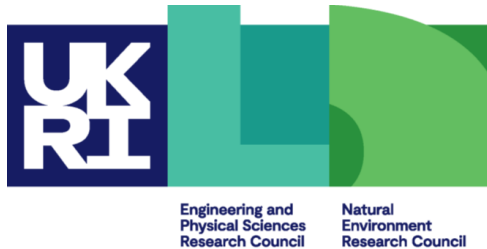


Non-Blocking Communications



Reusing this material



This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

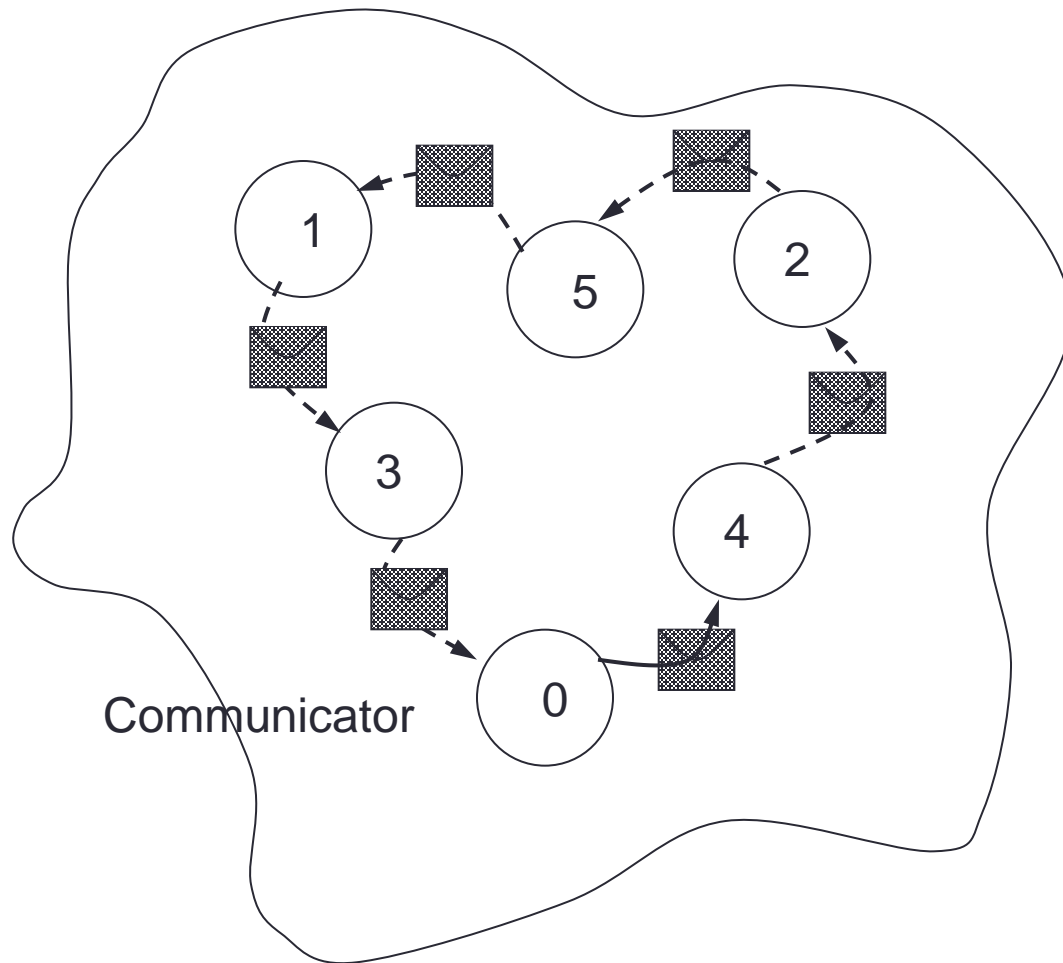
<http://creativecommons.org/licenses/by-nc-sa/4.0/>

This means you are free to copy and redistribute the material and adapt and build on the material under the following terms: You must give appropriate credit, provide a link to the license and indicate if changes were made. If you adapt or build on the material you must distribute your work under the same license as the original.

