Message Passing Programming

Introduction to MPI

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What is MPI?

MPI Forum

- First message-passing interface standard.
- Sixty people from forty different organisations.
- Users and vendors represented, from the US and Europe.
- Two-year process of proposals, meetings and review.
- *Message Passing Interface* document produced in 1993

Implementation

- MPI is a *library* of function/subroutine calls

- MPI is *not a language*

- There is *no such thing* as an MPI compiler

- The C or Fortran compiler you invoke knows nothing about what MPI actually does
  - only knows prototype/interface of the function/subroutine calls

Goals and Scope of MPI

- MPI's prime goals are:
  - To provide source-code portability.
  - To allow efficient implementation.

- It also offers:
  - A great deal of functionality.
  - Support for heterogeneous parallel architectures.

Header files

- C/C++:

```
#include <mpi.h>
```

- Fortran 77:

```
include 'mpif.h'
```

- Fortran 90:

```
use mpi
```

- Fortran 2008:

```
use mpi_f08
```

MPI Function Format

- C:

```
error = MPI_Xxxxx(parameter, ...);

MPI_Xxxxx(parameter, ...);
```

- Fortran:

```
CALL MPI_XXXXX(parameter, ..., IERROR)
```

  - **IERROR** optional in 2008 version *only*, otherwise *essential*

Handles

- MPI controls its own internal data structures.
- MPI releases `handles' to allow programmers to refer to these.
- C handles are of defined **`typedef`**s.
- Fortran handles are **`INTEGER`**s.

Initialising MPI

- C:

```
int MPI_Init(int *argc, char ***argv)
```

- Fortran:

```
MPI_INIT(IERROR)
INTEGER IERROR
```

- Must be the first MPI procedure called.
  - but multiple processes are already running before **`MPI_Init`**

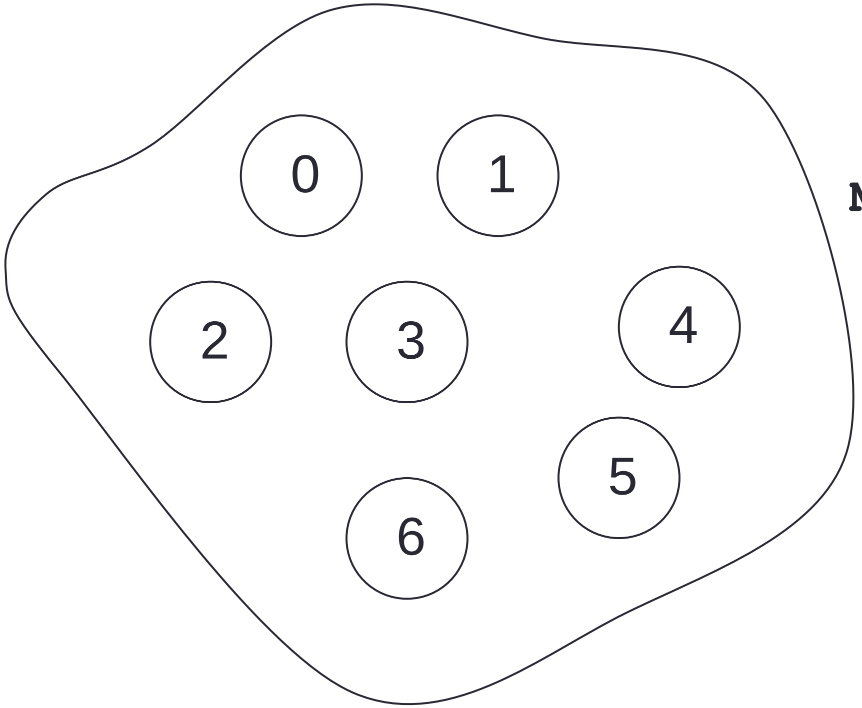
MPI_Init

```
int main(int argc, char *argv[])
{
  ...
  MPI_Init(&argc, &argv);
  ...

int main()
{
  ...
  MPI_Init(NULL, NULL);
  ...

program my_mpi_program
  integer :: ierror
  ...
  CALL MPI_INIT(IERROR)
```

MPI_COMM_WORLD



`MPI_COMM_WORLD`

Rank

- How do you identify different processes in a communicator?

```
MPI_Comm_rank(MPI_Comm comm, int *rank)

MPI_COMM_RANK(COMM, RANK, IERROR)
INTEGER COMM, RANK, IERROR
```

- The rank is not the physical processor number.
  - numbering is always 0, 1, 2, ..., N-1

MPI_Comm_rank

```
int rank;
...
MPI_Comm_rank(MPI_COMM_WORLD, &rank);
printf("Hello from rank %d\n", rank);
...
```

```
integer :: ierror
integer :: rank
...
CALL MPI_COMM_RANK(MPI_COMM_WORLD, rank, ierror)
write(*,*) 'Hello from rank ', rank
...
```

Size

- How many processes are contained within a communicator?

```
MPI_Comm_size(MPI_Comm comm, int *size)

MPI_COMM_SIZE(COMM, SIZE, IERROR)
      INTEGER COMM, SIZE, IERROR
```

Exiting MPI

- C:

```
int MPI_Finalize()
```

- Fortran:

```
MPI_FINALIZE(IERROR)
INTEGER IERROR
```

- Must be the last MPI procedure called.

What machine am I on?

- Can be useful on a cluster
  - e.g. to confirm mapping of processes to nodes/processors/cores

```
integer namelen
character*(MPI_MAX_PROCESSOR_NAME) :: procname
...
call MPI_GET_PROCESSOR_NAME(procname, namelen, ierror)
write(*,*) ‘rank ‘, rank, ‘ is on machine ‘, procname(1:namelen)
```

```
int namelen;
char procname[MPI_MAX_PROCESSOR_NAME];
...
MPI_Get_processor_name(procname, &namelen);
printf(“rank %d is on machine %s\n", rank, procname);
```

Summary

- Have covered some basic MPI calls
  - but no explicit message-passing yet
- Can still write useful programs
  - e.g. a task farm of independent jobs
- Need to compile and launch parallel jobs
  - procedure is not specified by MPI
  - next lecture gives machine-specific details