Messages

Reusing this material

Messages

- A message contains a number of elements of some particular datatype.
- MPI datatypes:
  - Basic types.
  - Derived types.
- Derived types can be built up from basic types.
- C types are different from Fortran types.

MPI Basic Datatypes - C

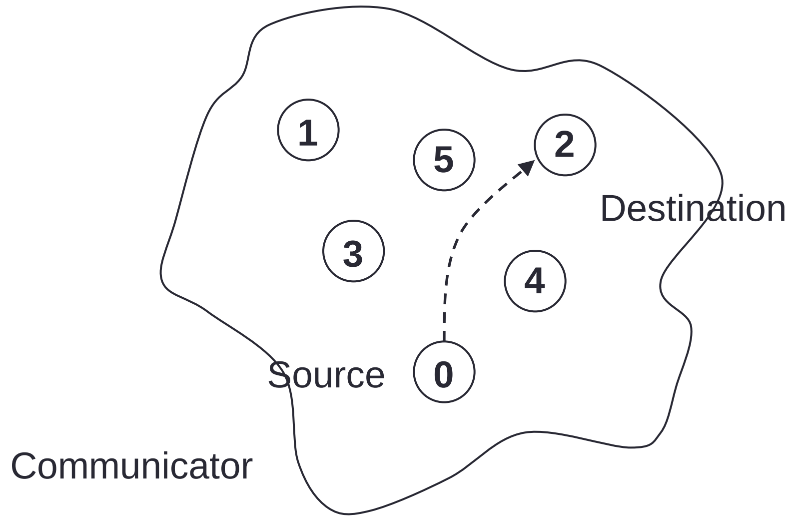
MPI Datatype	C datatype
MPI_CHAR	signed char
MPI_SHORT	signed short int
MPI_INT	signed int
MPI_LONG	signed long int
MPI_UNSIGNED_CHAR	unsigned char
MPI_UNSIGNED_SHORT	unsigned short int
MPI_UNSIGNED	unsigned int
MPI_UNSIGNED_LONG	unsigned long int
MPI_FLOAT	float
MPI_DOUBLE	double
MPI_LONG_DOUBLE	long double
MPI_BYTE	

MPI Basic Datatypes - Fortran

MPI Datatype	Fortran Datatype
MPI_INTEGER	INTEGER
MPI_REAL	REAL
MPI_DOUBLE_PRECISION	DOUBLE PRECISION
MPI_COMPLEX	COMPLEX
MPI_LOGICAL	LOGICAL
MPI_CHARACTER	CHARACTER(1)
MPI_BYTE	

Point-to-Point Communication

Point-to-Point Communication



- Communication between two processes.
- Source process sends message to destination process.
- Communication takes place within a communicator.
- Destination process is identified by its rank in the communicator.

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Point-to-point messaging in MPI

- Sender calls a SEND routine
  - specifying the data that is to be sent
  - this is called the *send buffer*
- Receiver calls a RECEIVE routine
  - specifying where the incoming data should be stored
  - this is called the *receive buffer*
- Data goes into the receive buffer
- Metadata describing message also transferred
  - this is received into separate storage
  - this is called the *status*

Communication modes

Sender mode	Notes
Synchronous send	Only completes when the receive has completed.
Buffered send	Always completes (unless an error occurs), irrespective of receiver.
Standard send	Either synchronous or buffered.
Receive	Completes when a message has arrived.

MPI Sender Modes

OPERATION	MPI CALL
Standard send	**`MPI_Send`**
Synchronous send	**`MPI_Ssend`**
Buffered send	**`MPI_Bsend`**
Receive	**`MPI_Recv`**

Sending a message

- C:

```
int MPI_Ssend(void *buf, int count,
              MPI_Datatype datatype,
              int dest,    int tag,
              MPI_Comm comm);
```

- Fortran:

```
MPI_SSEND(BUF, COUNT, DATATYPE, DEST,
          TAG, COMM, IERROR)

<type> BUF(*)
INTEGER COUNT, DATATYPE, DEST, TAG
INTEGER COMM, IERROR
```

Send data from rank 1 to rank 3

```
// Array of ten integers
int x[10];
...
if (rank == 1)
MPI_Ssend(x, 10, MPI_INT, 3, 0, MPI_COMM_WORLD);
```

dest

tag

```
// Integer scalar
int x;
...
if (rank == 1)
MPI_Ssend(&x, 1, MPI_INT, 3, 0, MPI_COMM_WORLD);
```

Send data from rank 1 to rank 3

dest

tag

```
! Array of ten integers
integer, dimension(10) :: x
...
if (rank .eq. 1)
CALL MPI_SSEND(x, 10, MPI_INTEGER, 3, 0,
               MPI_COMM_WORLD, ierr)
```

```
! Integer scalar
integer :: x
...
if (rank .eq. 1)
CALL MPI_SSEND(x, 1, MPI_INTEGER, 3, 0,
               MPI_COMM_WORLD, ierr)
```

