MPI Sessions: Leveraging Runtime Infrastructure to Increase Scalability of Applications at Exascale

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MPI Sessions

- MPI Sessions began as an effort to make aggressive additions/changes to MPI to ensure it's success at Exascale
  - Enable better scalability
  - Increase abstraction for better resource isolation
  - Support less tightly coupled applications
- History
  - Founding members met for ~1 year
  - MPI Forum has discussed these ideas and encouraged further work, which led to the Sessions working group

MPI Sessions

- What is … MPI Sessions?
  - A new way to initialize (and re-initialize) MPI
  - A new way to express scalable communication topologies
  - A new way to compose application components
  - A new way to compose/couple applications
  - A new way to leverage the greater capabilities of runtimes

Scalability Problem

- Requiring all processes' rank information in COMM_WORLD is too expensive
  - Why keep state for communication peers that will never be used by the application (connections)?
  - Why completely wire-up a network that doesn't need it?
- Solutions:
  - Only keep state for active communications
  - Dynamically gather required data when needed and store state for the future
  - Establish communication relationships/peers before communicating (**Best predictability of communication performance)**

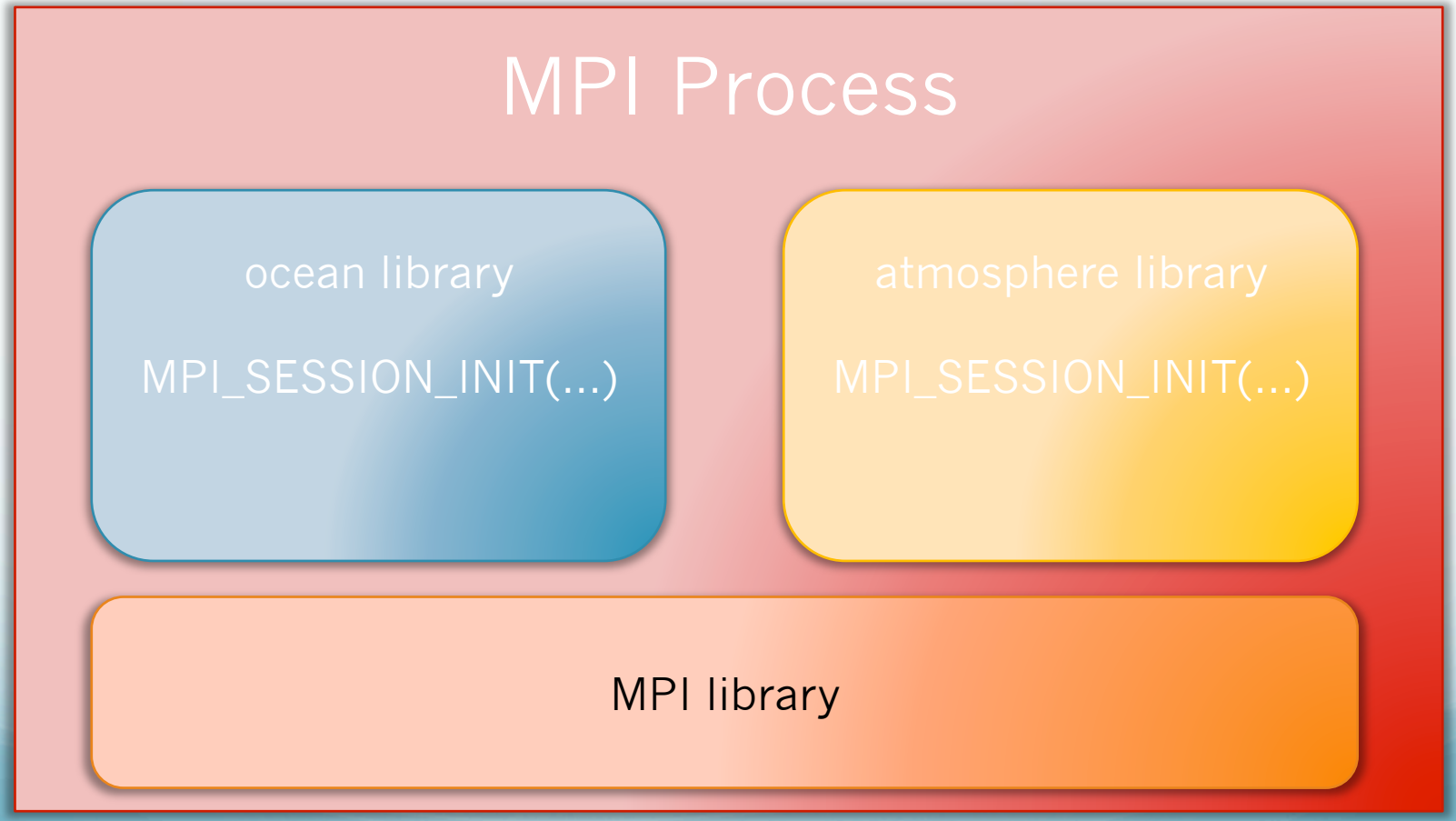
What MPI Sessions is *not*

- The only way to achieve memory/performance scalability
  - Many of the improvements MPI Sessions brings can be done outside of the API change proposal
  - Sessions forces/heavily encourages good scalable MPI implementation design
- A solution for all concurrency issues
  - Doesn't solve any of the issues of concurrency aside from memory scalability of key implementation data structures
- A Fault Tolerance solution (although it may help)
  - Dynamic node composition and potential replacement with help of runtime could aid fault tolerance efforts

New concept: “session”

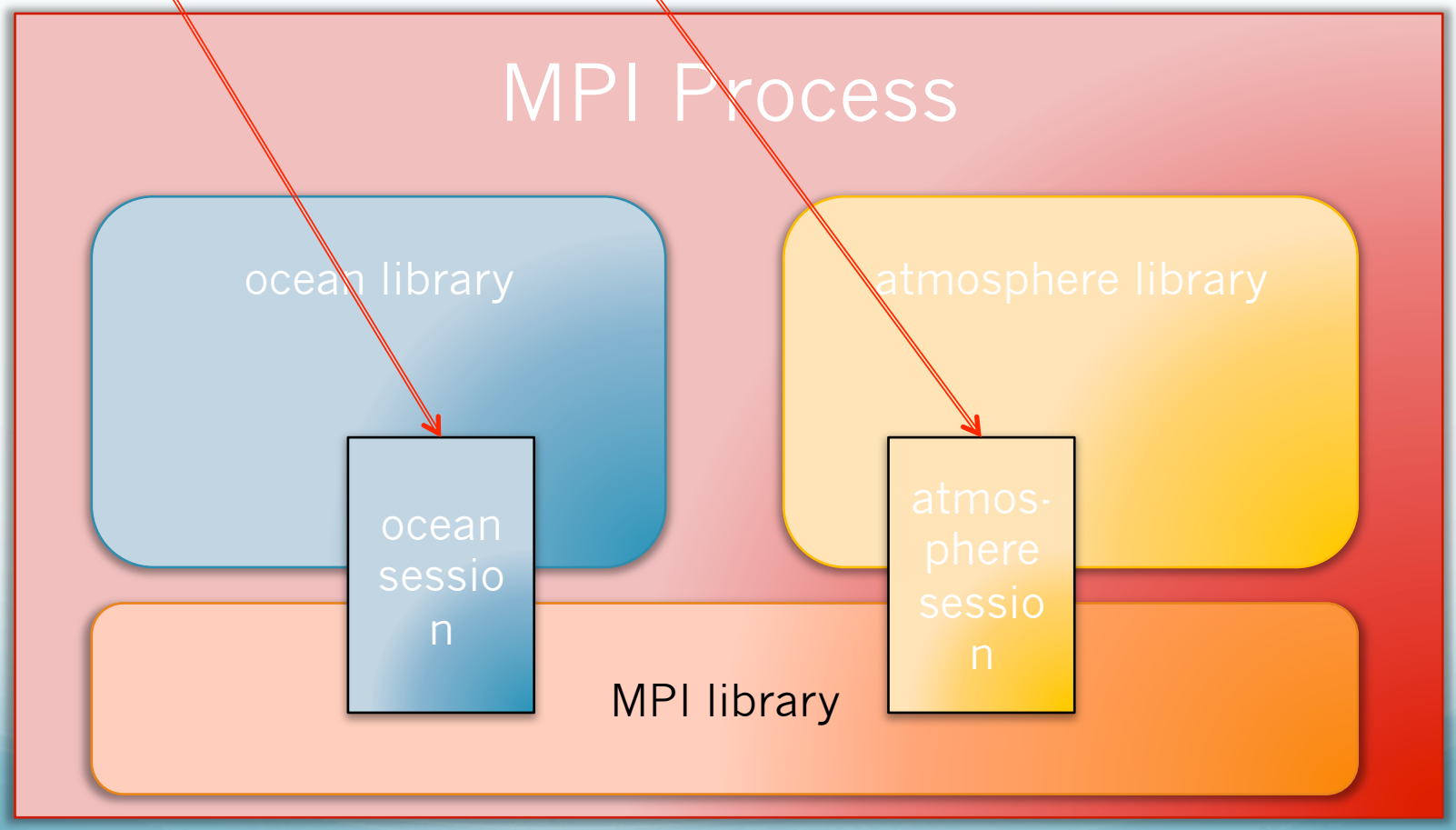
- A session is a local handle to the MPI library
  - Implementation intent: lightweight / uses very few resources
  - Can also cache some local state
- New routines to manage sessions
  - MPI_Session_init(..., &session);
  - MPI_Session_finalize(..., &session);
- Can have multiple sessions in an MPI process
- Can repeatedly init and finalize

