



Open MPI State of the Union XI Community Meeting SC18

Jeff
Squyres



George
Bosilca



Edgar
Gabriel



Josh
Ladd



Interactive / Online / SC thingy

- Online question topic submission: Linklings
- BOF feedback form

<https://www.open-mpi.org/sc18/>



EuroMPI'19
September 11-13 2019
Zurich, Switzerland
<https://eurompi19.inf.ethz.ch>

Important dates:

Submission server opens: January 14th, 2019
Full paper submission: April 15th, 2019 (AOE)
Notification: July 1st, 2019
Camera-ready: August 5th, 2019





Open MPI versioning

Quick review

Open MPI versioning

- Open MPI uses “**A.B.C**” version number triple
- Each number has a specific meaning:
 - A** This number changes when backwards compatibility breaks
 - B** This number changes when new features are added
 - C** This number changes for all other releases



Version Roadmaps

v2.1.x (*End of Life*)

SO LONG & THANKS
FOR ALL THE FISH



v3.0.x (Prior stable)

- Release managers
 - Brian Barrett, AWS
 - Howard Pritchard,
Los Alamos National Lab



- Current release: v3.0.3
 - October 29, 2018
 - v3.0.4 expected Q1'19
- Maintenance mode
 - No new features for life of series
- Major features
 - `MPI_THREAD_MULTIPLE` support by default

v3.1.x (Prior stable)

- Release managers
 - Brian Barrett, AWS
 - Jeff Squyres, Cisco
- Current release: v3.1.3
 - October 29, 2018
 - v3.1.4 expected Q1'19
- Maintenance mode
 - No new features for life of series
- Many usability features over 3.0.x



v4.0.0 just released!



v4.0.x (Current stable)

- Release managers
 - Howard Pritchard,
Los Alamos National Lab
 - Geoff Paulsen, IBM
- Lots of bug fixes and performance improvements
- **Big changes:**
 1. Removed MPI-1 APIs not prototyped in mpi.h by default
 2. IB support now via UCX
 3. ABI compatible with 3.x
 4. MPIR usage deprecated



PSA: Stop using MPI-1 removed APIs!

- MPI_ADDRESS
- MPI_ERRHANDLER_CREATE
- MPI_ERRHANDLER_GET
- MPI_ERRHANDLER_SET
- MPI_TYPE_EXTENT
- MPI_TYPE_HINDEXED
- MPI_TYPE_HVECTOR
- MPI_TYPE_STRUCT
- MPI_TYPE_LB
- MPI_TYPE_UB
- MPI_UB
- MPI_LB
- MPI_COMBINER_HINDEXED_INTEGER
- MPI_COMBINER_HVECTOR_INTEGER
- MPI_COMBINER_STRUCT_INTEGER
- MPI_HANDLER_FUNCTION

- All of these were:
 - Deprecated in MPI-2.0 in 1996
 - Removed in MPI-3.0 in 2012
- All have easy replacements
 - See “Removed MPI constructs” FAQ category
 - open-mpi.org/faq/
 - Includes code samples showing how to update your code

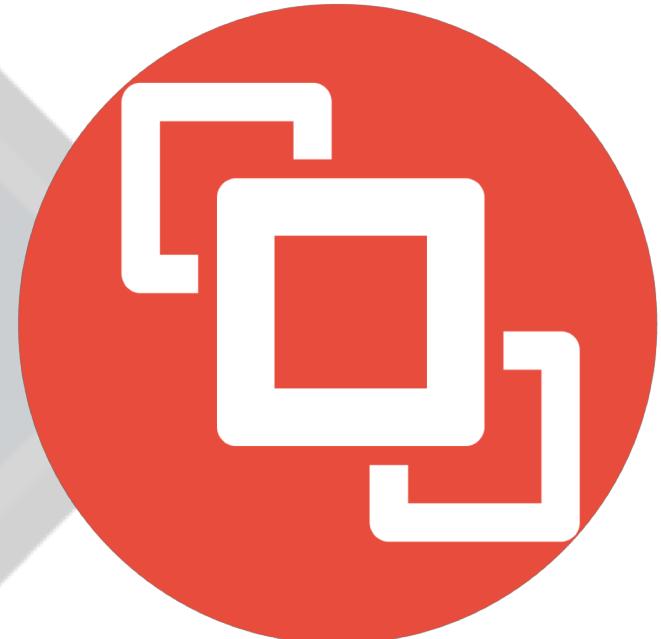
PSA: Stop using MPI-1 removed APIs!

- MPI_ADDRESS
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- MPI_UB
- MPI_LB
- MPI_COMBINER_HINDEXED_INTEGER
- MPI_COMBINER_HVECTOR_INTEGER
- MPI_COMBINER_STRUCT_INTEGER
- MPI_HANDLER_FUNCTION

- **NOT PROTOYPED IN v4.0.x mpi.h BY DEFAULT**
 - Applications using these removed symbols will fail to compile
 - The symbols are in libmpi, however (so ABI is preserved)
- Can use --enable-mpi1-compatibility to restore the removed mpi.h prototypes
 - This CLI option, prototypes, and symbols will exist for all v4.0.x releases
 - *...but may disappear in a future Open MPI release*

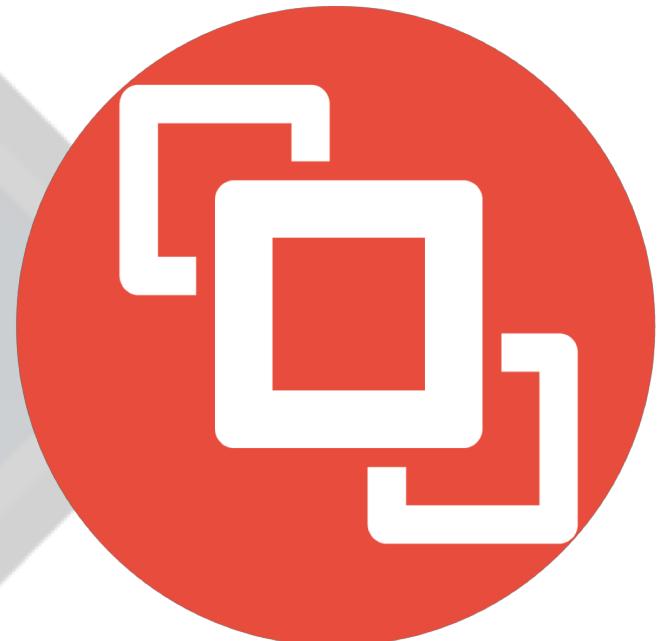
InfiniBand support → UCX PML

- OpenUCX (openucx.org) is now the preferred method for InfiniBand support
 - You may need to download/install OpenUCX before installing Open MPI
- By default, the openib BTL will refuse to run on IB devices
 - Unless manually enabled by setting the MCA param `btl_openib_allow_ib` to 1



v4.0.x: RoCE / iWARP → openib BTL

- RoCE and iWARP devices still default to the openib BTL
 - Can force the use of the UCX PML for RoCE/iWARP:
 - `mpirun --mca pml ucx --mca osc ucx ...`
- RoCE and iWARP will likely default to UCX in a future release



REMINDER

Deprecation notice: MPIR

- MPIR interface is used internally to launch / attach tools and debuggers
- The maintainer for Open MPI's MPIR is retiring!
- Initially announced at SC'17 BOF:
 - Unless someone else takes over, this is the plan:
 - Deprecation notice in NEWS in early CY2018
 - User runtime warnings in mid/late CY2018 (v4.0.0)
 - Removal in CY2019

