HPC.NRW

MPI in Small Bites

HPC.NRW Competence Network

THE COMPETENCE NETWORK FOR HIGH PERFORMANCE COMPUTING IN NRW.

Communicator and Group Handling

HPC.NRW Competence Network

MPI in Small Bites

Communication Contexts

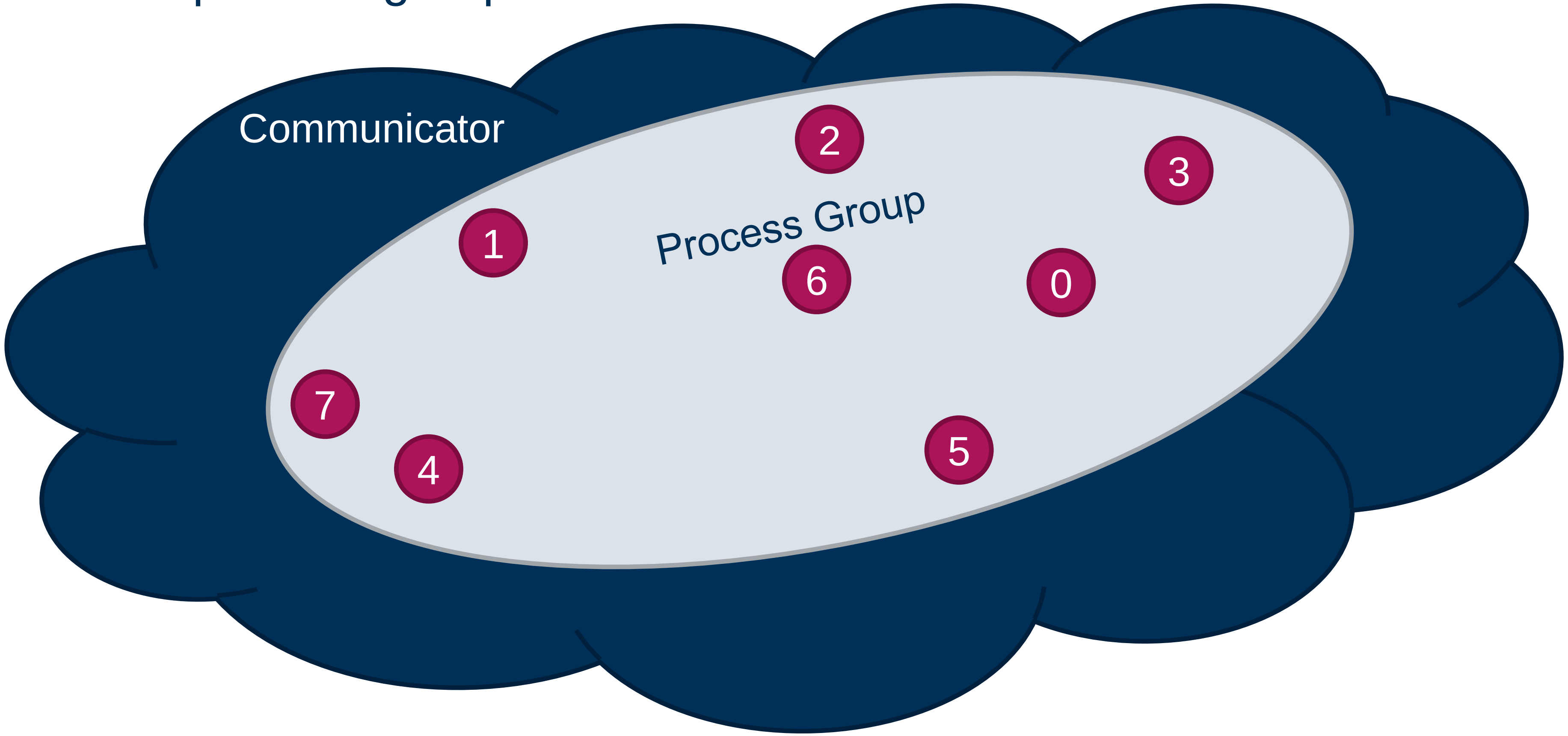
- Defines context for each communication operation in MPI
  - Group of participating peers (process group)
  - Error handlers for communication and I/O operations
  - Local key/value cache
  - Virtual topology information (optional)

