

# Message Passing Programming

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Modes, Tags and Communicators

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# 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

Process A



`Ssend(x, B)`

Wait in Ssend

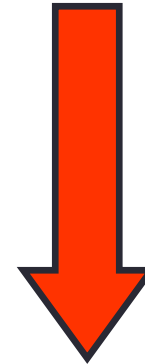


Ssend returns

`x` can be  
overwritten by A



Process B



Running other  
non-MPI code

`Recv(y, A)`

Data Transfer

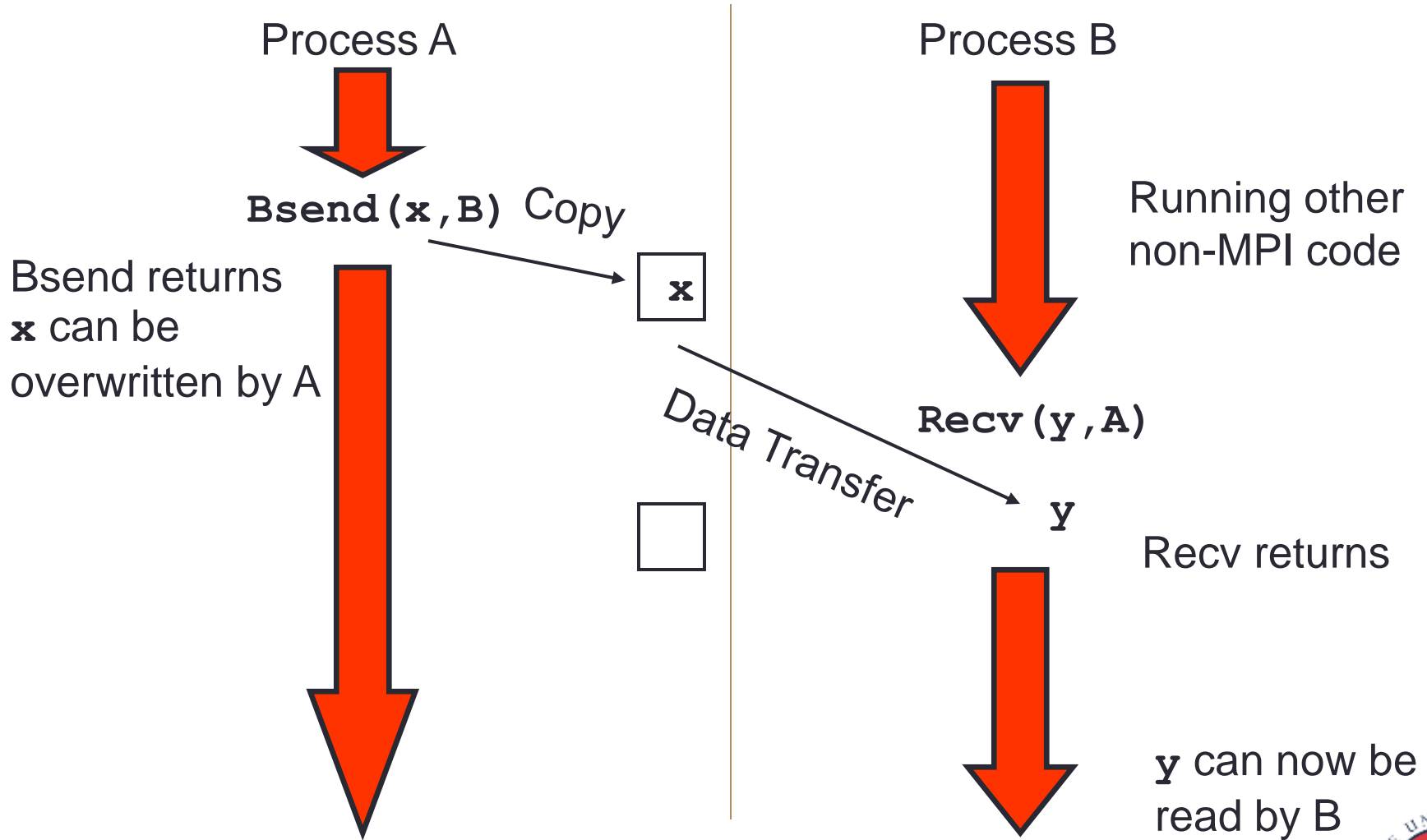


Recv returns

`y` can now be  
read by B



# 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

Process A



Send(x,B)  
Recv(x,B)

