Dynamic Processes: Spawn

Dynamic Processes

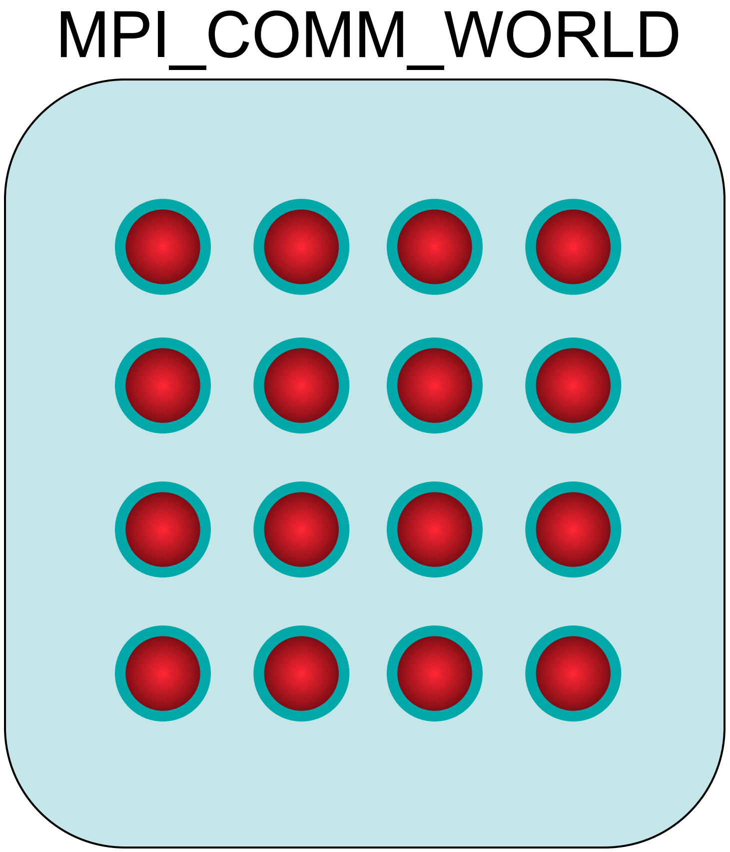
- Adding processes to a running job
  - As part of the algorithm i.e. branch and bound
  - When additional resources become available
  - Some master-slave codes where the master is started first and asks the environment how many processes it can create
- Joining separately started applications
  - Client-server or peer-to-peer
- Handling faults/failures

MPI-1 Processes

- All process groups are derived from the membership of the MPI_COMM_WORLD
  – No external processes
- Process membership static (vs. PVM)
  – Simplified consistency reasoning
  – Fast communication (fixed addressing) even across complex topologies
  – Interfaces well to many parallel run-time systems

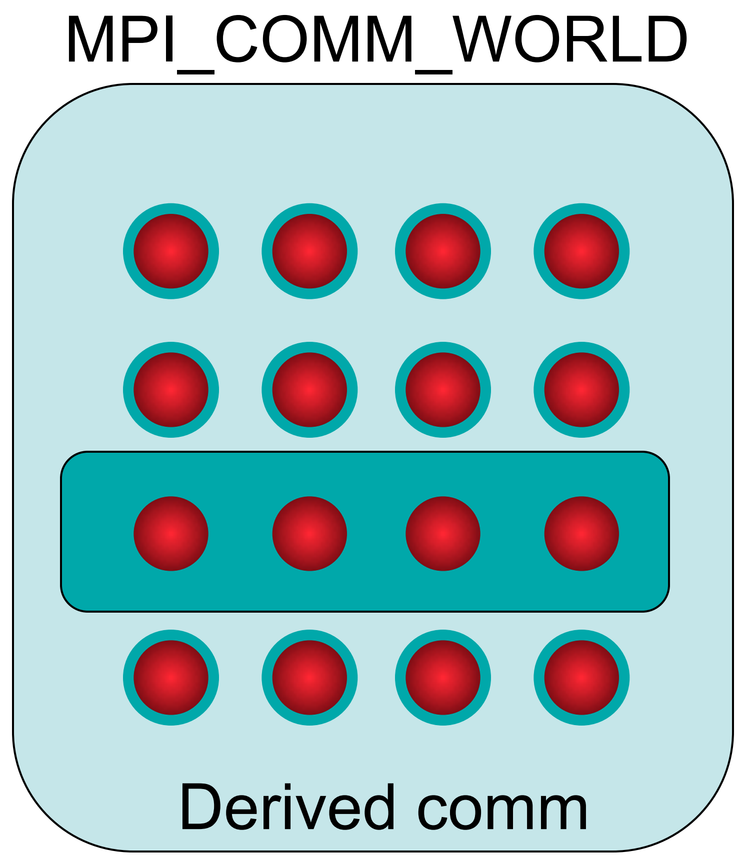
Static MPI-1 Job

- MPI_COMM_WORLD
- Contains 16 processes



Static MPI-1 Job

- MPI_COMM_WORLD
- Contains 16 processes
- Can only subset the original MPI_COMM_WORLD
  - No external processes



Disadvantages of Static Model

- Cannot add processes
- Cannot remove processes
  - If a process fails or otherwise disappears, all communicators it belongs to become invalid

➔ Fault tolerance undefined

MPI-2

- Added support for dynamic processes
  - Creation of new processes on the fly
  - Connecting previously existing processes
- Does not standardize inter-implementation communication
  - Interoperable MPI (IMPI) created for this

Open Questions

How do you add more processes to an already-running MPI-1 job?

- How would you handle a process failure?
- How could you establish MPI communication between two independently initiated, simultaneously running MPI jobs?

MPI-2 Process Management

- MPI-2 provides “spawn” functionality
  - Launches a child MPI job from a parent MPI job
- Some MPI implementations support this
  - Open MPI
  - LAM/MPI
  - NEC MPI
  - Sun MPI
- High complexity: how to start the new MPI applications ?

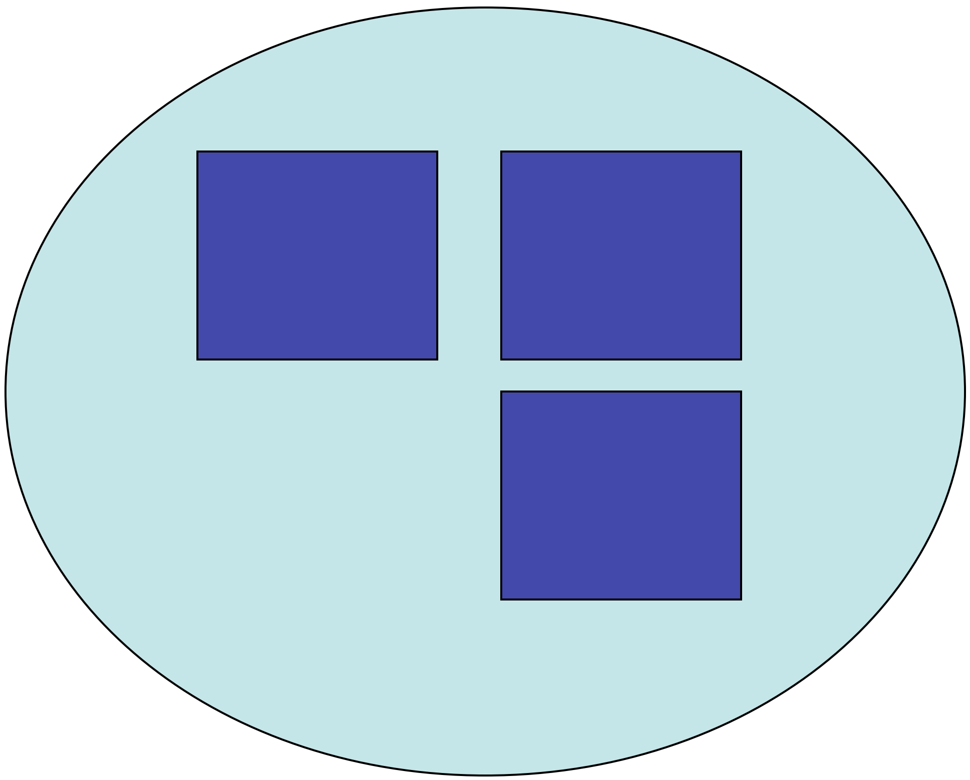
MPI-2 Spawn Functions

- MPI_COMM_SPAWN
  - Starts a set of new processes with the same command line
  - Single Process Multiple Data
- MPI_COMM_SPAWN_MULTIPLE
  - Starts a set of new processes with potentially different command lines
  - Different executables and / or different arguments
  - Multiple Processes Multiple Data

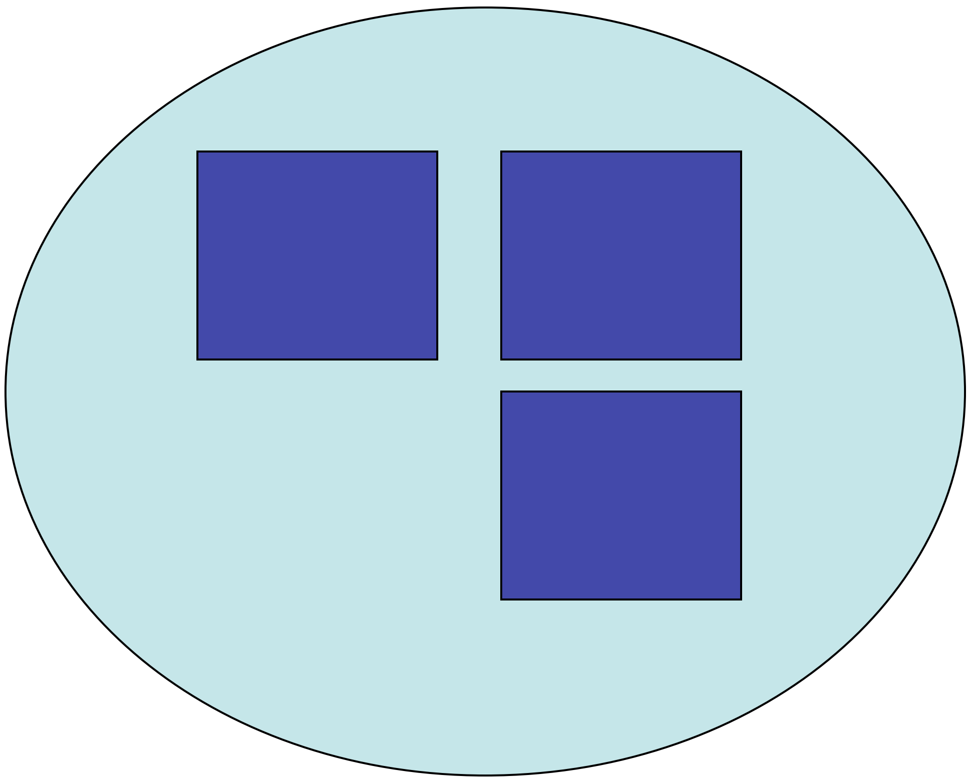
Spawn Semantics

- Group of parents collectively call spawn
  - Launches a new set of children processes
  - Children processes become an MPI job
  - An **inter**communicator is created between parents and children
- Parents and children can then use MPI functions to pass messages
- MPI_UNIVERSE_SIZE

