Should we enable MPI RMA calls from the GPU?

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Future of MPI RMA Workshop (FoRMA'22)

Outline

- Should we support RMA operations (MPI_Put, MPI_Get,..) to execute from the GPU?
- Some experimental results with MPICH-OFI for basic RMA operations

Partition Communication: Example in MPI 4.0

```
if (myrank == 0) {
  MPI_Psend_init(message, partitions, count, xfer_type,
     dest, tag, info, MPI_COMM_WORLD, &request);
  MPI_Start(&request);

  #pragma omp parallel for shared(request) num_threads(NUM_THREADS)
  for (int i = 0; i < partitions; i++) {
      /* compute and fill partition #i, then mark ready: */
      MPI_Pready(i, request);
  }
  while (!flag) {
     /* Do useful work */
     MPI_Test(&request, &flag, MPI_STATUS_IGNORE);
  }
  MPI_Request_free(&request);
}
```

```
if (myrank == 1) {
   MPI_Precv_init(message, partitions, count, xfer_type
      source, tag, info, MPI_COMM_WORLD, &request);
   MPI_Start(&request);

   while (!flag) {
    /* Do useful work */
      MPI_Test(&request, &flag, MPI_STATUS_IGNORE);
    }
  MPI_Request_free(&request);
}
```

Partition Communication

- The Hybrid WG has been discussing extending Partitioned Communication to support GPU-initiated communication
- In practice, that means that:
  - Application is using two-sided semantics
  - The communication (issued from the GPU) is using one-sided semantics
- If so, shouldn't we also enable RMA to execute from the GPU?

Partition Communication using SYCL

```
if (myrank == 0) {
  MPI_Psend_init(message, partitions, count, xfer_type,
    dest, tag, info, MPI_COMM_WORLD, &request);
  MPI_Start(&request);

  mQueue.submit([&](sycl::handler &h) {
    h.parallel_for(partitions, [=](id<1> i) {
      MPI_Pready(i, request);
    });
  });

  mQueue.wait();
  while (!flag) {
    /* Do useful work */
    MPI_Test(&request, &flag, MPI_STATUS_IGNORE);
  }
  MPI_Request_free(&request);
}
```

```
if (myrank == 1) {
   MPI_Precv_init(message, partitions, count, xfer_type
     source, tag, info, MPI_COMM_WORLD, &request);
    MPI_Start(&request);

  while (!flag) {
   /* Do useful work */
     MPI_Test(&request, &flag, MPI_STATUS_IGNORE);
   }
  MPI_Request_free(&request);
}
```

Partition Communication using SYCL – GPU-initiated communication

```
MPI_request req[2];
MPI_Prequest preq;
MPI_Psend_init(.., &req[0]);
MPI_Precv_init(...,&req[1]);
MPI_Prequest_create(req[0], MPI_INFO_NULL, &preq);

while (...) {
   MPI_Startall (2, req);
   MPI_Pbuf_prepare_all (2, preq);

    mQueue.submit([&](sycl::handler &h) {
       h.parallel_for(partitions, [=](id<1> i) {
          MPI_Pready(i, preq);
       });
    });

    mQueue.wait();
    MPI_Waitall (2, req);
}
```

Creates a request that can be accessed from the device

Tag matching and Keys exchange only needed once

Guarantees buffer is ready on receiver side

Executes from the Device

This is really a put operation

MPI RMA: GPU-initiated communication

Regular CPU code

```
MPI_Win_create (buffer, partitions*sizeof(int),
sizeof(int), MPI_INFO_NULL, MPI_COMM_WORLD, &win);

MPI_Win_fence(0, win);
if (myrank == 0) {
  for (int p=0;p<partitions;++p)
    MPI_Put (&data, …, win);
}

MPI_Win_fence(0, win);
MPI_Win_free(&win);
```

