OPENFABRICS ALLIANCE

2024 OFA Virtual Workshop

STATUS OF OPENFABRICS INTERFACES (OFI) SUPPORT IN MPICH

Yanfei Guo, Computer Scientist

Argonne National Laboratory

Argonne NATIONAL LABORATORY

OVERVIEW

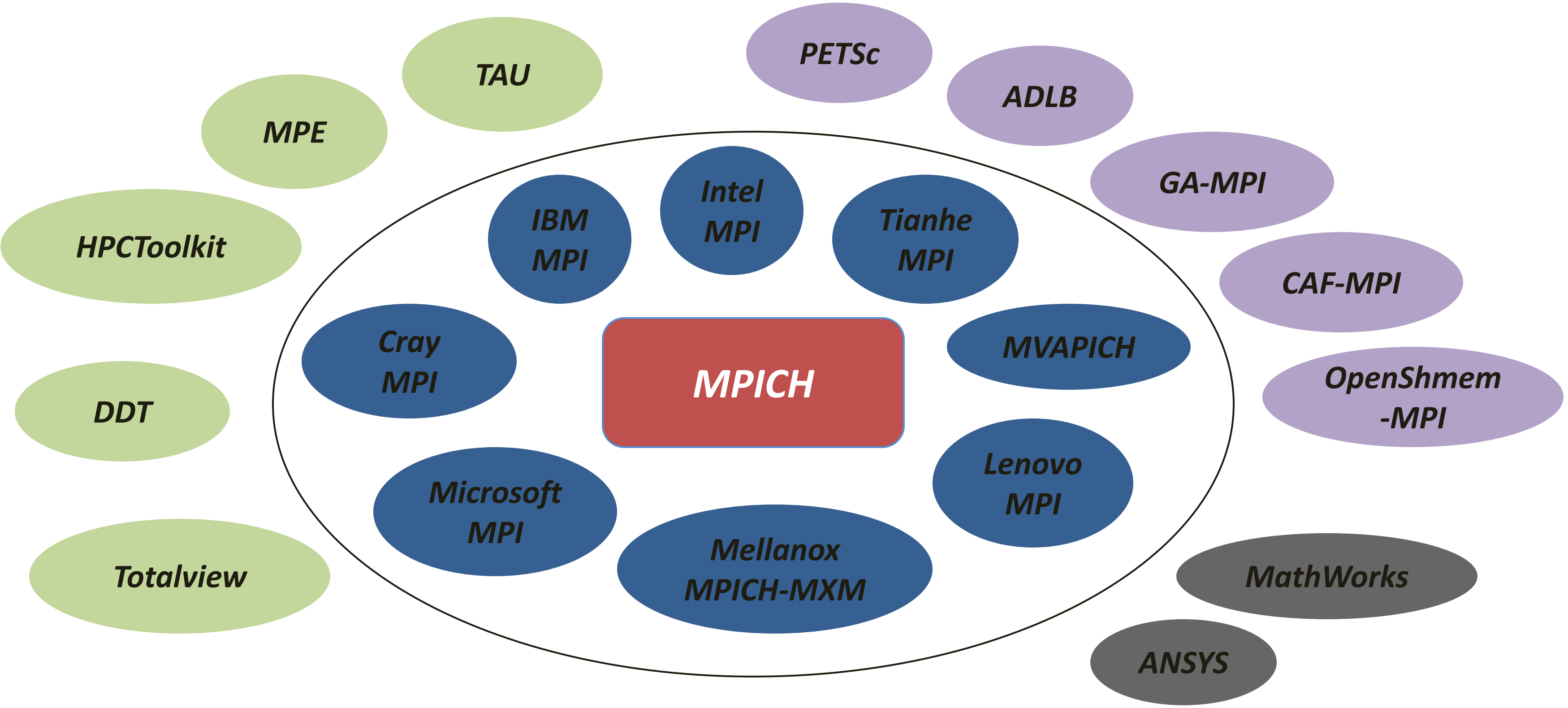
- What is MPICH?
- Why OFI?
- Current Support
- Future Plan

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 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
- **www.mpich.org**

