

Endpoints Proposal Update

Jim Dinan
MPI Forum Hybrid Working Group
June, 2014

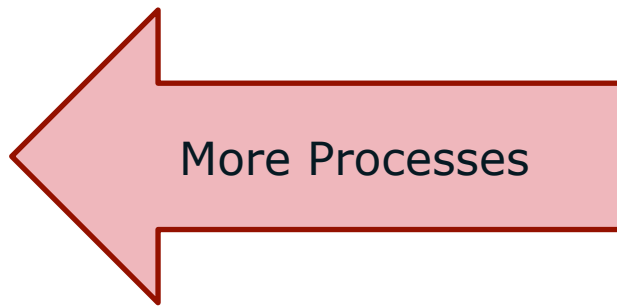
Outline

1. Big picture, performance perspective
2. New performance studies
 - Extended journal version of EuroMPI paper
 - Measure process/thread performance tradeoffs
 - Implementation work in progress
 - Results consistent with claims, will present in Japan
3. Endpoints interface review
4. Recent developments in the proposal
 - Primarily address gaps that arise when MPI processes share a virtual address space
 - Query function, communicator/group comparisons

Today: Threads/Processes Tradeoff

Communication throughput

Reduce memory pressure
Improve compute perf.



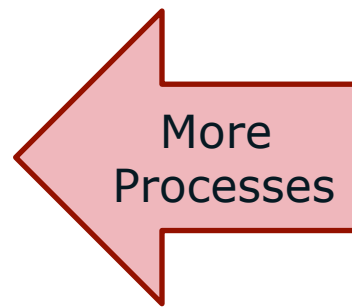
Threads/proc. are entangled, users must make tradeoff

- Benefits of threads to node-level performance/resources
- Versus benefits of processes to communication throughput

Future: MPI Endpoints

Communication throughput

Reduce memory pressure
Improve compute perf.



Enable threads to achieve process-like communication perf.

- Eliminate negative interference between threads
 - Both semantics (ordering) and mechanics (implementation issues)
- Enable threads to drive independent traffic injection/extraction points

Measure Process/Thread Tradeoffs

"Enabling Communication Concurrency through Flexible MPI Endpoints."
James Dinan, Ryan E. Grant, Pavan Balaji, David Goodell, Douglas Miller, Marc Snir, and Rajeev Thakur. Submitted to IJHPCA.

