2021 OFA Virtual Workshop

STATUS OF OPENFABRICS INTERFACES (OFI) SUPPORT IN MPICH

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OVERVIEW

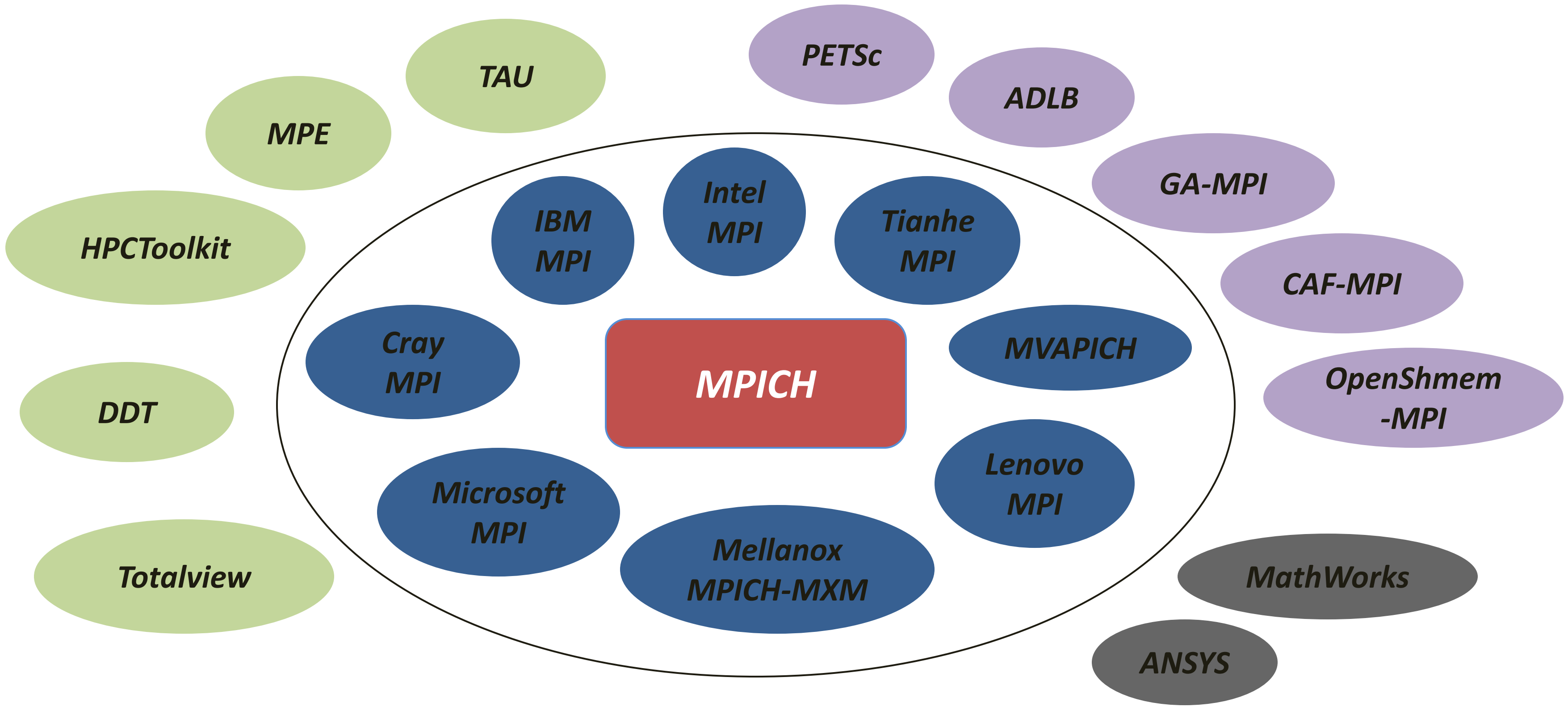
- **What is MPICH?**
- **Why OFI?**
- **Current Support**
  - MPICH 3.4 series (CH4)
  - MPICH 4.0a1 series (CH4)
- **Future Plan**

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 upcoming MPI-4.0)**
- **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-3.4**
- **Latest release is MPICH-4.0a1**
- **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"**