MPICH: GOAL AND PHILOSOPHY

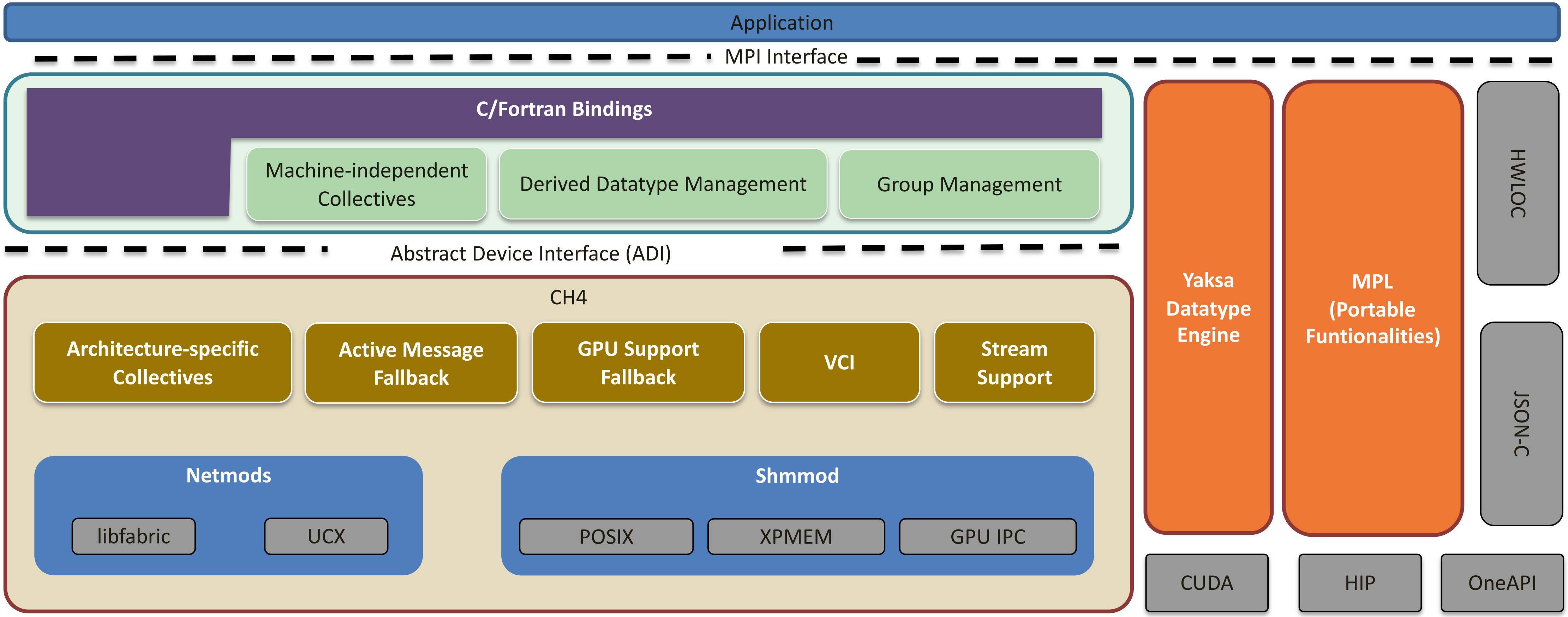
- **MPICH aims to be the preferred MPI implementation on the top machines in the world**
- **Our philosophy is to create an “MPICH Ecosystem”**



MOTIVATION

- **Why OFI/OFIWG?**
  - Support for diverse hardware through a common API
  - Actively, openly developed
    - Hosted on Github
  - Close abstraction for MPI
    - MPI community engaged from the start
  - Vendor Support
    - Slingshot
    - AWS EFA
  - Fully functional sockets provider
    - Prototype code on a laptop
  - Strong Vendor Support
    - Intel, HPE, ParaStation, etc.