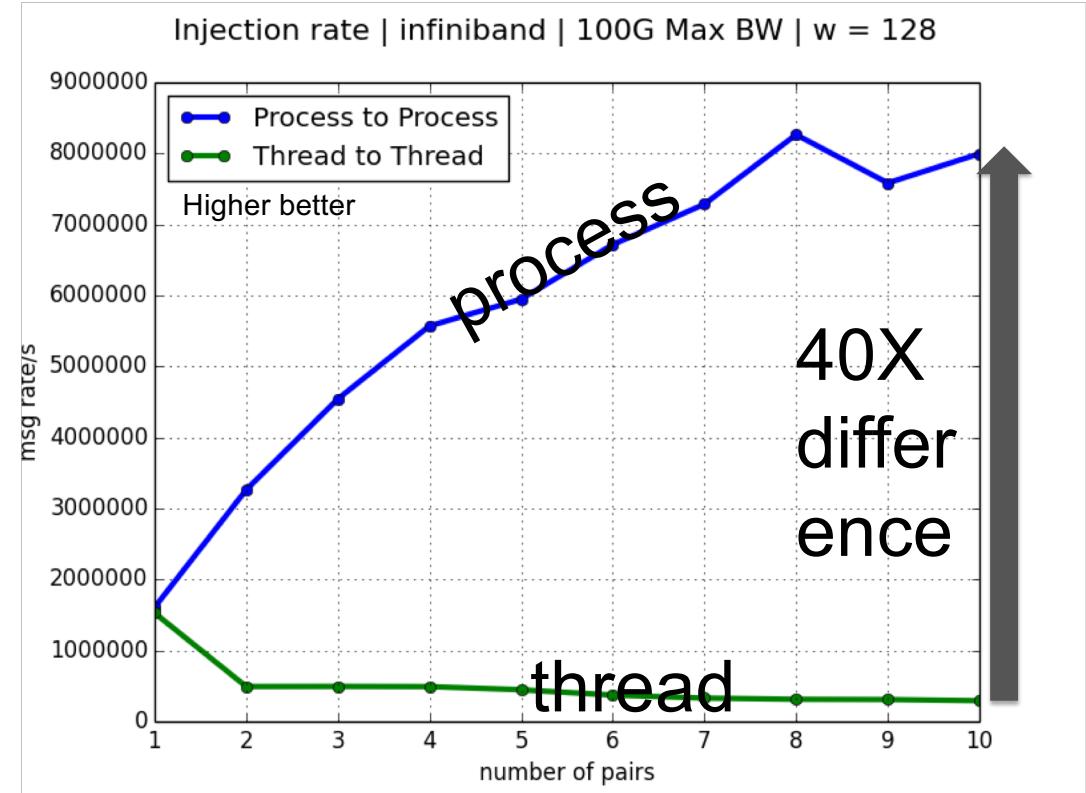
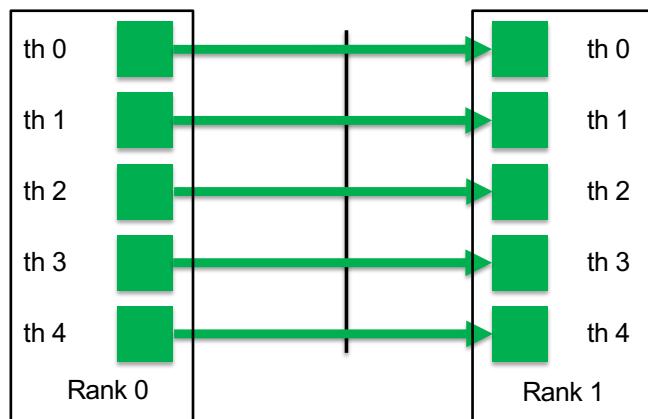
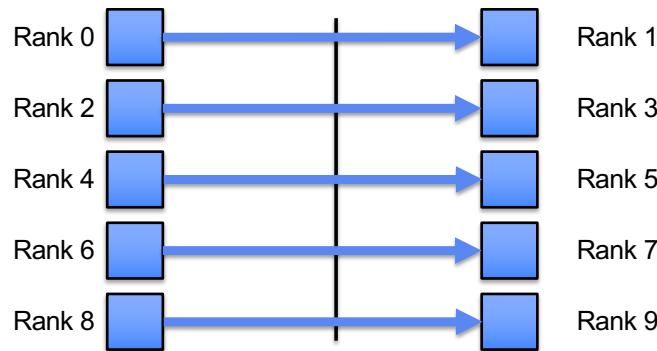


Threading, Collectives, Tools, Resilience

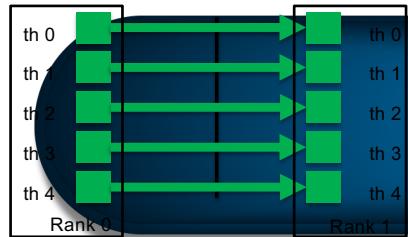
George Bosilca
University of Tennessee



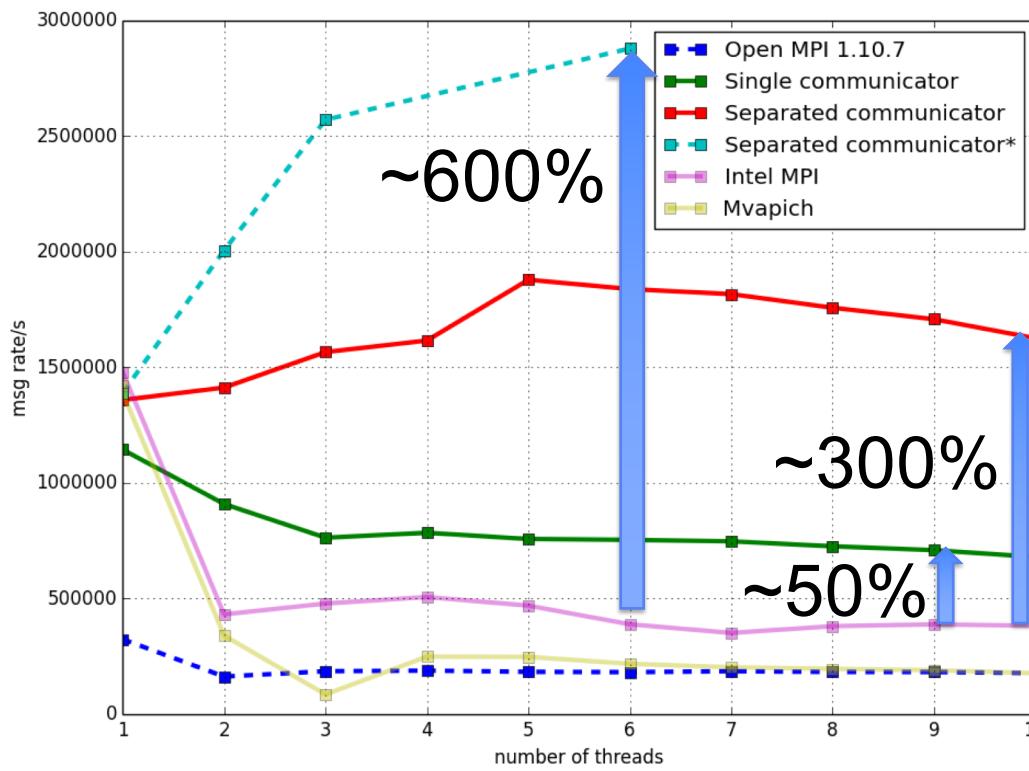
Threading support



Threading support



Injection rate | 100G Max BW | w = 128 | s = 1024 bytes



Open MPI 4.1
(with different
communicators)

