vaidyanathan D. K. Panda

Network Based Computing Laboratory (NBCL)

Ohio State University

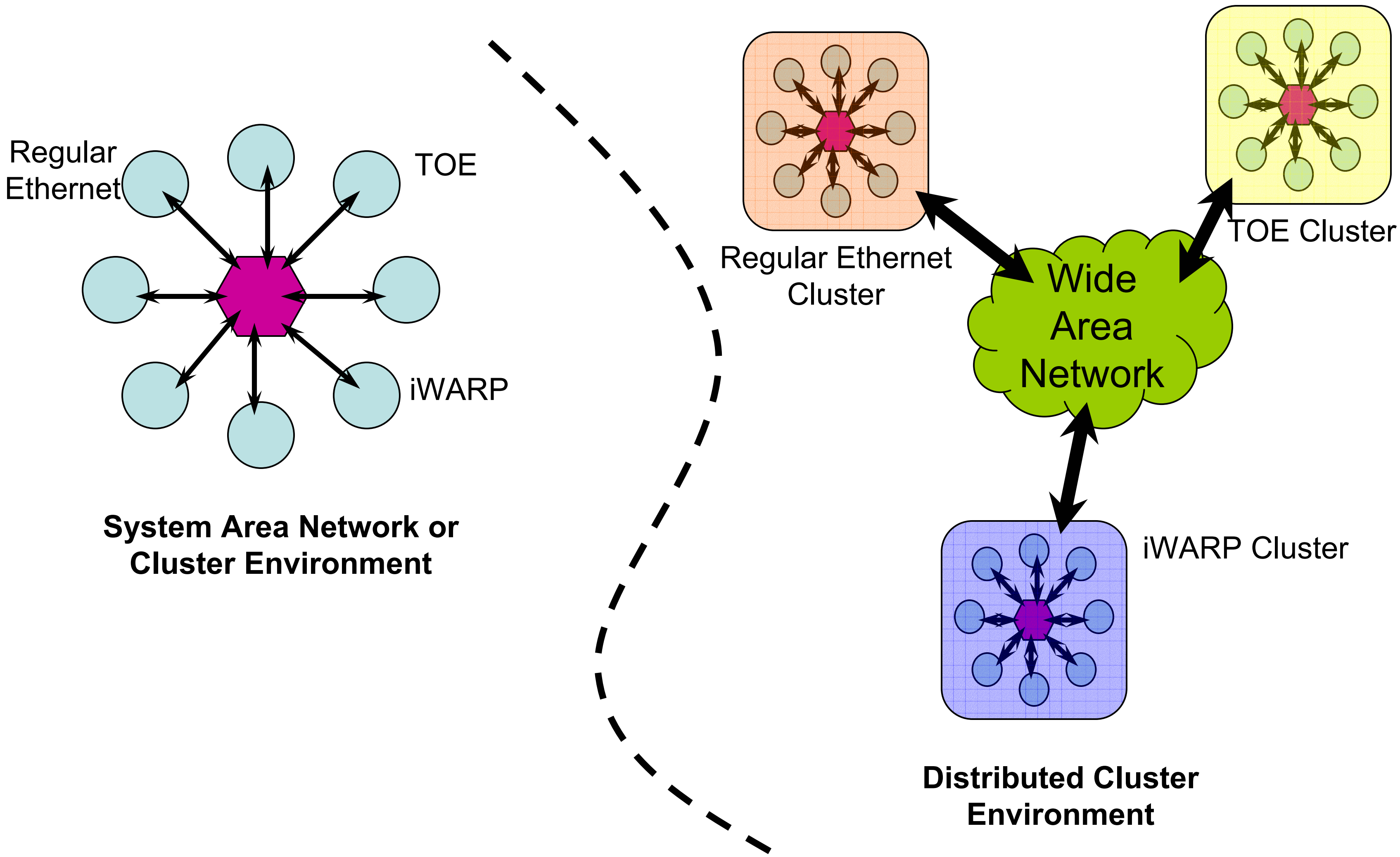
Ethernet Overview

- Ethernet is the most widely used network infrastructure today
- Traditionally Ethernet has been notorious for performance issues
  - Near an order-of-magnitude performance gap compared to other networks
    - Cost conscious architecture
    - Most Ethernet adapters were *regular (layer 2)* adapters
    - Relied on host-based TCP/IP for network and transport layer support
    - Compatibility with existing infrastructure (switch buffering, MTU)
  - Used by 42.4% of the Top500 supercomputers
  - Key: Reasonable performance at low cost
    - TCP/IP over Gigabit Ethernet (GigE) can nearly saturate the link for current systems
    - Several local stores give out GigE cards free of cost !
- 10-Gigabit Ethernet (10GigE) recently introduced
  - 10-fold (theoretical) increase in performance while retaining existing features

Ethernet: Technology Trends

- Broken into three levels of technologies
  - Regular Ethernet adapters *[feng03:hoti, feng03:sc, balaji04:rait]*
    - Layer-2 adapters
    - Rely on host-based TCP/IP to provide network/transport functionality
    - Could achieve a high performance with optimizations
  - TCP Offload Engines (TOEs) *[balaji05:hoti, balaji05:cluster]*
    - Layer-4 adapters
    - Have the entire TCP/IP stack offloaded on to hardware
    - Sockets layer retained in the host space
  - iWARP-aware adapters *[jin05:hpidc, wyckoff05:rait]*
    - Layer-4 adapters
    - Entire TCP/IP stack offloaded on to hardware
    - Support more features than TCP Offload Engines
      - No sockets ! Richer iWARP interface !
      - E.g., Out-of-order placement of data, RDMA semantics