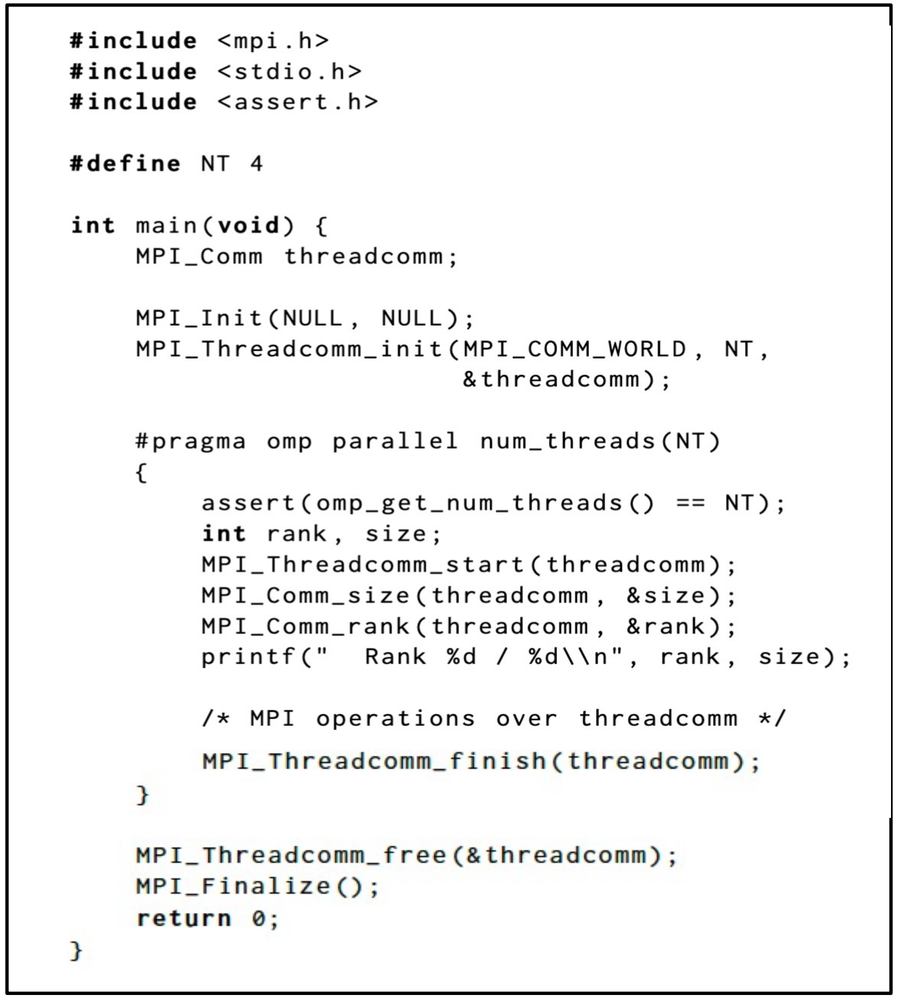
MPICH WITH CH4 DEVICE OVERVIEW



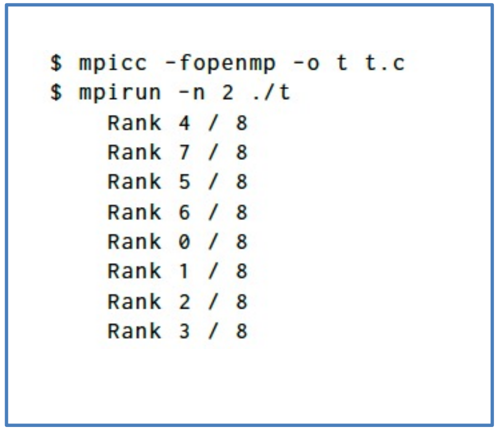
MPICH 4.2 RELEASE SERIES

- **Support for MPI 4.1 Specification**
  - `mpi_memory_alloc_kinds` info hint
  - `MPI_Request_get_status_{all,any,some}`
  - `MPI_Remove_error_{class,code,string}`
  - `MPI_{Comm,Session}_{attach,detach}_buffer`
  - `MPI_BUFFER_AUTOMATIC`
  - Split type `MPI_COMM_TYPE_RESOURCE_GUIDED`
- **New Experimental Features**
  - MPIX Thread Communicator
  - MPI-5 ABI
- **Enhanced GPU (esp. ZE) Support**

MPIX THREAD COMMUNICATOR

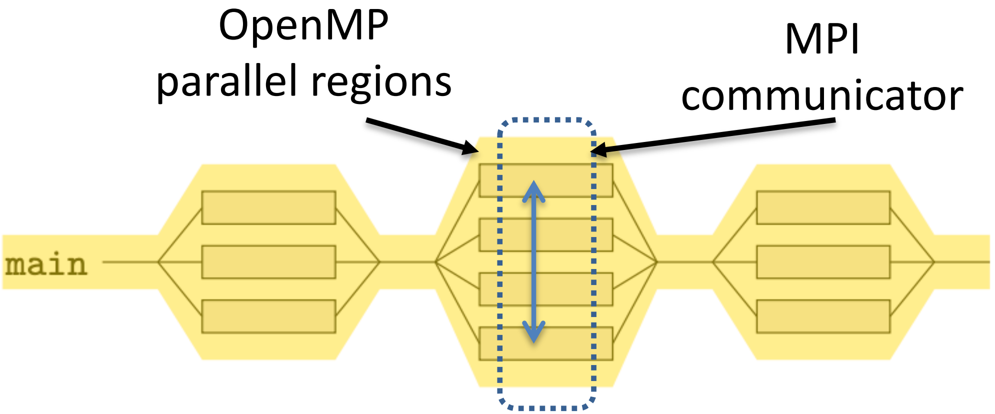


```
#include <mpi.h>
#include <stdio.h>
#include <assert.h>

#define NT 4

int main(void) {
    MPI_Comm threadcomm;

    MPI_Init(NULL, NULL);
    MPI_Threadcomm_init(MPI_COMM_WORLD, NT,
                        &threadcomm);

    #pragma omp parallel num_threads(NT)
    {
