OPENFABRICS ALLIANCE

2020 OFA Virtual Workshop

STATUS OF OPENFABRICS INTERFACES (OFI) SUPPORT IN MPICH

Yanfei Guo, Assistant Computer Scientist

Argonne National Laboratory

Argonne NATIONAL LABORATORY

AGENDA

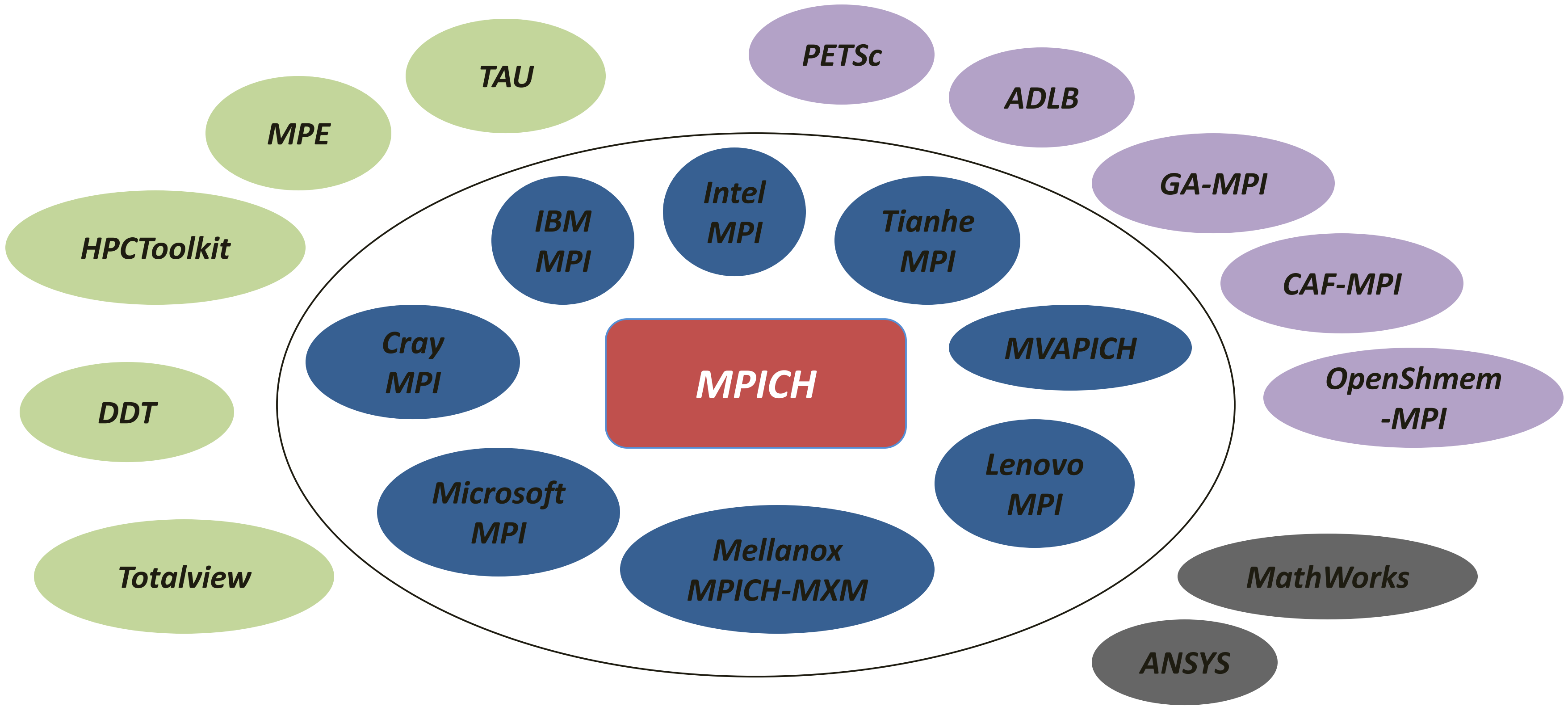
- **What is MPICH?**
- **Why OFI?**
- **Current support**
  - MPICH 3.3 series (CH4)
  - MPICH 3.4 series (CH4)
- **Ongoing work**
  - New Collective Framework
  - GPU Support

WHAT IS MPICH?