Current Usage of Ethernet



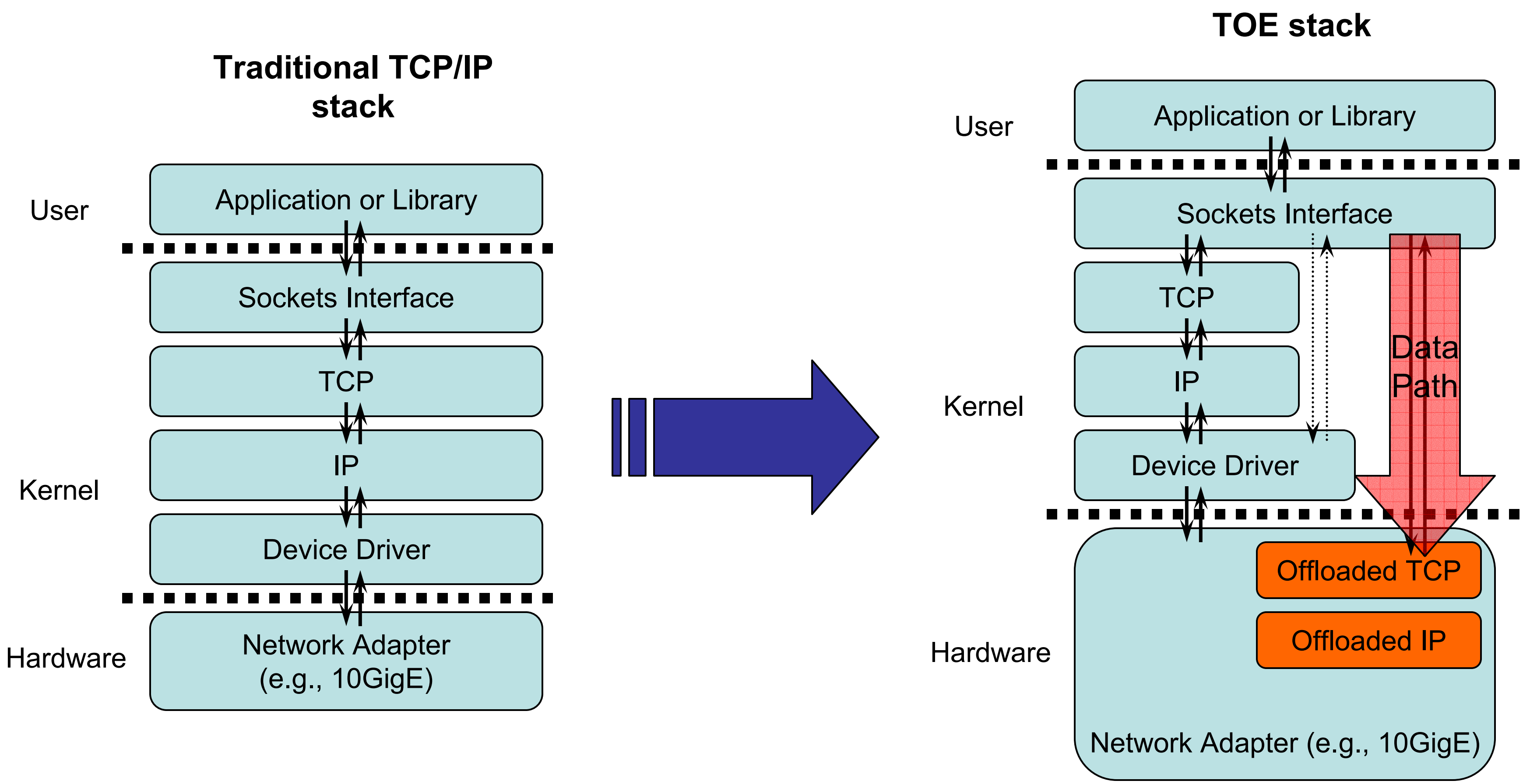
Problem Statement

- Regular Ethernet adapters and TOEs are completely compatible
  - Network level compatibility (Ethernet + IP + TCP + application payload)
  - Interface level compatibility (both expose the sockets interface)
- With the advent of iWARP, this compatibility is disturbed
  - Both ends of a connection need to be iWARP compliant
    - Intermediate nodes do not need to understand iWARP
  - The interface exposed is no longer sockets
    - iWARP exposes a much richer and newer API
    - Zero-copy, asynchronous and one-sided communication primitives
    - Not very good for existing applications
- Two primary requirements for a wide-spread acceptance of iWARP
  - Software Compatibility for Regular Ethernet with iWARP capable adapters
  - A common interface which is similar to sockets and has the features of iWARP

