Open MPI State of the Union Community Meeting SC '12

November 14, 2012

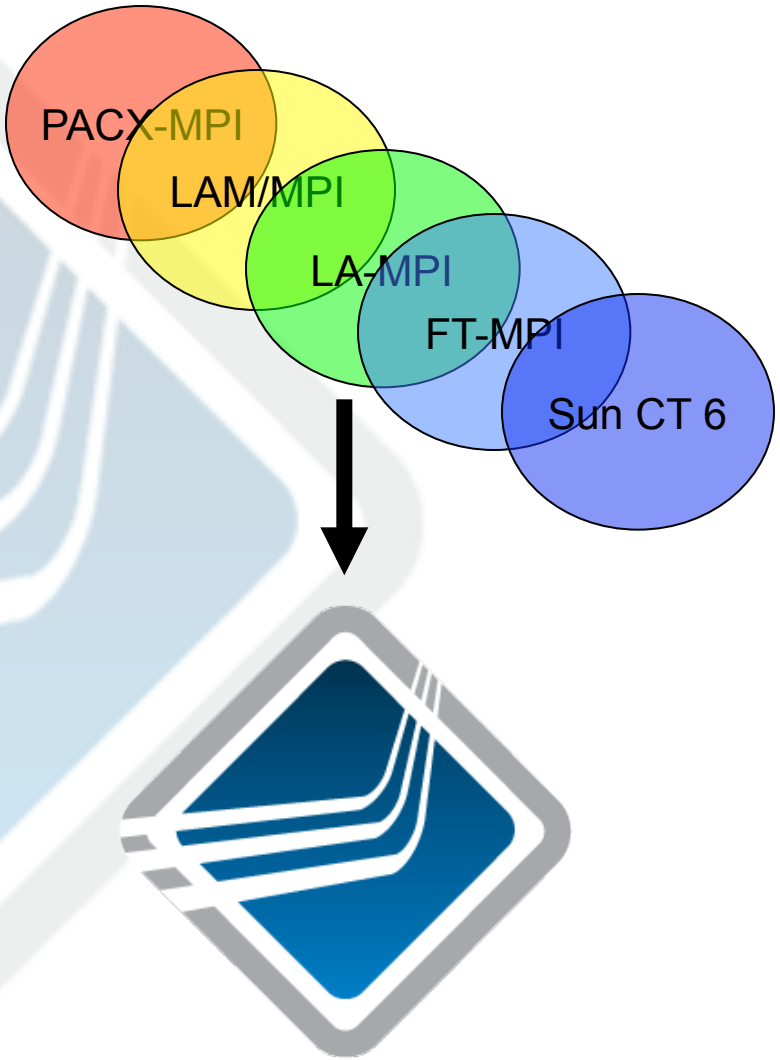
Jeff Squyres

George Bosilca

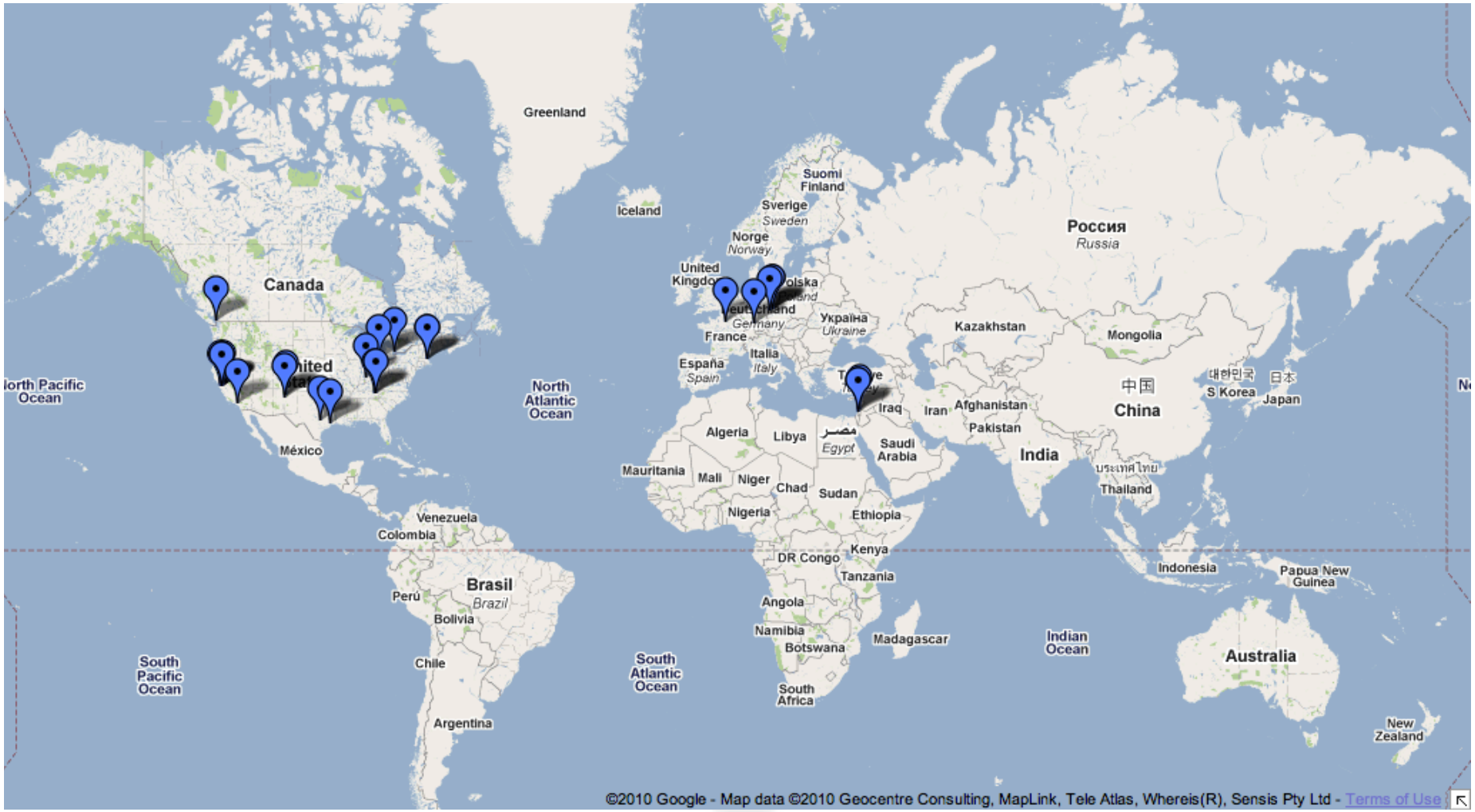
Brian Barrett

Open MPI Is…

- Evolution of several prior MPI's
- Open source project and community
  - Production quality
  - Vendor-friendly
  - Research- and academic-friendly
- MPI-2.1 compliant



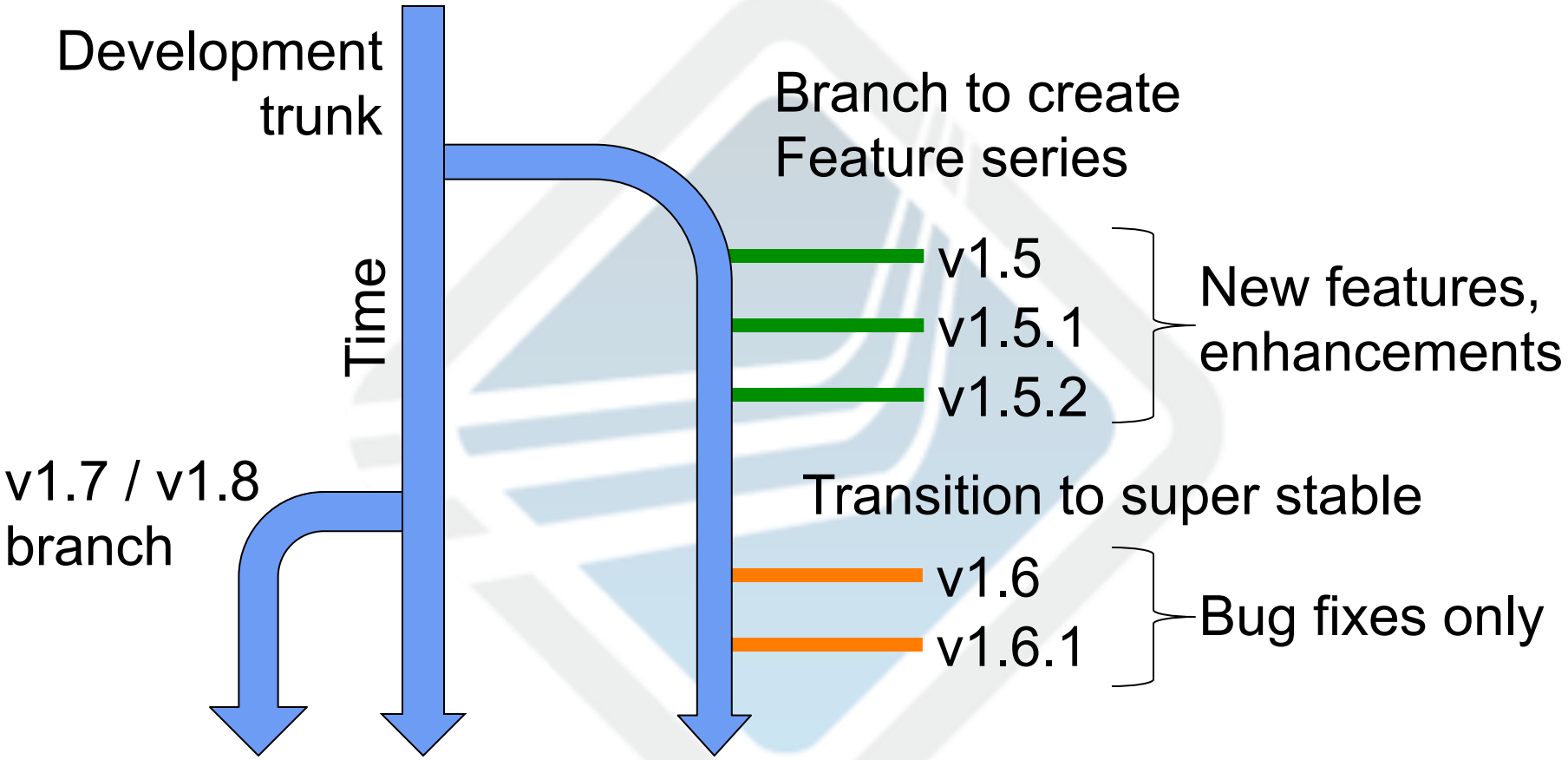
Members, Contributors, Partners



Versioning Scheme

- Open MPI has 2 concurrent release series
  - "Feature series" → v1.<odd>
  - "Super stable series" → v1.<even>
- Both are tested and QA'ed
  - Main difference between the two is time