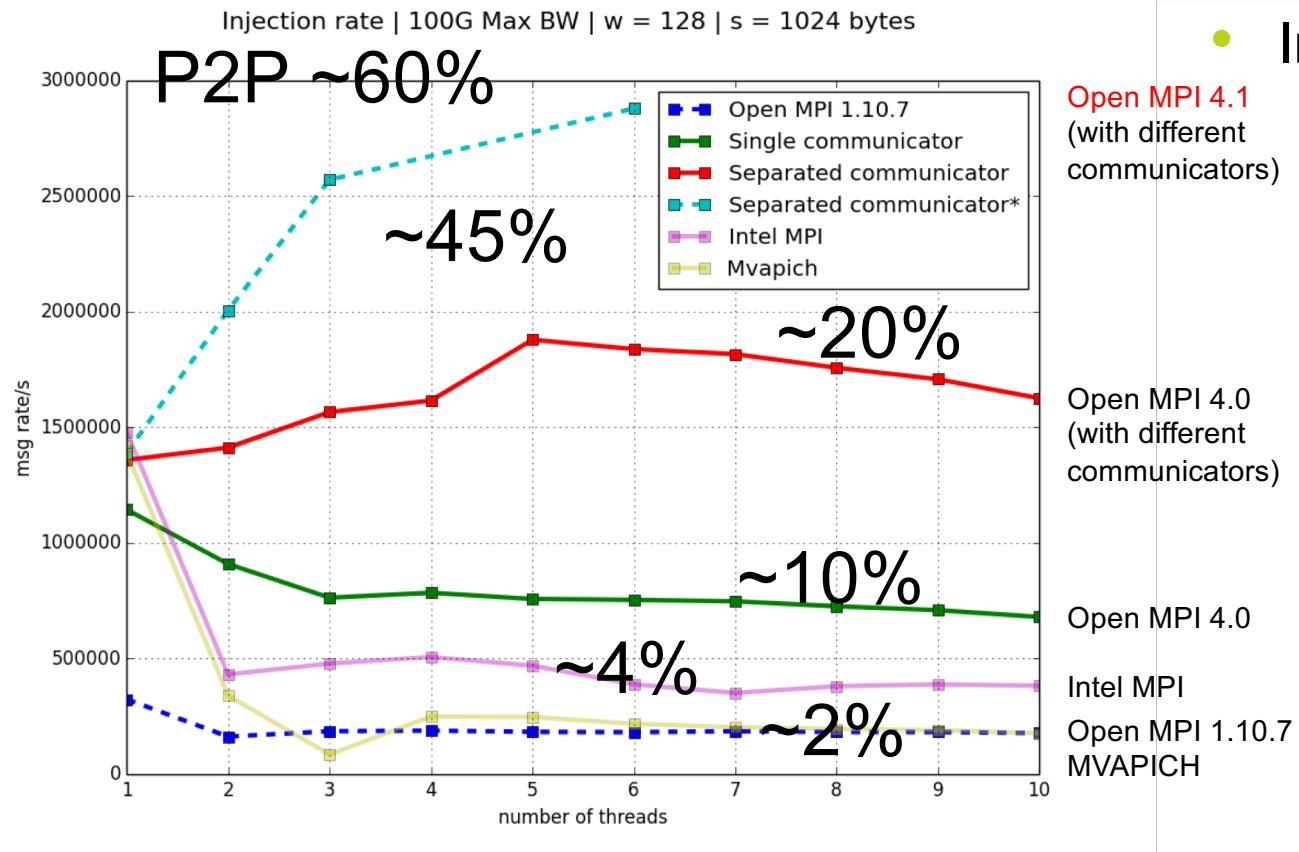
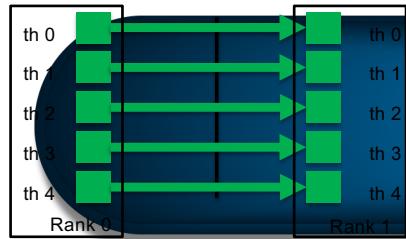
Open MPI 4.0
(with different
communicators)

Open MPI 4.0

Intel MPI

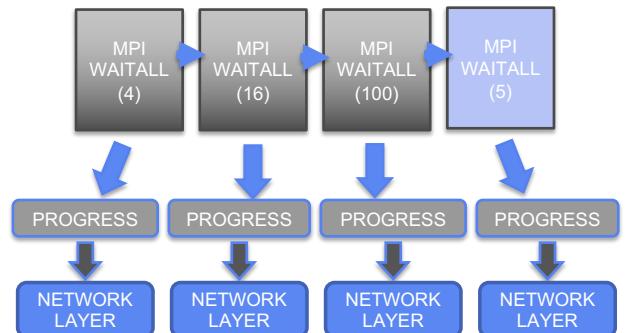
Open MPI 1.10.7
MVAPICH

Threading support



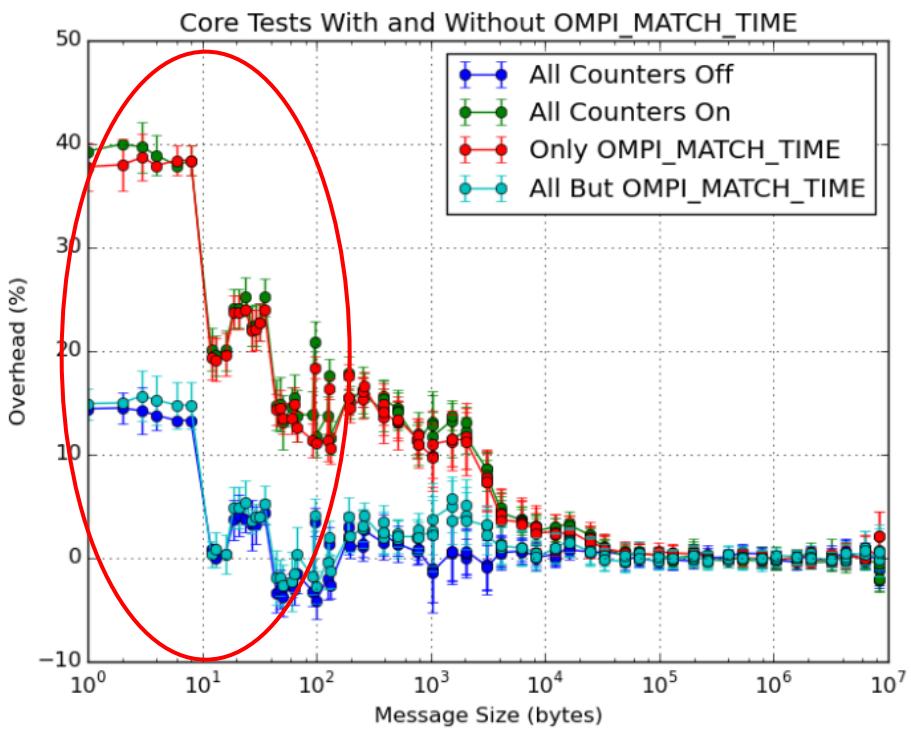
- Improvements:

- Synchronization primitive
- Unrestricted progress (protections done at the lowest level)
- Credit management
- Requests memory management
- Out-of-sequence management (limited bypass)

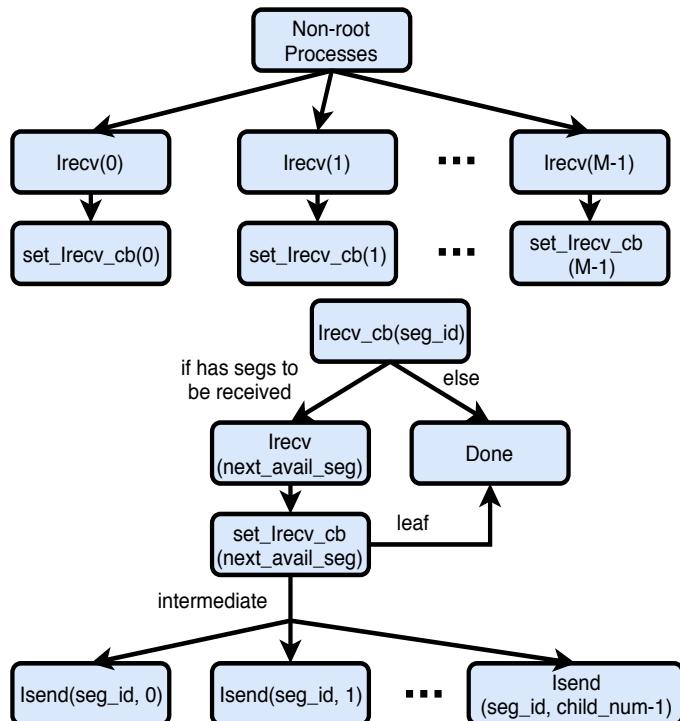


SPC: Software Performance Counters

- Similar to PAPI counters but exposing internal information not available through other means
 - Out-of-sequence messages, time to match, number of unexpected, instant bandwidth, collective bins
- Can be accessed via `MPI_T`, PAPI SDE, or shared file via PMIx plugins