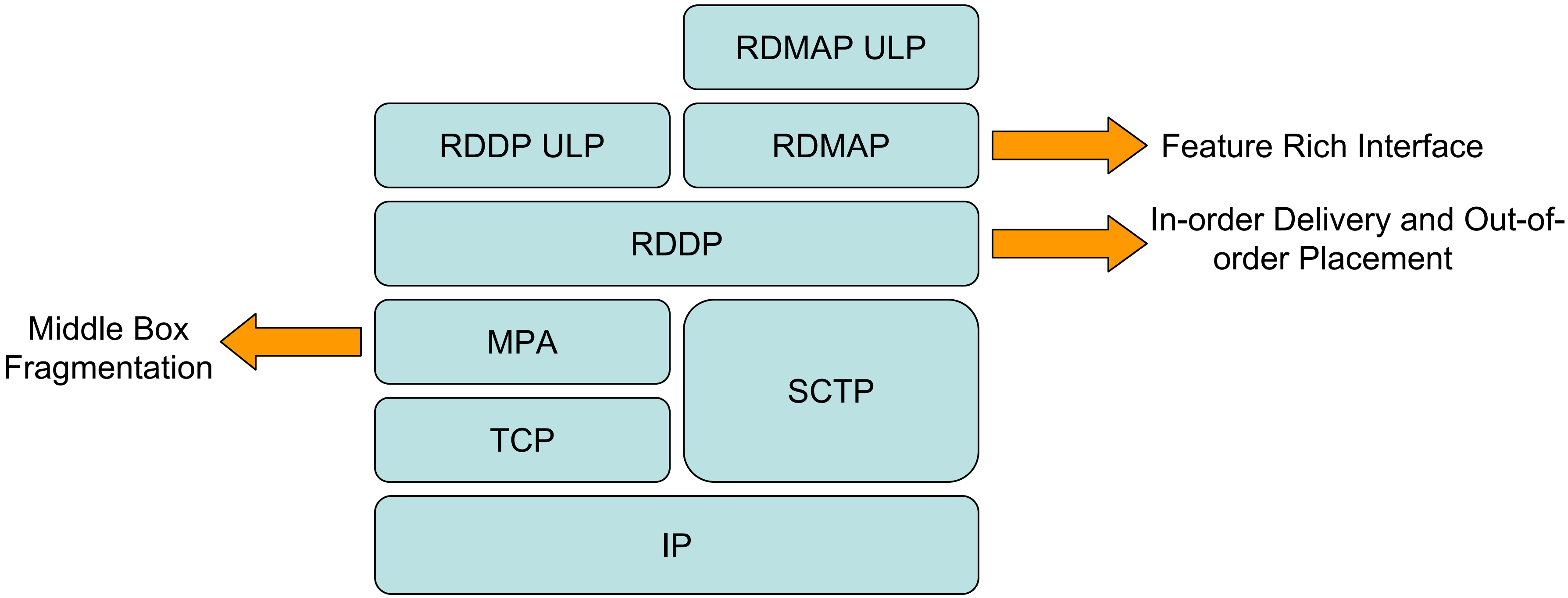
Presentation Overview

- Introduction and Motivation
- **TCP Offload Engines and iWARP**
- Overview of the Proposed Software Stack
- Performance Evaluation
- Conclusions and Future Work

What is a TCP Offload Engine (TOE)?



