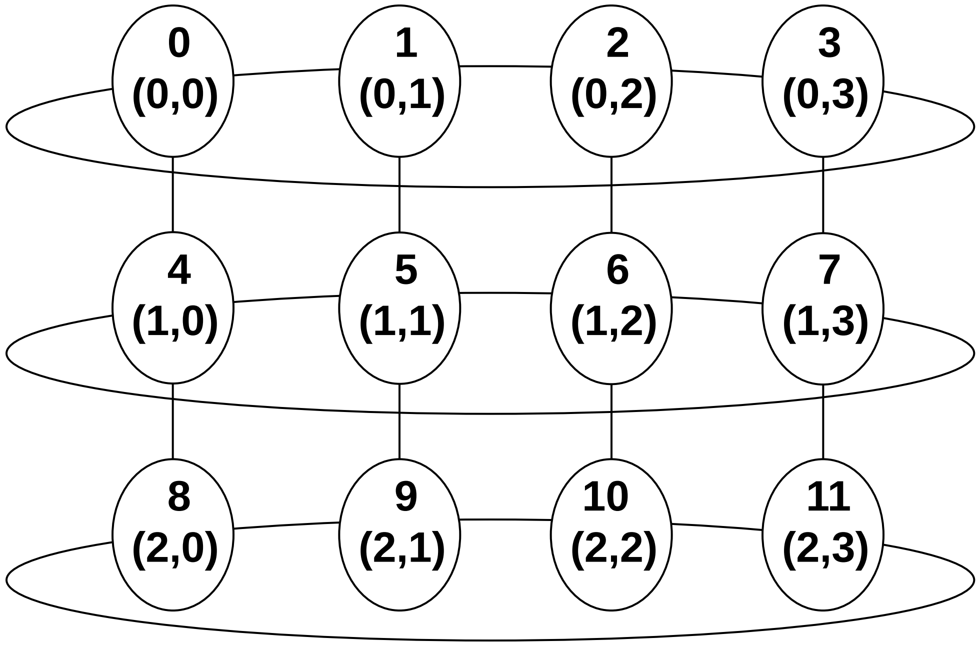
Virtual Topologies

- Convenient process naming.
- Naming scheme to fit the communication pattern.
- Simplifies writing of code.
- Can allow MPI to optimise communications.

How to use a Virtual Topology

- Creating a topology produces a new communicator.
- MPI provides ``mapping functions''.
- Mapping functions compute processor ranks, based on the topology naming scheme.

A 2-dimensional Cylinder



- Cartesian topologies
  - each process is “connected” to its neighbours in a virtual grid.
    - boundaries can be cyclic, or not.
    - optionally re-order ranks to allow MPI implementation to optimise for underlying network interconnectivity.
  - processes are identified by cartesian coordinates.
- Graph topologies
  - general graphs
  - not covered here

Creating a Cartesian Virtual Topology

- C:

```
int MPI_Cart_create(MPI_Comm comm_old,
          int ndims, int *dims, int *periods,
          int reorder, MPI_Comm *comm_cart)
```

- Fortran:

```
MPI_CART_CREATE(COMM_OLD, NDIMS, DIMS,
          PERIODS, REORDER, COMM_CART, IERROR)

INTEGER COMM_OLD, NDIMS, DIMS(*), COMM_CART, IERROR
LOGICAL PERIODS(*), REORDER
```

Balanced Processor Distribution

- C:

```
int MPI_Dims_create(int nnodes, int ndims,
                    int *dims)
```

- Fortran:

```
MPI_DIMS_CREATE(NNODES, NDIMS, DIMS, IERROR)

INTEGER NNODES, NDIMS, DIMS(*), IERROR
```

MPI_Dims_create

- Call tries to set dimensions as close to each other as possible

dims before the call	function call	dims on return
(0, 0)	MPI_DIMS_CREATE(6, 2, dims)	(3, 2)
(0, 0)	MPI_DIMS_CREATE(7, 2, dims)	(7, 1)
(0, 3, 0)	MPI_DIMS_CREATE(6, 3, dims)	(2, 3, 1)
(0, 3, 0)	MPI_DIMS_CREATE(7, 3, dims)	erroneous call

- Non zero values in dims sets the number of processors required in that direction.
  – WARNING:- make sure dims is set to 0 before the call!

Mapping process grid coordinates to ranks

- C:

```
int MPI_Cart_rank(MPI_Comm comm,
                  int *coords, int *rank)
```

- Fortran:

```
MPI_CART_RANK (COMM, COORDS, RANK, IERROR)

INTEGER COMM, COORDS(*), RANK, IERROR
```

Mapping ranks to process grid coordinates

- C:

```
int MPI_Cart_coords(MPI_Comm comm, int rank,
                    int maxdims, int *coords)
```

- Fortran:

```
MPI_CART_COORDS(COMM, RANK, MAXDIMS,COORDS,
                IERROR)

INTEGER COMM, RANK, MAXDIMS, COORDS(*), IERROR
```

Cartesian Mapping Functions

Computing ranks of my neighbouring processes
Following conventions of MPI_SendRecv

- C:

```
int MPI_Cart_shift(MPI_Comm comm,
                int direction, int disp,
                int *rank_source, int *rank_dest)
```

- Fortran:

```
MPI_CART_SHIFT(COMM, DIRECTION, DISP,
               RANK_SOURCE, RANK_DEST, IERROR)

INTEGER COMM, DIRECTION, DISP,
        RANK_SOURCE, RANK_DEST, IERROR
```

Non-existent ranks

- What if you ask for the rank of a non-existent process?
  - or look off the edge of a non-periodic grid?
- MPI returns a NULL processor
  - rank is MPI_PROC_NULL
- MPI_PROC_NULL is a black hole
  - sends and receives complete immediately
  - send buffer disappears, receive buffer isn’t touched
  - like UNIX /dev/null

- Cut a grid up into “slices”.
- A new communicator is produced for each slice.
- Each slice can then perform its own collective communications.
- `MPI_Cart_sub` and `MPI_CART_SUB` generate new communicators for the slices.
  - Use array to specify which dimensions should be retained in the new communicator.

Partitioning with MPI_CART_SUB

- C:

```
int MPI_Cart_sub (MPI_Comm comm,
        int *remain_dims,
        MPI_Comm *newcomm)
```

- Fortran:

```
MPI_CART_SUB (COMM, REMAIN_DIMS,
              NEWCOMM,IERROR)

INTEGER COMM, NEWCOMM, IERROR
LOGICAL REMAIN_DIMS(*)
```

Exercise

- See Exercise 6 on the sheet
- Rewrite the exercise passing numbers round the ring using a one-dimensional ring topology.