

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'
```

very outdated!

- 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*

- If successful, return value is **MPI_SUCCESS**

Handles

- MPI controls its own internal data structures.
- MPI releases 'handles' to allow programmers to refer to these.
- C handles are of defined **typedefs**.
- Fortran 90 handles are **INTEGERS**.
- Fortran 2008 handles are user-defined types as for C
 - will present Fortran 90 interface here
 - still the most commonly used

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(void)  
{
```

```
    ...  
    MPI_Init(NULL, NULL);  
    ...
```

```
program my_mpi_program
```

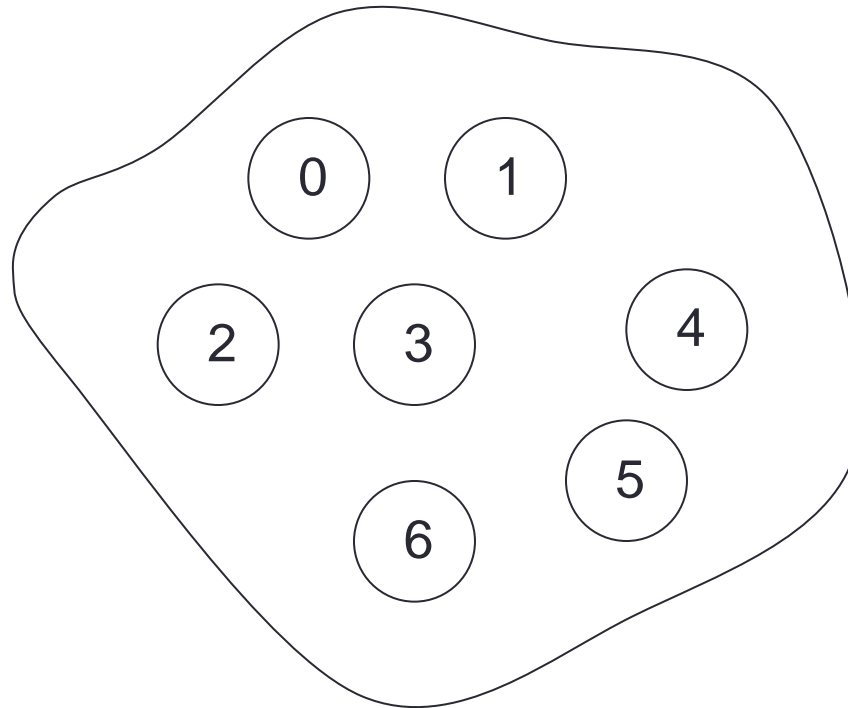
```
    integer :: ierror
```

```
    ...  
    CALL MPI_INIT(IERROR)
```

```
    ...
```

MPI_COMM_WORLD

Communicators



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/core

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

```
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)
```

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