Feature / Stable Series



v1.6 Roadmap

- v1.6.3 is the current stable release
  - Bug fixes only
  - v1.6.4 will likely happen… someday
- We encourage all users to move away from the v1.4 series
- v1.6 updates are boring (!)
  - … as they are intended to be

v1.7 Series

Brian Barrett

1.7 Goals

- MPI-3.0 compliance
- Better resource exhaustion resilience
- Thread safety
- Cray XE/XK/XC support
- Memory usage at scale

v1.7.0 Features

- Better Fortran bindings
- Java bindings
- Improved locality control infrastructure
- Improved run-time infrastructure
- New collectives
- MPI-3 features…

v1.7.0 MPI-3.0 Compliance

- Matched probe
- Nonblocking collective operations
  - Intercommunicators may slip to 1.7.1
- Version query
- MPI-3 Fortran support (f08 bindings)
- MPI_TYPE_CREATE_HINDEXED_BLOCK
- MPI_COMM_SPLIT_TYPE
- MPI_INFO_ENV support

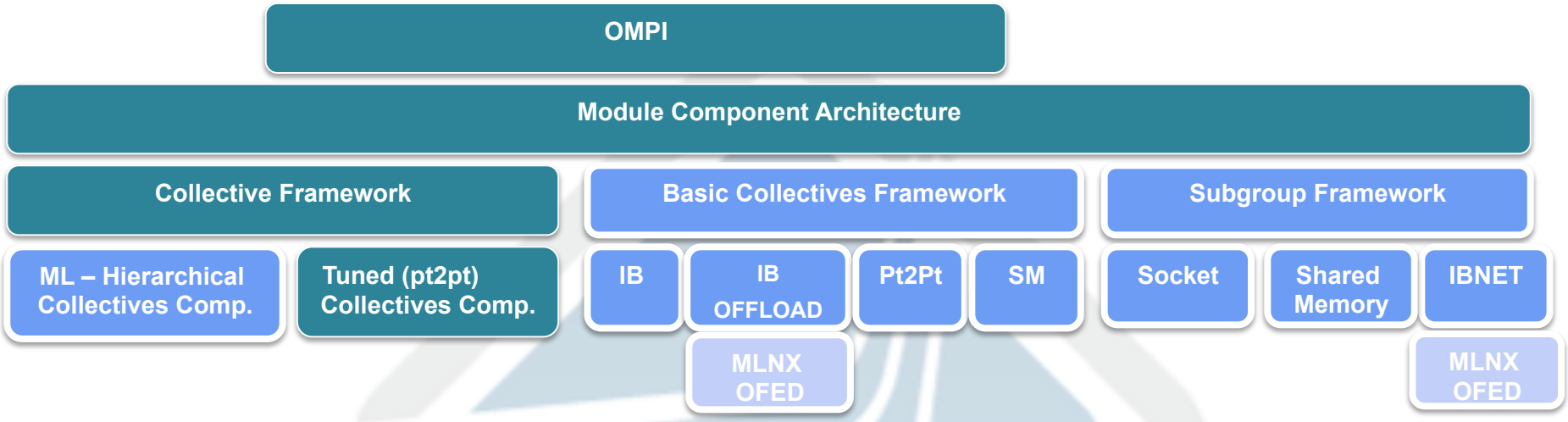
MPI-3.0 Plans

- Features for 1.7.1
  - New one-sided interface (including shared memory windows)
- Work in progress
  - Non-blocking collectives
  - Non-blocking/non-collective communicator duplication
  - MPIT Tools interface