        assert(omp_get_num_threads() == NT);
        int rank, size;
        MPI_Threadcomm_start(threadcomm);
        MPI_Comm_size(threadcomm, &size);
        MPI_Comm_rank(threadcomm, &rank);
        printf("  Rank %d / %d\\n", rank, size);

        /* MPI operations over threadcomm */

        MPI_Threadcomm_finish(threadcomm);
    }

    MPI_Threadcomm_free(&threadcomm);
    MPI_Finalize();
    return 0;
}
```



```
$ mpicc -fopenmp -o t t.c
$ mpirun -n 2 ./t
    Rank 4 / 8
    Rank 7 / 8
    Rank 5 / 8
    Rank 6 / 8
    Rank 0 / 8
    Rank 1 / 8
    Rank 2 / 8
    Rank 3 / 8
```

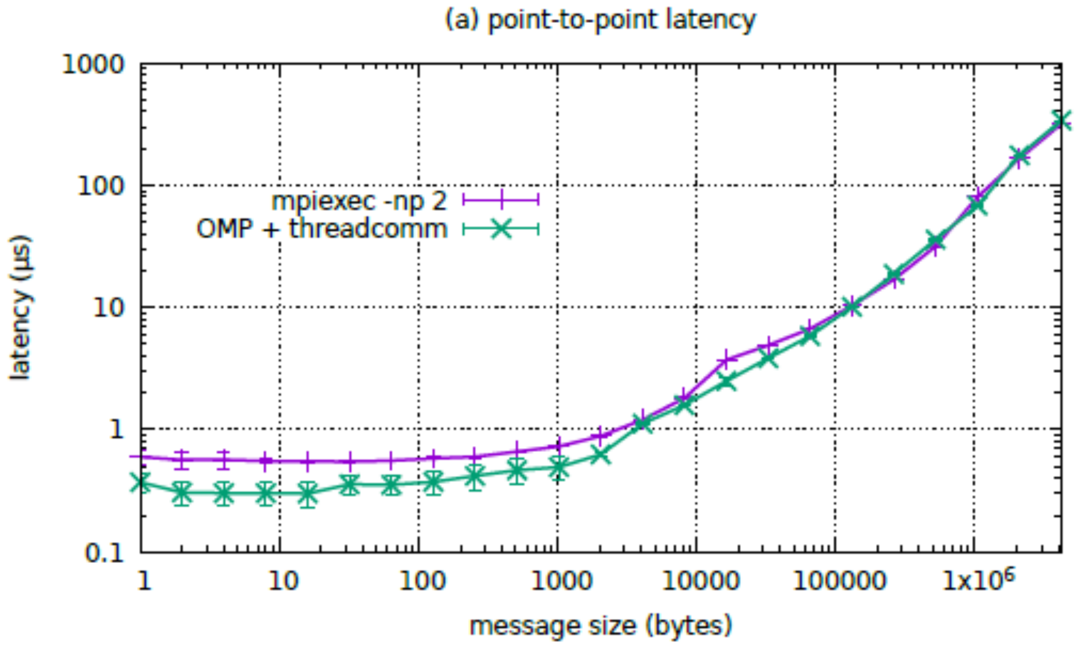
- MPI × Threads paradigm
  - Easy migration from MPI-only to MPI+OpenMP
- Internal Mechanism
  - On-node threads: send/recv ~= ld/st
  - Off-node threads: mapping to different communication contexts
- Supported Ops
  - Pt2pt, blocking collectives