Acknowledge EPCC as follows: “© EPCC, The University of Edinburgh, www.epcc.ed.ac.uk”

Note that this presentation contains images owned by others. Please seek their permission before reusing these images.

Deadlock



Completion

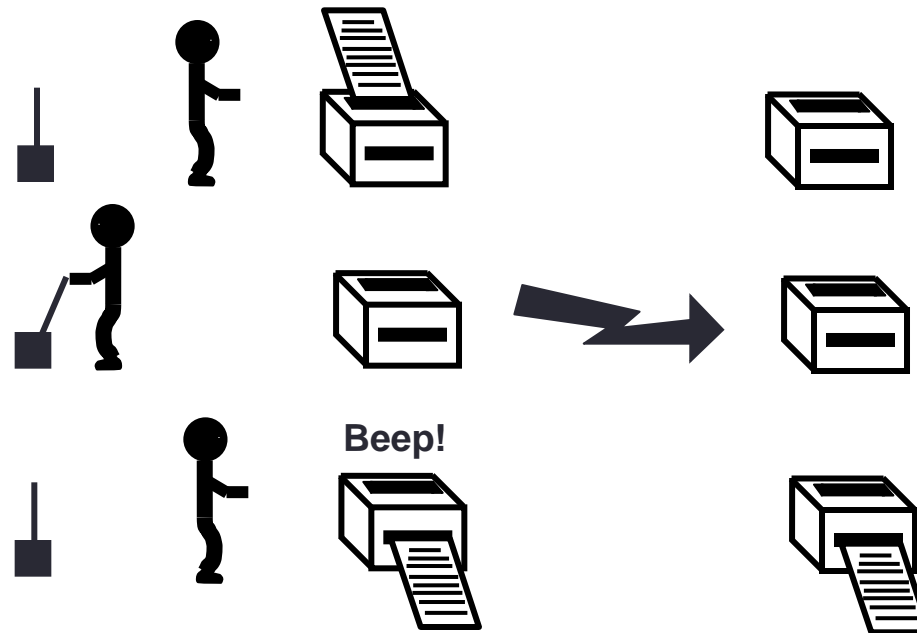
- The *mode* of a communication determines when its constituent operations complete.
 - i.e. synchronous / asynchronous
- The *form* of an operation determines when the procedure implementing that operation will return
 - i.e. when control is returned to the user program

Blocking Operations

- Relate to when the operation has completed.
- Only return from the subroutine call when the operation has completed.
- These are the routines you used thus far
 - `MPI_Ssend`
 - `MPI_Recv`

Non-Blocking Operations

- Return straight away and allow the sub-program to continue to perform other work. At some later time the sub-program can *test* or *wait* for the completion of the non-blocking operation.



