Getting Started (/getting-started)

Resources (/resources)

Research (/research)

Support & Services (/support-and-services)

About RCC (/about-rcc)

User Guide

SECTION NAVIGATION

Hybrid MPI/OpenMP jobs

MPI and OpenMP can be used at the same time to create a Hybrid MPI/OpenMP program.

Let's look at an example Hybrid MPI/OpenMP hello world program and explain the steps needed to compile and submit it to the queue. An example hybrid MPI hello world program: **hellohybrid.c** (../../_downloads/hellohybrid.c)

```c
#include <stdio.h>
#include <omp.h>
#include "mpi.h"

int main(int argc, char *argv[]) {
  int numprocs, rank, namelen;
  char processor_name[MPI_MAX_PROCESSOR_NAME];
  int iam = 0, np = 1;

  MPI_Init(&argc, &argv);
  MPI_Comm_size(MPI_COMM_WORLD, &numprocs);
  MPI_Comm_rank(MPI_COMM_WORLD, &rank);
  MPI_Get_processor_name(processor_name, &namelen);

  #pragma omp parallel default(shared) private(iam, np)
  {
    np = omp_get_num_threads();
    iam = omp_get_thread_num();
    printf("Hello from thread %d out of %d from process %d out of %d on %s\n",
           iam, np, rank, numprocs, processor_name);
  }

  MPI_Finalize();
}
```

To run the program on the RCC cluster, copy `hellohybrid.c` and `hellohybrid.sbatch` to your home directory, then compile the code interactively by entering the following commands into a terminal on a Midway2 login node:

```
module load openmpi
mpicc -fopenmp hellohybrid.c -o hellohybrid
```

Here we load the default MPI compiler, but it should be possible to use any available MPI compiler to compile and run this example. Note that the option **-fopenmp** must be used here to compile the program because the code includes OpenMP directives (use **-openmp** for the Intel compiler and **-mp** for the PGI compiler).

hellohybrid.sbatch (../../_downloads/hellohybrid.sbatch) is a submission script that can be used to submit a job to Midway2 to run the `hellohybrid` program.

```
#!/bin/bash

# A job submission script for running a hybrid MPI/OpenMP job on
# Midway2.

#SBATCH --job-name=hellohybrid
#SBATCH --output=hellohybrid.out
#SBATCH --ntasks=4
#SBATCH --cpus-per-task=8
#SBATCH --partition=broadwl
#SBATCH --constraint=edr

# Load the default OpenMPI module.
module load openmpi

# Set OMP_NUM_THREADS to the number of CPUs per task we asked for.
export OMP_NUM_THREADS=$SLURM_CPUS_PER_TASK

# Run the process with mpirun. Note that the -n option is not required
# in this case; mpirun will automatically determine how many processes
# to run from the Slurm settings.
mpirun ./hellohybrid
```

The options are similar to running an MPI job, with some differences:

- **--ntasks=4** specifies the number of MPI processes ("tasks").
- **--cpus-per-task=8** allocates 8 CPUs for each task.

- `export OMP_NUM_THREADS=$SLURM_CPUS_PER_TASK` sets the number of OpenMP threads to the number of requested cores (CPUs) for each task.

You can submit `hellohybrid.sbatch` using the following command from one of Midway2 login nodes:

```
sbatch hellohybrid.sbatch
```

Here is an example output of this program submitted to the `broadwl` partition on Midway2:

```
Hello from thread 0 out of 8 from process 0 out of 4 on midway2-0269.rcc.local
Hello from thread 6 out of 8 from process 0 out of 4 on midway2-0269.rcc.local
Hello from thread 0 out of 8 from process 1 out of 4 on midway2-0269.rcc.local
Hello from thread 7 out of 8 from process 1 out of 4 on midway2-0269.rcc.local
Hello from thread 3 out of 8 from process 1 out of 4 on midway2-0269.rcc.local
Hello from thread 2 out of 8 from process 0 out of 4 on midway2-0269.rcc.local
Hello from thread 3 out of 8 from process 0 out of 4 on midway2-0269.rcc.local
Hello from thread 4 out of 8 from process 0 out of 4 on midway2-0269.rcc.local
Hello from thread 5 out of 8 from process 0 out of 4 on midway2-0269.rcc.local
Hello from thread 1 out of 8 from process 0 out of 4 on midway2-0269.rcc.local
Hello from thread 7 out of 8 from process 0 out of 4 on midway2-0269.rcc.local
Hello from thread 2 out of 8 from process 1 out of 4 on midway2-0269.rcc.local
Hello from thread 1 out of 8 from process 1 out of 4 on midway2-0269.rcc.local
Hello from thread 4 out of 8 from process 1 out of 4 on midway2-0269.rcc.local
Hello from thread 5 out of 8 from process 1 out of 4 on midway2-0269.rcc.local
Hello from thread 6 out of 8 from process 1 out of 4 on midway2-0269.rcc.local
Hello from thread 0 out of 8 from process 2 out of 4 on midway2-0269.rcc.local
Hello from thread 7 out of 8 from process 2 out of 4 on midway2-0269.rcc.local
Hello from thread 4 out of 8 from process 2 out of 4 on midway2-0269.rcc.local
Hello from thread 5 out of 8 from process 2 out of 4 on midway2-0269.rcc.local
Hello from thread 1 out of 8 from process 2 out of 4 on midway2-0269.rcc.local
Hello from thread 6 out of 8 from process 2 out of 4 on midway2-0269.rcc.local
Hello from thread 3 out of 8 from process 2 out of 4 on midway2-0269.rcc.local
Hello from thread 2 out of 8 from process 2 out of 4 on midway2-0269.rcc.local
Hello from thread 0 out of 8 from process 3 out of 4 on midway2-0270.rcc.local
Hello from thread 7 out of 8 from process 3 out of 4 on midway2-0270.rcc.local
Hello from thread 4 out of 8 from process 3 out of 4 on midway2-0270.rcc.local
Hello from thread 6 out of 8 from process 3 out of 4 on midway2-0270.rcc.local
Hello from thread 3 out of 8 from process 3 out of 4 on midway2-0270.rcc.local
```

```
Hello from thread 3 out of 8 from process 3 out of 4 on midway2-0270.rcc.local
Hello from thread 2 out of 8 from process 3 out of 4 on midway2-0270.rcc.local
Hello from thread 5 out of 8 from process 3 out of 4 on midway2-0270.rcc.local
Hello from thread 1 out of 8 from process 3 out of 4 on midway2-0270.rcc.local
```

(http://www.uchicago.edu)

Research Computing Center
5607 S. Drexel Ave.
Chicago IL 60637

© (/user?destination=node/110) 2014 **The University of Chicago**

Request Account (https://rcc.uchicago.edu/getting-started/request-account)

User Guide (https://rcc.uchicago.edu/docs)

High Performance Computing (https://rcc.uchicago.edu/resources/high-performance-computing)

Location and Directions (https://rcc.uchicago.edu/about-rcc/location-contact)

Calendar (https://rcc.uchicago.edu/about-rcc/calendar)

Subscribe (https://rcc.uchicago.edu/subscribe)

Need Help?

Email: **help@rcc.uchicago.edu (mailto:help@rcc.uchicago.edu)** or **Request Support** (https://rcc.uchicago.edu/support-and-services/consulting-and-technical-support)

Walk-In Laboratory: **Regenstein Library**, suite 216

Call us at **(773) 795-2667** or consult the **User Guide** (http://docs.rcc.uchicago.edu)