Advanced GPU Support in MVAPICH-Plus

Presentation at OSU Booth (SC '22)

by

Hari Subramoni

The Ohio State University

E-mail: subramon@cse.ohio-state.edu

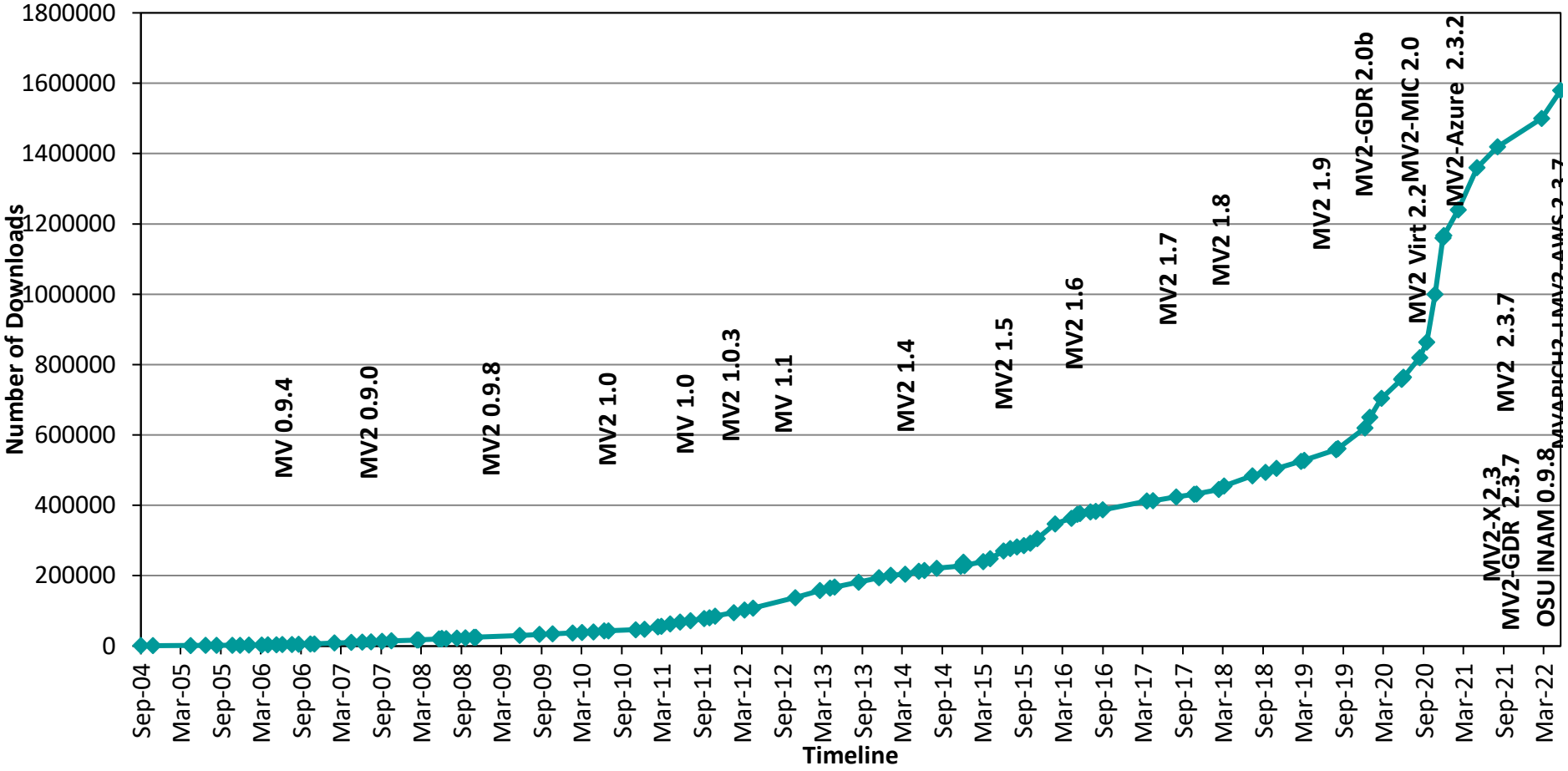
http://www.cse.ohio-state.edu/~subramon

Overview of the MVAPICH2 Project

- High Performance open-source MPI Library
- Support for multiple interconnects
  - InfiniBand, Omni-Path, Ethernet/iWARP, RDMA over Converged Ethernet (RoCE), AWS EFA, Rockport Networks, and Slingshot10/11, Broadcom, Cornelis Networks OPX
- Support for multiple platforms
  - x86, OpenPOWER, ARM, Xeon-Phi, GPGPUs (NVIDIA and AMD)
- Started in 2001, first open-source version demonstrated at SC '02
- Supports the latest MPI-3.1 standard
- http://mvapich.cse.ohio-state.edu
- Additional optimized versions for different systems/environments:
  - MVAPICH2-X (Advanced MPI + PGAS), since 2011
  - MVAPICH2-GDR with support for NVIDIA (since 2014) and AMD (since 2020) GPUs
  - MVAPICH2-MIC with support for Intel Xeon-Phi, since 2014
  - MVAPICH2-Virt with virtualization support, since 2015
  - MVAPICH2-EA with support for Energy-Awareness, since 2015
  - MVAPICH2-Azure for Azure HPC IB instances, since 2019
  - MVAPICH2-X-AWS for AWS HPC+EFA instances, since 2019
- Tools:
  - OSU MPI Micro-Benchmarks (OMB), since 2003
  - OSU InfiniBand Network Analysis and Monitoring (INAM), since 2015

- **Used by more than 3,275 organizations in 90 countries**
- **More than 1.63 Million downloads from the OSU site directly**
- Empowering many TOP500 clusters (June '22 ranking)
  - 7th , 10,649,600-core (Sunway TaihuLight) at NSC, Wuxi, China
  - 19th, 448, 448 cores (Frontera) at TACC
  - 34th, 288,288 cores (Lassen) at LLNL
  - 46th, 570,020 cores (Nurion) in South Korea and many others
- Available with software stacks of many vendors and Linux Distros (RedHat, SuSE, OpenHPC, and Spack)
- Partner in the 16th ranked TACC Frontera system
- **Empowering Top500 systems for more than 20 years**