SYCL code

```
MPI_Win_create (buffer, n*sizeof(int), sizeof(int),
MPI_INFO_NULL, MPI_COMM_WORLD, &win);

MPI_Win_fence(0, win);
if (myrank == 0) {
   mQueue.submit([&](sycl::handler &h) {
      h.parallel_for(partitions, [=](id<1> i) {
        MPI_Put (&data,…, win);   Executes from the Device
      });
    });
   mQueue.wait();
}

MPI_Win_fence(0, win);
MPI_Win_free(&win);
```

MPI RMA: Memory Allocation in the Device

Memory allocation functions need to take in the info argument information to determine:

1. Type of memory allocation (system, host, device, or shared),
2. Kind (CUDA, Level Zero, HIP, …),
3. Device/Subdevice in the system where to allocate the data.

MPI_Win_allocate (size, disp_unit, info, comm, baseptr, win)

MPI_Win_allocate_shared (size, disp_unit, info, comm, baseptr, win)

MPI_Alloc_mem (size, info, baseptr)

RMA Implementation in MPICH-OFI

RMA Design and implementation in MPICH-OFI can be found in:

"Efficient implementation of MPI-3 RMA over openFabrics interfaces",

by Hajime Fujita, Chongxiao Cao, Sayantan Sur, Charles Archer, Erik Paulson, and Maria Garzaran, PARCO Volume 87, Issue C, Sep 2019.

Early Experimental Results

Experimental Setup

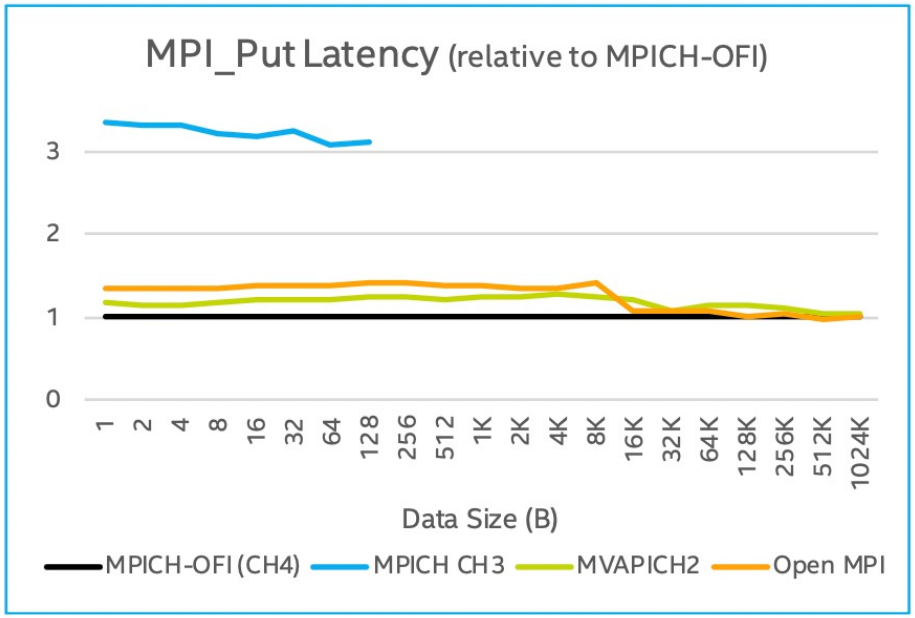
- CPU: Intel Xeon Gold6138
- Interconnect Intel Omni-Path Architecture
- OS: SUSE Linux Enterpirse Server 12 SP3
- Compiler: GCC 8.1.0 (-O3, LTO enabled)
- OFI libfabric: 1.6.1
- PSM2: 10.3.58
- IMB Benchmarks 2018 Update 1