Look at communication performance trends in many-core system

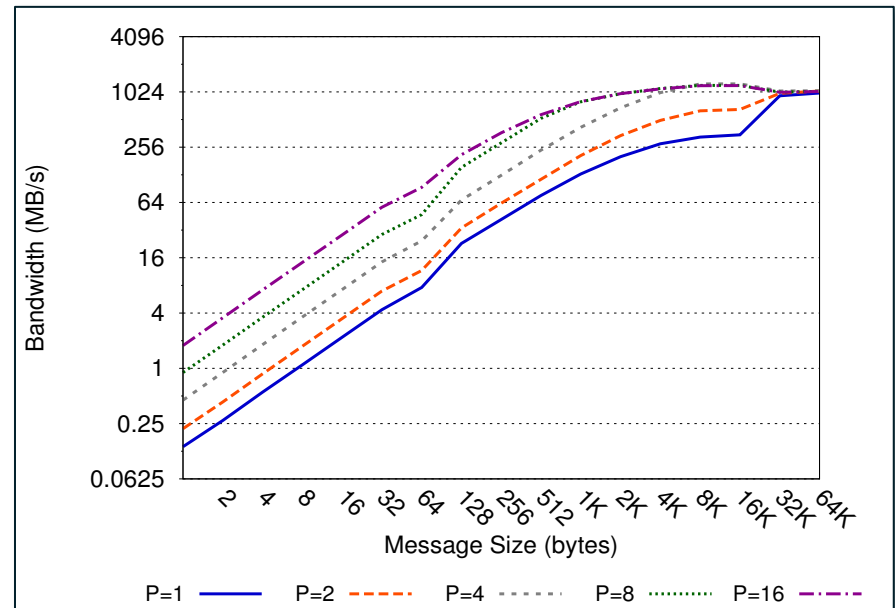
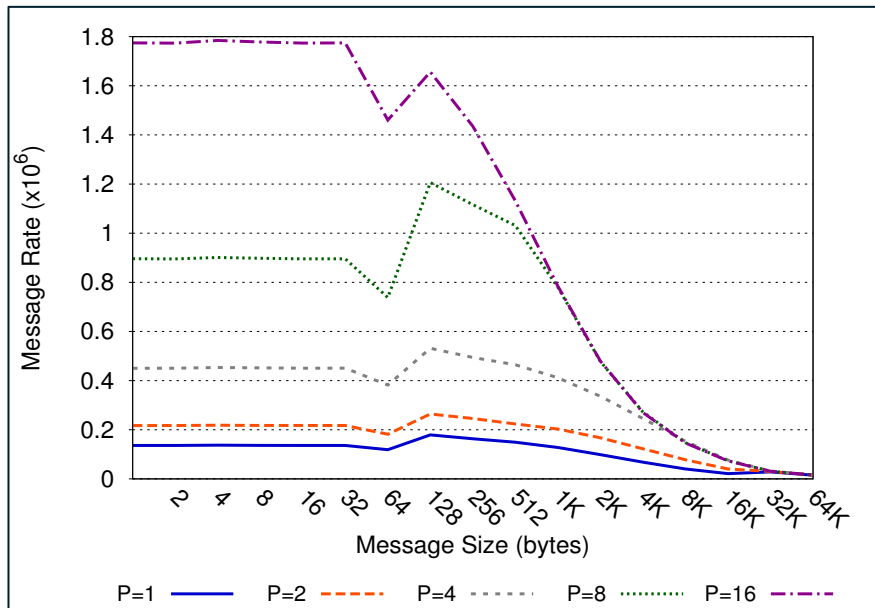
Identify/measure opportunities for endpoints to improve performance

System setup:

- Intel® Xeon Phi™ 5110P "Knight's Corner" Coprocessors
 - 60 cores @ 1.053 GHz, 8GB memory, 4-way hyperthreading
- Intel MPI Library v4.1 update 1, Intel C Compiler v13.1.2
 - Run in native mode – Phi cores do MPI processing
- Mellanox 4x QDR InfiniBand, max bandwidth 32 GB/sec

Intended to represent future systems where network is designed to support traffic from many cores

Impact of Increasing Num. Processes



Measure communication performance between two nodes

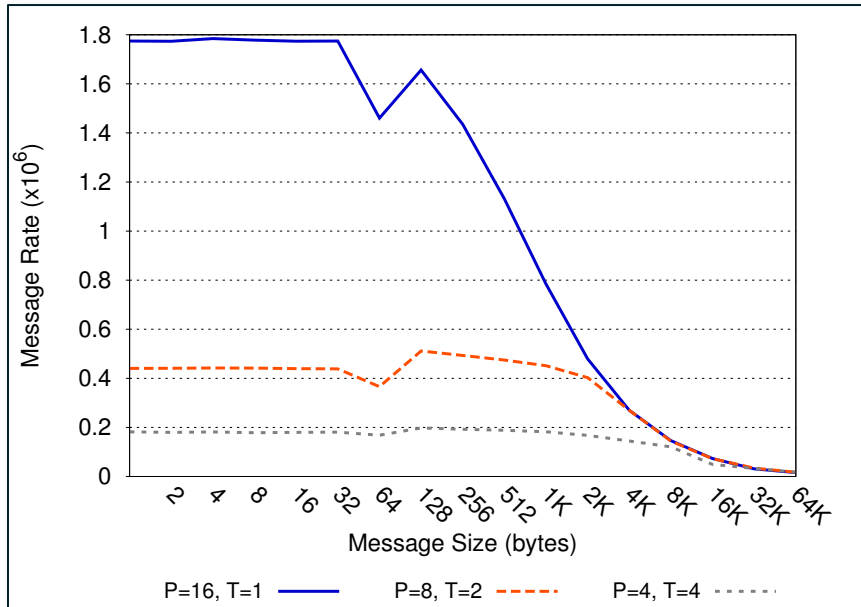
- OSU benchmark - N senders and N receivers per node
- Performance increases with more processes (P) driving communication