- Two types: intra-communicators (single world) and inter-communicators (across worlds)
  - Inter-communicators not covered here (→ Dynamic Process Management)

- Two predefined intra-communicators (pre MPI 4.0 and MPI 4.0 World Model):
  - **MPI_COMM_WORLD**
    contains all processes launched **initially** as part of the MPI program
  - **MPI_COMM_SELF**
    contains only the current process

Communicators

- Communicator – process group – ranks



Communicator Query Operations

- Obtain the size of the process group of a given communicator:

```
MPI_Comm_size (MPI_Comm comm, int *size)
```

  - Ranks in the group are numbered from 0 to size-1
- Obtain the rank of the calling process in the given communicator:

```
MPI_Comm_rank (MPI_Comm comm, int *rank)
```

- Special “null” rank – MPI_PROC_NULL
  - Can be source or destination of point-to-point communications
    - Corresponding communication call transforms into a no-op and returns immediately
  - Used to write symmetric code and handle process boundaries

Communicator comparison

- Comparing handles directly has limited value
  - No information about the opaque objects behind the handles

```
MPI_Comm_compare (MPI_Comm comm1, MPI_Comm comm2, int *result)
```

- Result can be:
  - MPI_IDENT
    - The communicators are identical (i.e., comm1 == comm2)
  - MPI_CONGRUENT
    - The underlying groups are identical in constituents and rank order, but the context is different (e.g., after duplication)
  - MPI_SIMILAR
    - The group members are the same, but in different order
  - MPI_UNEQUAL
    - Otherwise

Communicator creation

- Duplicate an existing communicator
  - MPI_Comm_dup, MPI_Comm_dup_with_info, MPI_Comm_idup
- Create new communicator for a subgroup of a communicator
  - MPI_Comm_create, MPI_Comm_create_group
- Split an existing communicator
  - MPI_Comm_split, MPI_Comm_split_type

Creating Communicator Copies

- Duplicate a given communicator:

```
MPI_Comm_dup (MPI_Comm comm, MPI_Comm *newcomm)
```

  - New communication context with same ranks and ordering
  - Easy isolation of encapsulated communication
    - Libraries should never communicate on MPI_COMM_WORLD directly

  - Potentially modified info settings are not duplicated

    → MPI_Comm_dup_with_info

  - Communicator creation can be costly
    - Nonblocking versions available

Destroying Communicators

- Communicators take up memory and other precious resources
- Should be freed once no longer needed

```
MPI_Comm_free (MPI_Comm *comm)
```

  - Marks **comm** for deletion
  - **comm** is set to **MPI_COMM_NULL** on return
  - The actual communicator object is only deleted once all pending operations are completed