U. Tennessee Research Update

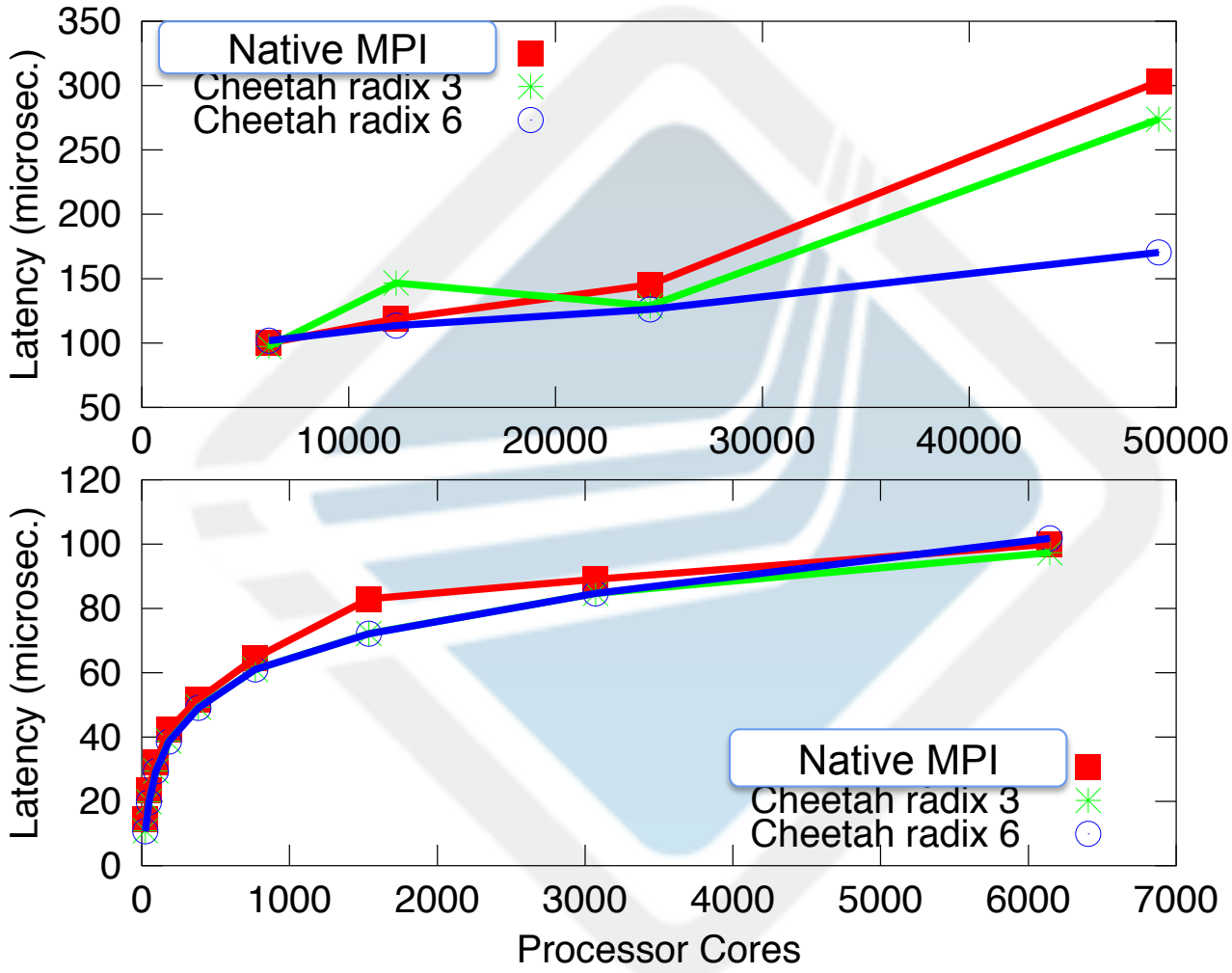
George Bosilca

Hierarchical Collectives Software Layers - Cheetah



OAK RIDGE National Laboratory

Barrier – Comparison with Native MPI



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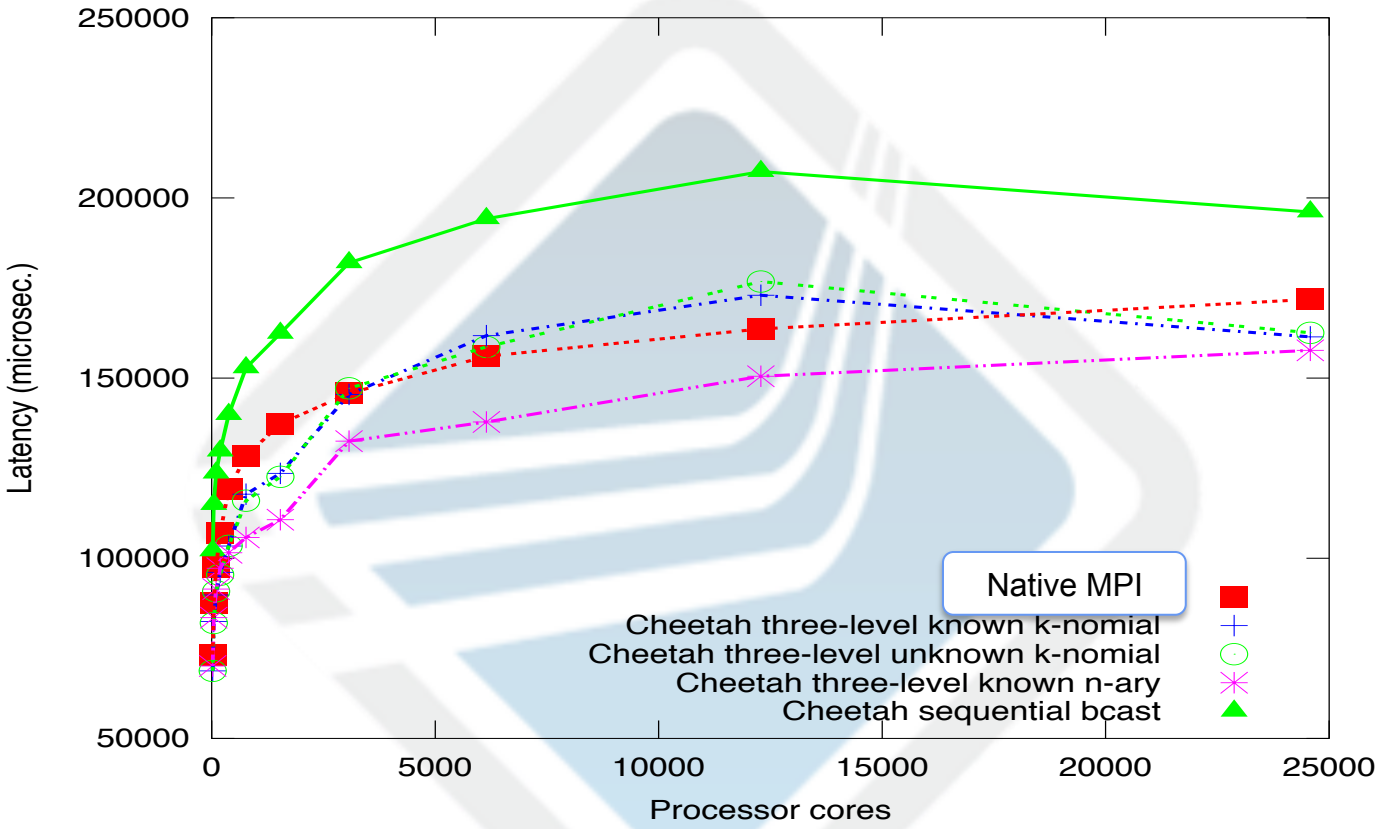
Large-Scale Broadcast Performance: OMPI vs Native MPI large message 16 MBytes



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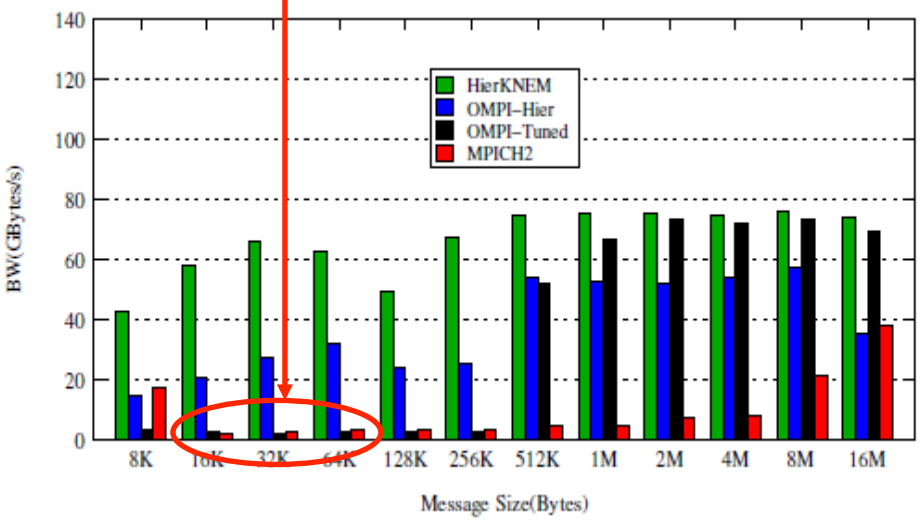
Aggregate Broadcast Bandwidth

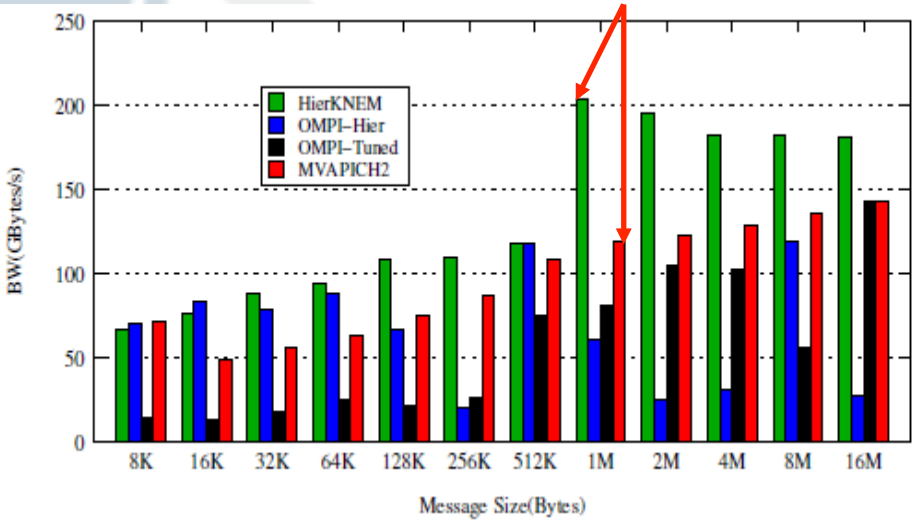
HierKNEM OMPI-Hierarch OMPI-Tuned

MPICH2 on Ethernet or MVAPICH2 on IB

30x speedup!



~2x speedup



(a)Ethernet Cluster (32nodes) **(b)InfiniBand Cluster (32nodes)**

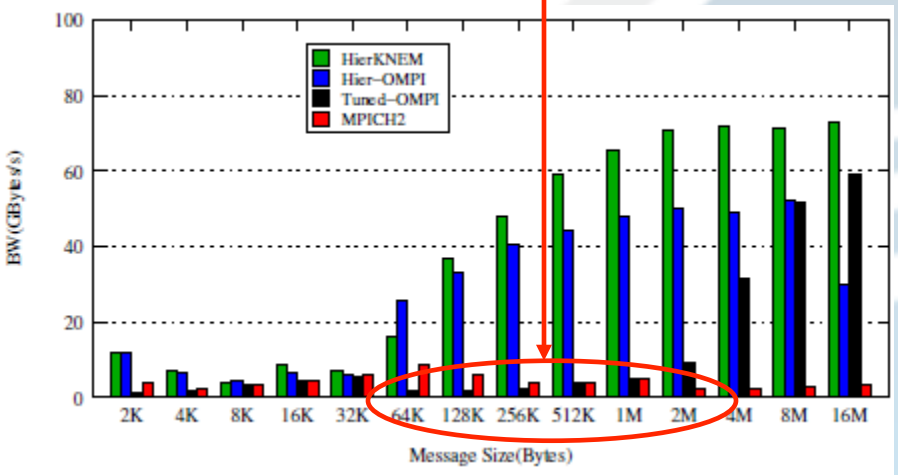
768 processes, 32 nodes, 24 cores/node

Aggregate Reduce Bandwidth

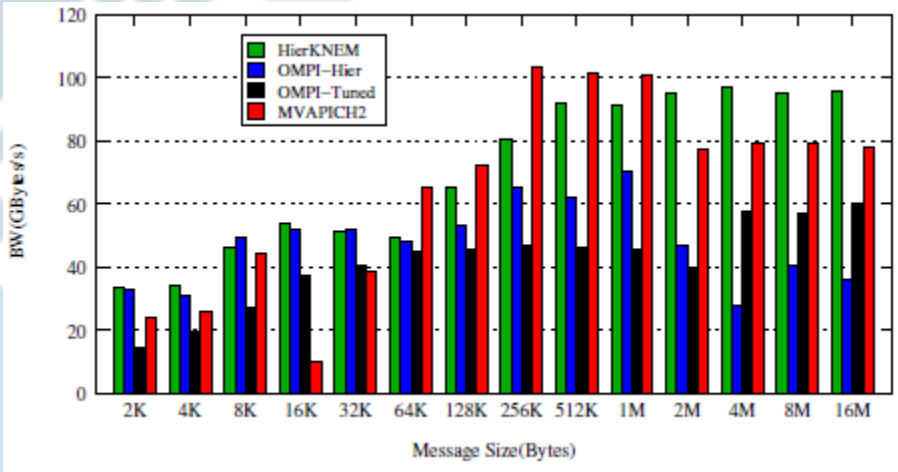
HierKNEM OMPI-Hierarch OMPI-Tuned

MPICH2 on Ethernet or MVAPICH2 on IB

3-10 X



(a)Ethernet Cluster (32nodes)

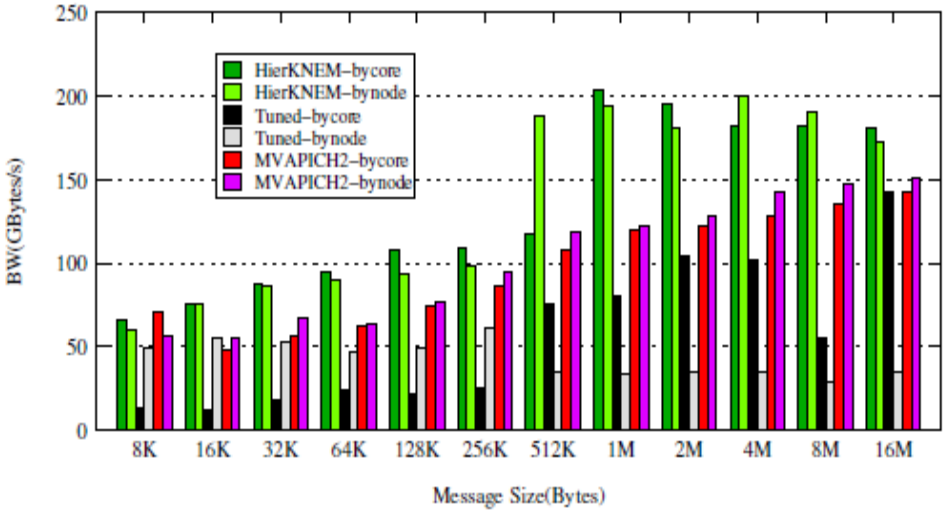


(b)InfiniBand Cluster (32nodes)

