The MPI Message-passing Standard
Lab Time Hands-on

SPD Course

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Remember!

- Simplest programs do not need much beyond Send and Recv, still…
- Each process lives in a separate memory space
  - Need to initialize all your data structures
  - Need to initialize your instance of the MPI library
  - Use MPI_COMM_WORLD
  - Need to define all your DataTypes
  - Should you make assumptions on process number?
  - How portable will your program be?
- Check your MPI man page about launching
  - E.g. **`mpirun –np 4 myprogram parameters`**

Initializing the runtime

- MPI_Init()
  - Shall be called before using any MPI calls (very few exceptions)
  - Initializes the MPI runtime for all processes in the running program, some kind of handshaking implied
    - e.g. creates **MPI_COMM_WORLD**
  - check its arguments!
- MPI_Finalize()
  - Frees all MPI resources and cleans up the MPI runtime, taking care of any operation pending
  - Any further call to MPI is forbidden
  - some runtime errors can be detected at finalize
    - e.g. calling finalize with communications still pending and unmatched

Note on mpich

- Mpich installation in the lab machine (centos 7) requires this in your .bash_profile

```
#####  MPICH
export PATH=/usr/local/bin:/usr/lib64/mpich/
bin:$PATH
export LD_LIBRARY_PATH=/usr/local/lib:/usr/
lib64/mpich/lib:$LD_LIBRARY_PATH
export MANPATH=/usr/share/man/mpich/:`manpath`
export PATH
```

- Mpirun becomes mpiexec, e.g.

```
mpiexec -np 2 pingpong "Hello world(s)"
```

Exercise 1

- Define the classical ping-pong program with 2 processes
  - they send back and fort a data buffer, the second process executes an operation on the data (e.g. sum 1).
  - Verify after a given number N of iterations, that the expected result is achieved.
  - Add printouts close to communications
  - Does it work? Why?
- Generalize the ping-pong example to N processes
  - Each process sends to the next one, with some processes being special, e.g.
  - Token ring (a process has to start and stop the token)
  - One-way pipeline (one process starts, one only receives)
  - Can you devise the proper communicator structure?

Getting your identity

- MPI_Comm_rank
  - After the MPI_Init
  - Returns the rank of the current process within a specified communicator
  - For now let's just use ranks related to MPI_COMM_WORLD
  - Example:

```
MPI_Comm_rank(MPI_COMM_WORLD, &myrank);
```

Writing “structured” MPI

- We’ll never stress this enough
  - Aim at separation of concern : avoid chaotically mixing up MPI primitives and sequential code
  - When possible, write a separate function/class for each type of process in your program
    - Parametric wrt to sequential program parameters and arguments, AND wrt parallel environment
    - E.g. Operates in a give communicator with known assumptions
    - Global initialization done by all processes, local initialization may be done locally (e.g. build a worker-specific communicator inside the farm implementation)
  - Sometimes it may be possible to write MPI code which is generic and may be reused → try to decouple these parts into separate functions

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Exercise 2

- Build datatypes for
  - a square matrix of arbitrary element types and constant size 120*120
  - a column of the matrix
  - a row of the matrix
  - a group of 3 columns of the matrix
  - the upward and downward diagonals of the matrix
- Perform a test of the datatypes within the code of exercise 1
  - Initialize the matrix in a known way, perform computation on the part that you pass along (e.g. multiply or increment its elements) and check the result you receive back