Processes represent “ideal” endpoints

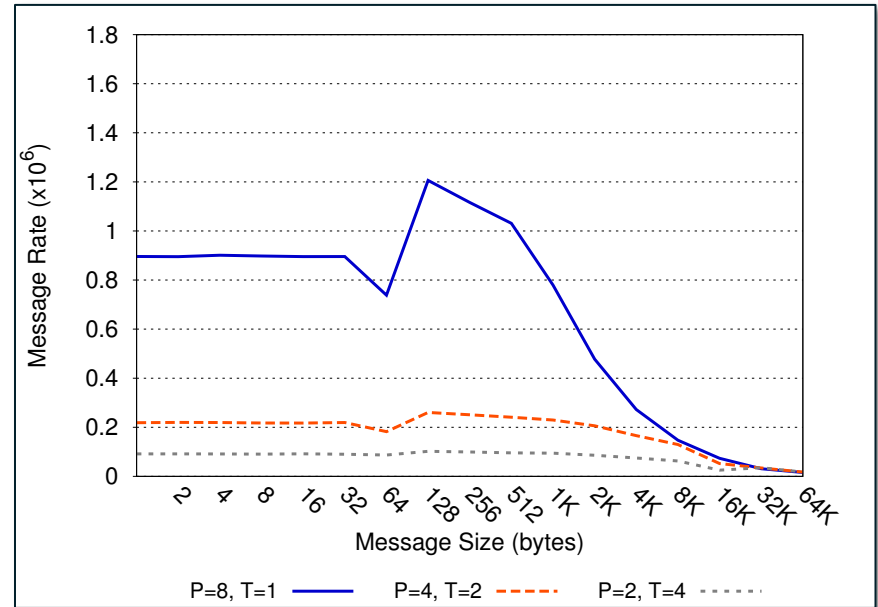
- Private communication state and communication resources
- Represent performance upper bound

Threads/Proc. Tradeoff (Msg. Rate)

16 Cores



8 Cores



"I have N cores, how do I use them?"

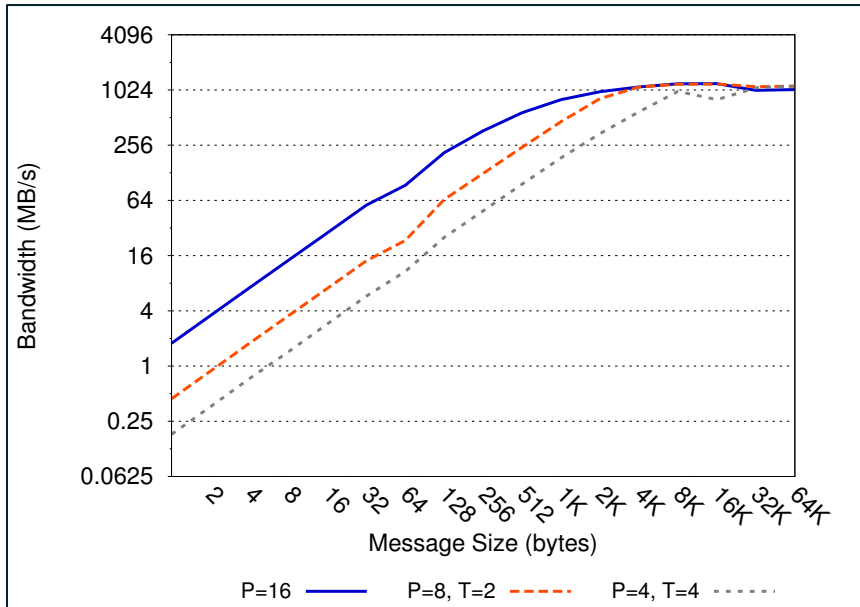
- Threads address node level concerns (e.g. memory pressure)
- Processes provide better communication performance