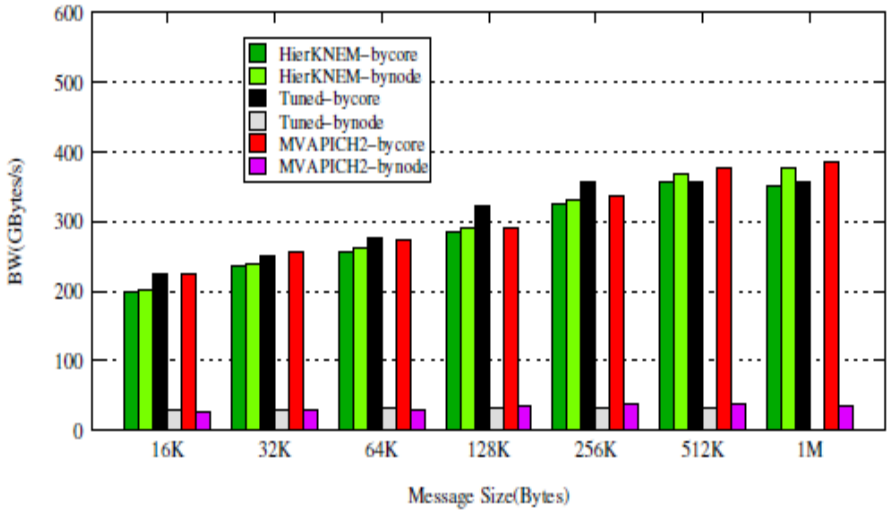
768 processes, 32 nodes, 24 cores/node

Insensitive to process mapping

HierKNEM-bycore
HierKNEM-bynode
Tuned-bycore
Tuned-bynode
MVAPICH2-bycore
MVAPICH2-bynode



(a) Broadcast

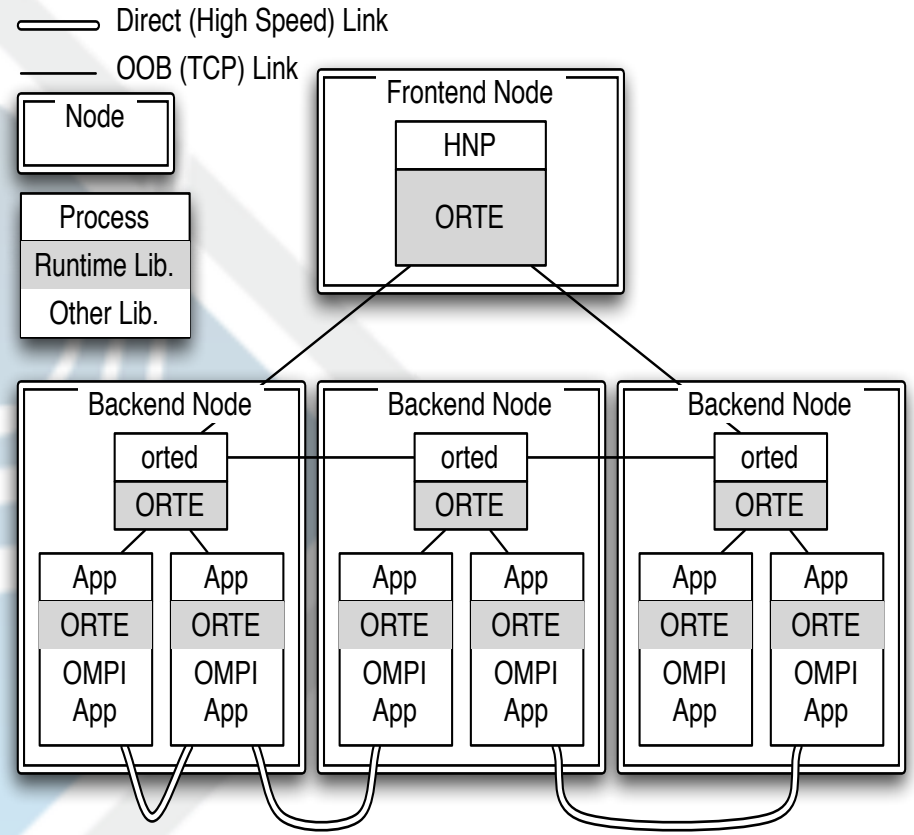


(b) Allgather

Impact of process mapping: aggregate Broadcast and Allgather bandwidth of the collective modules for two different process-core bindings: by core and by node (Parapluie cluster, IB20G, 768 processes, 24 cores/node).

Runtime ?

- A helper for starting parallel applications
  - Launch
  - Connect
  - Control
  - I/O
- Critical for the scalability and the resilience of any programming paradigm



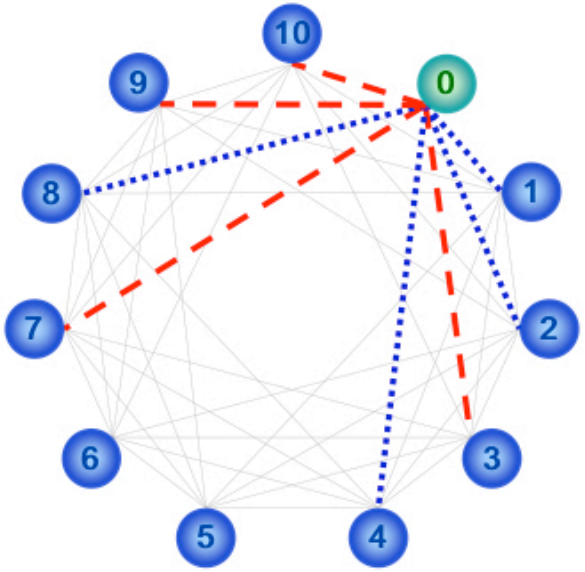
Communication Infrastructure

Undirected graph $G:=(V, E)$, $|V|=n$ (any size)

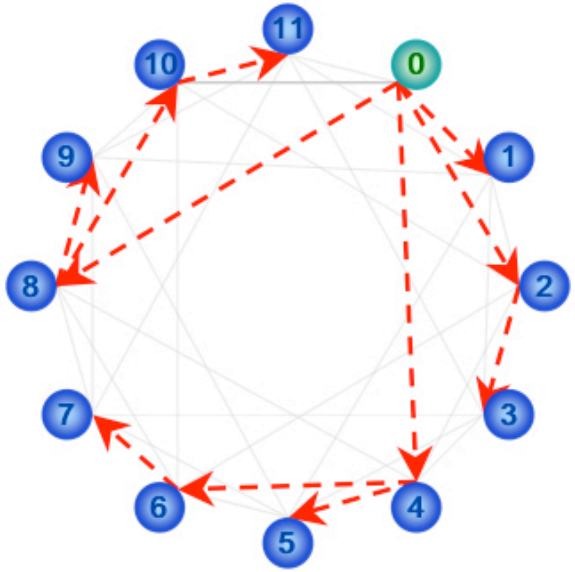
Node $i=\{0,1,2,\ldots,n\text{-}1\}$ has links to a set of nodes U