OpenMP parallel regions

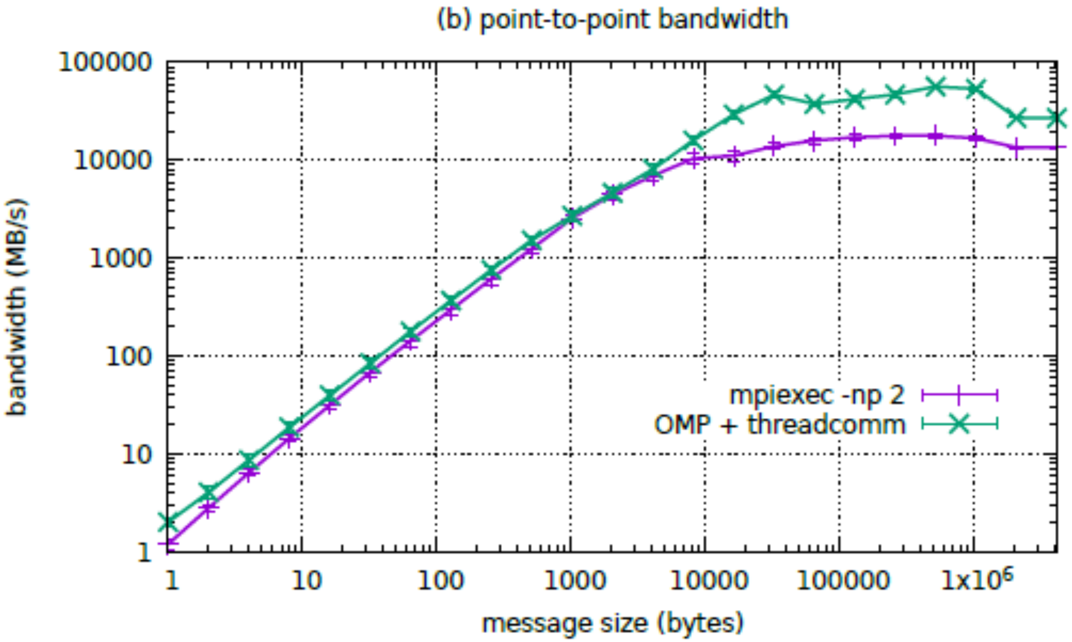
MPI communicator

LATENCY AND BANDWIDTH



MPI on threads ***VS***

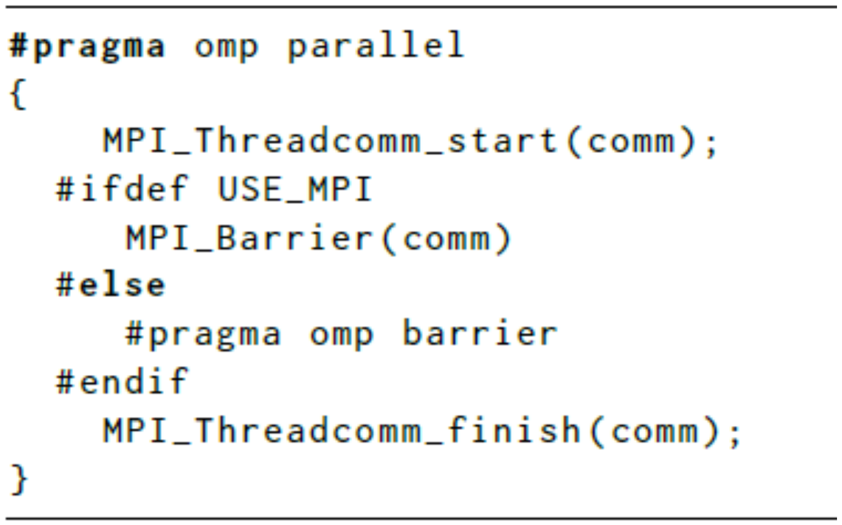
MPI on processes



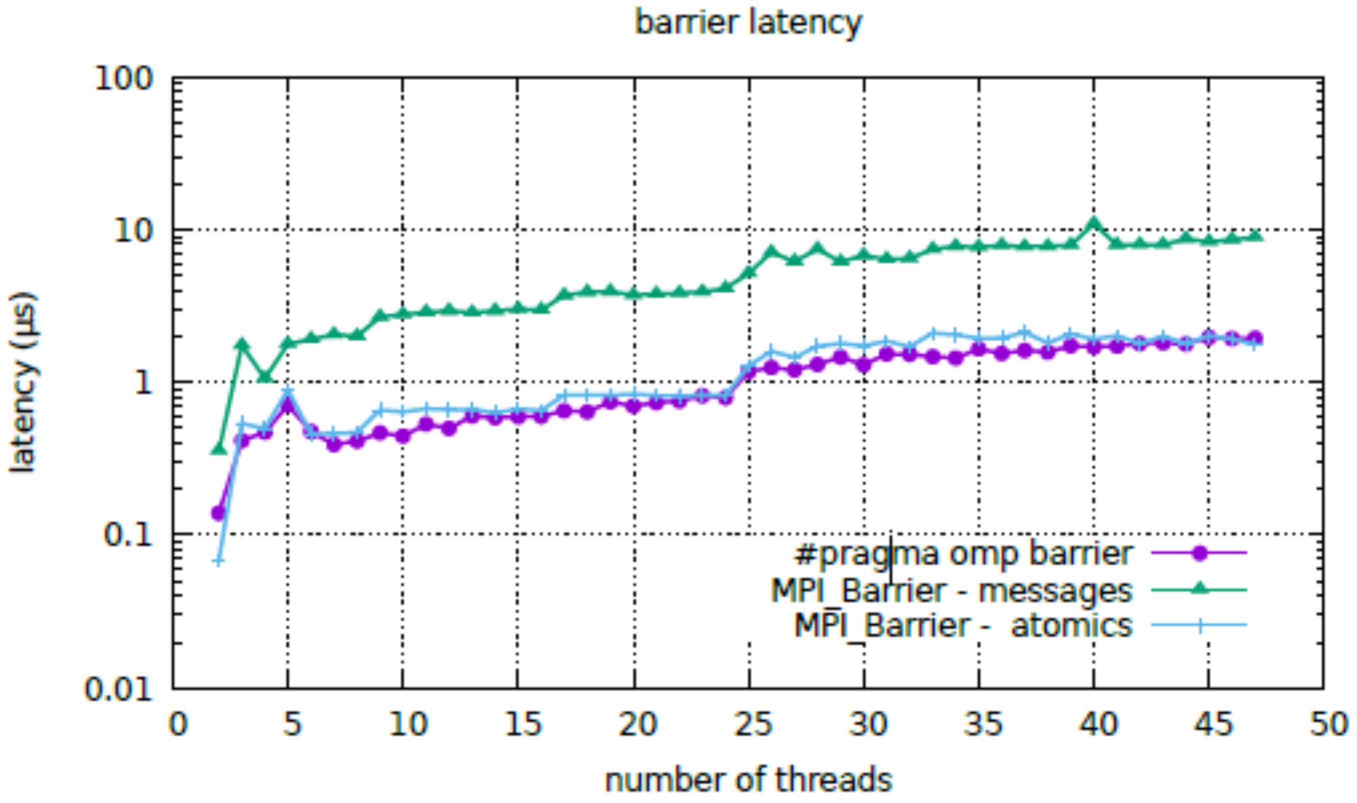
- Only practical difference
- No fundamental difference
- See paper for detailed discussions

Hui Zhou, Ken Raffenetti, Junchao Zhang, Yanfei Guo, Rajeev Thakur**. Frustrated With MPI+Threads? Try MPIxThreads!** . EuroMPI '23: Proceedings of the 30th European MPI Users' Group Meeting, https://doi.org/10.1145/3615318.3615320