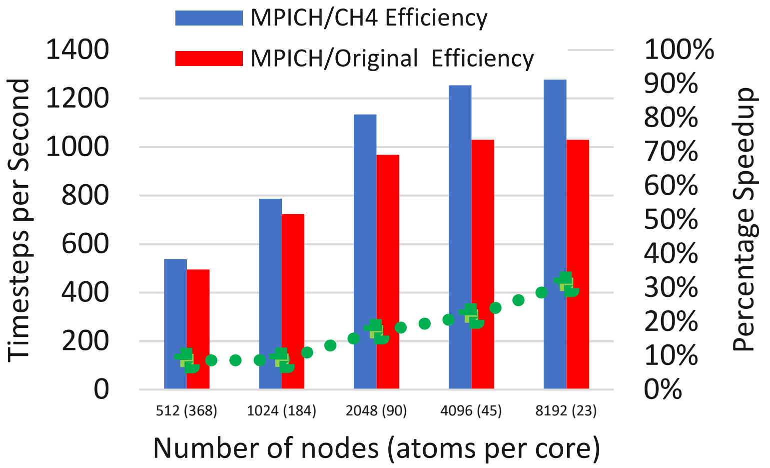


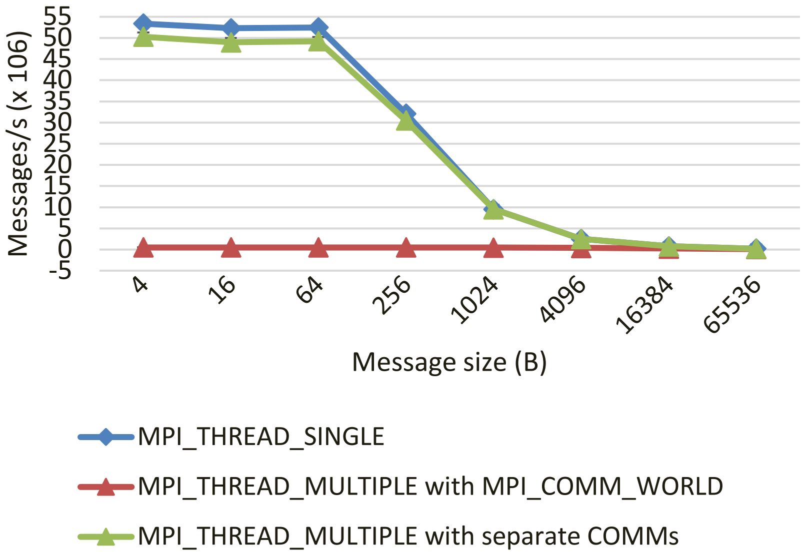
MOTIVATION

- **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

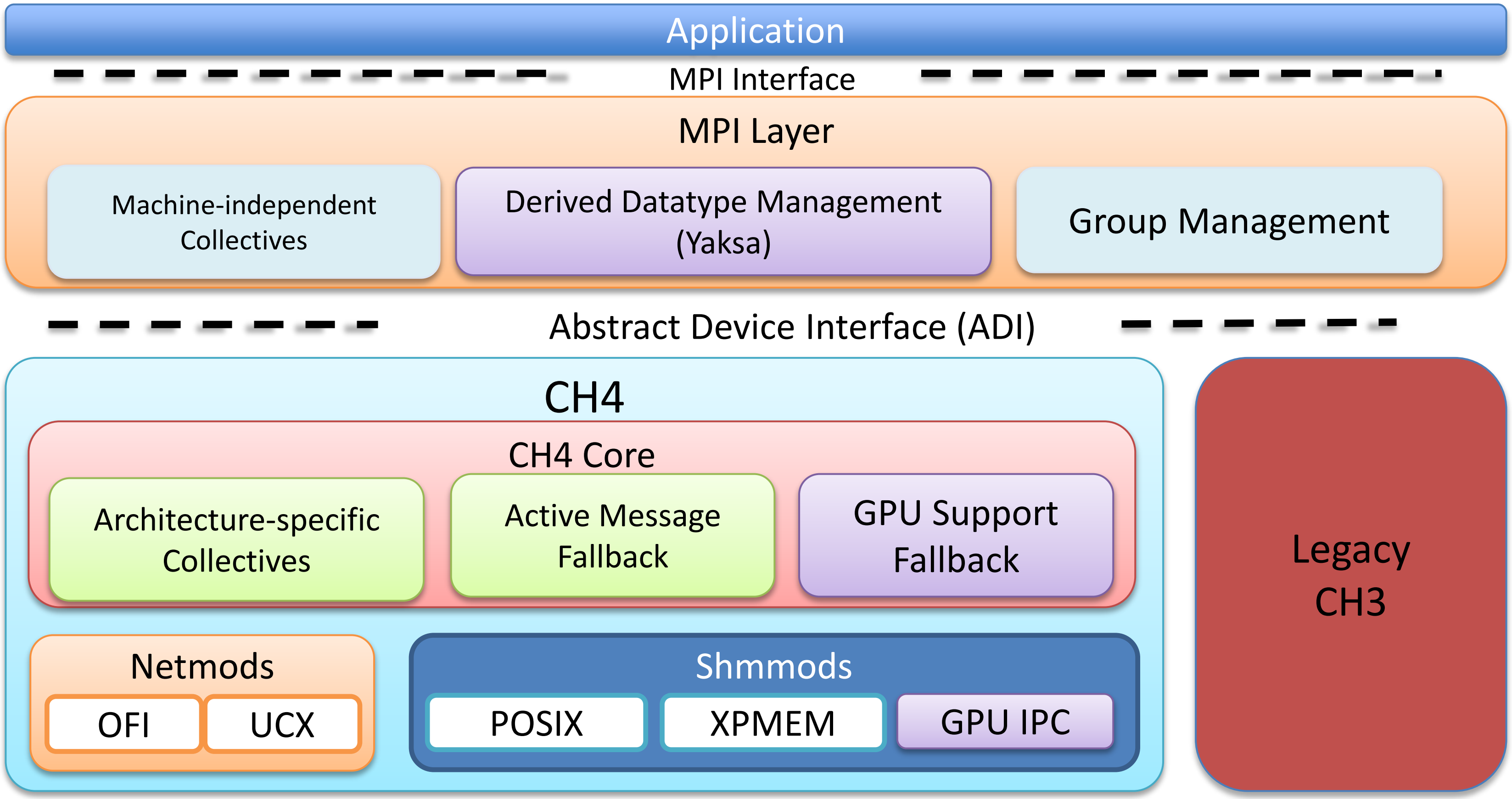
MPICH-3.4 SERIES

- **CH4 device being the default**
  - Replacement for CH3 as default option, CH3 still maintained till all of our partners have moved to CH4
  - Co-design effort
    - Weekly telecons with partners to discuss design and development issues
  - Three 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)
    - Support for GPU