$U=\{i\pm1, i\pm2,\ldots, i\pm2^k \mid 2^k < n\}$ in a circular space

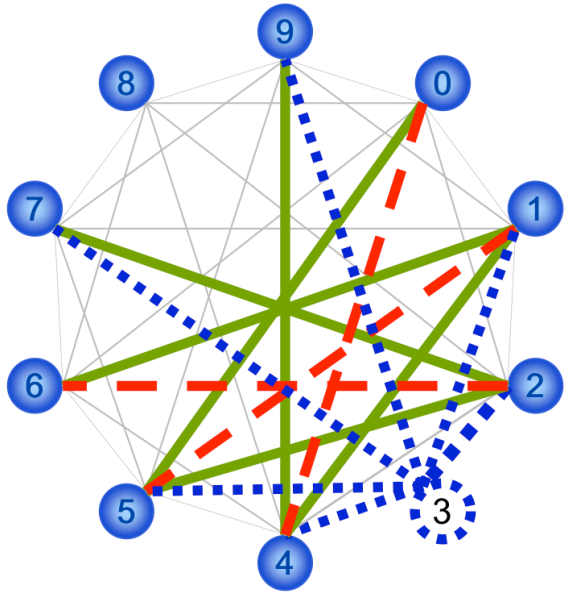
Binomial Graph



Merging all links creates binomial graph from each node of the graph

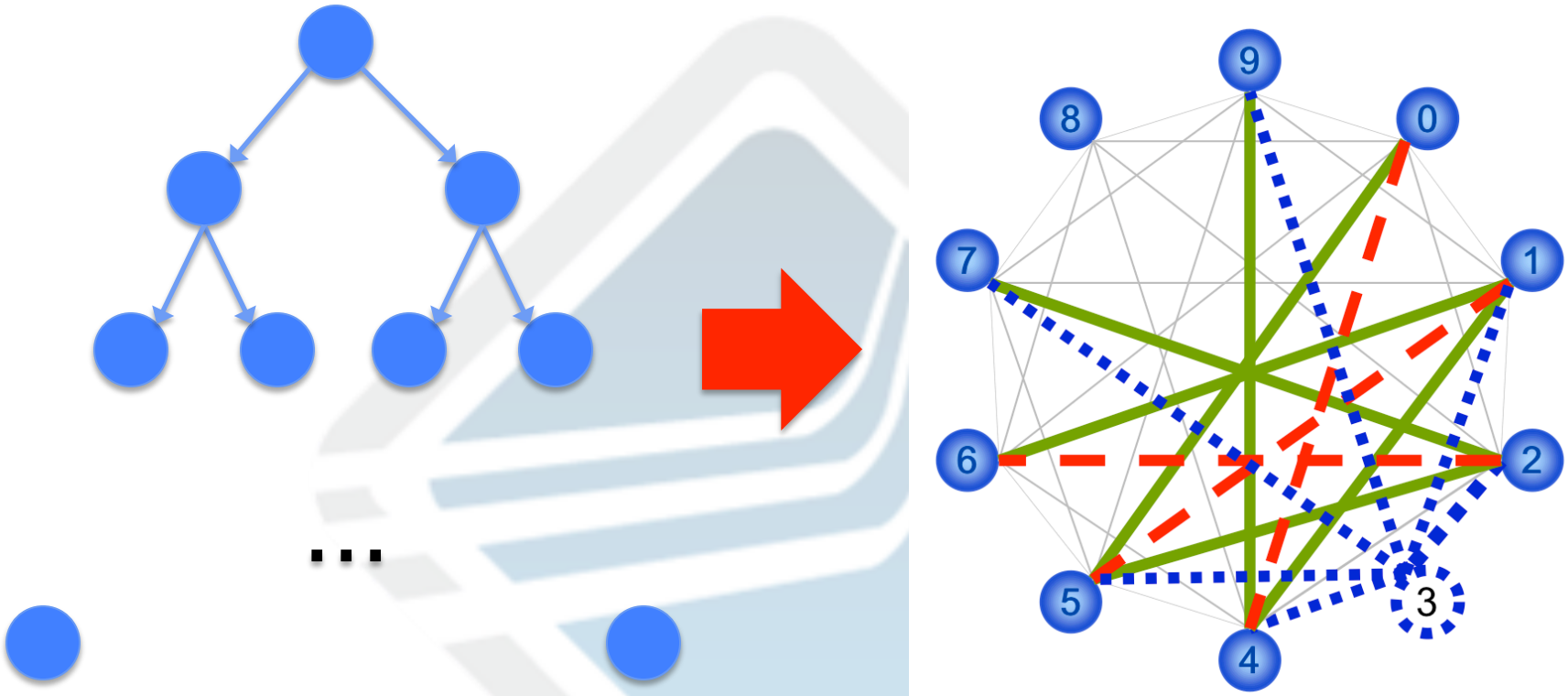


Broadcast from any node in $Log_2(n)$ steps



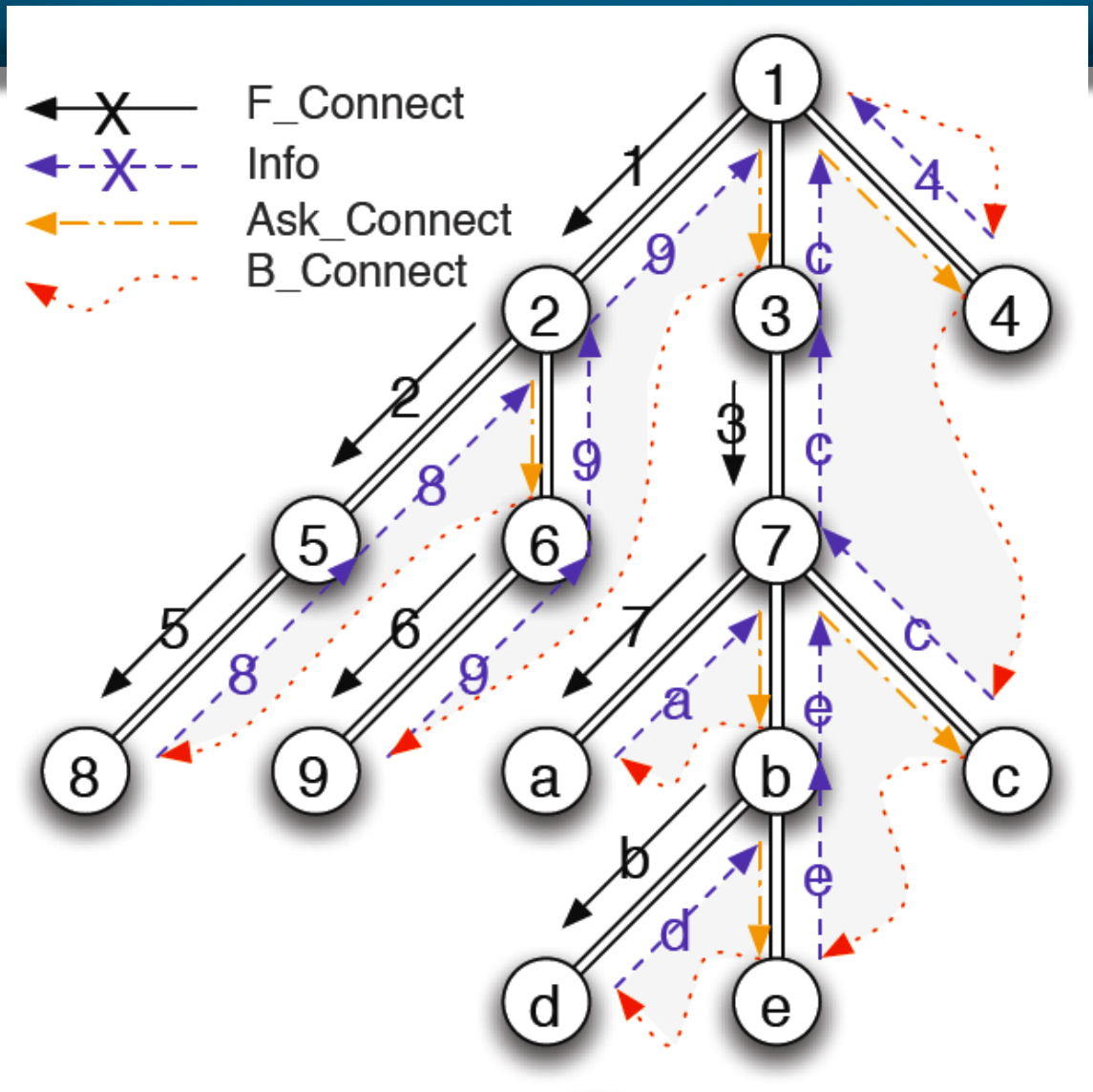
Stay connected in spite of failures

Runtime deployments



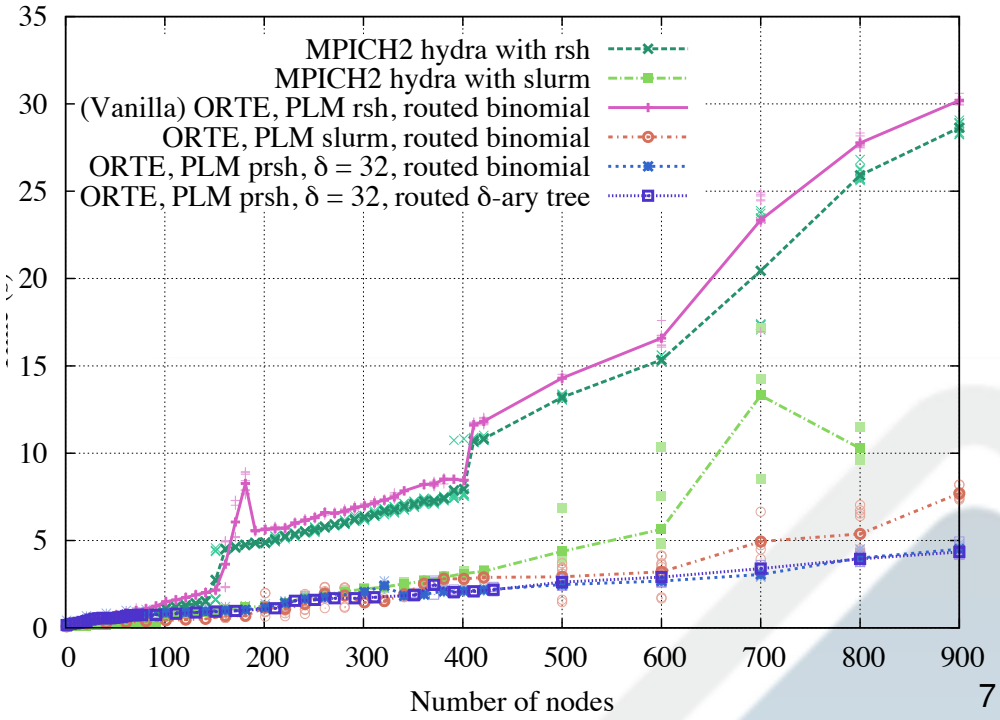
Building a BMG from the initial startup tree

