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Characteristics of collective operations

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- receive buffers must have the same size as send buffers
- **Examples:** broadcast, scatter, gather, global sum, global maximum, barrier synchronisation...

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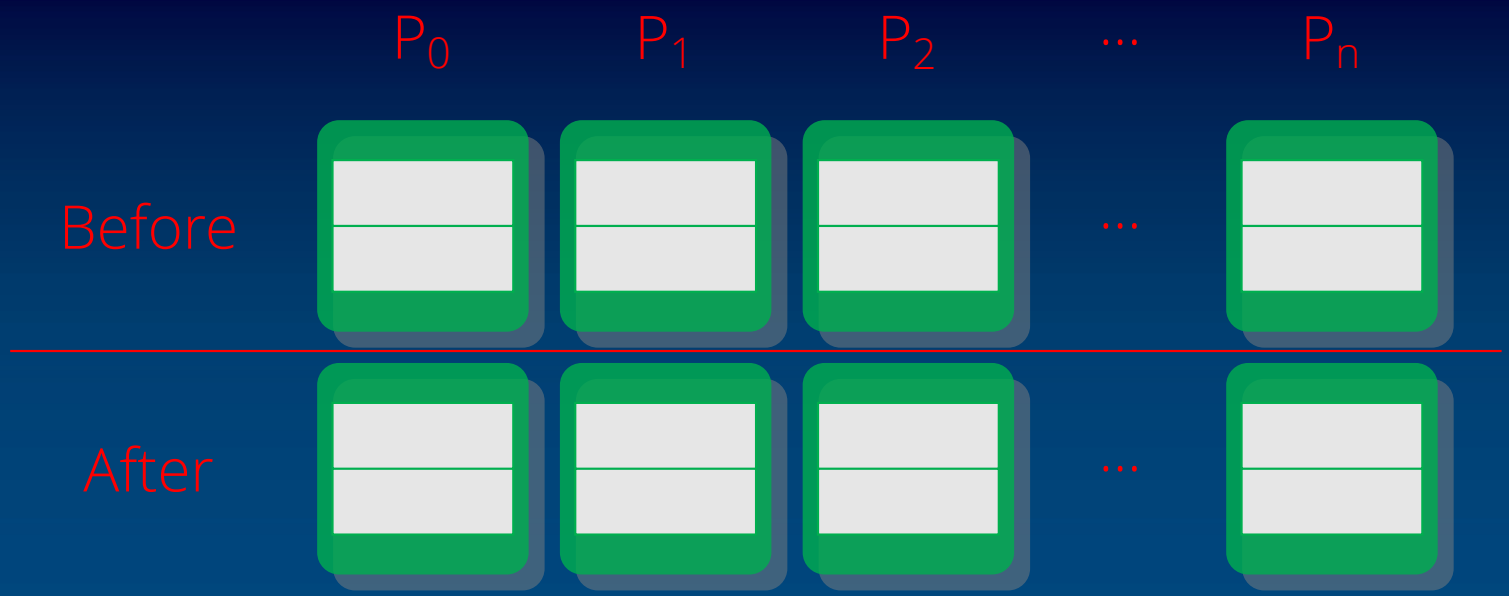
broadcast



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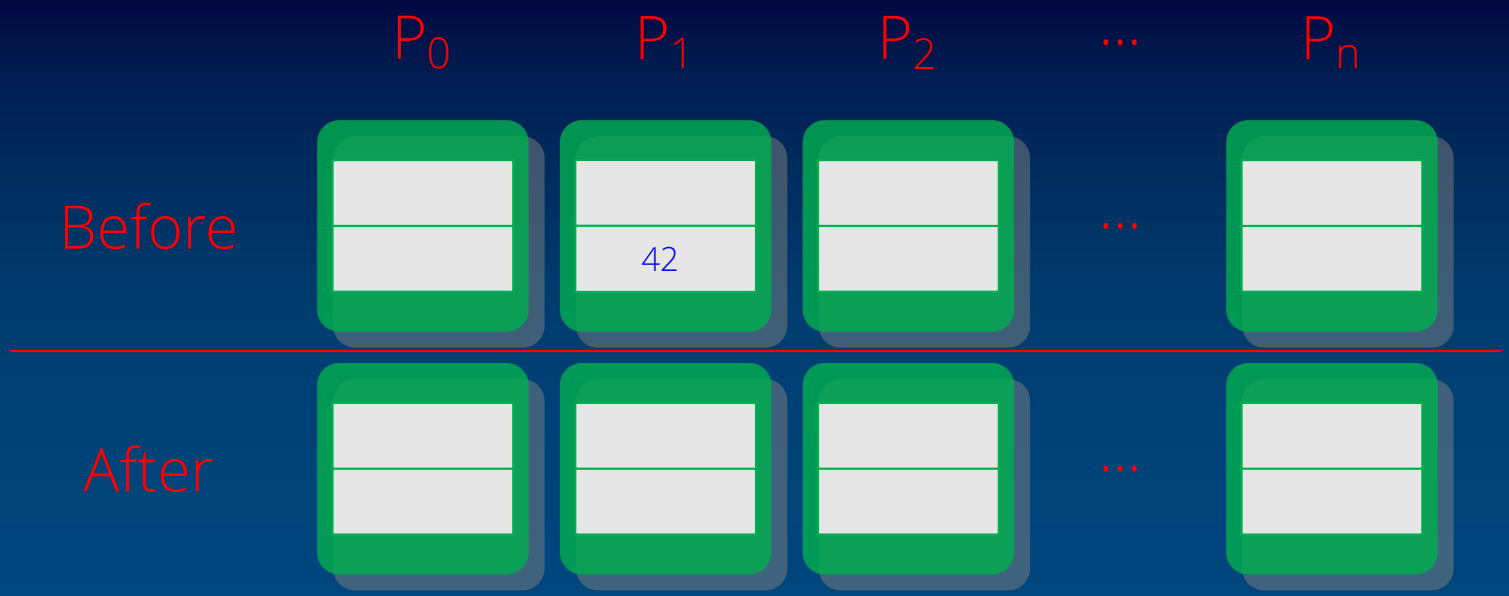
broadcast



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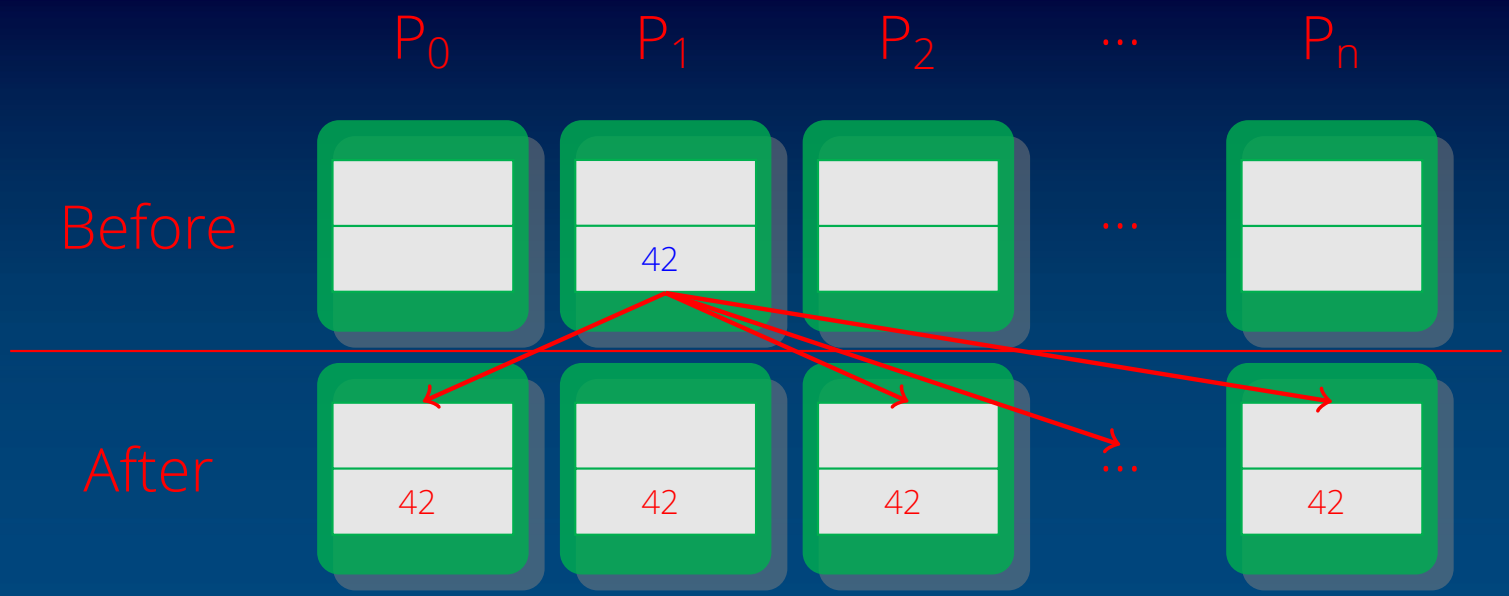
broadcast



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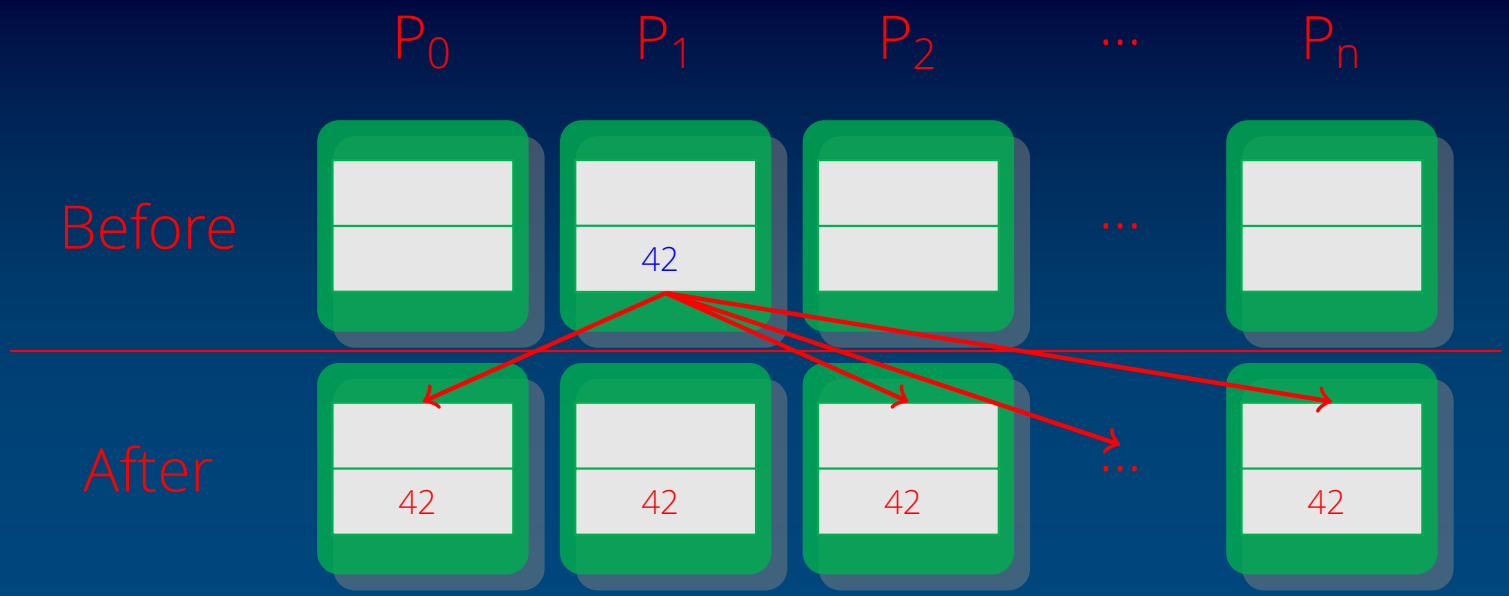


```
int MPI_Bcast(void *buffer, int count, MPI_Datatype datatype,
    int root, MPI_Comm comm)
```

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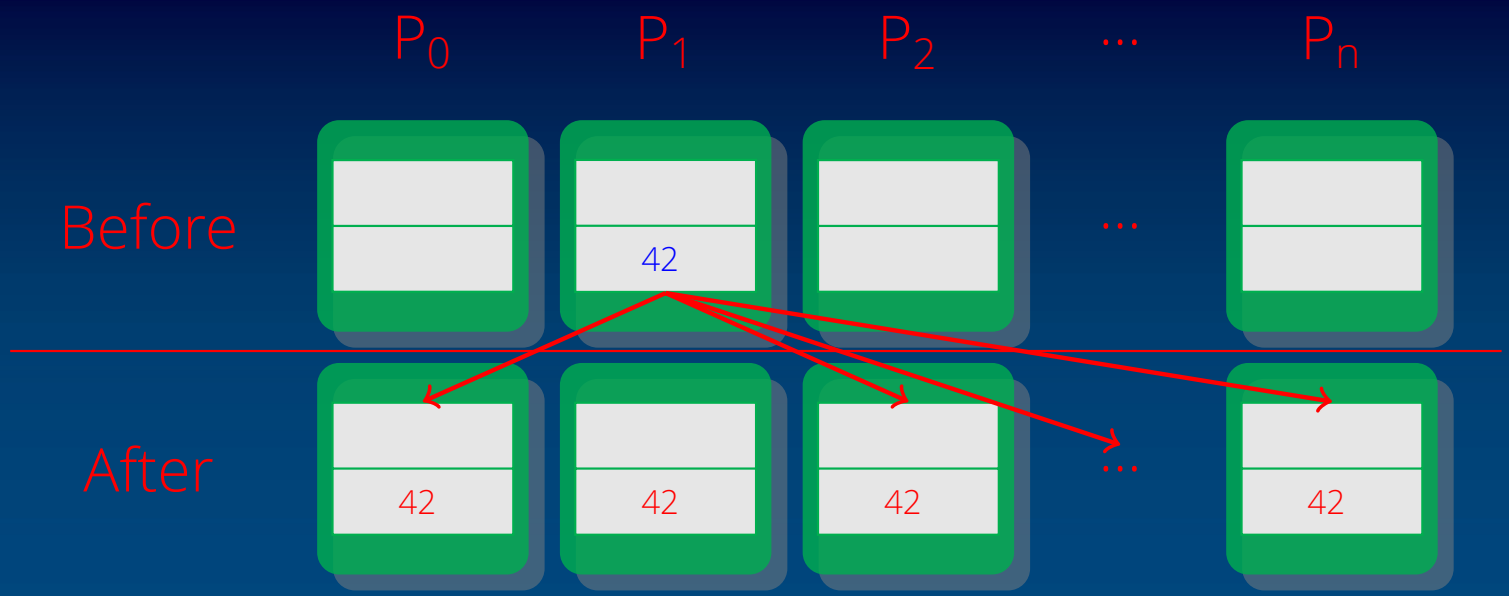
broadcast




```
int MPI_Bcast(void *buffer, int count, MPI_Datatype datatype,
    int root, MPI_Comm comm)
```

```
MPI_Bcast(buffer, count, datatype, root, comm, ierror)
    <type>  :: buffer(:)
    integer :: count, datatype, root, comm, ierror
```

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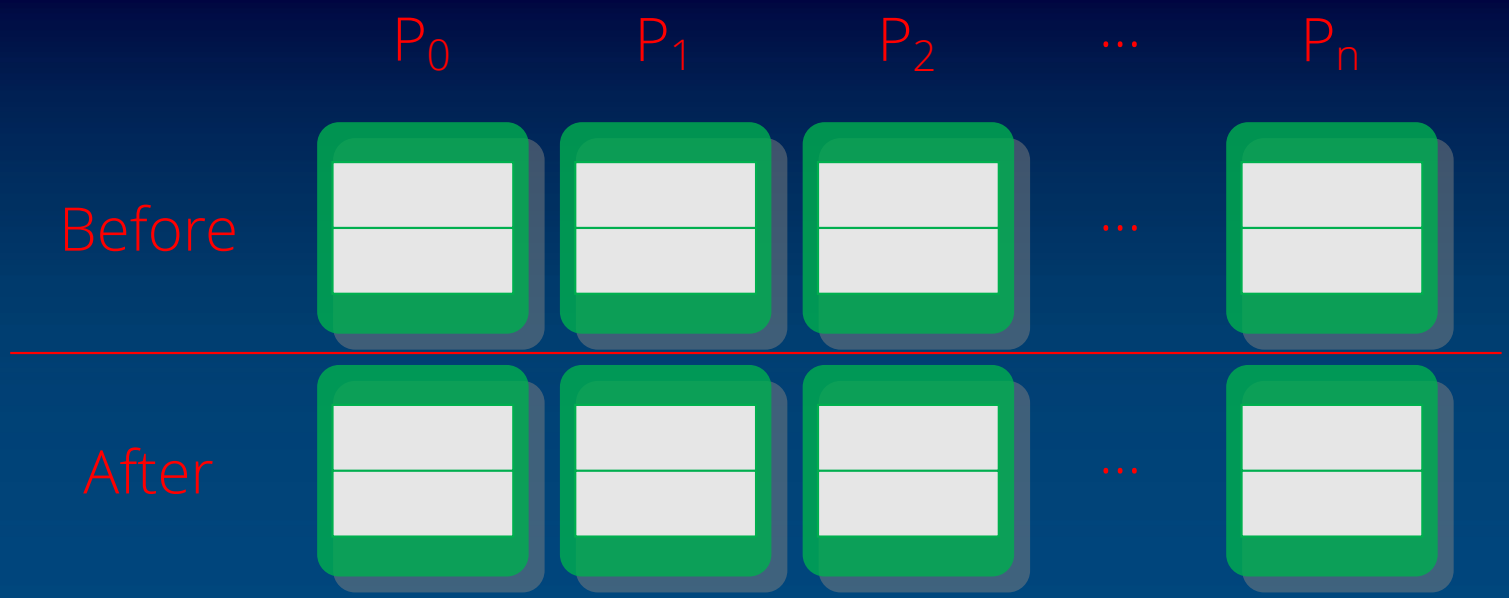
scatter



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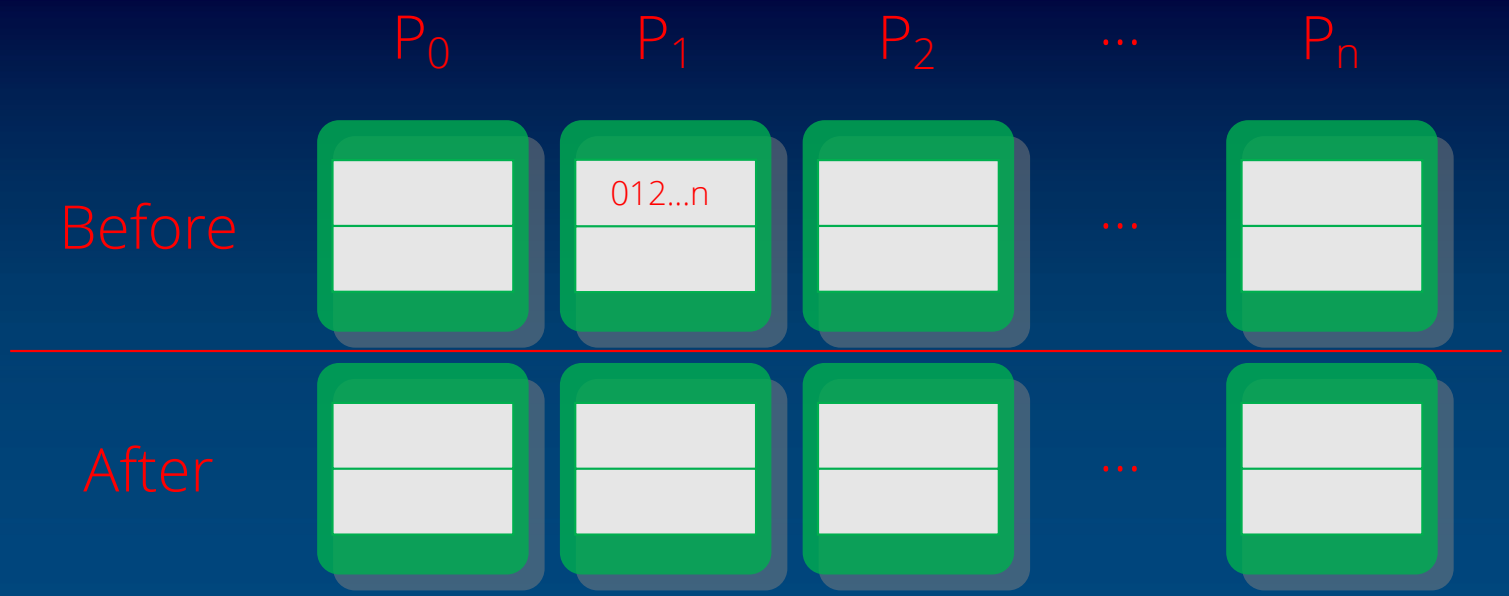
scatter