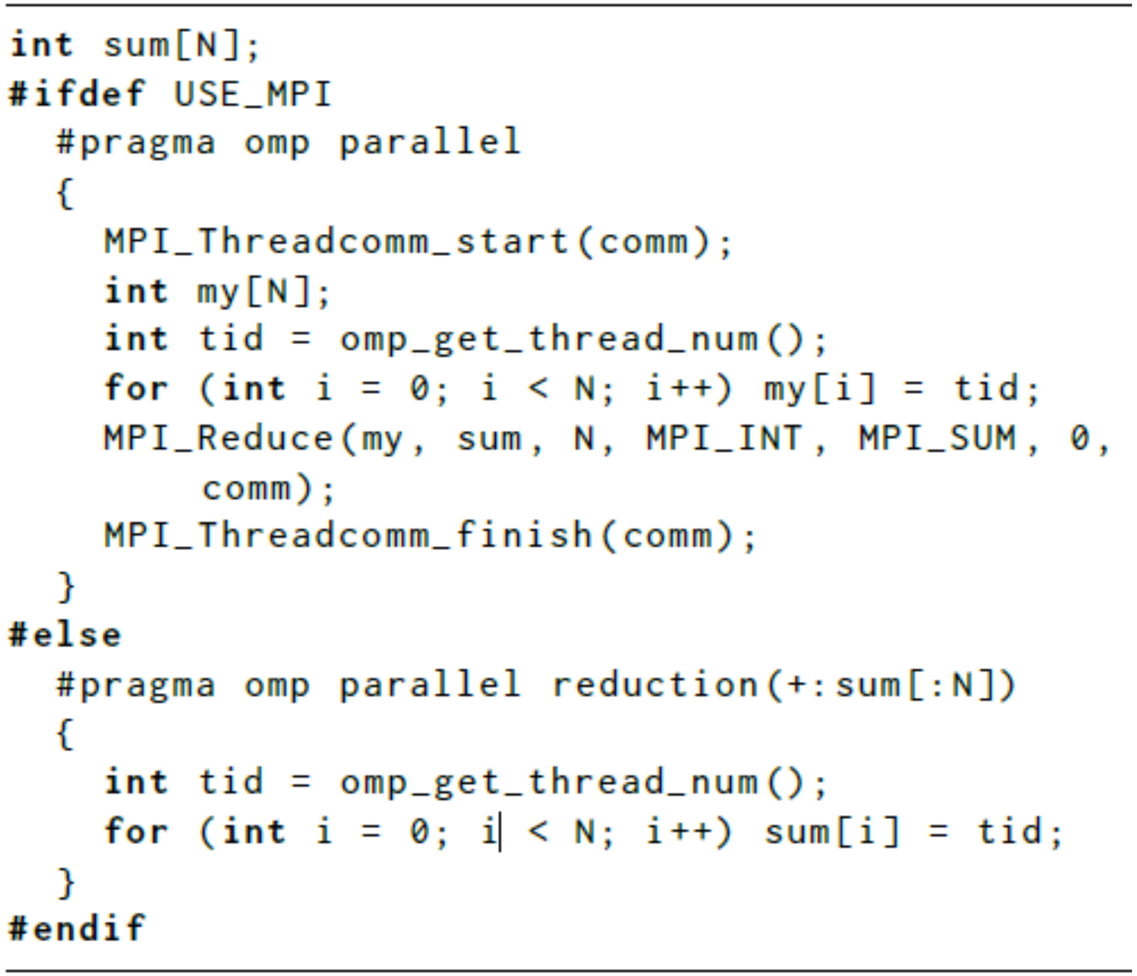
BARRIER



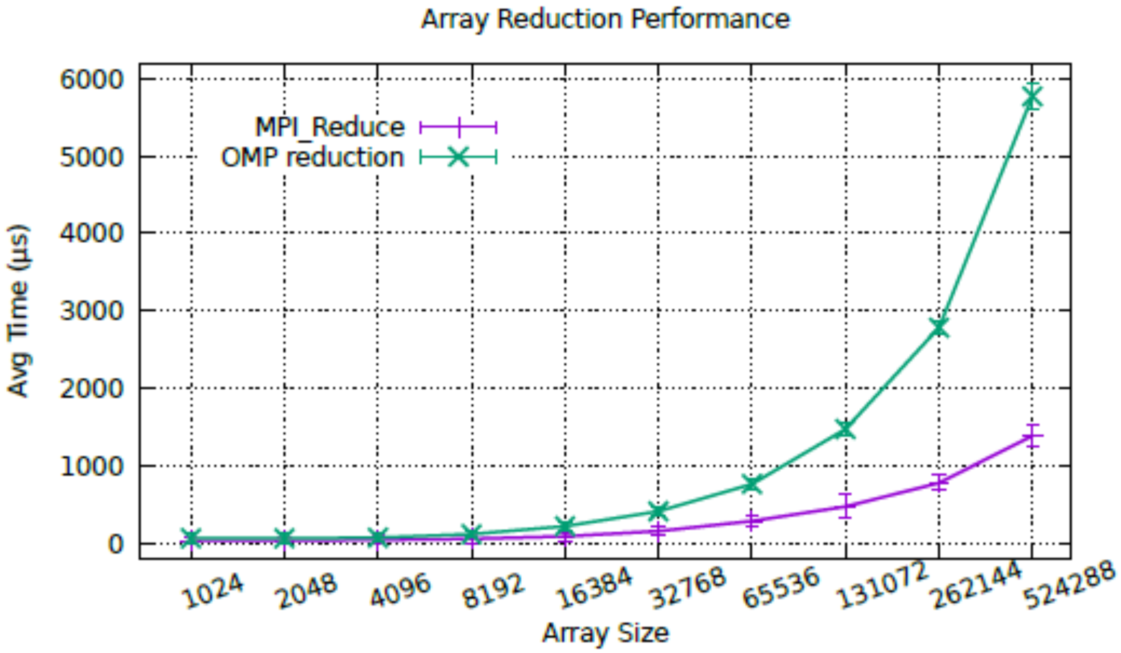
```
#pragma omp parallel
{
    MPI_Threadcomm_start(comm);
  #ifdef USE_MPI
     MPI_Barrier(comm)
  #else
     #pragma omp barrier
  #endif
    MPI_Threadcomm_finish(comm);
}
```