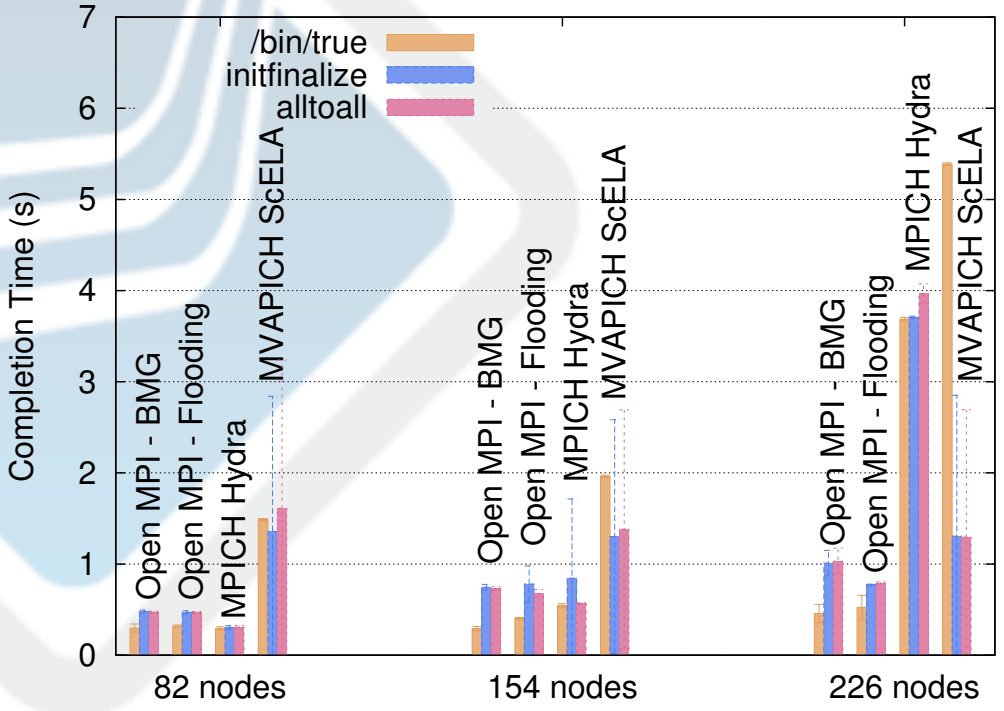
From a tree to a ring



Scalability

- Startup
  - Gracefully handle many processes per node
  - Minimize resource consumption while maximizing parallelism: build specialized network overlays
- Business card (Modex) exchange
  - Use the network overlays to exchange the business cards of the participating processes
  - Keep one single copy per node shared between all local processes
  - Update the data asynchronously

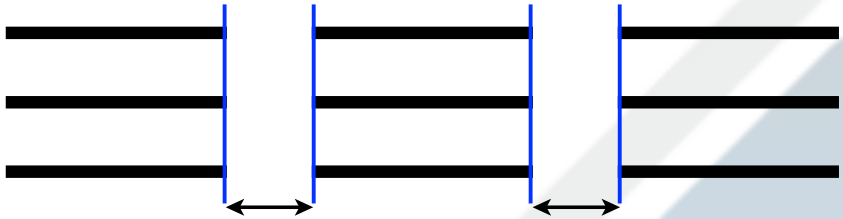




- Self-adapting algorithms to evolve from any type of spanning tree toward BMG
- Good candidate for resilient runtime

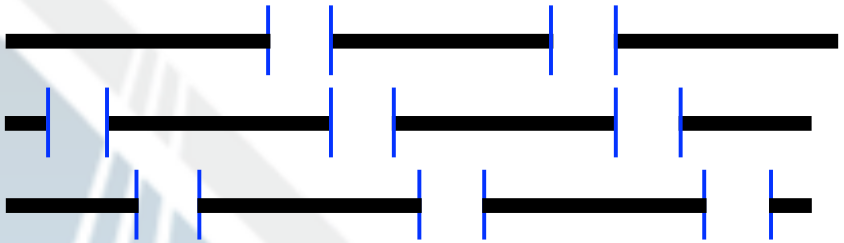
Supported C/R strategies

Coordinated C/R



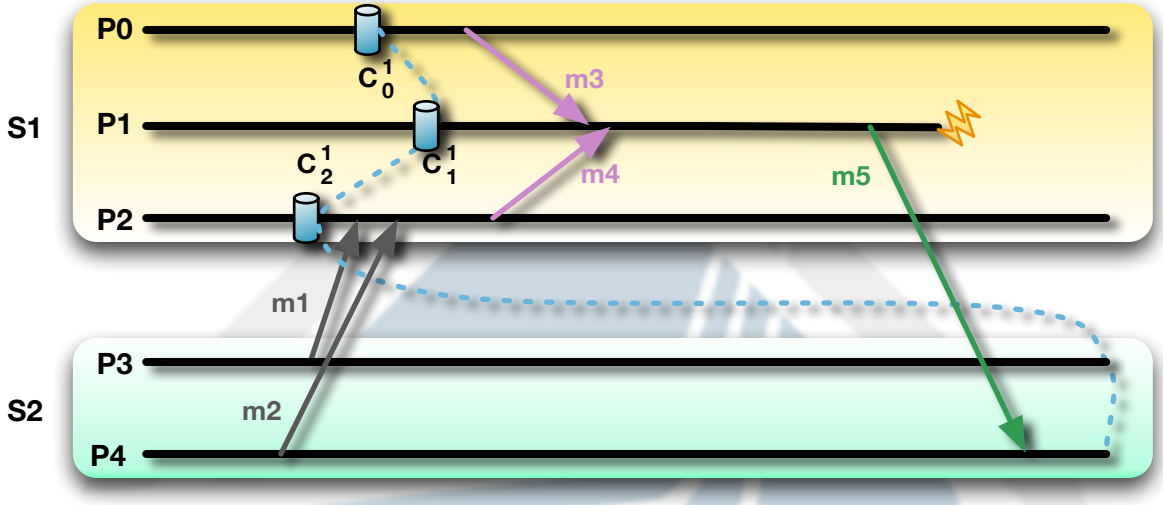
- A complete checkpoint is taken at specified time intervals
- In case of a failure all processes rollback to the last valid checkpoint
- The time to checkpoint strongly depends on the checkpoint support (I/O bandwidth)

Uncoordinated C/R



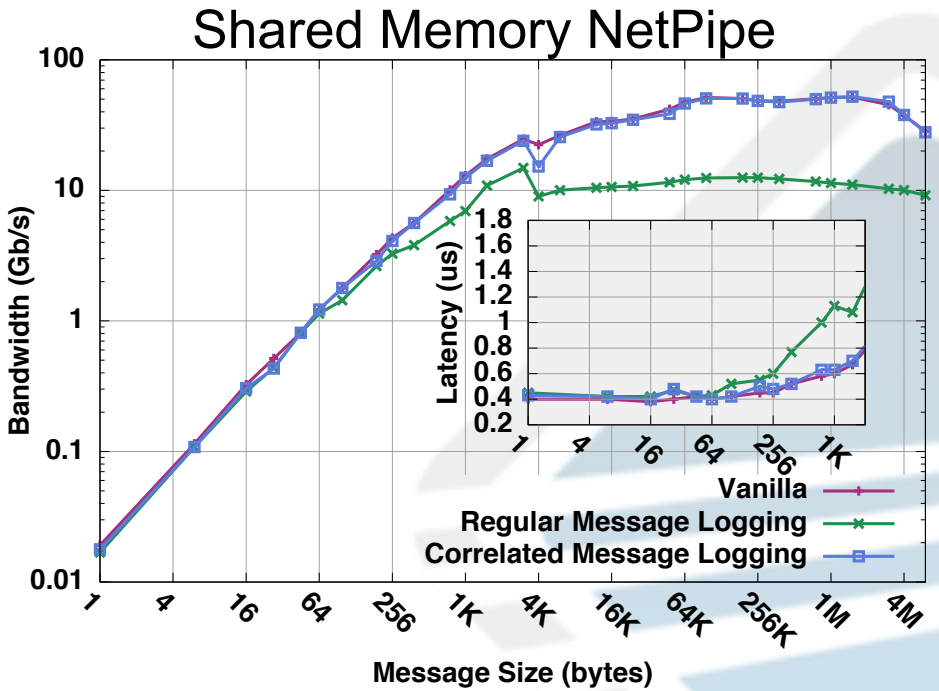
- A single checkpoint is taken at specified time intervals
- In case of a failure one process rollback to the last valid checkpoint
- The time to checkpoint barely depends on the checkpoint support (I/O bandwidth)

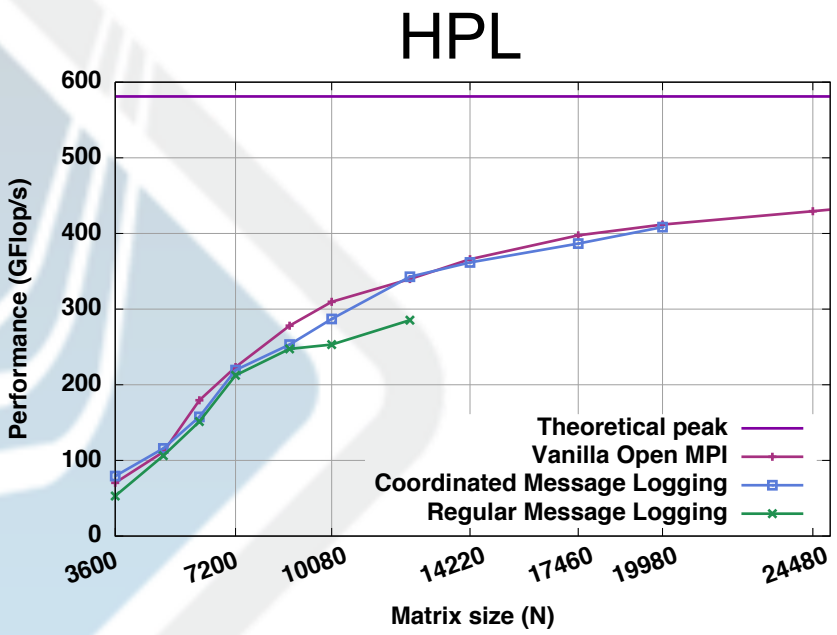
Correlated Set Coordinated Message Logging



- **Hybrid** between **coordinated** and **uncoordinated**
- **Codependent failures** are defined as sets of processes prone to fail simultaneously (cores of a same node)
- Codependent processes use coordinated checkpoint: relieves the need for expensive sender-based logging
- Non codependent processes are still uncoordinated and benefit from faster recovery

Correlated Set in Message Logging





Non deterministic events are still logged, but payload in a correlated set is not

