The MPI Message-passing Standard
Practical use and implementation (IV)

SPD Course

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COMMUNICATORS AND GROUPS

Comm.s & Groups motivation

- Flexible Communication shall provide
  - Safe communication space
  - Scope for communication (esp. collectives)
  - Abstract process naming
  - Option to augment semantics of the communication (by holding “attributes”)
  - With a unified mechanism
- These ideas root in the need to develop interoperable libraries, languages and run-time supports on top of MPI
- Corresponding concepts in MPI
  - Contexts
  - Groups of processes
  - Virtual Topologies
  - Attribute caching
  - Communicators

As Programming Abstraction

- Communicators are MPI basic mechanism
- They are global-scope object, created by handshake among processes, made of
  - Groups of processes
    - A group is a local object for naming
  - Context of communication
    - Any information needed to implement communications
  - Attributes : a generic caching mechanism
    - Either user-defined or MPI-implementer defined
    - Virtual Topologies
      - A special mapping of ranks to/from a topology
      - Often implemented via attributes

The General case

- Previous description : **IntraCommunicators**
  - One group of MPI processes with full communication connectivity

- **InterCommunicators** are slightly different
  - Two groups of processes
  - Communication allowed between processes of different groups
  - No virtual topology

- In the lessons we'll mainly focus on IntraCommunicators

The building bricks

- Group
  - Ordered set of process identifiers
  - From 0 to N-1, consecutive numbering
  - Handles to **Local** Opaque objects:
    - cannot fiddle with it
    - cannot transfer among processes
  - MPI_GROUP_EMPTY special handle for empty
  - MPI_GROUP_NULL invalid handle
- Context
  - Property only defined as associated to communicator
    No programming abstraction,
    no exhaustive definition in MPI standard
  - Conceptually: separation of communication spaces
  - Pragmatically described as a tag of low-level communications to associate them a communicator
  - Other implementation solutions / more details not provided
- Communicator = Group(s) + Context
  - Note that group is local, context agreement is global

Getting Info from a Group

MPI_GROUP_SIZE(group, size)

MPI_GROUP_RANK(group, rank)

MPI_GROUP_TRANSLATE_RANKS (group1, arrSize, ranks1, group2, ranks2)

- Translate ranks for processes between two groups
- Can receive MPI_PROC_NULL
- Can return MPI_PROC_NULL for some proc

MPI_GROUP_COMPARE(group1, group2, result)

- C prototype

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

- Returns MPI_IDENT, MPI_SIMILAR, MPI_UNEQUAL

GROUP CONSTRUCTORS

- Groups are local objects → Group operations are cheap
- MPI_COMM_GROUP(comm, group)
  - Get group from communicator
- All typical boolean ops:
  - Union, intersection, difference of two groups
  - Order of the first group is prevalent
- MPI_GROUP_INCL(group, n, ranks, newgroup)
  - Pick elements from a group, in order, to form a new one
- MPI_GROUP_EXCL(group, n, ranks, newgroup)
  - Deletes element from a group
- MPI_GROUP_RANGE_INCL ed EXCL
  - As above, but define RANGES of ranks
  - Triplets first, last, stride
- MPI_GROUP_FREE