Receiving a message

- C:

```
int MPI_Recv(void *buf, int count,
             MPI_Datatype datatype,
             int source, int tag,
             MPI_Comm comm, MPI_Status *status)
```

- Fortran:

```
MPI_RECV(BUF, COUNT, DATATYPE, SOURCE, TAG, COMM,
         STATUS, IERROR)

<type> BUF(*)
INTEGER COUNT, DATATYPE, SOURCE, TAG, COMM,
        STATUS(MPI_STATUS_SIZE), IERROR
```

Receive data from rank 1 on rank 3

src tag

```
int y[10];
MPI_Status status;
...
if (rank == 3)
MPI_Recv(y, 10, MPI_INT, 1, 0, MPI_COMM_WORLD, &status);
```

```
int y;
...
if (rank == 3)
MPI_Recv(&y, 1, MPI_INT, 1, 0, MPI_COMM_WORLD, &status);
```

Receive data from rank 1 on rank 3

```
integer, dimension(10) :: y
integer, dimension(MPI_STATUS_SIZE) :: status
...
if (rank .eq. 3)
CALL MPI_RECV(y, 10, MPI_INTEGER, 1, 0,
              MPI_COMM_WORLD, status, ierr)
```

src

tag

```
integer :: y
...
if (rank .eq. 3)
CALL MPI_RECV(y, 1, MPI_INTEGER, 1, 0,
              MPI_COMM_WORLD, status, ierr)
```

Synchronous Blocking Message-Passing

- Processes synchronise.
- Sender process specifies the synchronous mode.
- Blocking: both processes wait until the transaction has completed.

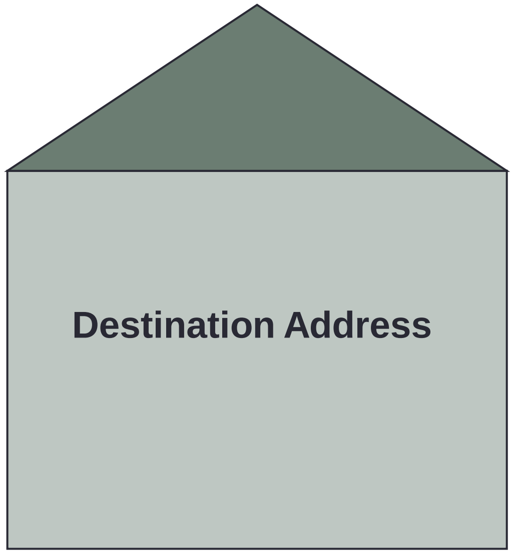
For a communication to succeed:

- Sender must specify a valid destination rank.
- Receiver must specify a valid source rank.
- The communicator must be the same.
- Tags must match.
- Message types must match.
- Receiver's buffer must be large enough.

Wildcarding

- Receiver can wildcard.
- To receive from any source **`MPI_ANY_SOURCE`**
- To receive with any tag **`MPI_ANY_TAG`**
- Actual source and tag are returned in the receiver's **`status`** parameter.

Communication Envelope



Sender’s Address

For the attention of:

Data

Item 1

Item 2

Item 3

Commmunication Envelope Information

- Envelope information is returned from **`MPI_RECV`** as status
- Information includes:
  - Source: **`status.MPI_SOURCE`** or **`status(MPI_SOURCE)`**
  - Tag: **`status.MPI_TAG`** or **`status(MPI_TAG)`**
  - Count: **`MPI_Get_count`** or **`MPI_GET_COUNT`**

Received Message Count

- C:

```
int MPI_Get_count( MPI_Status *status,
                   MPI_Datatype datatype,
                   int *count)
```

- Fortran:

```
MPI_GET_COUNT(STATUS, DATATYPE, COUNT, IERROR)

INTEGER STATUS(MPI_STATUS_SIZE), DATATYPE, COUNT, IERROR
```

Receive data from rank 1 on rank 3

```
int y[10];
int count;
MPI_Status status;
if (rank == 3) {

  MPI_Recv(y, 10, MPI_INT, MPI_ANY_SOURCE, MPI_ANY_TAG,
           MPI_COMM_WORLD, &status);

  printf("Received from rank %d\n", status.MPI_SOURCE);
  printf("Value of tag is    %d\n", status.MPI_TAG);

  MPI_Get_count(&status, MPI_INT, &count);
  printf("Number of integers %d\n", count);
}
```