Spawn Example

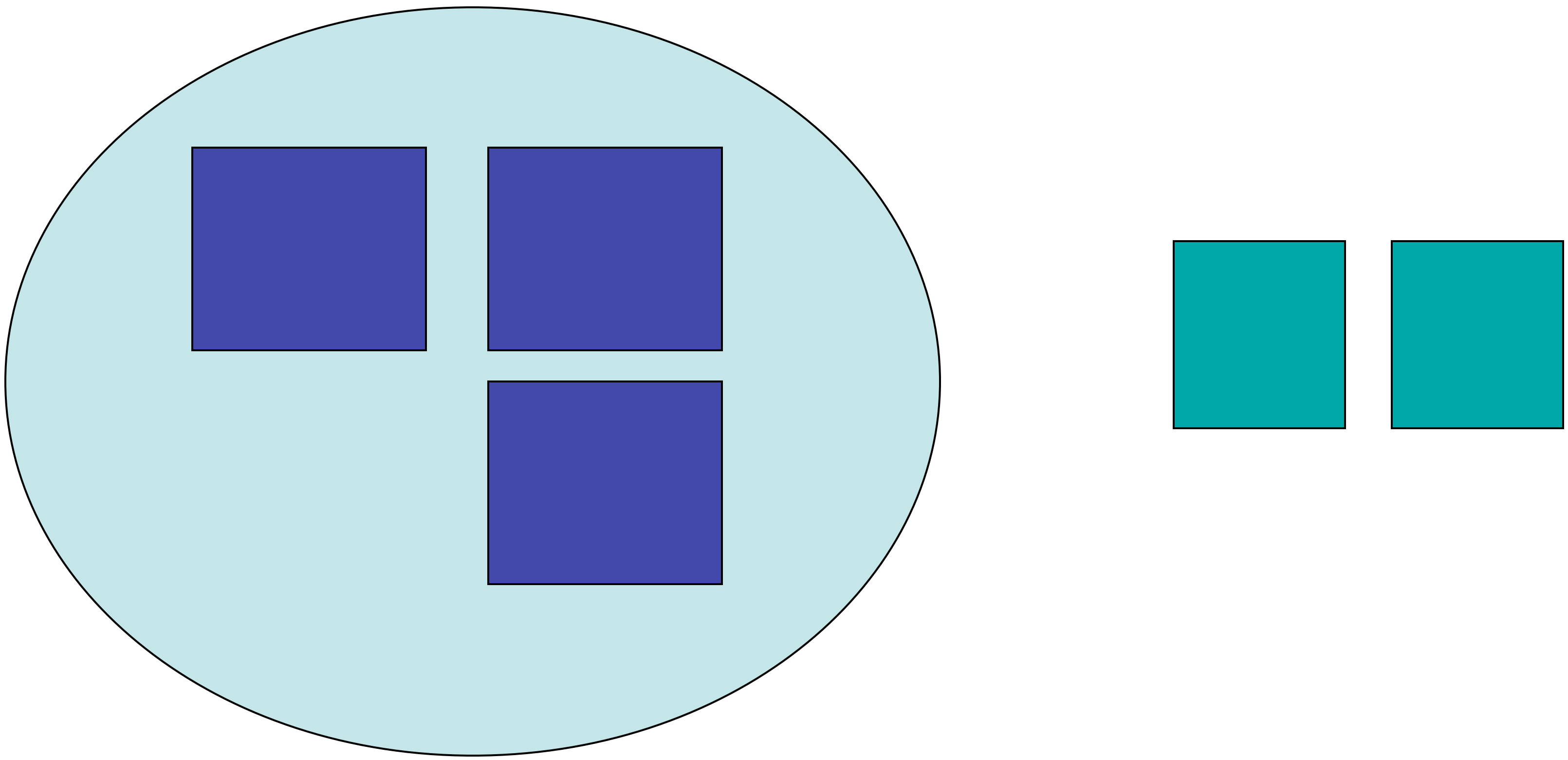


Spawn Example



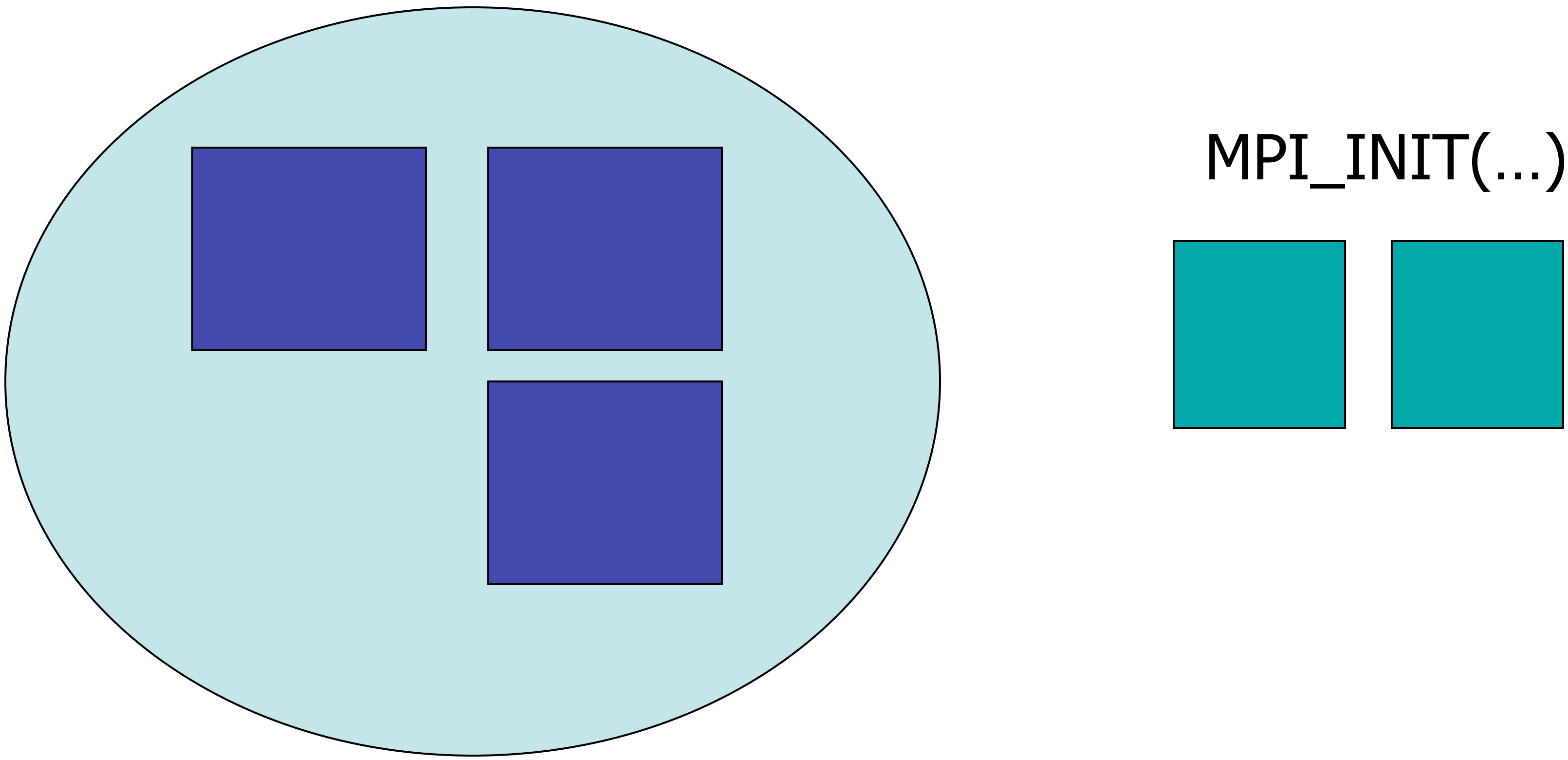
Parents call MPI_COMM_SPAWN

Spawn Example



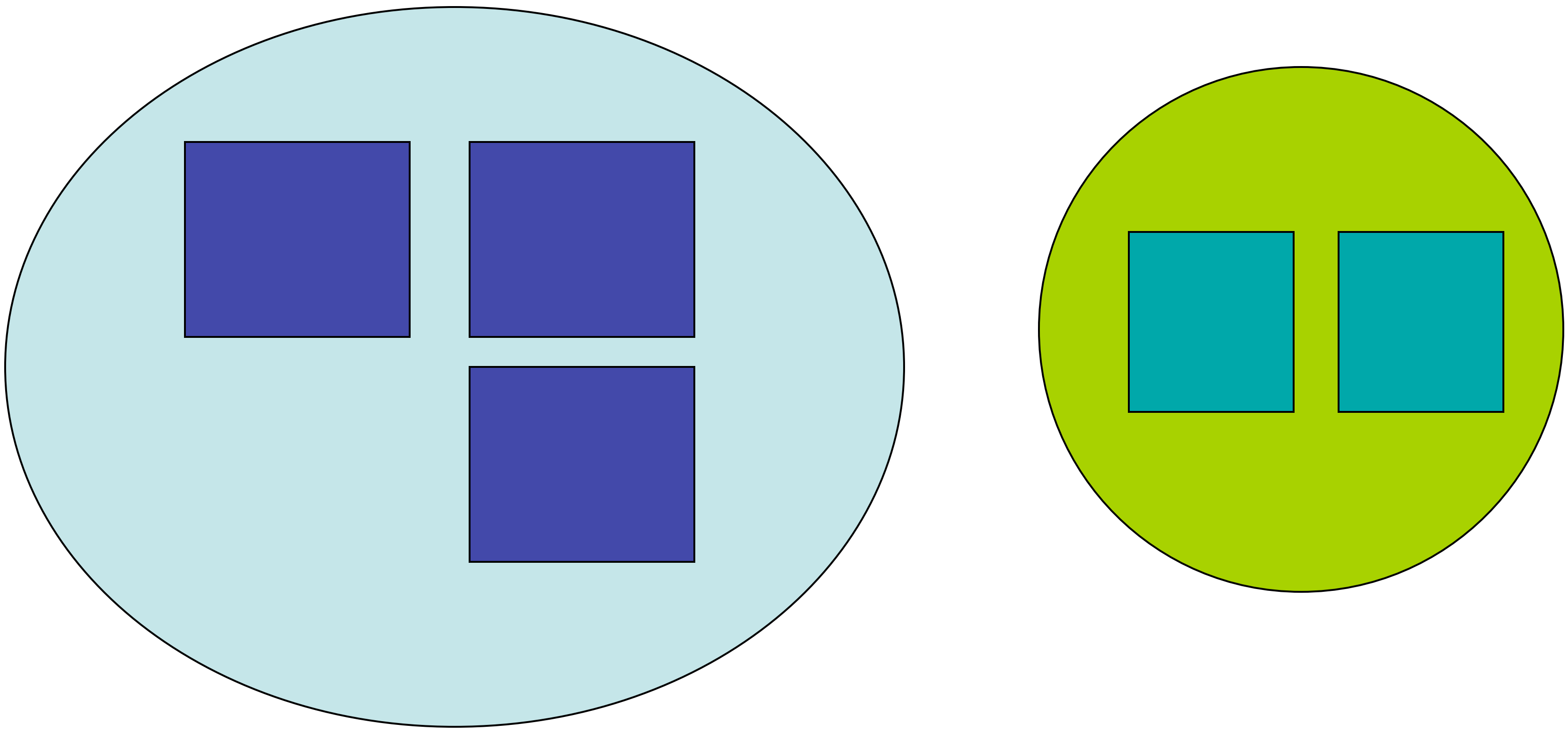