Communicator operations

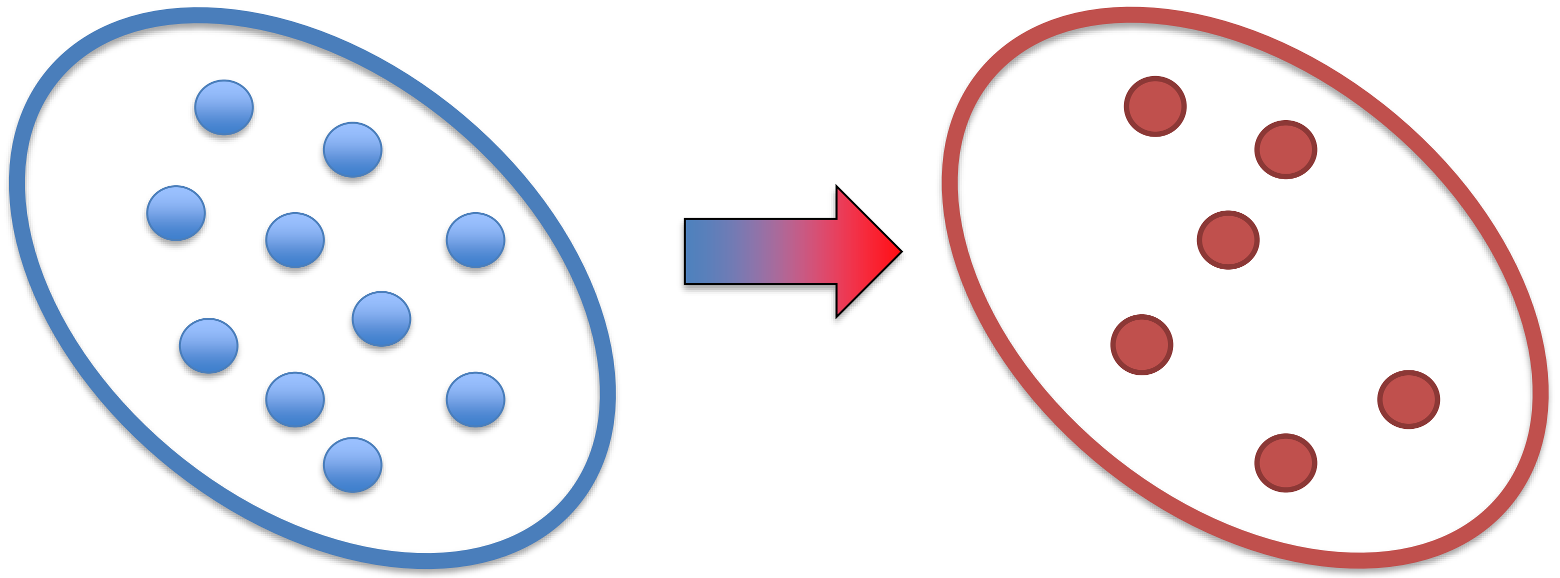
- We'll stay with intracommunicators for now
- The cheap ones: get info out of a Comm.
  - int MPI_Comm_size(MPI_Comm comm, int *size)
  - int MPI_Comm_rank(MPI_Comm comm, int *rank)
  - int MPI_Comm_compare(MPI_Comm comm1,
    MPI_Comm comm2, int *result)
    - MPI_IDENT (same Comm) MPI_CONGRUENT (same group)
      MPI SIMILAR (same set of proc.s) MPI_UNEQUAL
- The constructors
  - int MPI_Comm_dup(MPI_Comm comm, MPI_Comm *newcomm)
    - Create a perfect copy (also comm info if info callbacks allow it), but with different context
    - A separate primitive allows replacing the comm. info
- And now for the real thing…

IntraCommunicator Create

- int MPI_Comm_create(MPI_Comm comm, MPI_Group group, MPI_Comm *newcomm)
  - A communicator is always built inside another communicator
    - MPI_Comm_World is the starting point
  - Cached attributes are lost in newcomm
  - Collective call : all processes in the communicator
  - Should have same parameters from all but…
  - Agreement on group parameter
    - Either all the same (MPI1.1), or all **disjoint** (MPI2.2)
    - May create more comm.s at the same time
    - A process may not be part → returns MPI_NULL_COMM
- MPI_COMM_FREE()