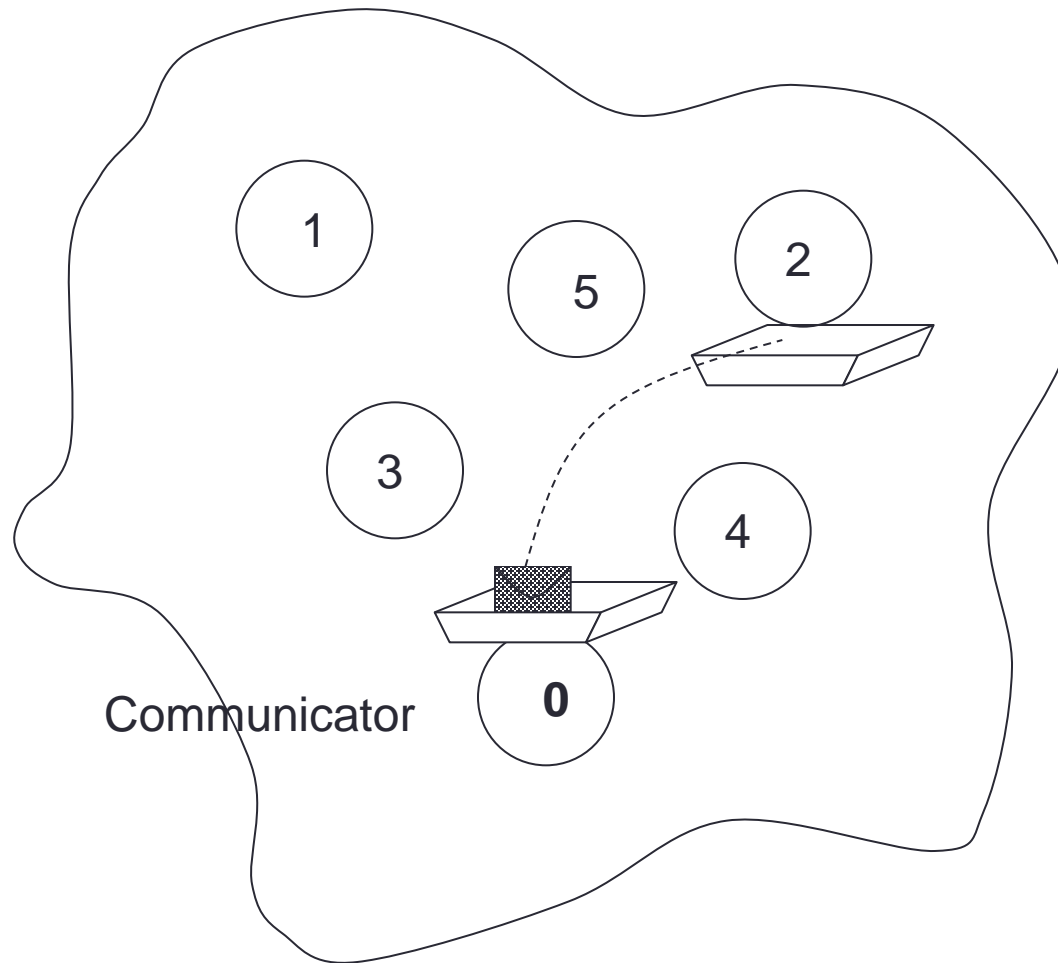
Non-Blocking Operations

- All non-blocking operations should have matching wait operations. Some systems cannot free resources until wait has been called.
- A non-blocking operation immediately followed by a matching wait is equivalent to a blocking operation.
- Non-blocking operations are not the same as sequential subroutine calls as the operation continues after the call has returned.

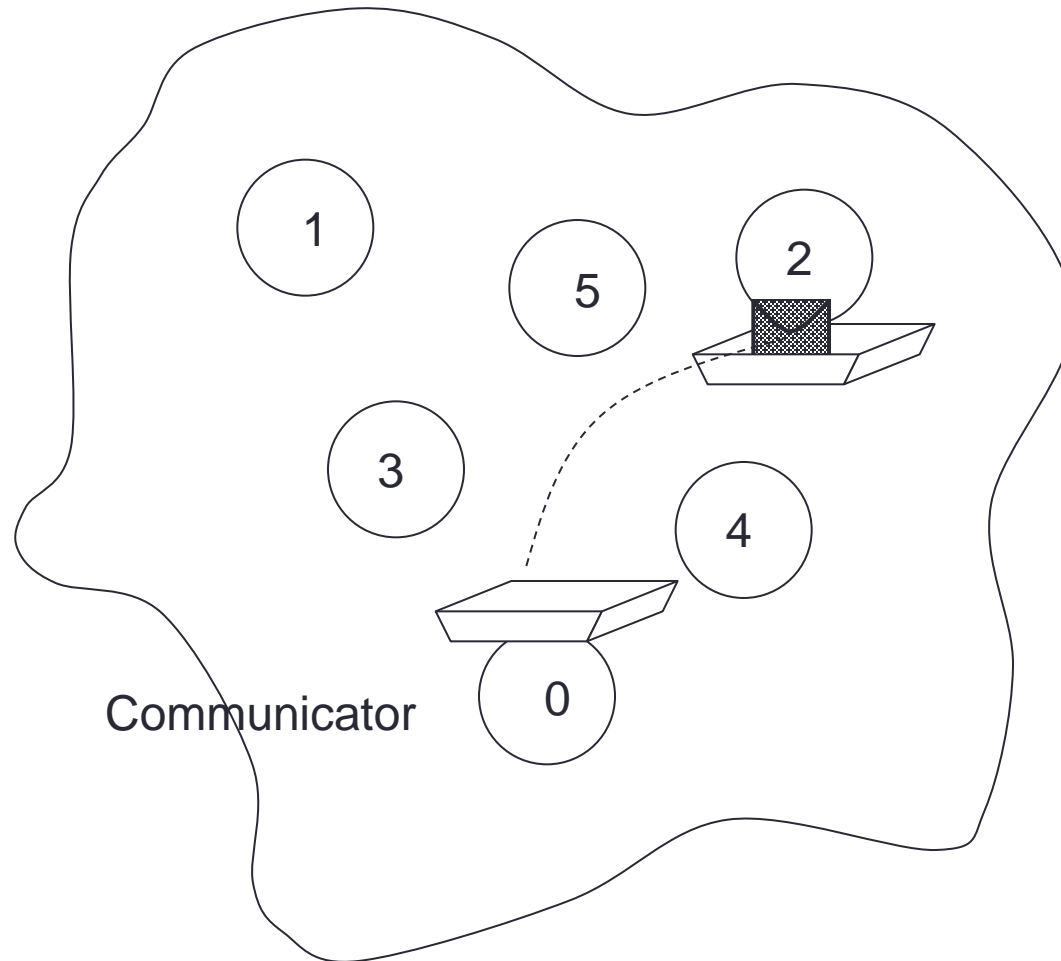
Non-Blocking Communications

- Separate communication into three phases:
- Initiate non-blocking communication.
- Do some work (perhaps involving other communications?)
- Wait for non-blocking communication to complete.

Non-Blocking Send



Non-Blocking Receive



Handles used for Non-blocking Comms

- datatype same as for blocking (**MPI_Datatype** or **INTEGER**).
- communicator same as for blocking (**MPI_Comm** or **INTEGER**).
- request **MPI_Request** or **INTEGER**.
- *A request handle* is allocated when a communication is initiated.

Non-blocking Synchronous Send

- C:

```
int MPI_Issend(void* buf, int count,  
              MPI_Datatype datatype, int dest,  
              int tag, MPI_Comm comm,  
              MPI_Request *request)
```

```
int MPI_Wait(MPI_Request *request,  
            MPI_Status *status)
```

- Fortran:

```
MPI_ISSEND(buf, count, datatype, dest,  
          tag, comm, request, ierror)
```

```
MPI_WAIT(request, status, ierror)
```

Non-blocking Receive

- C:

```
int MPI_Irecv(void* buf, int count,  
              MPI_Datatype datatype, int src,  
              int tag, MPI_Comm comm,  
              MPI_Request *request)
```

```
int MPI_Wait(MPI_Request *request,  
             MPI_Status *status)
```

- Fortran:

```
MPI_IRecv(buf, count, datatype, src,  
          tag, comm, request, ierror)
```

```
MPI_WAIT(request, status, ierror)
```

Blocking and Non-Blocking

- Send and receive can be blocking or non-blocking.
- A blocking send can be used with a non-blocking receive, and vice-versa.
- Non-blocking sends can use any mode - synchronous, buffered or standard

Communication Modes

NON-BLOCKING OPERATION	MPI CALL
Standard send	MPI_ISEND
Synchronous send	MPI_ISSEND
Buffered send	MPI_IBSEND
Receive	MPI_Irecv

Completion

- Waiting versus Testing.
- C:

```
int MPI_Wait(MPI_Request *request,  
             MPI_Status *status)  
  
int MPI_Test(MPI_Request *request,  
             int *flag,  
             MPI_Status *status)
```

- Fortran:

```
MPI_WAIT(handle, status, ierror)  
  
MPI_TEST(handle, flag, status, ierror)
```