- **MPICH is a high-performance and widely portable open-source implementation of MPI**
- **It provides all features of MPI that have been defined so far (up to and include MPI-3.1)**
- **Active development lead by Argonne National Laboratory and University of Illinois at Urbana-Champaign**
  - Several close collaborators who contribute features, bug fixes, testing for quality assurance, etc.
    - IBM, Microsoft, Cray, Intel, Ohio State University, Queen's University, Mellanox, RIKEN AICS and others
- **Current stable release is MPICH-3.3.2**
- **Latest release is MPICH-3.4a2**
- **www.mpich.org**

MPICH: GOAL AND PHILOSOPHY

- MPICH aims to be the preferred MPI implementation on the top machines in the world
- Our philosophy is to create an "MPICH Ecosystem"



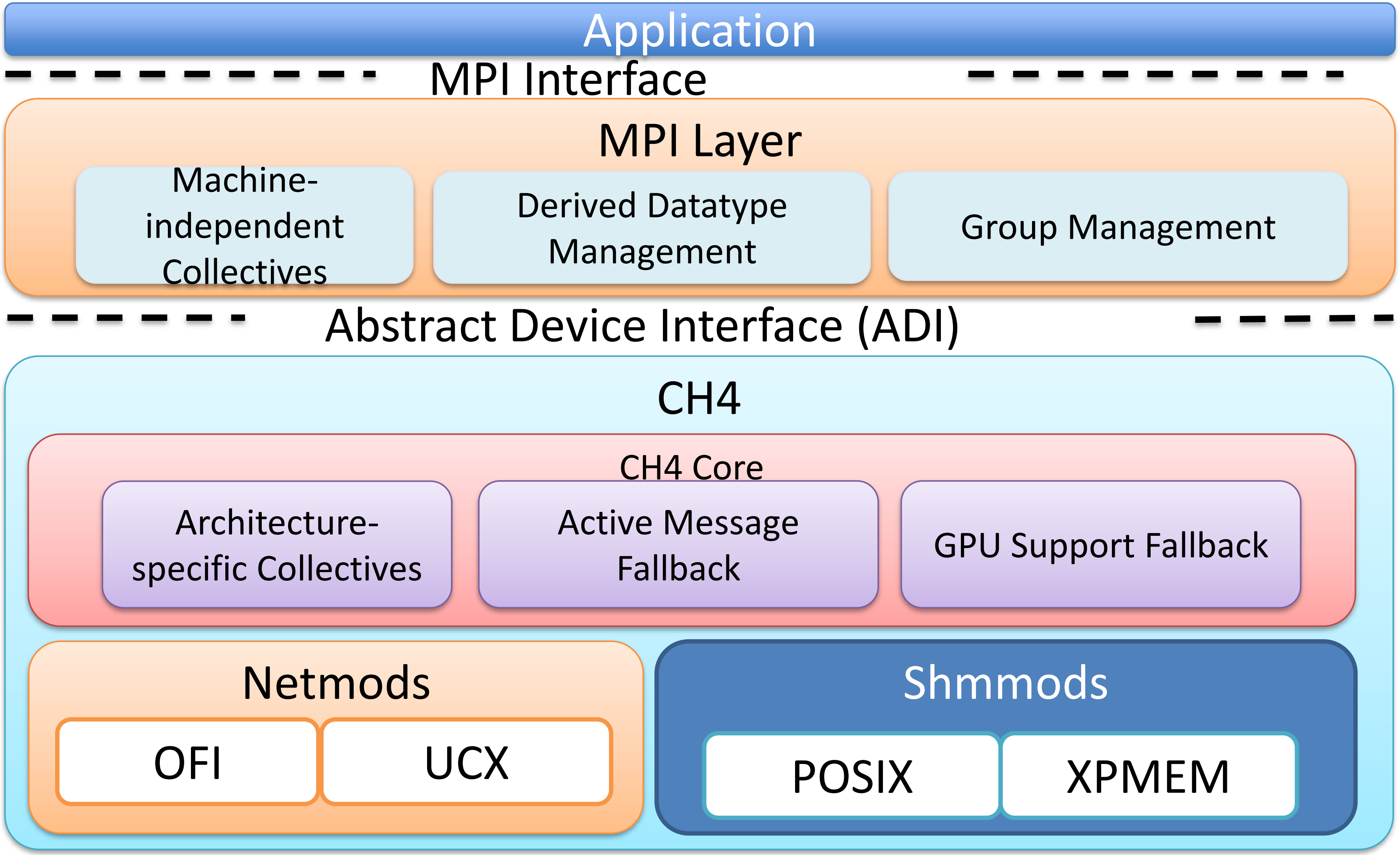
MOTIVATION

- **Why OFI/OFIWG?**
  - Support for diverse hardware through a common API
  - Actively, openly developed