Collective Communication

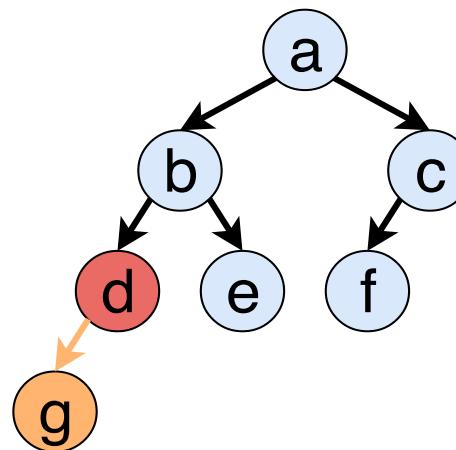


Data Dependency:

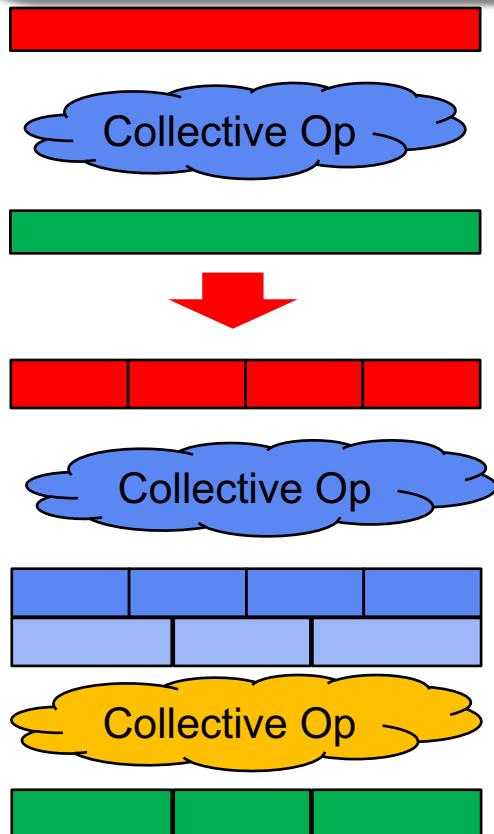
- same as previous implementation.

Synchronization Dependency:

- Segment independence
 - Rebalance
 - Decouple receiving of next segment and sending of current segment
- Child independence
 - Decouple the data transfer from different children



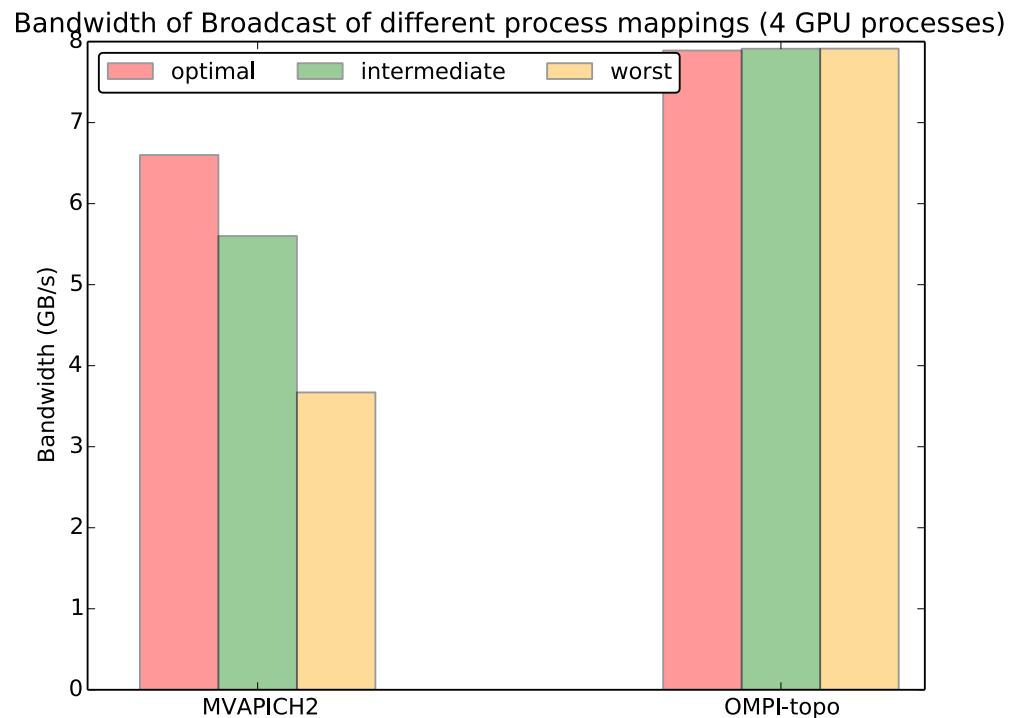
Collective communications



- Dataflow collective: different algorithms compose naturally (using a dynamic granularity for the pipelining fragments)
- Architecture aware: Each level reshape tuned collective to account for architecture capabilities
- The algorithm automatically adapts to network conditions
- Resistant to system noise

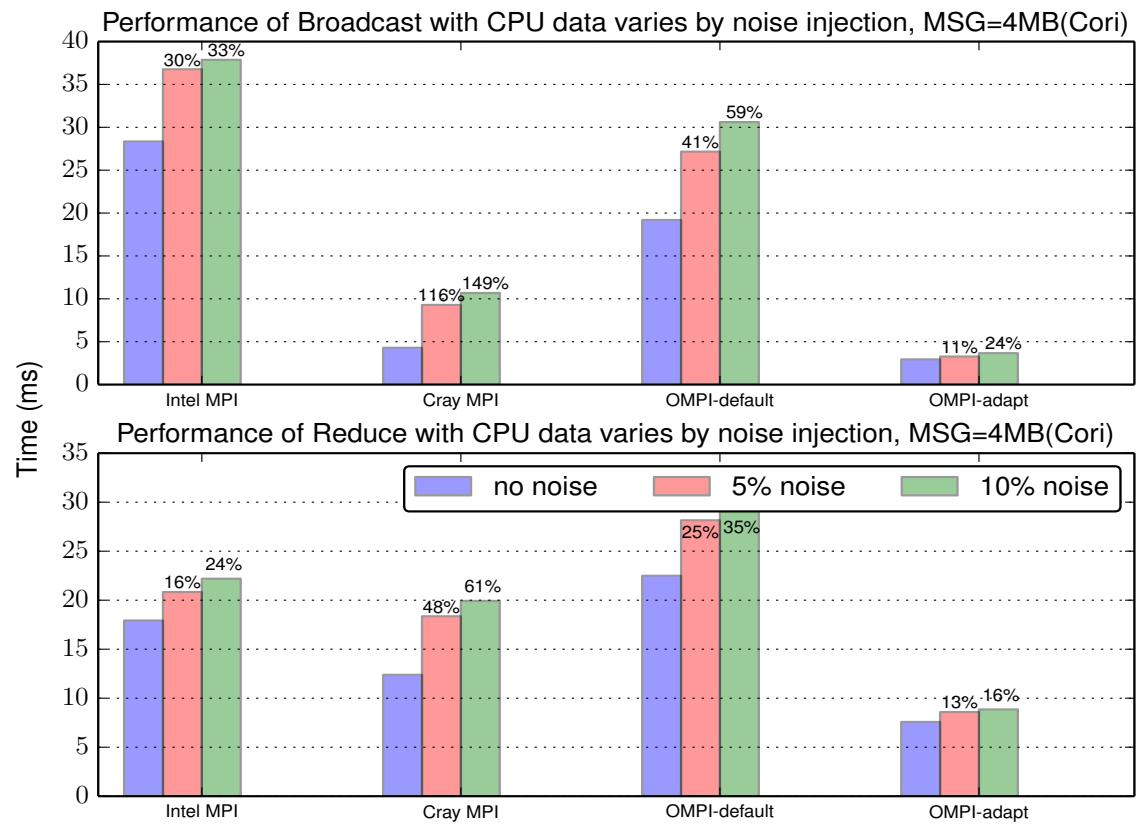
Collective Communication

Process location
Noise Reduction
Shared Memory
Hybrid Architecture



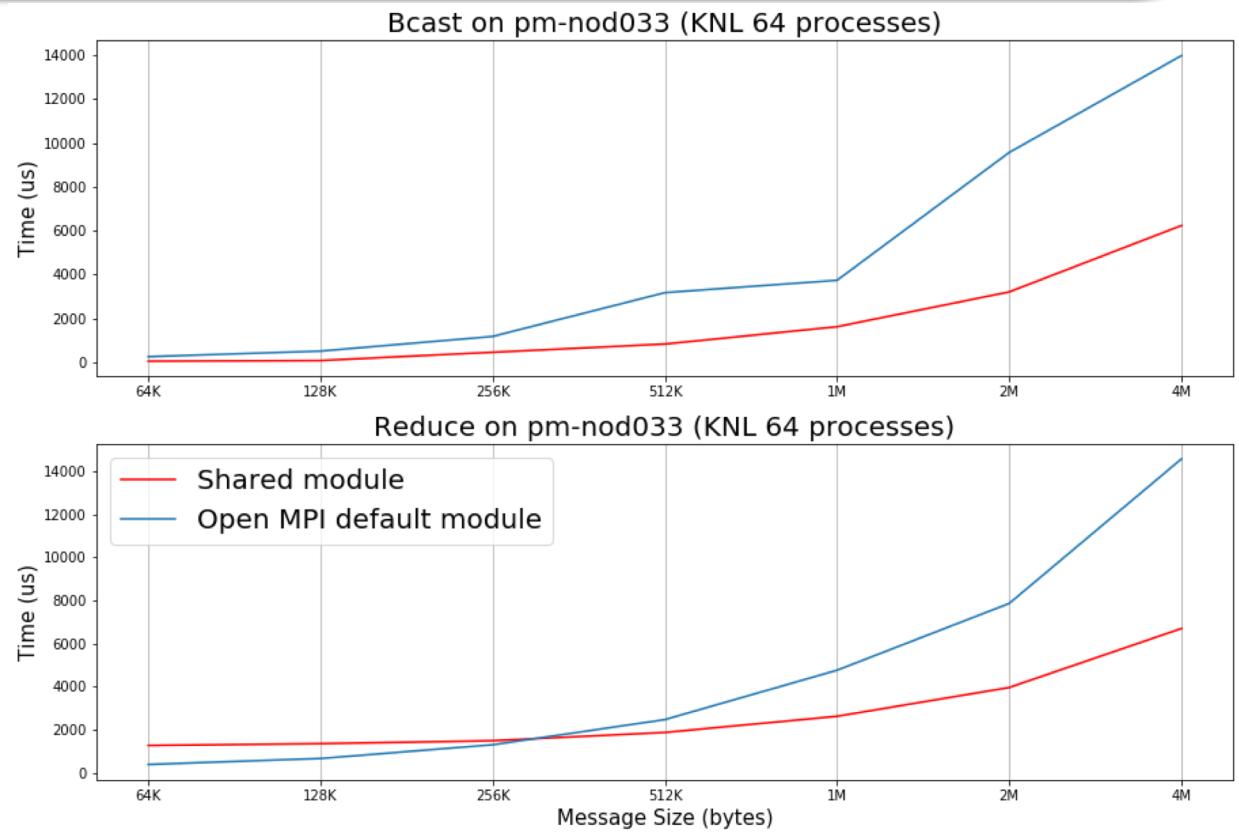
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Collective Communication

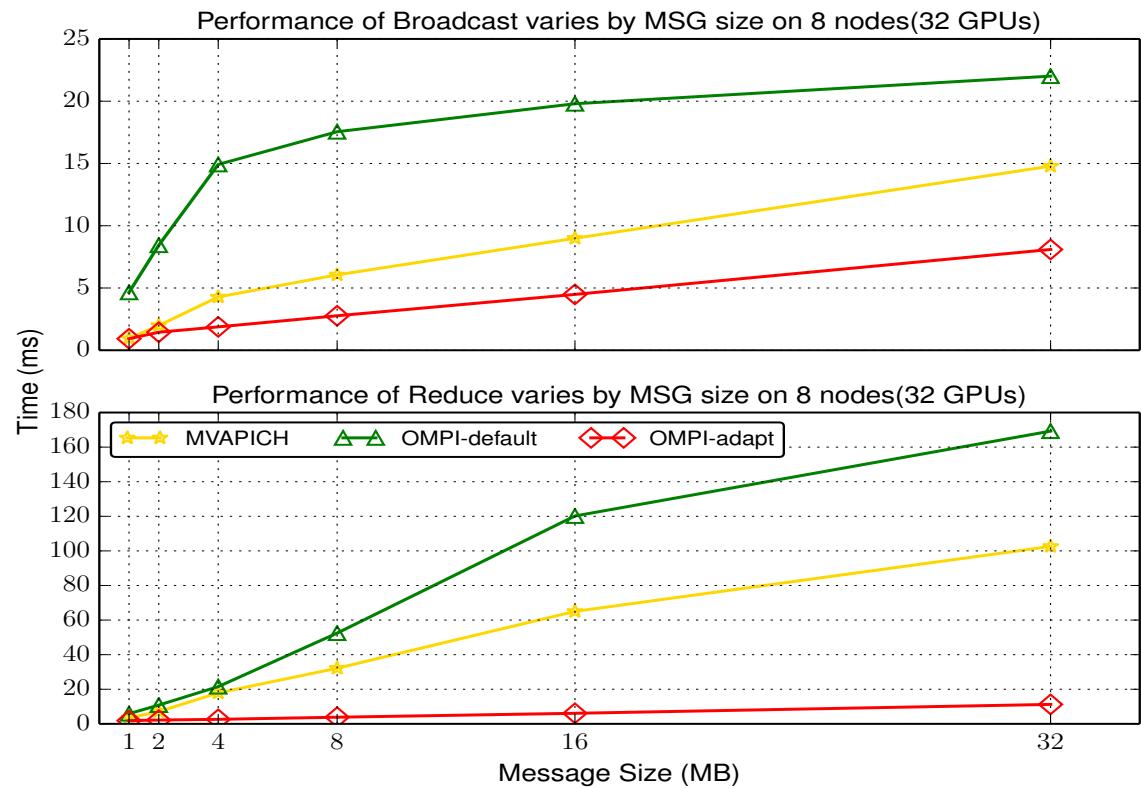
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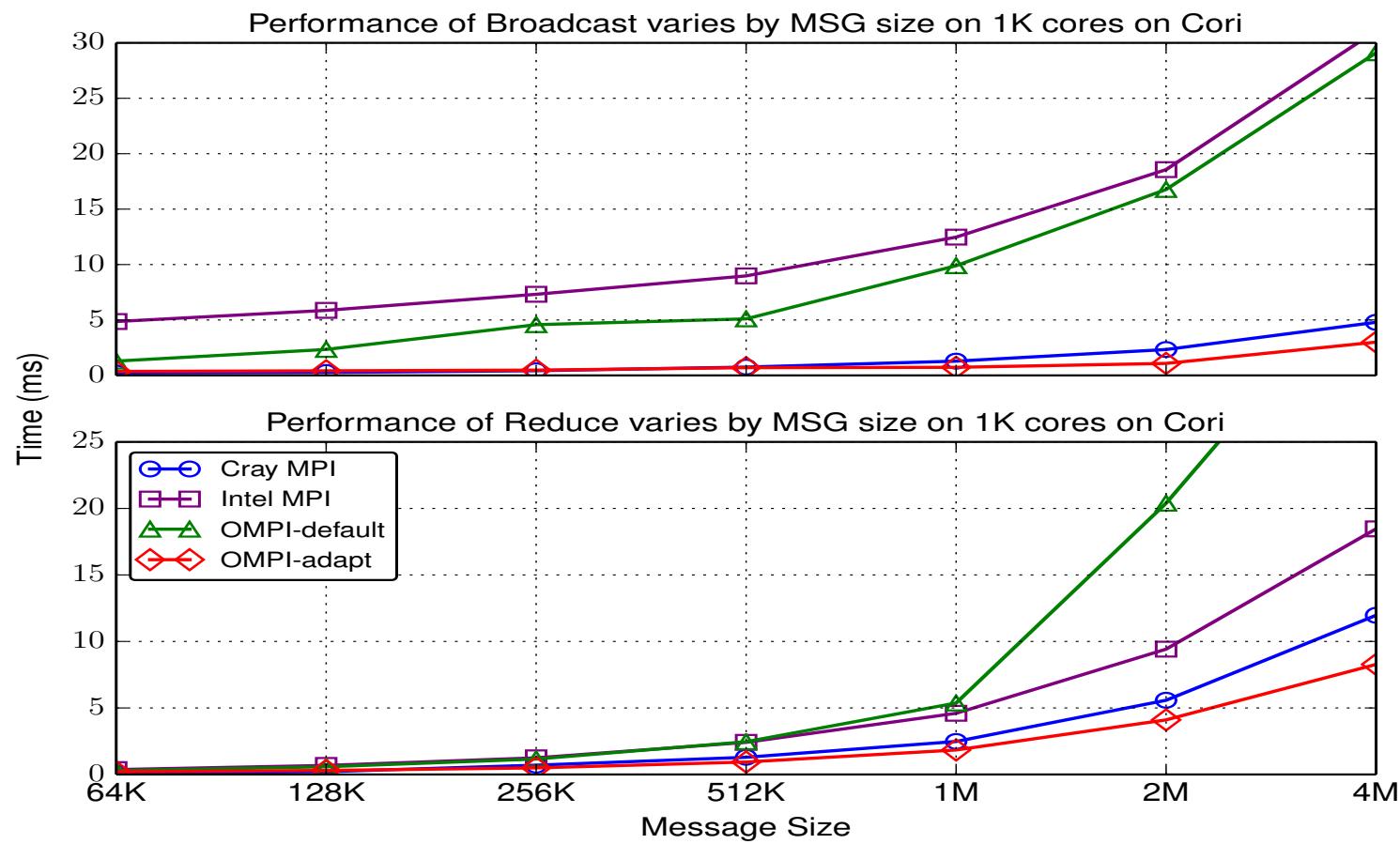
Collective Communication