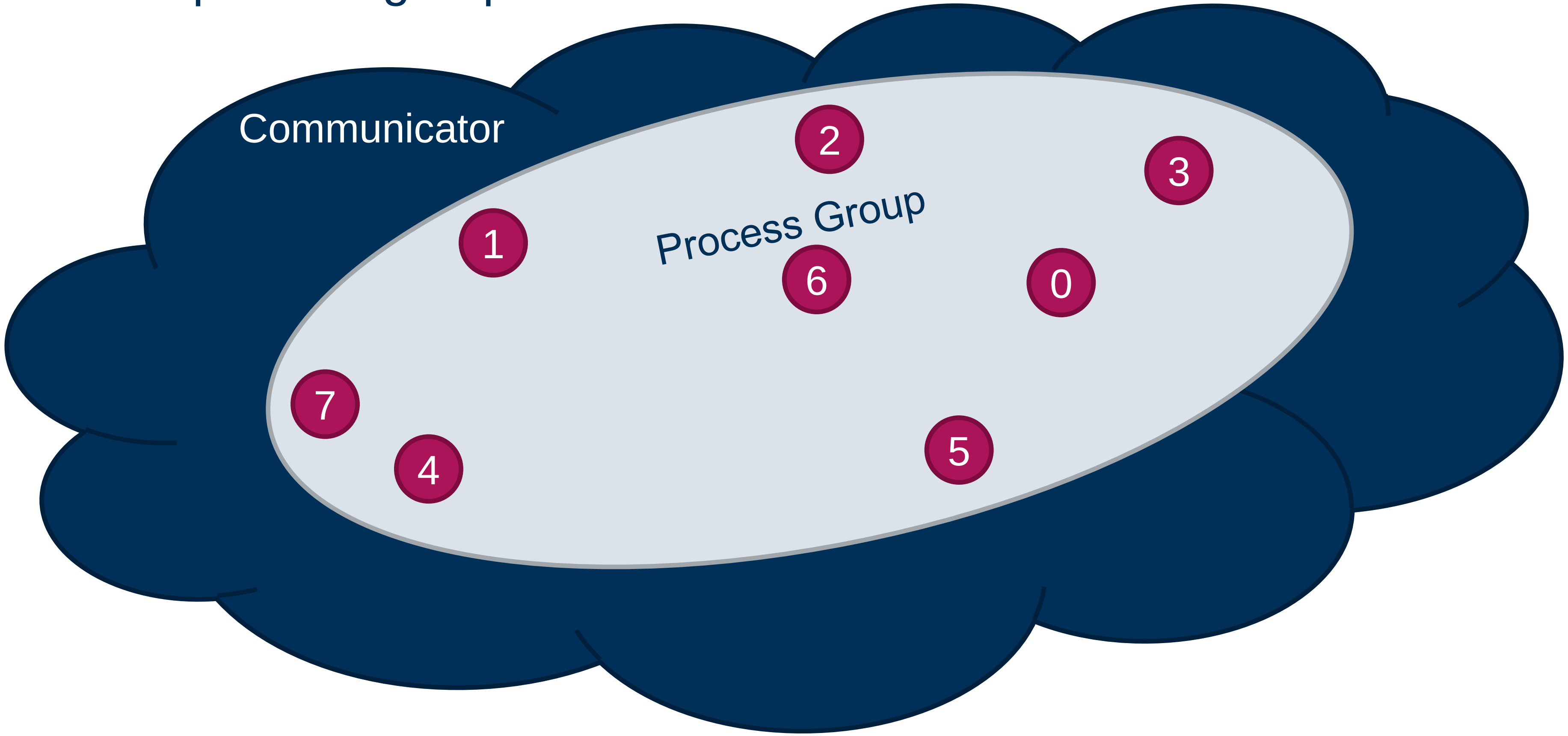
- It is erroneous to free predefined communicators MPI_COMM_WORLD, MPI_COMM_SELF or MPI_COMM_NULL

Communicator creation

- Duplicate an existing communicator
  - MPI_Comm_dup, MPI_Comm_dup_with_info
  - MPI_Comm_idup, MPI_Comm_idup_with_info (since MPI 4.0)
- Create new communicator for a subgroup of a communicator
  - MPI_Comm_create, MPI_Comm_create_group
- Split an existing communicator
  - MPI_Comm_split, MPI_Comm_split_type

Communicators

- Communicator – process group – ranks



Groups

- Ordered set of processes
  - Rank is actually a characteristic of the communicator’s underlying group

- MPI processes can be part of different groups
- Multiple communicators can be based on the same group

Communicator Query Operations

- Obtain the size of a process group:

```
MPI_Group_size (MPI_Group group, int *size)
```

  - ranks in the group are numbered from 0 to size-1

- Obtain the rank of the calling process in the given process group:

```
MPI_Group_rank (MPI_Group group, int *rank)
```