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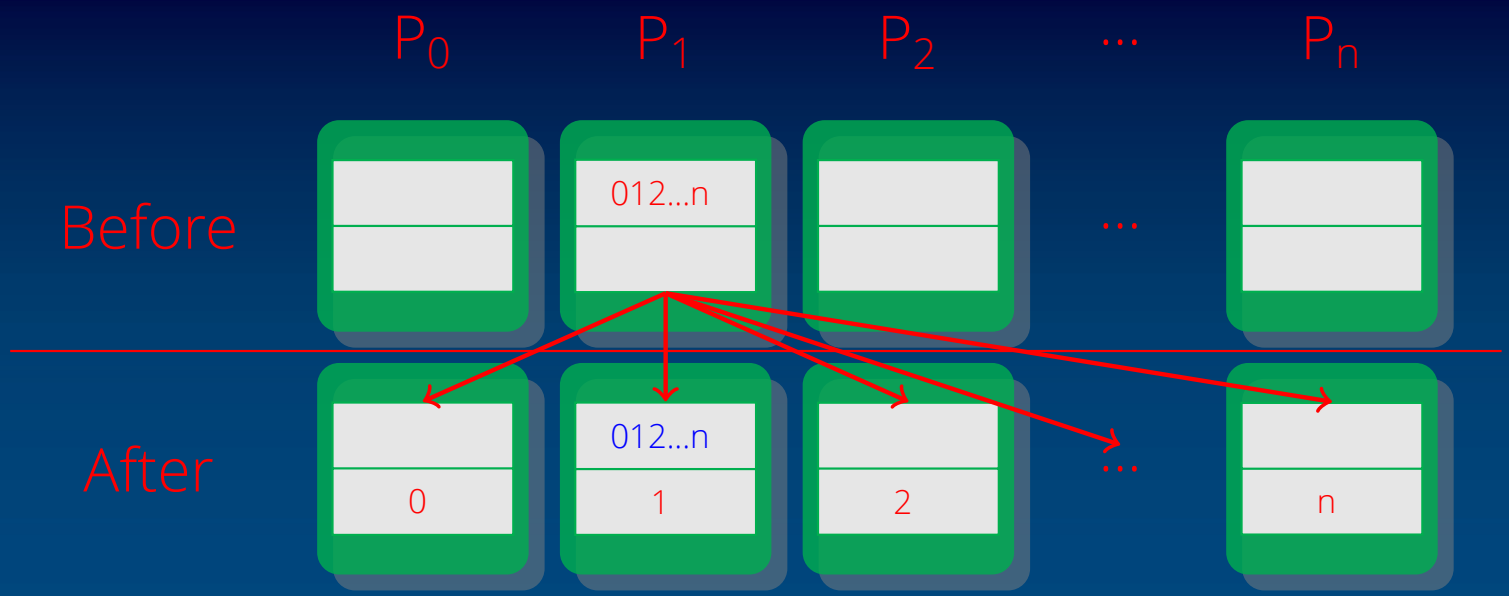
scatter



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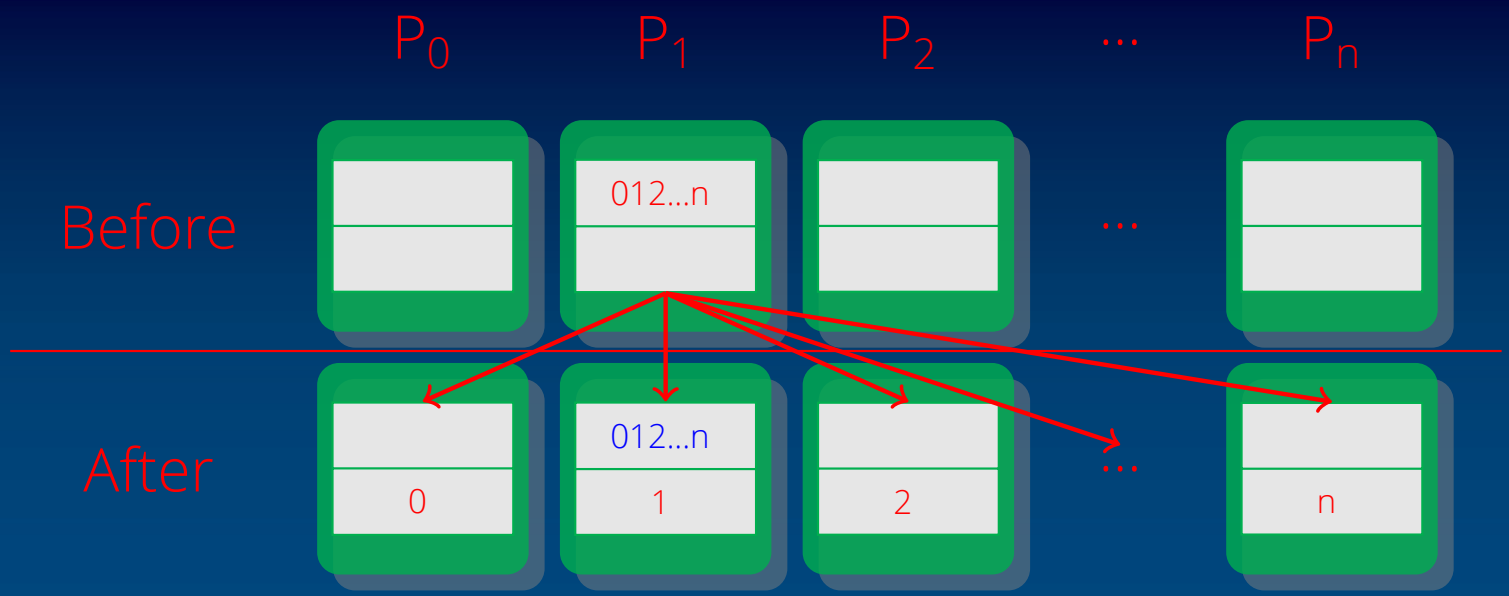
scatter




```
int MPI_Scatter(void *sendbuf, int sendcount, MPI_Datatype
    sendtype, void *recvbuf, int recvcount, MPI_Datatype
    recvtype, int root, MPI_Comm comm)
```

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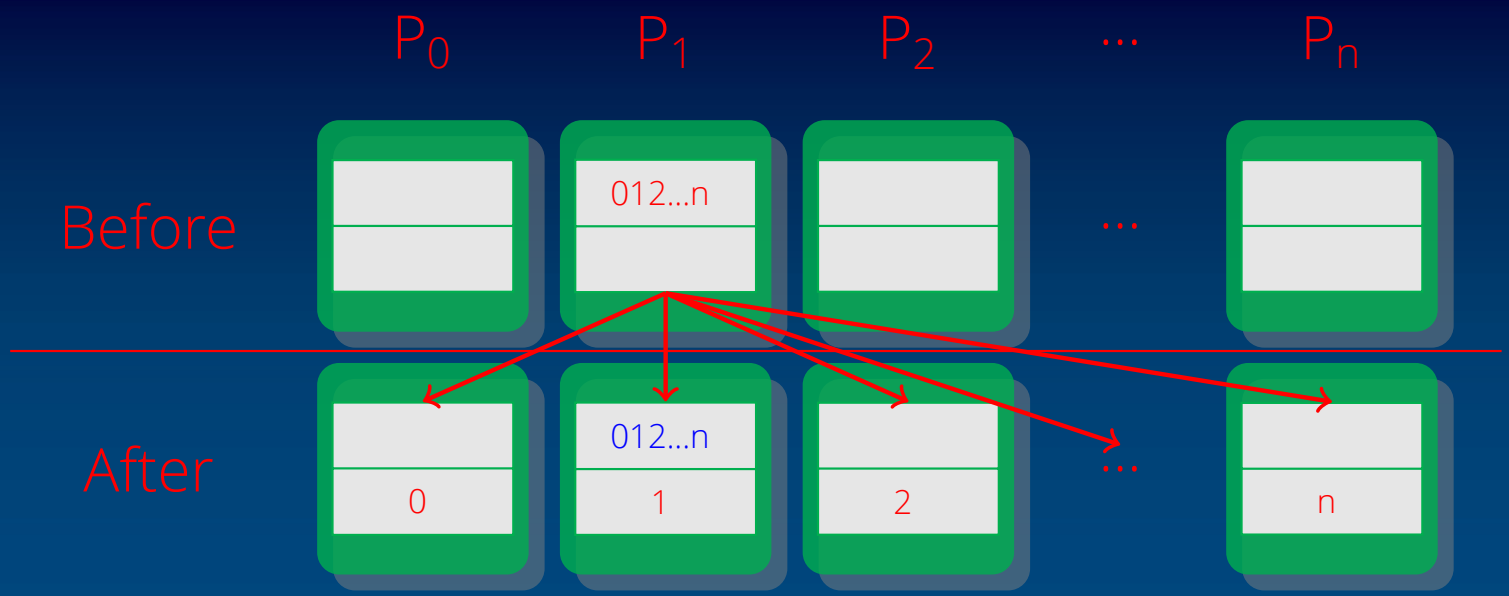
scatter




```
int MPI_Scatter(void *sendbuf, int sendcount, MPI_Datatype
    sendtype, void *recvbuf, int recvcount, MPI_Datatype
    recvtype, int root, MPI_Comm comm)
```

```
MPI_Scatter(sendbuf, sendcount, sendtype, recvbuf, recvcount,
    recvtype, root, comm, ierror)
    <type>  :: sendbuf(:), recvbuf(:)
    integer :: sendcount, sendtype, recvcount, recvtype, root
    integer :: comm, ierror
```

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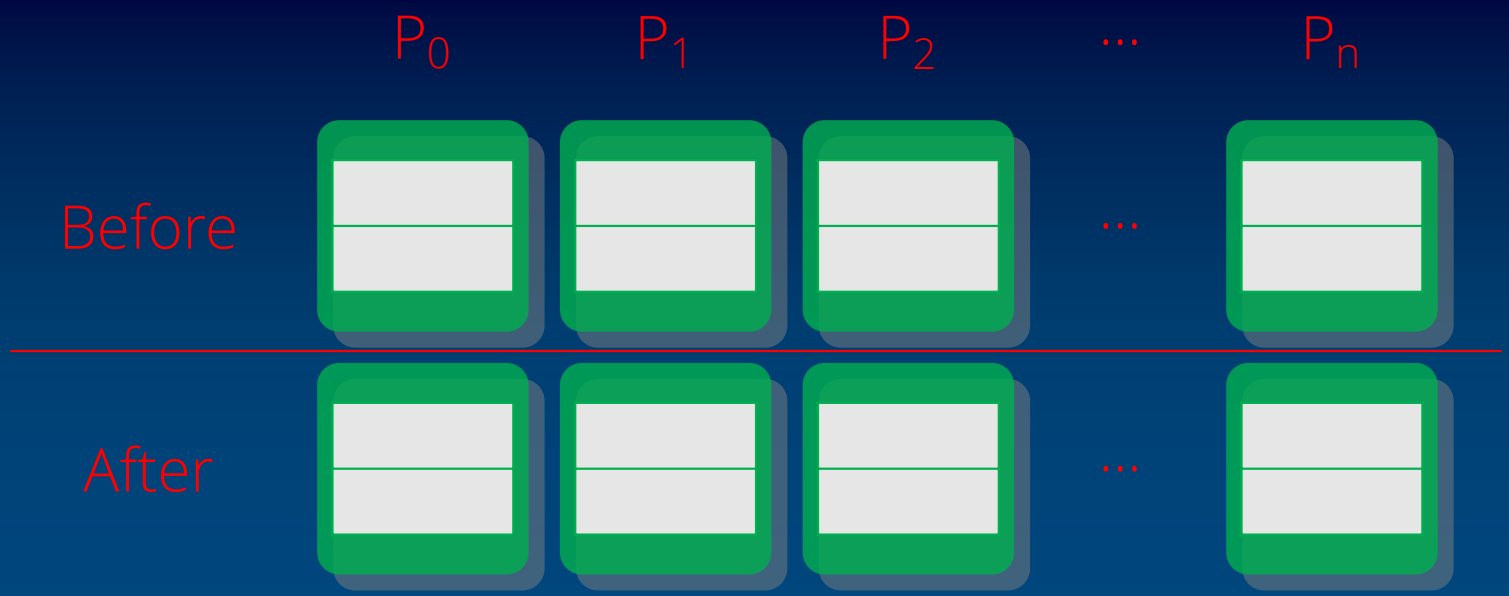
gather



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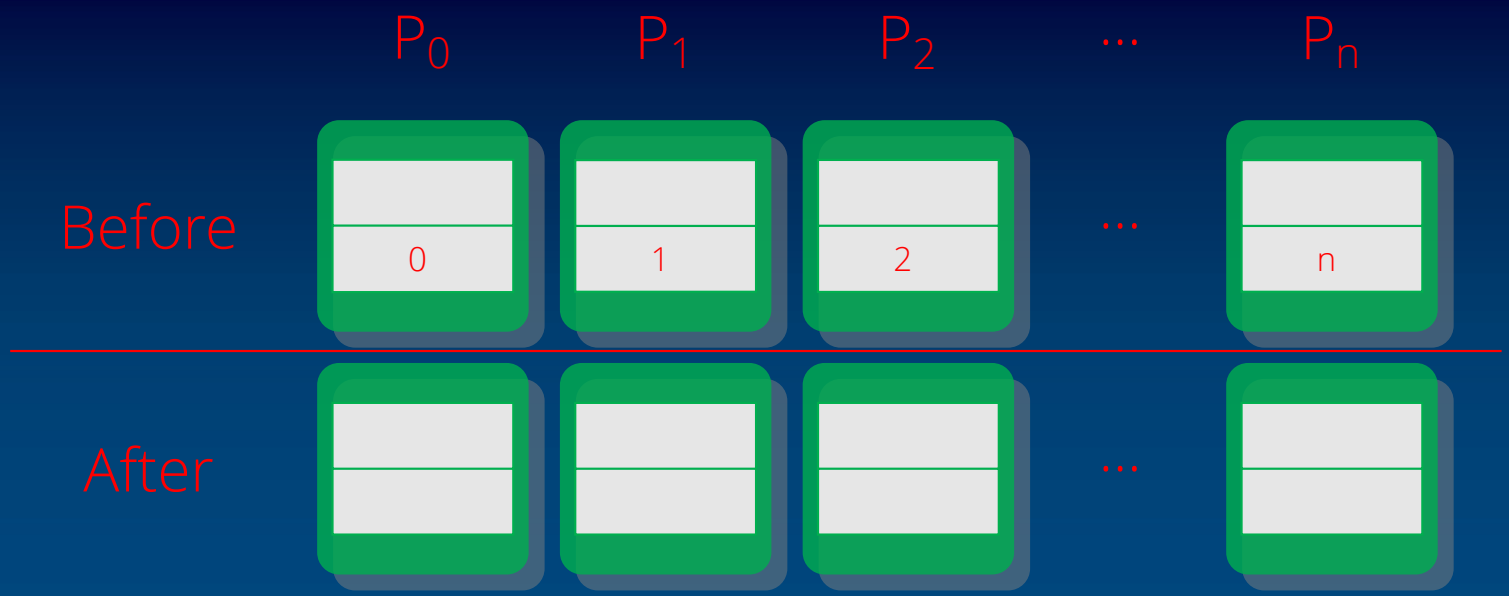
gather



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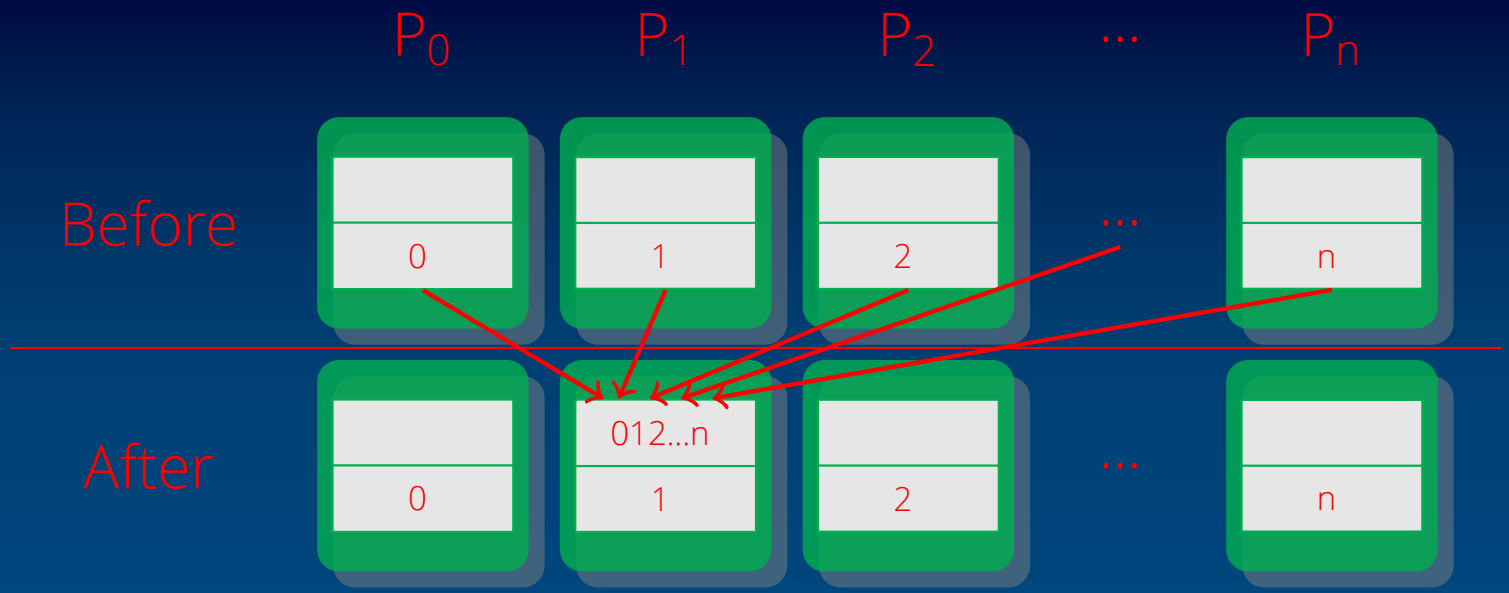
gather



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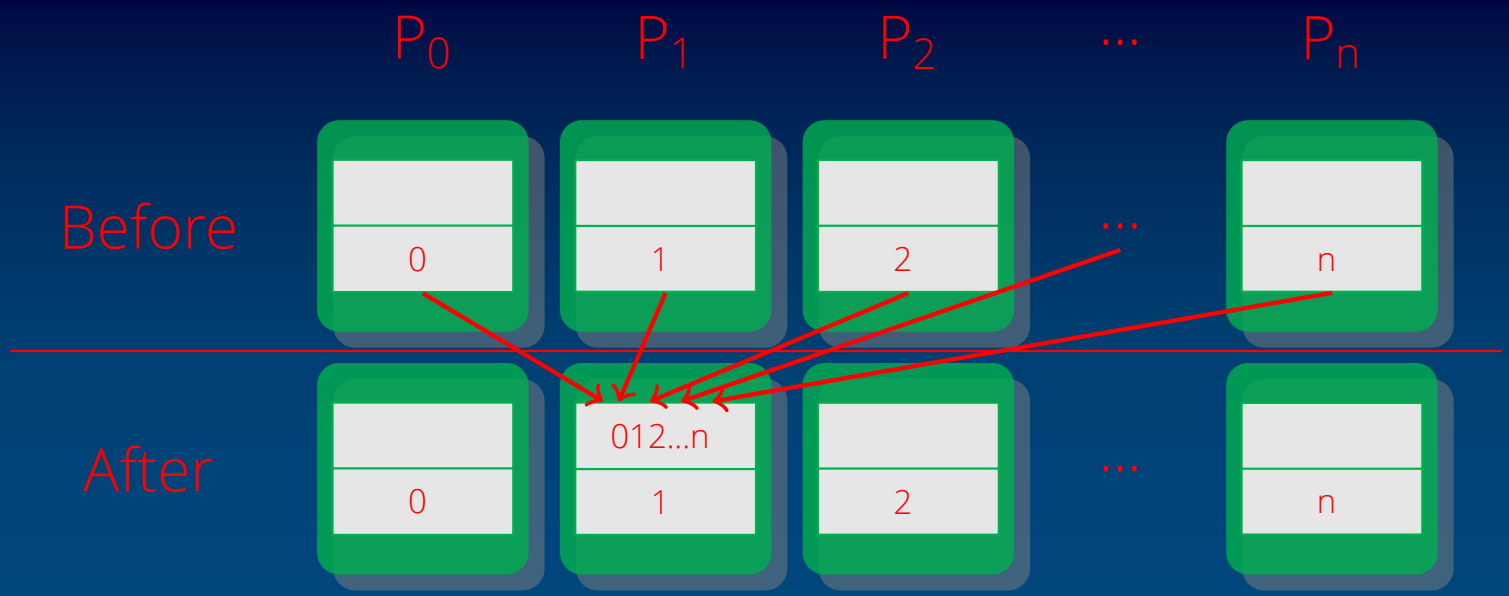


```
int MPI_Gather(void *sendbuf, int sendcnt, MPI_Datatype
    sendtype, void *recvbuf, int recvcnt, MPI_Datatype recvtype
    , int root, MPI_Comm comm)
```

