# Message Passing Programming

Modes, Tags and Communicators





#### Overview

- Lecture will cover
  - explanation of MPI modes (Ssend, Bsend and Send)
  - meaning and use of message tags
  - rationale for MPI communicators
- These are all commonly misunderstood
  - essential for all programmers to understand modes
  - often useful to use tags
  - certain cases benefit from exploiting different communicators





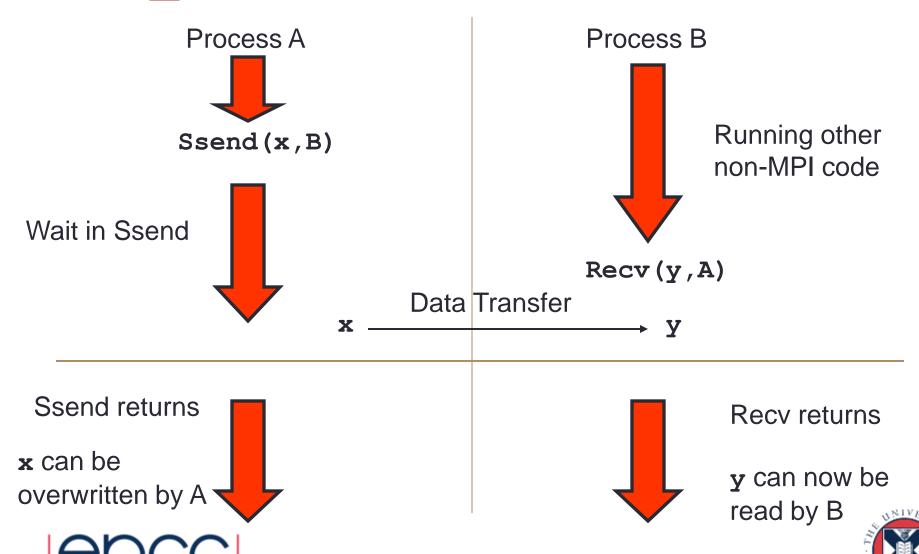
#### Modes

- MPI\_Ssend (Synchronous Send)
  - guaranteed to be synchronous
  - routine will not return until message has been delivered
- MPI Bsend (Buffered Send)
  - guaranteed to be asynchronous
  - routine returns before the message is delivered
  - system copies data into a buffer and sends it later on
- MPI\_Send (standard Send)
  - may be implemented as synchronous or asynchronous send
  - this causes a lot of confusion (see later)

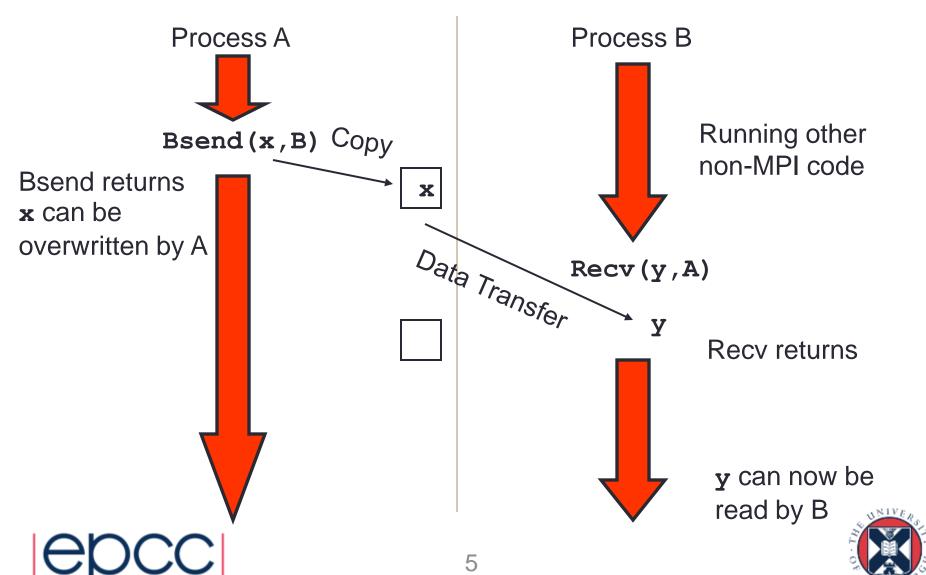




### MPI\_Ssend



#### MPI\_Bsend



#### **Notes**

- Recv is always synchronous
  - if process B issued Recv before the Bsend from process A, then B would wait in the Recv until Bsend was issued
- Where does the buffer space come from?
  - for Bsend, the user provides a single large block of memory
  - make this available to MPI using MPI\_Buffer\_attach
- If A issues another Bsend before the Recv
  - system tries to store message in free space in the buffer
  - if there is not enough space then Bsend will FAIL!





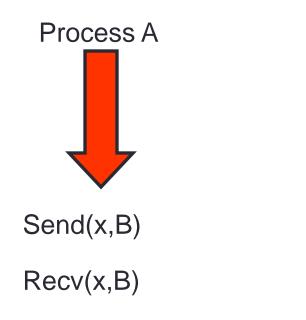
#### Send

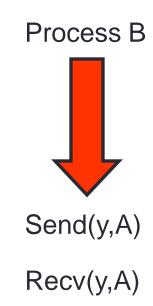
- Problems
  - Ssend runs the risk of deadlock
  - Bsend less likely to deadlock, and your code may run faster, but
    - the user must supply the buffer space
    - the routine will FAIL if this buffering is exhausted
- MPI\_send tries to solve these problems
  - buffer space is provided by the system
  - Send will normally be asynchronous (like Bsend)
  - if buffer is full, **Send** becomes synchronous (like **Ssend**)
- MPI\_send routine is unlikely to fail
  - but could cause your program to deadlock if buffering runs out





# MPI\_Send





- This code is NOT guaranteed to work
  - will deadlock if Send is synchronous
  - is guaranteed to deadlock if you use Ssend!





