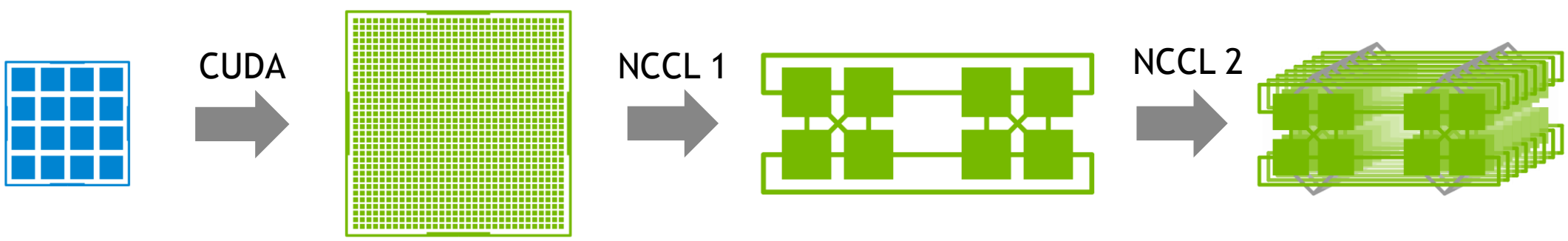
NCCL 2.0

Sylvain Jeaugey

DEEP LEARNING ON GPUS

Making DL training times shorter

Deeper neural networks, larger data sets … training is a very, very long operation !



Multi-core CPU

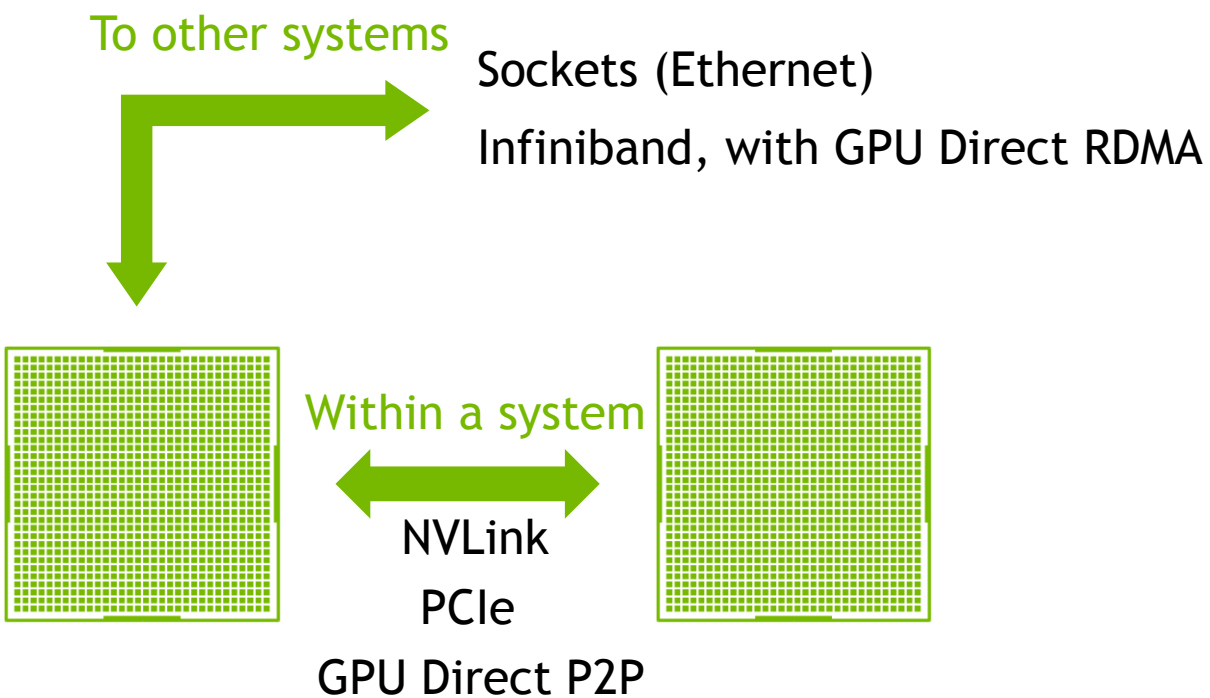
GPU

Multi-GPU

Multi-GPU
Multi-node

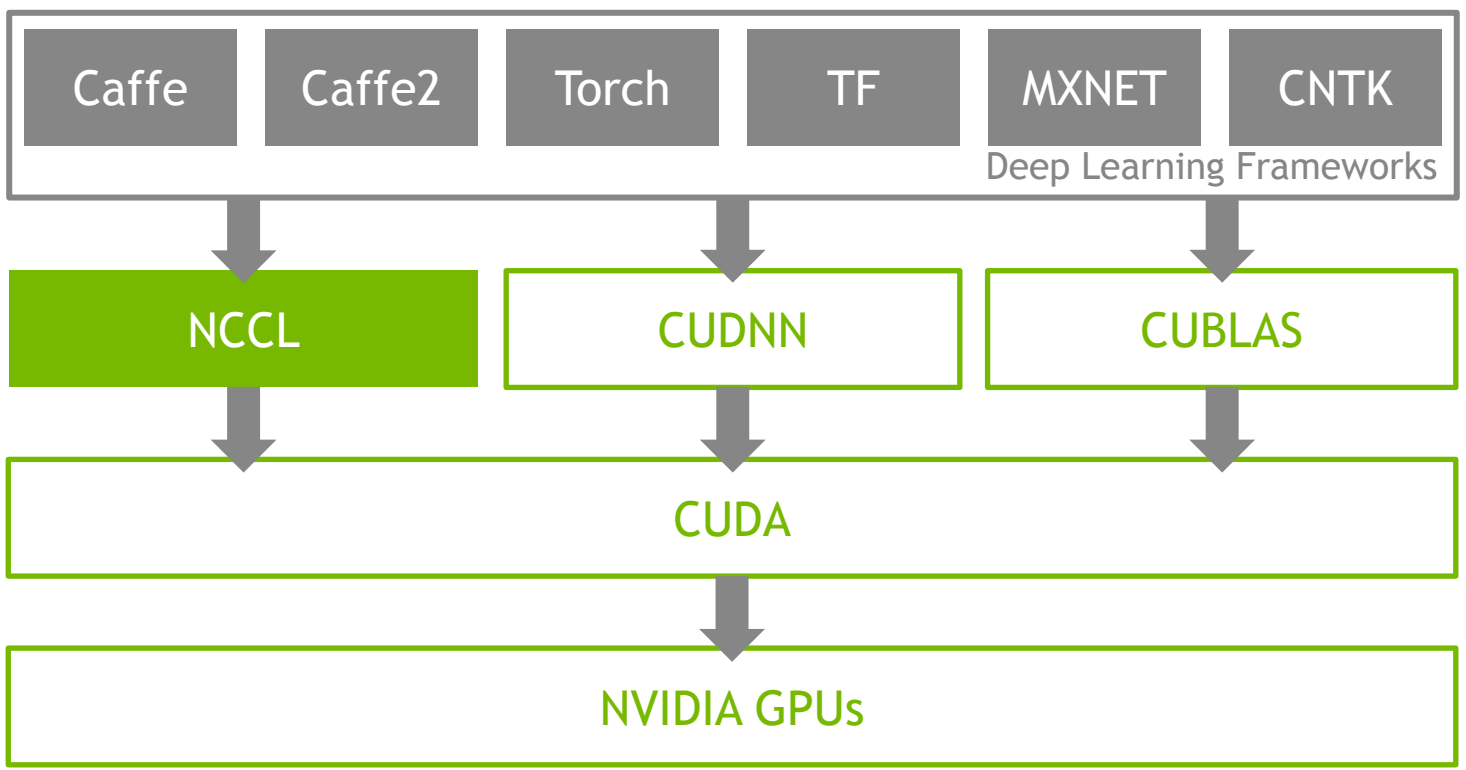
NCCL

A multi-GPU communication library



NCCL

Architecture



AGENDA

NCCL
- History
- Design

NCCL 2.0
- New features
- API Changes

Performance

Future

HISTORY

Q4 2015: NCCL 1.x

Open-source research project on github, helping Deep Learning frameworks compute on multiple GPUs with efficient collective operations.

Limited to intra-node.

Q2 2017: NCCL 2.x and beyond

NVIDIA Library, multi-node support and improved API.

DESIGN

What is NCCL ?

Optimized collective communication library between CUDA devices.

Easy to integrate into any DL framework, as well as traditional HPC apps using MPI.

Runs on the GPU using asynchronous CUDA kernels, for faster access to GPU memory, parallel reductions, NVLink usage.

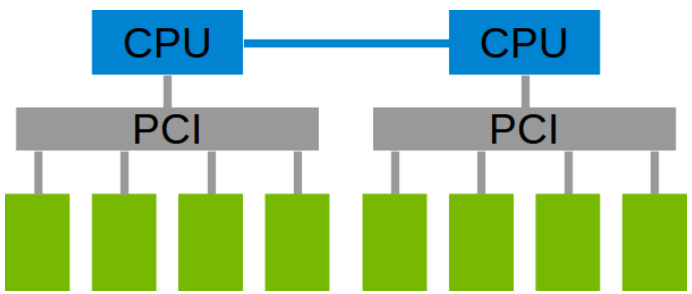
Operates on CUDA pointers. Operations are tied to a CUDA stream.

Uses as little threads as possible to permit other computation to progress simultaneously.

DESIGN

Rings

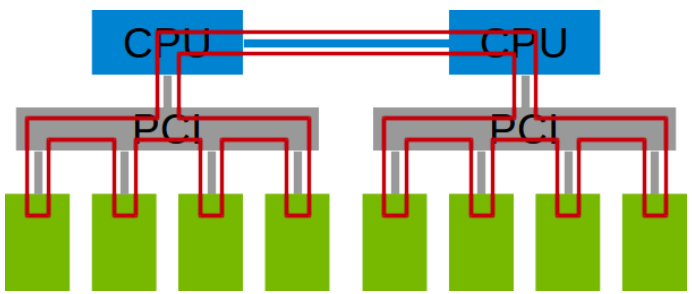
NCCL uses rings to move data across all GPUs and perform reductions.



DESIGN

Rings

NCCL uses rings to move data across all GPUs and perform reductions.

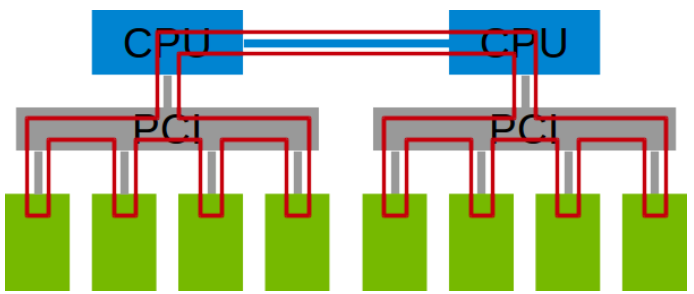


PCIe / QPI : 1 unidirectional ring

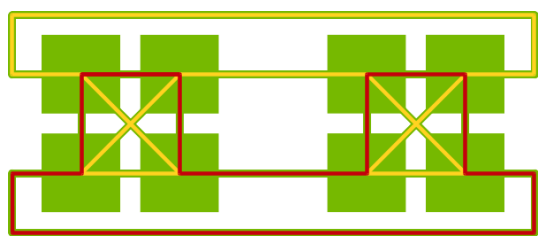
DESIGN

Rings

NCCL uses rings to move data across all GPUs and perform reductions.



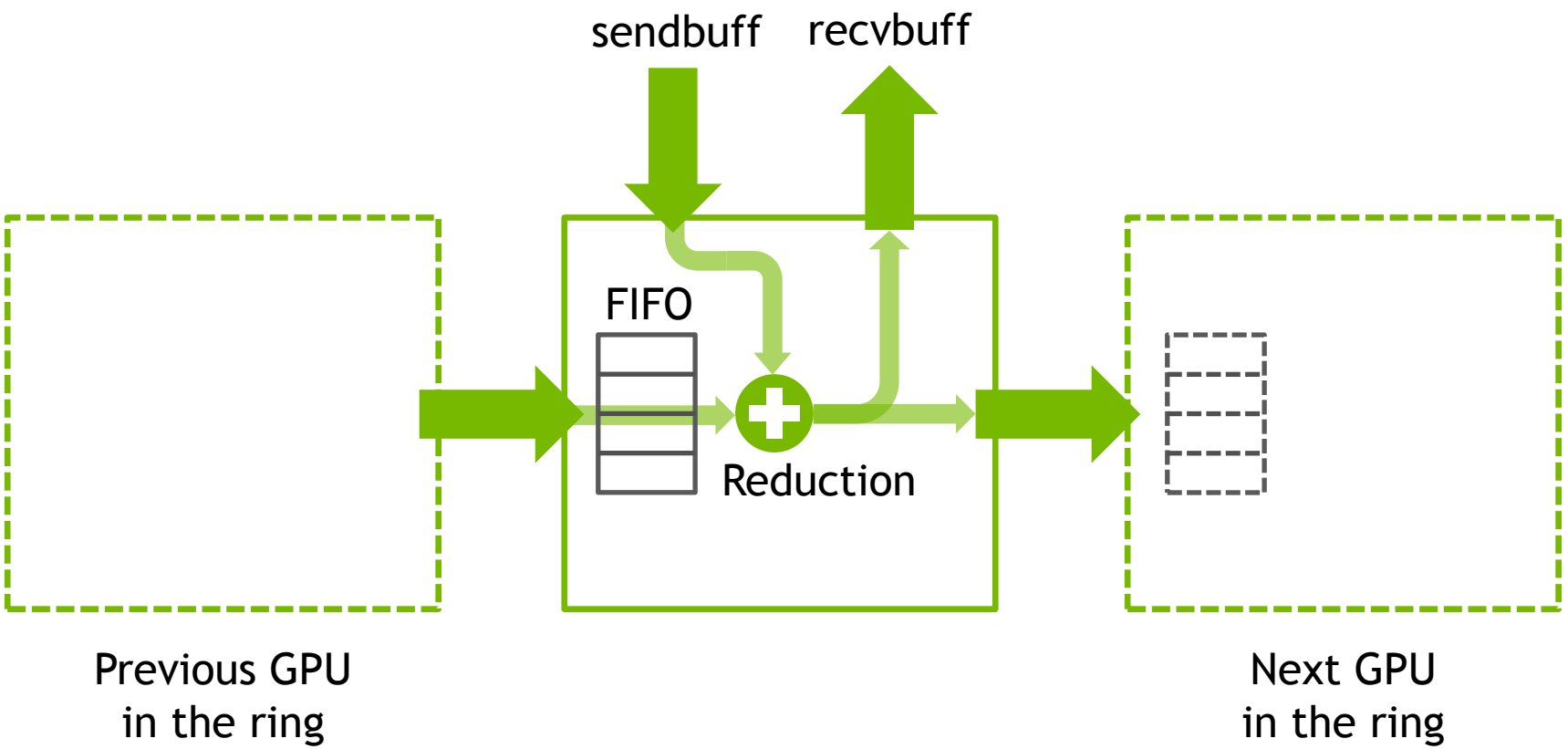
PCIe / QPI : 1 unidirectional ring



DGX-1 : 4 unidirectional rings

DESIGN

Kernels



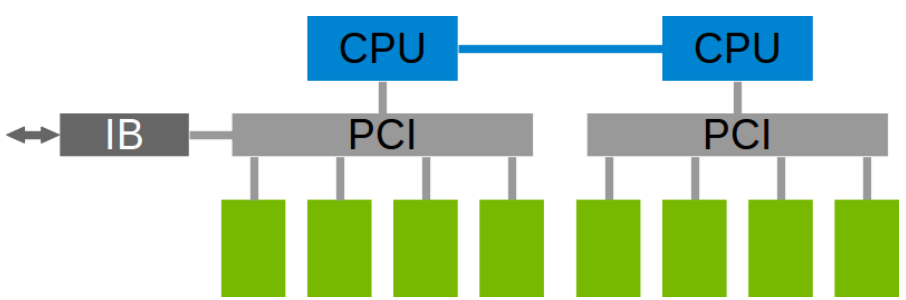
NCCL 2.0

NCCL 2.0

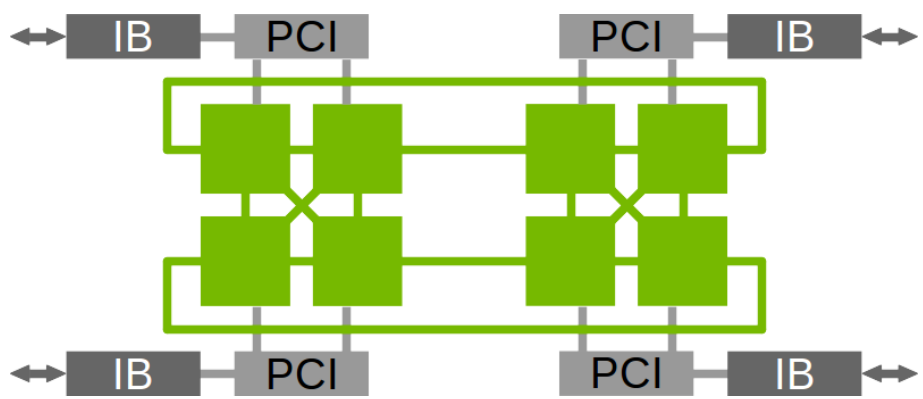
Inter-node communication

Inter-node communication using Sockets or Infiniband verbs, with multi-rail support, topology detection and automatic use of GPU Direct RDMA.

Optimal combination of NVLink, PCI and network interfaces to maximize bandwidth and create rings across nodes.



PCIe, Infiniband



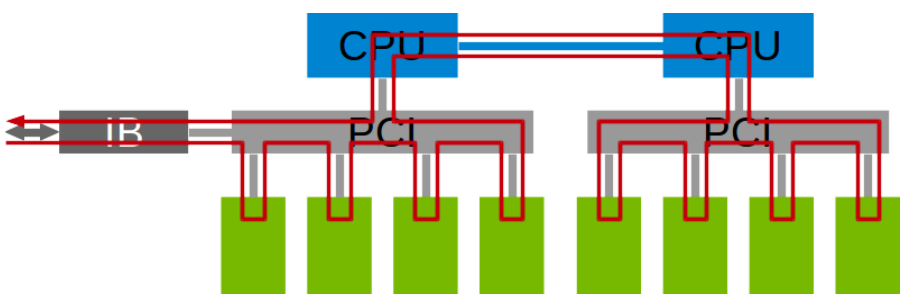
DGX-1 : NVLink, 4x Infiniband

NCCL 2.0

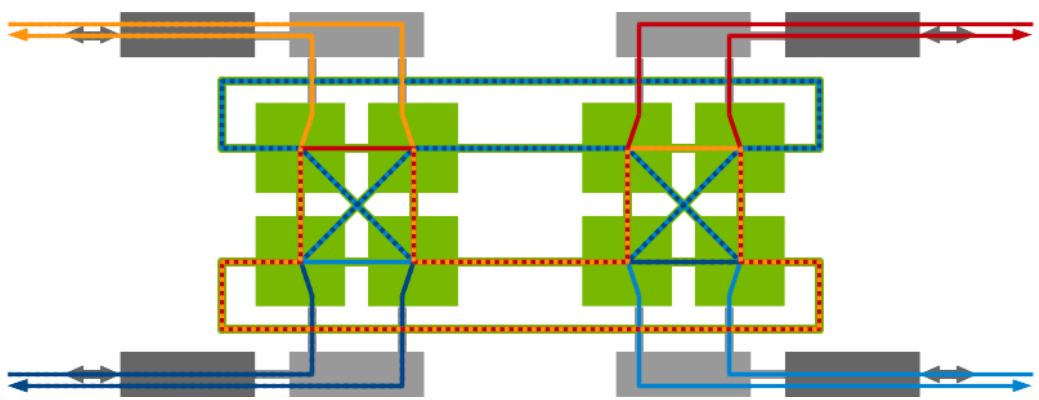
Inter-node communication

Inter-node communication using Sockets or Infiniband verbs, with multi-rail support, topology detection and automatic use of GPU Direct RDMA.

Optimal combination of NVLink, PCI and network interfaces to maximize bandwidth and create rings across nodes.



PCIe, Infiniband

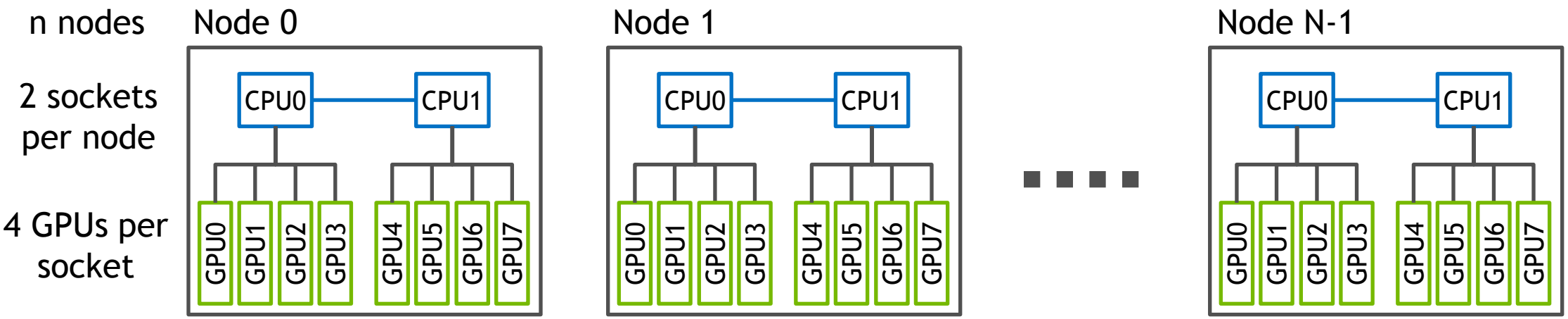


DGX-1 : NVLink, 4x Infiniband

NCCL 2.0

Processes, threads and GPUs

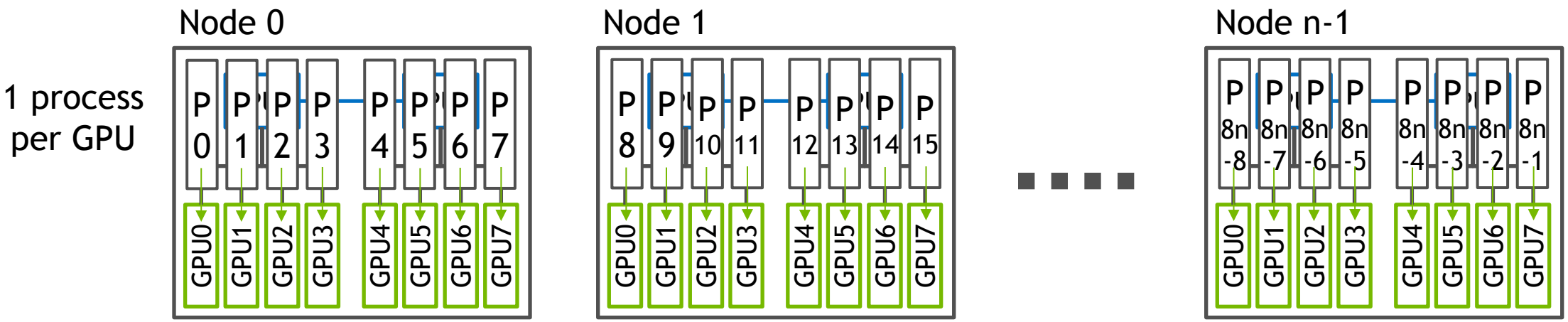
Supports a combination of processes (potentially across nodes), threads per process and GPUs per thread.



NCCL 2.0

Processes, threads and GPUs

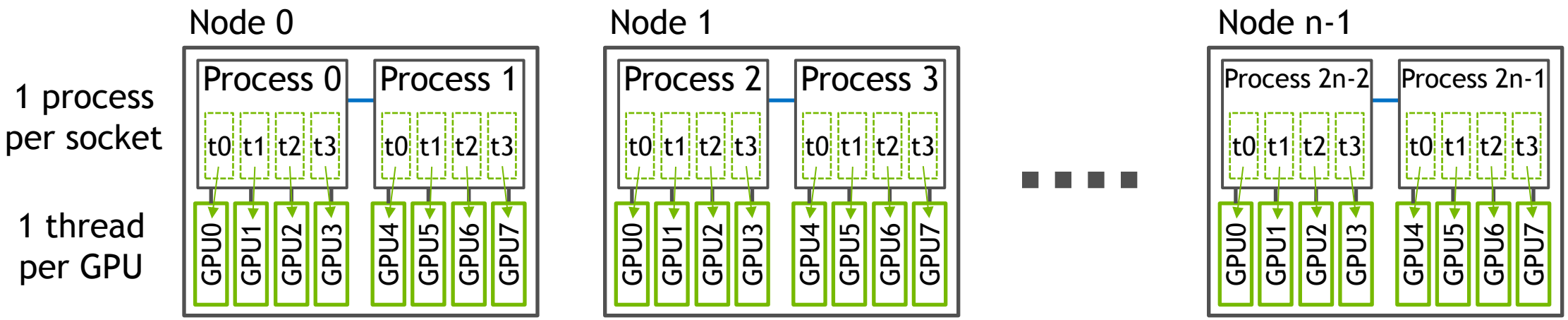
Supports a combination of processes (potentially across nodes), threads per process and GPUs per thread.



NCCL 2.0

Processes, threads and GPUs

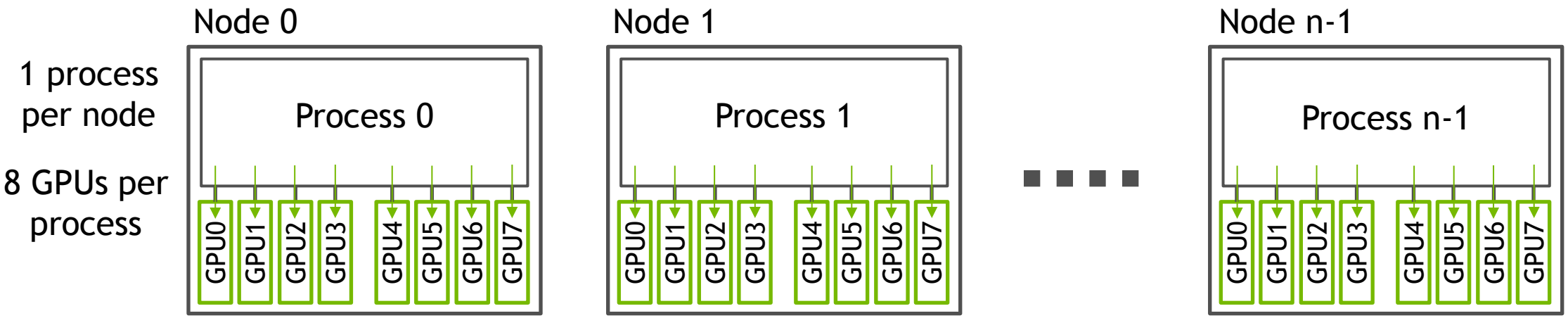
Supports a combination of processes (potentially across nodes), threads per process and GPUs per thread.



NCCL 2.0

Processes, threads and GPUs

Supports a combination of processes (potentially across nodes), threads per process and GPUs per thread.



NCCL 2.0 API

Group calls

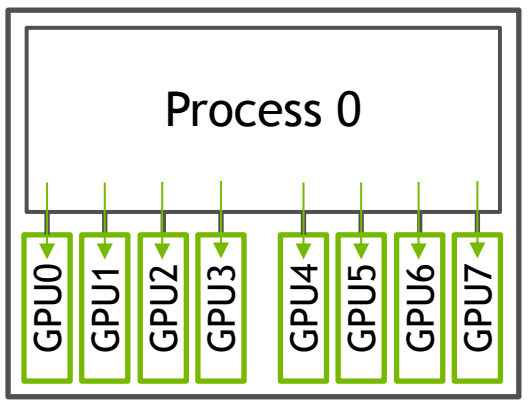
NCCL 2.0 is introducing mandatory new verbs ncclGroupStart/ncclGroupEnd when managing multiple devices from a single thread

NCCL 1.x :

```
for (int i=0; i<ngpus; i++) {
  cudaSetDevice(devices[i]);
  ncclAllReduce(…, comms[i], streams[i]);
}
```

NCCL 2.0 :

```
ncclGroupStart();
for (int i=0; i<ngpus; i++) {
  ncclAllReduce(…, comms[i], streams[i]);
}
ncclGroupEnd();
```

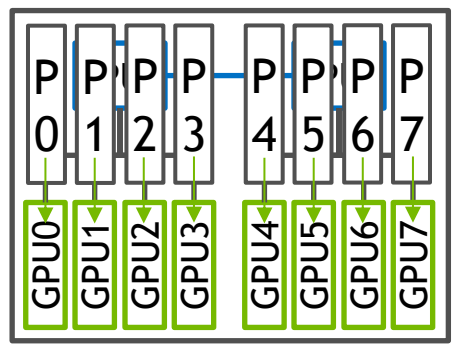


NCCL 2.0 API

Integration with parallel environments

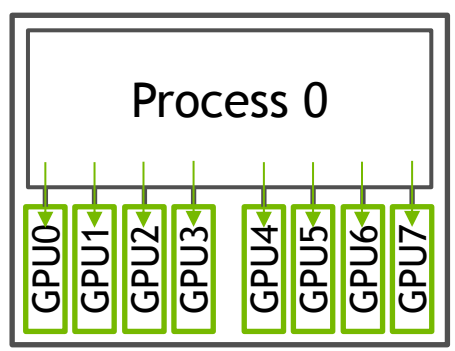
Inter-node communicator creation still uses the NCCL 1.x verbs :
ncclGetUniqueId/ncclCommInitRank

```
if (rank == 0) ncclGetUniqueId(&id)
My_Bcast(&id);
ncclCommInitRank(&comm, nranks, id, rank);
```



Multi-process + multi-GPU per process (from a single thread) :
combine ncclCommInitRank with ncclGroupStart/ncclGroupEnd

```
if (rank == 0) ncclGetUniqueId(&id)
My_Bcast(&id);
ncclGroupStart();
for (int i=0; i<ndev; i++) {
  cudaSetDevice(devices[i]);
  ncclCommInitRank(&comm, ndev*nranks, id, ndev*rank+i);
}
ncclGroupEnd();
```



NCCL 2.0 API

Others

Other small API adjustments over the NCCL 1.x API :

Counts are now of type size_t instead of int

allGather arguments order has been fixed to be similar to other operations

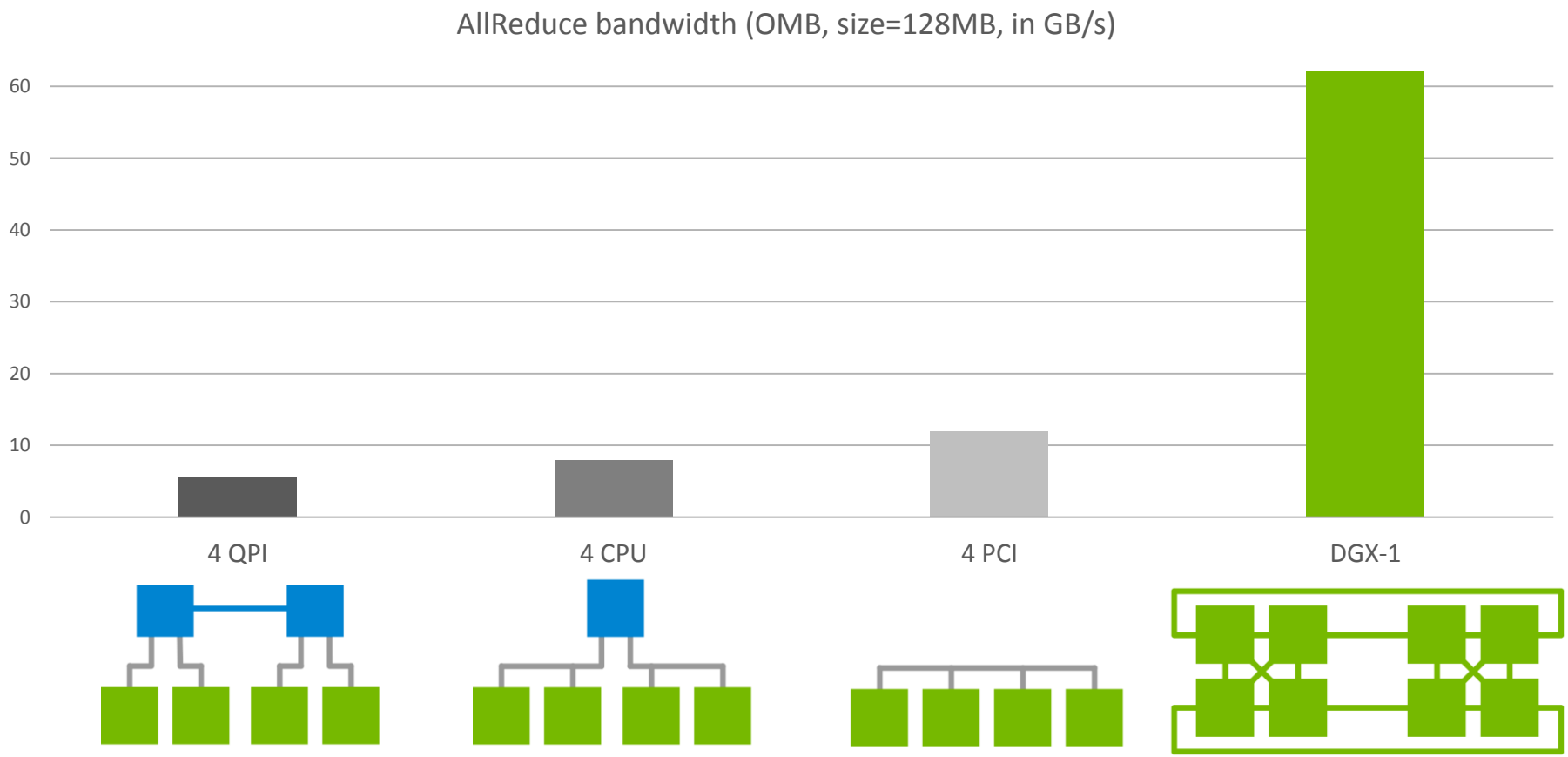
Additions/clarification on datatypes :
integral : **int8** = char, **uint8**, **int32** = int, **uint32**, int64, uint64
floating point : **float16** = half, **float32** = float, **float64** = double

Clarifications and fixes for allgather and reduce_scatter send/receive counts and in-place operations

PERFORMANCE

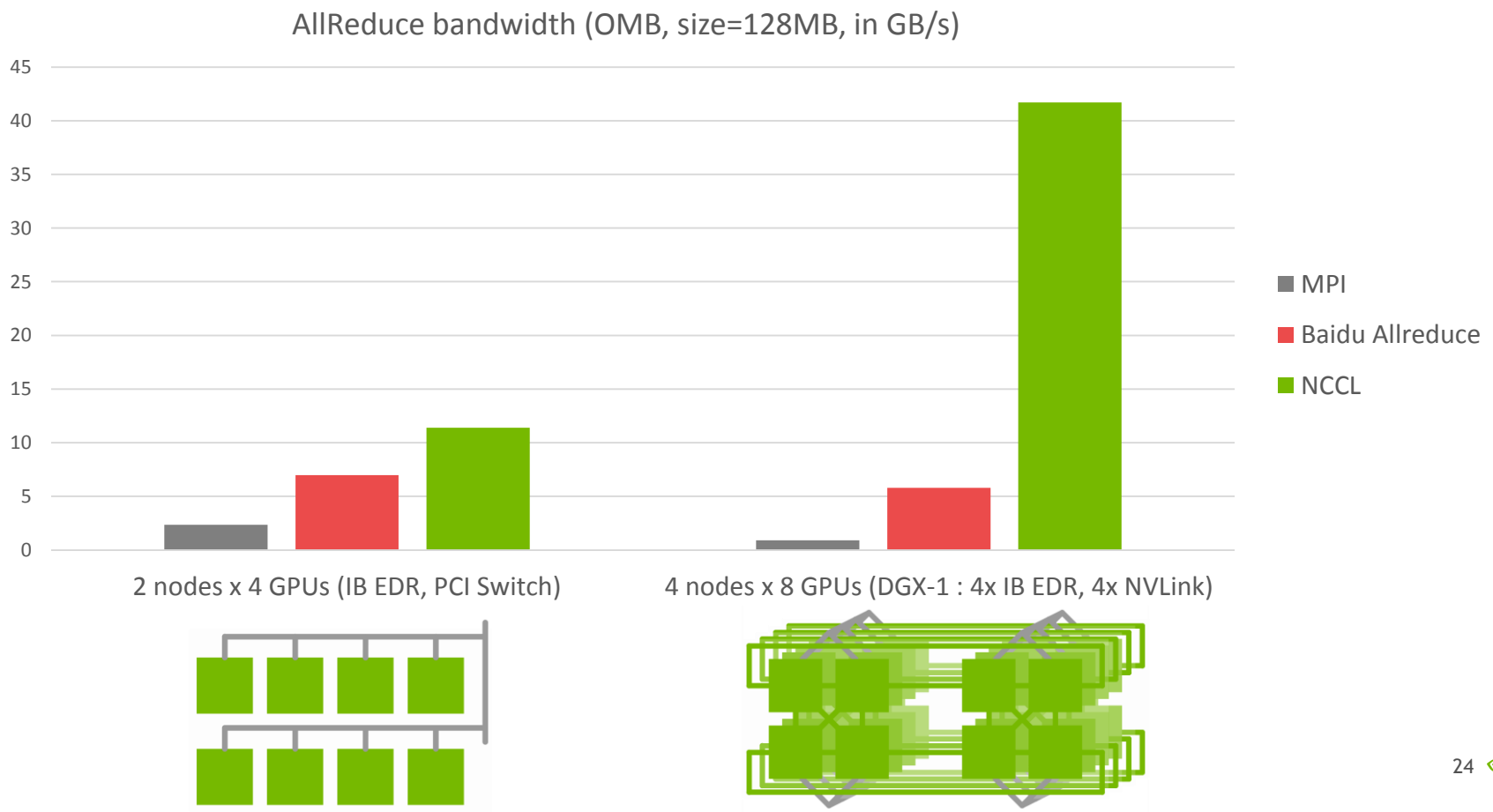
PERFORMANCE

Intra-node performance



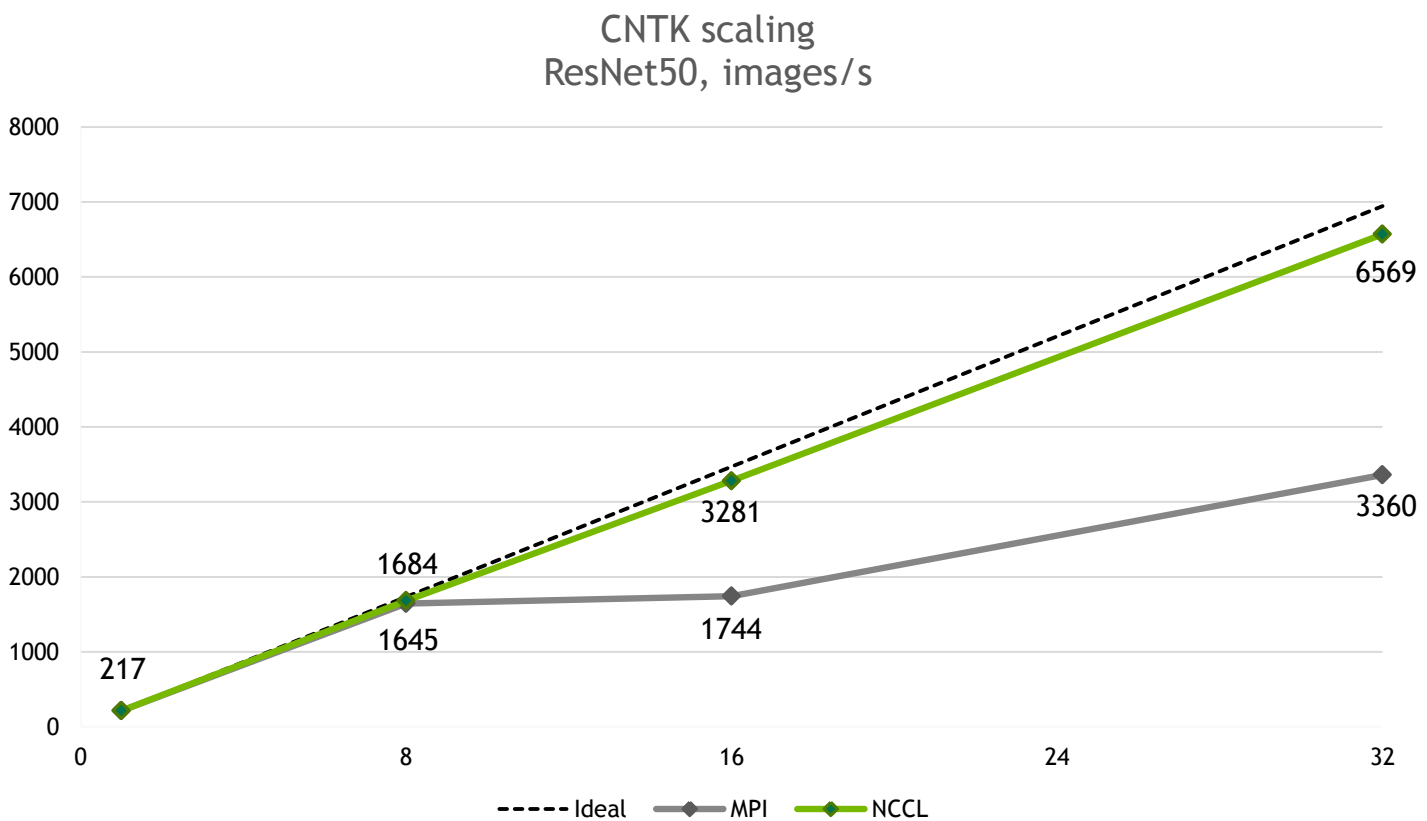
PERFORMANCE

Inter-node performance



PERFORMANCE

Deep Learning - CNTK



FUTURE

FUTURE

Top asked features

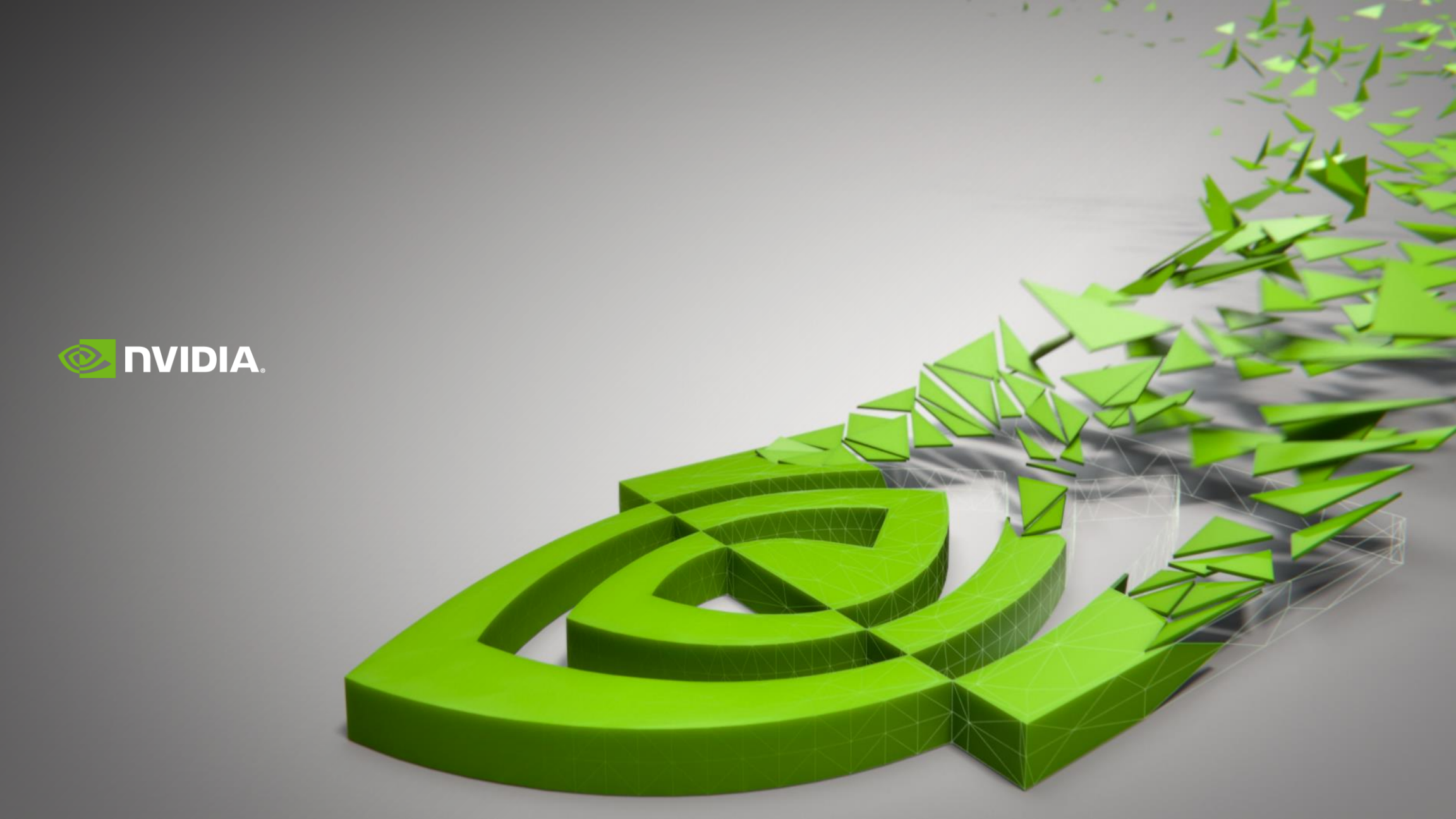
Additional communication primitives :
 point-to-point communication
 scatter (1 to N), gather (N to 1), alltoall (N to N)
 neighbor collectives (send/receive in multiple dimensions)

User-defined reduction operations
 also, trying to merge computation and communication better

Windows support

Please let us know your needs !

Connect with experts / NCCL session : Wed Apr 10, 4pm


NVIDIA