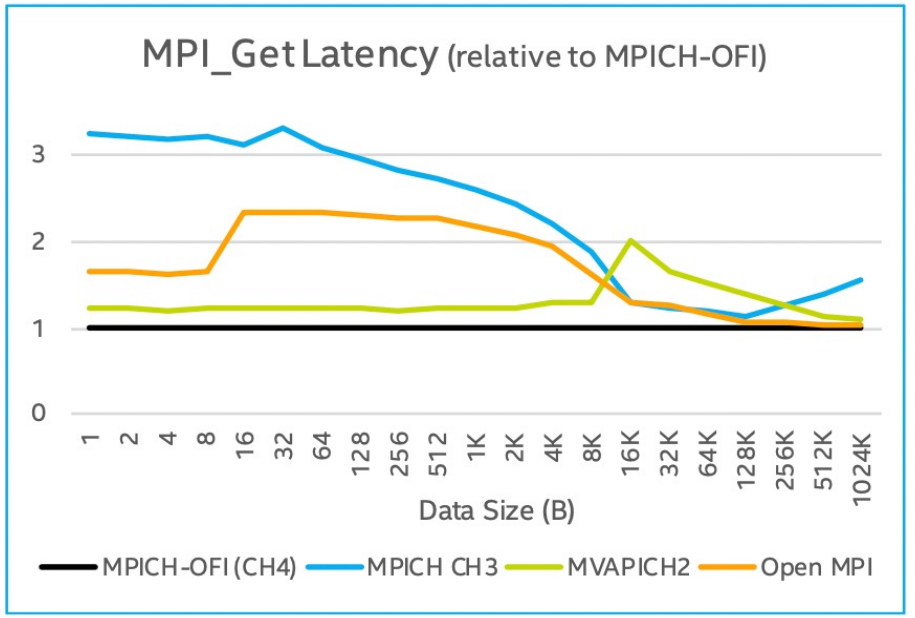
Comparison between:

- MPICH-OFI. MPICH 3.3b3
- MPICH CH3. MPICH 3.3b3 configured with CH3
- MVAPICH2 version 2.3. Configured to use PSM2 directly
- Open MPI version 3.1.1 with PSM2 (since it was faster than using OFI).

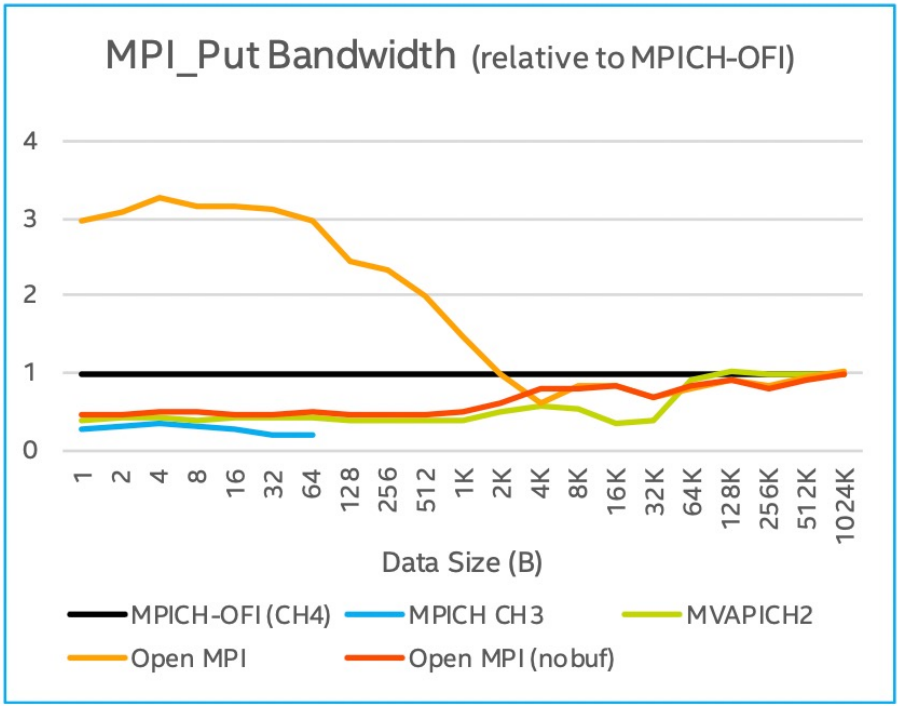
See all experimental setup details in the paper

