MPI Forum:
Preview of the MPI 3 Standard

LEADERSHIP
COMPUTING FACILITY
NATIONAL CENTER FOR COMPUTATIONAL SCIENCES

presented by
Richard L. Graham- Chairman
George Bosilca

Oak Ridge National Laboratory
U.S. Department of Energy

Outline

- Goal
- Forum Structure
- Meeting Schedule
- Scope
- Voting Rules

Goal

To produce new versions of the MPI standard that better serves the needs of the parallel computing user community

Structure

- Chairman and Convener: Rich Graham
- Secretary: Jeff Squyres
- Steering committee:
  Jack Dongarra
  Al Geist
  Rich Graham
  Bill Gropp
  Andrew Lumsdaine
  Rusty Lusk
  Rolf Rabenseifner

MPI 2.2 Standad

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MPI 2.2 - Scope

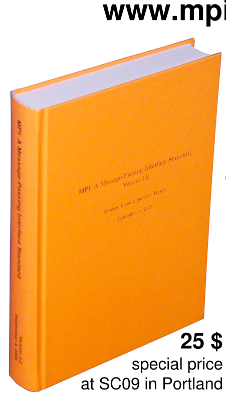
Scope: Small changes to the standard. A small change is defined as one that does not break existing user code - either by interface changes or semantic changes - and does not require large implementation changes.

Lead: Bill Gropp

- Released Sept 4th, 2009 in Helsinki, Finland
- Highlights
  - Modernize C and Fortran language support
  - Deprecate C++ bindings
  - Fix graph interface scalability issues
  - Allowing concurrent read access to user send buffers
  - Many miscellaneous corrections

We are a member of the Message Passing Interface (MPI) Forum

The new MPI-2.2 Standard (Sep. 2009) is now available:
www.mpi-forum.org



Service for all MPI users:

Hardcover book (647 pp.)
is sold at cost
on HLRS booth #2245

and at MPI-3 BOF
Wednesday Nov.18, 5:30 – 7pm,
D135-136

H L R S

25 $
special price
at SC09 in Portland

In USA:
Without shipping costs
only at SC09

MPI-3 Progress

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MPI 3.0 - Scope

Additions to the standard that are needed for better platform and application support. These are to be consistent with MPI being a library providing of parallel process management and data exchange. This includes, but is not limited to, issues associated with scalability (performance and robustness), multi-core support, cluster support, and application support.

Lead: Rich Graham

Backwards compatibility maybe maintained - Routines may be deprecated

- Target release date: Still being release
  - Considering Sept, 2011, with incremental draft standard releases

- Comments on plan are solicited:
  http://mpi-forum.questionpro.com/
  Password: mpi3

Mailing list: mpi-comments@mpi-forum.org

Subscribe at: http://lists.mpi-forum.org/

Current Active Working Groups

- Collective Operations and Topologies : Torsten Hoefler Andrew Lumsdaine - Indiana University
- Backwards Compatibility – David Solt, HP
- Fault Tolerance : Richard Graham - Oak Ridge National Laboratory
- Fortran Bindings : Craig Rasmussen - Los Alamos National Laboratory
- Remote Memory Access : Bill Gropp, University of Ilinois Champaign/Urbana - Rajeev Thakur, Argonne National Laboratory
- Tools support: Martin Schulz and Bronis de Supinski, Lawrence Livermore National Laboratory
- Hybrid Programming: Pavan Balaji, Argonne National Laboratory

Backward Compatibility - Charter

- Address backward compatibility issues
- The goal is to provide recommendations to MPI 3.0 proposals and introduce new proposals when appropriate to provide a reasonable transition of MPI 2.x users and the implementations that support those users to MPI 3.0 without hindering the general goals of MPI 3.0.

Backward Compatibility Premises

- MPI-2 code should run on MPI-3 implementations without substantial source code changes
  - substantial == ? not easily automated
- 3.0 document must not require indefinite support for multiple versions of the standard.
  - a transition period may be acceptible

Backward Compatibility Current Idea

- Use symbol-specific version numbering, with macro (or weak symbol?) mapping the "best" name to most current name, by default.
- Use a global preprocessor macro to map all versioned symbols to the version provided by a particular version of MPI standard.
- Use symbol-specific macro to override version mapping for a particular symbol.

Backward Compatibility - Examples

- Size of the count argument in interface functions
  - int MPI_Isend(void *buf, int count, MPI_Datatype datatype, int dest, int tag, MPI_Comm comm, MPI_Request *request)
  - Maybe add MPI_Count handle
  - Do we add a 2nd set of interface functions ?
    - int MPI_Isend_ex(void *buf, MPI_Count count, MPI_Datatype datatype, int dest, int tag, MPI_Comm comm, MPI_Request *request)
  - Do we break backward compatibility ?
    - int MPI_Isend(void *buf, MPI_Count count, MPI_Datatype datatype, int dest, int tag, MPI_Comm comm, MPI_Request *request)
  - Do we just leave this as is ?

