OpenMP

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Outline

- What is OpenMP?
- Why do we care about it?
- What does it take to write an OpenMP program?
- What does it take to compile an OpenMP program?
- What does it take to run an OpenMP program?
What is OpenMP?

- Shared Memory Parallelism
- Multithreaded code (what’s a thread?)
- OpenMP == “Open Multi Processing”
- Just like MPI, OpenMP is a standard. This one consists of:
  - Compiler directives
  - Functions
  - Environment variables
- Since it’s only a standard, we must have an implementation
  - Intel compilers, GNU compilers
- Only C/C++/Fortran
Hints to the compiler; Suggestions for it to do something special with your code.

Is the compiler required to listen to you? (Hint: it’s not)

These directives are called “pragmas” (i.e., *pragmatic*)

The most common pragma looks like this:

- `#pragma omp parallel for`
  - (We’ll get more into what it actually means later)

They will control *how* our code gets parallelized
The OpenMP functions allow us to gather information about—and alter—the OpenMP runtime environment.

Just like with MPI, we must include the OpenMP library:

```
#include <omp.h>
```

Then we can use OpenMP functions like:

```
omp_get_thread_num();
```

These functions will let us get, and use, the OpenMP equivalent of MPI’s rank and size.
Environment Variables

- The Environment Variables provide a way for us to dictate certain features of the OpenMP runtime.
- For example, the number of threads:
  - `setenv OMP_NUM_THREADS=8`
  - This will tell the environment to run our program with 8 threads.
- Other options include:
  - `OMP_SCHEDULE`
  - `OMP_STACKSIZE`
Why do we care?

- MPI is hard
- OpenMP is easy (you’ll see soon)
- No need to pass data around
- Avoid lots of concurrency issues and complications arising from complex MPI code
- “Instant” gratification

Why might OpenMP/SharedMemory be “bad”? 
Let’s start with the canonical “Hello World”:

```c
int main () {
    printf(“Hello World!
”);
}
```
Write OpenMP

- Now with an OpenMP pragma:

```c
int main () {
    #pragma omp parallel
    {
        printf("Hello World!\n");
    }
}
```
Better Example

#include <stdio.h>

int main () {
    int i;

    #pragma omp parallel for
    for (i = 0; i < 10; i++) {
        printf("i=%d\n", i);
    }
}

OpenMP
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Compile (and Run) OpenMP

- **DO THIS ON AL-SALAM**

  cd
  ./qsub-interactive-1-node
  cp -r ~fitz/BWUPEP2011_OpenMP .
gcc -fopenmp -o for for.c
  ./for

- What happened?
Modifications

- What happens if you split up the printf inside the for loop?
  - printf("i=");
  - printf("%d\n", i);
- What does the output look like? Why is this happening?
- Do we want to “fix” it?
Rank and size again

```c
#include <omp.h>
#include <stdio.h>
#define WORKLOAD 1

int main () {
    int rank, size, i;
    #pragma omp parallel
    {
        rank = omp_get_thread_num();
        for(i=1; i<WORKLOAD; ++i);
        printf("Hello World from thread %d\n", rank);
        if ( rank == 0 ) {
            size = omp_get_num_threads();
            printf("There are %d threads\n",size);
        }
    }
    return 0;
}
```
Rank and size again

- What does it do? (Hint: not what we want)
- Thoughts for improving? (Hint: SMP)
Your turn…

- Take a look at the other code in the BWUPEP2011_OpenMP directory (timing.c). Read it, try to understand it, run it, see if you can change it to get different behavior.

- Take a look at your serial calculatePI code, try to add OpenMP to it (Hint: it should only take one pragma; think reduce too)

- Take a look at the serial NBody code. Remember the gprof’ing we did? Given that information, where do you think the best place for an OpenMP pragma is? Try it!