Process location
Noise Reduction
Shared Memory
Hybrid Architecture

PSG Cluster:
4*K40/node
FDR IB

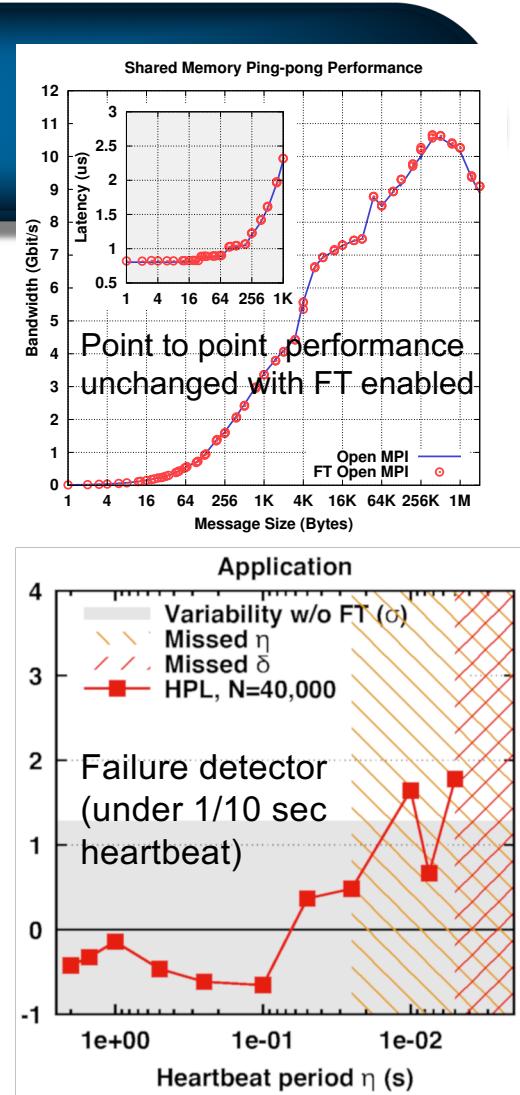


Collective Communication



Resilience - User Level Failure Mitigation (ULFM)

- Move the underlying resilient mechanisms outside ULFM/OMPI
 - Failure detector and reliable broadcast in PMIx
 - Used in OMPI ULFM and SUNY OpenSHMEM
- ULFM 2.1 released
 - Based on OMPI master (will remain in sync)
 - Transition to integrate ULFM in OMPI master
- Scalable fault tolerant algorithms demonstrated in practice for revoke, agreement, and failure detection (SC'14, EuroMPI'15, SC'15, SC'16)





OMPIO

Edgar Gabriel
University of Houston



OMPIO

- Highly modular architecture for parallel I/O
- Key features:
 - Tightly integrated with the Open MPI architecture (frameworks/modules, derived datatype handling, progress engine, etc.)
 - Support for multiple collective I/O algorithms
 - Automatic adjustments of number of aggregators
 - Multiple mechanisms available for shared file pointer operations

This work is funded in part by NSF grant SI2-SSI 1663887.

OMPIO

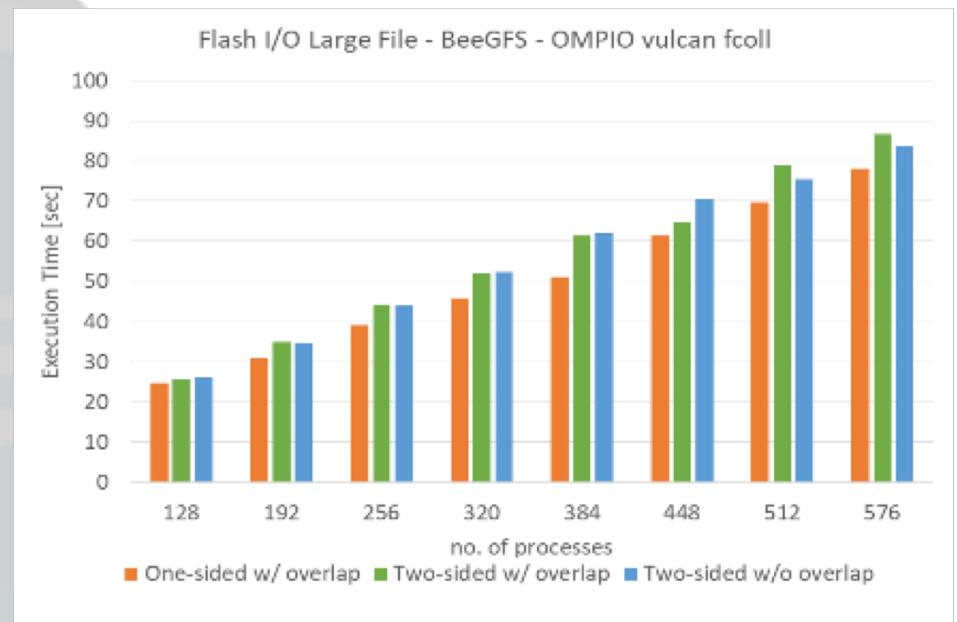
- New features:
 - Multi-threading support (Open MPI 3.1.0)
 - Better support for NFS file systems (Open MPI 3.1.1)
 - Support for CUDA GPU buffers (Open MPI 4.0.0)
 - New collective I/O component: vulcan (Open MPI 4.0.0)
 - Revamp of shared file pointer operations (Open MPI 4.0.0)
 - Support for more MPI I/O hints (Open MPI 4.0.0)

OMPIO file systems

- Generic Unix FS (XFS, EXT4)
- BeeGFS
- Lustre
- PVFS2/OrangeFS
- NFS

vulcan collective I/O component

- Features:
 - Overlaps two internal iterations of the algorithm
 - Uses asynchronous I/O (if available)
 - Communication based on two-sided (current release) and one-sided operations (upcoming release)
 - No data sieving





Mellanox Update

Joshua Ladd



UCX in Open MPI

- UCX PML replaces OpenIB BTL as the out-of-the-box network substrate for Infiniband fabrics in v4.x.
 - UCX GitHub – <https://github.com/openucx/ucx>
 - UCX now available in most Linux distros, will be in-box in the near future
- UCX transparently supports high-performance RDMA offloads:
 - Scalable reliable connections with DC transport (ConnectIB and higher)
 - MPI hardware tag matching offload (ConnectX-5 and higher)
 - Adaptive routing and out-of-order data placement (ConnectX-5 and higher)
 - GPU direct RDMA
- New in 2018:
 - Full GPU support on Nvidia (CUDA TL), and AMD (ROCM TL) GPUs.
 - Hardware-offloaded bitwise atomics, for OpenSHMEM v1.4.
 - Support for non-blocking memory registration.
 - Emulation layer for RMA/atomics over older hardware, shared memory, and TCP.
 - UCX OSC with multithreaded optimizations.
 - Multi-rail and HDR support.
 - Small message optimization with ConnectX-5 MEMIC.
 - Malloc hooks using binary instrumentation (BISTRO.)