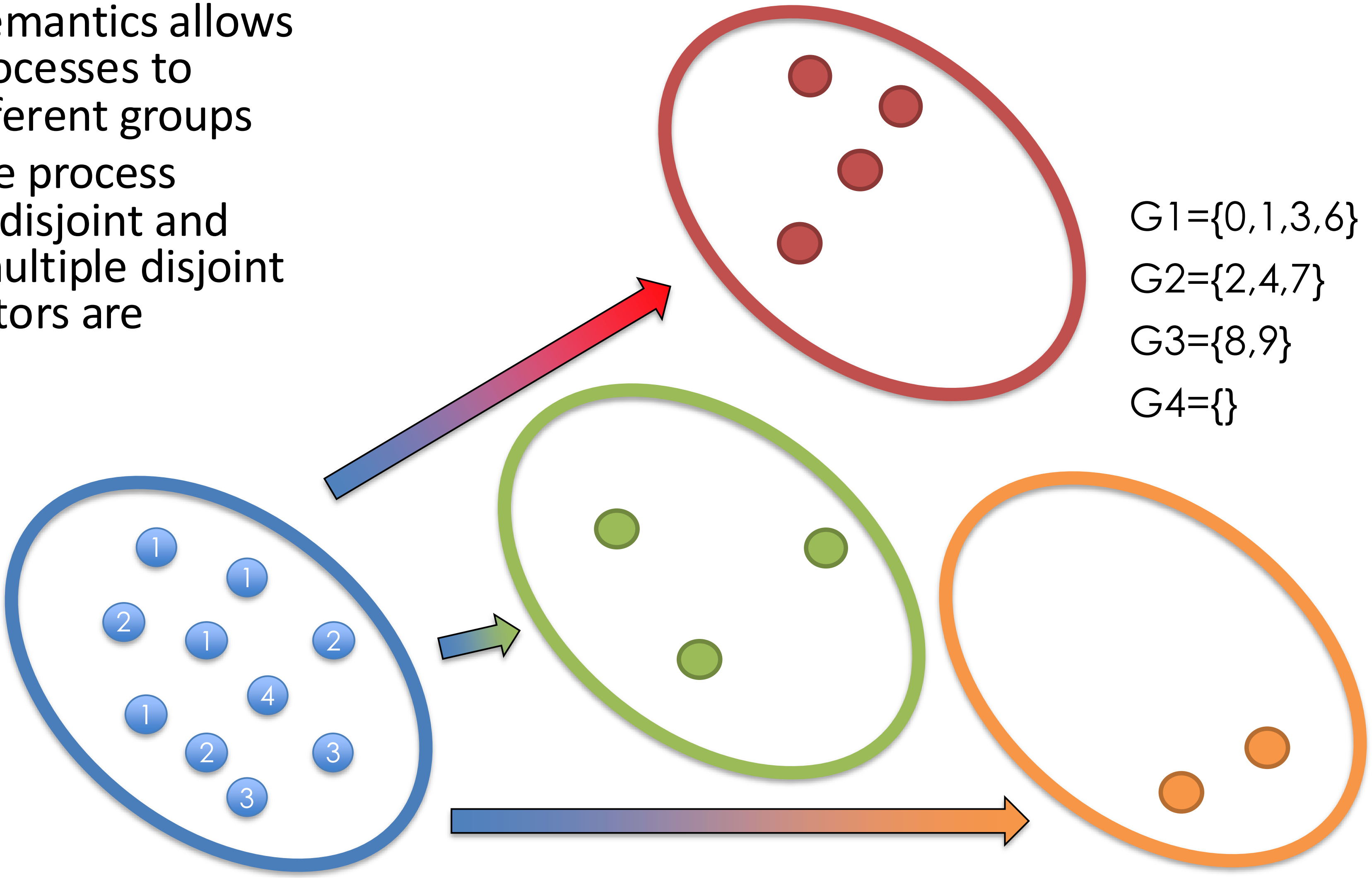
MPI_Comm_create (in MPI 1)

- All processes call with same parameters
  - the same group
- some join the new communicator, some don't
  - they get MPI_NULL_COMM back



MPI_Comm_create (in MPI 2)

- Extended semantics allows different processes to propose different groups
- Provided the process subsets are disjoint and coherent, multiple disjoint communicators are created



