Non-Blocking Communications

Engineering and Physical Sciences Research Council

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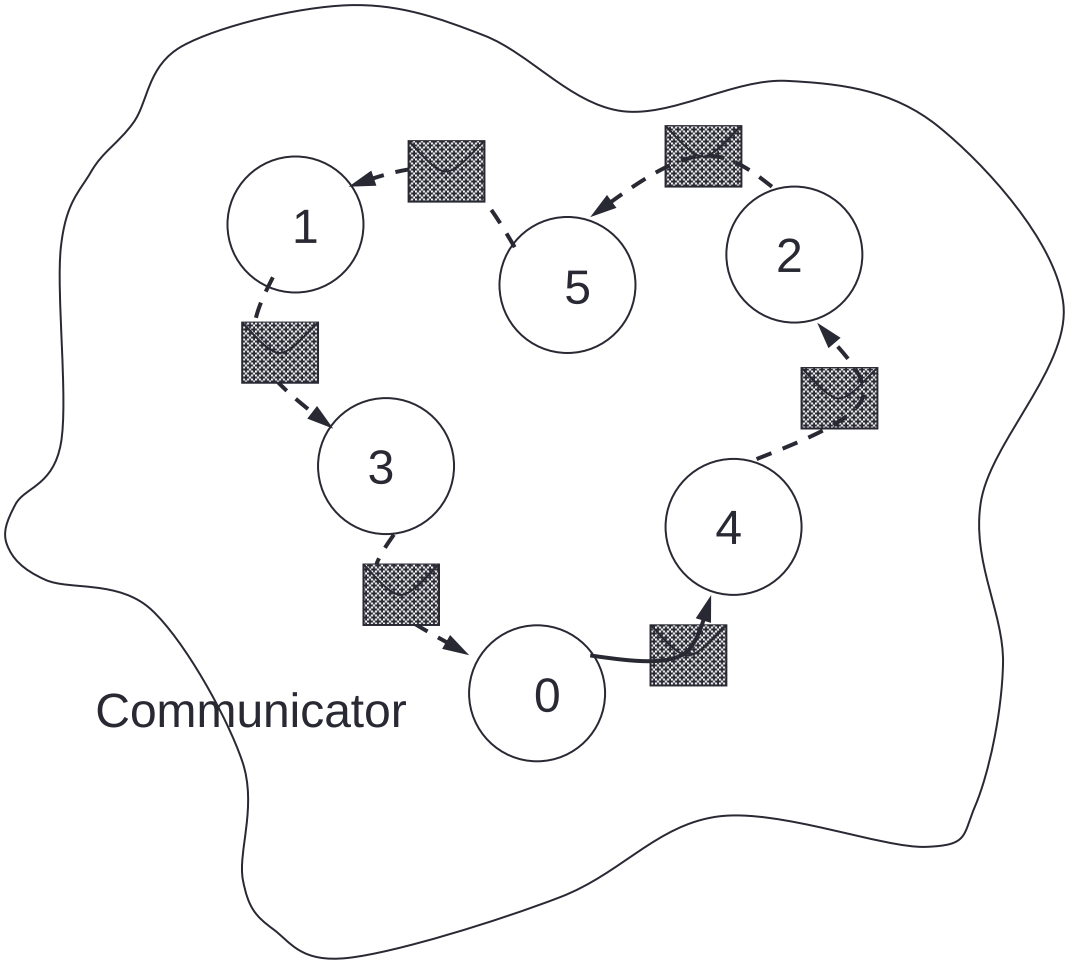
Reusing this material

Deadlock



Completion

- The *mode* of a communication determines when its constituent operations complete.
  - i.e. synchronous / asynchronous