MPI Forum Fault Tolerance Working Group

Define a minimal set of semantics and interfaces to enable fault tolerant applications and libraries to be constructed portably

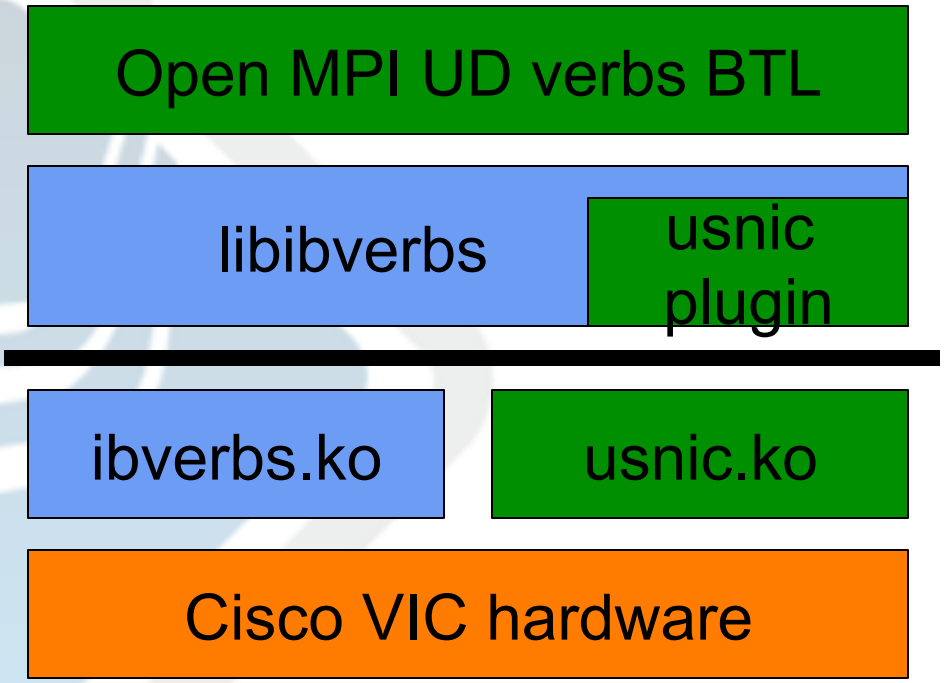
- User Level Failure Mitigation
  - **MPI Forum Fault Tolerance Working Group:** https://svn.mpi-forum.org/trac/mpi-forum-web/wiki/FaultToleranceWikiPage
- Prototype in Open MPI is guiding proposal development
  - http://fault-tolerance.org/

Cisco + Other Updates

Jeff Squyres

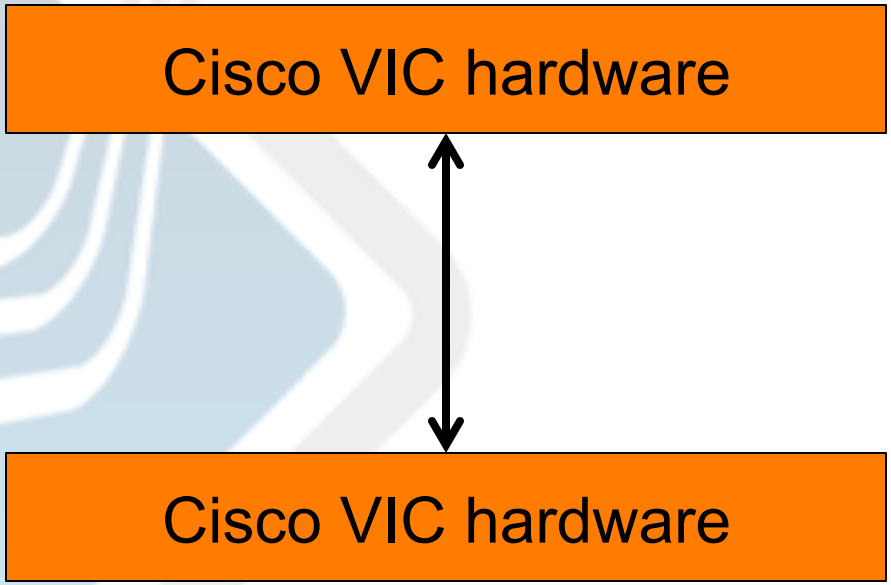
Cisco Ultra Low Latency Ethernet

- Cisco Ethernet Virtual Interface Card (VIC)
- "Userspace NIC" (USNIC) mode
  - OS bypass
  - Hardware offload
- Exports UD verbs interface



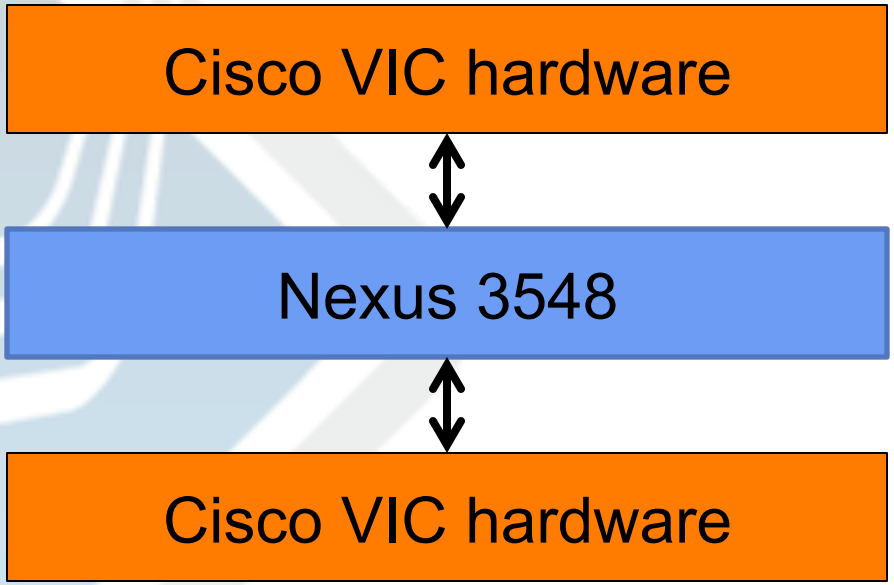
Cisco Ultra Low Latency Ethernet

- Back-to-back verbs latency
  - 1.7us HRT ping-pong



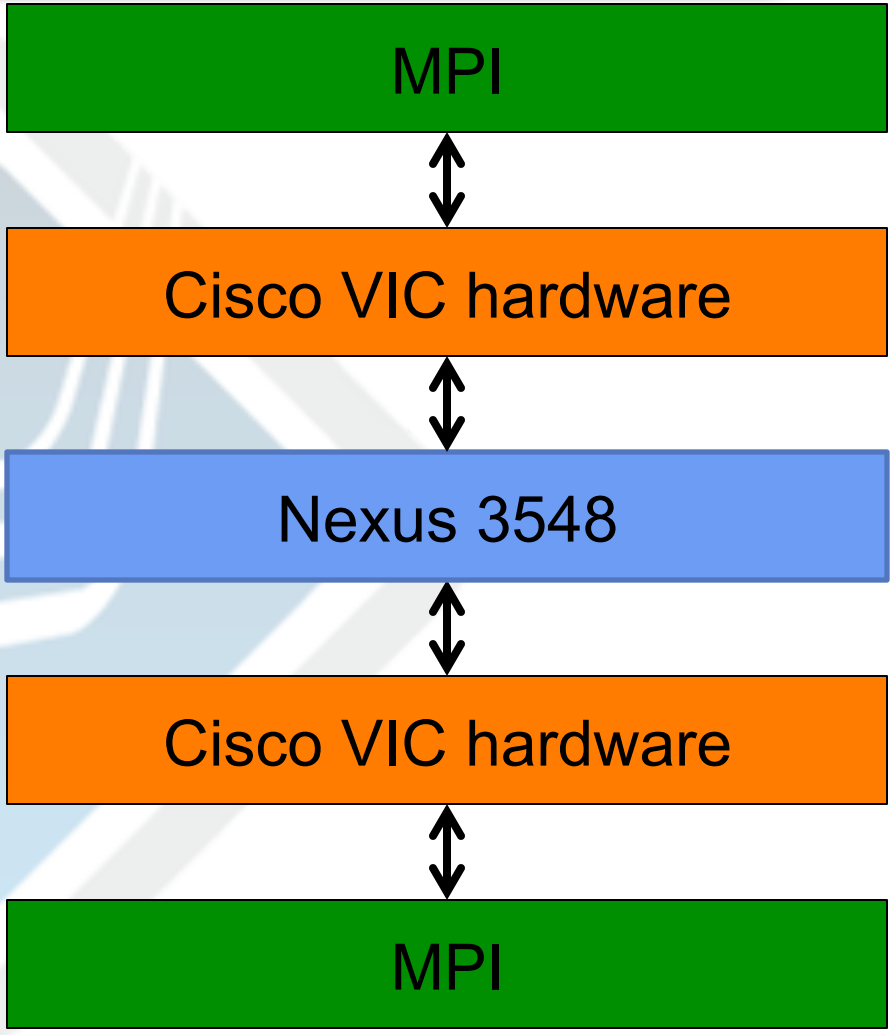
Cisco Ultra Low Latency Ethernet

- Back-to-back verbs latency
  - 1.7us HRT ping-pong
- Cisco's lowest latency switch
  - 190ns port-to-port



Cisco Ultra Low Latency Ethernet

- Back-to-back verbs latency
  - 1.7us HRT ping-pong
- Cisco's lowest latency switch
  - 190ns port-to-port
- Prototype Open MPI BTL plugin
  - 300-400ns
- Total: ~2.2-2.3us



Mo' Betta Fortran Bindings

- Revamped "F90" bindings support
  - use mpi
- Prototypes for *all* MPI subroutines
  - …but not for gfortran ☹