Example (C)

```
MPI_Request request;
MPI_Status status;

if (rank == 0)
{
    MPI_Issend(sendarray, 10, MPI_INT, 1, tag,
               MPI_COMM_WORLD, &request);
    Do_something_else_while Issend_happens();
    // now wait for send to complete
    MPI_Wait(&request, &status);
}
else if (rank == 1)
{
    MPI_Irecv(recvarray, 10, MPI_INT, 0, tag,
               MPI_COMM_WORLD, &request);
    Do_something_else_while Irecv_happens();
    // now wait for receive to complete;
    MPI_Wait(&request, &status);
}
```

Example (Fortran)

```
integer :: request
integer, dimension(MPI_STATUS_SIZE) :: status

if (rank == 0) then

    CALL MPI_Issend(sendarray, 10, MPI_INTEGER, 1, tag,
                   MPI_COMM_WORLD, request, ierror)
    CALL Do_something_else_while Issend_happens()
    ! now wait for send to complete
    CALL MPI_Wait(request, status, ierror)

else if (rank == 1) then

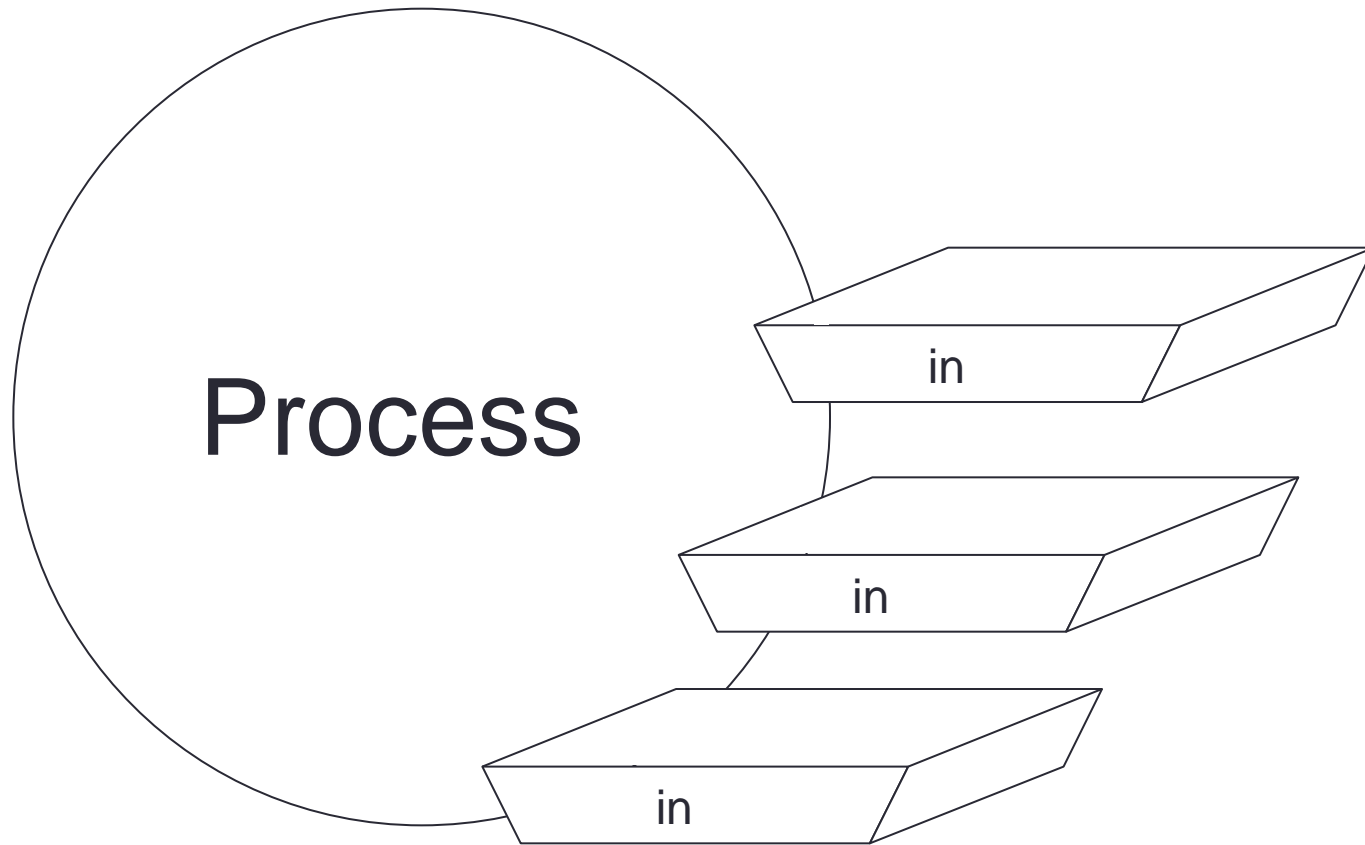
    CALL MPI_Irecv(recvarray, 10, MPI_INTEGER, 0, tag,
                  MPI_COMM_WORLD, request, ierror)
    CALL Do_something_else_while Irecv_happens()
    ! now wait for receive to complete
    CALL MPI_Wait(request, status, ierror)

endif
```