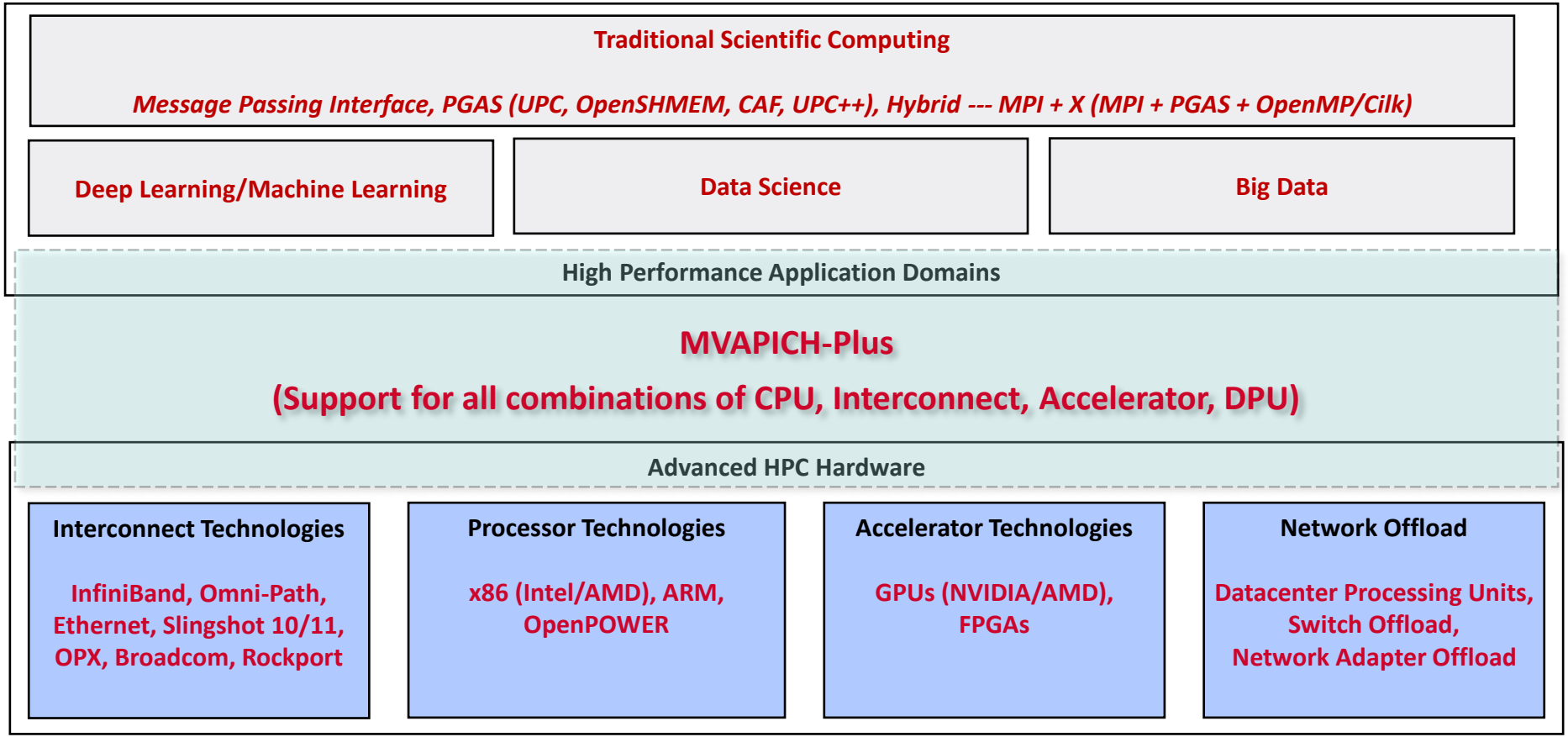
MVAPICH2 Release Timeline and Downloads



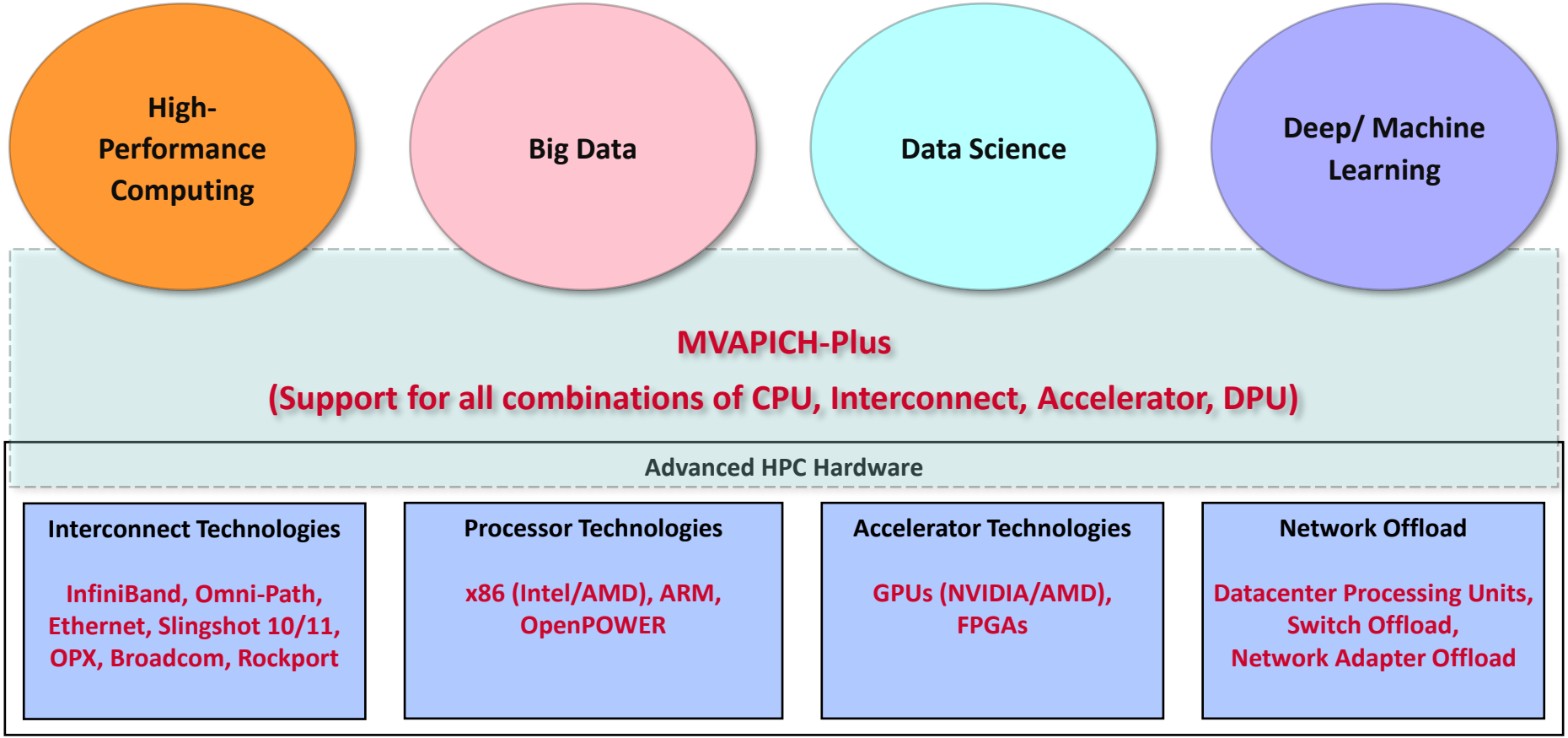
Production Quality Software Design, Development and Release

- Rigorous Q&A procedure before making a release
  - Exhaustive unit testing
  - Various test procedures on diverse range of platforms and interconnects
  - Test 19 different benchmarks and applications including, but not limited to
    - OMB, IMB, MPICH Test Suite, Intel Test Suite, NAS, Scalapak, and SPEC
  - Spend about 18,000 core hours per commit
  - Performance regression and tuning
  - Applications-based evaluation
  - Evaluation on large-scale systems
- All versions (alpha, beta, RC1 and RC2) go through the above testing

One Runtime to Rule them all!