MPI Session


MPI Process
ocean library
MPI_SESSION_INIT(...)
atmosphere library
MPI_SESSION_INIT(...)
MPI library

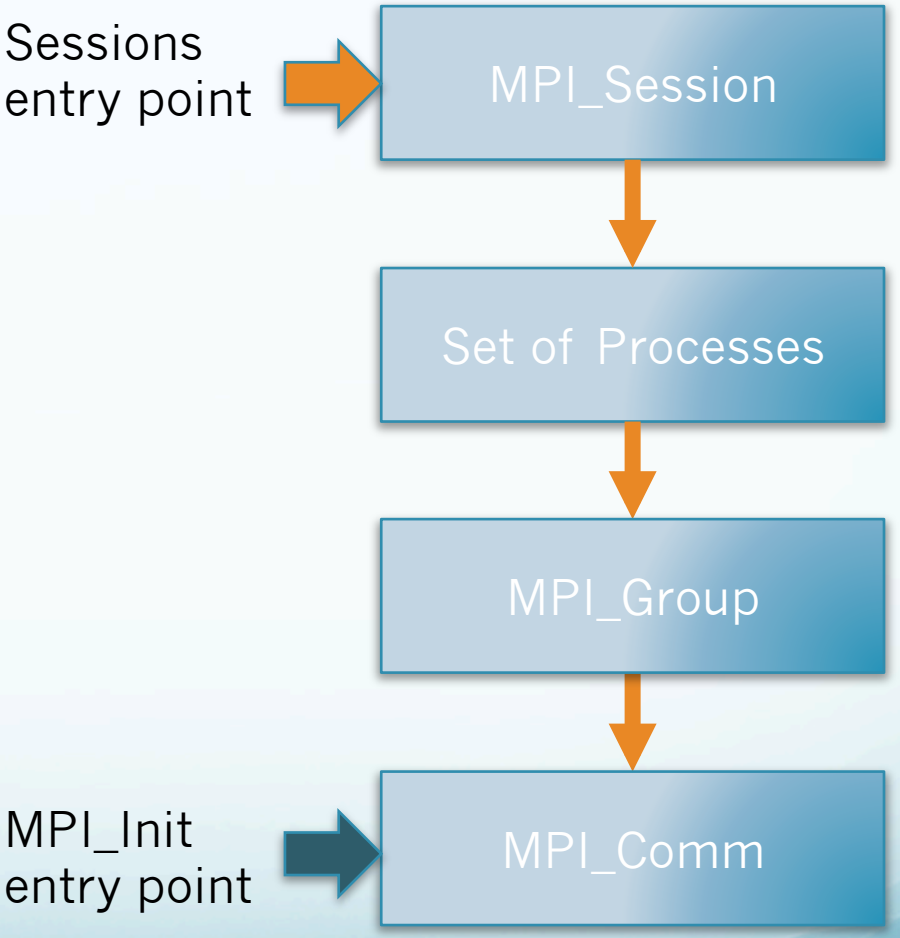
MPI Session