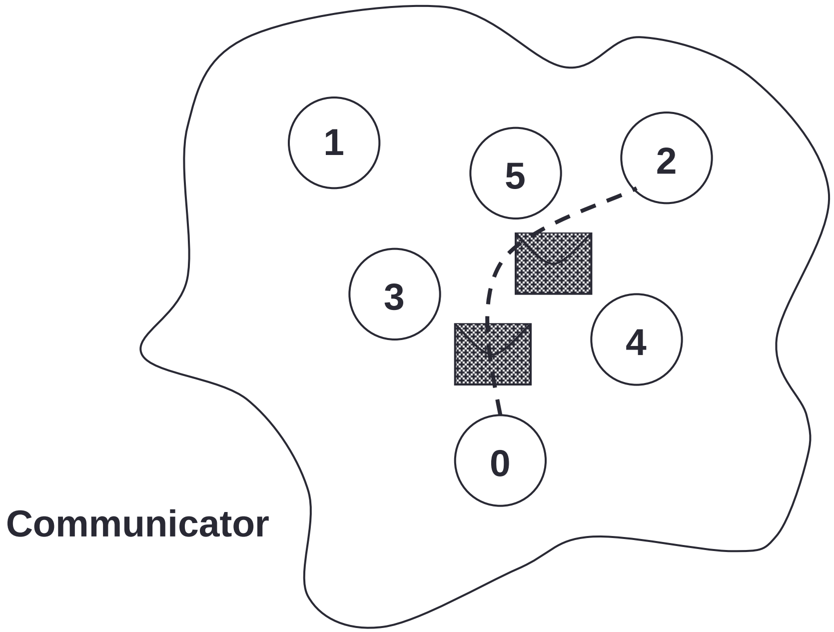
Receive data from rank 1 on rank 3

```
integer, dimension(10) :: y
integer, dimension(MPI_STATUS_SIZE) :: status
integer :: count
if (rank .eq. 3) then
  CALL MPI_RECV(y, 10, MPI_INTEGER, MPI_ANY_SOURCE, &
           MPI_ANY_TAG, MPI_COMM_WORLD, status, ierr)

  write(*,*) "Received from rank ", status(MPI_SOURCE)
  write(*,*) "Value of tag is    ", status(MPI_TAG)

  CALL MPI_GET_COUNT(status, MPI_INTEGER, count, ierr);
  write(*,*) "Number of integers ", count
end if
```

Fortran 2008 interface

```
use mpi_f08

type(MPI_Comm)      :: comm
type(MPI_Datatype) :: datatype
type(MPI_Status)    :: status

integer, dimension(10) :: y
integer :: src

comm     = MPI_COMM_WORLD
datatype = MPI_INTEGER

if (rank == 3)  &
  call MPI_Recv(y, 10, datatype, MPI_ANY_SOURCE, 0, comm, status)

src = status%MPI_SOURCE
```

Message Order Preservation



- Messages do not overtake each other.
- This is true even for non-synchronous sends.

Message Matching (i)

Rank 0:

```
Ssend(msg1, dest=1, tag=1)
Ssend(msg2, dest=1, tag=2)
```

Rank 1:

```
Recv(buf1, src=0, tag=1)
Recv(buf2, src=0, tag=2)
```

- buf1 = msg1; buf2 = msg2
- Sends and receives correctly matched

Message Matching (ii)

Rank 0:

```
Ssend(msg1, dest=1, tag=1)
Ssend(msg2, dest=1, tag=2)
```

Rank 1:

```
Recv(buf2, src=0, tag=2)
Recv(buf1, src=0, tag=1)
```

- Deadlock (due to synchronous send)
- Sends and receives incorrectly matched

Message Matching (iii)

Rank 0:

```
Bsend(msg1, dest=1, tag=1)
Bsend(msg2, dest=1, tag=1)
```

Rank 1:

```
Recv(buf1, src=0, tag=1)
Recv(buf2, src=0, tag=1)
```

- buf1 = msg1; buf2 = msg2
- Messages have same tags but matched in order

Message Matching (iv)

Rank 0:

```
Bsend(msg1, dest=1, tag=1)
Bsend(msg2, dest=1, tag=2)
```

Rank 1:

```
Recv(buf2, src=0, tag=2)
Recv(buf1, src=0, tag=1)
```

- buf1 = msg1; buf2 = msg2
- Do not *have* to receive messages in order!

Message Matching (v)

Rank 0:

```
Bsend(msg1, dest=1, tag=1)
Bsend(msg2, dest=1, tag=2)
```

Rank 1:

```
Recv(buf1, src=0, tag=MPI_ANY_TAG)
Recv(buf2, src=0, tag=MPI_ANY_TAG)
```

- buf1 = msg1; buf2 = msg2
- Messages *guaranteed* to match in send order
  - examine status to find out the actual tag values

Message Order Preservation

- If a receive matches multiple messages in the "inbox"
  - then the messages will be received in the order they were sent
- Only relevant for multiple messages from the same source

Timers

- C:

```
double MPI_Wtime(void);
```

- Fortran:

```
DOUBLE PRECISION MPI_WTIME()
```

- Time is measured in seconds.
- Time to perform a task is measured by consulting the timer before and after
  - subtract values to get elapsed time
- Modify your program to measure its execution time and print it out.

Exercise – Calculation of Pi

- See Exercise 2 on the exercise sheet
- Illustrates how to divide work based on rank
  - and how to send point-to-point messages in an SPMD code
- Notes:
  - the value of *N* in the expansion of pi is not the same as the number of processors
  - you should expect to write a program such as *N*=100 running on 4 processors
  - your code should be able to run on any number of processors
  - do not hard code the number of processors in your program!
- If you finish the pi example you may want to try Exercise 3 (ping-pong) but it is not essential