iWARP Protocol Suite



Courtesy iWARP Specification

More details provided in the paper or in the iWARP Specification

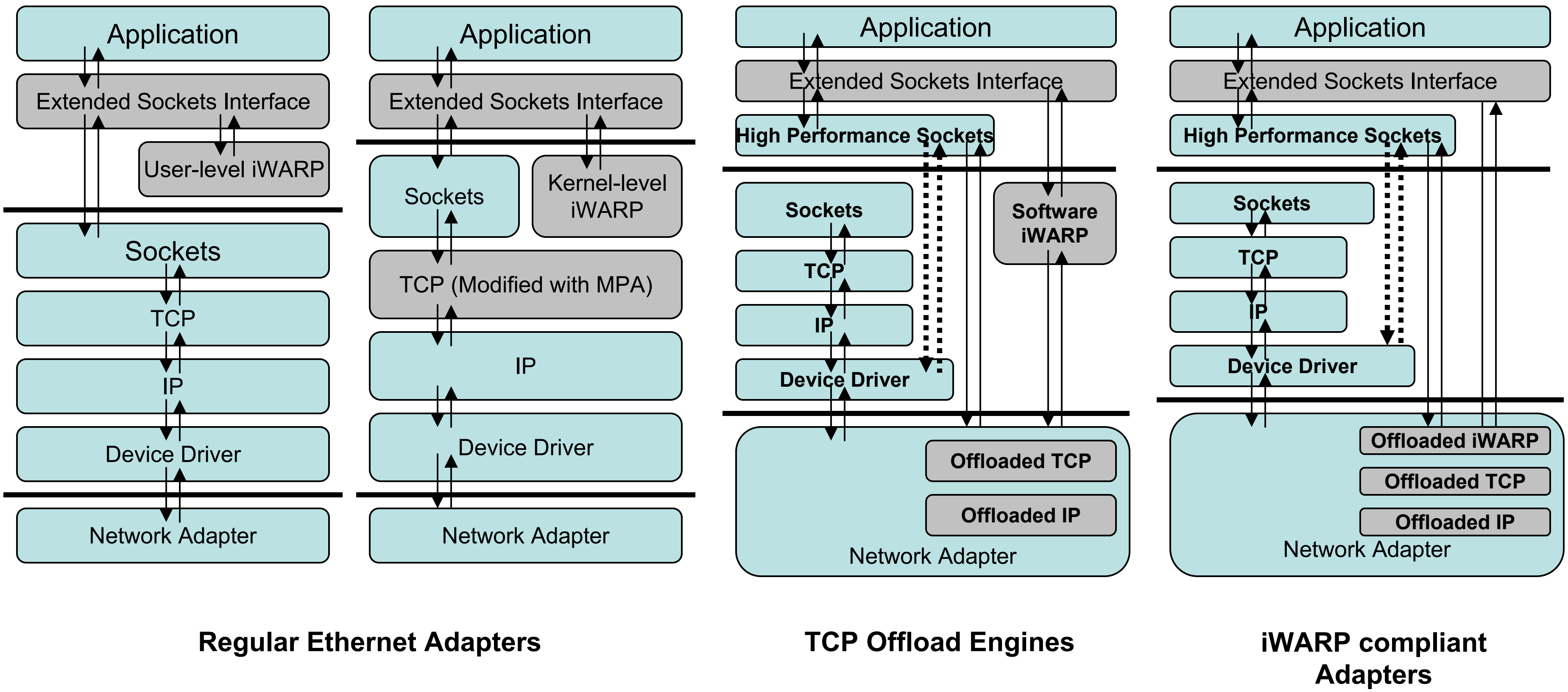
Presentation Overview

- Introduction and Motivation
- TCP Offload Engines and iWARP
- **Overview of the Proposed Software Stack**
- Performance Evaluation
- Conclusions and Future Work

Proposed Software Stack

- The Proposed Software stack is broken into two layers
  - Software iWARP implementation
    - Provides wire compatibility with iWARP-compliant adapters
    - Exposes the iWARP feature set to the upper layers
    - Two implementations provided: User-level iWARP and Kernel-level iWARP
  - Extended Sockets Interface
    - Extends the sockets interface to encompass the iWARP features
    - Maps a single file descriptor to both the iWARP as well as the normal TCP connection
    - Standard sockets applications can run WITHOUT any modifications
    - Minor modifications to applications required to utilize the richer feature set

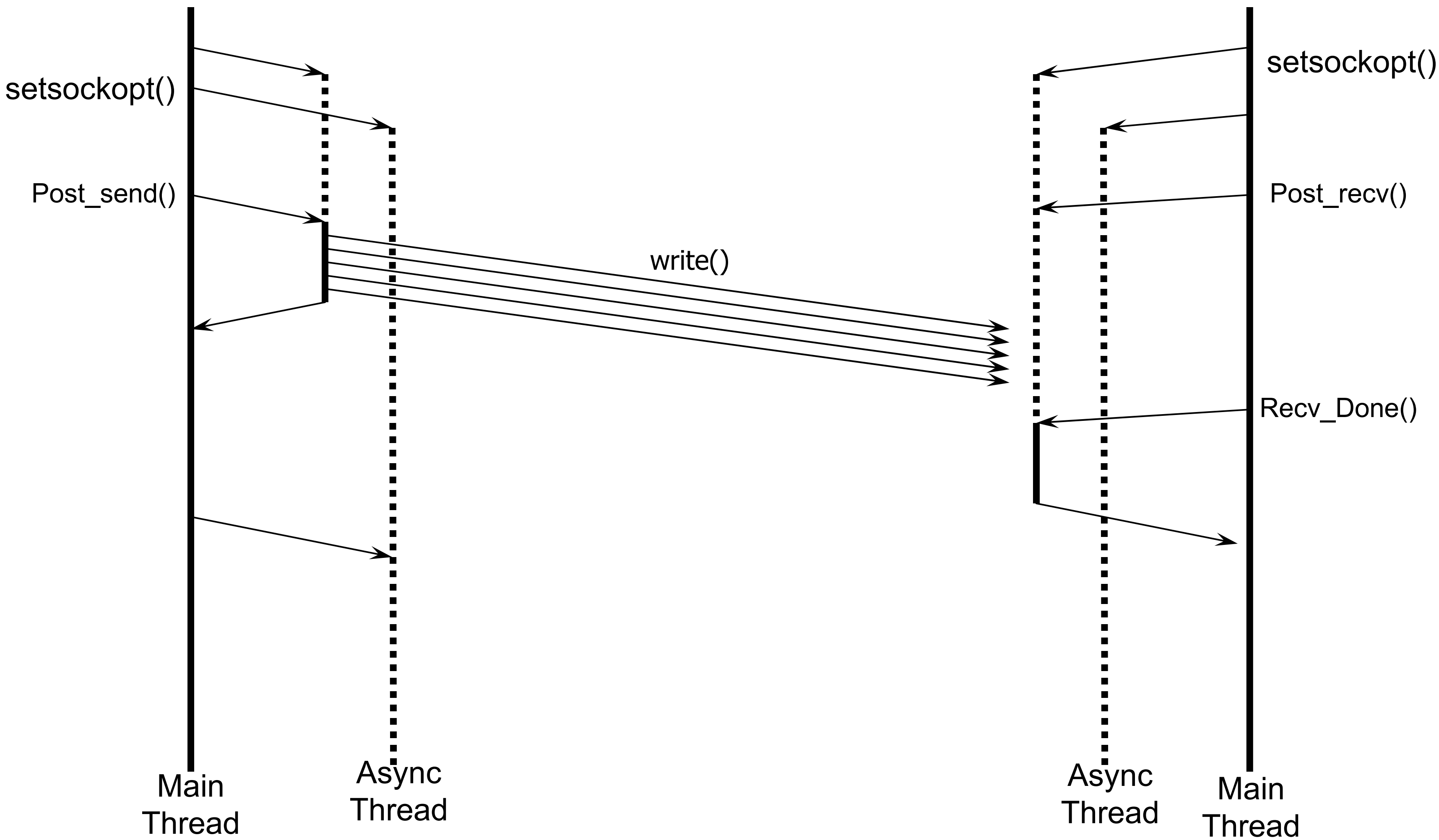
Software iWARP and Extended Sockets Interface