Two processes are launched

Spawn Example



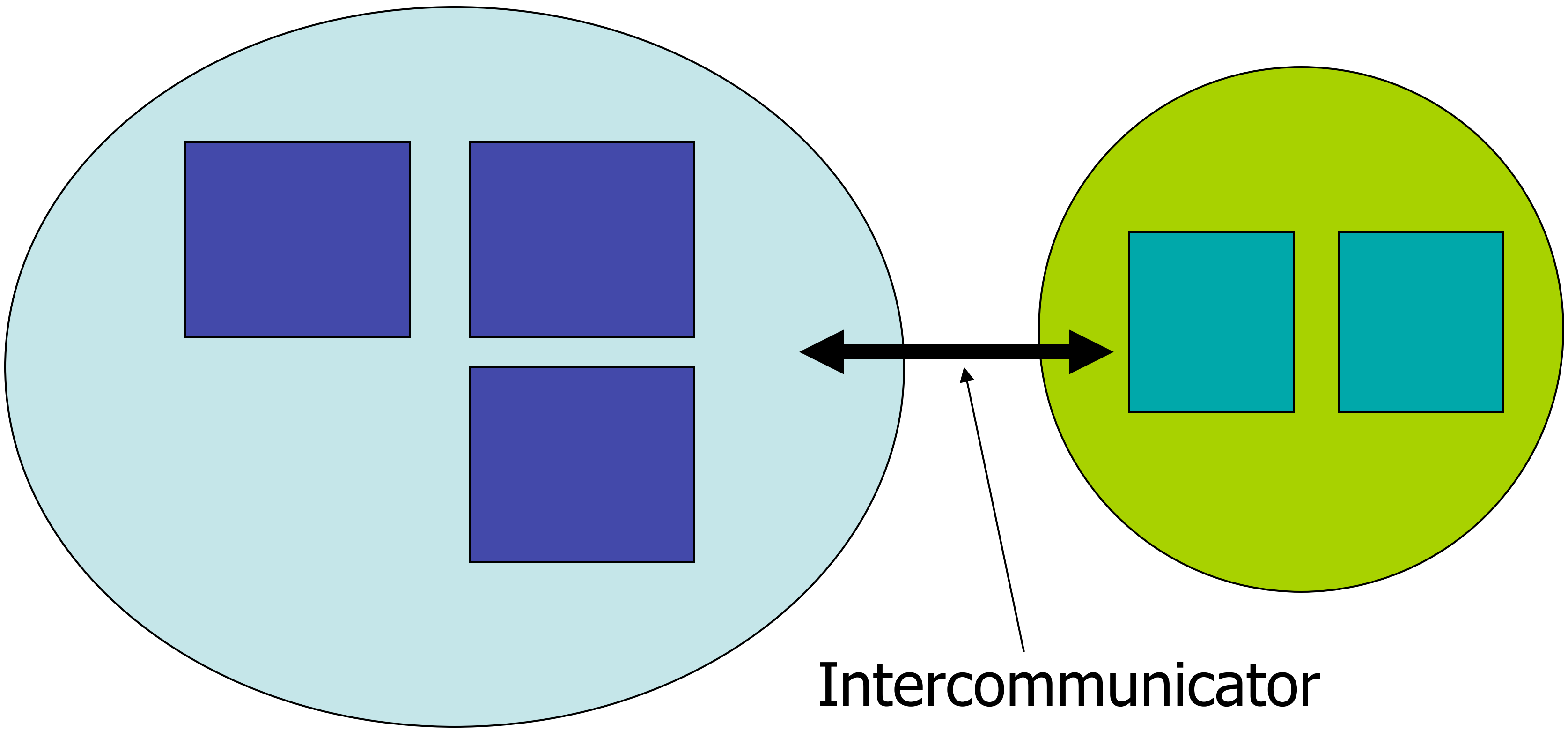
Children processes call MPI_INIT

Spawn Example



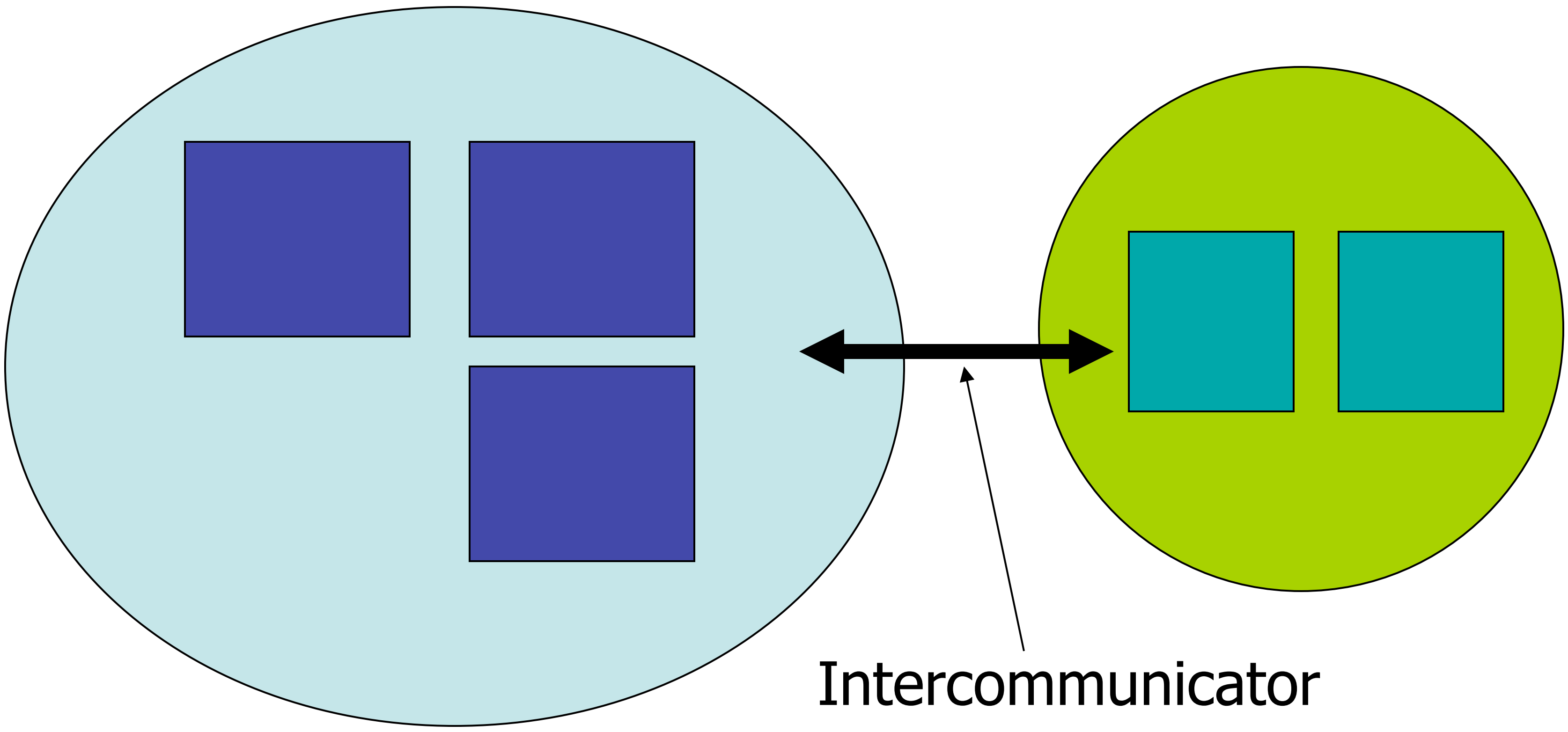
Children create their own MPI_COMM_WORLD