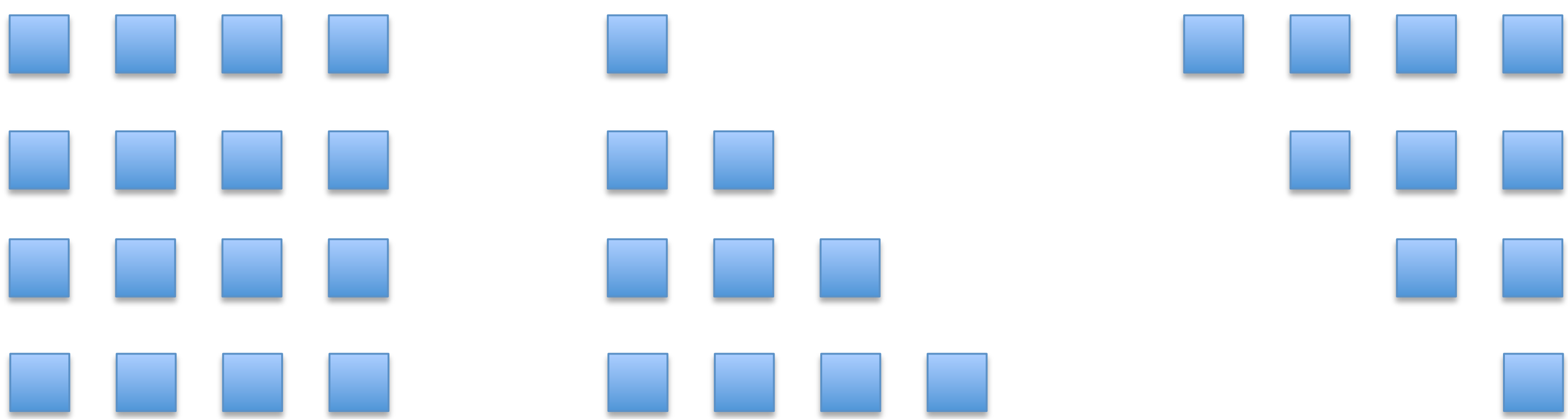
Remember

- MPI_TYPE_COMMIT(datatype)
  - Mandatory to enables a newly defined datatype for use in all other MPI primitives
  - Consolidates datatype definition, making it permanent
  - May compile internal information needed to the MPI library runtime
    - e.g. : optimized routines for data packing & unpacking
- MPI_TYPE_FREE(datatype)
  - Free library memory used by a datatype that is no longer needed

Exercise 3

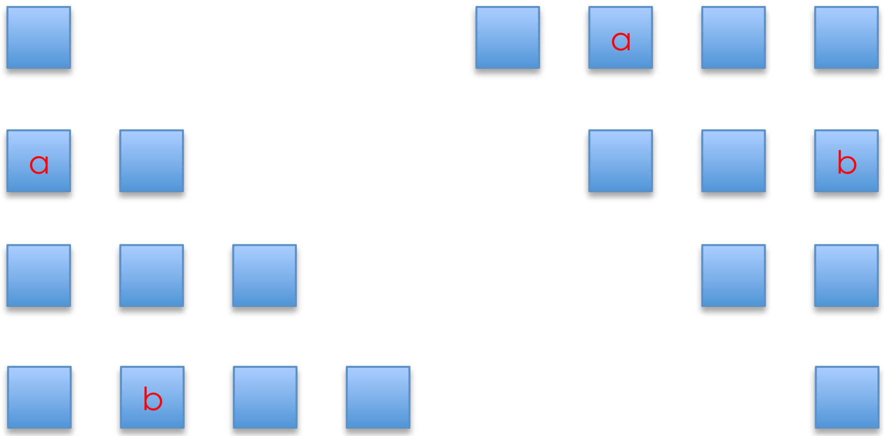
- Define a datatype for a square matrix **with parametric size**
  - Define a datatype for its lower triagular matrix
  - Define one for its upper triangular.
- Test the them within the code of exercise 1

$A_{i,j}$ i,j in $1..n$ $\qquad$ $A_{i,j}$ $i \geq j$ $\qquad$ $A_{i,j}$ $i \leq j$



Exercise 3 (II)

- In the two-process program
  - initialize randomly a square matrix
  - send the lower triangular and
  - receive it back as upper triangular in the same buffer.
- Is the result a symmetric matrix?
  - How do you need to modify one of the two triangular datatypes in order to achieve that?
- In the end we want $A_{i,j} = B_{j,i}$



Exercise 4

- How do you implement an asynchronous communication with given asincrony?
  - Implement a communication with asynchrony 1
  - Implement a communication with asynchrony K

- Assigned asynchrony of degree K: asynchronous communication (sender does not block) which becomes synchronous if more than K messages are still pending.
- Receiver can skip at most K receives before sender blocks

- Can you rely on MPI buffering?
- How would you implement a fixed size buffer?