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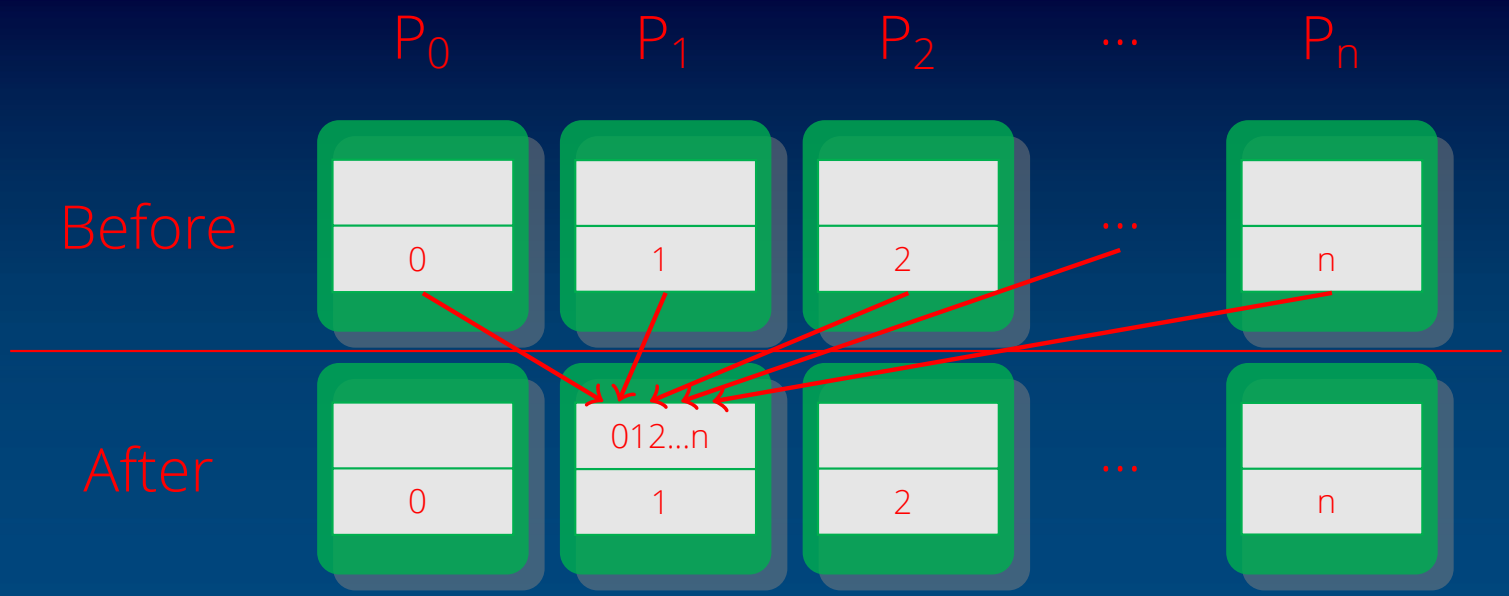
gather




```
int MPI_Gather(void *sendbuf, int sendcnt, MPI_Datatype
    sendtype, void *recvbuf, int recvcnt, MPI_Datatype recvtype
    , int root, MPI_Comm comm)
```

```
MPI_Gather(sendbuf, sendcount, sendtype, recvbuf, recvcount,
    recvtype, root, comm, ierror)
    <type>  :: sendbuf(:), recvbuf(:)
    integer :: sendcount, sendtype, recvcount, recvtype, root
    integer :: comm, ierror
```

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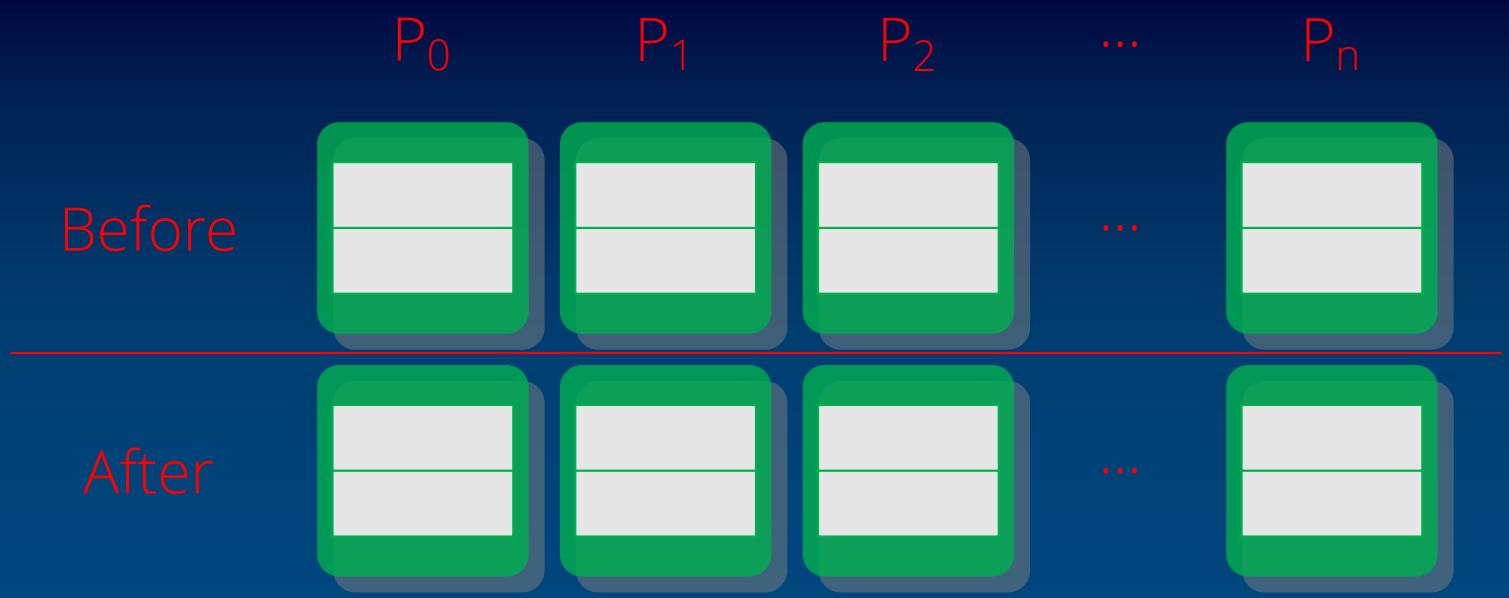
AllGather



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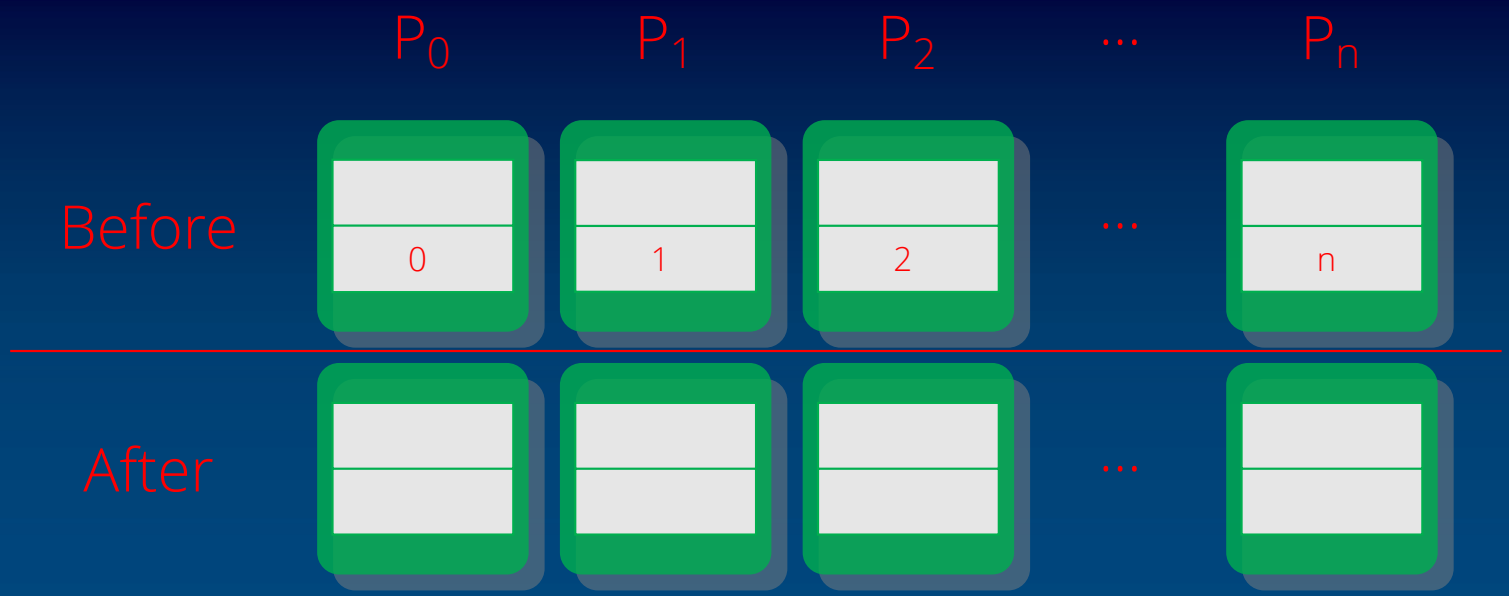

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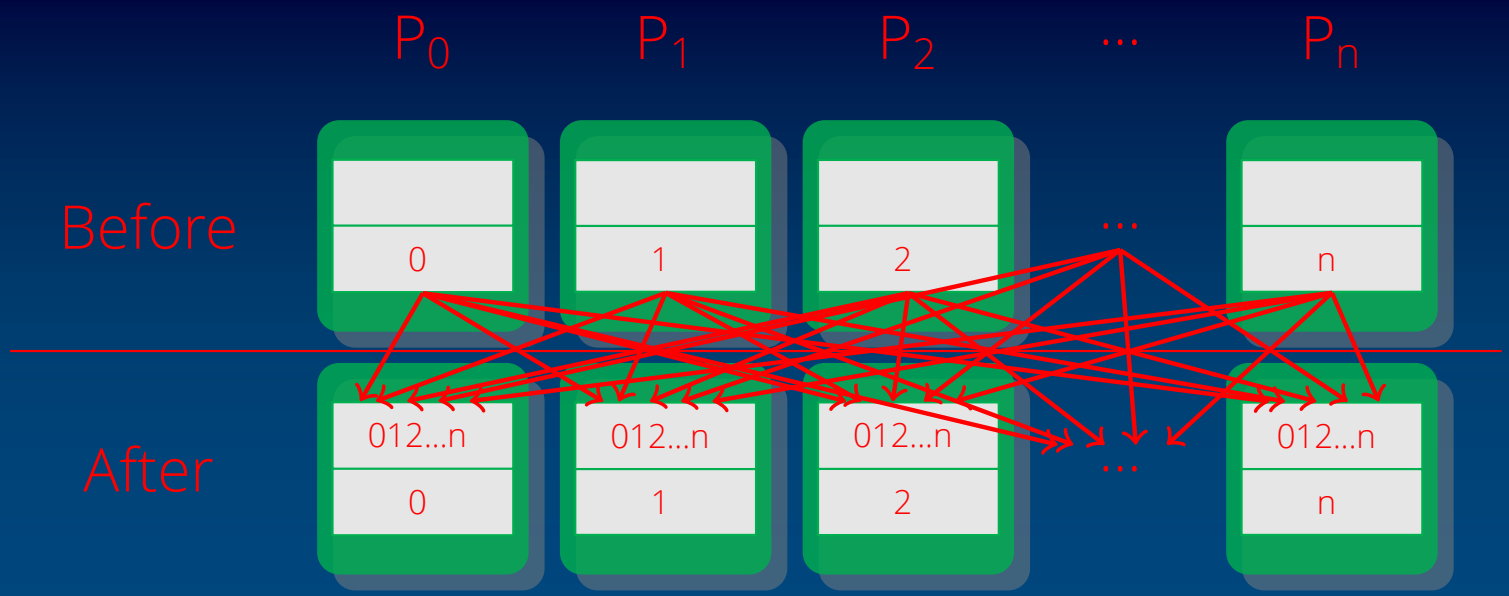

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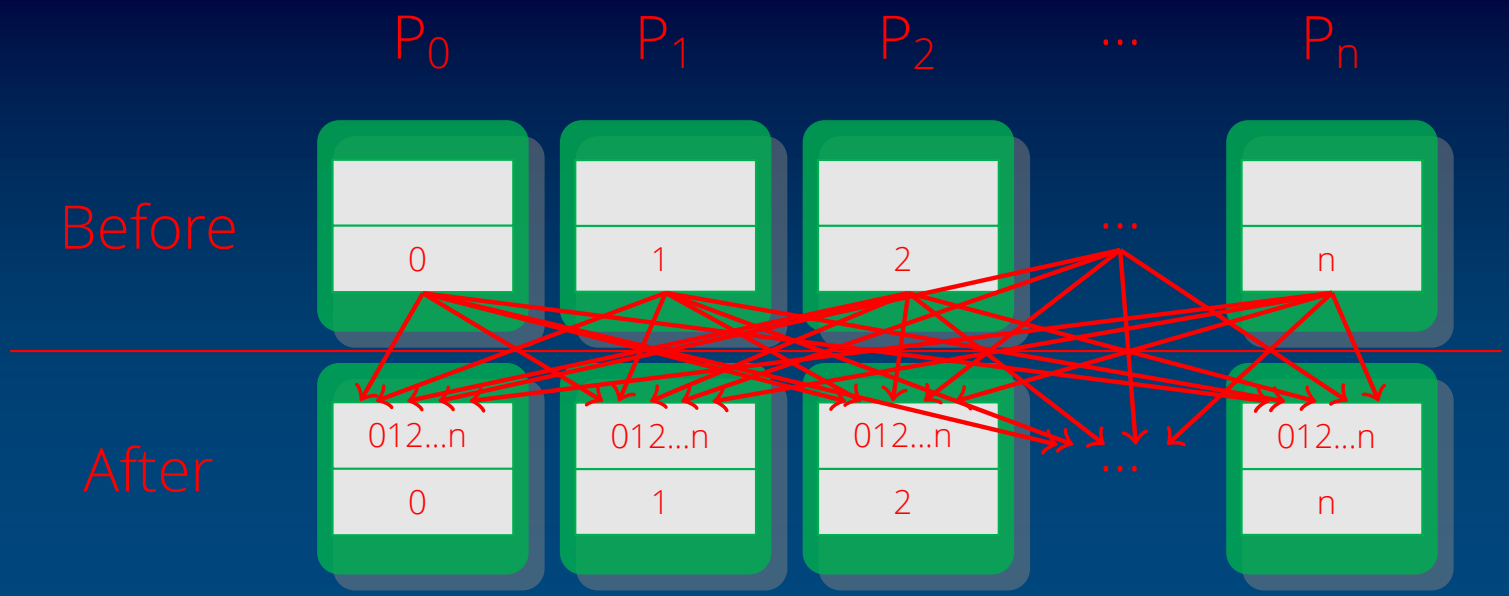


```
int MPI_Allgather(void *sendbuf, int  sendcount, MPI_Datatype
    sendtype, void *recvbuf, int recvcount, MPI_Datatype
    recvtype, MPI_Comm comm)
```

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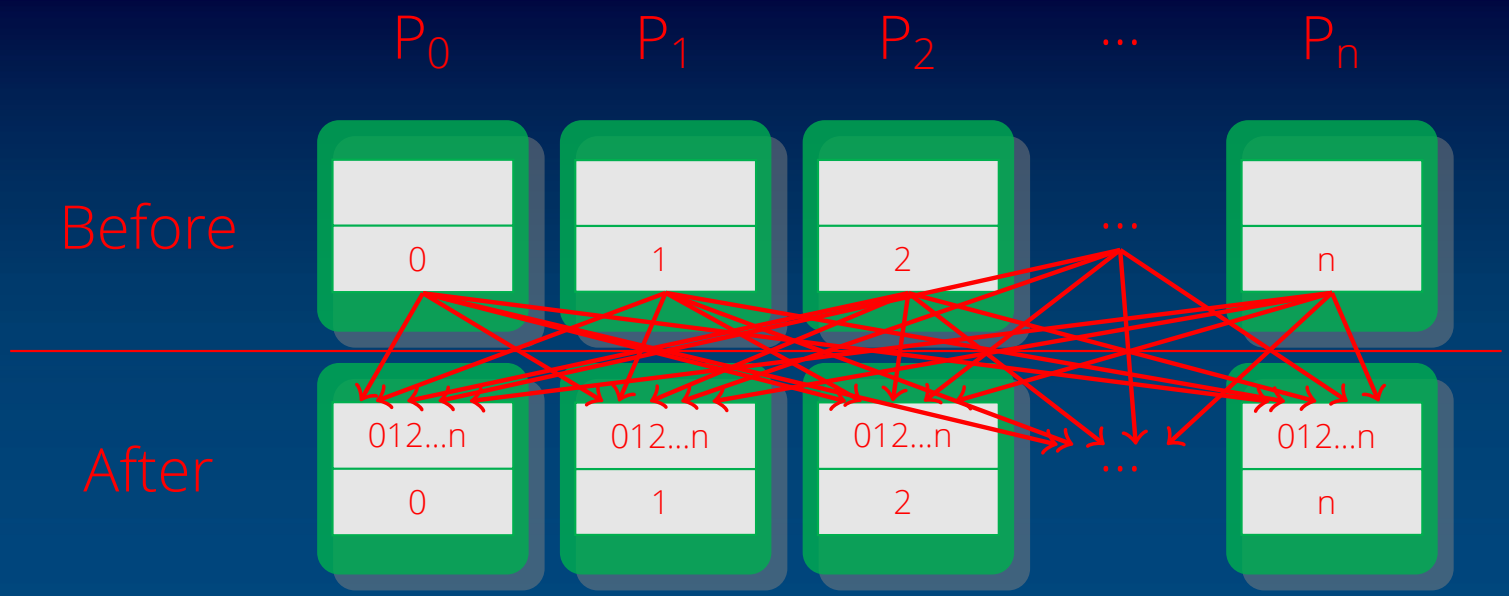
AllGather




```
int MPI_Allgather(void *sendbuf, int  sendcount, MPI_Datatype
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    recvtype, MPI_Comm comm)
```

```
MPI_Allgather(sendbuf, sendcount, sendtype, recvbuf, recvcount,
     recvtype, comm, ierror)
    <type>  :: sendbuf (:), recvbuf (:)
    integer :: sendcount, sendtype, recvcount, recvtype, comm,
        ierror
```

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AlltoAll

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AlltoAll

P_0	1	2	3	4	5	6	7	8
P_1	9	10	11	12	13	14	15	16
P_2	17	18	19	20	21	22	23	24
P_3	25	26	27	28	29	30	31	32

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5	6	13	14	21	22	29	30
7	8	15	16	23	24	31	32

```
int MPI_Alltoall(void *sendbuf, int sendcount, MPI_Datatype
    sendtype, void *recvbuf, int recvcount, MPI_Datatype
    recvtype, MPI_Comm comm)
```

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AlltoAll

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```
int MPI_Alltoall(void *sendbuf, int sendcount, MPI_Datatype
    sendtype, void *recvbuf, int recvcount, MPI_Datatype
    recvtype, MPI_Comm comm)
```