HCOLL in Open MPI

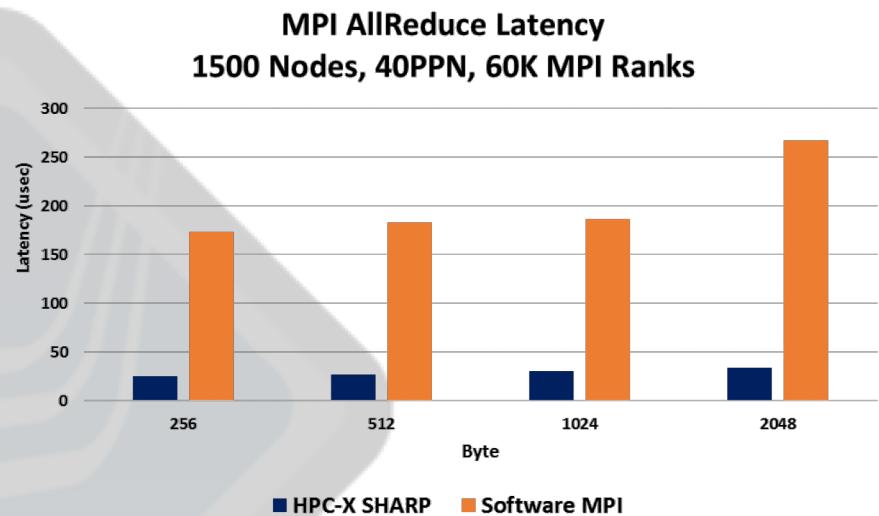
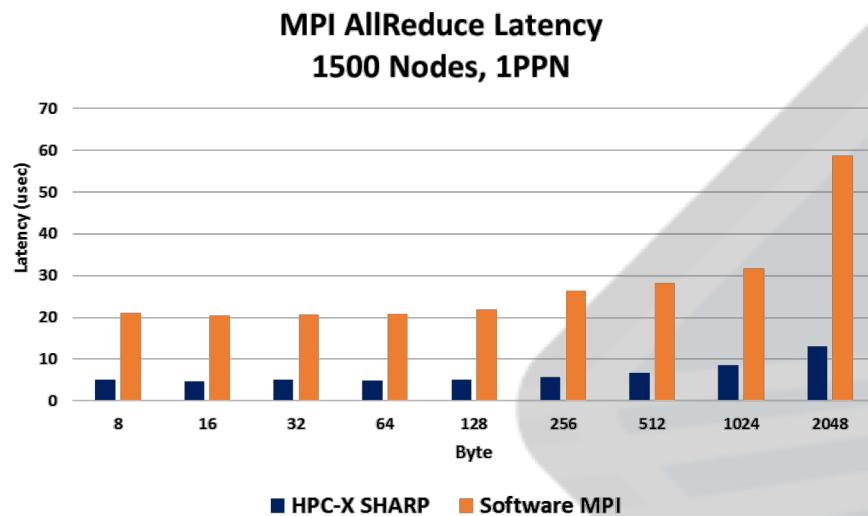
- Designed for exascale systems, now targeting Machine Learning frameworks.
- Deployed in production on Summit and Sierra
 - SHARP based allreduce, barrier
 - Multicast based broadcast
 - Highly optimized shared memory collectives
 - Optimized multithreaded
- Features targeting Machine Learning Workloads
 - Collectives over GPU Memory
 - SHARP small data reductions.
 - SHARP large data reduction(HDR ConnectX-6 / Quantum switch.)
 - Streaming reliable multicast for large data broadcast over GPU buffers.
 - UCX/GPU memory scatter-reduce-allgather algorithm for large data reductions.
 - Hierarchical GPU collectives.
 - Support for FP16 on Nvidia GPUs
 - Reductions on the GPU device
 - Reductions in the Switch.

OpenSHMEM v1.4 in Open MPI

- Available starting in Open MPI v4.0.0
- Contains many new features, allowing users to manage much more flexibility in communication and computation of OpenSHMEM programs
 - New feature list (specification 1.4, Annex G)
 - Communication management routines (context object)
 - Thread safety support
 - Sync routines
 - Test routines
 - Calloc routine for symmetric objects
 - Bitwise atomic operations

SHARP AllReduce Performance Advantages

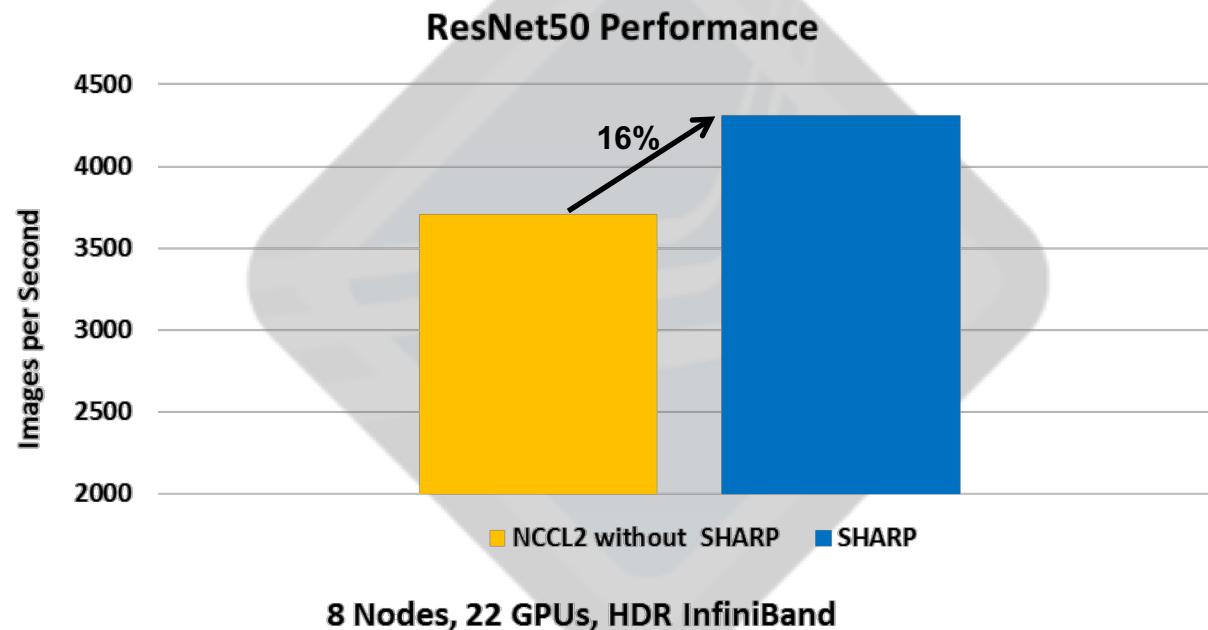
1500 Nodes, 60K MPI Ranks, Dragonfly+ Topology