Endpoints will enable threads to behave like processes

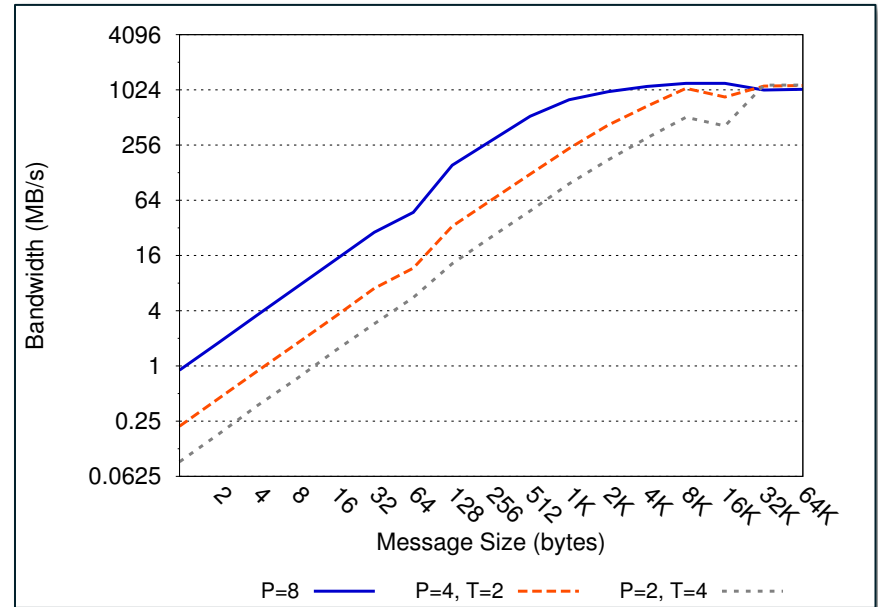
- Decouple threads in mechanics – private communication state
- Decouple threads in semantics – isolate in message ordering

Threads/Proc. Tradeoff (BW)