```
MPI_Alltoall(sendbuf, sendcount, sendtype, recvbuf, recvcount,
    recvtype, comm, ierror)
    <type>  :: sendbuf(:), recvbuf(:)
    integer :: sendcount, sendtype, recvcount, recvtype
    integer :: comm, ierror
```

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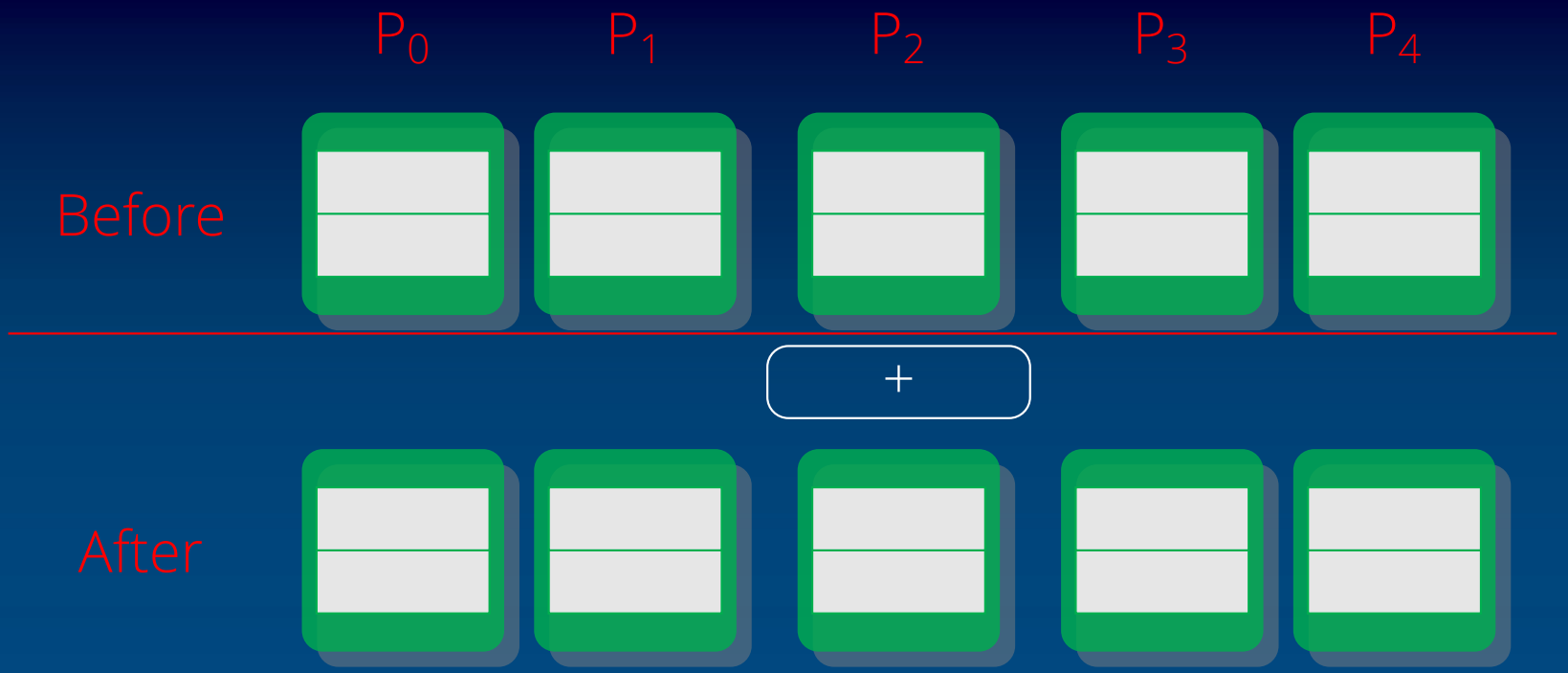
reduce



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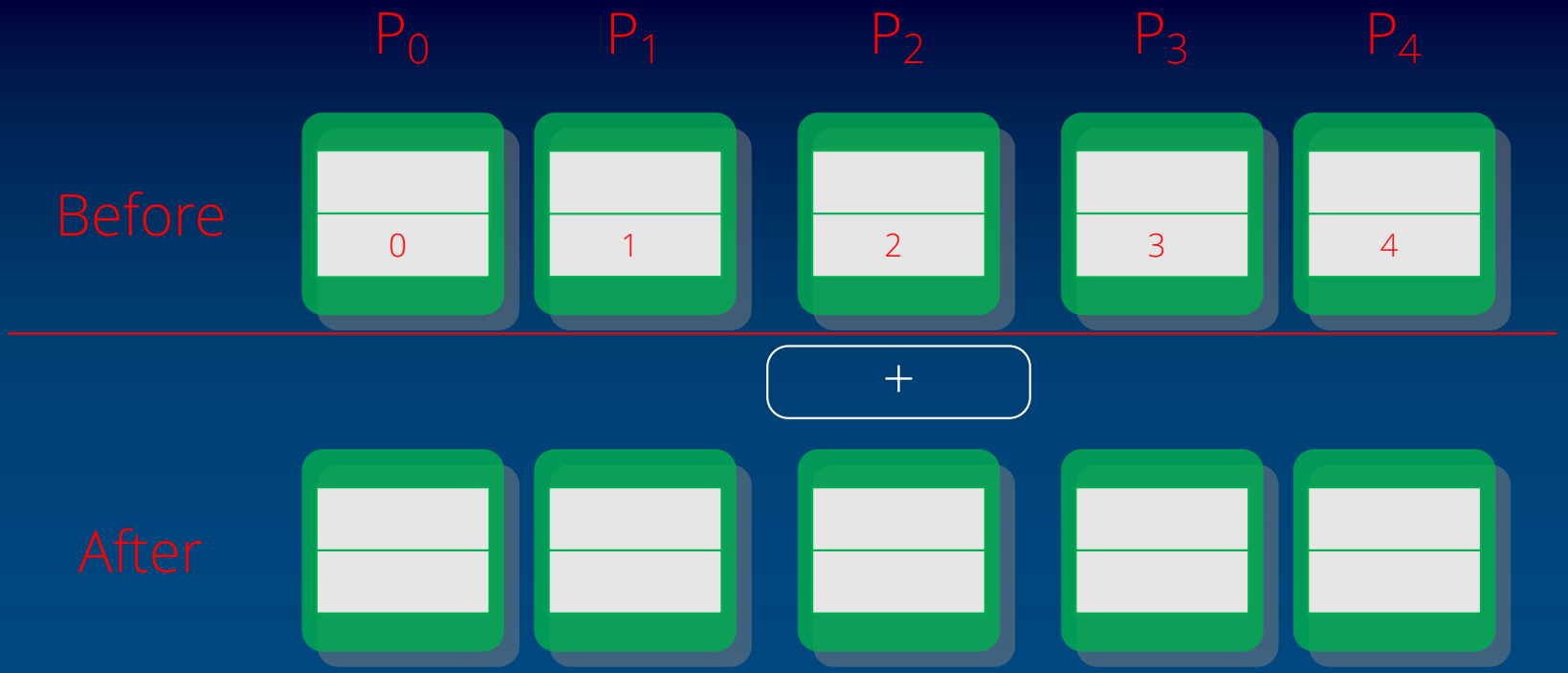
reduce



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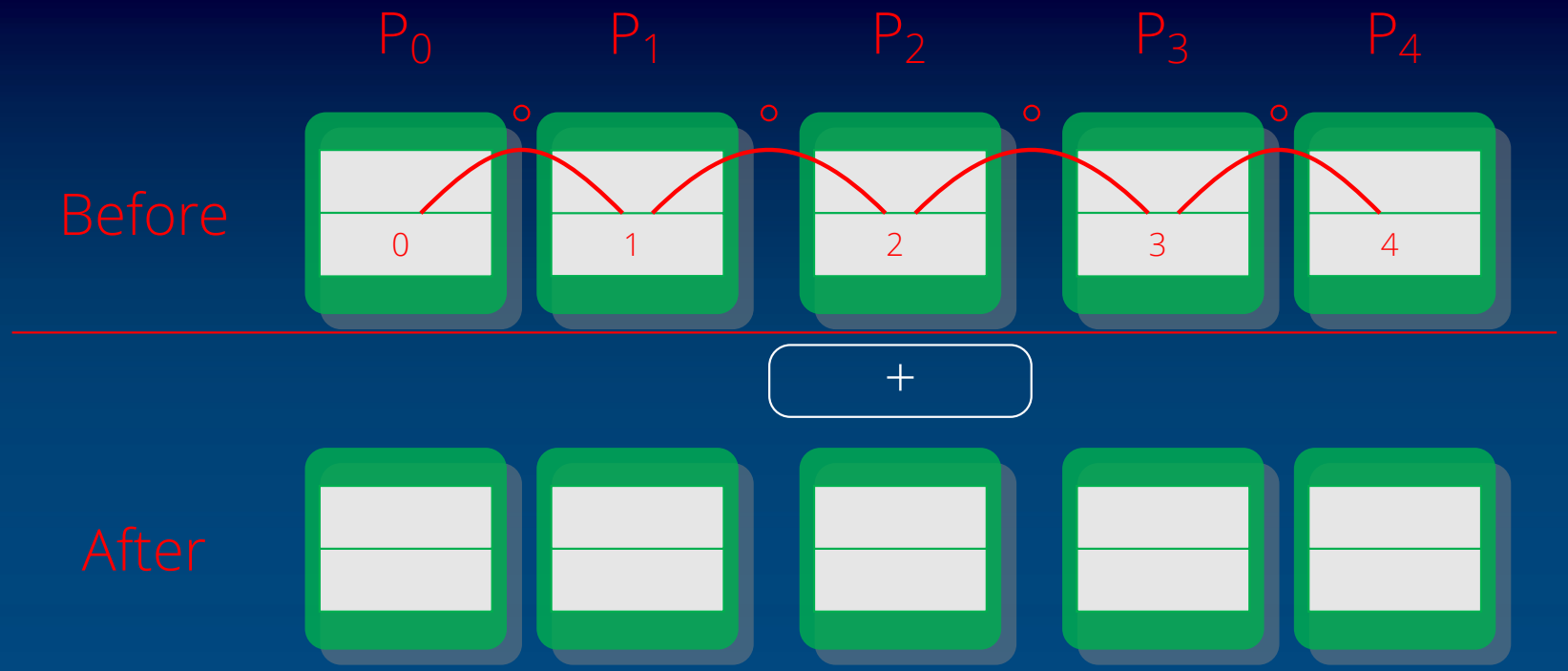
reduce



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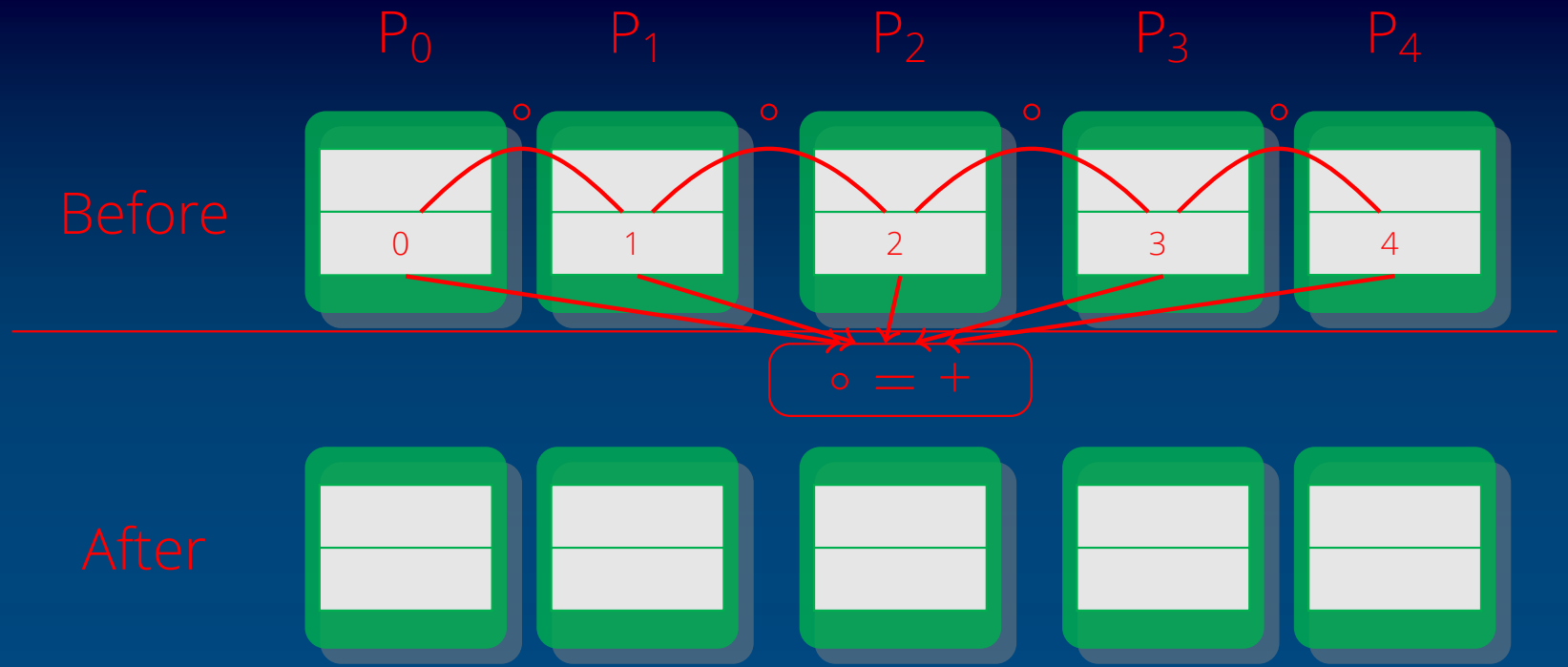
reduce



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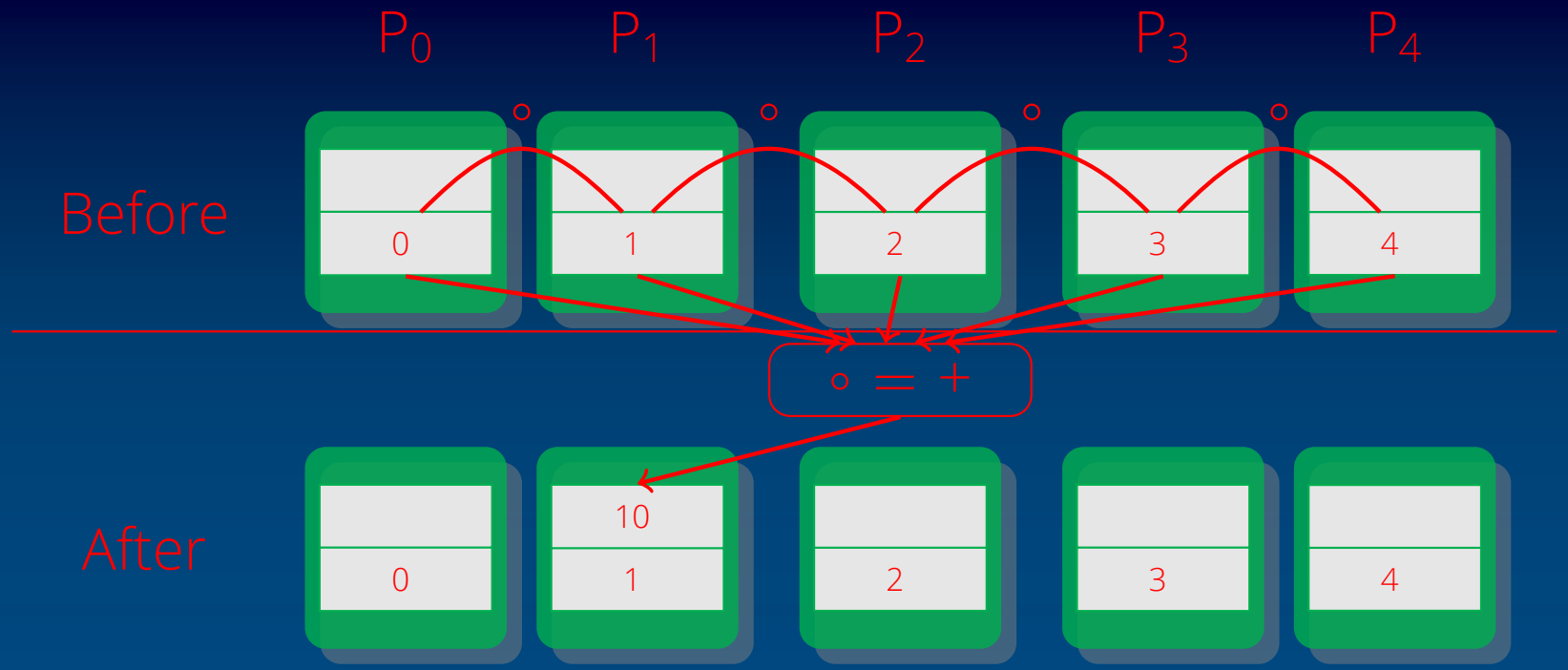
reduce



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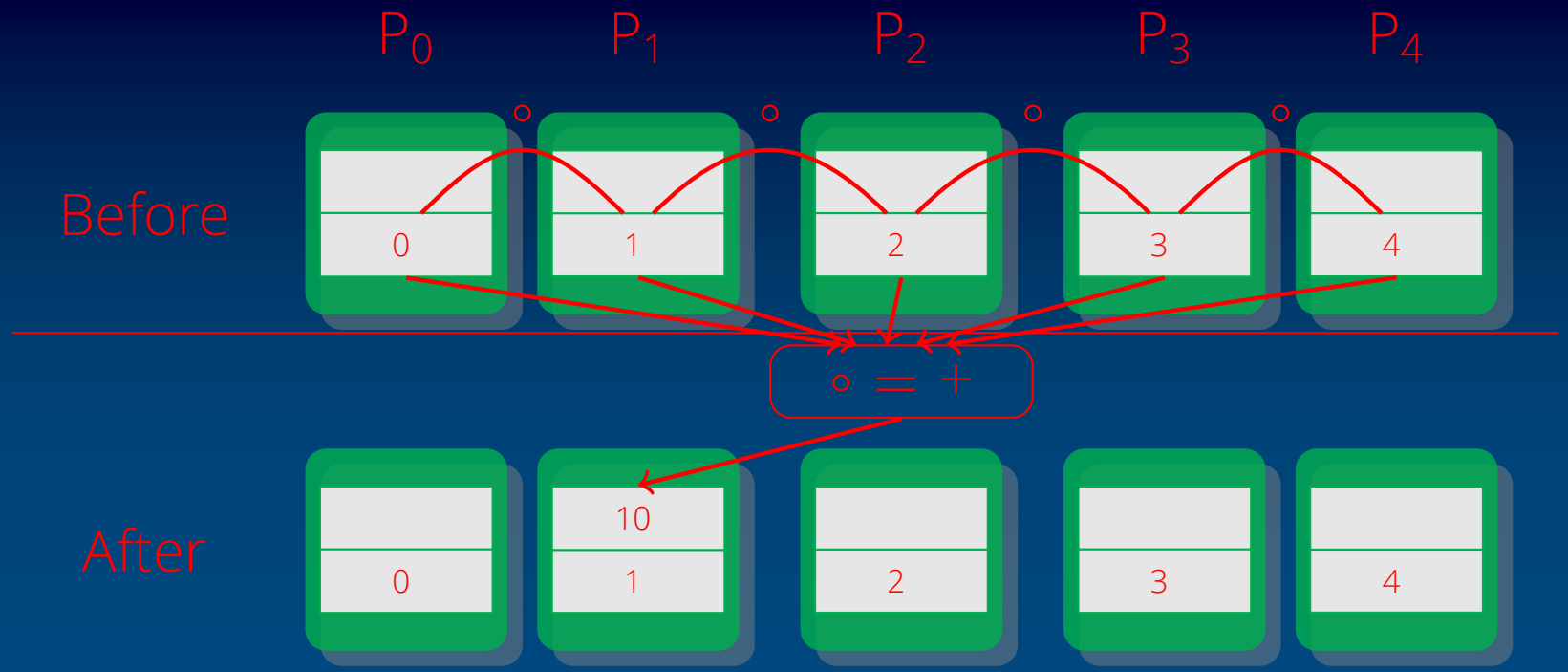
reduce




```
int MPI_Reduce(void *sendbuf, void *recvbuf, int count,
    MPI_Datatype datatype, MPI_Op op, int root, MPI_Comm comm)
```

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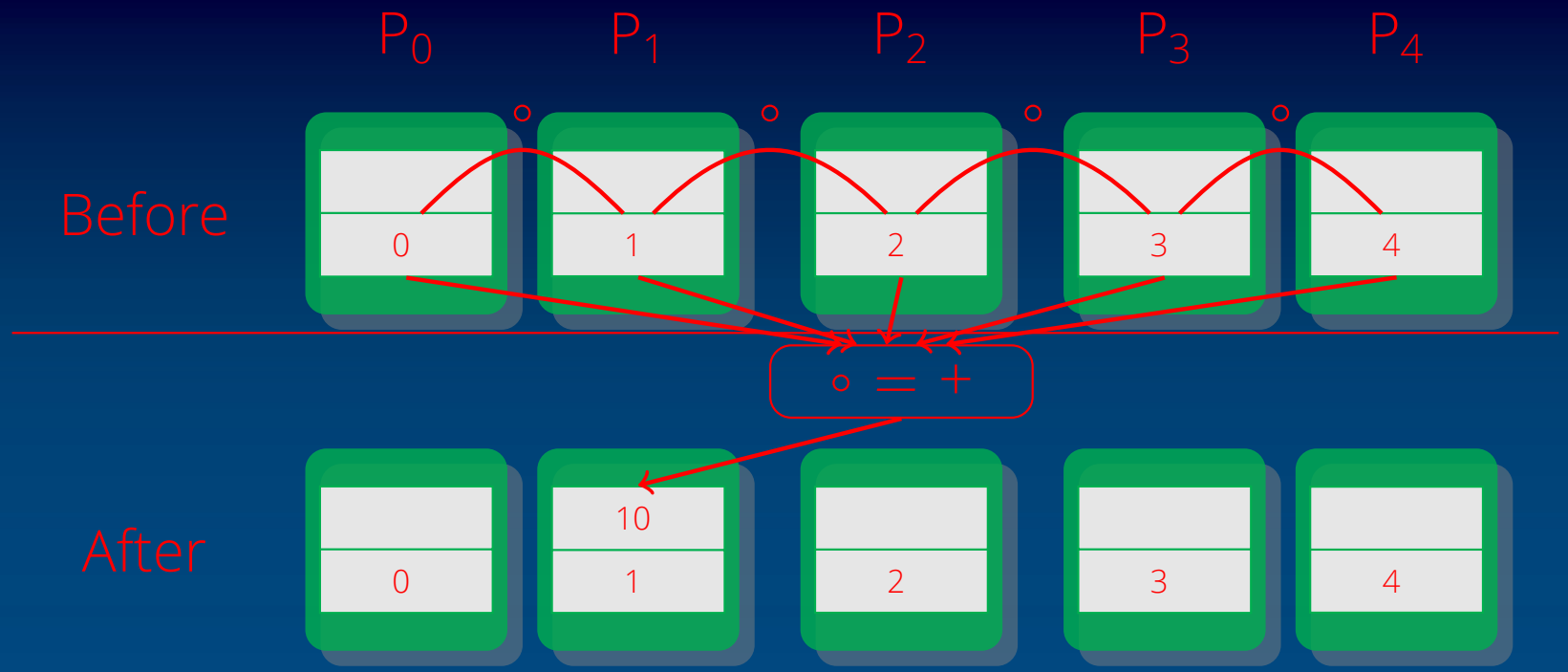
reduce




```
int MPI_Reduce(void *sendbuf, void *recvbuf, int count,
    MPI_Datatype datatype, MPI_Op op, int root, MPI_Comm comm)
```