Unique handles to the underlying MPI library

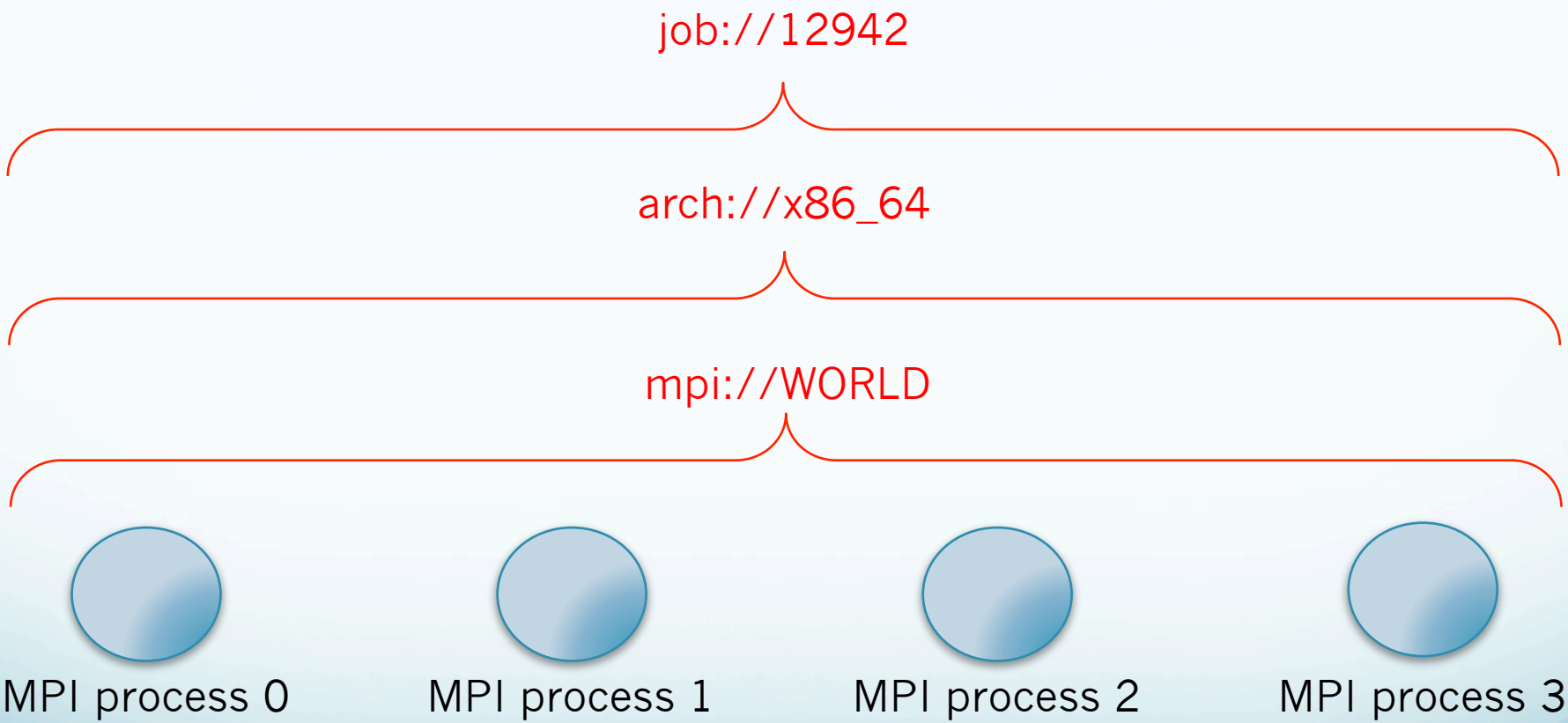


Overview

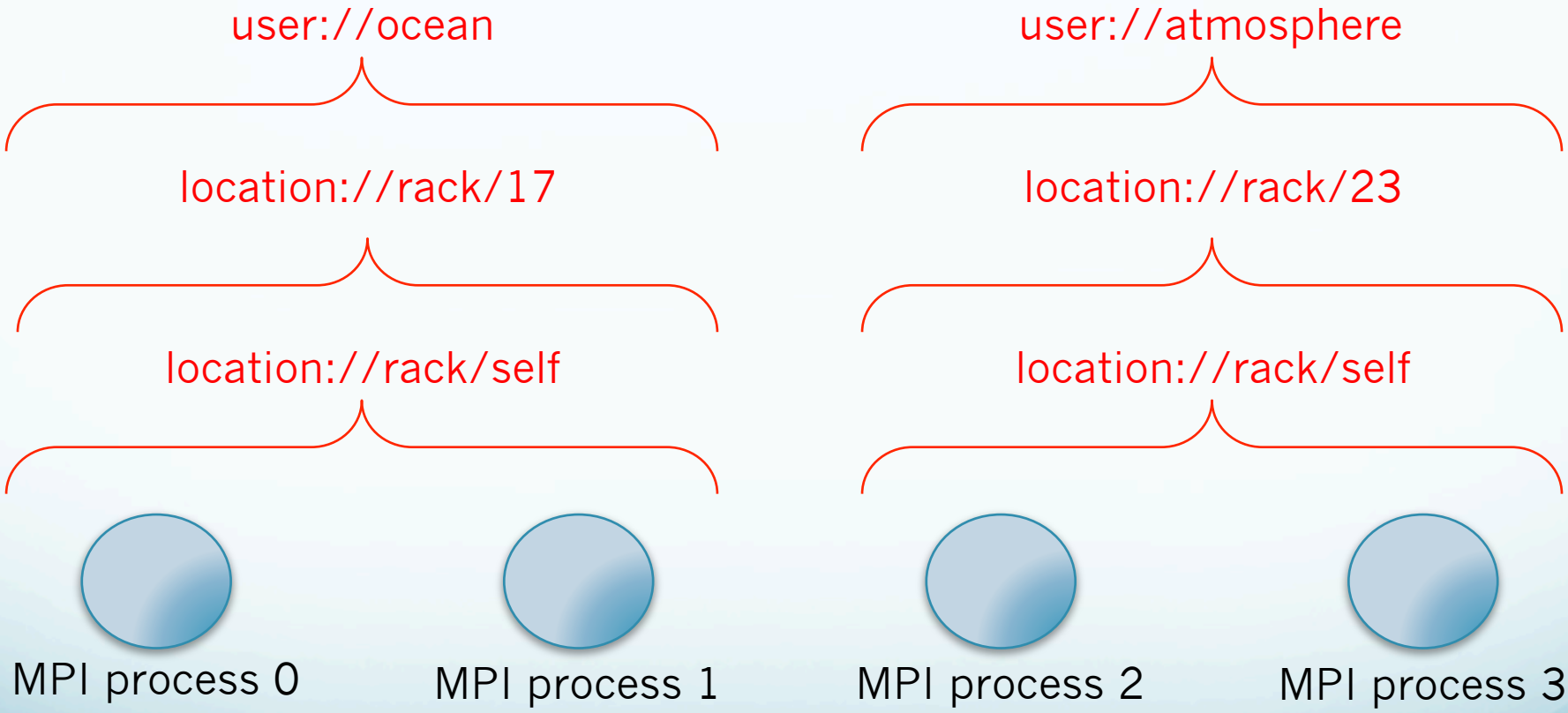
- Initialize an MPI_Session
- Query the underlying run-time system
- Choose a “set” of processes
- Create an MPI_Group
- Manipulate the MPI_Group (if desired)
- Create an MPI_Comm (applying a topology, if desired)



