Parallel and Distributed Computing
CSE4001

Hybrid OpenMP & MPI Program

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Audio for the entire Assignment

How do OpenMP & MPI work

OpenMP

Parallel code with **OpenMP** marks, through a special directive, sections to be executed in parallel. The part of the code that's marked to run in parallel will cause threads to form. The main thread(thread id=0, generally) is the master thread. The slave threads all run in parallel and run the same code.

MPI

MPI uses the notion of process rather than processor. Program copies are mapped to processors by the **MPI** runtime. In that sense, the parallel machine can map to 1 physical processor, or N where N is the total number of processors available, or something in between.

CODE

C: > Projects > PDC_Proj > hybrid > C hybrid.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();
}
```

OUTPUT

```
vjk@DESKTOP-ECQ3CPO: /mnt/c/Projects/PDC_proj/hybrid
vjk@DESKTOP-ECQ3CPO:/mnt/c/Projects/PDC_proj/hybrid$ mpicc -fopenmp hybrid.c -o hybrid
vjk@DESKTOP-ECQ3CPO:/mnt/c/Projects/PDC_proj/hybrid$ export OMP_NUM_THREAD=4
vjk@DESKTOP-ECQ3CPO:/mnt/c/Projects/PDC_proj/hybrid$ mpirun -n 4 ./hybrid
--------------------------------------------------------------------------
WARNING: Linux kernel CMA support was requested via the
btl_vader_single_copy_mechanism MCA variable, but CMA support is
not available due to restrictive ptrace settings.

The vader shared memory BTL will fall back on another single-copy
mechanism if one is available. This may result in lower performance.

  Local host: DESKTOP-ECQ3CPO
--------------------------------------------------------------------------
Hello from thread 2 out of 8 from process 0 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 5 out of 8 from process 1 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 3 out of 8 from process 1 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 4 out of 8 from process 1 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 1 out of 8 from process 1 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 7 out of 8 from process 1 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 2 out of 8 from process 2 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 0 out of 8 from process 2 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 3 out of 8 from process 2 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 7 out of 8 from process 3 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 2 out of 8 from process 3 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 3 out of 8 from process 3 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 0 out of 8 from process 3 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 4 out of 8 from process 3 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 7 out of 8 from process 2 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 1 out of 8 from process 0 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 0 out of 8 from process 0 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 5 out of 8 from process 0 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 3 out of 8 from process 0 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 6 out of 8 from process 0 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 7 out of 8 from process 0 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 4 out of 8 from process 0 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 6 out of 8 from process 1 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 2 out of 8 from process 1 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 0 out of 8 from process 1 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 1 out of 8 from process 3 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 6 out of 8 from process 3 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 5 out of 8 from process 3 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 1 out of 8 from process 2 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 4 out of 8 from process 2 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 6 out of 8 from process 2 out of 4 on DESKTOP-ECQ3CPO
Hello from thread 5 out of 8 from process 2 out of 4 on DESKTOP-ECQ3CPO
[DESKTOP-ECQ3CPO:00094] 3 more processes have sent help message help-btl-vader.txt / cma-permission-denied
[DESKTOP-ECQ3CPO:00094] Set MCA parameter "orte_base_help_aggregate" to 0 to see all help / error messages
vjk@DESKTOP-ECQ3CPO:/mnt/c/Projects/PDC_proj/hybrid$
```