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\* \* \*

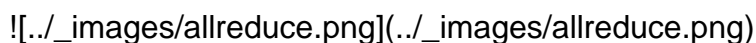
## # Collective Operations¶

Collective operations have to be called for each rank (hence CUDA device), using the same count and the same datatype, to form a complete collective operation. Failure to do so will result in undefined behavior, including hangs, crashes, or data corruption.

## ## AllReduce¶

The AllReduce operation performs reductions on data (for example, sum, min, max) across devices and stores the result in the receive buffer of every rank.

In a `_sum_` allreduce operation between `_k_` ranks, each rank will provide an array in of N values, and receive identical results in array out of N values, where  $out[i] = in_0[i] + in_1[i] + \dots + in_{(k-1)}[i]$ .

The diagram shows a sequence of ranks (0 to k-1) each with an input buffer 'in' and an output buffer 'out'. Arrows indicate data flow from each 'in' buffer to a central reduction point, and then from that point to each 'out' buffer, illustrating that all ranks receive the result of the reduction.

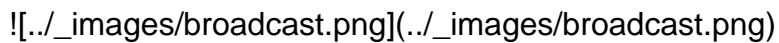
All-Reduce operation: each rank receives the reduction of input values across ranks.

Related links: [`ncclAllReduce()`](../api/colls.html#c.ncclAllReduce "ncclAllReduce").

## ## Broadcast¶

The Broadcast operation copies an N-element buffer from the root rank to all

the ranks.

![\_images/broadcast.png](../\_images/broadcast.png)

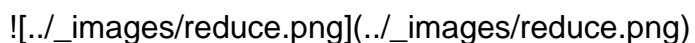
Broadcast operation: all ranks receive data from a "root" rank.

Important note: The root argument is one of the ranks, not a device number, and is therefore impacted by a different rank to device mapping.

Related links: [ncclBroadcast()](../api/colls.html#c.ncclBroadcast "ncclBroadcast").

## ## Reduce¶

The Reduce operation performs the same operation as AllReduce, but stores the result only in the receive buffer of a specified root rank.

![\_images/reduce.png](../\_images/reduce.png)

Reduce operation: one rank receives the reduction of input values across ranks.

Important note: The root argument is one of the ranks (not a device number), and is therefore impacted by a different rank to device mapping.

Note: A Reduce, followed by a Broadcast, is equivalent to the AllReduce operation.

Related links: [`ncclReduce()`](../api/colls.html#c.ncclReduce "ncclReduce").

## ## AllGather¶

The AllGather operation gathers  $N$  values from  $k$  ranks into an output buffer of size  $k*N$ , and distributes that result to all ranks.

The output is ordered by the rank index. The AllGather operation is therefore impacted by a different rank to device mapping.

![\_images/allgather.png](../\_images/allgather.png)

AllGather operation: each rank receives the aggregation of data from all ranks in the order of the ranks.

Note: Executing ReduceScatter, followed by AllGather, is equivalent to the AllReduce operation.

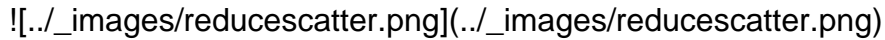
Related links: [`ncclAllGather()`](../api/colls.html#c.ncclAllGather "ncclAllGather").

## ## ReduceScatter¶

The ReduceScatter operation performs the same operation as Reduce, except that the result is scattered in equal-sized blocks between ranks, each rank getting a chunk of data based on its rank index.



The ReduceScatter operation is impacted by a different rank to device mapping since the ranks determine the data layout.



Reduce-Scatter operation: input values are reduced across ranks, with each rank receiving a subpart of the result.

Related links: `[`ncclReduceScatter()`](../api/colls.html#c.ncclReduceScatter "ncclReduceScatter")`

[\[Next \]\(data.html "Data Pointers"\)](#) [\[ Previous\]\(communicators.html "Creating a Communicator"\)](#)

\* \* \*

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