    - Bi-weekly calls
    - Hosted on Github
  - Close abstraction for MPI
    - MPI community engaged from the start
  - Fully functional sockets provider
    - Prototype code on a laptop
  - Strong Vendor Support

MPICH-3.3 SERIES

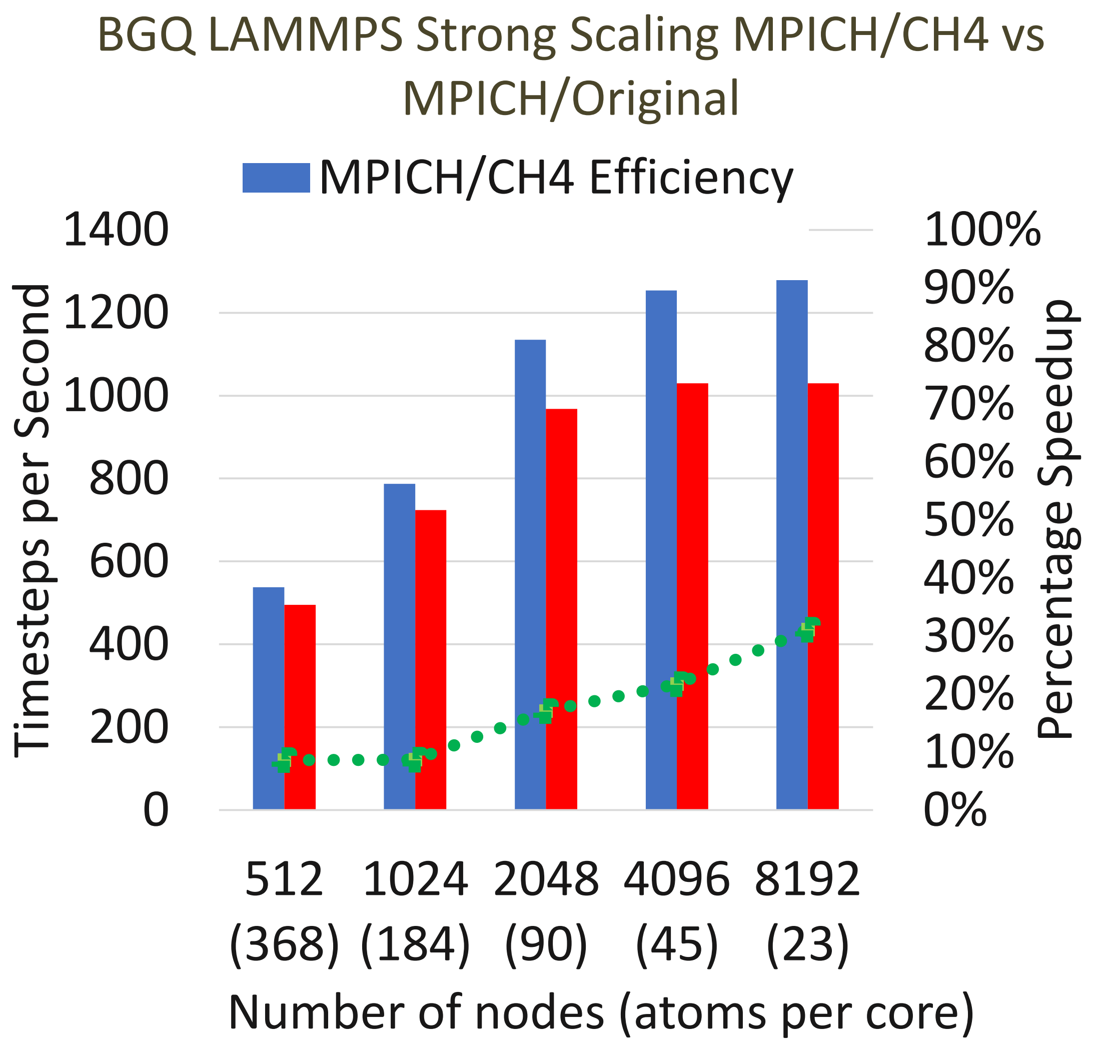
- **Introducing the CH4 device**
  - Replacement for CH3, but we will maintain CH3 till all of our partners have moved to CH4
  - Co-design effort
    - Weekly telecons with partners to discuss design and development issues
  - Two primary objectives:
    - Low-instruction count communication
      - Ability to support high-level network APIs (OFI, UCX)
      - E.g., tag-matching in hardware, direct PUT/GET communication
    - Support for very high thread concurrency
      - Improvements to message rates in highly threaded environments (MPI_THREAD_MULTIPLE)
      - Support for multiple network endpoints (THREAD_MULTIPLE or not)

MPICH WITH CH4 DEVICE OVERVIEW



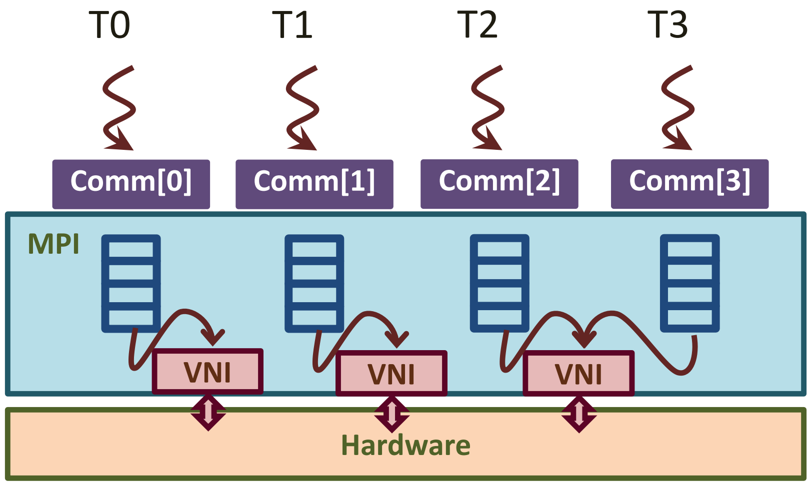
MPICH PERFORMANCE AND SCALABILITY

- **Lightweight communication**
  - Reducing overhead in instruction count and memory usage
  - Inline Libfabric with MPICH further reduces overhead
- **Improvements in MPI one-sided communication**
  - Enabling HW accelerated RMA
- **Communication hints**
  - Allowing user to tell MPI to optimize for the crucial subset of features



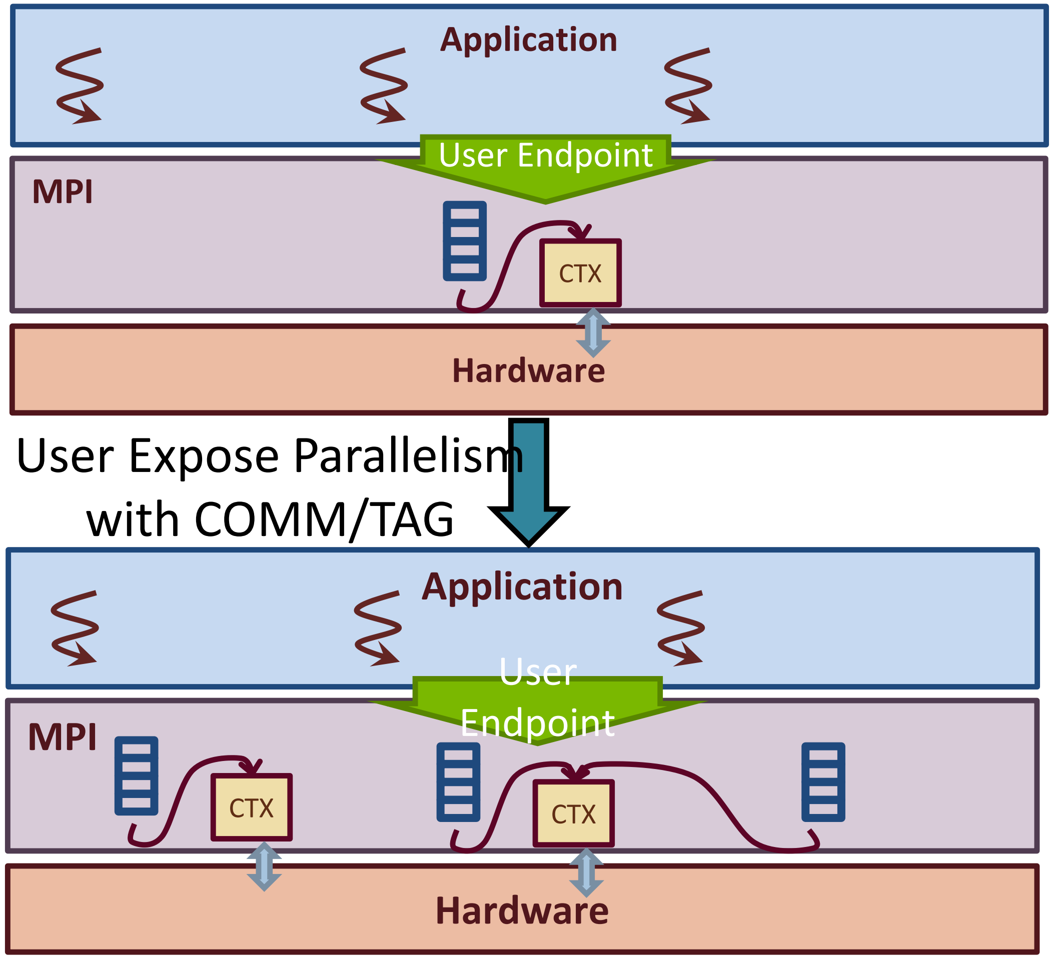
MULTIPLE VIRTUAL NETWORK INTERFACE (VNI)

- **Virtual Network Interface (VNI)**
  - Each VNI abstracts a set of network resources
  - Some networks support multiple VNIs: InfiniBand contexts, scalable endpoints over Intel Omni-Path
  - Traditional MPI implementation uses single VNI
    - Serializes all traffic
    - Does not fully exploit network hardware resources
- **Utilizing multiple VNIs to maximize independence in communication**
  - Separate VNIs per communicator or per RMA window
  - Distribute traffic between VNIs with respect to ranks, tags, and generally out-of-order communication
  - M-N mapping between Work-Queues and VNIs