Spawn Example



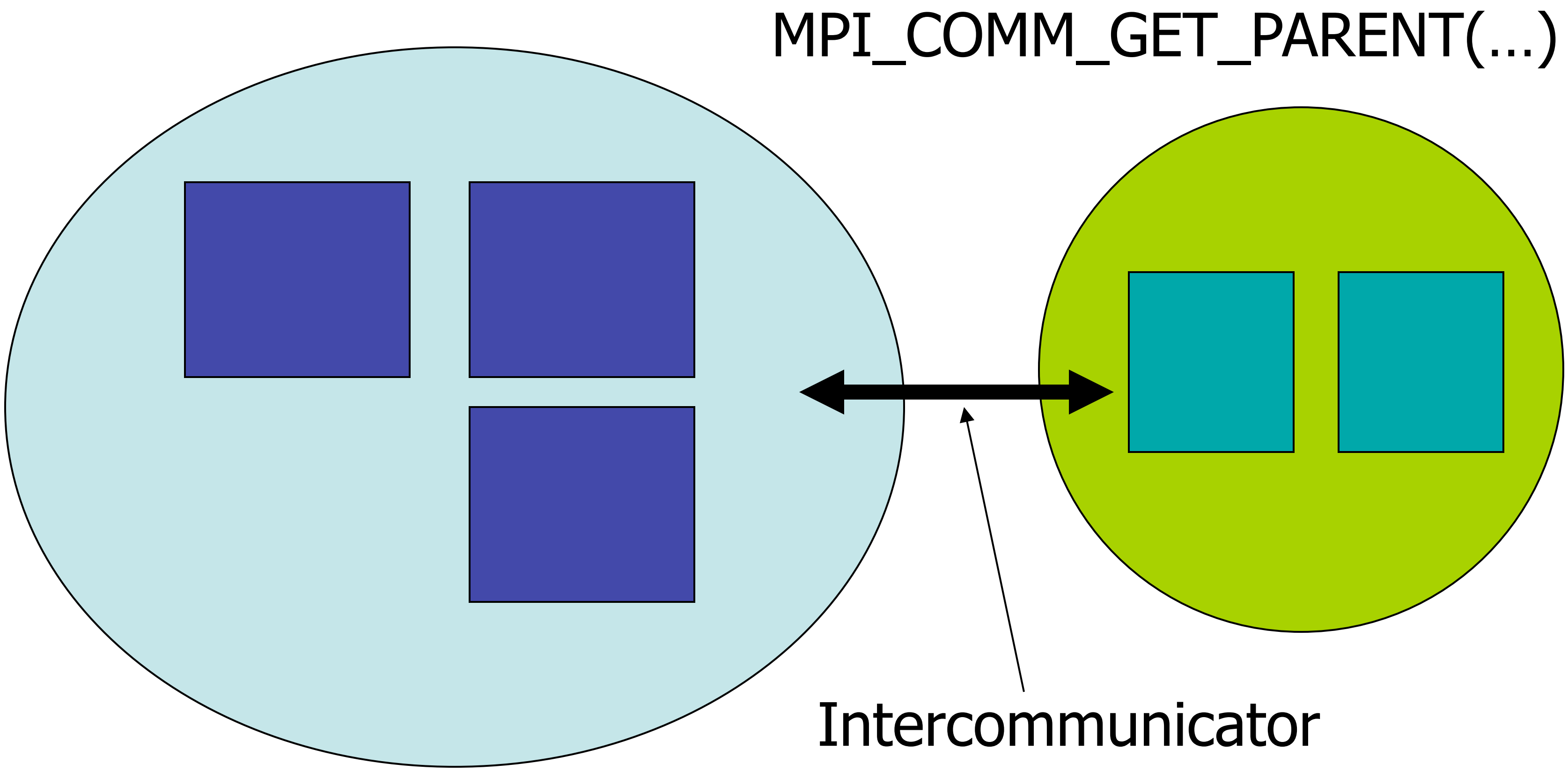
An intercommunicator is formed between parents and children

Spawn Example



Intercommunicator is returned from MPI_COMM_SPAWN

Spawn Example



Children call MPI_COMM_GET_PARENT to get intercommunicator

Master / Slave Demonstration

- Simple ‘PVM’ style example
  - User starts singleton master process
  - Master process spawns slaves
  - Master and slaves exchange data, do work
  - Master gathers results
  - Master displays results
  - All processed shut down

Master / Slave Demonstration

Master program

```
MPI_Init(…)
MPI_Spawn(…, slave, …);

for (i=0; i < size; i++)
   MPI_Send(work, …,i,
   …);
for (i=0; i < size; i++)
   MPI_Recv(presults, …);
calc_and_display_result(…
   )
MPI_Finalize()
```

Slave program

```
MPI_Init(…)
MPI_Comm_get_parent
   (&intercomm)
MPI_Recv(work,…,
   intercomm)
result =
   do_something(work)
MPI_Send(result,…,
   intercomm)
MPI_Finalize()
```

MPI “Connected”

- “Two processes are connected if there is a communication path directly or indirectly between them.”
  - E.g., belong to the same communicator
  - Parents and children from SPAWN are connected
- Connectivity is transitive
  - If A is connected to B, and B is connected to C
  - A is connected to C

MPI “Connected”

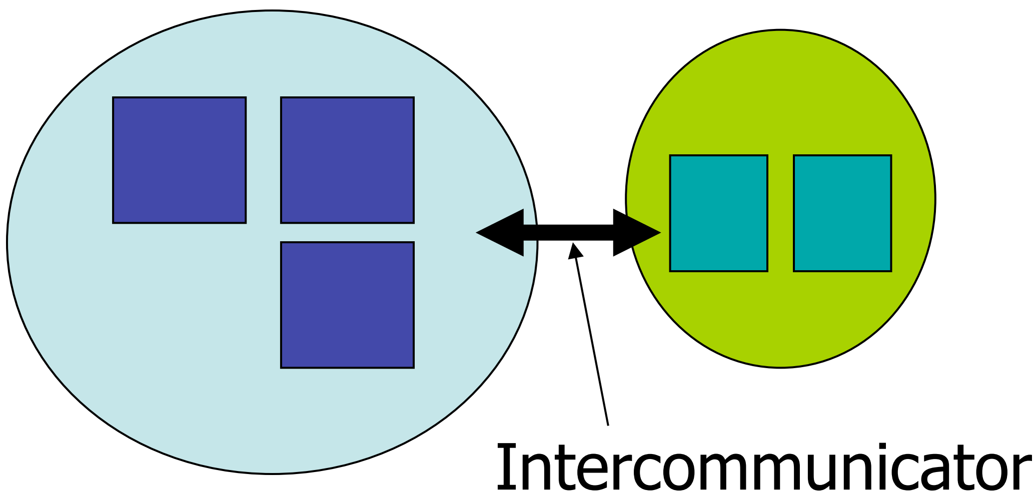
- Why does “connected” matter?
  - MPI_FINALIZE is collective over set of connected processes
  - MPI_ABORT *may* abort all connected processes
- How to disconnect?
  - …stay tuned

Multi-Stage Spawning

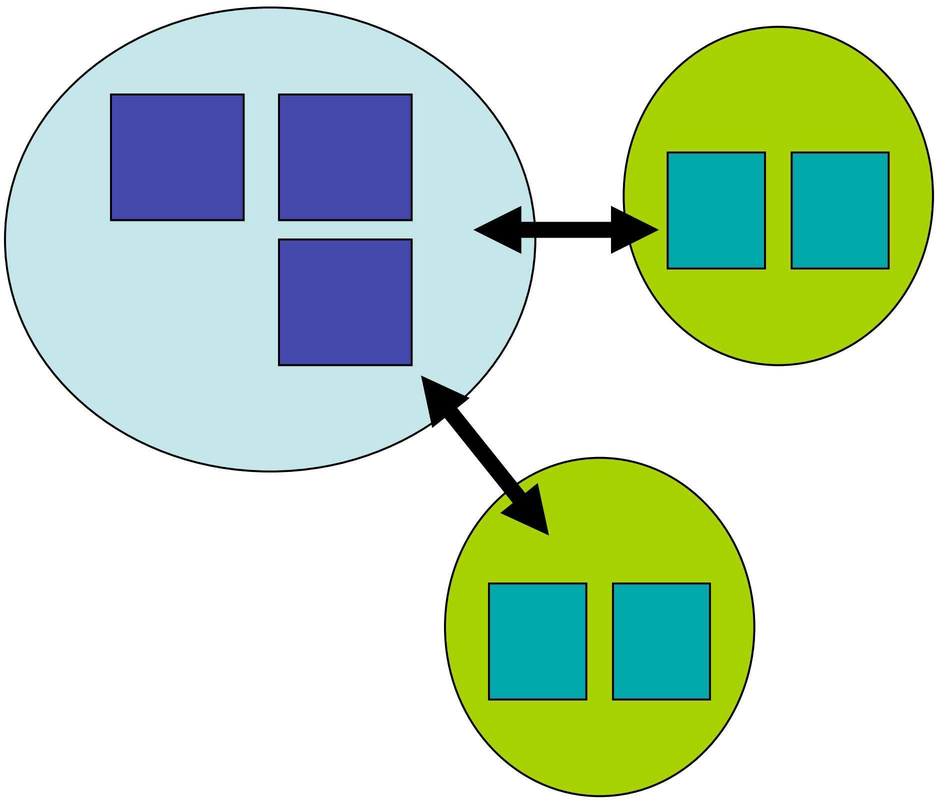
- What about multiple spawns?
  - Can sibling children jobs communicate directly?
  - Or do they have to communicate through a common parent?

➔ Is all MPI dynamic process communication hierarchical in nature?