One Runtime to Rule them all!



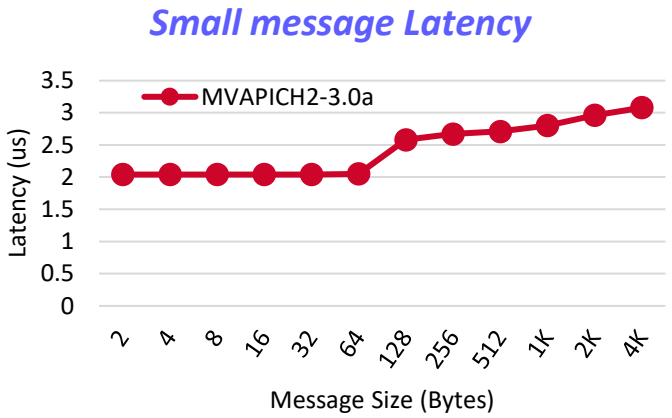
MVAPICH-Plus

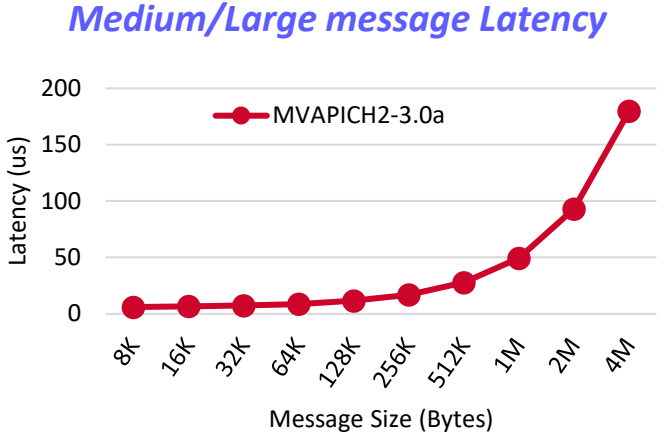
- Released on 11/11/2022
- Based on MVAPICH 3.0
- Advanced MPI with unified MVAPICH2-GDR and MVAPICH2-X features
- Support for NVIDIA and AMD GPUs
- Optimized designs for HPC, DL, ML, Big Data and Data Science applications
- Added support for the ch4:ucx and ch4:ofi devices
- Added support for the Cray Slingshot 11 interconnect over OFI
  - Supports Cray Slingshot 11 network adapters
- Added support for the Cornelis OPX library over OFI
  - Supports Intel Omni-Path adapters
- Added support for the Intel PSM3 library over OFI
  - Supports Intel Columbiaville network adapters
- Added support for IB verbs over UCX
  - Supports IB and RoCE network adapters

Features of OFI and UCX Support

- Support a broad range of interconnects with widely used libraries
  - Configure with `--with-device=ch4:ofi` or `--with-device=ch4:ucx`
- Runtime provider selection via CVARs
  - `MPIR_CVAR_OFI_USE_PROVIDER=<prov>`
- System default, embedded, or custom installation of OFI/UCX
  - Configure with `--with-libfabric=embedded` or `--with-libfabric=<path>`
  - Configure with `--with-ucx=embedded` or `--with-ucx=<path>`
- Enhanced MVAPICH2 collective designs

MPI Level Latency on Slingshot 11

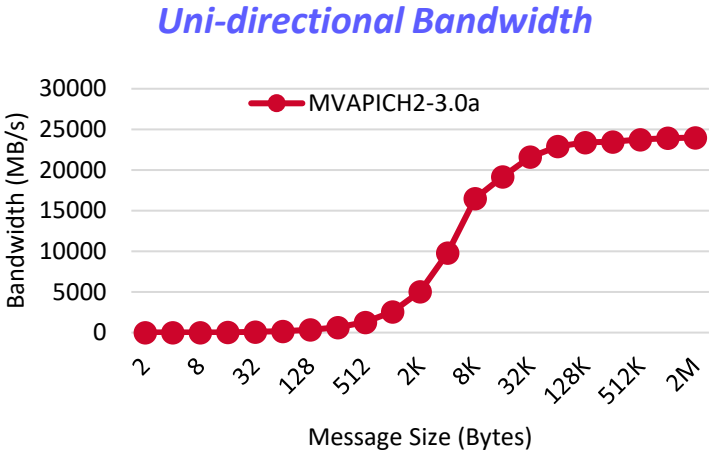


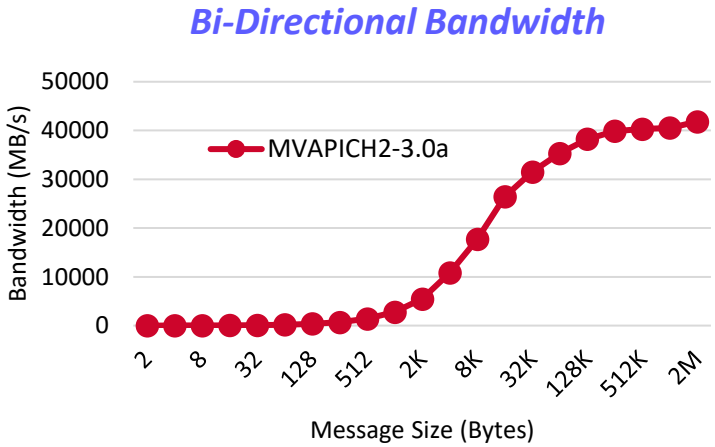


- **2us** inter-node point-to-point latency for small messages

Interconnect : Cray HPE Slingshot 11
Library : MVAPICH2 3.0a
CPU : AMD EPYC 7763 (milan) Processor