Examples of sets



Examples of sets



But wait…how do I get sets?

- Short answer:
  MPI_Session_get_names(
  MPI_Session session,
  char **set_names)

Example list of set names returned
mpi://WORLD
mpi://SELF
arch://x86_64
location://rack/17
job://12942
user://ocean

- Longer answer:
  - Need more/better information from the runtime
  - Good news: runtimes have evolved to provide more than basic MPI requirements
  - Providing sets is relatively easy

Using everything so far

- Once a Session is created and a set is queried:
  - Create and manipulate groups from the set
    - Just like you can today out of communicators, same functionality
  - Create a communicator from a group
    - Much like MPI_Comm_create_group today, but with sets in place of the originating/parent communicator
  - Old method: Init->comm_create_group(COMM_WORLD)
  - Sessions method: session_create->query sets->create group->create comm

What to do with INIT and FINALIZE?

- Sessions does not require MPI_INIT/FINALIZE
  - Sessions uses session_init/session_finalize instead
  - However, this is backward compatible…
- INIT/FINALIZE creates an implicit session
  - You cannot extract an MPI_Session handle for the implicit session created by MPI_INIT[_THREAD]
- Yes, you can still use INIT/FINALIZE in the same MPI process as other sessions

Living without COMM_WORLD

- There are benefits beyond optimization/fewer resource requirements
- You can now directly create specific types of communicators without a parent communicator (cartesian, distgraph, etc)

For those that can't give it up

- COMM_WORLD is simply a special case of a set->communicator creation, one that contains all processes in a job that would be contained in today's COMM_WORLD, with a flat all-to-all topology

Law of least astonishment

Intercommunicators and Sessions

- Sessions allow for very easy inter-communicator creation
  - Query multiple sets and use group operations on them
  - The communication channel to use is now provided by the runtime
    - No need for network hardware specific code to know how/where to exchange information
    - The runtime now does the work (which is not that hard for the runtime)

Intercommunicators

- Create inter-communicators amongst multiple applications easily (n applications)
  - Create a Session
  - Query sets with desired application names (assuming that you have permissions on the apps)
  - Create groups from each set (n groups)
  - Create union of groups
  - Create communicator from group

Sessions Encourage Good MPI Design

- Optimizations to MPI can be done outside of Sessions
- Sessions strongly encourages good MPI design through requirements
  - Confining set space and peer communication requirements
  - Encouraging (not forcing) non-global wireup at initialization time
  - Standardizing runtime interactions (capabilities)
- Allowing good MPI design with backwards compatibility
  - MPI_Init still works
    - Can utilize underlying sessions architecture to provide dynamic conn.
    - Improve legacy code performance transparently
    - Don't have dynamic COMM_WORLD (can't have everything)

Conclusions

- MPI Sessions leverages modern runtime capabilities for MPI
- Designed to encourage highly scalable MPI implementation design
- Fully backwards compatible
- Provides easy inter communicator creation

Thank You for Listening

Questions?

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