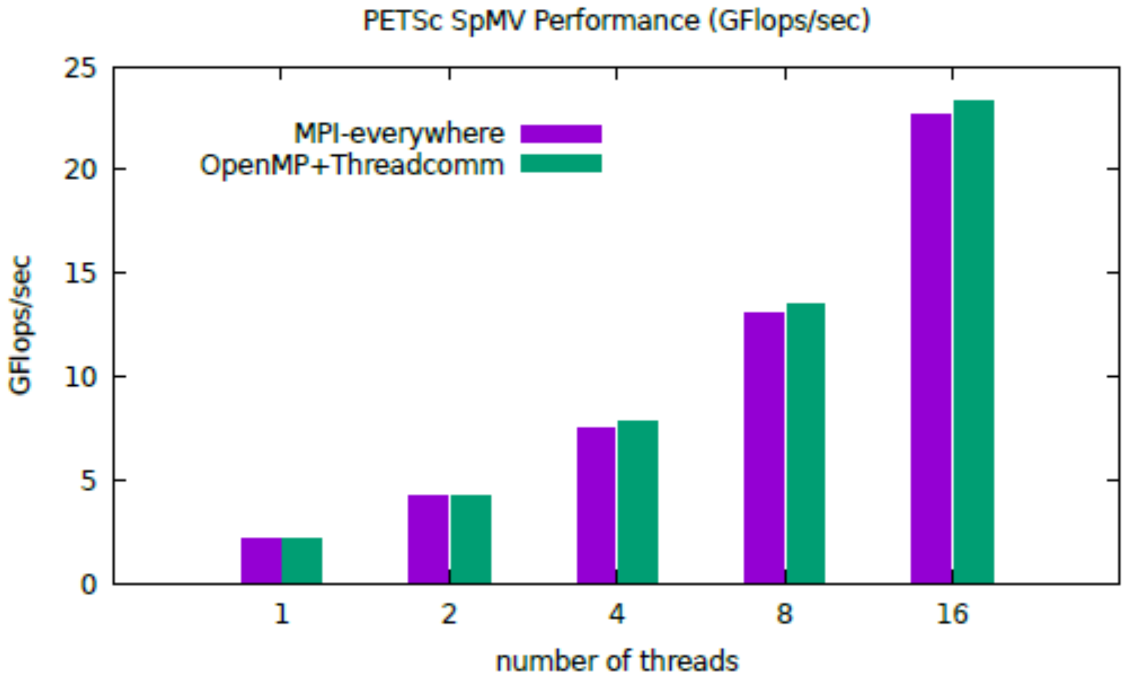
REDUCTION

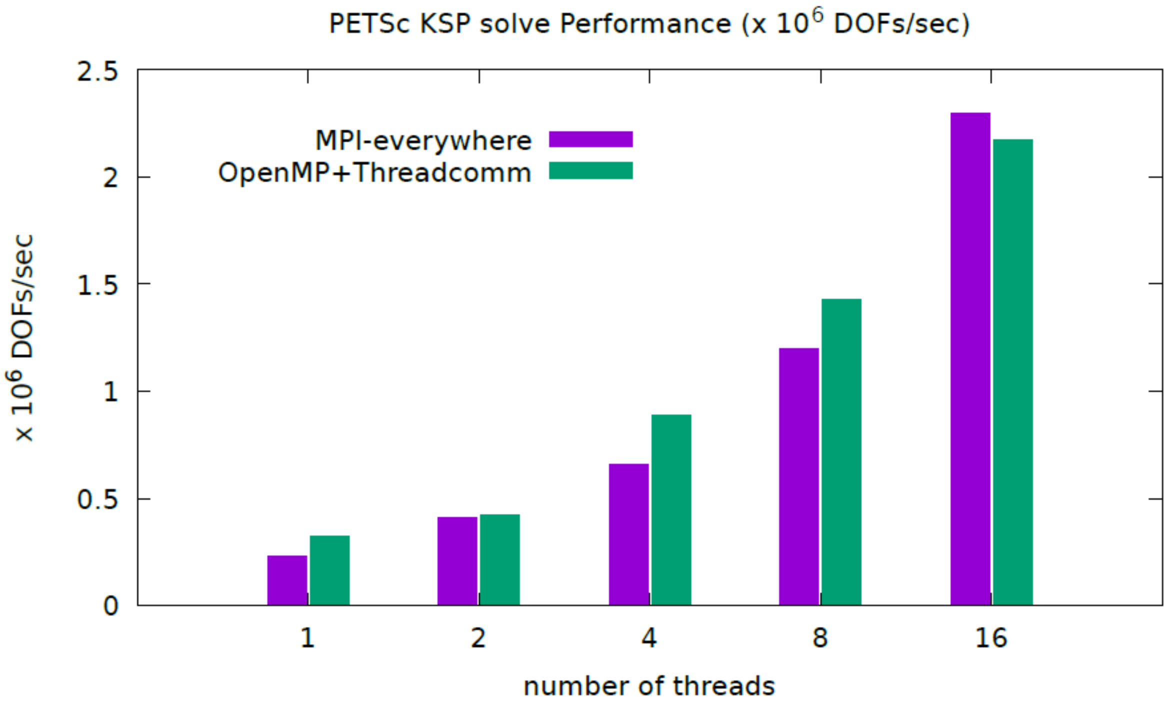


```
int sum[N];
#ifdef USE_MPI
  #pragma omp parallel
  {
    MPI_Threadcomm_start(comm);
    int my[N];
    int tid = omp_get_thread_num();
    for (int i = 0; i < N; i++) my[i] = tid;
    MPI_Reduce(my, sum, N, MPI_INT, MPI_SUM, 0,
        comm);
    MPI_Threadcomm_finish(comm);
  }
#else
  #pragma omp parallel reduction(+:sum[:N])
  {
    int tid = omp_get_thread_num();
    for (int i = 0; i < N; i++) sum[i] = tid;
  }
#endif
```