MPI Level Bandwidth on Slingshot 11

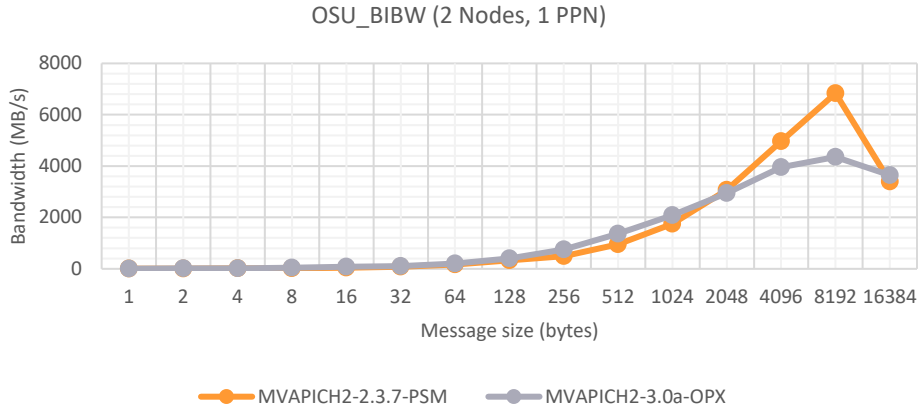


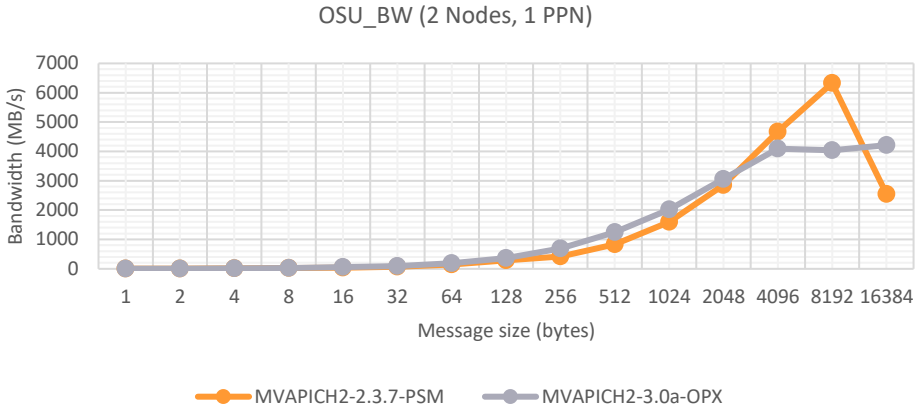


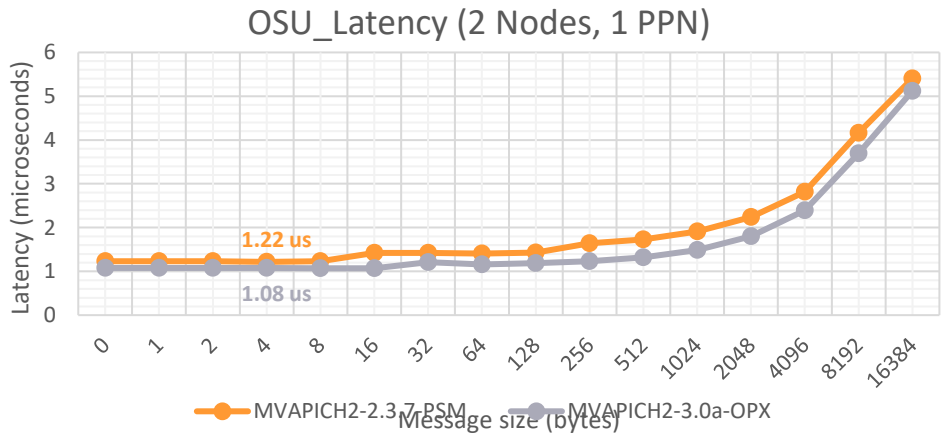
- **23,985 MB/s** uni-directional peak bandwidth
- **42,034 MB/s** bi-directional peak bandwidth

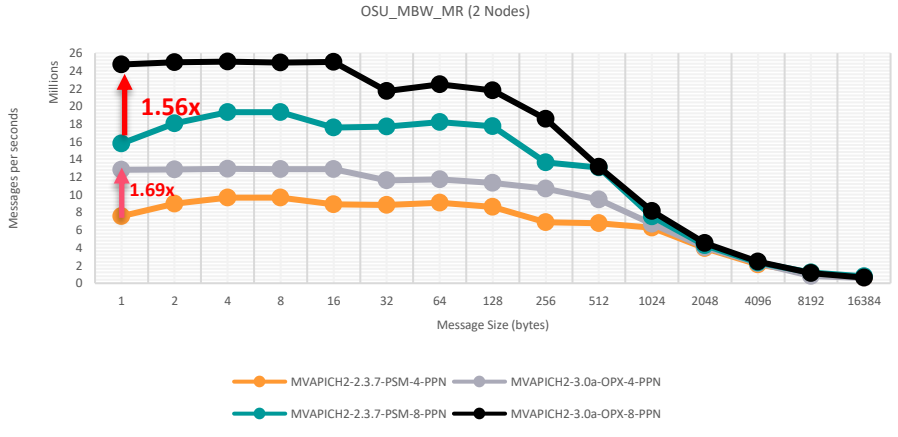
Interconnect : Cray HPE Slingshot 11 (200 Gbps)
Library : MVAPICH2 3.0a
CPU : AMD EPYC 7763 (milan) Processor

MVAPICH2-3.0a+OPX vs MVAPICH2-2.3.7+PSM2 (Early Performance Results)









System: Intel Xeon Bronze (Skylake) 3106 CPU @ 1.70GHz (4 nodes, 16 cores/node, 8 x 2 sockets) with Omni-Path 100Gbps

GPU-Aware (CUDA/ROCm) MPI Library: MVAPICH-GPU

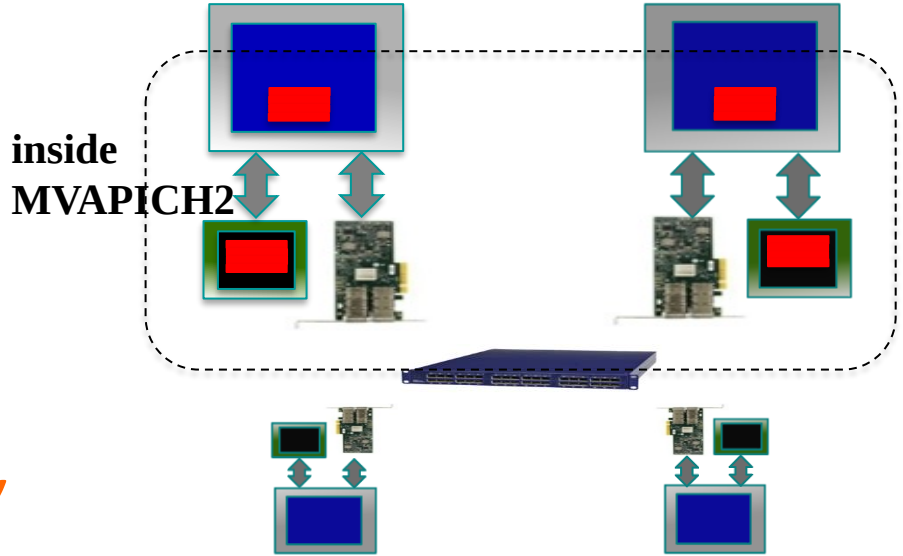
- Standard MPI interfaces used for unified data movement
- Takes advantage of Unified Virtual Addressing (>= CUDA 4.0)
- Overlaps data movement from GPU with RDMA transfers

At Sender:

```
MPI_Send(s_devbuf, size, …);
```

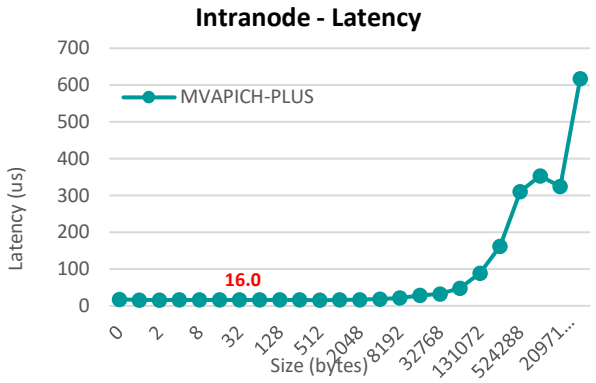
At Receiver:

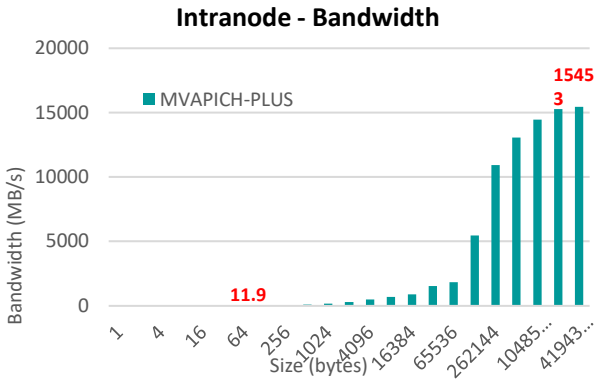
```
MPI_Recv(r_devbuf, size, …);
```

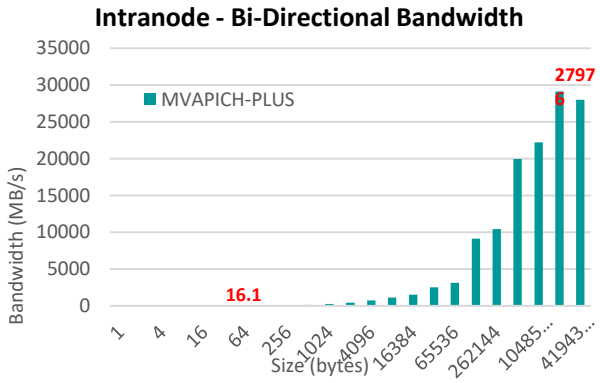


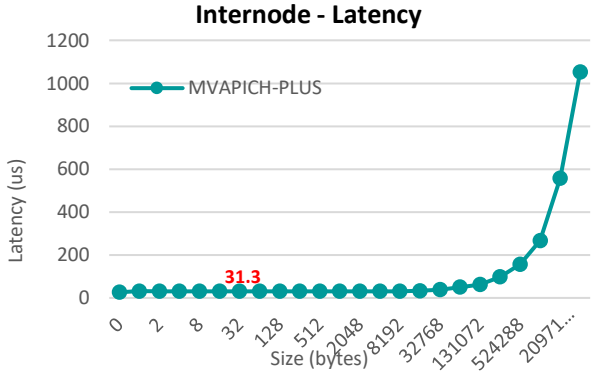
High Performance and High Productivity

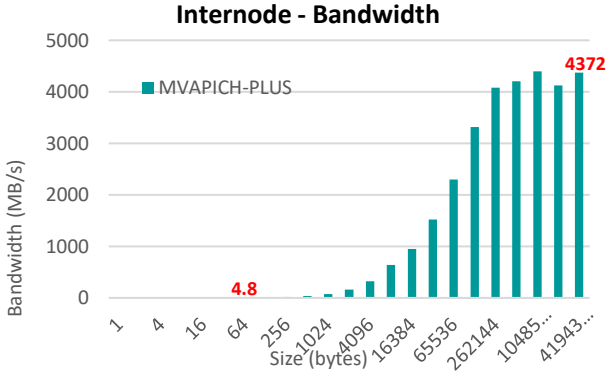
MVAPICH-PLUS - Point-to-Point on GPU

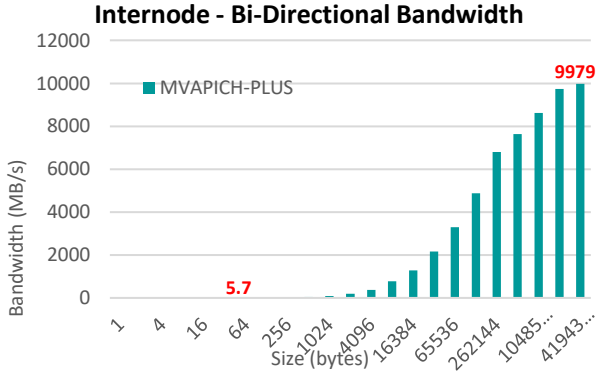






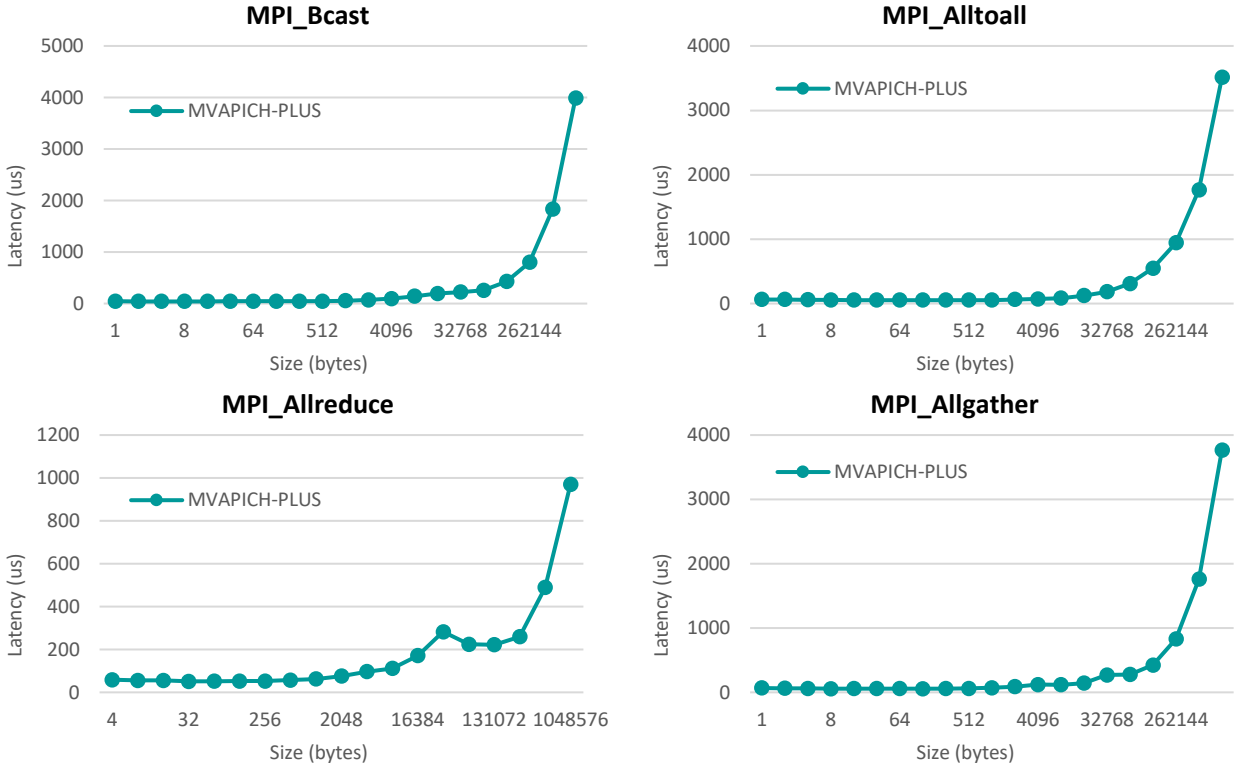






- NVIDIA A100 GPUs with CUDA version 11.5 and NCCL version 2.14.3