Group comparison

- Comparing handles directly has limited value
  - No information about the opaque objects behind the handles

```
MPI_Group_compare (MPI_Group group1, MPI_Group group2, int *result)
```

- Result can be:
  - MPI_IDENT
    - The groups are identical (i.e., comm1 == comm2)
    - The underlying groups are identical in constituents and rank order
  - MPI_SIMILAR
    - The group members are the same, but in different order
  - MPI_UNEQUAL
    - Otherwise

Identifying ranks across different groups

```
MPI_Group_translate_ranks (MPI_Group group1, int n, const int ranks1[],
                           MPI_Group group2, int rank2[])
```

- **n** indicates the length of the two arrays **ranks1** and **rank2**
- **ranks1** holds a list of valid ranks in **group1**
- **ranks2** returns the corresponding rank in **group2** at the same index
  - MPI_UNDEFINED if no correspondence exists

Group constructors

- No mechanism to build a group from scratch
  - Groups need to be derived from a base group

- Obtain the group of a given communicator

```
MPI_Comm_group (MPI_Comm comm, MPI_Group *group)
```

  - Obtain the group of predefined communicator MPI_COMM_WORLD and derive from it

Group constructors – Set operations on group

- Build unions and or intersections of the process groups

```
MPI_Group_union (MPI_Group group1, MPI_Group group2, MPI_Group *newgroup)
MPI_Group_intersection (MPI_Group group1, MPI_Group group2, MPI_Group *newgroup)
```

- Remove ranks of a second group from those present in a first group

```
MPI_Group_difference (MPI_Group group1, MPI_Group group2, MPI_Group *newgroup)
```

- Explicitly list ranks to retain in (or remove from) a given group

```
MPI_Group_incl (MPI_Group group, int n, const int ranks[], MPI_Group *newgroup)
MPI_Group_excl (MPI_Group group, int n, const int ranks[], MPI_Group *newgroup)
MPI_Group_range_incl (MPI_Group group, int n, const int ranks[][3], MPI_Group *newgroup)
MPI_Group_range_excl (MPI_Group group, int n, const int ranks[][3], MPI_Group *newgroup)
```

  - Ranges are arrays of triples in the form [first rank, last rank, stride]

Destroying Groups

- Groups take up memory and other precious resources
- Should be freed once no longer needed

```
MPI_Group_free (MPI_Group *group)
```

  - Marks **group** for deletion
  - **group** is set to **MPI_GROUP_NULL** on return
  - The actual group object is only deleted once all internal references are released

Communicator creation from groups

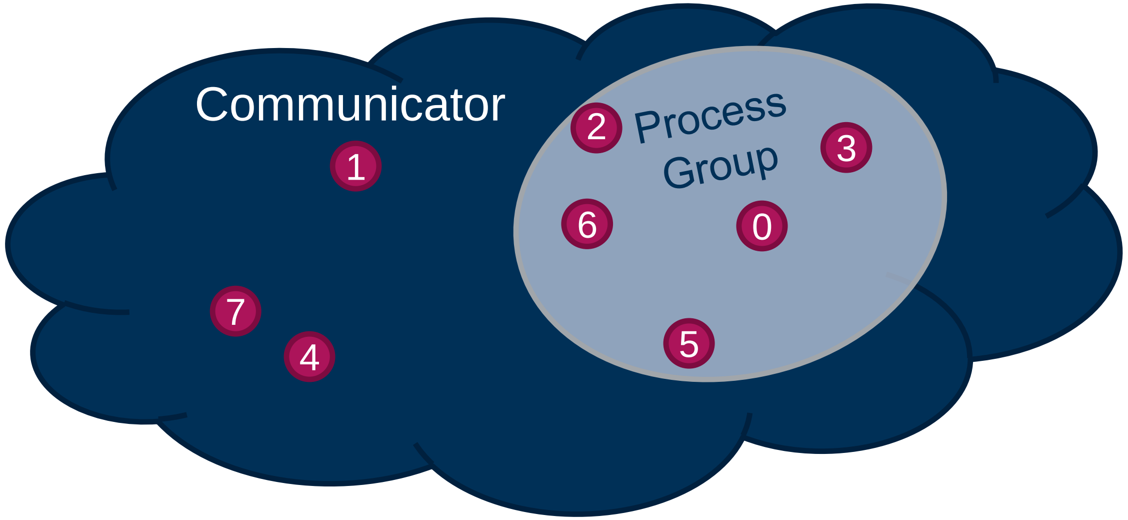
- Create new communicator for a subgroup of a communicator

```
MPI_Comm_create (MPI_Comm comm, MPI_Group group, MPI_Comm *newcomm)
```