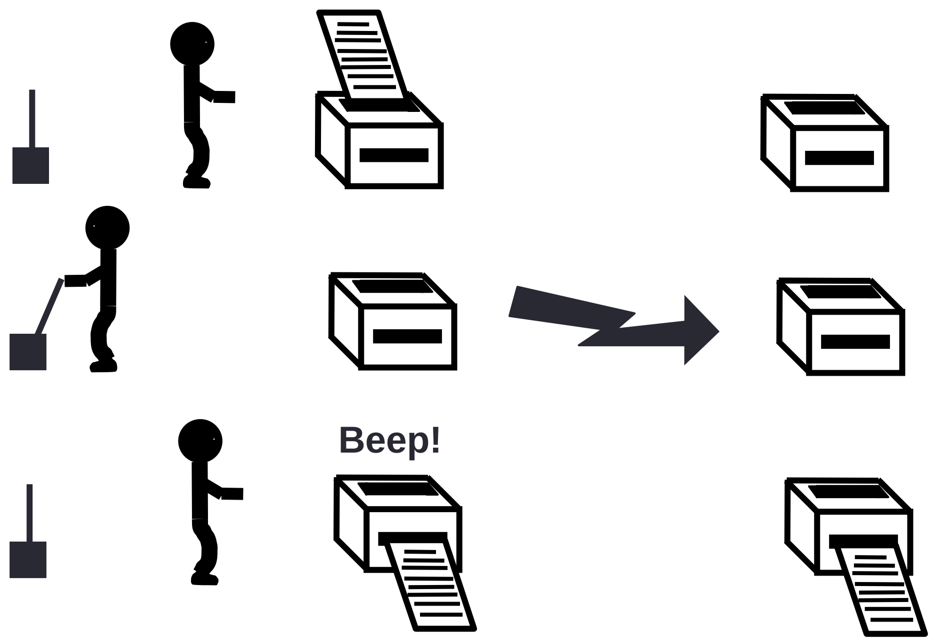
- The *form* of an operation determines when the procedure implementing that operation will return
  - i.e. when control is returned to the user program

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.