SHARP Enables Highest Performance

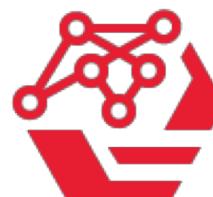
SHARP Performance Advantage for AI

- SHARP provides 16% Performance Increase for deep learning, initial results
- TensorFlow with Horovod running ResNet50 benchmark, HDR InfiniBand (ConnectX-6, Quantum)





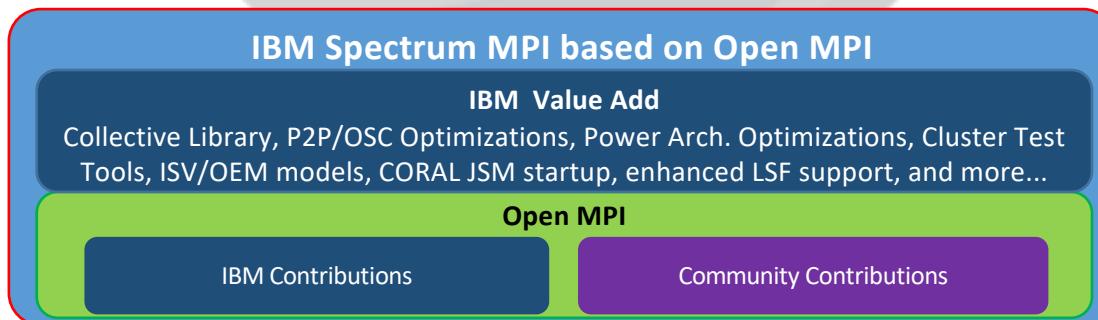
IBM Spectrum MPI



IBM **Spectrum MPI**

IBM Spectrum MPI

- IBM Spectrum MPI is a pre-built, pre-packaged version of community Open MPI plus IBM value add components.
- Spectrum MPI is based on Open MPI release branches
 - SMPI 10.1.0 based on OMPI v2.0.x branch
 - SMPI 10.2.0 based on OMPI v3.0.x branch
- Supporting scalable application performance on a variety of HPC systems including **ORNL's Summit** and **LLNL's Sierra** systems.
 - Improvements in MPI point-to-point, collective, and one-sided performance at all scales



Summary of Key Features

- Improved usability via command line options and packaging of tools
 - Interconnect selection (`-tcp`, `-ibv`, `-pami`), network selection (`-netaddr rank:10.10.1.0/24`)
 - Display table of interconnects used by your application
 - Supports multiple PMPI based tools both pre-packaged (e.g., Jumpshot by using `-entry mpe`) & user defined libraries (`-entry mpe,mylib`)
 - `$MPI_ROOT` mechanism to quickly switch between different SMPI versions
 - Single install for multiple compilers (GNU, XL, PGI)
- Performance optimizations
 - Shared memory optimizations for POWER9 and PAMI cross memory attach
 - PAMI point-to-point and one-sided components support async. progress, hardware tag matching, on-demand paging, hardware data gather/scatter, dynamic tasking, POWER9 tunneled atomics, IB hardware atomics
 - CUDA IPC and GPU Direct support for Power Systems
 - libcollectives library of IBM tuned collective operations with the ability to automatically chooses 'best' algorithm at runtime based on a variety of criteria.

```
$ mpirun -np 4 -prot -TCP ./hello
Host 0 [node01] ranks 0 - 1
Host 1 [node02] ranks 2 - 3

host | 0      1
=====|=====
 0 : shm  tcp
 1 : tcp  shm

Connection summary:
on-host: all connections are shm
off-host: all connections are tcp

0/ 4) [node01] 61808 Hello, world!
1/ 4) [node01] 61809 Hello, world!
2/ 4) [node02] 10697 Hello, world!
3/ 4) [node02] 10698 Hello, world!
```



ARM Update

arm

Arm Update

- Open MPI works on Arm!

- <https://developer.arm.com/products/software-development-tools/hpc/resources/porting-and-tuning/building-openmpi-with-arm-compiler>
- <https://developer.arm.com/products/software-development-tools/hpc/resources/porting-and-tuning/building-openmpi-with-openucx>

Arm Update

- Active collaboration between LANL and Arm to enable CI and MTT testing on Arm
 - Arm CI machines with InfiniBand hosted at HPCAC
 - Arm CI/MTT machines hosted at LANL



AWS & Open MPI

Brian Barrett & Raghu Raja



TCP Transport

- Improving network configuration support
 - Multiple IPs per network device (in master)
 - Differing number of interfaces
 - Complex routing configurations
- Multiple TCP connections between ranks
 - The `btl_tcp_links` MCA parameter had been around for many releases, but had bit-rotted
 - Works for simple cases, expanding in future

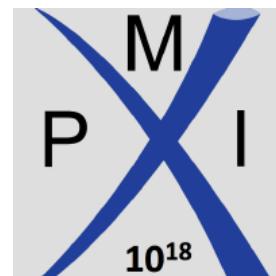
CI Testing

- “Pull Request Build Checker” running in AWS
- 23 test builds for every PR, all but 3 run in AWS
- Working on accelerating test execution time



PMIx in OMPI

Ralph H. Castain
Joshua Hursey



Current State

- PMIx plays integral role today
 - Embedded for “simple install”
 - OMPI 4.x → PMIx 3.x
 - OMPI 3.x → PMIx 2.x
 - Symbol-shifted to avoid conflicts with application-level bindings
- ORTE
 - Primary RTE for unmanaged environments

Future Directions

- PMIx as “First Class Citizen”
 - Direct use of PMIx functions
 - No more symbol shifting
- ORTE → PRRTE (pronounced: purr-tay)
 - Reduce RTE “cost” by sharing it with PMIx
 - PMIx-based tools

*PMIx BoF: Wed, 5:45-6:15pm
Focus: Application-level examples!
(<https://pmix.org>)*



Fujitsu Limited

FUJITSU

MPI for the Post-K Computer

- Post-K MPI based on Open MPI
 - Work on A64FX (Armv8.2-A + SVE) and TofuD
 - Plan to use Open MPI v4.0 and PMIx v2.1
- Contribution to Open MPI from post-K MPI
 - Persistent collectives [see *next page*]
 - Datatype for half-precision floating point [*early 2019*]
 - Thread parallelization of pack/unpack [*early 2019*]

The post-K computer is underdevelopment by RIKEN and Fujitsu

Persistent Collectives in MPI-4.0 (or MPI-3.2)

- Persistent collectives are in Open MPI 4.0.x
- Overlap computation & communication and reduce communication initialization cost
- Use *MPIX_* prefix because standardization is not complete
- Performance is similar to nonblocking collectives

See *man MPIX_Barrier_init* for details

```
MPIX_Bcast_init(  
    buf, count, ..., &req);  
for (...) {  
    MPI_Start(&req);  
    // ... your computation  
    MPI_Wait(&req, &stat);  
}  
MPI_Request_free(&req);
```



Bull Open MPI

Guillaume Papauré

Atos | montblanc-project.eu | @MontBlanc_EU



This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement n° 671697

Performance oriented MPI

- Application performance
 - Hierarchical collectives optimizations (work done with University Tennessee Knoxville [UTK])
 - Tuned for Bull eXascale Interconnect (BXI)
 - portals4 offload: tag matching, rendezvous, non blocking collectives
 - Tera-1000: 8256 nodes, 11.9 Tflops, 14th TOP500 (June 2018)
- MPI+X
 - Bull Hybrid Communication Optimizer
(currently Open MPI+OpenMP; other runtimes planned)
 - One sided notifications support in Open MPI OSC

User oriented MPI

- Ease of use
 - Hybrid MPI+OpenMP mpirun options
 - User parameters profiles
 - Collectives numerical reproducibility (work done with UTK)
- Fits with increasing HPC heterogeneity
 - ARM, x86_64, GPU+affinity
 - gcc, Intel compiler, ARM compiler
 - Supports all the way up through MPI_THREAD_MULTIPLE



Wrap up

Where do we need help?

- Code
 - Any bug that bothers you
 - Any feature that you can add
- ***User documentation***
- Testing (CI, nightly)
- Usability
- Release engineering

We ❤️ ↗



Come join us!