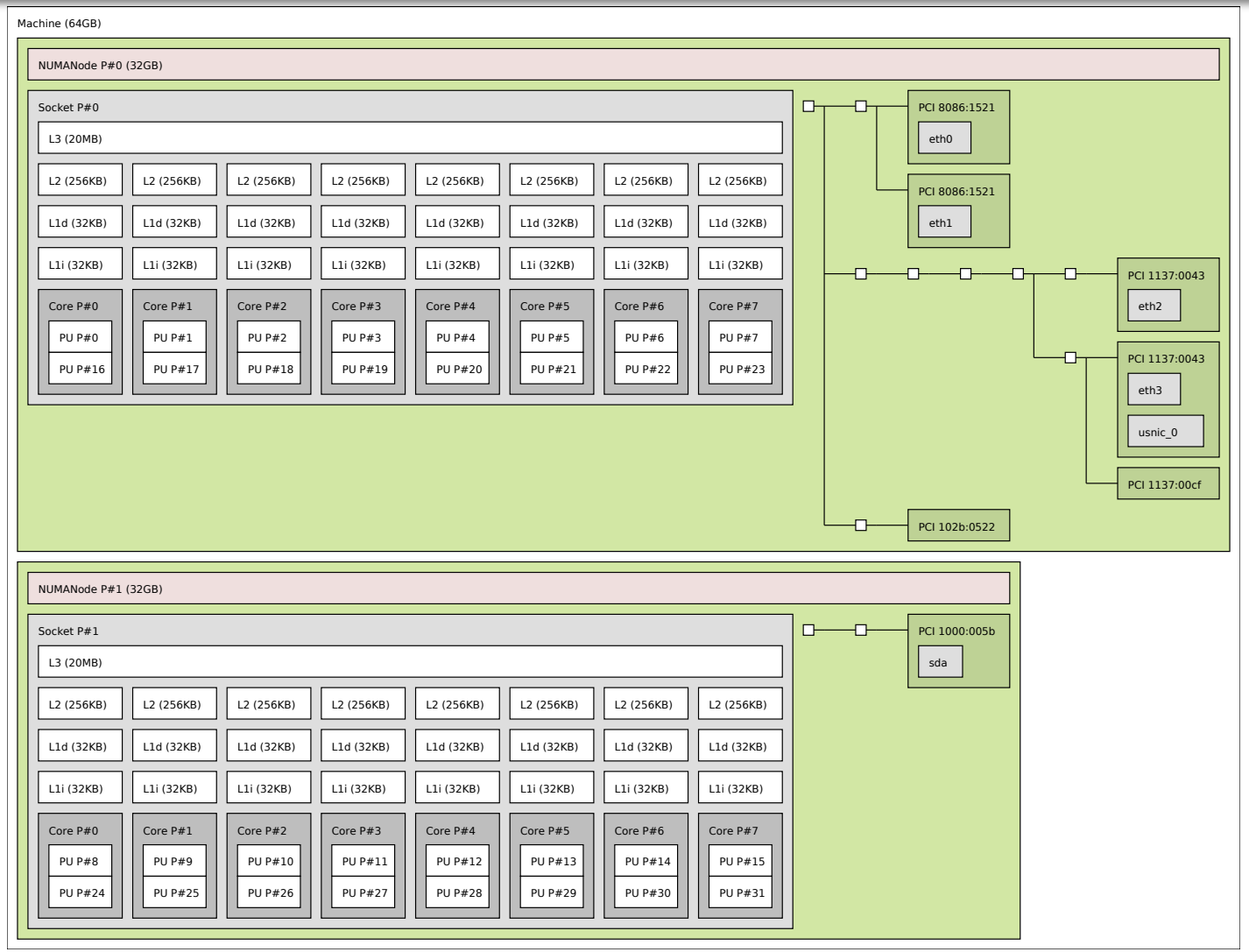
Mo' Betta Fortran Bindings

- "F08" bindings ("use mpi_f08")
  - New for MPI-3
- Many new features, including:
  - MPI handle type safety!
  - Type(MPI_Comm) :: my_comm
- Tested with:
  - Intel, Absoft, Portland compilers
  - …no gfortran support ☹ (YET)

Better Processor / Memory Affinity

- Uses Hardware Locality (hwloc)
  - Sub-project of Open MPI
- Shameless plug:
  - http://www.open-mpi.org/projects/hwloc/

Hwloc of Sandy Bridge Server



Better Processor / Memory Affinity

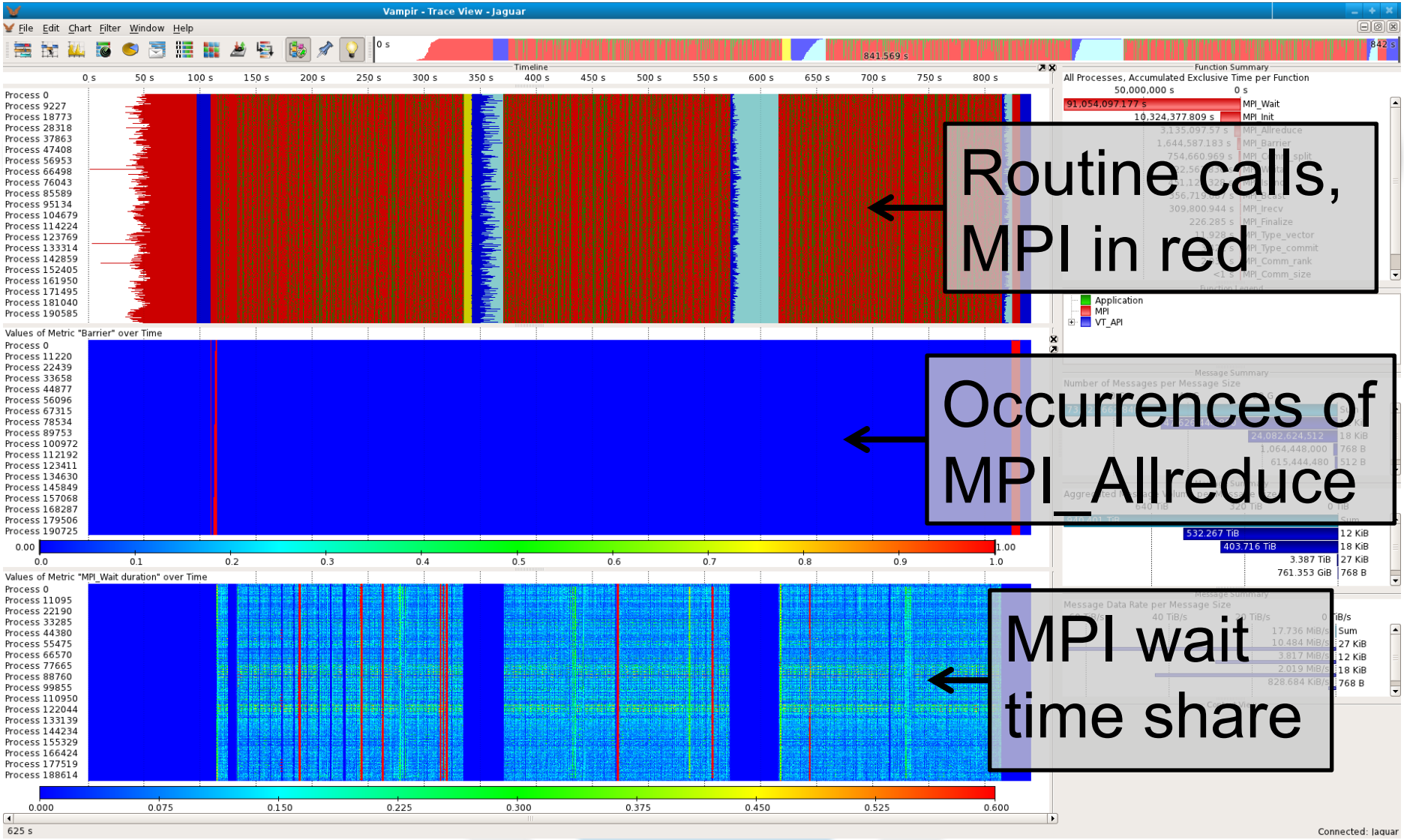
- Probe nodes for topology at run-time
- Smallest unit of affinity is hyperthread
  - “mpirun –bind-to-core” binds to all hyperthreads in a core
- “mpirun –report-bindings” much more readable

Better Processor / Memory Affinity

- Affinity is complicated!
- Evolving hardware architectures
  - Evolving application affinity needs
- Location Aware Mapping Algorithm
  - New / additional affinity options
  - v1.7.x (probably: x=1)

VampirTrace at Scale

- Last scalability limit for tracing $x \cdot 10^5$ procs: No HPC FS handles one file per process
- I/O Forwarding Scalability Layer (IOFSL)
  - Forwarding, buffering, aggregation, of I/O ops.
  - Map many logical files to few physical files on few IOFSL servers in “atomic append” mode
  - Open Source project, see http://www.iofsl.org/
- Full-system run on ORNL’s JaguarPF (XT5)
- In cooperation with ORNL and ANL



Trace of S3D combustion code with 200,448 procs on ORNL's JaguarPF, recorded using 672 IOFSL servers ($9.4 \cdot 10^{11}$ events, 4.2 TB compressed)

VampirTrace for MPI + CUDA

- VampirTrace supports MPI + CUDA
  - One/multiple CUDA devices per MPI process
  - API calls (host) and kernel executions (device)
  - GPU hardware performance counters
  - Host interactions (allocation, transfers, sync.)
  - NVIDIA‘s CUPTI tool interface
- Now also supports NVIDIA CARMA devices

Visit ZIH booth 4036, hall 2,
win a NVIDIA Tesla K20 card!

...this is just a sample

- Many more projects are occurring in the Open MPI community.
  - clang compiler extensions
  - MOSIX support
  - ...
- Come get involved!

Come Join Us!

http://www.open-mpi.org/