Process B



Send(y,A)  
Recv(y,A)

- 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:

```
int MPI_Probe(int source, int tag,  
              MPI_Comm comm, MPI_Status *status)
```
- 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

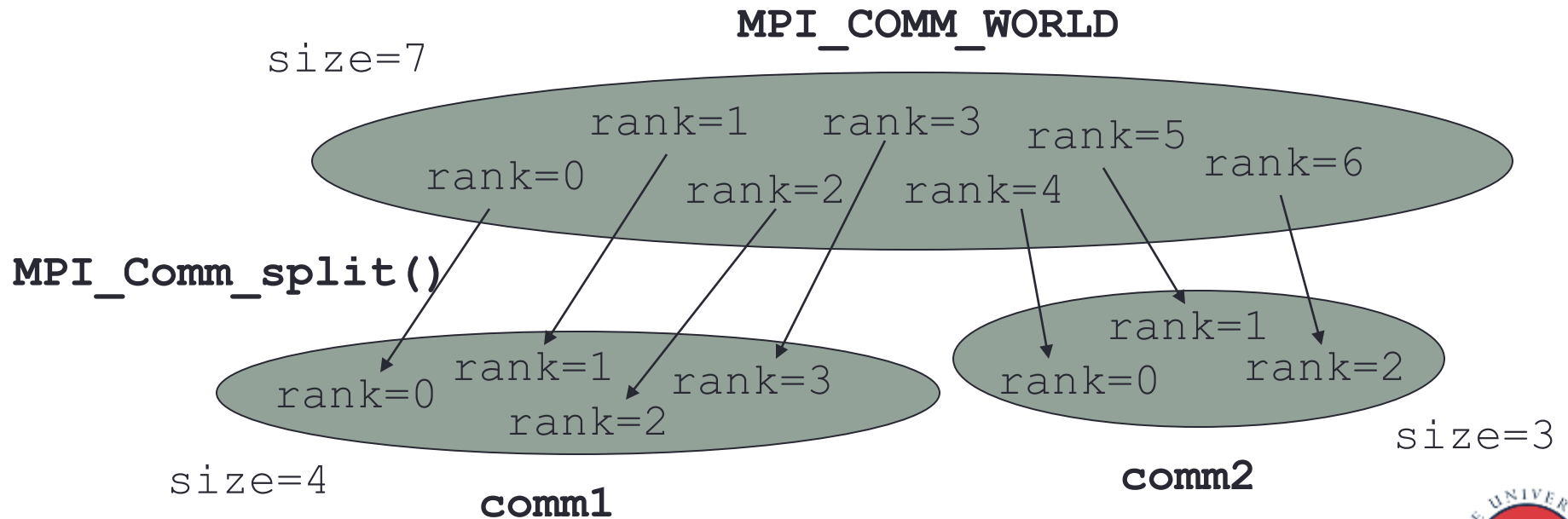
- Every message can have a tag
  - this is a non-negative integer value
  - maximum value can be queried using **MPI\_TAG\_UB** attribute
  - MPI guarantees to support tags of at least 32767
  - not everyone uses them; many MPI programs set all tags to zero
- Tags can be useful in some situations
  - 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.:

```
MPI_Comm comm;           /* or INTEGER for Fortran */  
comm = MPI_COMM_WORLD;  
...  
MPI_Comm_rank(comm, &rank);  
MPI_Comm_size(comm, &size);  
....
```