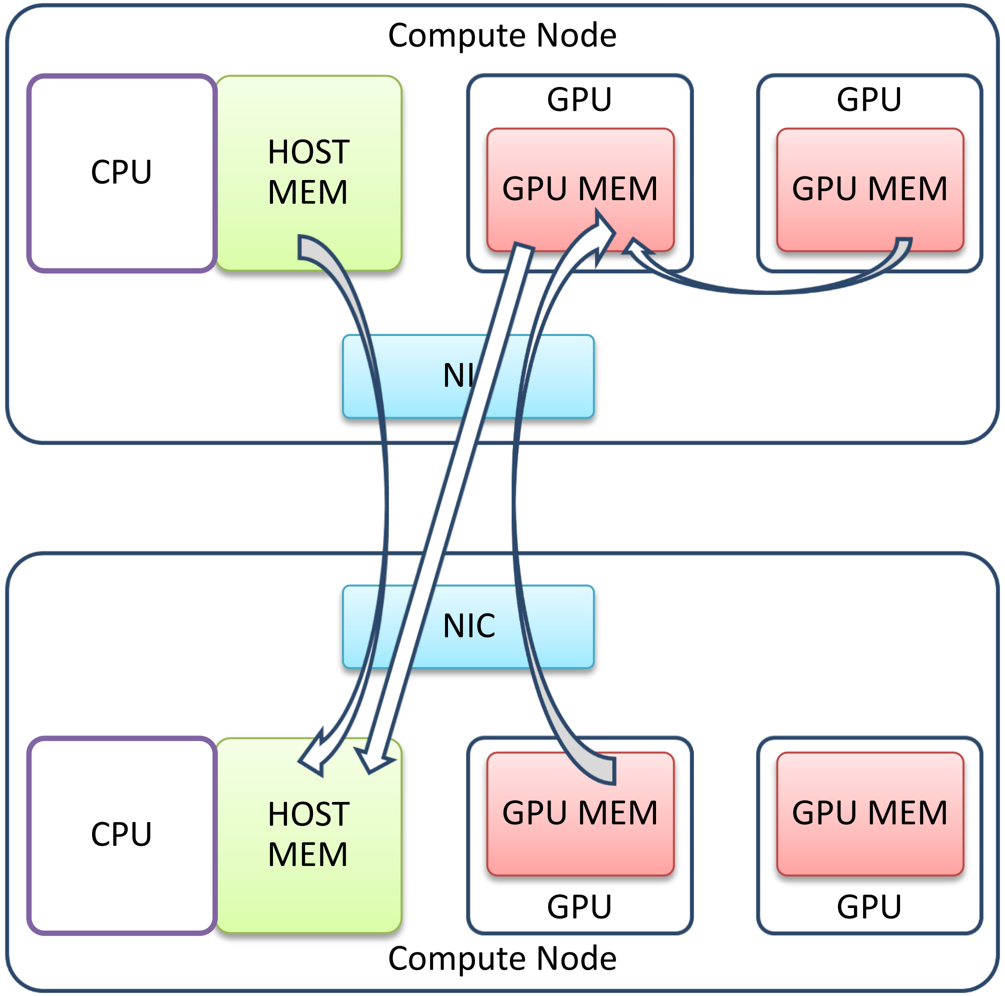


MPICH WITH CH4 DEVICE OVERVIEW



SUPPORTING GPU IN MPI COMMUNICATION (1/4)

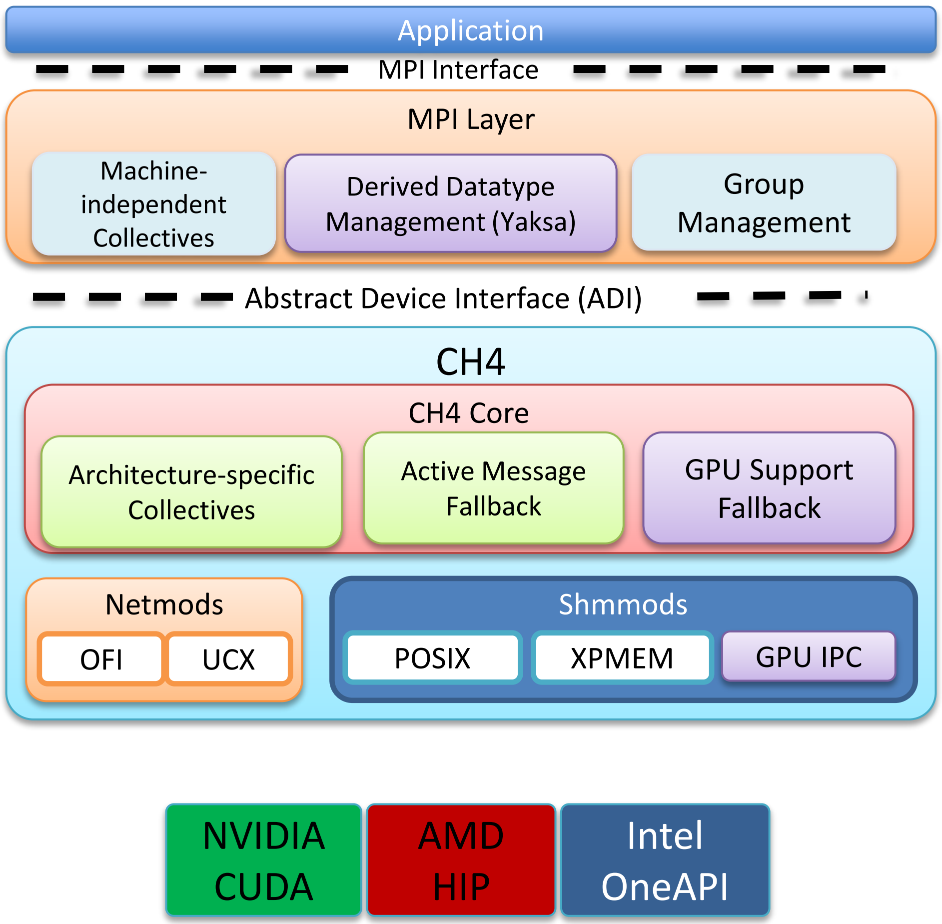
- **Required Features for GPU Support**
  - Using GPU memory in intra-/inter-node communication
  - Supporting MPI features such as datatype, collectives, RMA
  - Supporting Multiple Vendors and Multiple GPU Devices