16 Cores



8 Cores



Thread/processes tradeoff impacts bandwidth

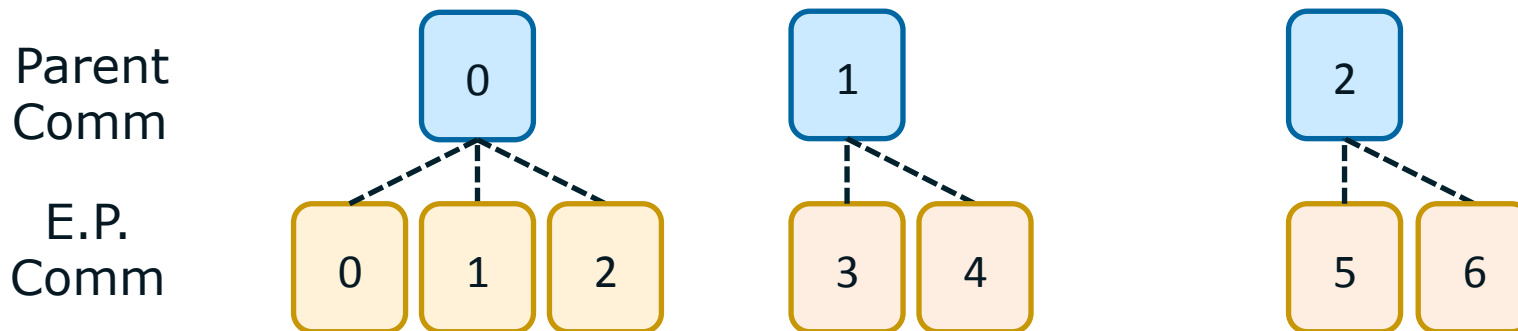
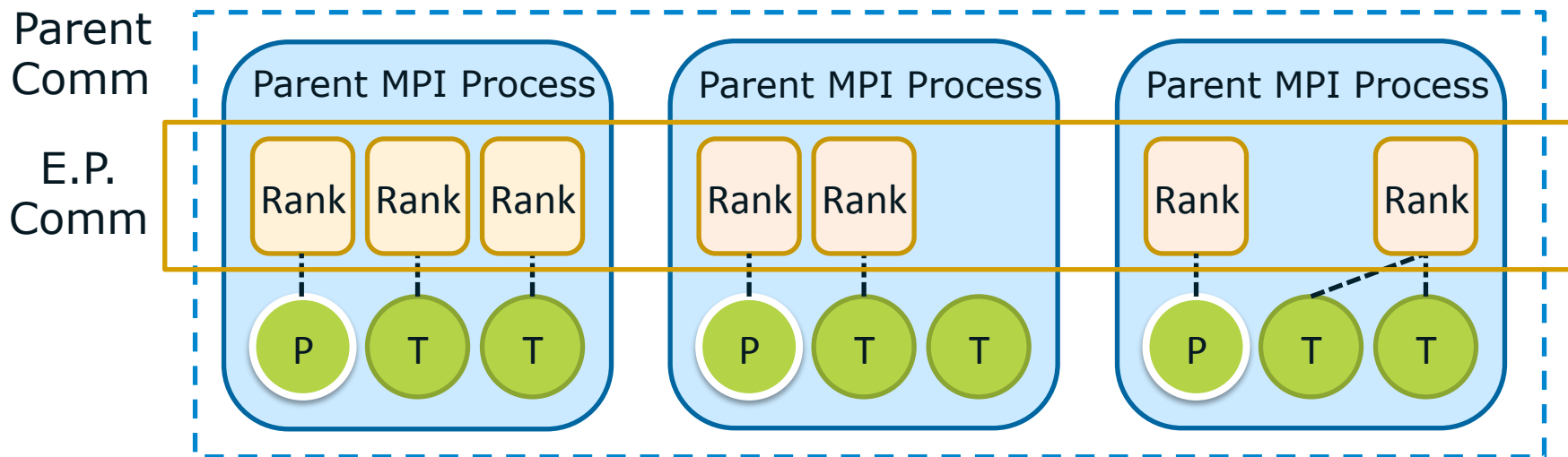
Saturate for 32KiB+ messages

More processes = better throughput for smaller messages

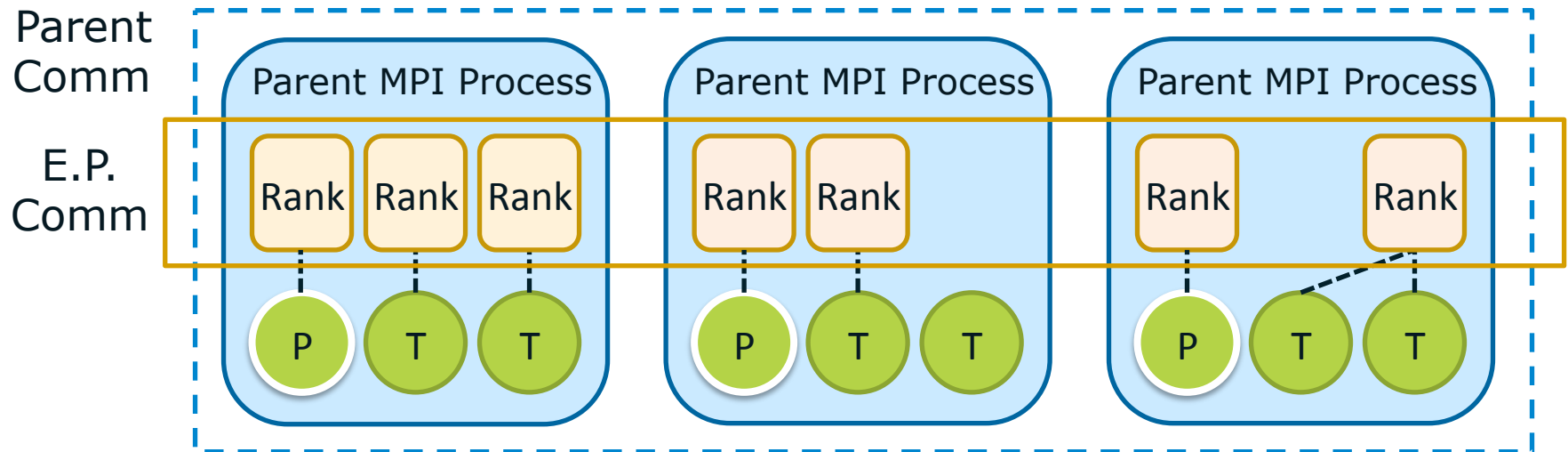
Highlights the problem, hope to show the solution next time

MPI Endpoints

Relax the 1-to-1 mapping of ranks to threads/processes



MPI Endpoints Semantics



MPI Process: Set of resources supporting execution of MPI comm's

- MPI rank and execution resources to drive it when needed
- Endpoints have MPI process semantics (e.g. progress, matching, ...)
 - Collectives are called concurrently on all endpoints (MPI processes)

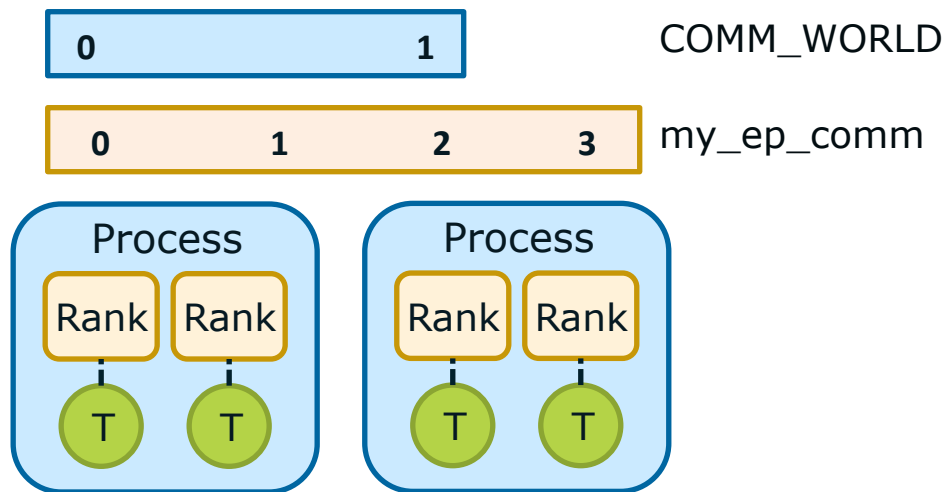
Improve programmability of MPI + Threads

- Allow threads to be MPI processes, addressable through MPI
- Make number of VA spaces free parameter for apps

Enable threads to act like processes / have process-like performance

- Per-thread communication state/resources, process-like performance

MPI Endpoints API



```
MPI_Comm_create_endpoints(MPI_Comm parent_comm, int my_num_ep,  
    MPI_Info info, MPI_Comm out_comm_handles[])
```

Creates new MPI ranks from existing ranks in parent comm.

- Each process in parent comm. requests a number of endpoints

Outputs handles correspond to different ranks in the same comm.

- Takes TLS out of the implementation and off the critical path

Can return `MPI_ERR_ENDPOINTS` if endpoints could not be created

Hybrid MPI+OpenMP Example

With Endpoints

```
int main(int argc, char **argv) {
    int world_rank, tl;
    int max_threads = omp_get_max_threads();
    MPI_Comm ep_comm[max_threads];

    MPI_Init_thread(&argc, &argv, MPI_THREAD_MULTIPLE, &tl);
    MPI_Comm_rank(MPI_COMM_WORLD, &world_rank);

#pragma omp parallel
    {
        int nt = omp_get_num_threads();
        int tn = omp_get_thread_num();
        int ep_rank;
#pragma omp master
        {
            MPI_Comm_create_endpoints(MPI_COMM_WORLD, nt, MPI_INFO_NULL, ep_comm);
        }
#pragma omp barrier
        MPI_Comm_rank(ep_comm[tn], &ep_rank);
        ... // Do work based on 'ep_rank'
        MPI_Allreduce(..., ep_comm[tn]);

        MPI_Comm_free(&ep_comm[tn]);
    }
    MPI_Finalize();
}
```

Recent Developments

1. MPI_Comm_free() semantics
2. Query function
3. Communicator comparison
4. Group comparison

MPI_Comm_free() with Endpoints

Past: Called in series on endpoints in a hosting MPI_COMM_WORLD process

- Enable endpoints communicators to be freed when using thread level < MPI_THREAD_MULTIPLE
- Changes MPI_Comm_free semantics, would have to always do a hierarchical free algorithm on endpoints even when using MPI_THREAD_MULTIPLE
- Breaks collective semantic that is expected by attribute callbacks

New approach: Leave this undefined for now, can define MPI_Comm_free_endpoints in future

- Would need to forbid collective attribute callbacks

Query Function: What to query?

Find out if processes share an address space

- Libraries need to determine whether memory and other resources are private to an MPI rank
- Existing issue when MPI processes impl. as threads
- Also an issue with MPI endpoints
- Pursuing as a separate ticket (#425)

Query number of endpoints:

- Split with MPI_COMM_TYPE_ENDPOINTS
- MPI_Comm_num_endpoints(MPI_Comm comm,
int *num_ep, int *ep_id)

Query if any processes in comm. are in same VA space:

- MPI_[Comm,Group,Win,File,]_has_sharing(..., int *flag)

Communicator Comparison

When MPI processes share a VA space, it becomes possible for a process to see multiple handles to different ranks in the same communicator

Currently comm. comparison can result in:
MPI_IDENT, MPI_CONGRUENT, MPI_UNEQUAL

Past: Return MPI_IDENT, then check ranks to see if they differ.

New proposal: Return MPI_ALIASED to indicate same object, different ranks

Group Comparison

`out_comm_handles[0]` corresponds to calling process' rank in parent communicator

All other output ranks are new ranks that don't appear in any other group

Needed for group operations to make sense

- Consider `my_num_ep == 1` at all processes
- Comparison with parent group should be CONGRUENT
- `MPI_Group_translate_ranks` between output and parent communicators should yield same ranks

More Info

Endpoints:

- <https://svn.mpi-forum.org/trac/mpi-forum-web/ticket/380>

Hybrid Working Group:

- <https://svn.mpi-forum.org/trac/mpi-forum-web/wiki/MPI3Hybrid>

Legal Disclaimer & Optimization Notice

INFORMATION IN THIS DOCUMENT IS PROVIDED "AS IS". NO LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT. INTEL ASSUMES NO LIABILITY WHATSOEVER AND INTEL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY, RELATING TO THIS INFORMATION INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products.

Copyright © , Intel Corporation. All rights reserved. Intel, the Intel logo, Xeon, Xeon Phi, Core, VTune, and Cilk are trademarks of Intel Corporation in the U.S. and other countries.

Optimization Notice

Intel's compilers may or may not optimize to the same degree for non-Intel microprocessors for optimizations that are not unique to Intel microprocessors. These optimizations include SSE2, SSE3, and SSSE3 instruction sets and other optimizations. Intel does not guarantee the availability, functionality, or effectiveness of any optimization on microprocessors not manufactured by Intel. Microprocessor-dependent optimizations in this product are intended for use with Intel microprocessors. Certain optimizations not specific to Intel microarchitecture are reserved for Intel microprocessors. Please refer to the applicable product User and Reference Guides for more information regarding the specific instruction sets covered by this notice.

Notice revision #20110804