Designing the Software Stack

- User-level iWARP implementation
  - Non-blocking Communication Operations
  - Asynchronous Communication Progress
- Kernel-level iWARP implementation
  - Zero-copy data transmission and single-copy data reception
  - Handling Out-of-order segments
- Extended Sockets Interface
  - Generic Design to work over any iWARP implementation

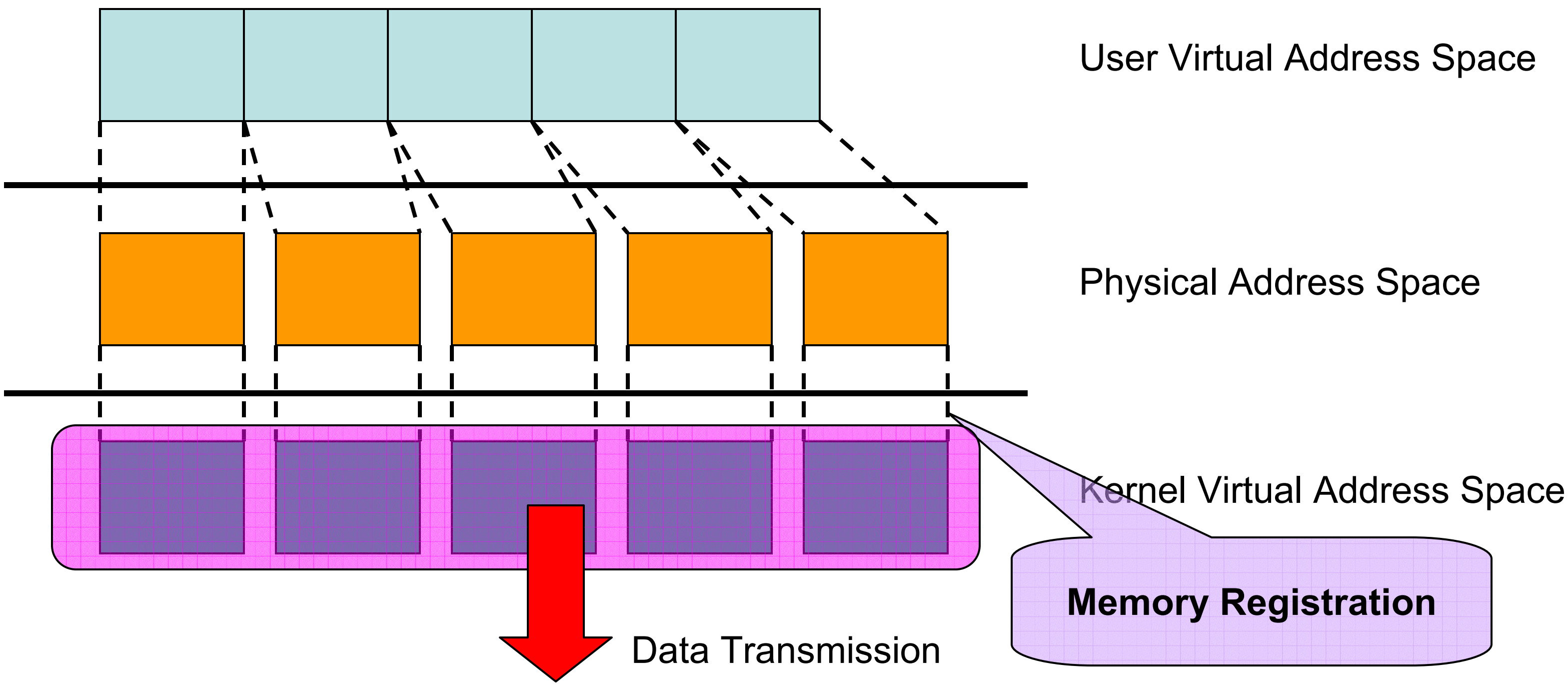
Non-Blocking and Asynchronous Communication