Important notes

- Synchronous mode affects what completion means
 - after a wait on `MPI_Issend`, you know the routine has completed
 - the message has been sent
 - it is safe to overwrite the send buffer
 - after a wait on `MPI_Isend`, you know the routine has completed
 - the message may have been sent, or may have been copied by MPI
 - it is safe to overwrite the send buffer
 - the request can be re-used after a wait
 - with multiple non-blocking comms you must have multiple requests
- You *must not* access send or receive buffers until communications are complete
 - cannot overwrite send buffer until after a wait on **`Issend`** / **`Isend`**
 - cannot read from a receive buffer until after a wait on **`Irecv`**

Testing Multiple Non-Blocking Comms



Multiple Communications

- Wait or test for completion of *all* messages.
 - `MPI_Waitall` / `MPI_Testall`
 - supply an array of requests and array of statuses
 - waits until all complete / tests if all complete and returns flag
- Test or wait for completion of one message.
 - `MPI_Waitany` / `MPI_Testany`
 - supply an array of requests and a single status
 - waits until any one is complete / tests if any complete and returns flag
 - also returns index of which request completed (if flag is true for test)
- Test or wait for completion of as many messages as possible.
 - `MPI_Waitsome` / `MPI_Testsome`
 - arrays of requests, statuses, indices; returns count of relevant requests

Combined Send and Receive

- Specify all send / receive arguments in one call
 - MPI implementation avoids deadlock
 - useful in simple pairwise communications patterns, but not as generally applicable as non-blocking

```
int MPI_Sendrecv(void *sendbuf, int sendcount, MPI_Datatype sendtype,  
                int dest, int sendtag,  
                void *recvbuf, int recvcount, MPI_Datatype recvtype,  
                int source, int recvtag,  
                MPI_Comm comm, MPI_Status *status);
```

```
MPI_SENDRECV(sendbuf, sendcount, sendtype, dest, sendtag,  
             recvbuf, recvcount, recvtype, source, recvtag,  
             comm, status, ierror)
```

Exercise: Rotating data around a ring

- See Exercise 5 on the sheet
- Arrange processes to communicate round a ring.
- Each process stores a copy of its rank in an integer variable.
- Each process communicates this value to its right neighbour, and receives a value from its left neighbour.
- Each process computes the sum of all the values received.
- Repeat for the number of processes involved and print out the sum stored at each process.

Possible solutions

- Non-blocking send to forward neighbour
 - blocking receive from backward neighbour
 - wait for forward send to complete
- Non-blocking receive from backward neighbour
 - blocking send to forward neighbour
 - wait for backward receive to complete
- Non-blocking send to forward neighbour
- Non-blocking receive from backward neighbour
 - wait for forward send to complete
 - wait for backward receive to complete

Notes

- Your neighbours *do not change*
 - send to left, receive from right, send to left, receive from right, ...
- You *do not alter* the data you receive
 - receive it
 - add it to your running total
 - pass the data *unchanged* along the ring
- You *must not access* send or receive buffers until communications are complete
 - cannot read from a receive buffer until after a wait on **Irecv**
 - cannot overwrite a send buffer until after a wait on **Isend**