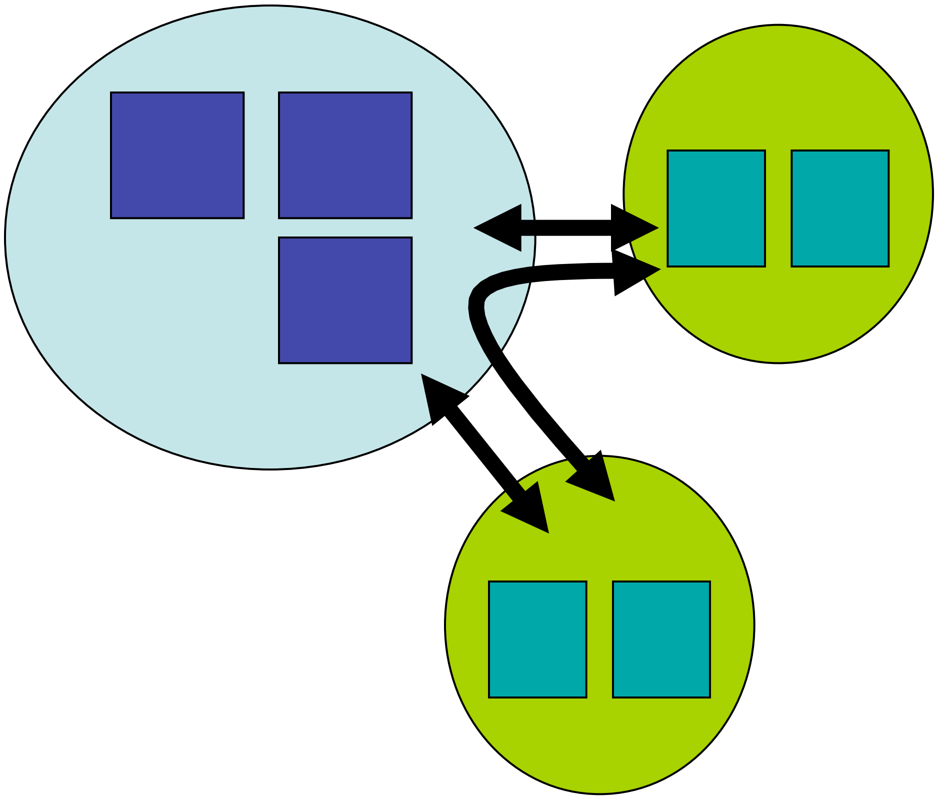
Multi-Stage Spawning



Multi-Stage Spawning

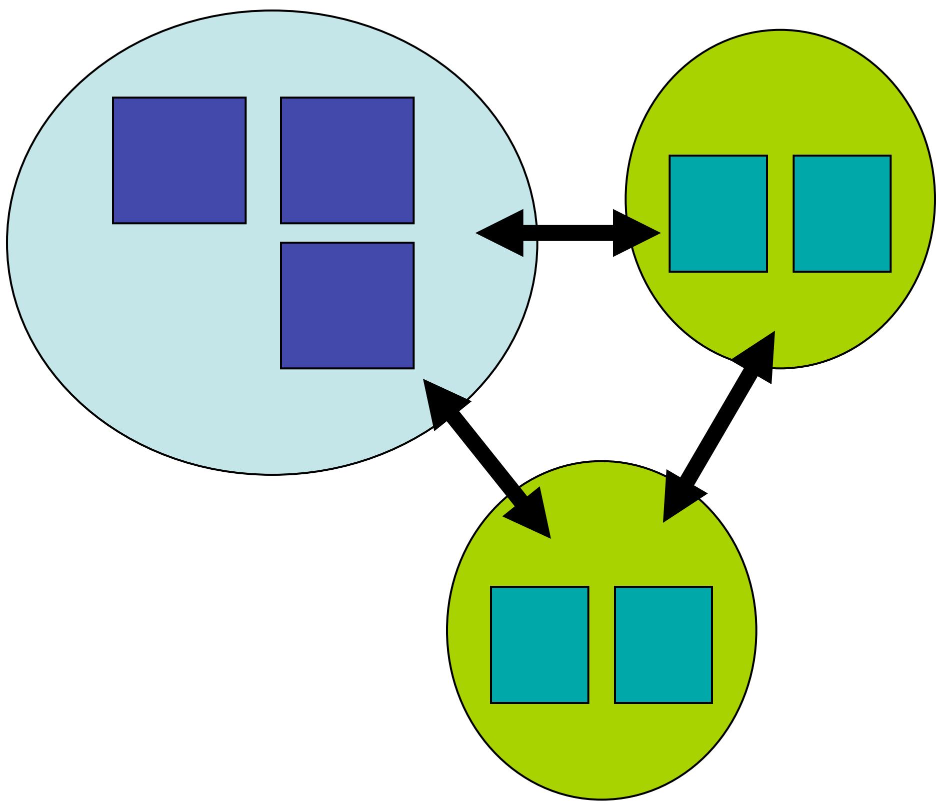


Multi-Stage Spawning



Do we have to do this?

Multi-Stage Spawning



Or can we do this?

Dynamic Processes:
Connect / Accept

Establishing Communications

- MPI-2 has a TCP socket style abstraction
  - Process can accept and connect connections from other processes
  - Client-server interface
- MPI_COMM_CONNECT
- MPI_COMM_ACCEPT

Establishing Communications

- How does the client find the server?
  - With TCP sockets, use IP address and port
  - What to use with MPI?
- Use the MPI name service
  - Server opens an MPI “port”
  - Server assigns a public “name” to that port
  - Client looks up the public name
  - Client gets port from the public name
  - Client connects to the port

Server Side

- Open and close a port
  - MPI_OPEN_PORT(info, port_name)
  - MPI_CLOSE_PORT(port_name)
- Publish the port name
  - MPI_PUBLISH_NAME(service_name, info, port_name)
  - MPI_UNPUBLISH_NAME(service_name, info, port_name)

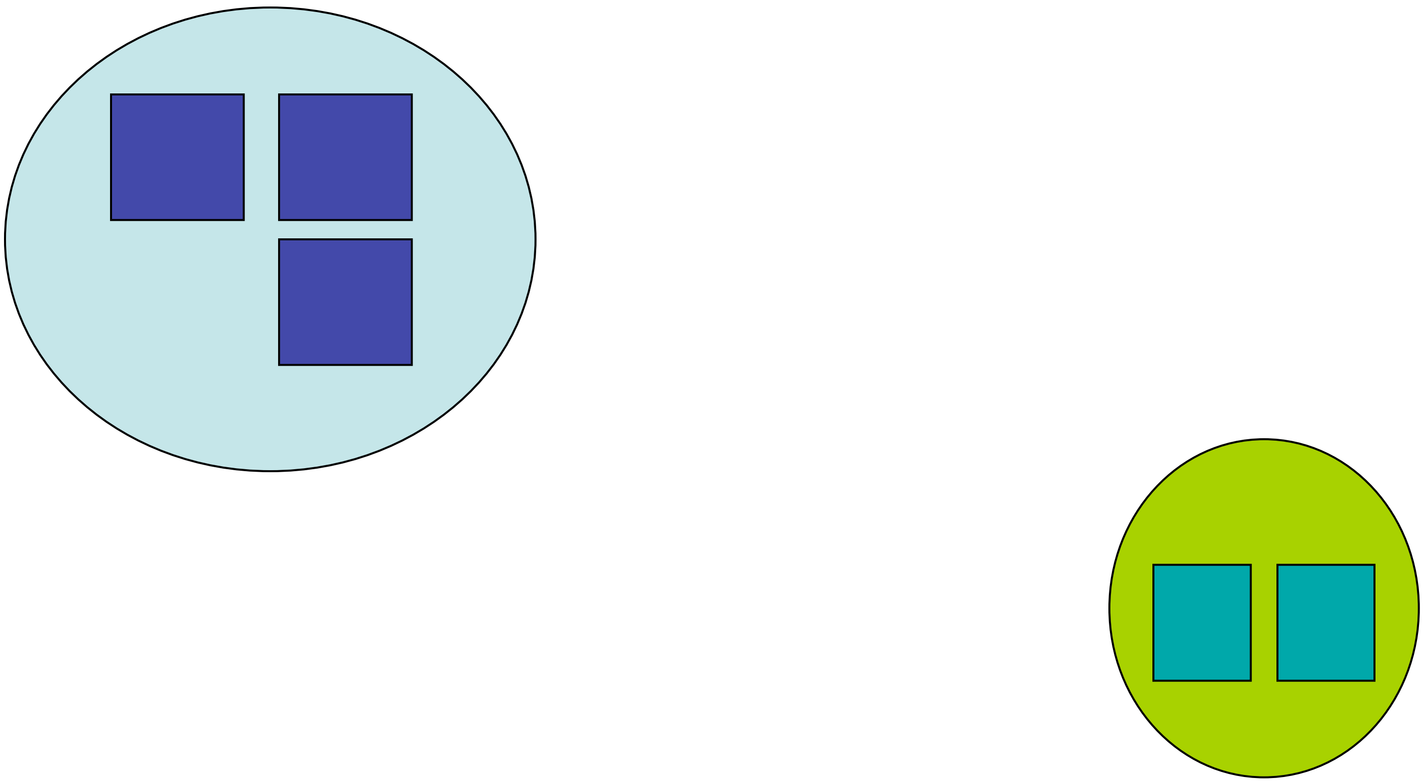
Server Side

- Accept an incoming connection
  - MPI_COMM_ACCEPT(port_name, info, root, comm, newcomm)
  - comm is a **intra**communicator; local group
  - newcomm is an **inter**communicator; both groups

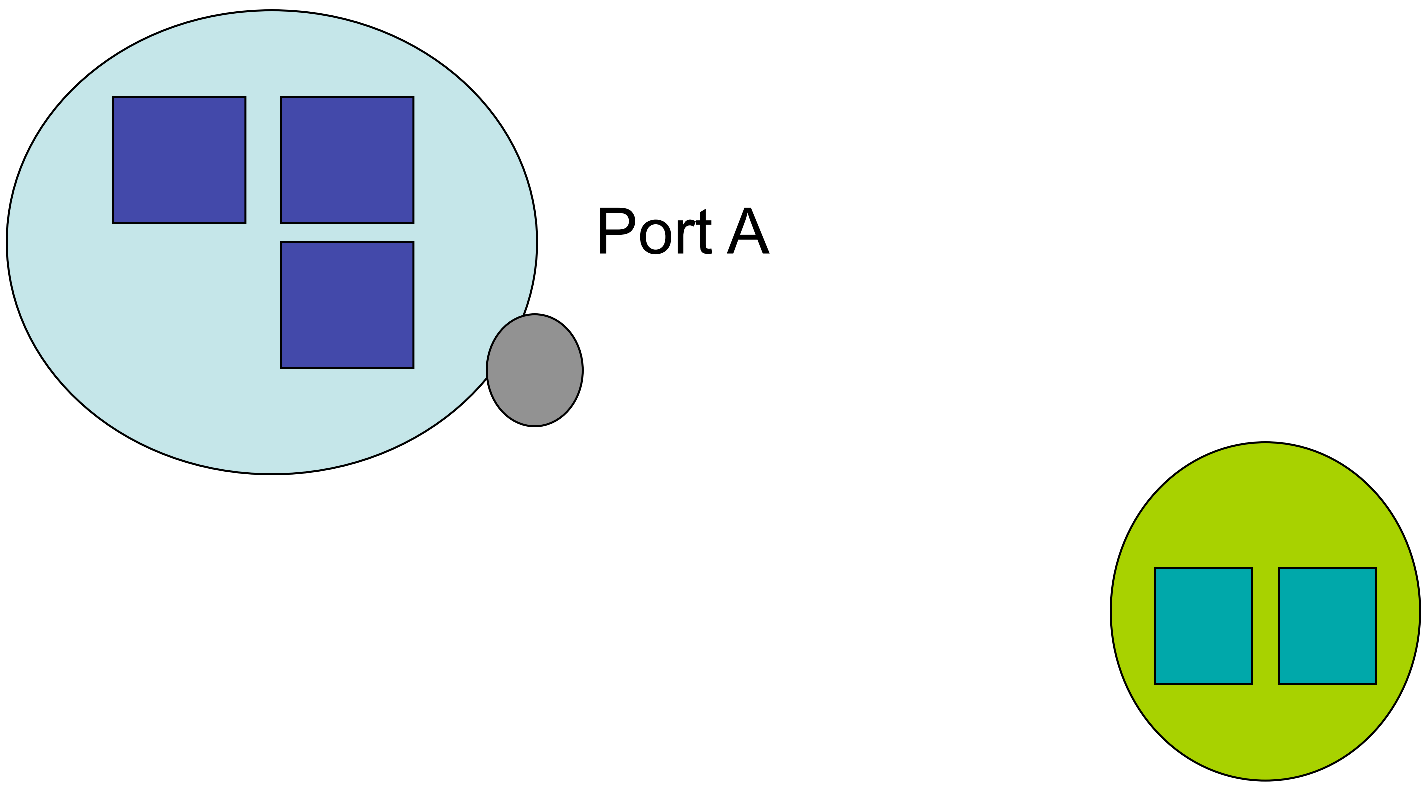
Client Side

- Lookup port name
  - MPI_LOOKUP_NAME(service_name, info, port_name)
- Connect to the port
  - MPI_COMM_CONNECT(port_name, info, root, comm, newcomm)
  - comm is a **intra**communicator; local group
  - newcomm is an **inter**communicator; both groups