The GPU support in MPICH is developed in close collaboration with vendor partners including Including AMD, Cray, Intel, Mellanox and NVIDIA

SUPPORTING GPU IN MPI COMMUNICATION (2/4)

- **Native GPU Data Movement**
  - Multiple forms of “native” data movement
  - GPU Direct RDMA is generally achieved through Libfabrics or UCX (we work with these libraries to enable it)
  - GPU Direct IPC is integrated into MPICH
- **GPU Fallback Path**
  - GPU Direct RDMA may not be available due to system setup (e.g. library, kernel driver, etc.)
  - GPU Direct IPC might not be possible for some system configurations
  - GPU Direct (both forms) might not work for noncontiguous data
  - Datatype and Active Message Support



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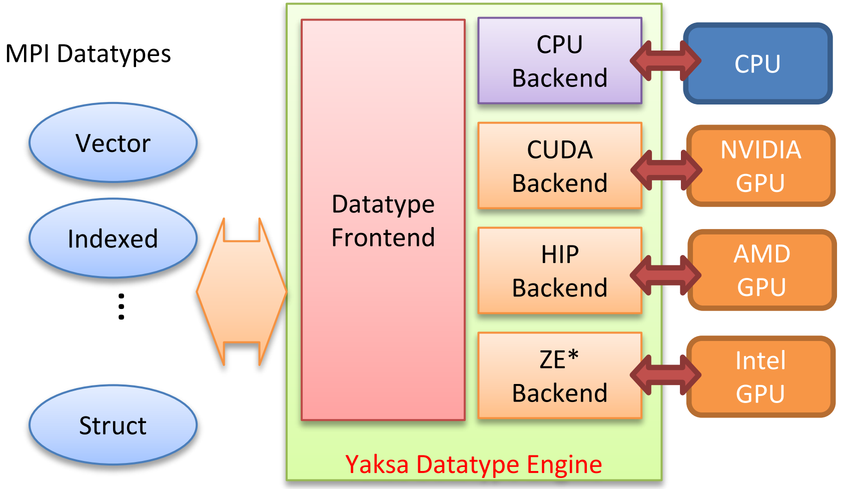
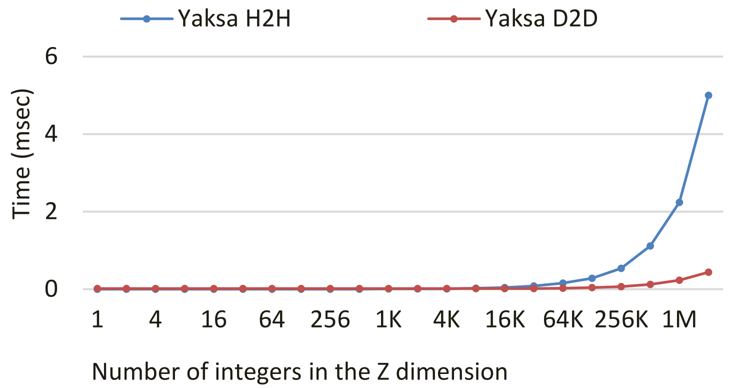
SUPPORTING GPU IN MPI COMMUNICATION (3/4)