Communicator Splitting

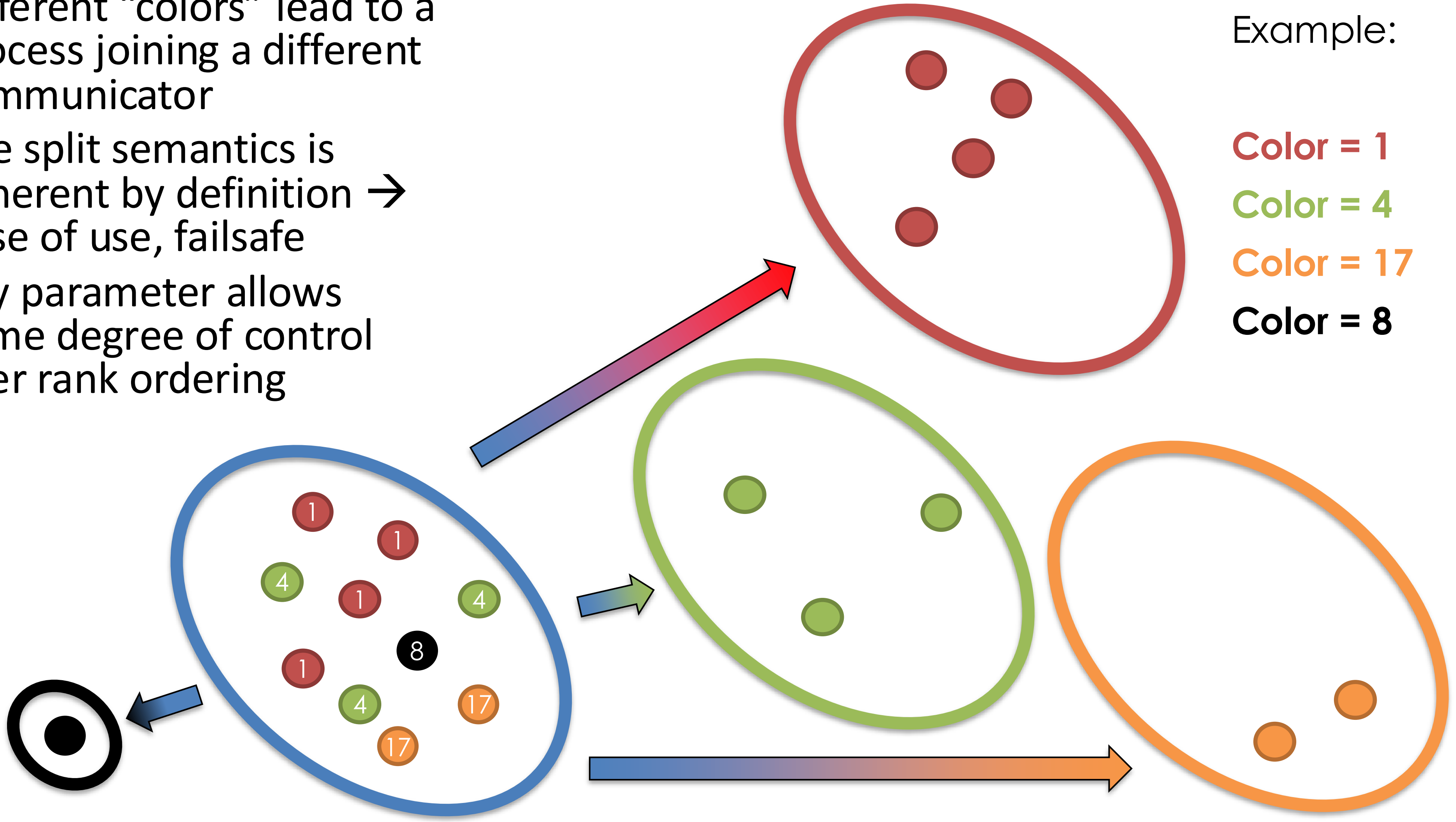
- int MPI_Comm_split(MPI_Comm comm, int color, int key, MPI_Comm *newcomm)
  - Collective call
  - *color* and *key* parameters vary among processes
    - color >= 0 , or MPI_UNDEFINED
  - Describe the splitting of a communicator in order to form several non-overlapping new ones
  - Processes can join the new communicator of the given “color” without knowing its composition in advance
    - a little bit more communication is needed under the hood
  - The key parameters allows some control on the ordering of processes (rank assignment) in the new communicator(s)
    - New ranks are ordered by keys, ties broken by old rank

MPI_Comm_split ()

- Different “colors” lead to a process joining a different communicator
- The split semantics is coherent by definition → ease of use, failsafe
- Key parameter allows some degree of control over rank ordering

Example:

Color = 1
Color = 4
Color = 17
Color = 8



References

- MPI standard Relevant Material for 4th lesson
  - Chapter 7: up to 7.5, however
    - skip intercommunicators at least initially (in 7.6)
    - skip incomplete communicator operations
    - you can skip info keys (although 7.4.4 is interesting)
    - skip hardware hints and virtual topologies (v.t. are actually in chapter 8)

Exercises

- Consider an application so structured
  - a pipeline of 4 stages
  - the 1st and last stages are simple sequential processes with access to I/O
  - the 2nd stage is a farm module with emitter, collector and pf sequential workers
  - the 3rd stage is a map with emitter, collector and pm sequential workers
- Devise a strategy to create communicators for the following subset of processes
  - C1, C2, C3, C4 : the processes of each stage
  - C5, C6 : the farm and map set of workers
  - C7, C8 : the farm emitter and workers, as well as farm workers and collector
  - C9, C10 : same for the map
- Try to minimize the number of primitives called, and simplify communicator creation
- Consider the impact of partially merging some stages to remove some support processes, e.g.:
  - farm collector and map emitter are the same process
  - both farm collector and map emitter are removed (* this requires extra work)