Connect / Accept Example

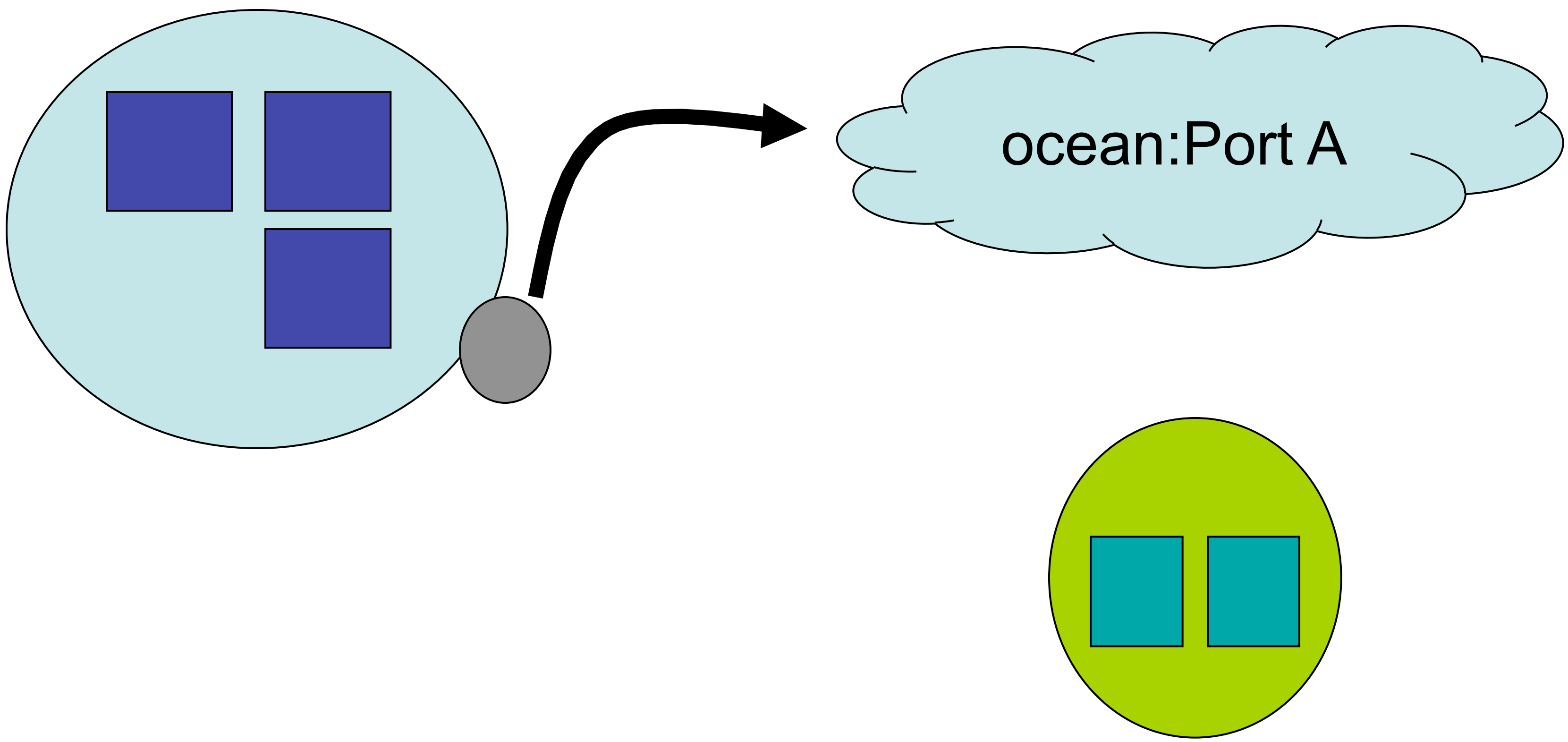


Connect / Accept Example



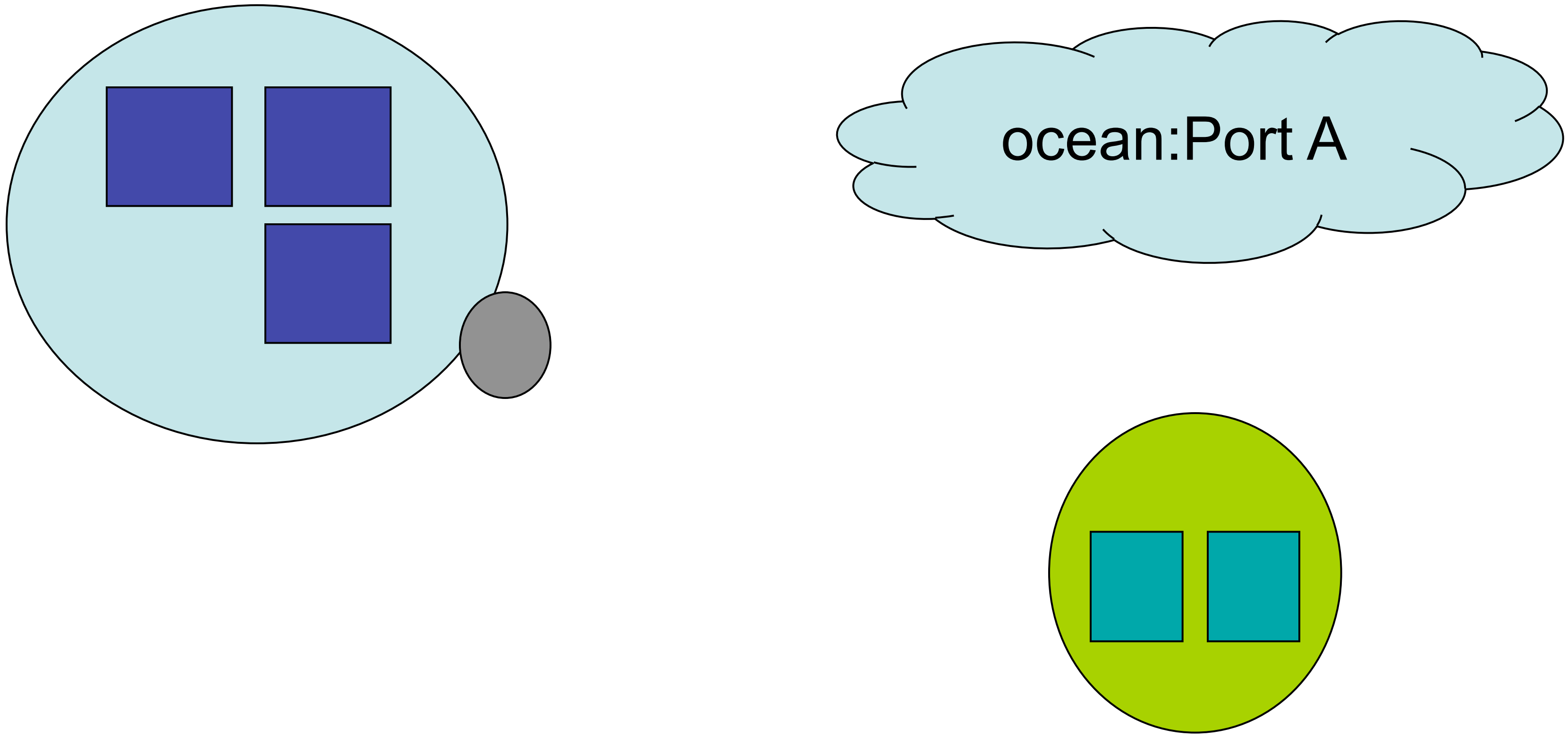
Server calls MPI_OPEN_PORT

Connect / Accept Example



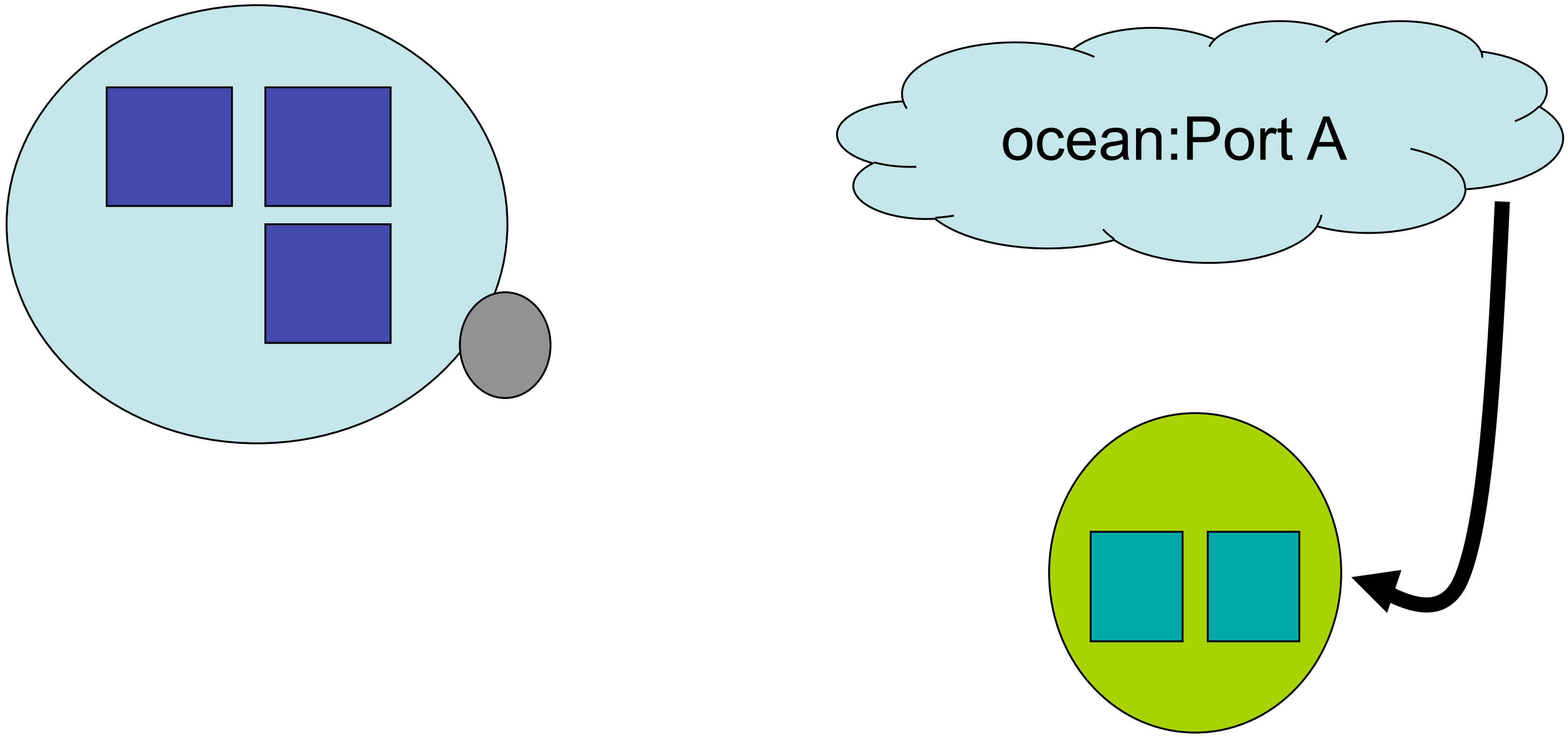
Server calls MPI_PUBLISH_NAME(“ocean”, info, port_name)