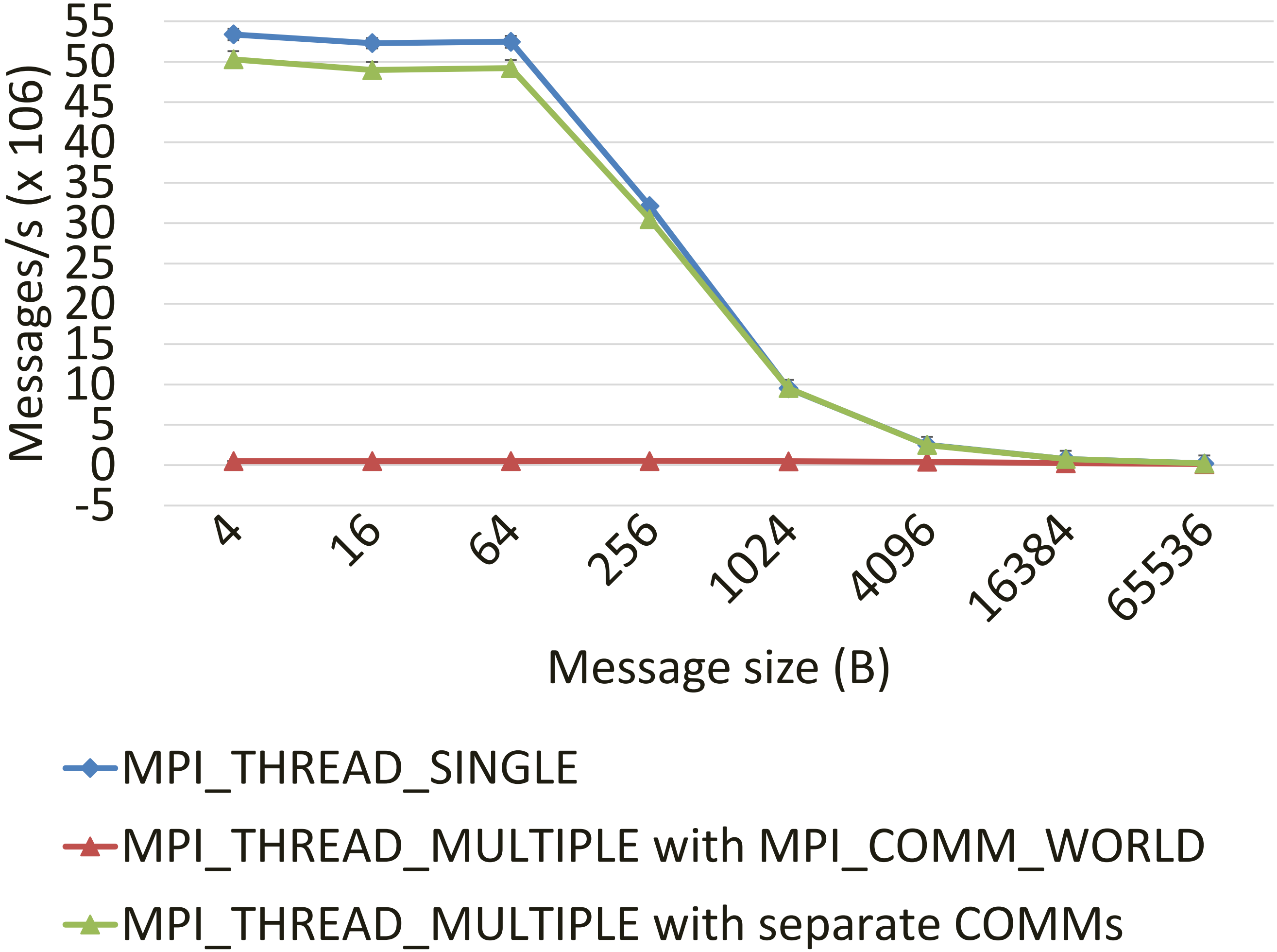


MPI+THREAD HYBRID PROGRAMMING PERFORMANCE

Multithreaded Transfer Model Current MPI (3.1)



Work-Queue Data Transfer Model with MPI Endpoints



UPCOMING MPICH-3.4 AND FUTURE PLANS

- **New Collective Framework**
  - Optimizing collective based on communication characteristic and availability of HW acceleration
  - JSON configuration generated by external profiler
- **GPU Support**
  - Communication using GPU-resident buffers
  - Non-contiguous datatypes

- **Thanks to Intel for the significant work on this infrastructure**
- **Two major improvements:**
  - C++ Template-like structure (still written in C)
    - Allows collective algorithms to be written in template form
    - Provides “generic” top-level instantiation using point-to-point operations
    - Allows device-level machine specific optimized implementations (e.g., using triggered operations for OFI or HCOLL for UCX)
  - Several new algorithms for a number of blocking and nonblocking collectives (performance tuning still ongoing)

Contributed by Intel (with some minor help from Argonne)

SELECTING COLLECTIVE ALGORITHM

- **Choose Optimal Collective Algorithms**
  - Optimized algorithm for certain communicator size, message size
  - Optimized algorithm using HW collective support
  - Making decision on each collective call
- **Generated Decision Tree**
  - JSON file describing choosing algorithms with conditions
  - JSON file created by profiling tools
  - JSON parsed at MPI_Init time and applied to the library

Contributed by Intel (with some minor help from Argonne)