Collective Operations

Goals:

- update the collective communication functions based on our experience since MPI-2.1
- enable more scalable design and more flexible specification of application communication patterns
- enable intelligent mapping and optimization strategies for application communications
- explore new ways to express application communication (beyond point-to-point)
- discuss possible scalability issues (communicator and group management)
- collective communication support for higher-level libraries

Collective Operations

- Assumption:
  - the scale of systems increases steadily
  - hierarchical (e.g., multi-core) systems will become more common
  - capabilities of network interfaces increase
  - future network might be sparse and with lower effective bisection bandwidth
  - higher-level languages become more important in parallel programming

Collective Operations

Done:

- Nonblocking Collectives: part of MPI-3 draft standard
  - MPI_Ibcast(&buf, 1, MPI_INT, 0, comm, &req)
  - /* compute */
  - MPI_Wait(&req, MPI_STATUS_IGNORE);
  - reference/preview implementation: LibNBC

Collective Operations

Under consideration:

- Topological Collectives
  - MPI_Neighbor_reduce(), MPI_Neighbor_alltoall(), MPI_Neighbor_gather()
  - Hoefler, Traeff: "Sparse Collective Operations for MPI"
- Streaming Collectives
  - react to data as it comes in
  - not decided yet, is there a need for this?
- Persistent Collectives
  - persistent P2P does not seem to be used much

Fault Tolerance

- Goal: To define any additional support needed in the MPI standard to enable implementation of portable Fault Tolerant solutions for MPI based applications.
- Assumptions:
  - Backward compatibility is required.
  - Errors are associated with specific call sites.
  - An application may choose to be notified when an error occurs anywhere in the system.
  - An application may ignore failures that do not impact its MPI requests.
  - An MPI process may ignore failures that do not impact its MPI requests
  - An application that does not use collective operations will not require collective recovery
  - Byzantine failures are not dealt with

Fault Tolerance

- Goal: To define any additional support needed in the MPI standard to enable implementation of portable Fault Tolerant solutions for MPI based applications.
  - Support restoration of consistent internal state
  - Add support to for building fault-tolerant “applications” on top of MPI (piggybacking)

Fault Tolerance

Items being discussed

- Define consistent error response and reporting across the standard
- Clearly define the failure response for current MPI dynamics - master/slave fault tolerance
- Recovery of
  - Communictors
  - File handles
  - RMA windows
- Data piggybacking
- Dynamic communicators
- Asynchronous dynamic process control

Remote Memory Access

- Goal: To provide improved support for Remote Memory Access.
  - Read-Modify-Write operations
  - Flexible RMA synchronization
  - Scalable (not global) completion
  - Registration of data for one-sided operations
  - Support for non-contiguous data, and for overlapping regions

Just getting off the ground

- Current “proposals”
  - Fix performance issues within the current standard specification
  - New interface where users can specify
    - Completion semantics
    - Synchronous/Asynchronous
    - Ordering
  - Simplified implementation
    - Restricting use support (predefined data types)
    - User responsible for data consistency

Tools

- The goal of the tools WG are interfaces to
  - Ease and standardize tool deployment and control
  - Enable more introspection into the internals of an MPI implementation
- Support for wide range of tools, including, but not limited to
  - Performance measurements tools
  - Debuggers
  - Correctness checkers
- Motivation:
  - Provide reliable and portable interfaces
  - Ability to create cross-platform tools
- All efforts are complimentary to the existing PMPI interface

Tools

- A Process Acquisition Interface close to the MPIR pseudo standard
  - Locate all MPI tasks for external tools
- A Performance Information Interface providing low level performance details
  - Access to configuration variables and MPI internal performance counters
- Symbol Detection Interface
  - Enable the dynamic detection of debugger extensions
- The existing Message Queue Interface with extensions for Collectives
  - Introspection of the messages queues during debugging.
- An interface to query information about opaque MPI handles
  - Ability for debuggers to show context for datatypes, communicators, ...

There are Severe Problems with the Existing MPI Fortran Interfaces

- Use of “mpif.h” provides no type checking.
- The MPI Fortran module is impossible to fully implement in a standards-compliant way.
- Very scary issues with compiler optimizations:
  - The Fortran compiler may employ copyin/copyout semantics, thus completely interfering with asynchronous MPI calls.
  - The Fortran compiler can legally move code statements surrounding MPI_Wait calls. This may break code in an unpredictable fashion.

Goals of the MPI-3 Fortran Effort

- Provide a Fortran standards-compliant mechanism to suppress copy-in/copy-out semantics and code motion for MPI asynchronous operations.
- Provide explicit interfaces that suppress argument checking for MPI choice buffers (C (void *) formal parameters).
- Allow vendors to take advantage of the Fortran 2003 interoperability standard with C.
- Examine the feasibility of simplifying the Fortran interfaces by making some of the arguments optional.
- Design a palatable application migration path from older MPI Fortran bindings to the new/proposed MPI-3 bindings.