- **MPICH support for using complex noncontiguous buffers with GPU**
  - Buffer with complex datatype is not directly supported by the network library
  - Packing complex datatype from GPU into contiguous send buffer
  - Unpacking received data back into complex datatype on GPU
- **Yaksa: A high performance datatype engine**
  - Used for internal datatype representation in MPICH
  - Front-end provide interface for MPI datatypes
  - Multiple backend to leverage different hardware for datatype handle
  - Generated GPU kernels for packing/unpacking



*Intel OneAPI library



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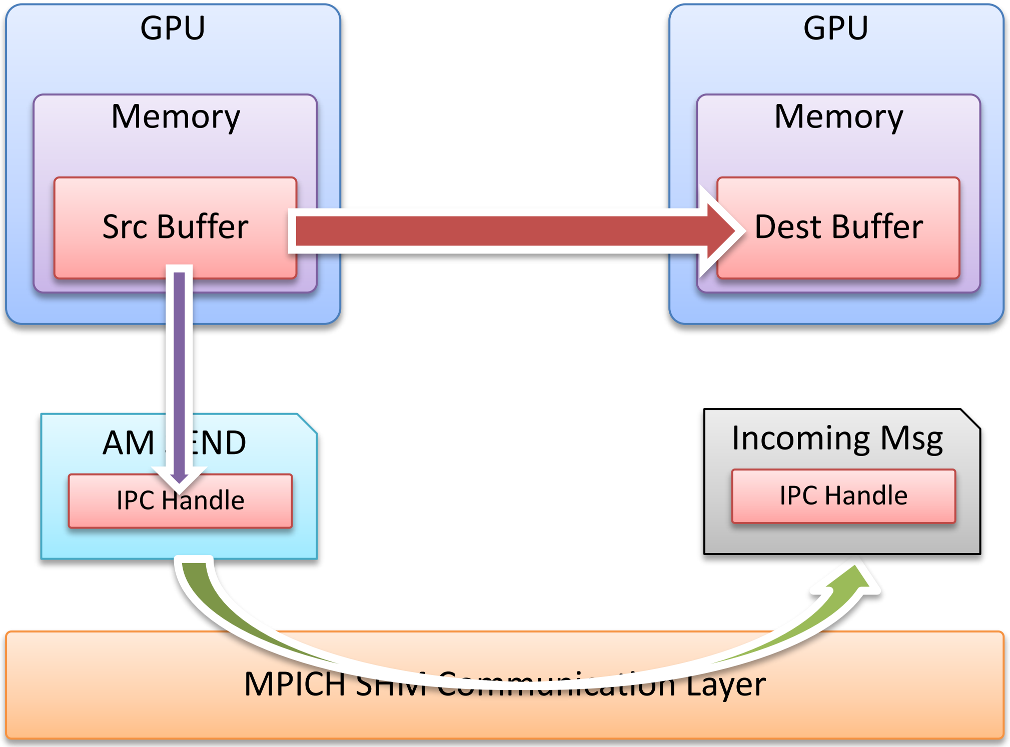
SUPPORTING GPU IN MPI COMMUNICATION (4/4)

- **Supporting Multiple GPU Node**
  - Data movement between GPU devices
  - Utilizing high bandwidth inter-GPU links (e.g. NVLINK)
- **GPU-IPC Communication via Active Message**
  - Create IPC handles for GPU buffers
  - Send IPC handles to target process
  - Receiver initiate Read/Write using the IPC handle
- **Fallback Path in General SHM Active Message**
  - When IPC is not available for the GPU-pair



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GPU TRIGGERED/INITIATED COMMUNICATION

- **Synchronize communication with GPU**
  - Communication controlled by CPU
  - Sync cost and kernel launching cost
- **MPI-4 Partitioned Communication**
  - Pready/Parrived
- **Stream-triggered Operation**
  - Persistent request
- **Passing Stream in MPI Operation**

NEW COLLECTIVE INFRASTRUCTURE

- **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)

MPICH-4.0 ROADMAP

- **MPICH-4.0a1 available at http://github.com/pmodels/mpich**
- **MPICH-4.0 GA coming next this summer**
  - MPI-4 support
  - Improvement on collective with GPU buffers
  - More

OPENFABRICS ALLIANCE

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THANK YOU

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