Lab 9

CSEN 145L: Hybrid MPI and OpenMP

In this lab, you will implement and execute a hybrid parallel sorting algorithm using MPI (Message Passing Interface) for inter-process communication and OpenMP for intra-process multithreading. The sorting algorithm is based on distributing the data across multiple processes, performing local sorting in parallel using OpenMP, and then merging the sorted data globally using MPI.

You are provided with qsort_hybrid.cpp and you are required to complete the code. A stub code is already given and you have to implement the final version by completing the code sections

To get Started, Clone or download the lab09 folder from github.

1. The code works by initializing an array of specific size and populating it with random values and then it distributes chunks to other processes, locally sorts using qsort algorithm with OpenMP, and merges the resulting partially sorted lists into the globally sorted list.

2. Complete the remaining code

3. To compile/execute and test your code, you will need to request resources from WAVE HPC by either requesting interactive (srun method) or non-interactive (sbatch) resources.

A. Srun method:

srun --partition=cmp --cpus-per-task=4 --mem=8GB --nodes=1 --ntasks-per-node=4 --ntasks 4 --pty /bin/bash

This configuration will let you run your code on a total of 4 processes, each with 4 threads.

After you are allotted the requested resources, your current node will change from login1/2/3 to cpuXX or memXX.

1. Loading the environment
   Load Open MPI module using module load

module load OpenMPI
or
module load OpenMPI/4.1.5

2. Now to compile and execute your code, you will need to compile it using **mpic++**

To, Compile .cpp files using
Ex: mpic++ -fopenmp -o qsort_hybrid qsort_hybrid.cpp

To run your code,
mpirun -np 4 ./qsort_hybrid 4

This will run the mpi job with 4 processes and each process would utilize 4 threads.

B. Sbatch Method:

This method follows all the steps explained above since they are already present in the given **lab09_job.sh** bash file.

```
#!/bin/bash
#SBATCH --partition=cmp       # Specify the partition, gpu or hub
#SBATCH --nodes=1             # Number of nodes
#SBATCH --ntasks-per-node=4         # Number of tasks (4 task)
#SBATCH --ntasks=4           #total number of  tasks
#SBATCH --cpus-per-task=4      # Number of CPU cores per task
#SBATCH --mem=8GB             # Memory allocation
#SBATCH --time=01:00:00       # Max runtime (1 hour)
#SBATCH --output=qsort_output.log # Log standard output to file
#SBATCH --error=qsort_error.log   # Log error output to file
# Email notifications
#SBATCH --mail-type=BEGIN,END,FAIL  # Send email on job start, end, or failure
#SBATCH --mail-user=your_email@example.com  # Replace with your email address
# Load the OpenMPI module
module load OpenMPI/4.1.5
# Compile the MPI  code
 mpic++ -fopenmp -o qsort_hybrid qsort_hybrid.cpp
mpirun -np 4 ./qsort_hybrid 4
```

Final Deliverables: Submit qsort_hybrid.cpp and log file of the output