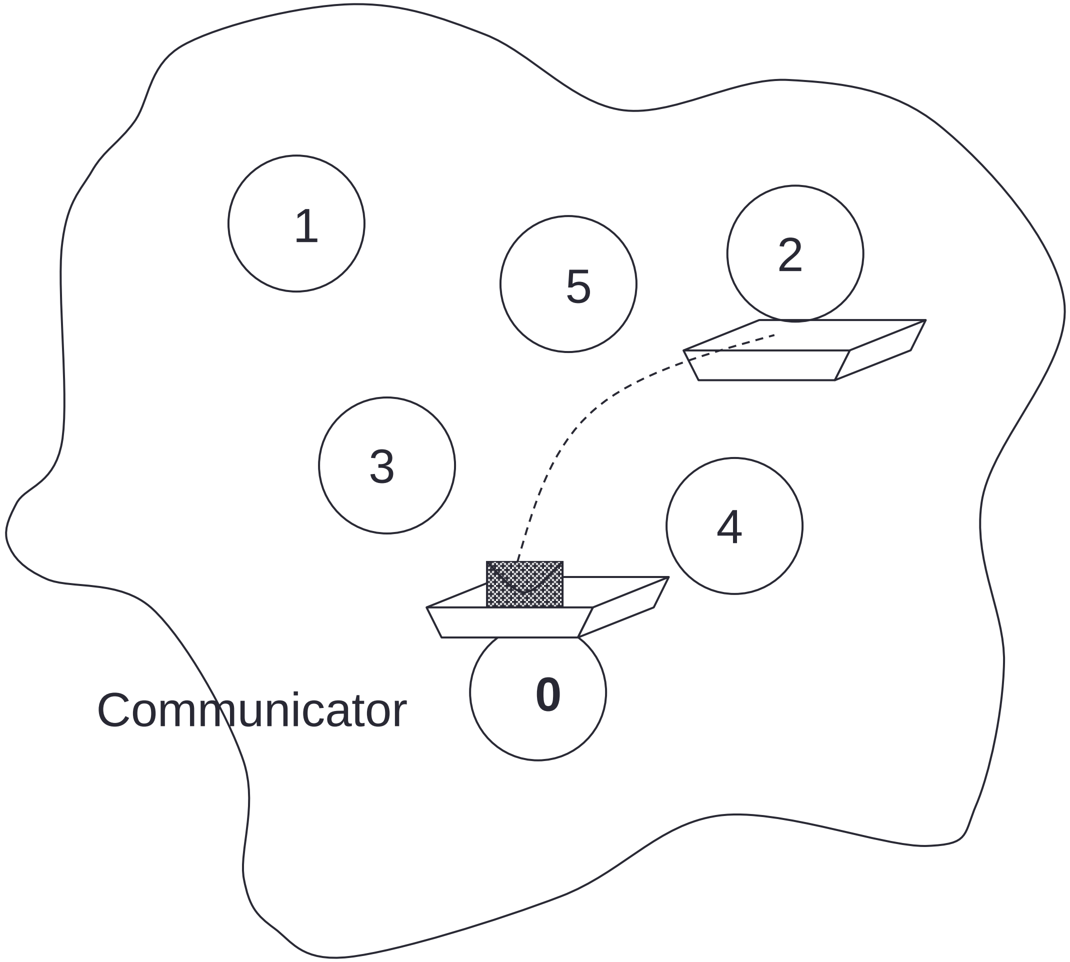
Non-Blocking Operations

- 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.

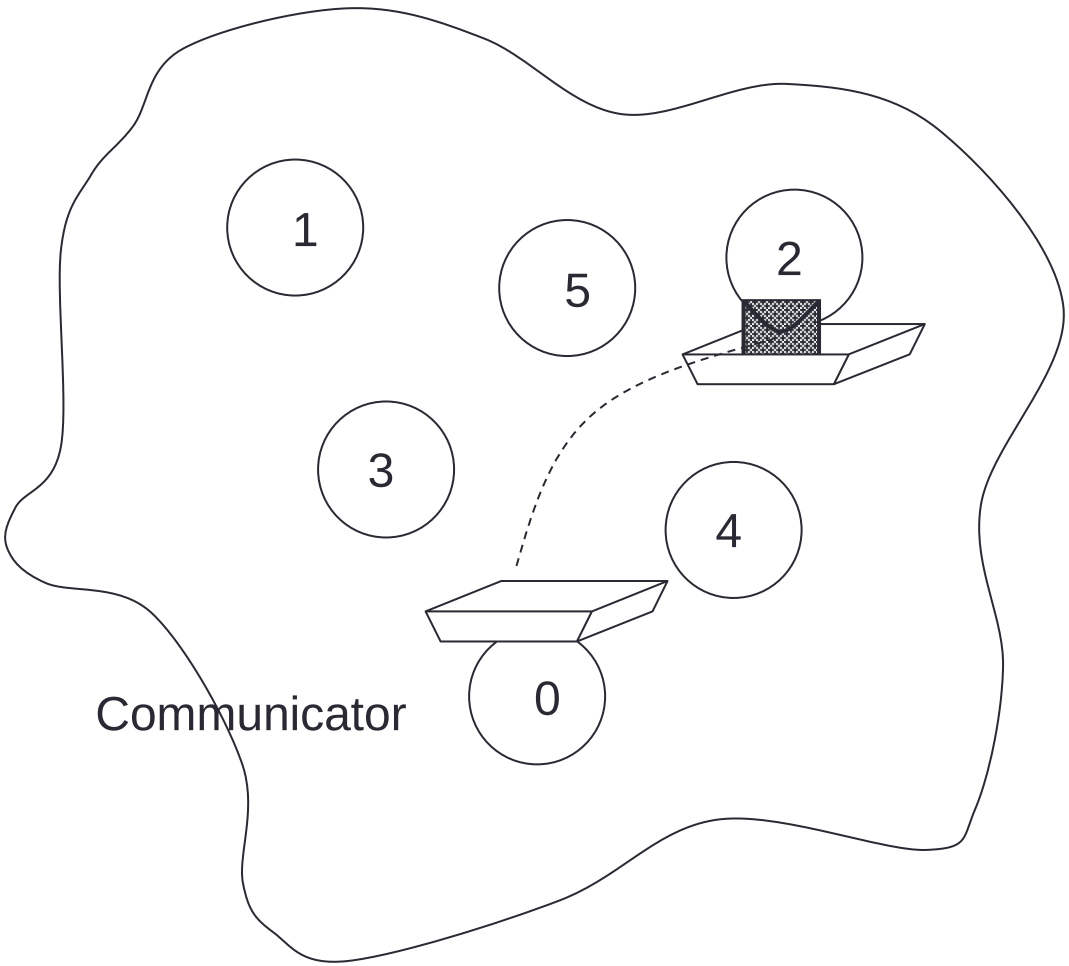
Non-Blocking Communications

- 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
- Synchronous mode affects completion, not initiation.