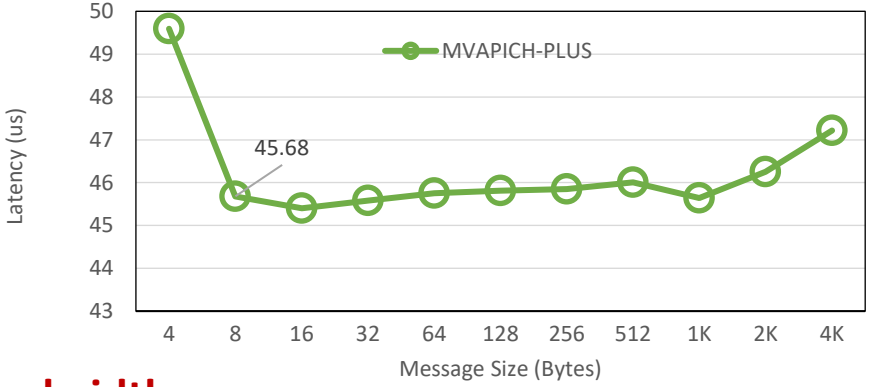
MVAPICH-PLUS - Collective on GPU (8 nodes, 16 GPU)

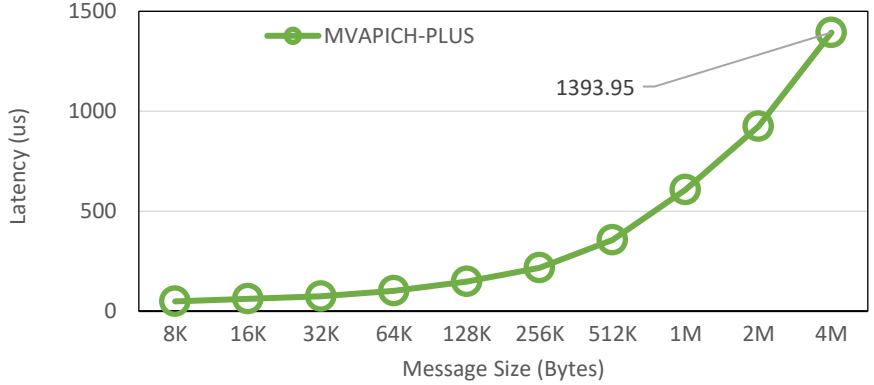


- NVIDIA A100 GPUs with CUDA version 11.5 and NCCL version 2.14.3

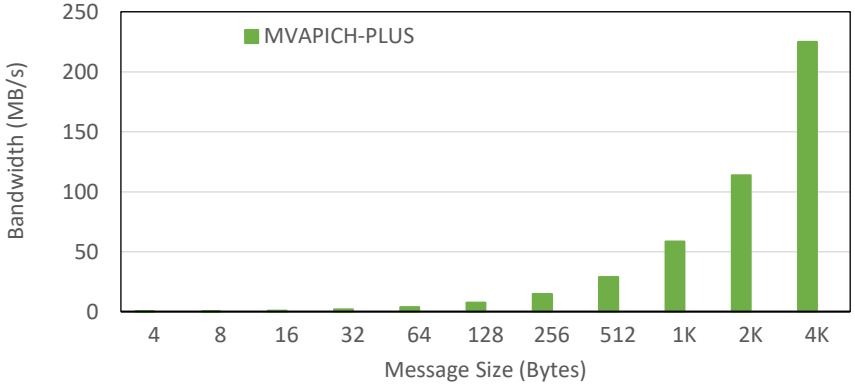
Point-to-Point Inter-Node Performance on AMD GPUs

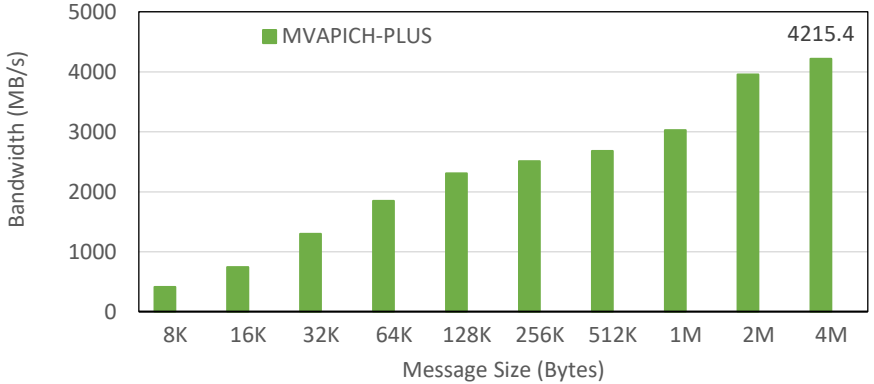
Latency:





Bandwidth:

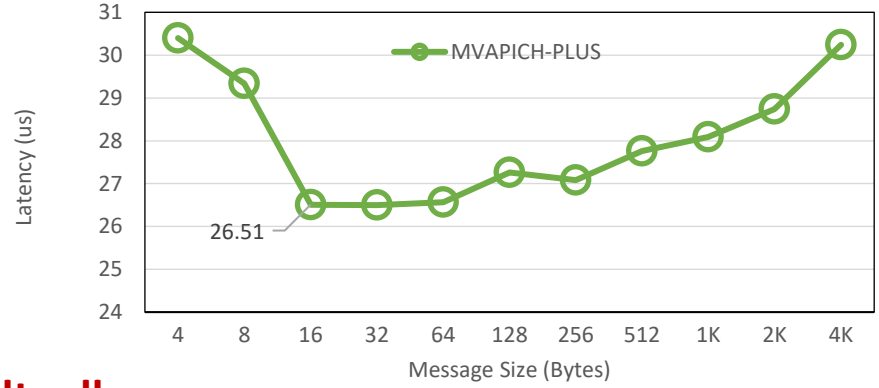


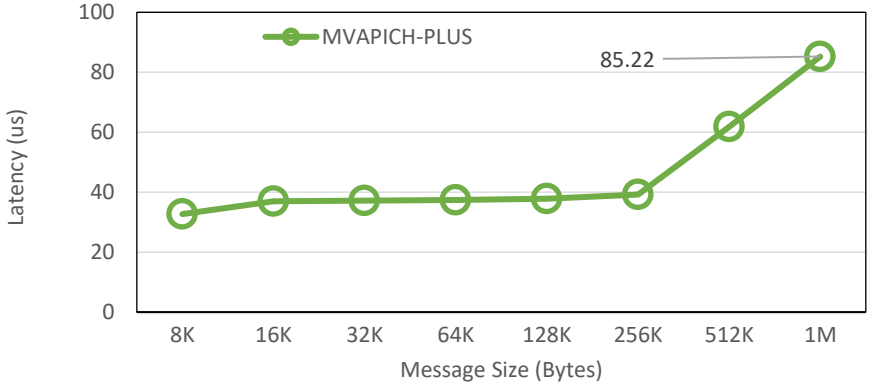


Tioga - ROCm-5.3.0 (MI250-X GPUs)