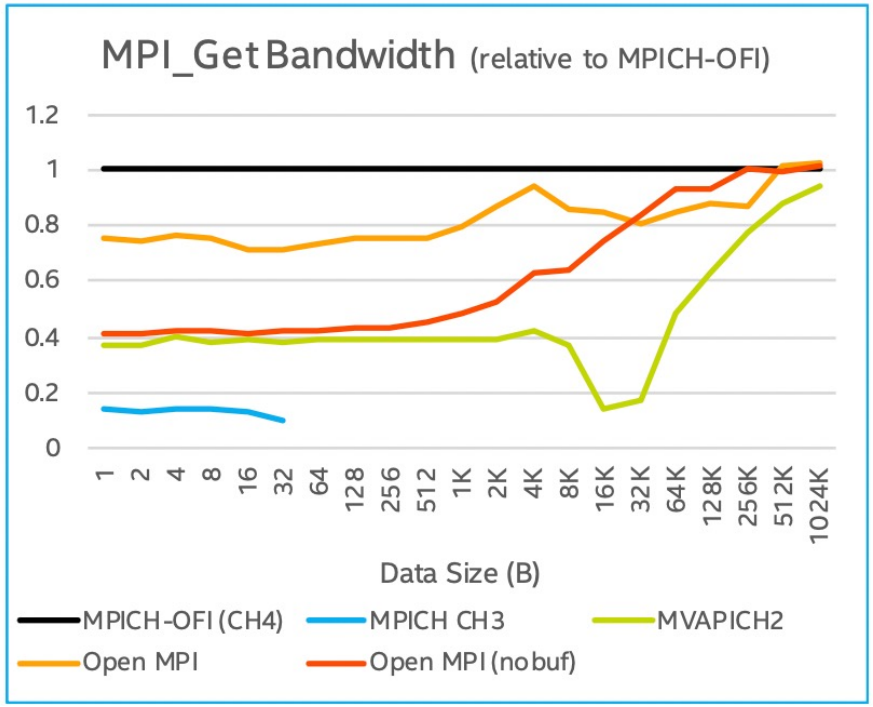
Latency


MPI_Put Latency (relative to MPICH-OFI)
3
2
1
0
1
2
4
8
16
32
64
128
256
512
1K
2K
4K
8K
16K
32K
64K
128K
256K
512K
1024K
Data Size (B)
MPICH-OFI (CH4)
MPICH CH3
MVAPICH2
Open MPI


MPI_Get Latency (relative to MPICH-OFI)
3
2
1
0
1
2
4
8
16
32
64
128
256
512
1K
2K
4K
8K
16K
32K
64K
128K
256K
512K
1024K
Data Size (B)
MPICH-OFI (CH4)
MPICH CH3
MVAPICH2
Open MPI

Bandwidth


MPI_Put Bandwidth (relative to MPICH-OFI)
4
3
2
1
0
1
2
4
8
16
32
64
128
256
512
1K
2K
4K
8K
16K
32K
64K
128K
256K
512K
1024K
Data Size (B)
MPICH-OFI (CH4)
MPICH CH3
MVAPICH2
Open MPI
Open MPI (nobuf)


MPI_Get Bandwidth (relative to MPICH-OFI)
1.2
1
0.8
0.6
0.4
0.2
0
1
2
4
8
16
32
64
128
256
512
1K
2K
4K
8K
16K
32K
64K
128K
256K
512K
1024K
Data Size (B)
MPICH-OFI (CH4)
MPICH CH3
MVAPICH2
Open MPI
Open MPI (nobuf)

Questions?

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