Connect / Accept Example



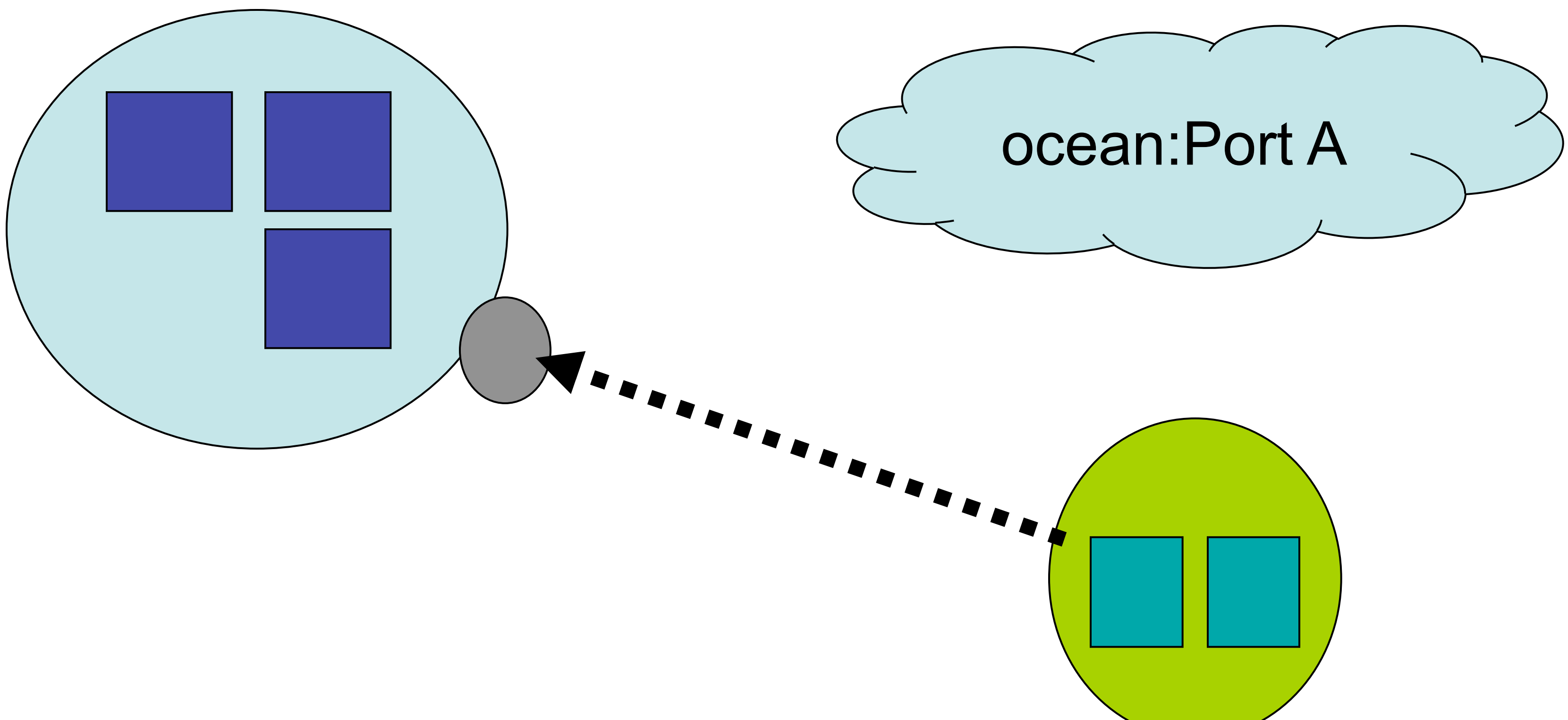
Server blocks in MPI_COMM_ACCEPT("Port A", …)

Connect / Accept Example



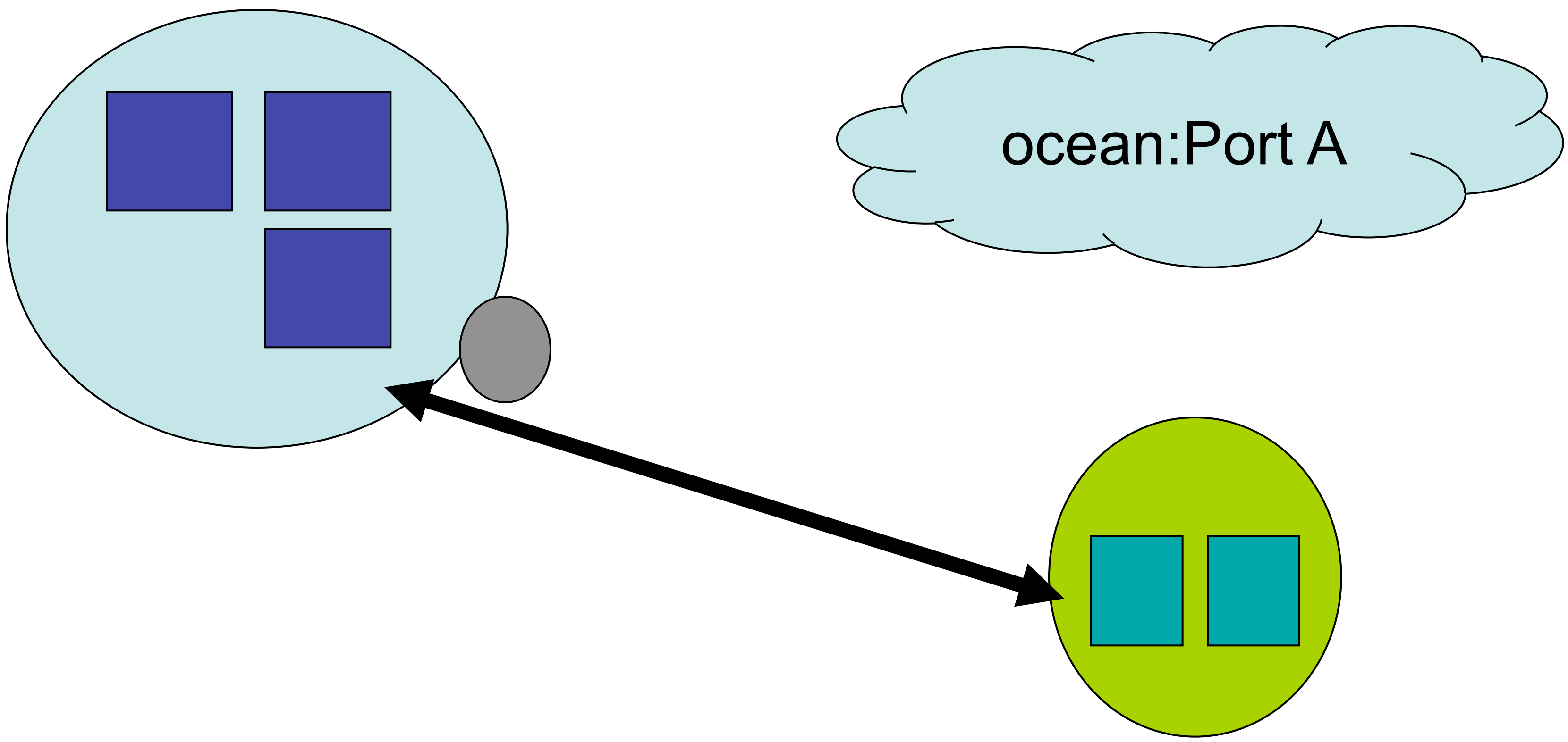
Client calls MPI_LOOKUP_NAME("ocean", ...), gets "Port A"