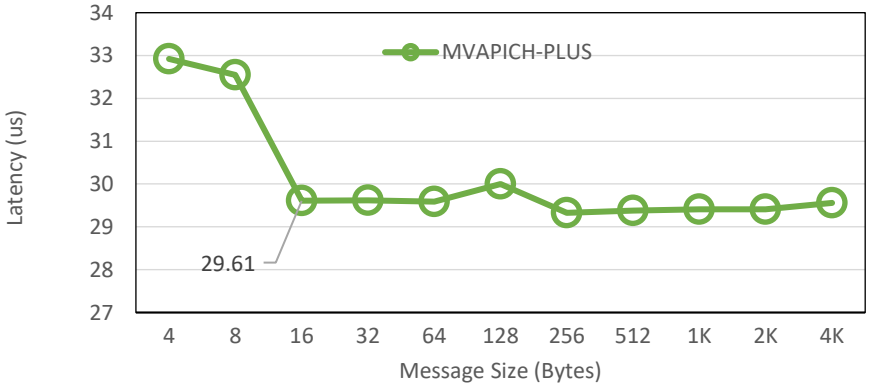
Collective Performance on AMD GPUs

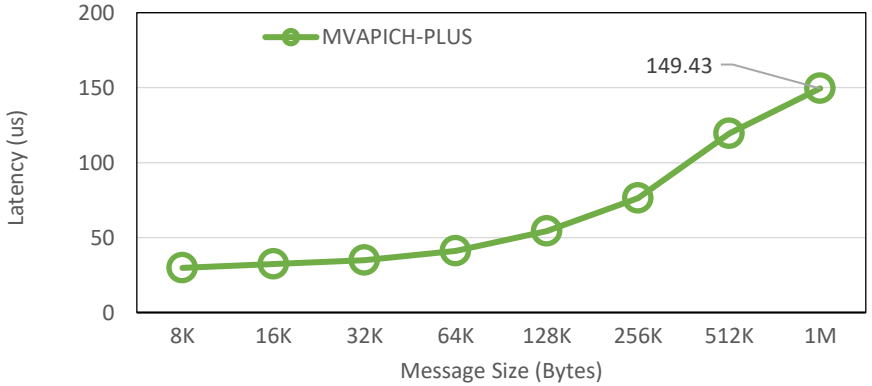
Bcast:





Alltoall:

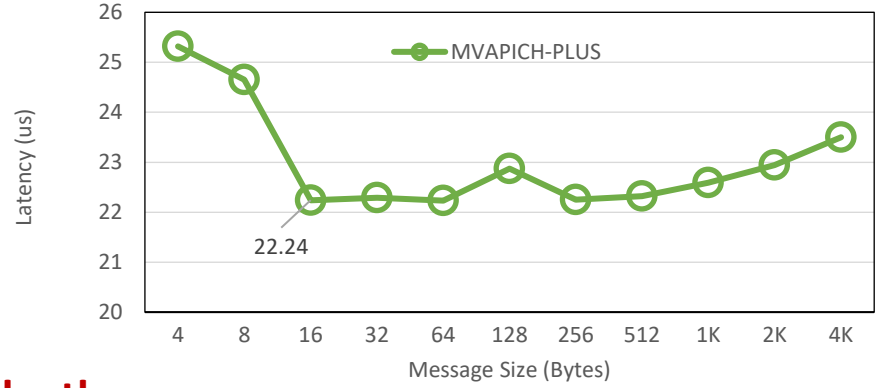


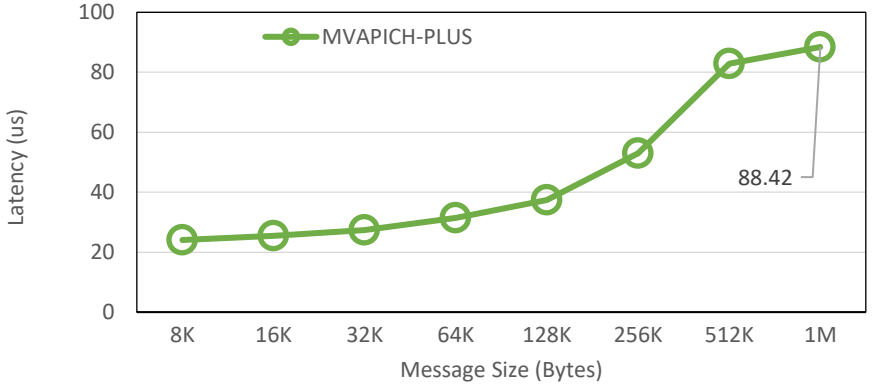


Tioga - ROCm-5.3.0 (MI250-X GPUs) – 8 GPUs

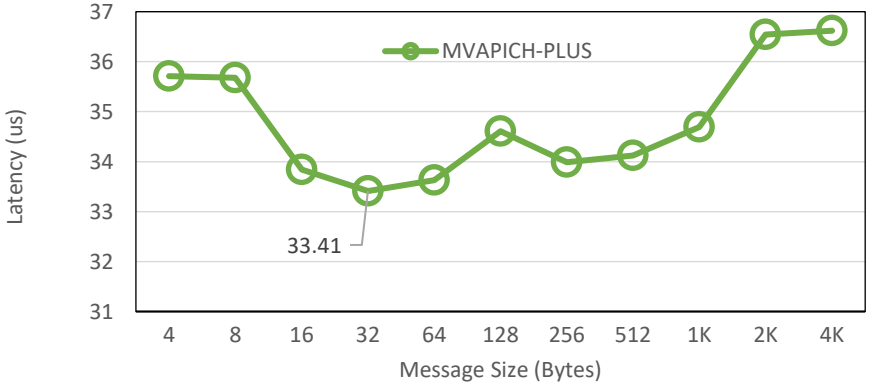
Collective Performance on AMD GPUs (Cont.)

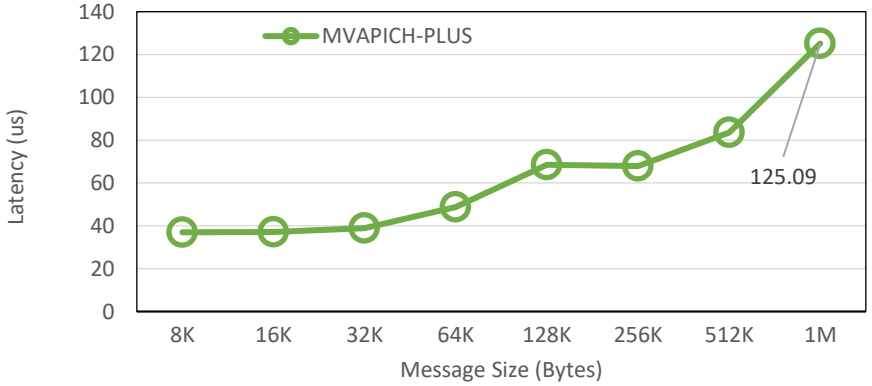
Gather:





Allgather:

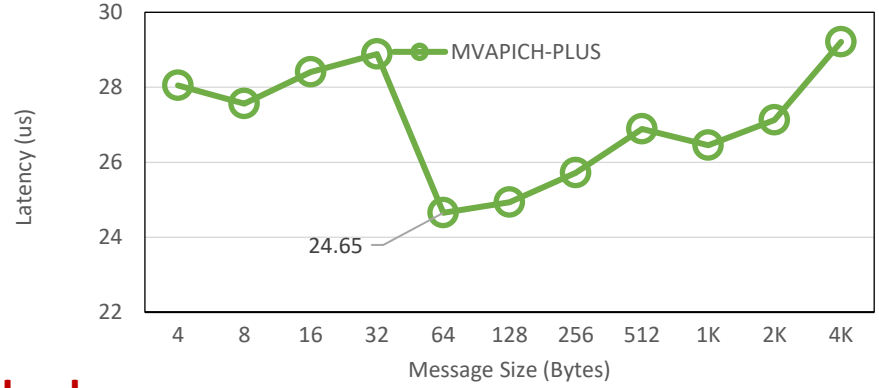


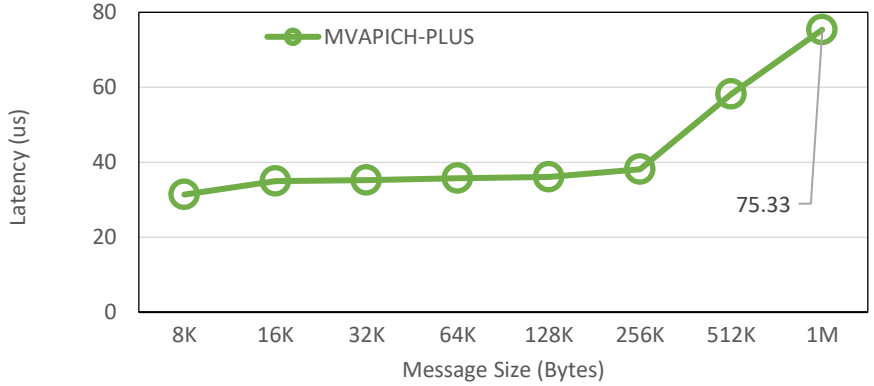


Tioga - ROCm-5.3.0 (MI250-X GPUs) – 8 GPUs

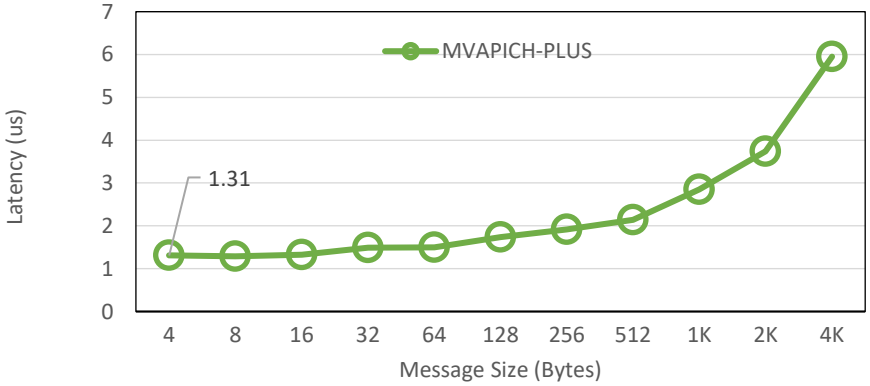
Collective Performance on AMD GPUs (Cont.)

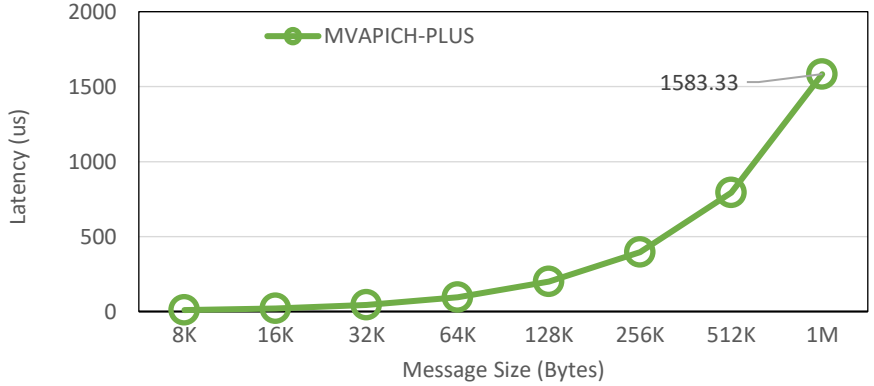
Reduce:





Allreduce:





Tioga - ROCm-5.3.0 (MI250-X GPUs) – 8 GPUs

MVAPICH2-Plus Upcoming Features for HPC and DL

- On-the-fly Compression for All_Gather Collective
- Scalable Distributed Training with Model-/Hybrid Parallelism for out-of-core DNN Models
- Scaling Single-Image Super-Resolution Training

MVAPICH2 – Future Roadmap and Plans for Exascale

- Making CH4 channel default
  - Early 2023
- Performance and Memory scalability toward 1M-10M cores
- Hybrid programming (MPI + OpenSHMEM, MPI + UPC, MPI + CAF …)
  - MPI + Task*
- Enhanced Optimization for GPUs and FPGAs*
- Taking advantage of advanced features of Mellanox InfiniBand
  - Tag Matching*
  - Adapter Memory*
- Enhanced communication schemes for upcoming architectures
  - NVLINK*
  - CAPI*
  - Bluefield2*
- Extended topology-aware collectives
- Extended Energy-aware designs and Virtualization Support
- Extended Support for MPI Tools Interface (as in MPI 3.0)
- Extended FT support
- Support for * features will be available in future MVAPICH2 Releases

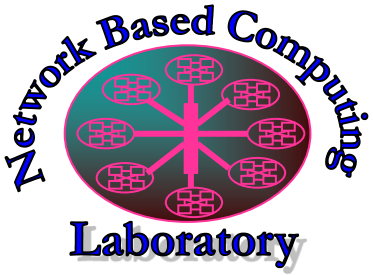
Join us for Multiple Events at SC '22

- Presentations at OSU and X-Scale Booth (#4305)
  - Members of the MVAPICH, HiBD and HiDL members
  - External speakers
- Presentations at SC main program (Tutorials, Workshops, BoFs, Posters, and Doctoral Showcase)
- Presentation at many other booths (Mellanox, Intel, Microsoft, and AWS) and satellite events
- Complete details available at

  http://mvapich.cse.ohio-state.edu/conference/904/talks/

Thank You!

panda@cse.ohio-state.edu



Network-Based Computing Laboratory
http://nowlab.cse.ohio-state.edu/

The High-Performance MPI/PGAS Project
http://mvapich.cse.ohio-state.edu/

The High-Performance Big Data Project
http://hibd.cse.ohio-state.edu/

The High-Performance Deep Learning Project
http://hidl.cse.ohio-state.edu/