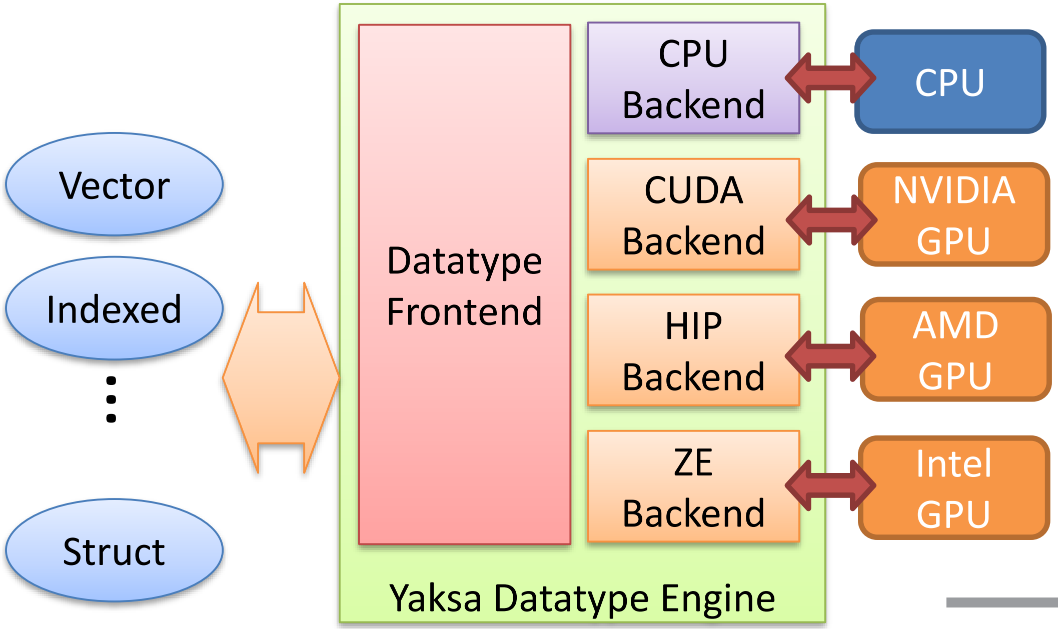
GPU SUPPORT PLAN

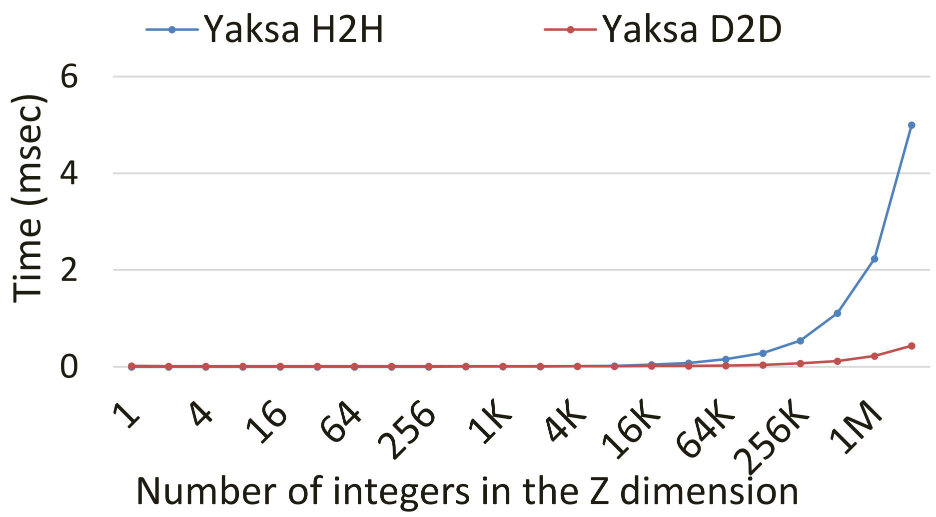
- **Internode**
  - Native GPU support through Librabric and UCX
  - Developing fallback path for no native GPU support
- **Intranode**
  - GPU support in SHM
- **Intranode**
  - Supporting non-contiguous datatype for GPU
  - Packing/Unpacking using host/device buffer

Partnership with Intel, Cray, Mellanox, NVIDIA and AMD

CURRENT STATE OF GPU SUPPORT

- **Native Internode**
  - With Libfabric, UCX and supported GPUs
- **Yaksa Datatype Engine (https://github.com/pmodels/yaksa)**
  - Support H2D, D2H, D2D
  - Packing to appropriate GPU or CPU stage buffer for either native or fallback route
  - 1.0 release with CUDA backend
  - Intel is contributing on the Intel Xe backend





Packing the Y-Z plane of a 3D matrix (2x2x<dims>)

MPICH-3.4 ROADMAP

- **CH4 already in at http://github.com/pmodels/mpich**
- **MPICH-3.4 GA coming out this summer**
  - Multi-VNI support
  - Collective Selection Framework

OPENFABRICS ALLIANCE

2020 OFA Virtual Workshop

THANK YOU

Yanfei Guo, Assistant Computer Scientist

Argonne National Laboratory

Argonne NATIONAL LABORATORY