Connect / Accept Example



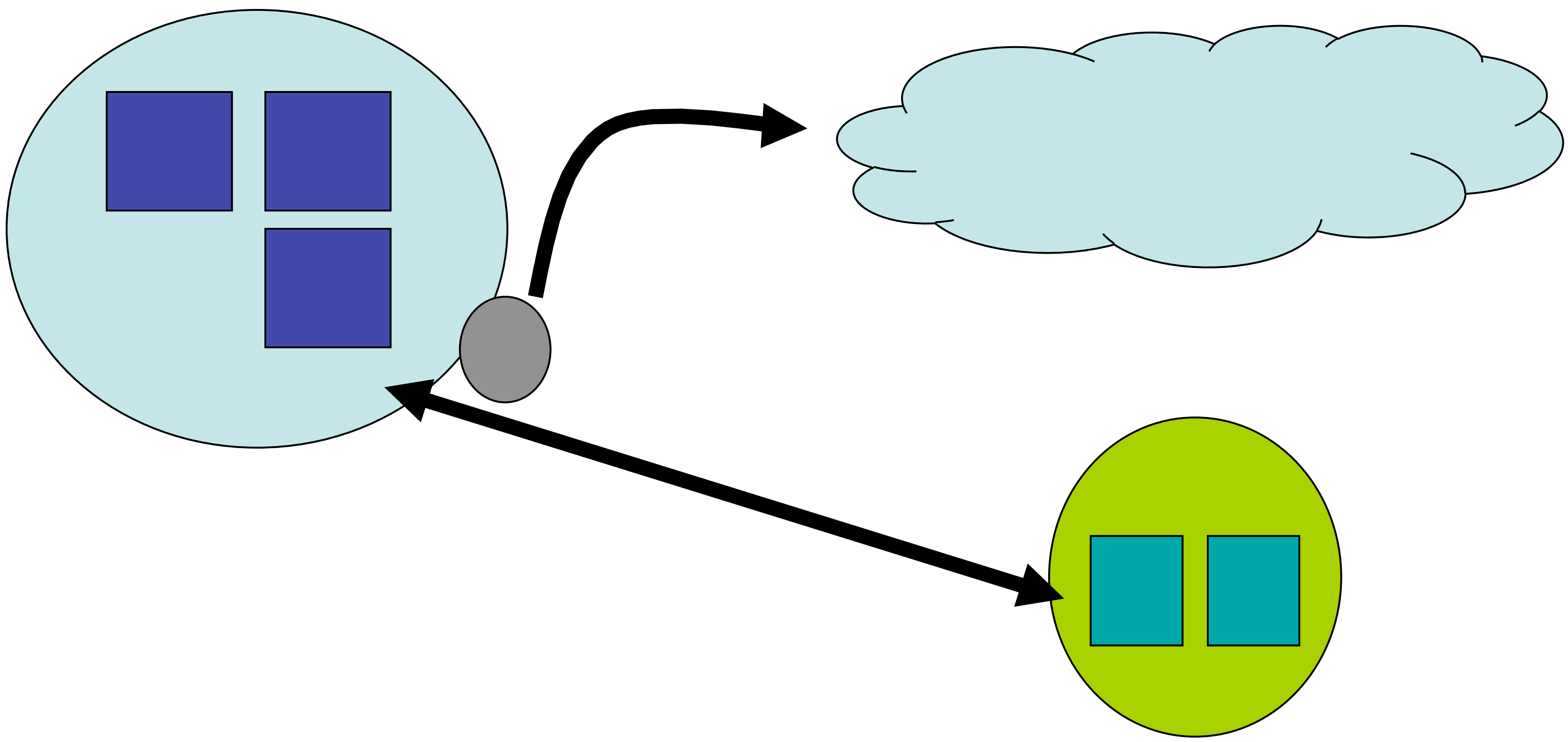
Client calls MPI_COMM_CONNECT("Port A", ...)

Connect / Accept Example



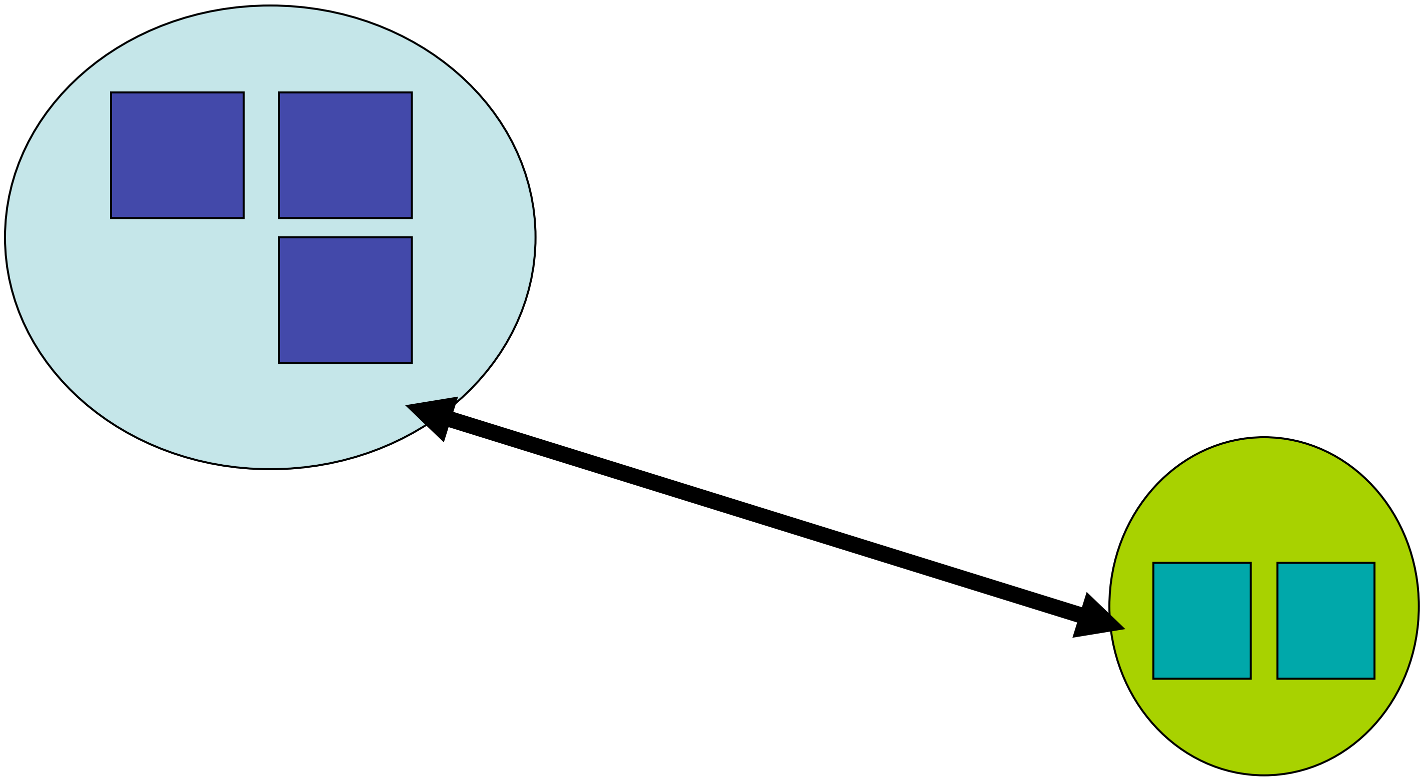
Intercommunicator formed; returned to both sides

Connect / Accept Example



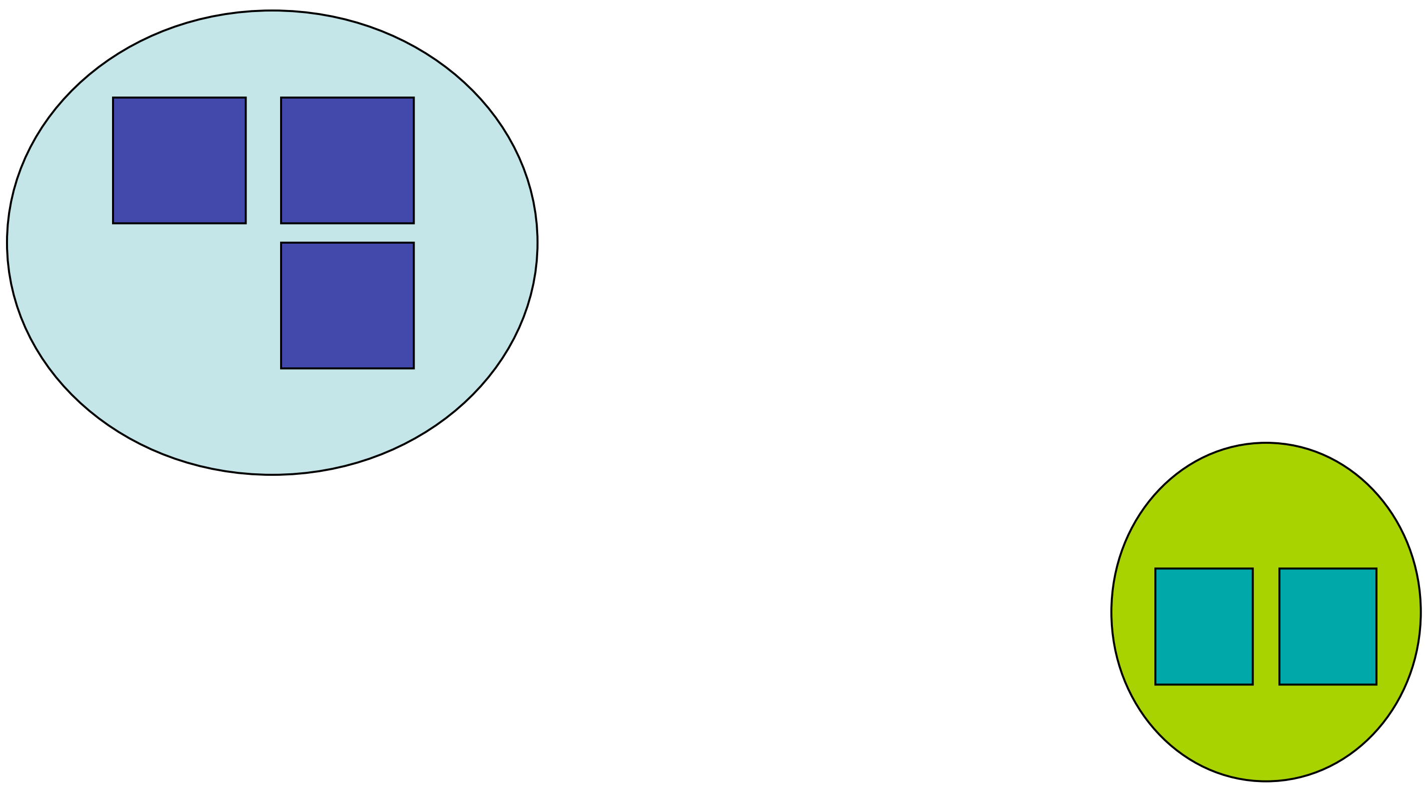
Server calls MPI_UNPUBLISH_NAME(“ocean”, …)

Connect / Accept Example



Server calls MPI_CLOSE_PORT

Connect / Accept Example



Both sides call MPI_COMM_DISCONNECT

Summary

- Summary
  - Server opens a port
  - Server publishes public “name”
  - Client looks up public name
  - Client connects to port
  - Server unpublishes name
  - Server closes port
  - Both sides disconnect

➔ Similar to TCP sockets / DNS lookups

MPI_COMM_JOIN

- A third way to connect MPI processes
  - User provides a socket between two MPI processes
  - MPI creates an intercommunicator between the two processes

➔ Will not be covered in detail here

Disconnecting

- Once communication is no longer required
  - MPI_COMM_DISCONNECT
  - Waits for all pending communication to complete
  - Then formally disconnects groups of processes -- no longer “connected”
- Cannot disconnect MPI_COMM_WORLD