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)
```

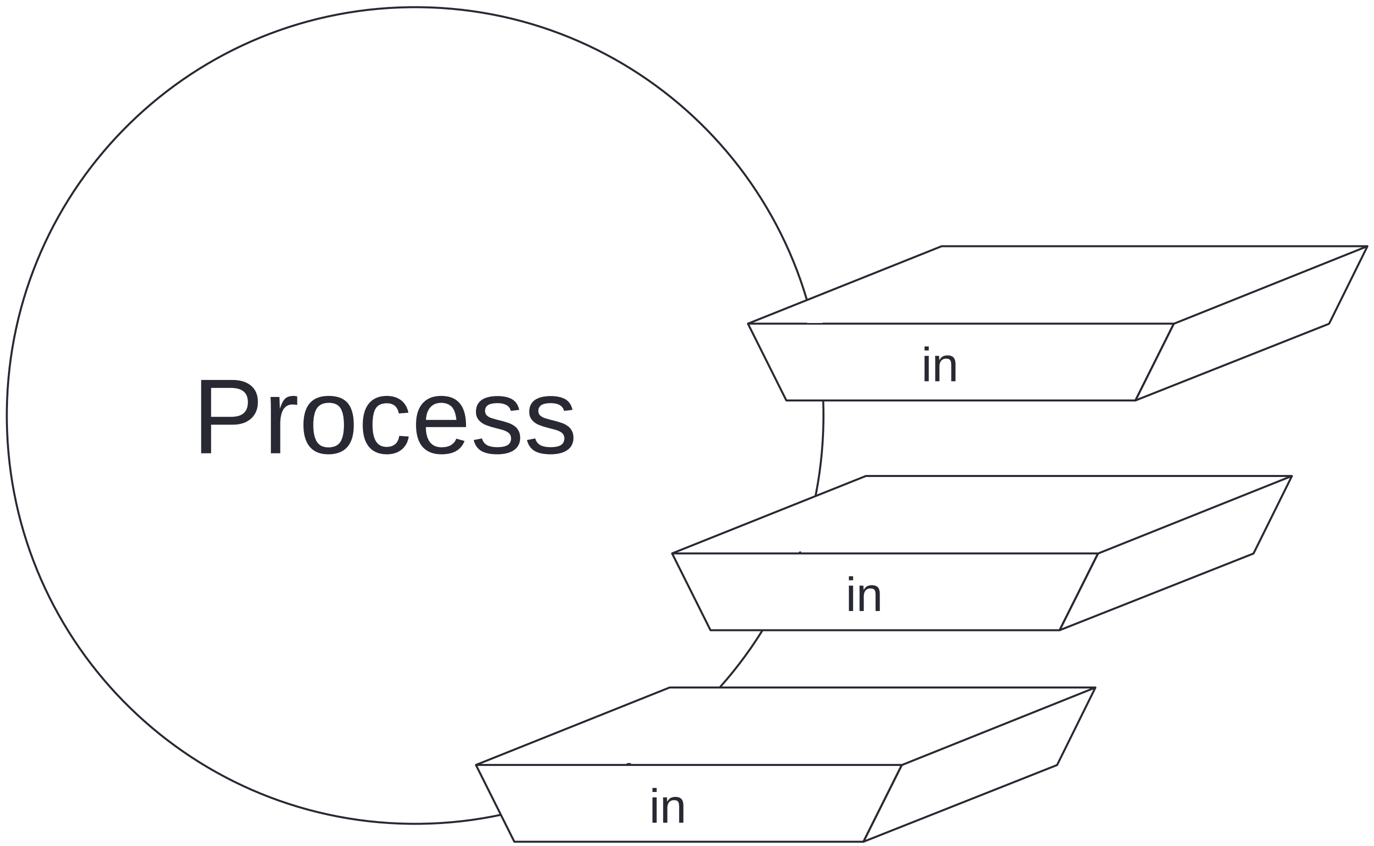
Example (C)

```
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
```

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 information around a ring

- See Exercise 4 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 you 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 **`issend`**