

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

Process A



$\text{Ssend}(x, B)$

Wait in Ssend



Ssend returns

x can be
overwritten by A



Process B



Running other
non-MPI code

$\text{Recv}(y, A)$

Data Transfer

x

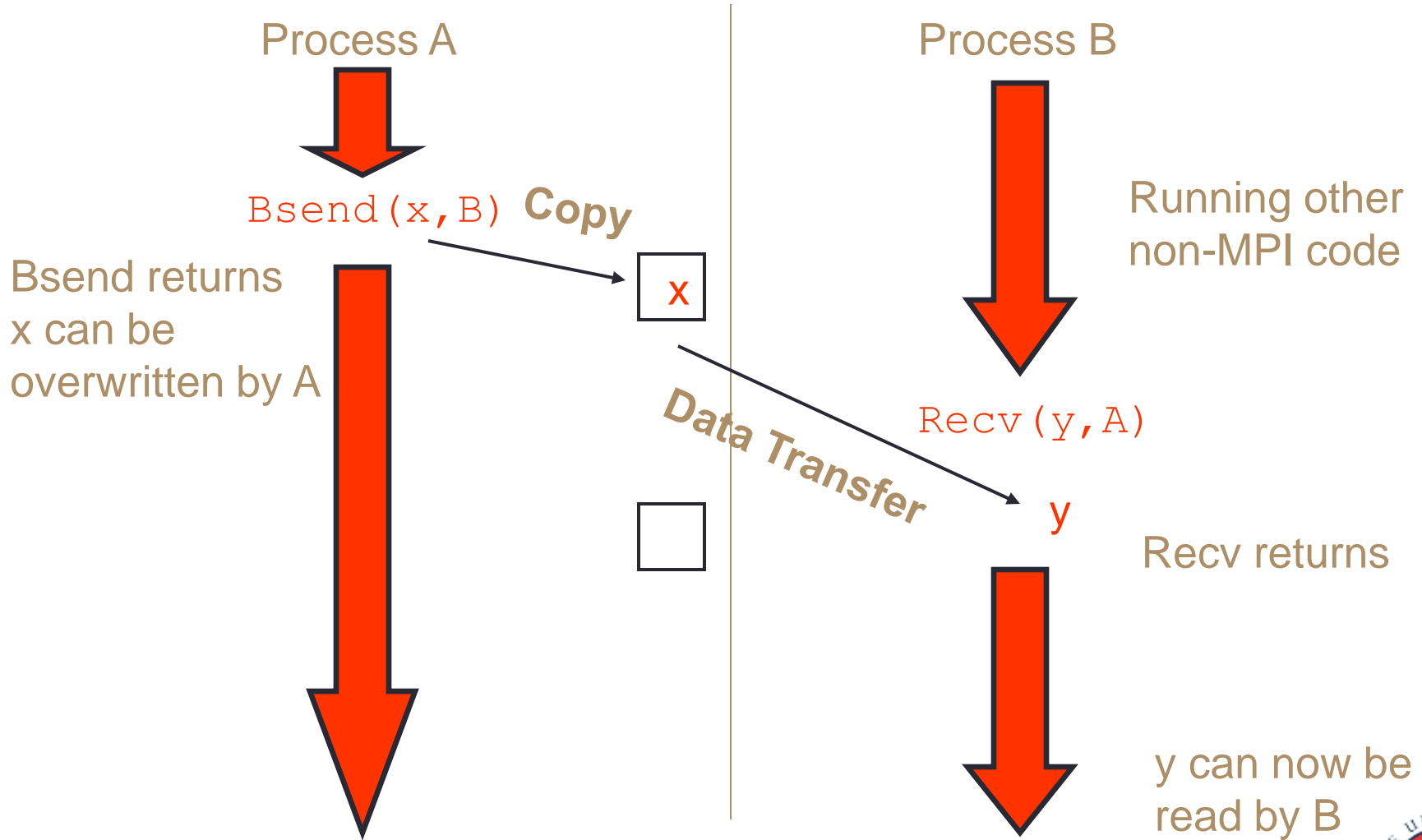
y

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 used **Ssend**!

Solutions

- To avoid deadlock
 - ✦ either match sends and receives explicitly
 - ✦ eg 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

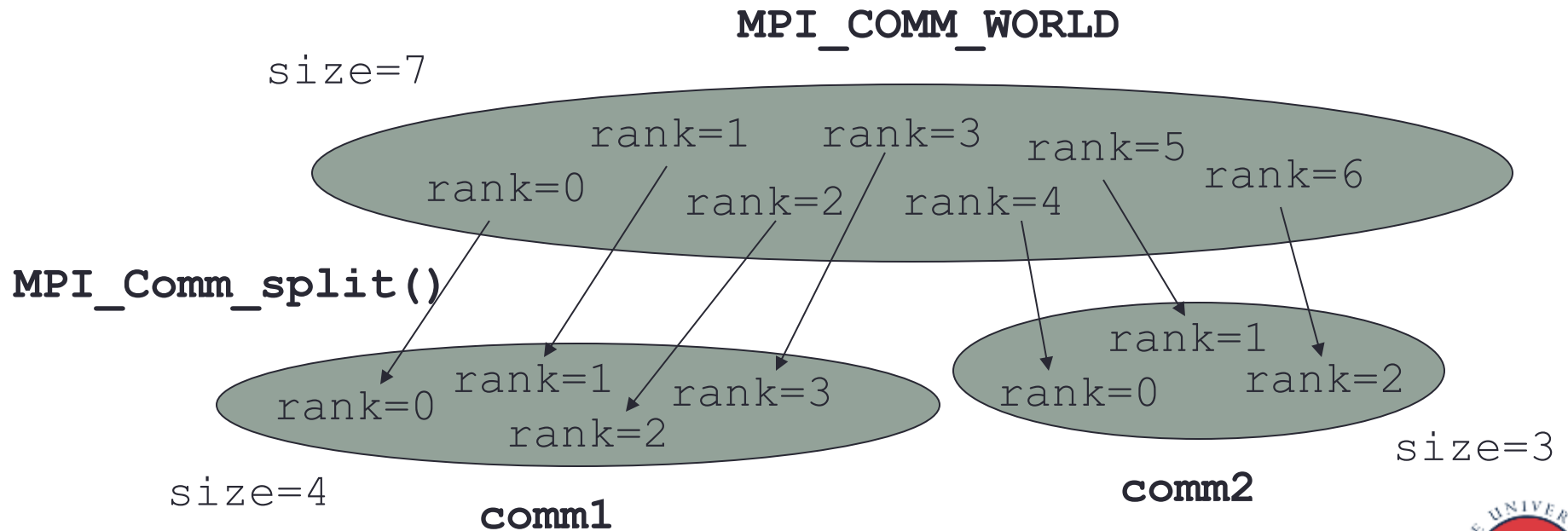
- Every message can have a tag
 - ✦ this is a non-negative integer value
 - ✦ maximum value can be queried using `MPI_TAG_UB` attribute
 - ✦ MPI guarantees to support tags of at least 32767
 - ✦ not everyone uses them; many MPI programs set all tags to zero
- Tags can be useful in some situations
 - ✦ 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 (eg 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);  
....
```