Highlight of things to come

- New syntax has been added to the Fortran language, specifically for MPI interfaces using void * buffers, indicating *any type, any rank*:
  - `TYPE(*), DIMENSION(..) :: buffer`
- Derived types have been defined to enhance type safety:
  - `MPI_Comm, MPI_Datatype, MPI_Errhandler, MPI_Info, MPI_Request, and MPI_Status`
- The ierr argument in Fortran calls is optional.
- `TARGET` and `ASYNCHRONOUS` attributes are to be employed by users to inhibit compiler optimizations.

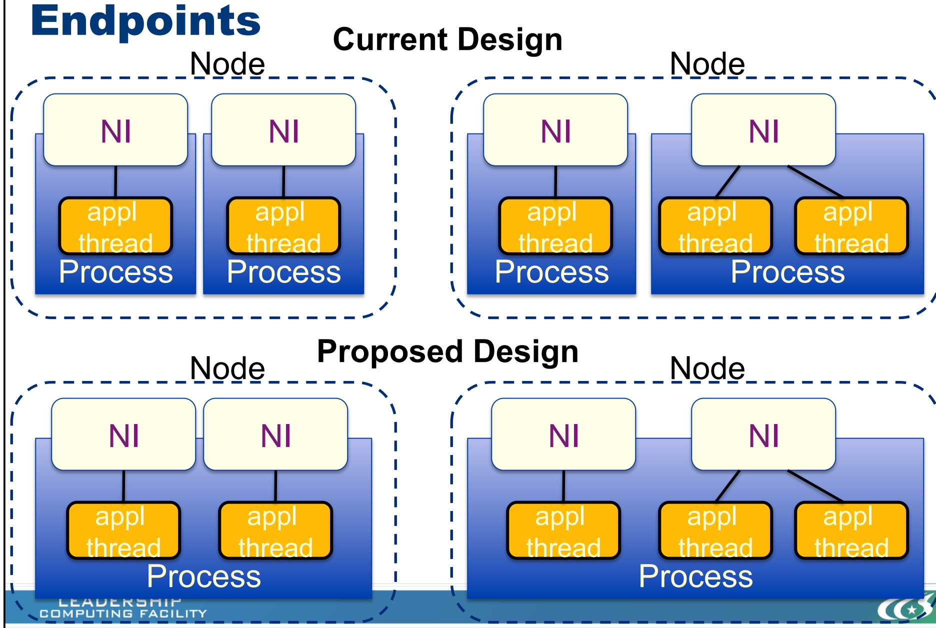
Hybrid Programming

- Goals:
  - Ensure that MPI has the features necessary to facilitate efficient hybrid programming
  - Investigate what changes are needed in MPI to better support:
    - Traditional thread interfaces (e.g., Pthreads, OpenMP)
    - Emerging interfaces (like TBB, OpenCL, CUDA, and Ct)
    - PGAS (UPC, CAF, etc.)

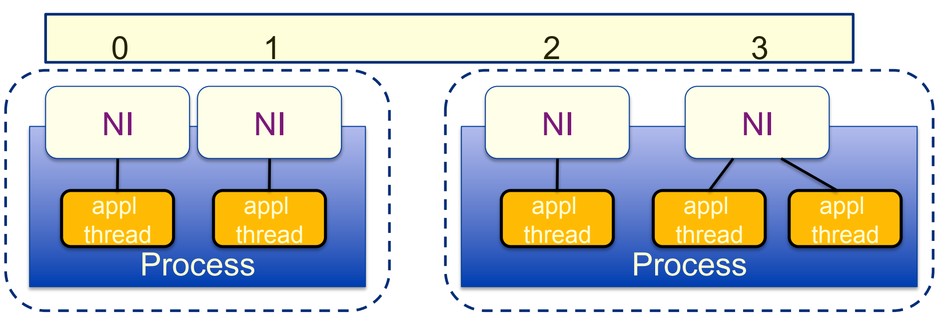
Example issues being addressed

- Threads as first-class citizens (rank != process)
  - Lockless Communication for MPI+threads
  - Allow MPI implementations to avoid internal locks when multiple threads communicate using MPI
  - Useful to boost performance on multi- and many-core architectures
- Interoperating MPI with PGAS languages
  - Hybrid programs that can make MPI and/or PGAS calls
- Additional API to improve programmability for MPI + threads applications
  - E.g., allowing a thread to receive the data related to a request that it probed

Example Proposal: Threads with Endpoints



MPI_COMM_EWORLD



- Each MPI Endpoint has unique rank in MPI_COMM_EWORLD
  - rank in derived communicators computed using MPI rules
- MPI code executed by thread(s) attached to endpoint
  - Including collectives
  - thread is attached to at most one endpoint

On Line Information

meetings.mpi-forum.org

- Meeting Schedule
- Meeting logistics
- Mailing list signup
- Mail archives
- Wiki pages for each working group

- Comments on plan are solicited:
  http://mpi-forum.questionpro.com/
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