```
MPI_Reduce(sendbuf, recvbuf, count, datatype, op, root, comm,
    ierror)
    <type>  :: sendbuf(:), recvbuf(:)
    integer :: count, datatype, op, root, comm, ierror
```

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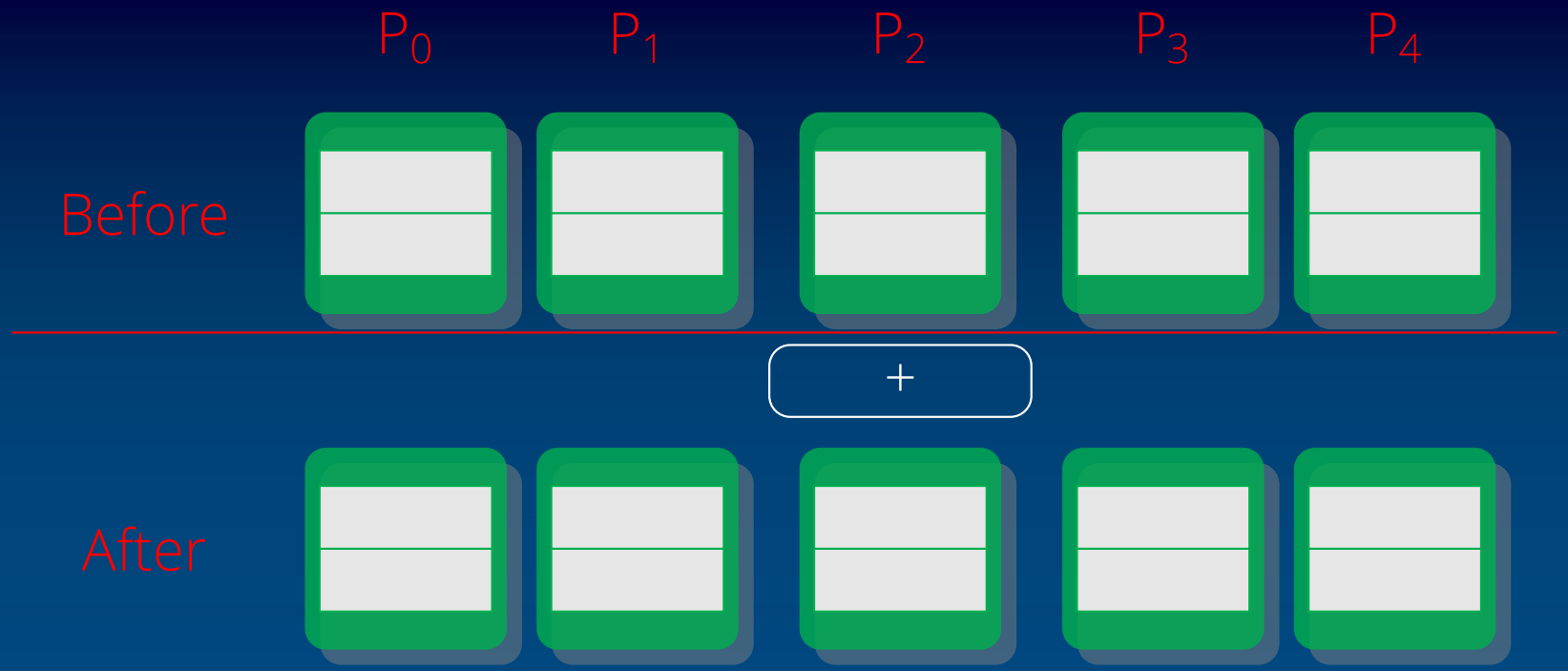
allreduce



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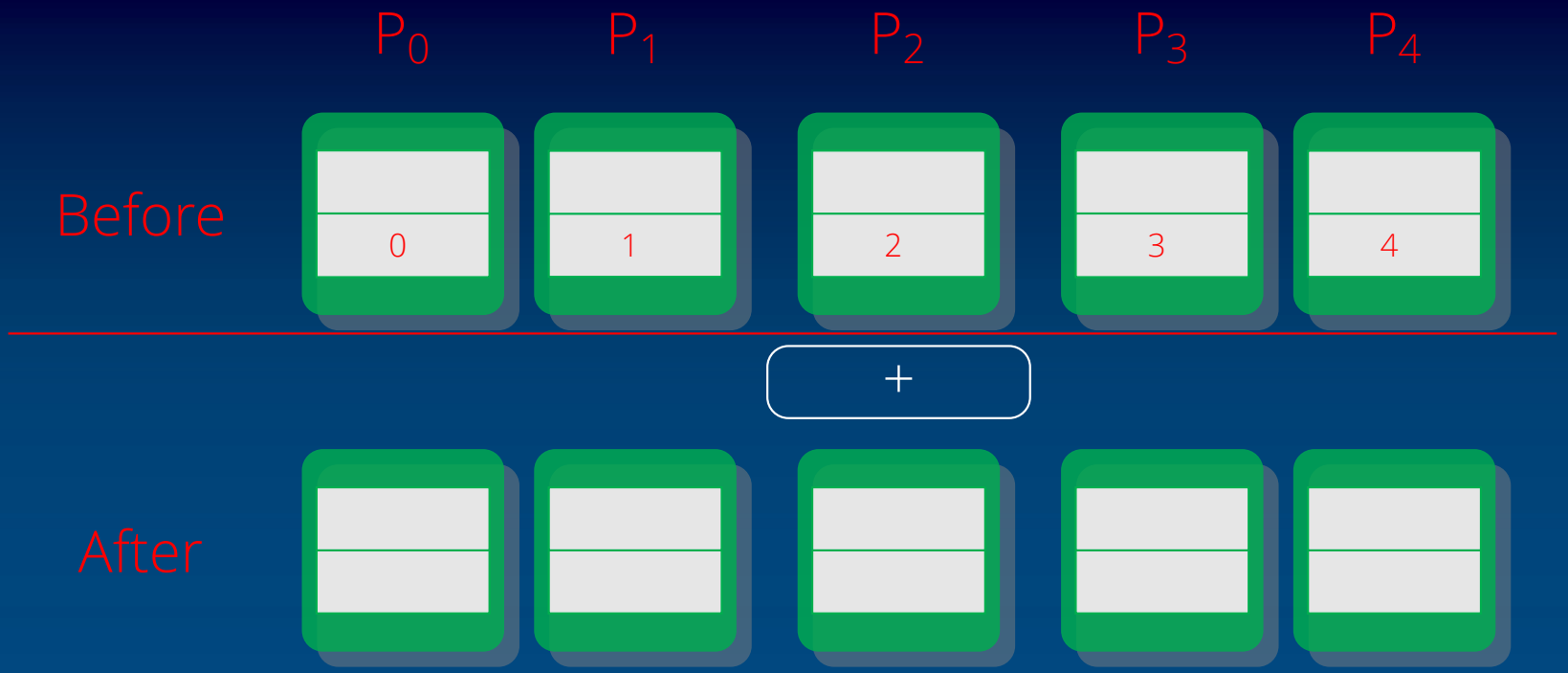
allreduce



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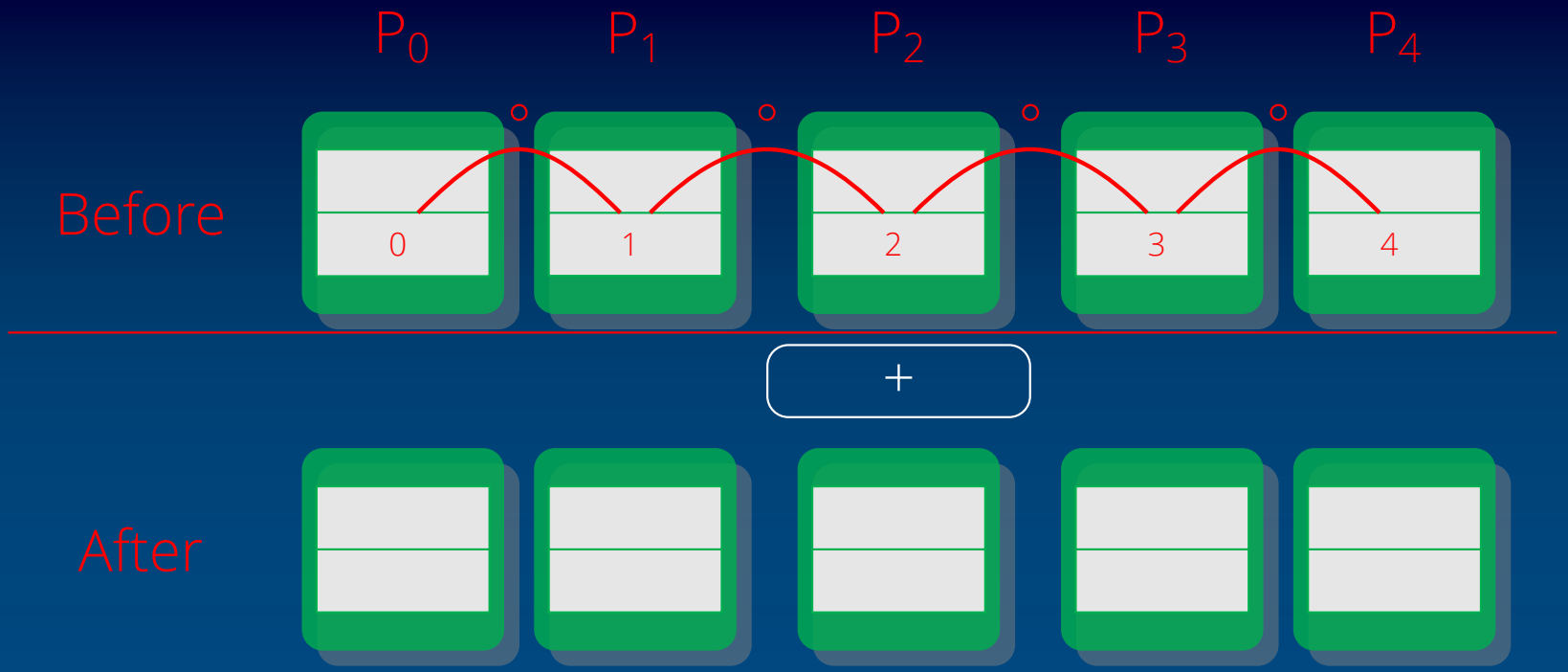
allreduce



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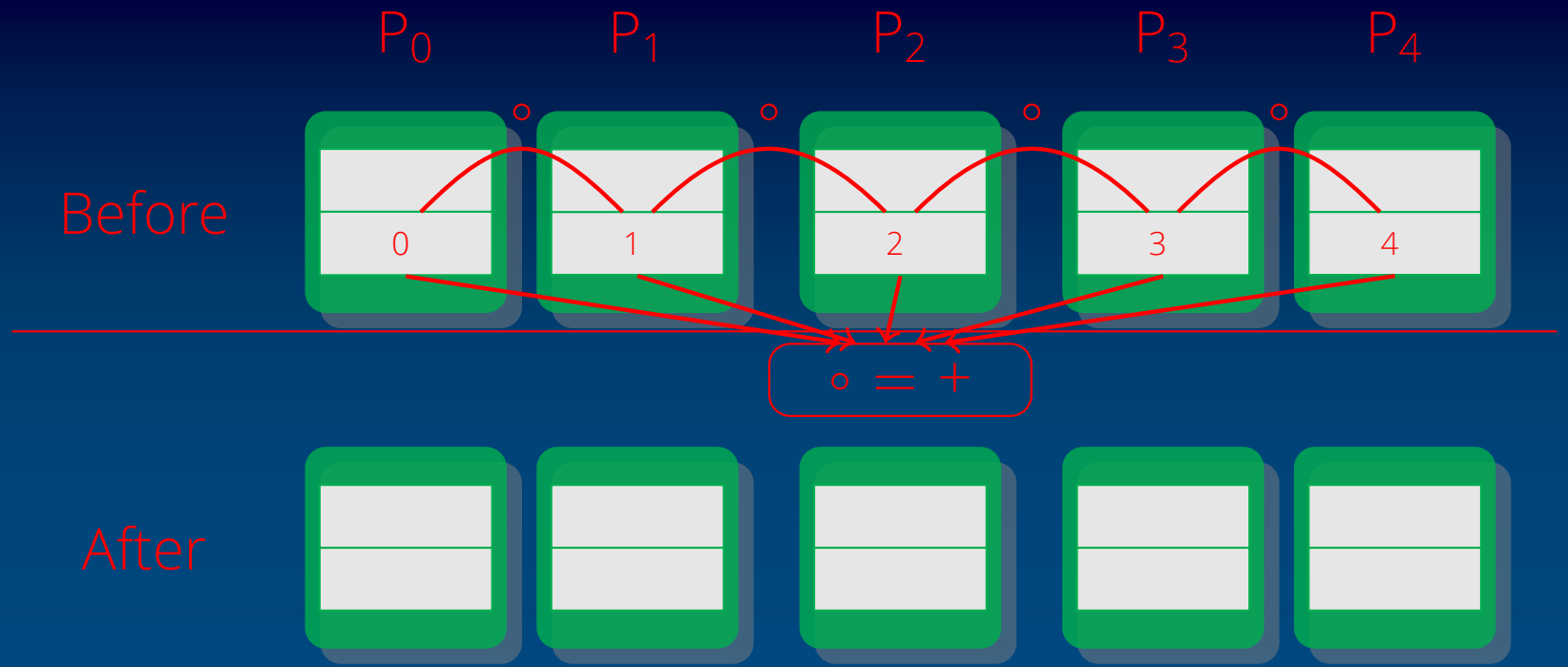
allreduce



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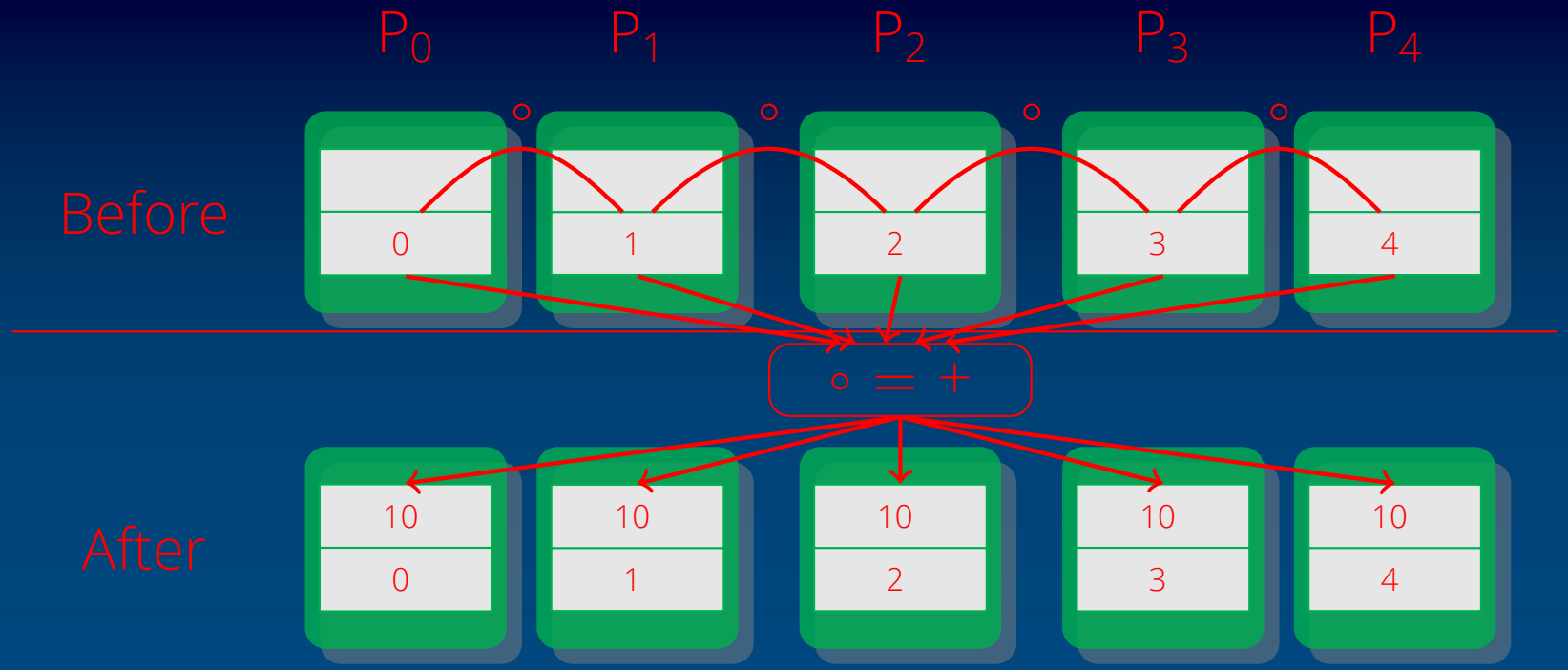
allreduce



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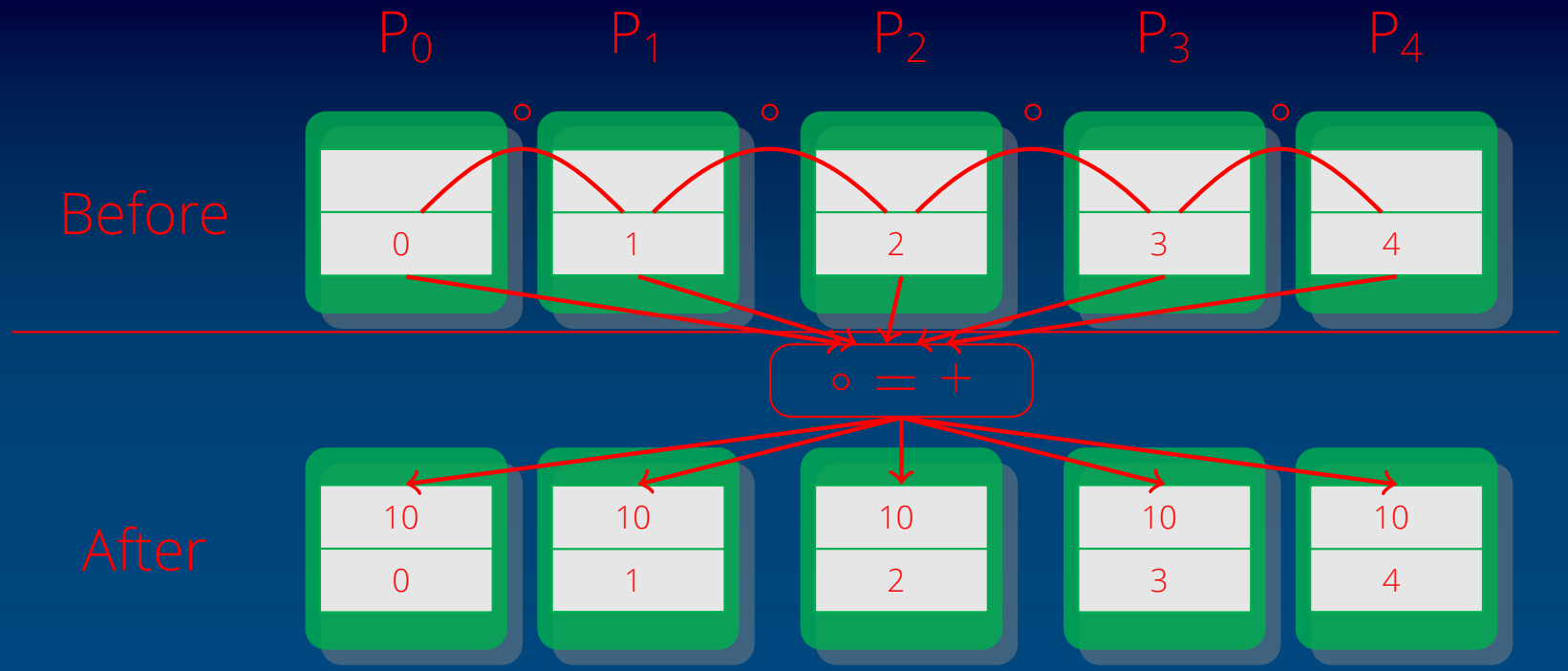
allreduce




```
int MPI_Allreduce(void *sendbuf, void *recvbuf, int count,
    MPI_Datatype datatype, MPI_Op op, MPI_Comm comm)
```

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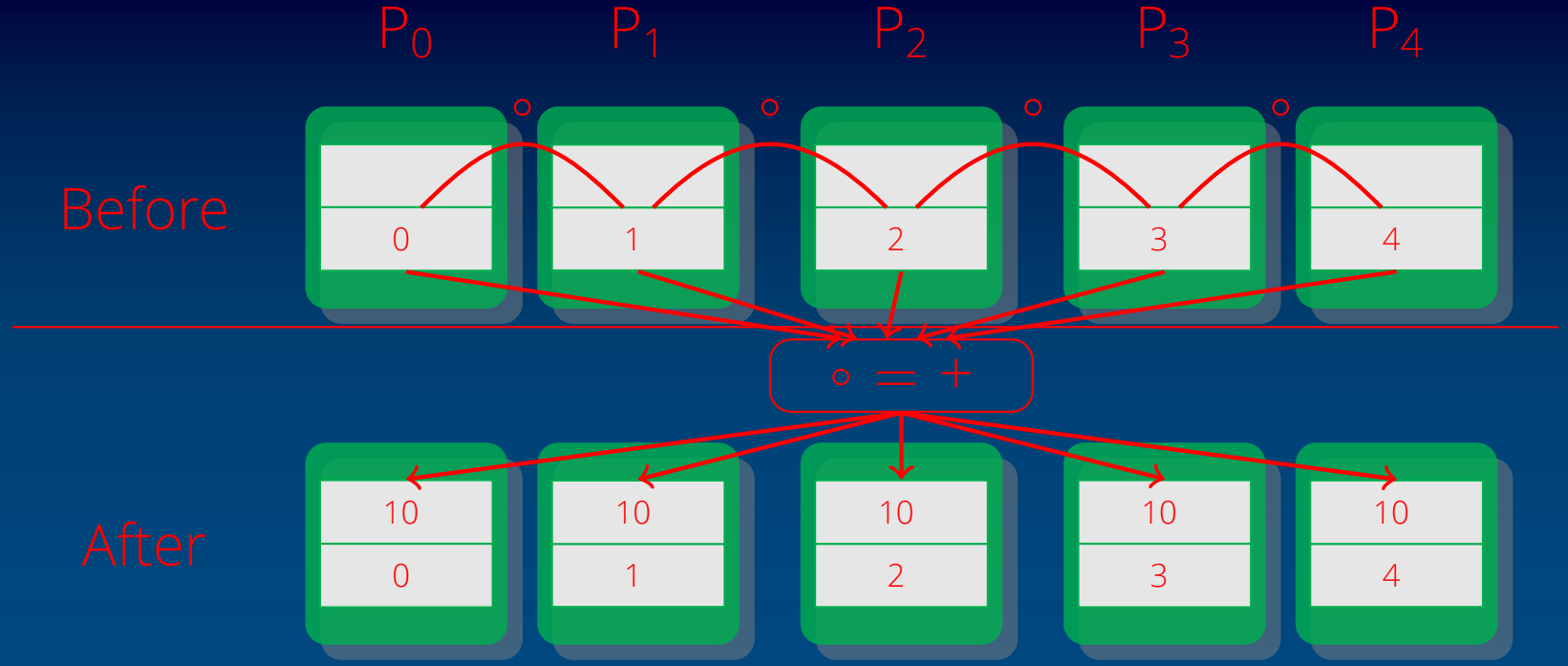
allreduce