PETSC + THREADCOMM PERFORMANCE



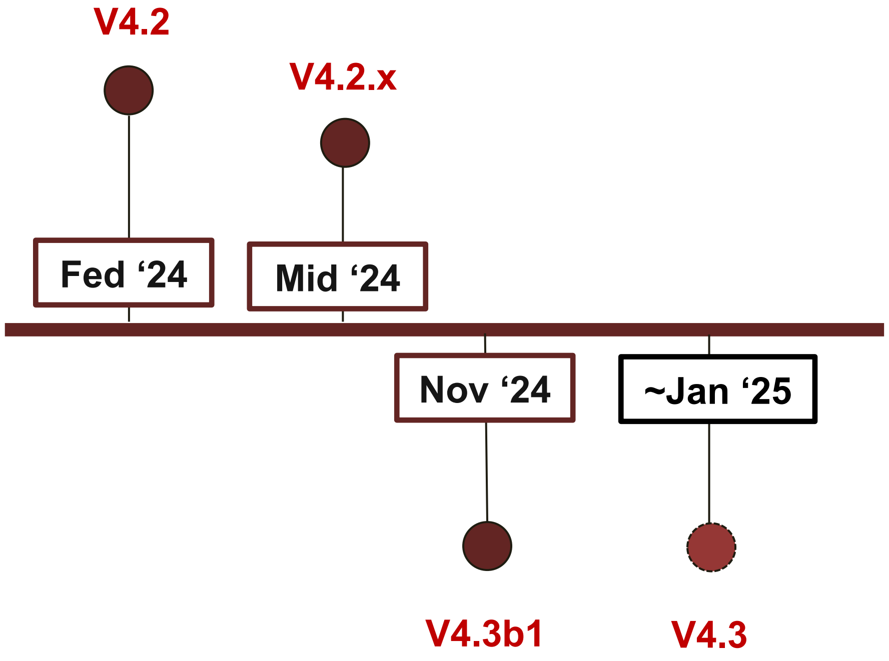


SUPPORT MPI-5 ABI

- **A working proposal currently being developed in MPI Forum**
- **Build once, work with either MPICH or Open MPI derivatives**
- **MPICH-4.2 support both MPICH ABI and optionally MPI-5 ABI**
  - `mpicc` builds MPICH ABI, `mpicc_abi` builds MPI-5 ABI
  - `libmpi.so` implements MPICH ABI, `libmpi_abi.so` implements MPI-5 ABI
  - `mpi.h` will effectively become `mpi_abi.h` when `mpicc_abi` is used. User code always `#include <mpi.h>`

MPICH 4.3 ROADMAP

- **MPICH-4.3a1 2H 2024**
- **MPICH-4.3b1 targeted for SC24**
  - 4.2.x branch will be created
- **GA release in early 2025**
- **Critical bug fixes will be backported to 4.2.x**

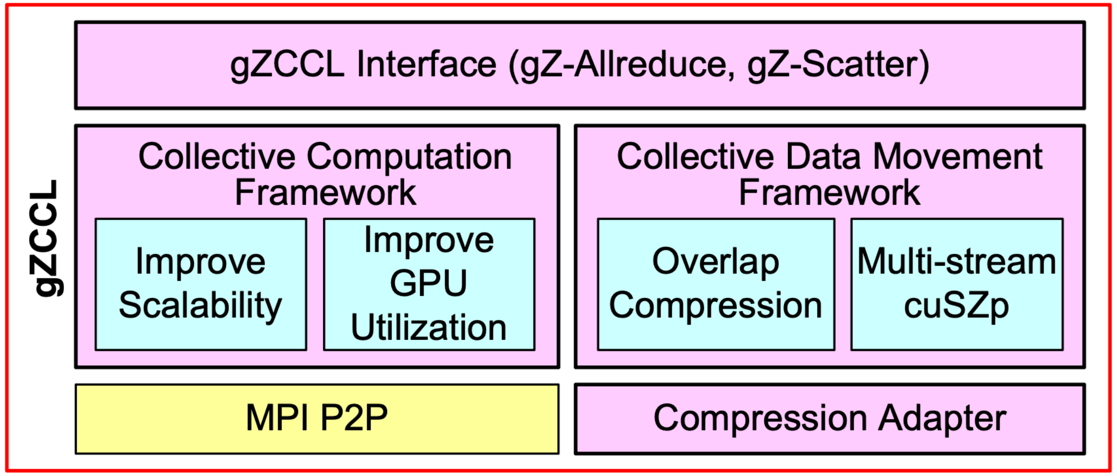


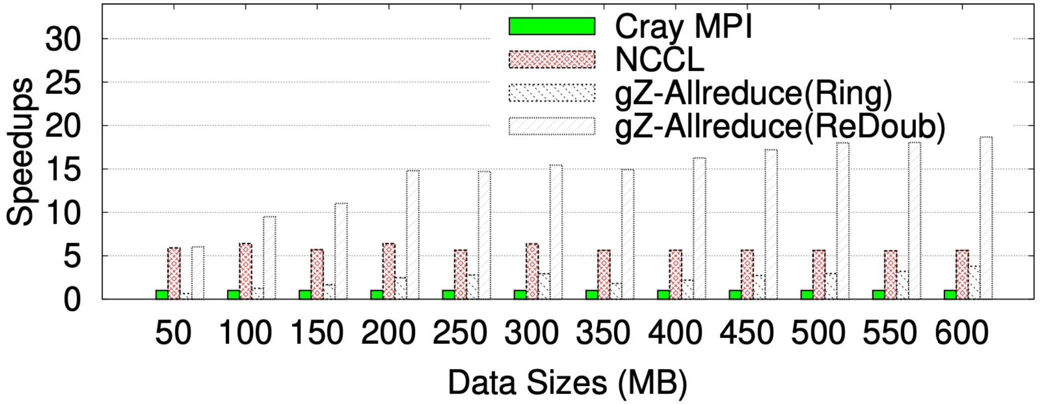
MPICH 4.3 FEATURES

- **Standard and Quality of Life Improvements**
  - Enhance support for MPI sessions
  - Support mpi_memory_alloc_kinds side document specifications
  - Support runtime loading of selected dependency libraries (e.g. libfabric, CUDA, ROCm, etc.)
  - Continue prototyping standard MPI ABI
- **Performance Optimization and New Architectures**
  - Optimized partitioned communication
  - Support dynamic VCIs
  - Performance imrpovemetn Yaksa Datatype Engine
  - Collective arch overhaul for better support of topology aware collective algorithms and external CCL libraries (libfabric collectives, UCC, etc.)

MPI COLLECTIVE WITH LOSSY COMPRESSION

- **Integrating Lossy Compression with MPI Collective for Large Message Transfer**
- **Efficient Scheduling of Compression and Communication**
- **Relying on Regular MPI P2P**





Jiajun Huang, et el. **gZCCL: Compression-Accelerated Collective Communication Framework for GPU Clusters,** accepted by ICS 2024

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THANK YOU

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