- Collective in comm (for ranks ∉ group: newcomm=MPI_COMM_NULL)

```
MPI_Comm_create_group (MPI_Comm comm, MPI_Group group, int tag,
                       MPI_Comm *newcomm)
```

  - Collective in group



Communicator creation

- Duplicate an existing communicator
  - MPI_Comm_dup, MPI_Comm_dup_with_info
  - MPI_Comm_idup, MPI_Comm_idup_with_info (since MPI 4.0)

- Create new communicator for a subgroup of a communicator
  - MPI_Comm_create, MPI_Comm_create_group

- Split an existing communicator
  - MPI_Comm_split, MPI_Comm_split_type

Communicator splitting

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- Split existing communicators into parts

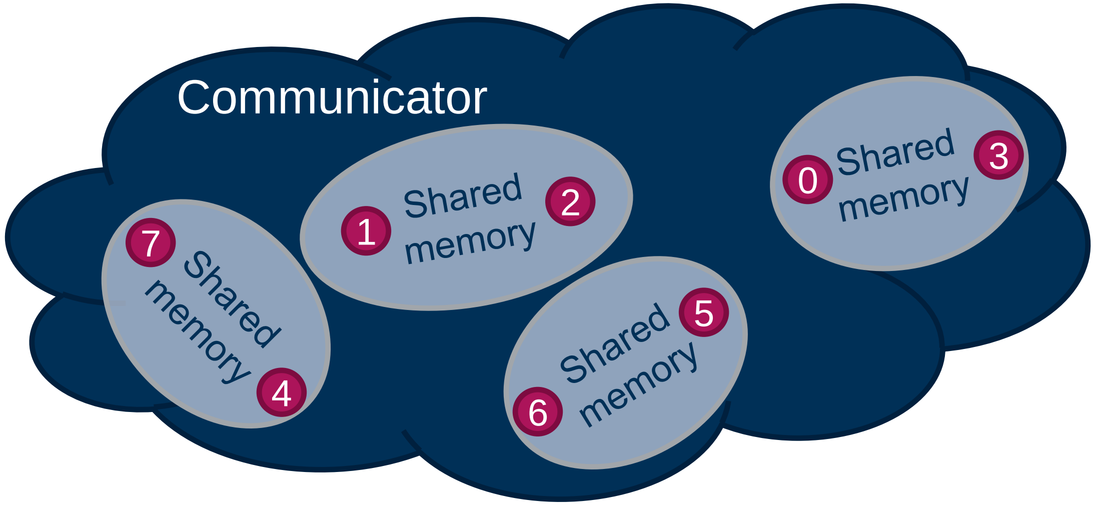
```
MPI_Comm_split (MPI_Comm comm, int color, int key, MPI_Info info, MPI_Comm *newcomm)
```

  - Split by some characteristics (e.g., rank % n, rank < n, rank / n)

```
MPI_Comm_split_type (MPI_Comm comm, int split_type, int key, MPI_Info info,
                     MPI_Comm *newcomm)
```

  - Split into shared memory groups
  - key controls the rank order within newcomm
  - Useful for shared memory windows

    → One-sided communication



Communicator
7
Shared memory
4
1
Shared memory
2
Shared memory
6
5
0
Shared memory
3