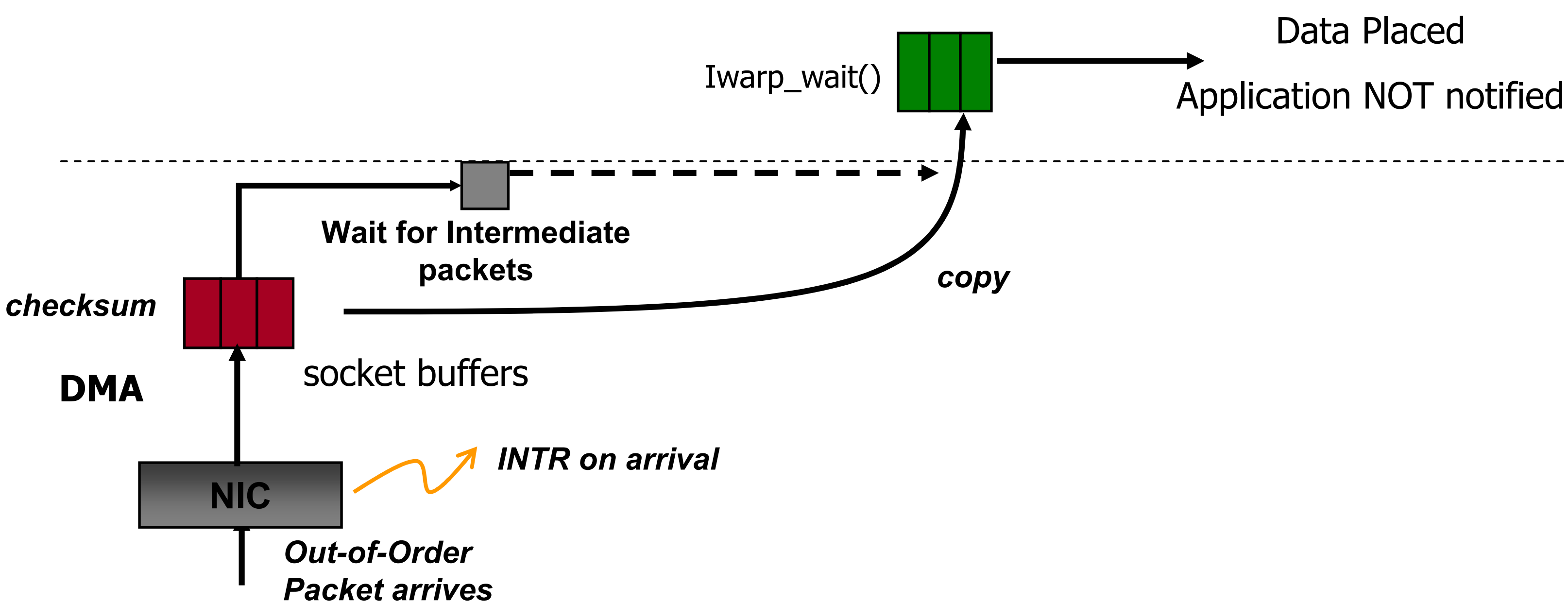
User-level iWARP is a multi-threaded implementation

Zero-copy Transmission in Kernel-level iWARP

- Memory map user buffers to kernel buffers
- Mapping needs to be in place till the reliability ACK is received
- Buffers are mapped during memory registration
  - Avoids mapping overhead during data transmission



Handling Out-of-order Segments



- Data is retained in the Socket buffer even after it is placed !
- This ensures that TCP/IP handles reliability and not the iWARP stack