```
int MPI_Allreduce(void *sendbuf, void *recvbuf, int count,
    MPI_Datatype datatype, MPI_Op op, MPI_Comm comm)
```

```
MPI_Allreduce(sendbuf, recvbuf, count, datatype, op, comm,
    ierror)
    <type>  :: sendbuf(*), recvbuf(*)
    integer :: count, datatype, op, comm, ierror
```

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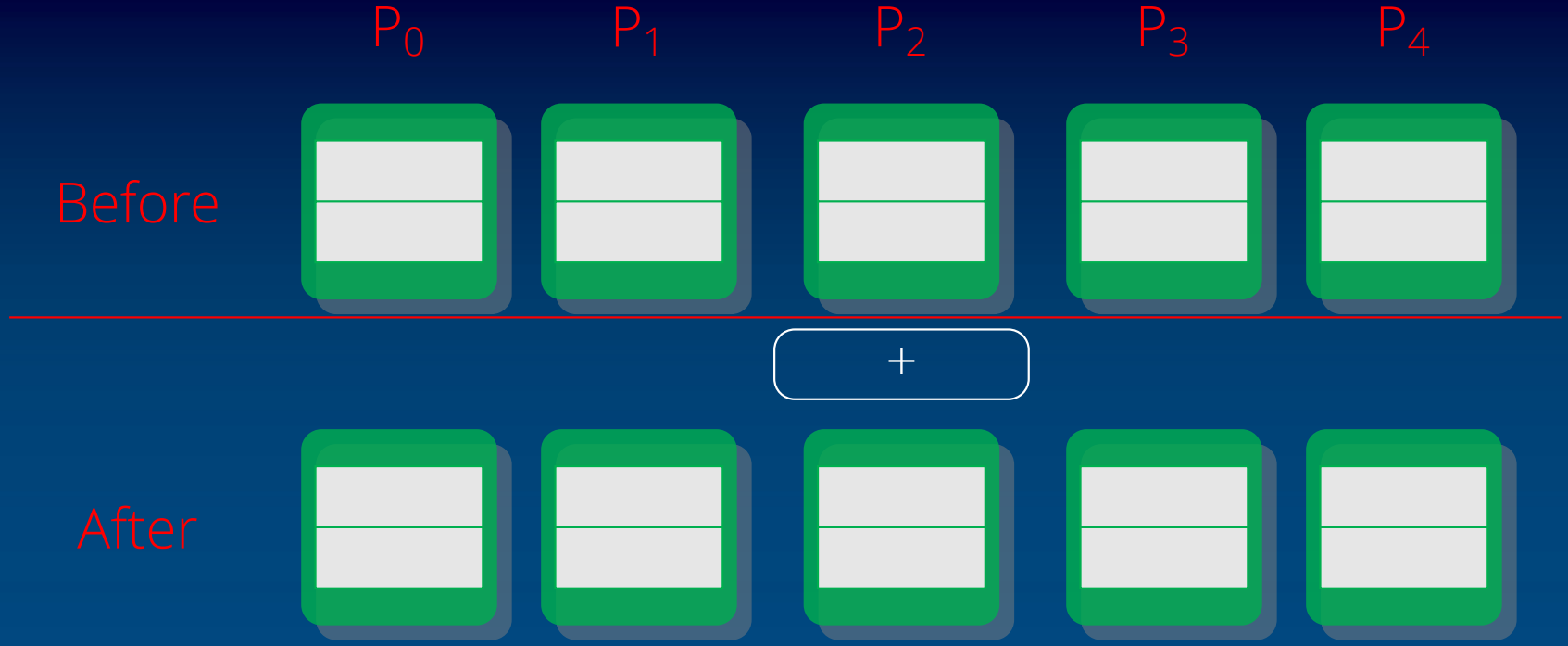
scan



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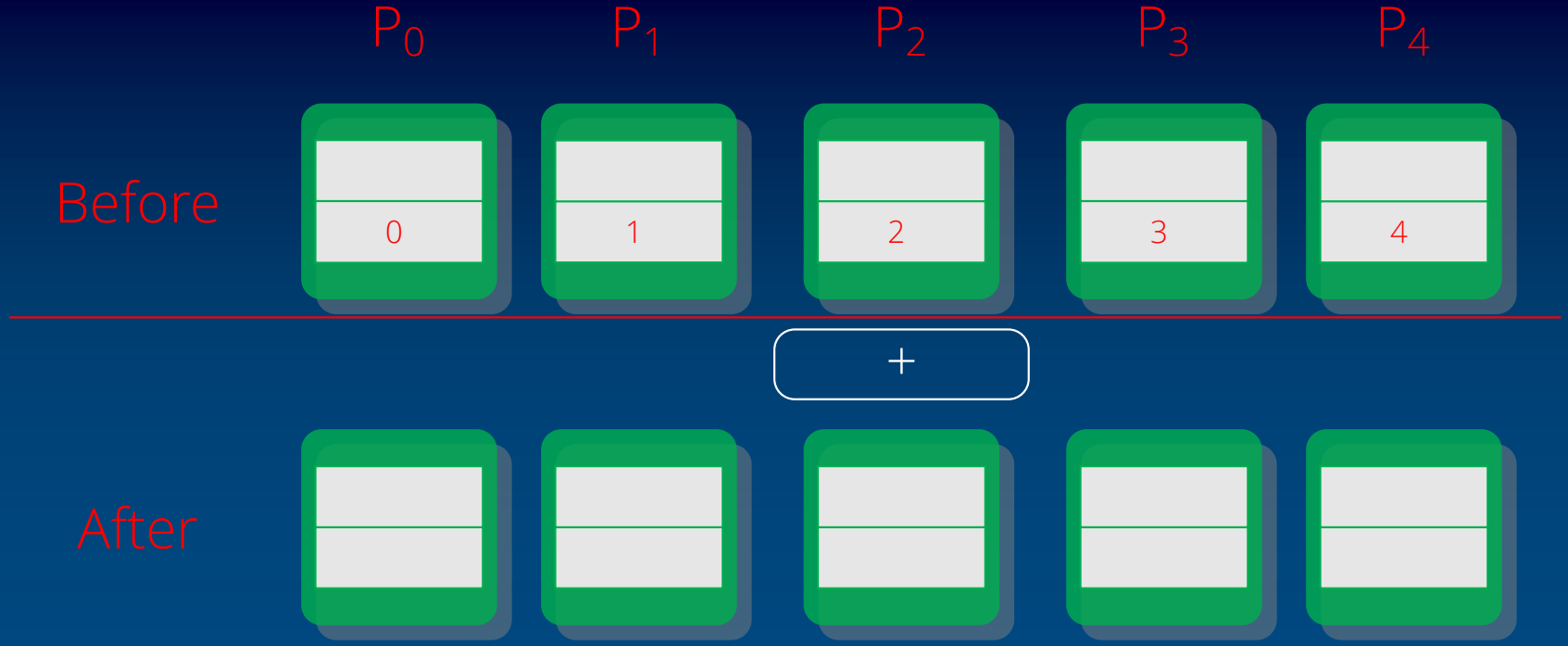
scan



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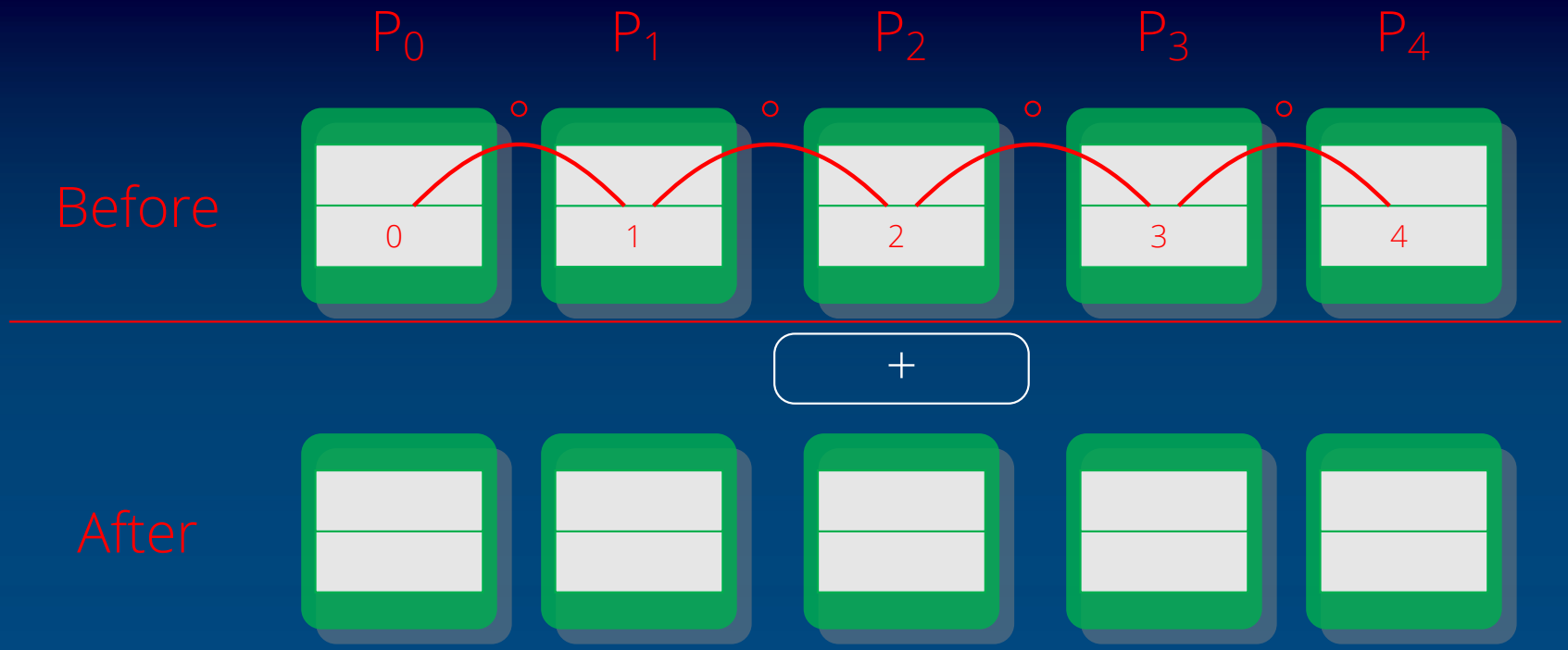
scan



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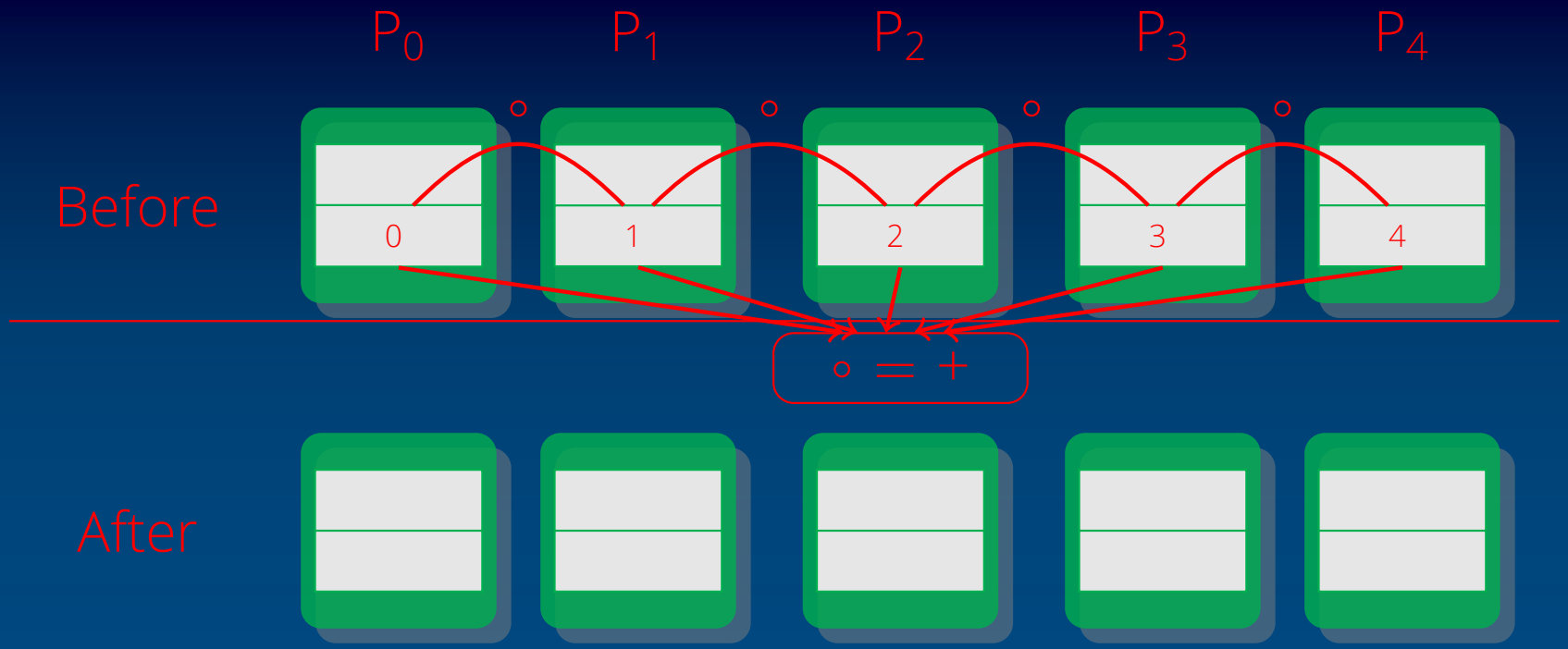
scan



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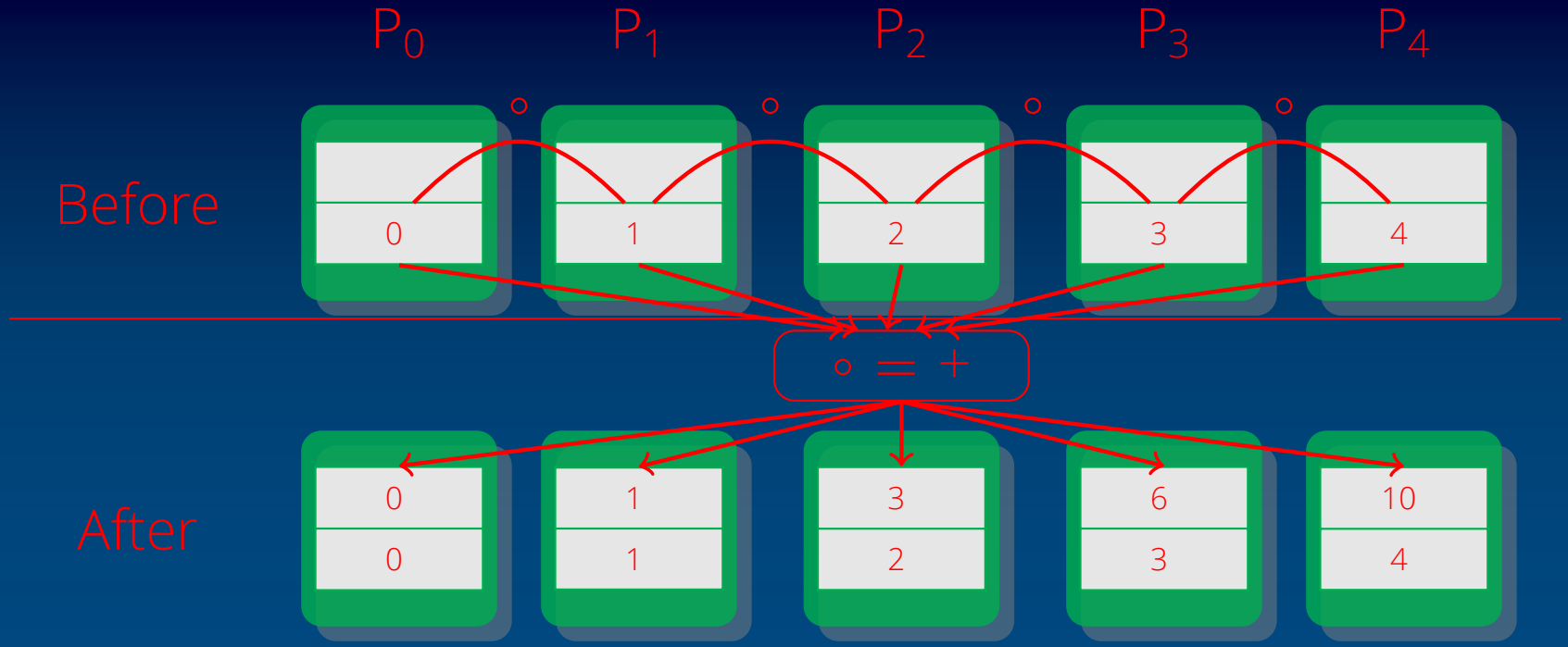
scan



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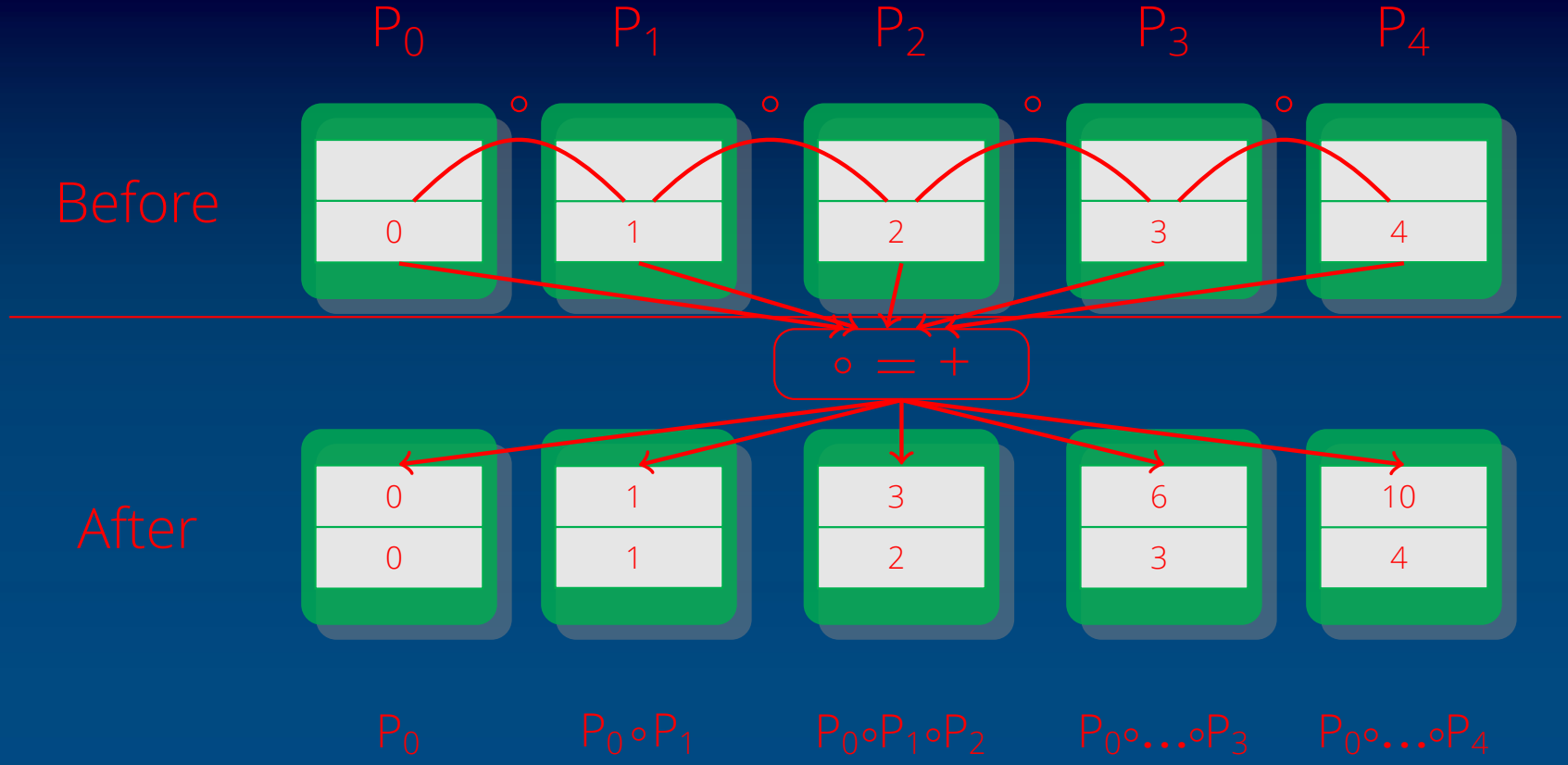
scan



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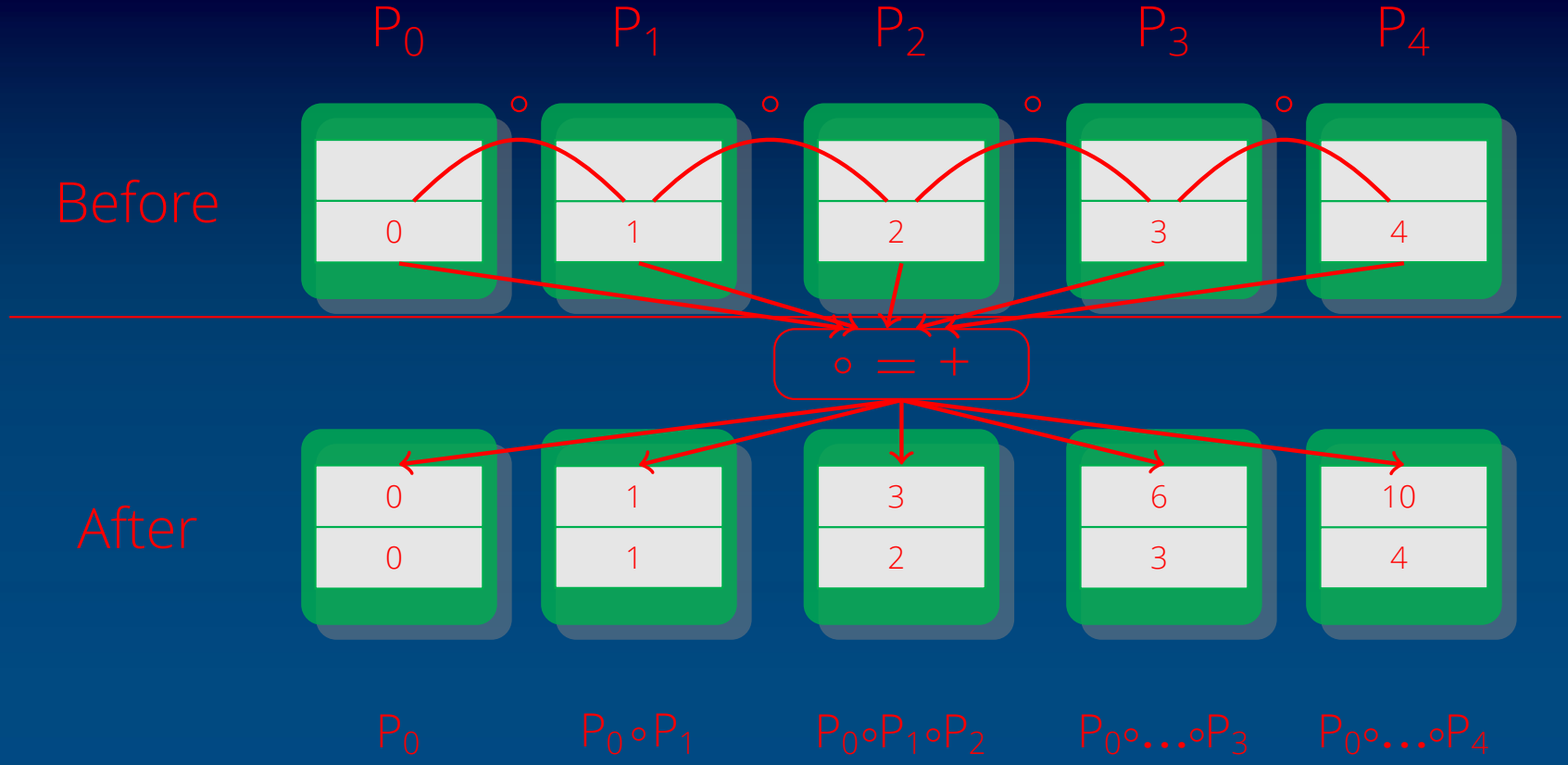
scan