#### Solutions

- To avoid deadlock
  - either match sends and receives explicitly
  - e.g. for ping-pong
    - process A sends then receives
    - process B receives then sends
- For a more general solution use non-blocking communications (see later)
- For this course you should program with Ssend
  - more likely to pick up bugs such as deadlock than Send





# Checking for Messages

- MPI allows you to check if any messages have arrived
  - you can "probe" for matching messages
  - same syntax as receive except no receive buffer specified
- e.g. in C:

- Status is set as if the receive took place
  - e.g. you can find out the size of the message and allocate space prior to receive
- Be careful with wildcards
  - you can use, e.g., MPI\_ANY\_SOURCE in call to probe
  - but must use **specific** source in receive to guarantee matching same message
  - e.g. MPI\_Recv(buff, count, datatype, status.MPI\_SOURCE, ...)





## **Tags**

- Every message can have a tag
  - this is a non-negative integer value
  - maximum value can be queried using MPI\_TAG\_UB attribute
  - MPI guarantees to support tags of at least 32767
  - not everyone uses them; many MPI programs set all tags to zero
- Tags can be useful in some situations
  - can choose to receive messages only of a given tag
- Most commonly used with MPI\_ANY\_TAG
  - receives the most recent message regardless of the tag
  - user then finds out the actual value by looking at the status





#### Communicators

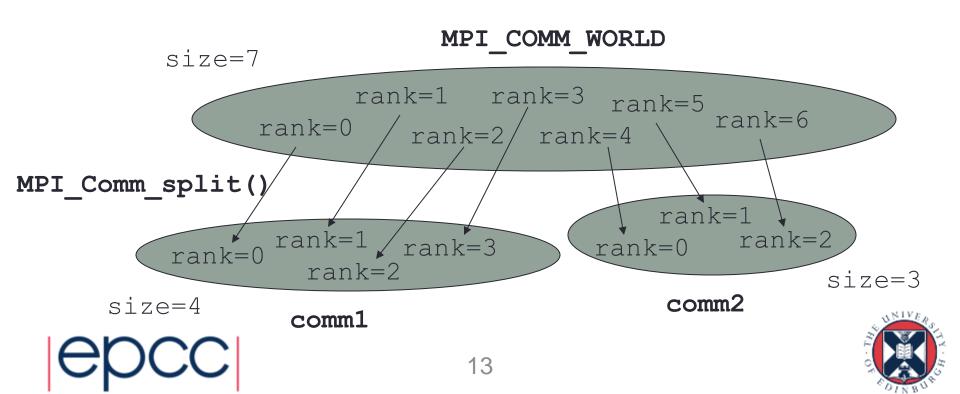
- All MPI communications take place within a communicator
  - a communicator is fundamentally a group of processes
  - there is a pre-defined communicator: **MPI\_COMM\_WORLD** which contains ALL the processes
    - also MPI\_COMM\_SELF which contains only one process
- A message can ONLY be received within the same communicator from which it was sent
  - unlike tags, it is not possible to wildcard on comm





## Uses of Communicators (i)

- Can split MPI\_COMM\_WORLD into pieces
  - each process has a new rank within each sub-communicator
  - guarantees messages from the different pieces do not interact
    - can attempt to do this using tags but there are no guarantees



## Uses of Communicators (ii)

- Can make a copy of MPI COMM WORLD
  - e.g. call the MPI Comm dup routine
  - containing all the same processes but in a new communicator
- Enables processes to communicate with each other safely within a piece of code
  - guaranteed that messages cannot be received by other code
  - this is **essential** for people writing parallel libraries (e.g. a Fast Fourier Transform) to stop library messages becoming mixed up with user messages
    - user cannot intercept the the library messages if the library keeps the identity of the new communicator a secret
    - not safe to simply try and reserve tag values due to wildcarding





## Summary (i)

- Question: Why bother with all these send modes?
- Answer
  - it is a little complicated, but you should make sure you understand
  - Ssend and Bsend are clear
    - map directly onto synchronous and asynchronous sends
  - Send can be either synchronous or asynchronous
    - MPI is trying to be helpful here, giving you the benefits of Bsend if there is sufficient system memory available, but not failing completely if buffer space runs out
    - in practice this leads to endless confusion!
- The amount of system buffer space is variable
  - programs that run on one machine may deadlock on another
  - you should NEVER assume that Send is asynchronous!





# Summary (ii)

- Question: What are the tags for?
- Answer
  - if you don't need them don't use them!
    - perfectly acceptable to set all tags to zero
  - can be useful for debugging
    - e.g. always tag messages with the rank of the sender





## Summary (iii)

- Question: Can I just use MPI COMM WORLD?
- Answer
  - yes: many people never need to create new communicators in their MPI programs
  - however, it is probably bad practice to specify MPI\_COMM\_WORLD explicitly in your routines
    - using a variable will allow for greater flexibility later on, e.g.:



