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Centro Svizzero di Calcolo Scientifico
Swiss National Supercomputing Centre

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GPU-aware MPI

Summer School 2019 – Effective High Performance Computing

Radim Janalík, USI
Tim Robinson, CSCS

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Communication model and performance

MPI with data in device memory

Use GPUs to parallelize on-node computation

- . . . and MPI for communication between nodes.

To use with data that is in buffers in GPU memory:

1. Allocate buffers in host memory;
2. Manually copy from device to host memory;
3. Perform MPI communication with host buffers;
4. Copy received data from host to device memory.

This approach can be very fast.

- Have a CPU thread dedicated to asynchronous host-device and MPI communication

GPU-aware MPI

GPU-aware MPI implementations can automatically handle MPI transactions with pointers to GPU memory

- GPUdirect Peer to Peer among GPUs on the same node
- GPUdirect RDMA among GPUs on different nodes
- MVAPICH, OpenMPI, Cray MPI, . . .

How it works

- Each pointer passed to MPI is checked to see if it is in host or device memory. If not set, MPI assumes that all pointers are to host memory, and your application will probably crash with segmentation faults
- Small messages between GPUs (up to 8 k) are copied directly with RDMA
- Larger messages are pipelined via host memory

How to use G2G communication

- Set the environment variable `export MPICH_RDMA_ENABLED_CUDA=1`
  - If not set, MPI assumes that all pointers are to host memory, and your application will probably crash with segmentation faults
- Experiment with the environment variable `MPICH_G2G_PIPELINE`
  - Sets the maximum number of 512 kB message chunks that can be in flight (default 16)

MPI with G2G example

```
MPI_Request srequest, rrequest;
auto send_data = malloc_device<double>(100);
auto recv_data = malloc_device<double>(100);

// call MPI with GPU pointers
MPI_Irecv(recv_data, 100, MPI_DOUBLE, source, tag, MPI_COMM_WORLD,
     &rrequest);
MPI_Isend(send_data, 100, MPI_DOUBLE, target, tag, MPI_COMM_WORLD,
     &srequest);
```

Capabilities and Limitations

- Support for most MPI API calls (point-to-point, collectives, etc)
- Robust support for common MPI API calls
  - i.e. point-to-point operations
- No support for user-defined MPI data types

Exercise: MPI with G2G

- 2D stencil with MPI in `04.MPI_Network/cxx/1.diffusion2d_mpi.cu`
- Implement the G2G version
  1. can you observe any performance differences?

Exercises: 2D Diffusion with MPI Results

Time for 10,000 time steps $128 \times 131{,}072$ on P100 GPUs

nodes	G2G off	G2G on
1	5.579	5.580
2	3.083	2.811
4	1.909	1.426
8	1.203	0.737
16	0.836	0.399

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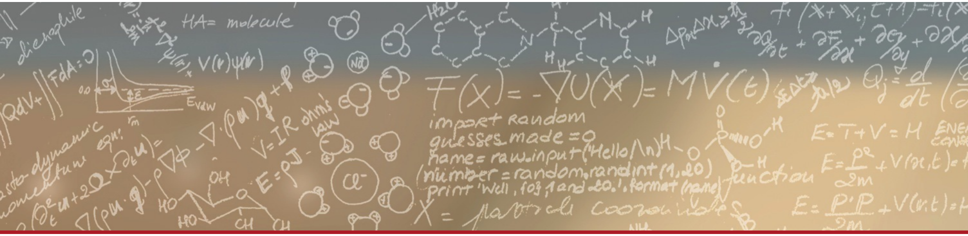

Thank you for your attention.