```
int MPI_Scan(void *sendbuf, void *recvbuf, int count,
    MPI_Datatype datatype, MPI_Op op, MPI_Comm comm)
```

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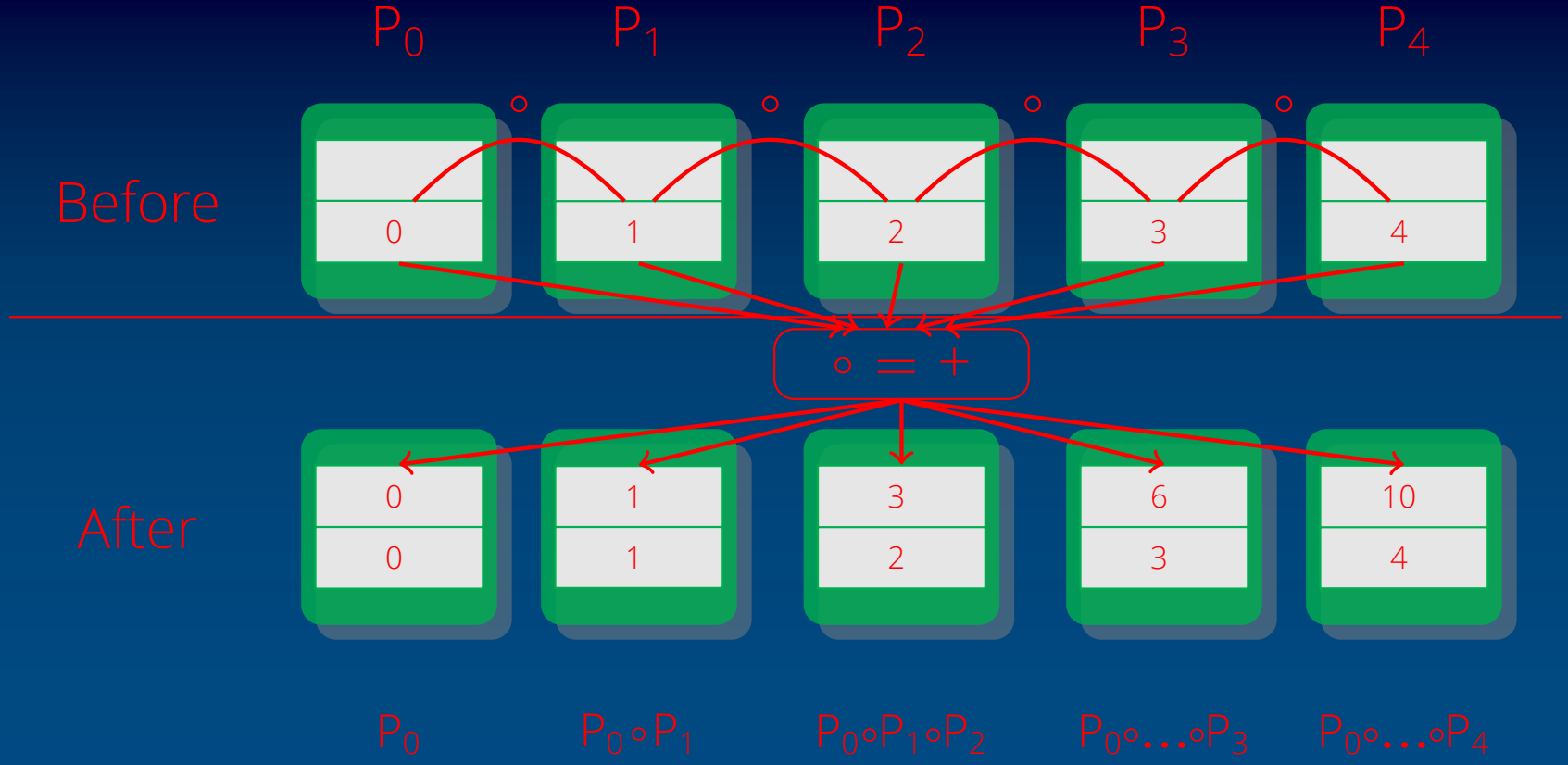
scan




```
int MPI_Scan(void *sendbuf, void *recvbuf, int count,
    MPI_Datatype datatype, MPI_Op op, MPI_Comm comm)

MPI_Scan(sendbuf, recvbuf, count, datatype, op, comm, ierror)
    <type>  :: sendbuf(:), recvbuf(:)
    integer :: count, datatype, op, comm, ierror
```

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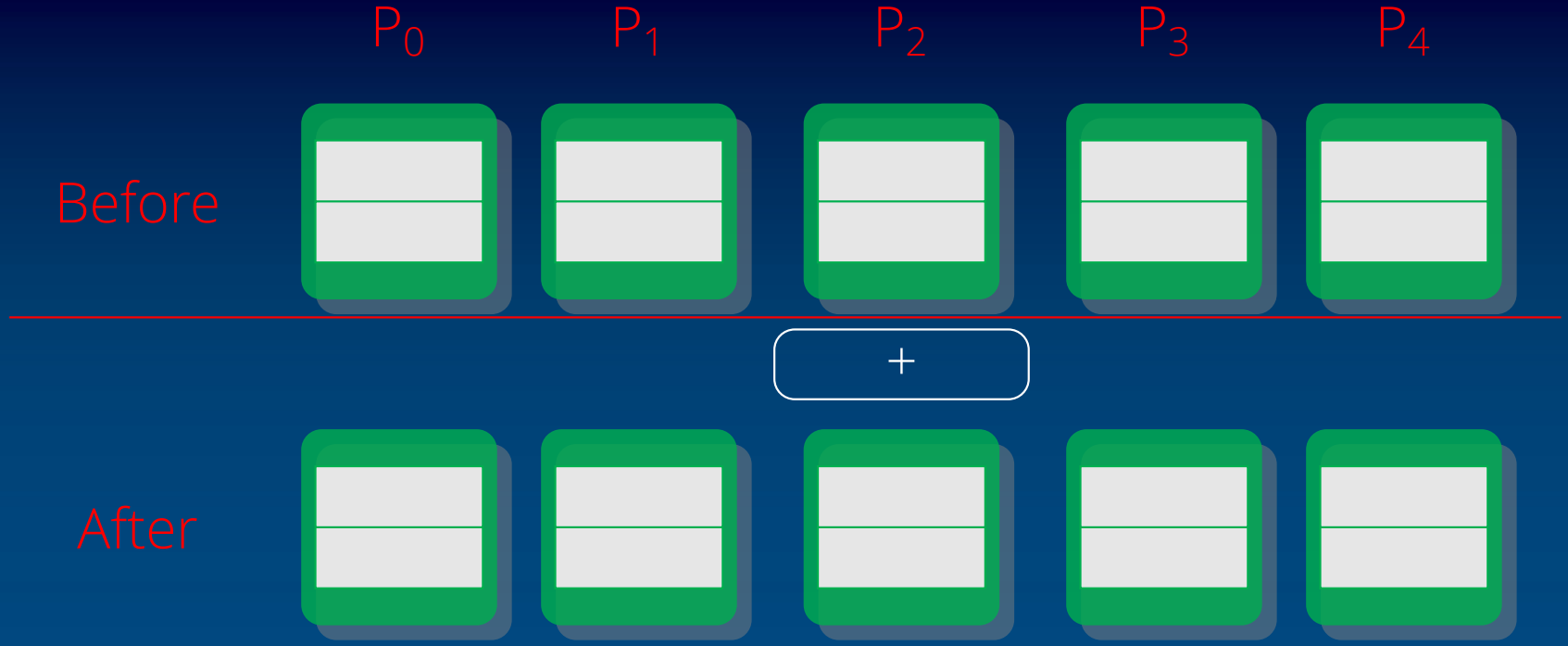
ExScan



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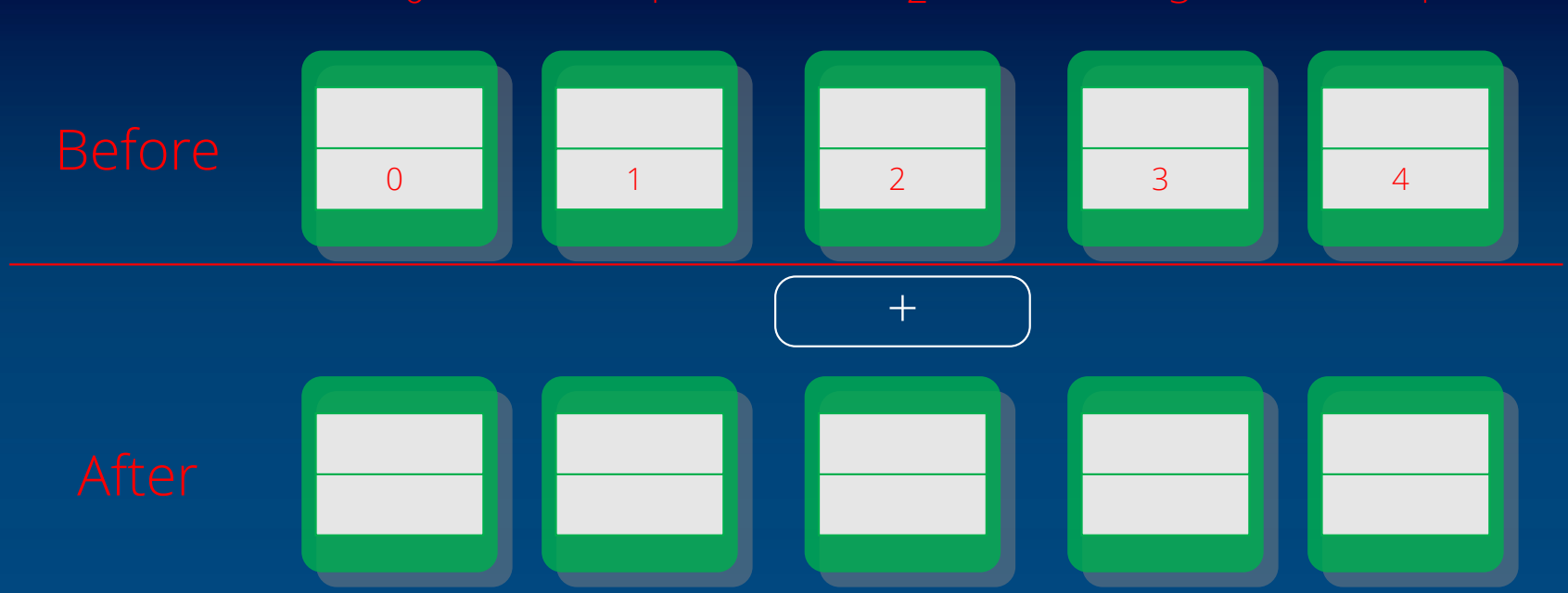
ExScan



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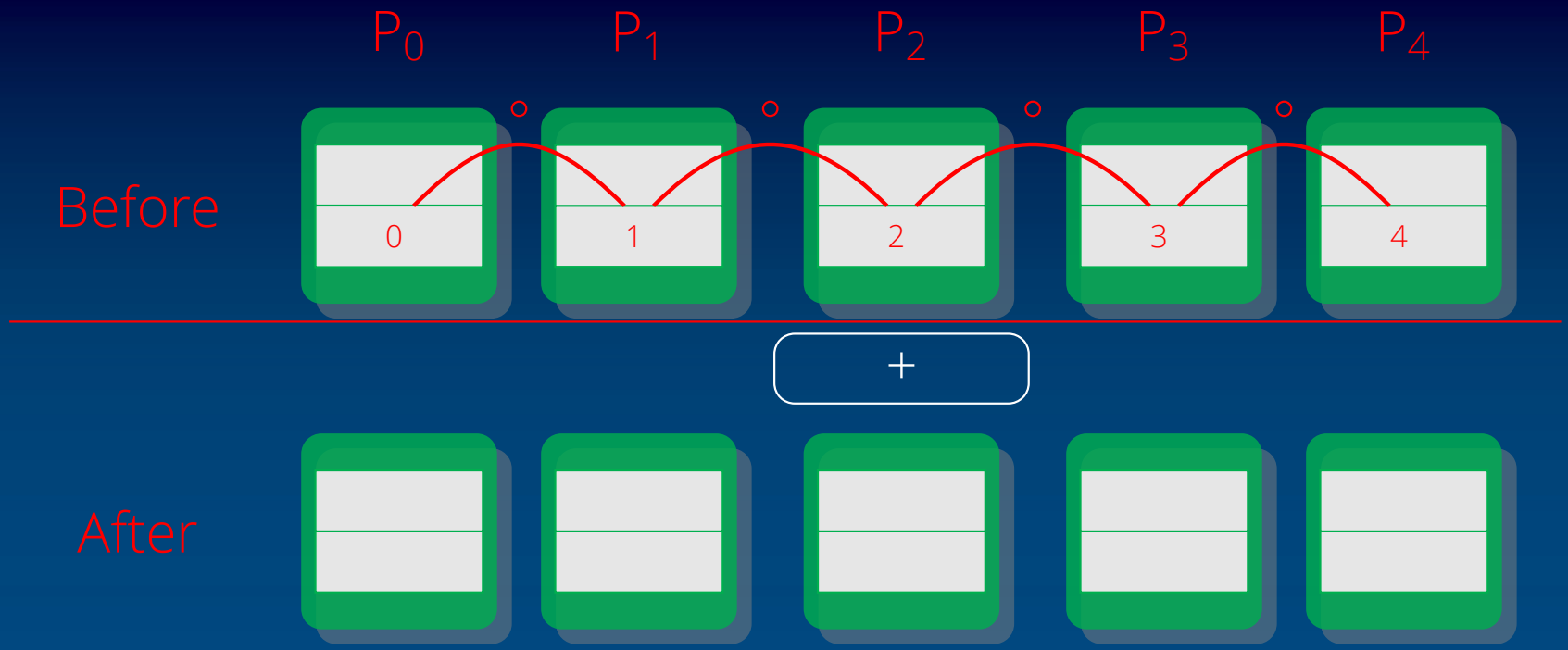
ExScan



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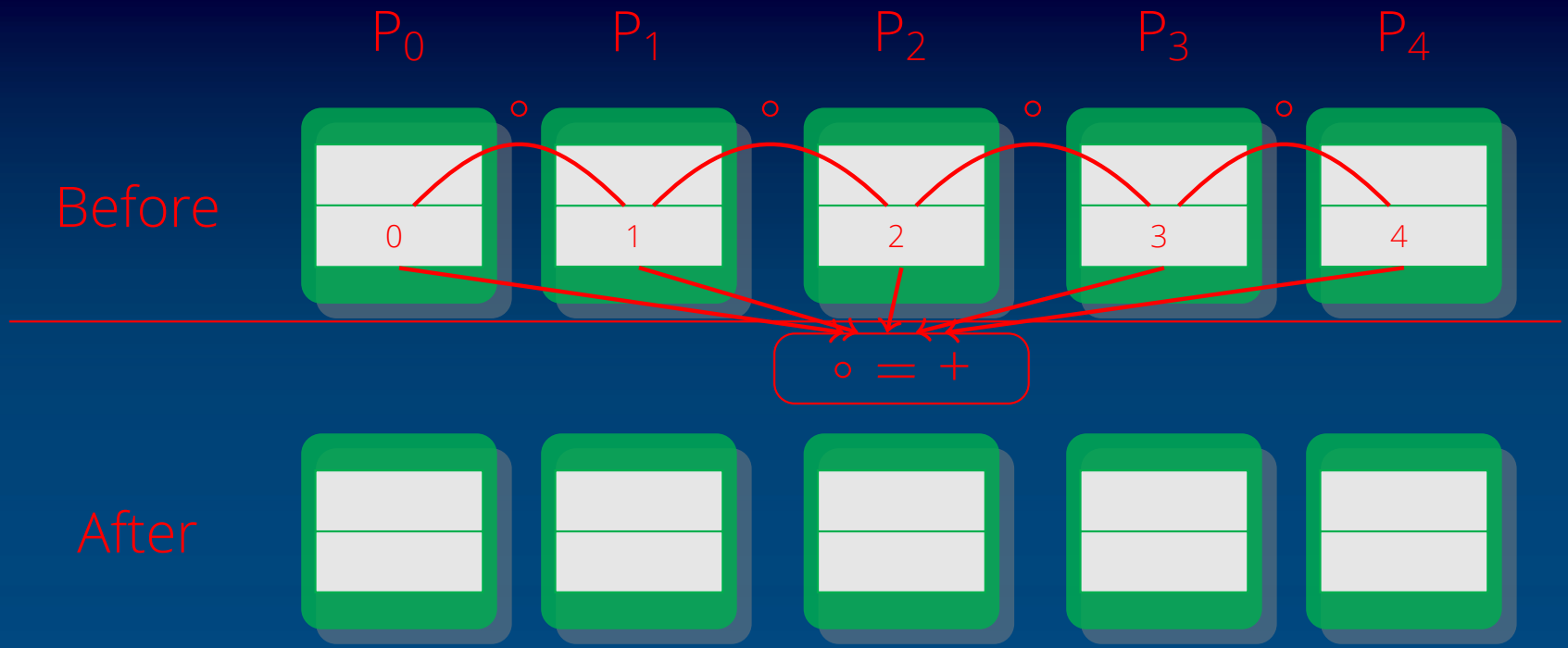
ExScan



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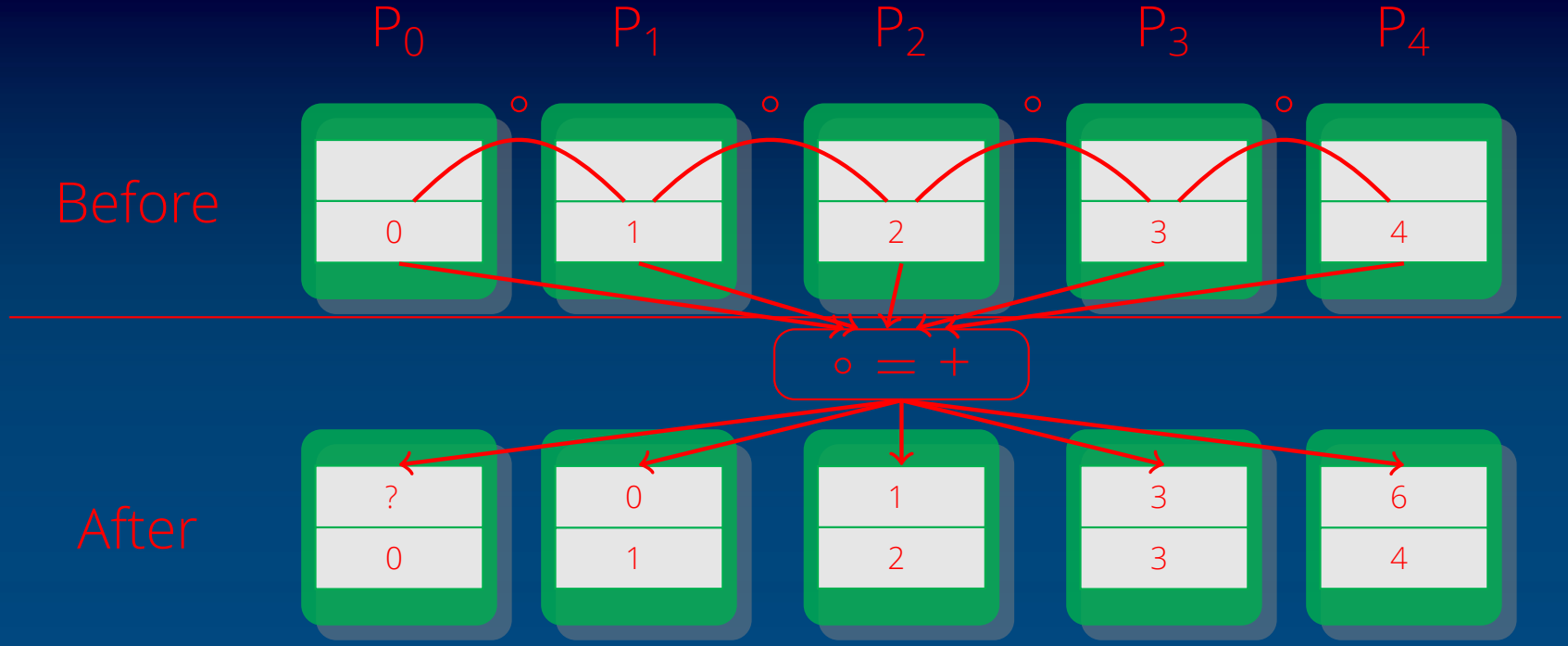
ExScan



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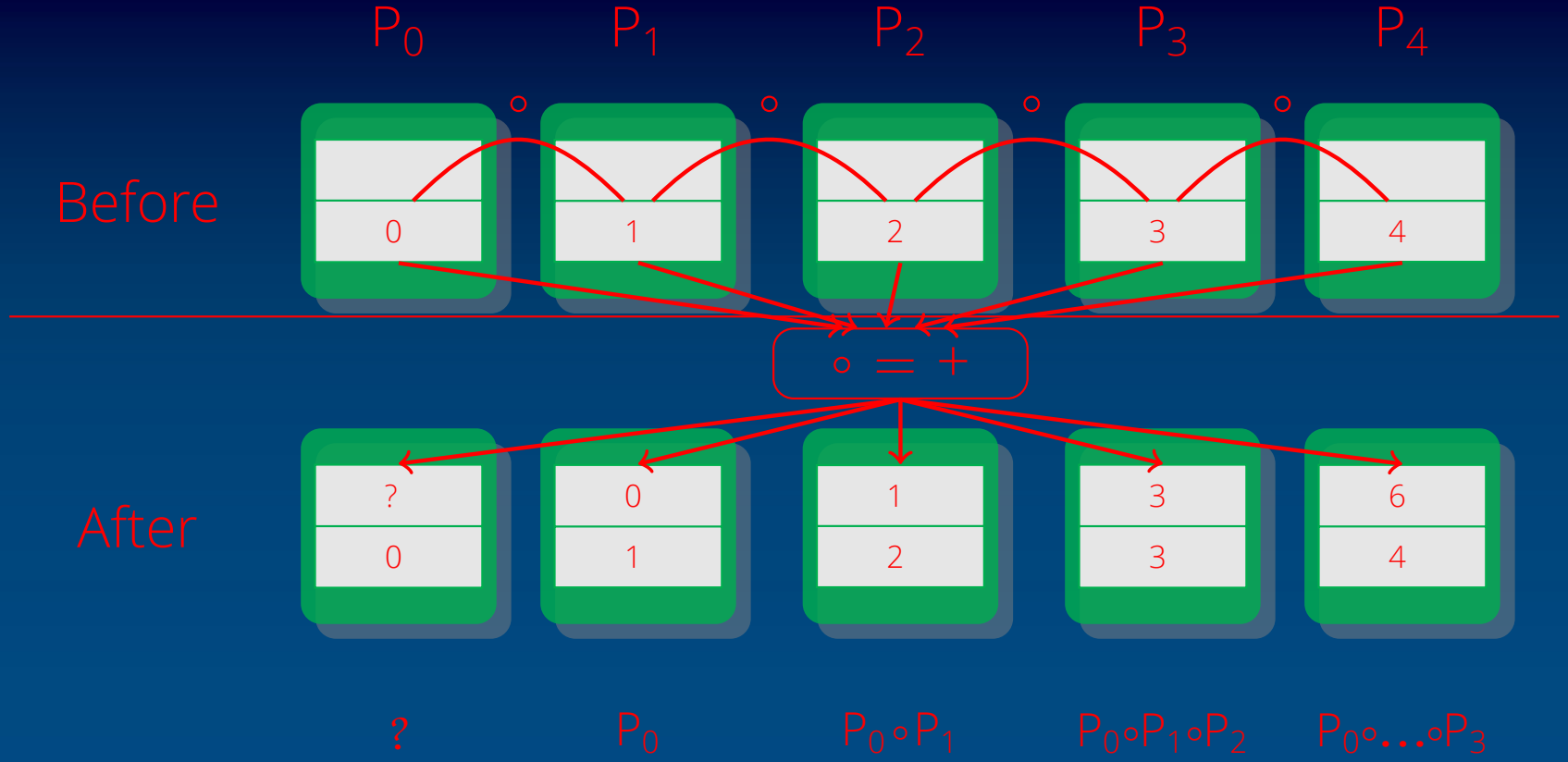
ExScan



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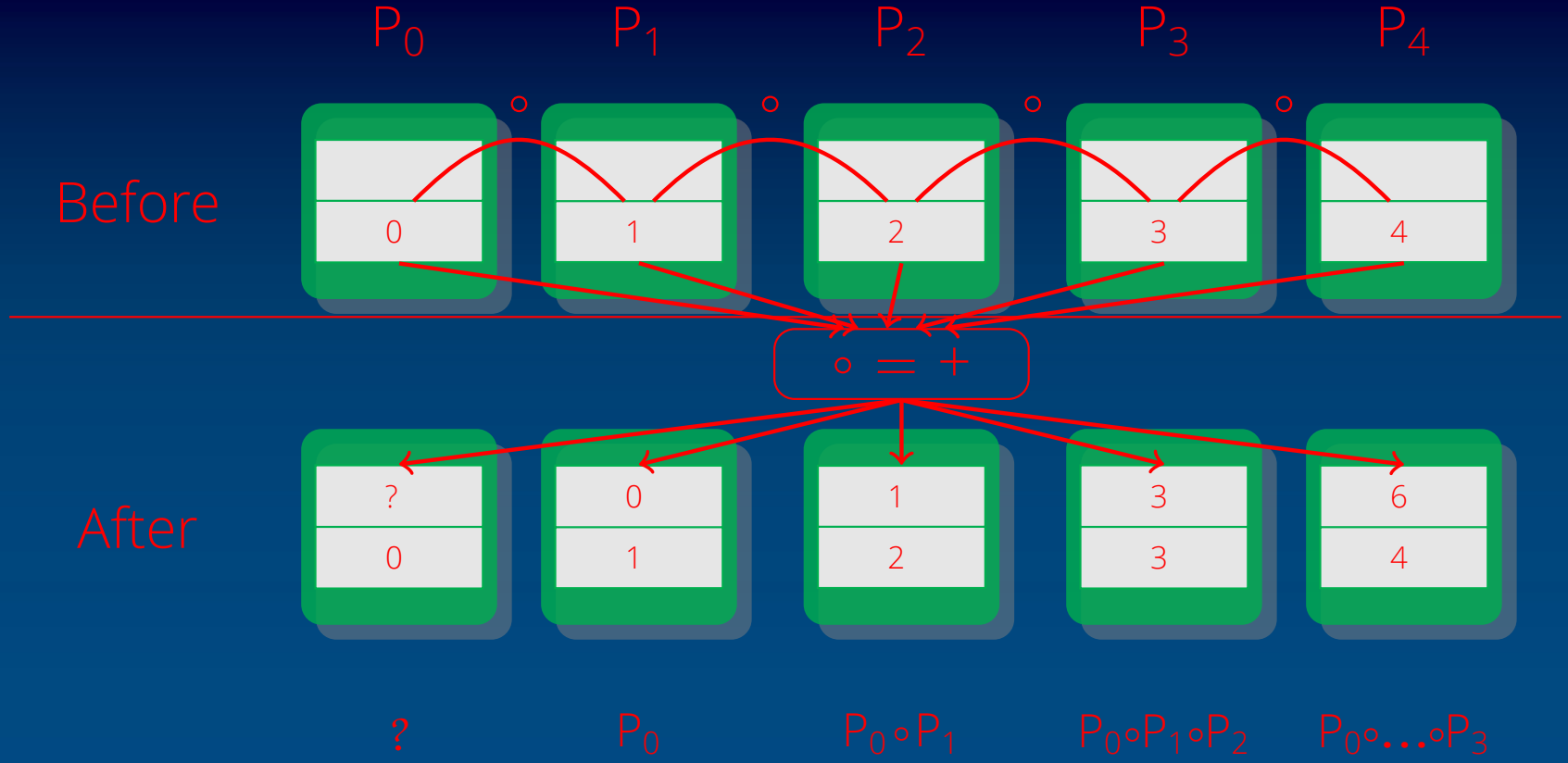
ExScan