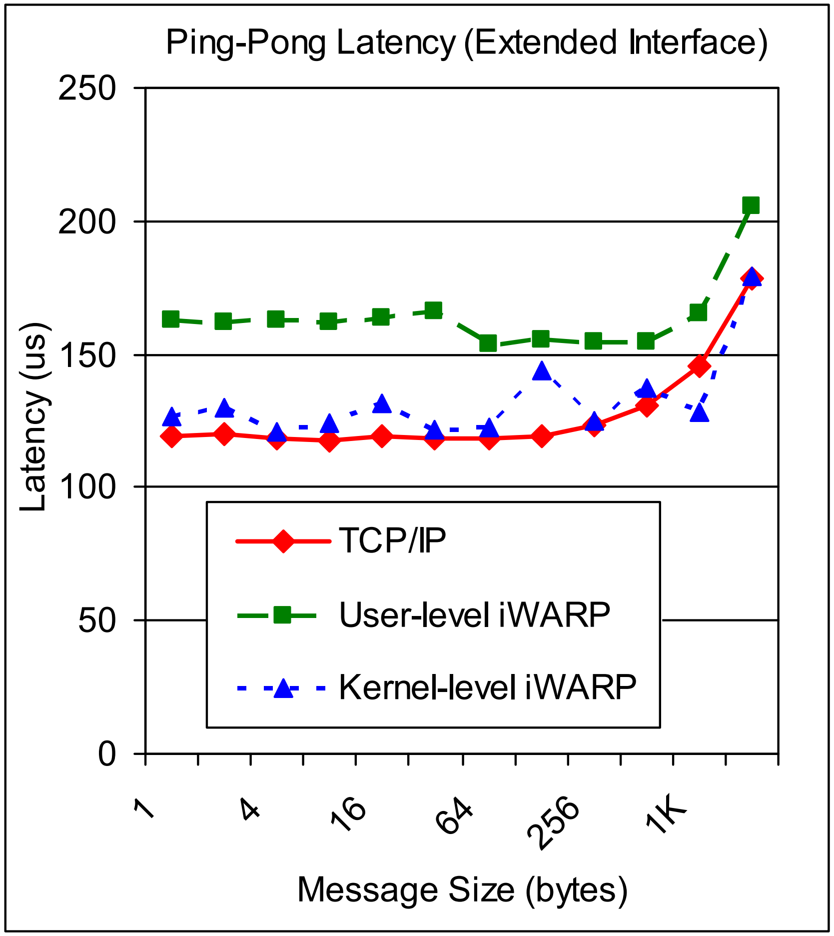
Presentation Overview

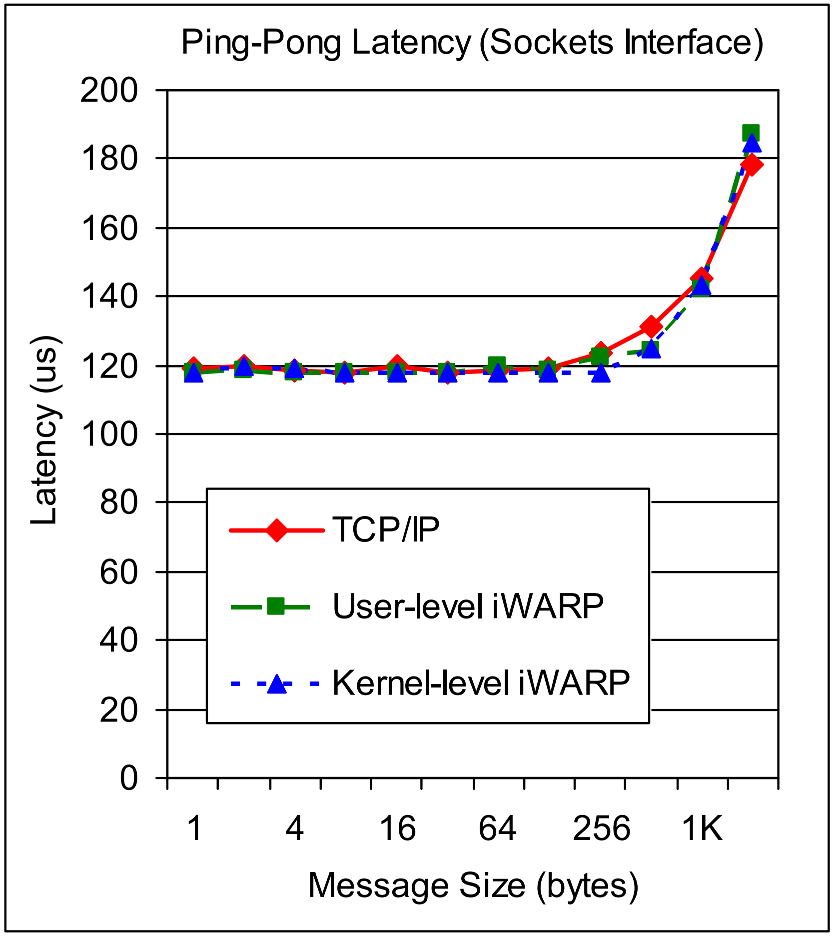
- Introduction and Motivation
- TCP Offload Engines and iWARP
- Overview of the Proposed Software Stack
- **Performance Evaluation**
- Conclusions and Future Work

Experimental Test-bed

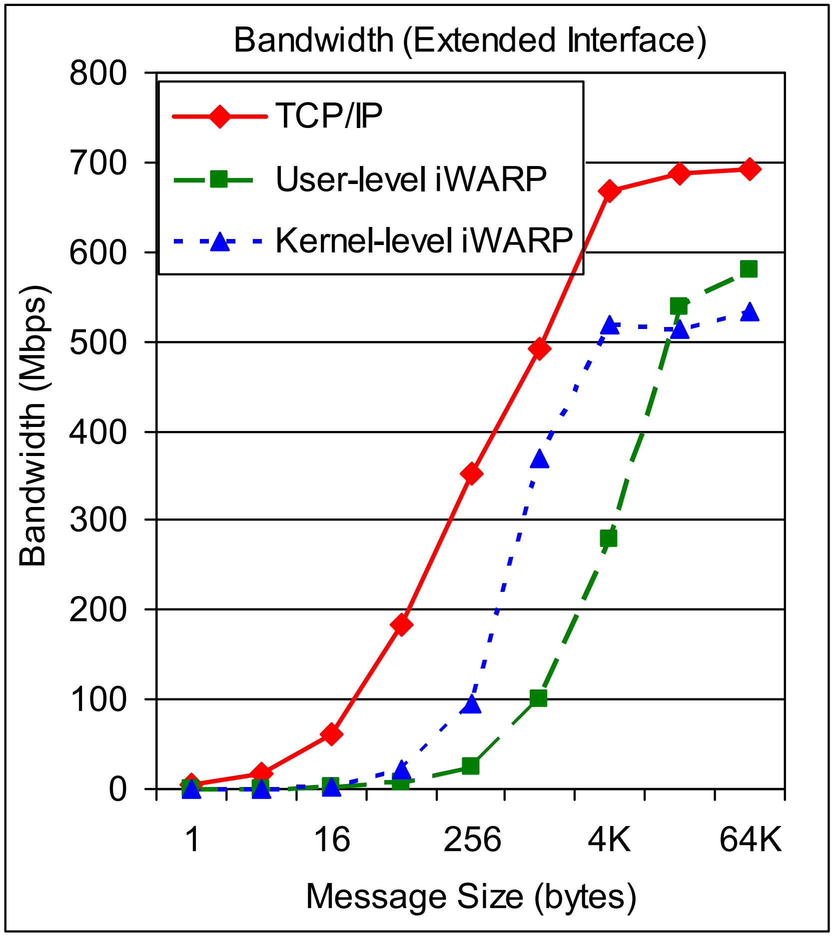
- Cluster of Four Node P-III 700MHz Quad-nodes
- 1GB 266MHz SDRAM
- Alteon Gigabit Ethernet Network Adapters
- Packet Engine 4-port Gigabit Ethernet switch
- Linux 2.4.18-smp

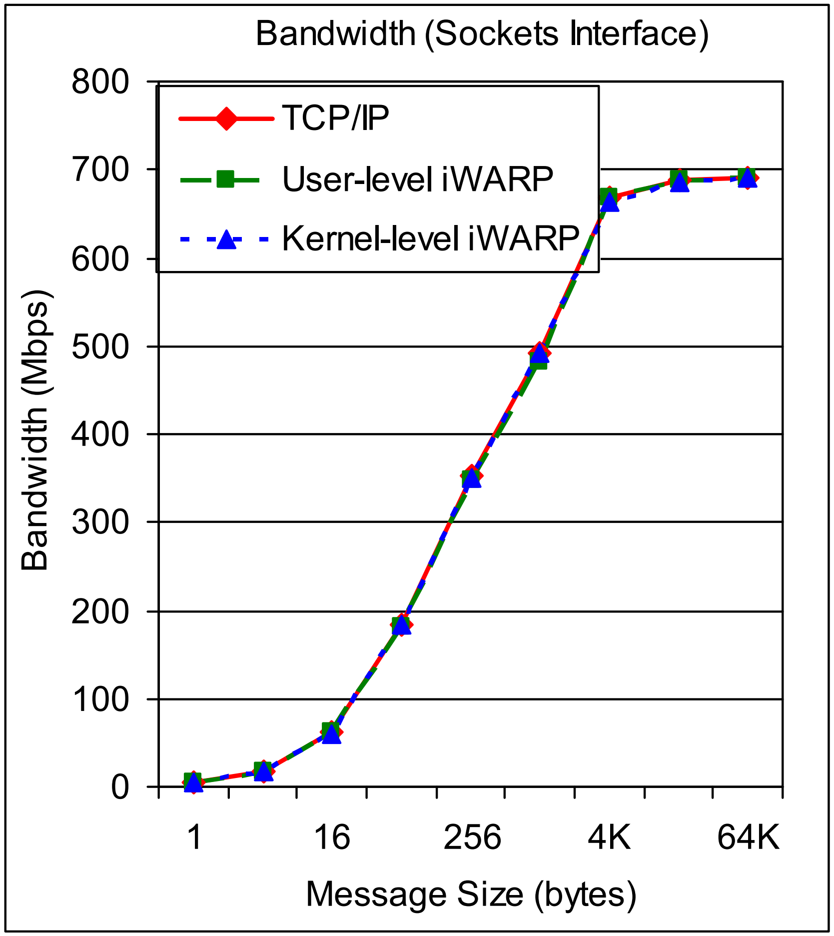
Ping-Pong Latency Test





Uni-directional Stream Bandwidth Test





Software Distribution

- Public Distribution of User-level and Kernel-level Implementations
  - User-level Library
  - Kernel module for 2.4 kernels
  - Kernel patch for 2.4.18 kernel
  - Extended Sockets Interface for software iWARP
- Contact Information
  - {panda, balaji}@cse.ohio-state.edu
  - http://nowlab.cse.ohio-state.edu

Presentation Overview

- Introduction and Motivation
- TCP Offload Engines and iWARP
- Overview of the Proposed Software Stack
- Performance Evaluation
- **Conclusions and Future Work**

Concluding Remarks

- Ethernet has been broken down into three technology levels
  - Regular Ethernet, TCP Offload Engines and iWARP-compliant adapters
  - Compatibility between these technologies is important
- Regular Ethernet and TOE are completely compatible
  - Both the wire protocol and the ULP interface are the same
  - iWARP does not share such compatibility
- Two primary requirements for a wide-spread acceptance of iWARP
  - Software Compatibility for Regular Ethernet with iWARP capable adapters
  - A common interface which is similar to sockets and has the features of iWARP
- We provided a software stack which meets these requirements

Continuing and Future Work

- The current Software iWARP is only built for Regular Ethernet
  - TCP Offload Engines provide more features than Regular Ethernet
  - Needs to be extended to all kinds of Ethernet networks
    - E.g., TCP Offload Engines, iWARP-compliant adapters, Myrinet 10G adapters
- Interoperability with Ammasso RNICs
  - Modularized approach to enable/disable components in the iWARP stack
- Simulated Framework for studying NIC architectures
  - NUMA Architectures on the NIC for iWARP Offload
- Flow Control/Buffer Management Features for Extended Sockets

Acknowledgments

United States Department of Energy
Science, Technology and Energy for our Future

SeaFire® Micros, Inc.

AMMASSO

Web Pointers

NBCL

Website: http://www.cse.ohio-state.edu/~balaji

Group Homepage: http://nowlab.cse.ohio-state.edu

Email: balaji@cse.ohio-state.edu