```
int MPI_Exscan(void *sendbuf, void *recvbuf, int count,
    MPI_Datatype datatype, MPI_Op op, MPI_Comm comm)
```

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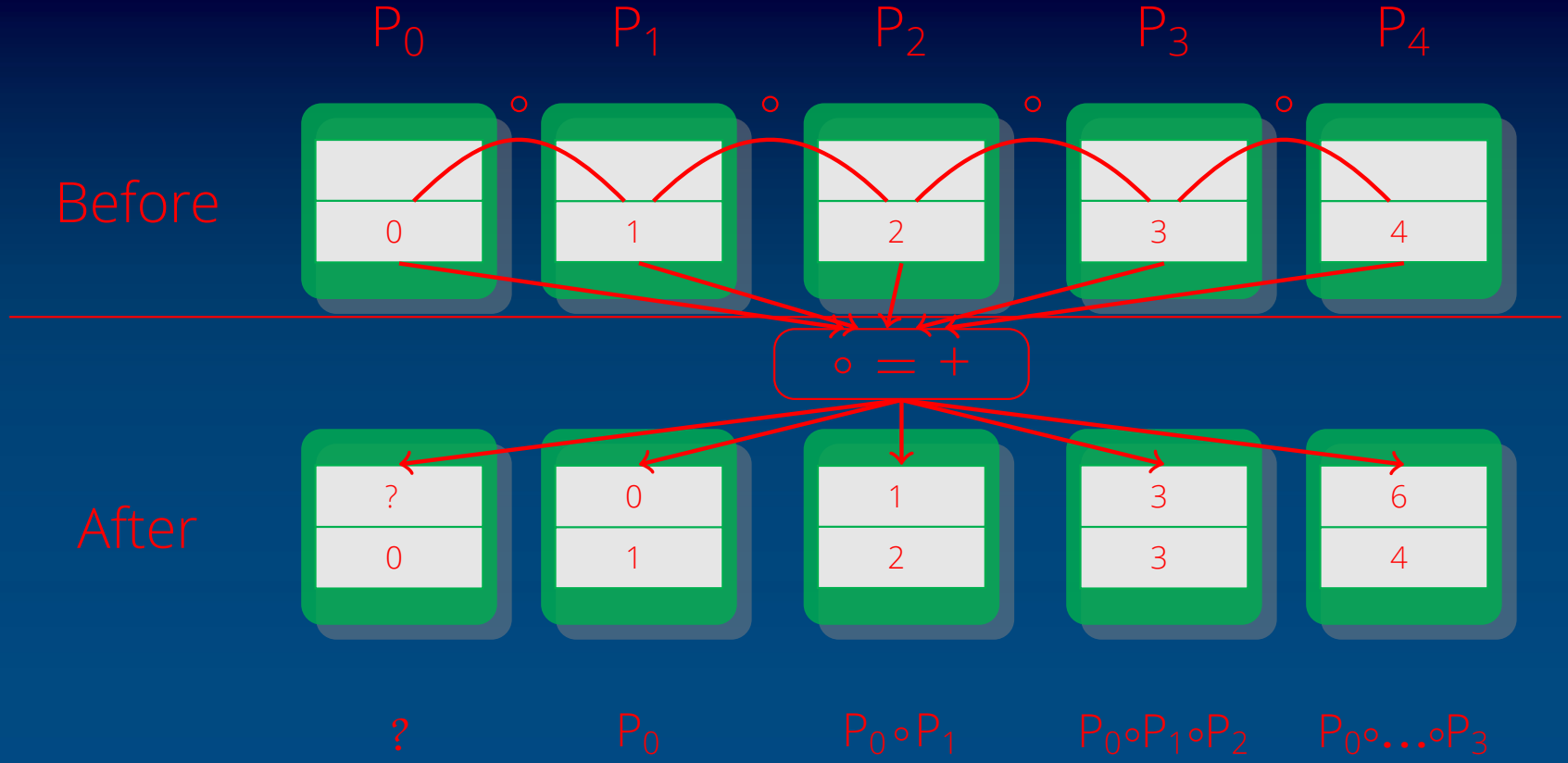
ExScan




```
int MPI_Exscan(void *sendbuf, void *recvbuf, int count,
    MPI_Datatype datatype, MPI_Op op, MPI_Comm comm)

MPI_Exscan(sendbuf, recvbuf, count, datatype, op, comm, ierror)
    <type>  :: sendbuf(:), recvbuf(:)
    integer :: count, datatype, op, comm, ierror
```

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MPI reduction operations

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MPI reduction operations

- associative

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MPI reduction operations

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- operates on single variables or vector elements

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MPI reduction operations

- associative
- operates on single variables or vector elements
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- results may differ when reduction is applied to floats.

Handle Name	Operation
MPI_MAX	maximum
MPI_MIN	minimum
MPI_SUM	sum
MPI_PROD	product
MPI_LAND	logical and
MPI_BAND	bit-wise and
MPI_LOR	logical or
MPI_BOR	bit-wise or
MPI_LXOR	logical xor
MPI_BXOR	bit-wise xor
MPI_MAXLOC	max value and location
MPI_MINLOC	min value and location

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user-defined MPI operation

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user-defined MPI operation

associative

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user-defined MPI operation

- associative
- acts on vectors

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user-defined MPI operation

- associative
- acts on vectors
- prototype of the function specified in standard

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user-defined MPI operation

- associative
- acts on vectors
- prototype of the function specified in standard

```
void MPI_User_function(void *invec, void *inoutvec, int *len,
    MPI_Datatype *datatype);
```

```
subroutine user_function(invec, inoutvec, length, MPItype)
<type>  :: invec(length), inoutvec(length)
integer :: length, MPItype
```

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user-defined MPI operation

- associative
- acts on vectors
- prototype of the function specified in standard

```
void MPI_User_function(void *invec, void *inoutvec, int *len,
    MPI_Datatype *datatype);
```

```
subroutine user_function(invec, inoutvec, length, MPItype)
<type>  :: invec(length), inoutvec(length)
integer :: length, MPItype
```

```
int MPI_Op_create(MPI_User_function *function, int commute, MPI_Op *op)
int MPI_op_free(MPI_Op *op)
```

```
MPI_Op_create(function, commute, op, ierror)
external function
logical :: commute
integer :: op, ierror
MPI_Op_free(op, ierror)
integer :: op, ierror
```

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Generalized collectives

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Generalized collectives

- MPI_Allgatherv
- MPI_Alltoallv
- MPI_Alltoallw
- MPI_Gatherv
- MPI_Scatterv
- MPI_Reduce_scatter

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Generalized collectives

- MPI_Allgatherv
- MPI_Alltoallv
- MPI_Alltoallw
- MPI_Gatherv
- MPI_Scatterv
- MPI_Reduce_scatter

```
int MPI_Alltoallv(void *sendbuf, int *sendcounts, int *sdispls,
      MPI_Datatype sendtype, void *recvbuf, int *recvcounts, int
      *rdispls, MPI_Datatype recvtype, MPI_Comm comm)
```

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Generalized collectives

- MPI_Allgatherv
- MPI_Alltoallv
- MPI_Alltoallw
- MPI_Gatherv
- MPI_Scatterv
- MPI_Reduce_scatter

```
int MPI_Alltoallv(void *sendbuf, int *sendcounts, int *sdispls,
      MPI_Datatype sendtype, void *recvbuf, int *recvcounts, int
      *rdispls, MPI_Datatype recvtype, MPI_Comm comm)
```

```
MPI_Alltoallv(sendbuf, sendcounts, sdispls, sendtype, recvbuf,
    recvcounts, rdispls, recvtype, comm, ierror)
    <type>  :: sendbuf(:), recvbuf(:)
    integer :: sendcounts(:), sdispls(:), sendtype
    integer :: recvcounts(:), rdispls(:), recvtype
    integer :: comm, ierror
```

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barrier

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```
int MPI_Barrier(MPI_Comm comm)
```

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barrier


```
int MPI_Barrier(MPI_Comm comm)
```

```
MPI_Barrier(comm, ierror)
    integer :: comm, ierror
```

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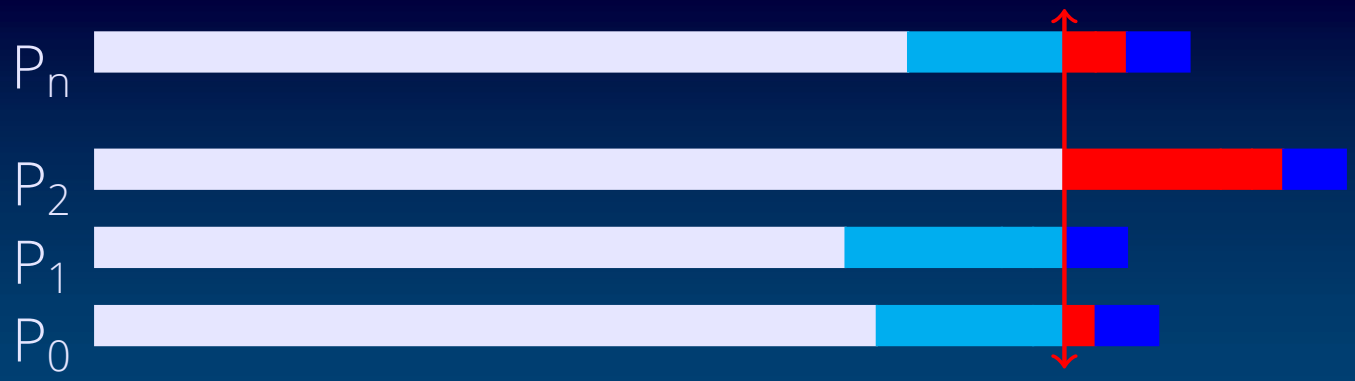
barrier




```
int MPI_Barrier(MPI_Comm comm)
```

```
MPI_Barrier(comm, ierror)
    integer :: comm, ierror
```

- **never use in production** useful only in debugging

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barrier


```
int MPI_Barrier(MPI_Comm comm)
```

```
MPI_Barrier(comm, ierror)
    integer :: comm, ierror
```

- **never use in production** useful only in debugging
- synchronisation, in general, does not need to be done by hand, data communication does it for you