OpenMP Lab

https://github.com/ResearchComputing/USGS_2016/

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Source Code

All of the source code is online, in a github repository:

`https://github.com/ResearchComputing/USGS_2016_02_09-10`

Login to Yeti

1. Log in to Yeti.

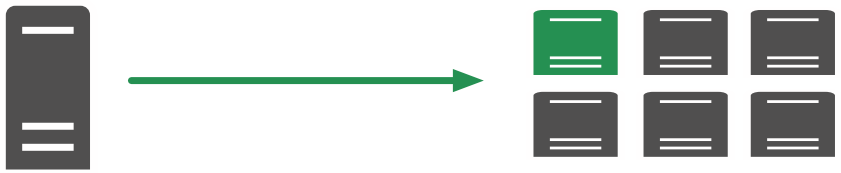
```
laptop ~$ ssh yeti.cr.usgs.gov
```

2. Clone the git repository

```
yeti-login01 ~$ git clone \
 https://github.com/ResearchComputing/USGS_2016_02_09-10
```

3. Start a compute job.

```
yeti-login01 ~$ sinteractive -A training  \
                             -p UV        \
                             -t 01:00:00 -n 1   \
                             --cpus-per-task=4  \
                             --reservation=training_UV_1
```



4. Load the Intel parallel studio module

```
compute80 ~$ module load intel/psxe-2015
```

This contains the C, C++ and Fortran compilers as well as the Intel MPI library.

Language	Compiler
C	icc
C++	icpc
Fortran	ifort

Number of threads

Figure out how many threads we have.
Using the `omp_get_thread_num()` library call.

Example	Source
Fortran	`thread_num/thread_num_f.f90`
C	`thread_num/thread_num_c.c`

- Compiling the program.

  Intel `icc -qopenmp -o thread_num_c thread_num_c.c`
  GCC `gcc -fopenmp -o thread_num_c thread_num_c.c`
  PGI `pgcc -mp -o thread_num_c thread_num_c.c`
  IBM `xlc -qsmp=omp -o thread_num_c thread_num_c.c`

- Execute the program, specifying different numbers of threads.
  1. `./thread_num_c`
  2. `env OMP_NUM_THREADS=1 ./thread_num_c`
  3. `env OMP_NUM_THREADS=64 ./thread_num_c`

- What is the output?
  - Threads printed out their identification number.
  - Random order of numbers. Threads execute independently and in general order will be random.

Preprocessor

Using the pre-processor with C and Fortran code.

- Using `ifdef`'s within the source code file, means you can compile your code with OpenMP directives with out using OpenMP.

Example	Source
Pre-processor in Fortran	`ifdef/if.F90`

Loops

Example	Source
Array addition using a for loop	`loop/for.c`
First private in a parallel region	`loop/first.c`
Last private in a parallel region	`loop/last.c`
Reduction operator	`loop/total.c`

Sections

Example	Source
Distribute independent work	`sections/sections.f90`

Synchronization

Example	Source
Synchronization using a barrier	`sync/barrier.c`
An ordered reduction	`sync/ordered.c`

Alignment

Data alignment is crucial when using SIMD directives for vectorization.

Example	Source
Alignment in C	`align/align_c.c`
Alignment in Fortran	`align/align_f.F90`

Note icc, gcc and gfortran pre-processors have `__BIGGEST_ALIGNMENT__` defined. However ifort does not (it is currently an open feature request). So the `Makefile` defines it for Fortran.

Target

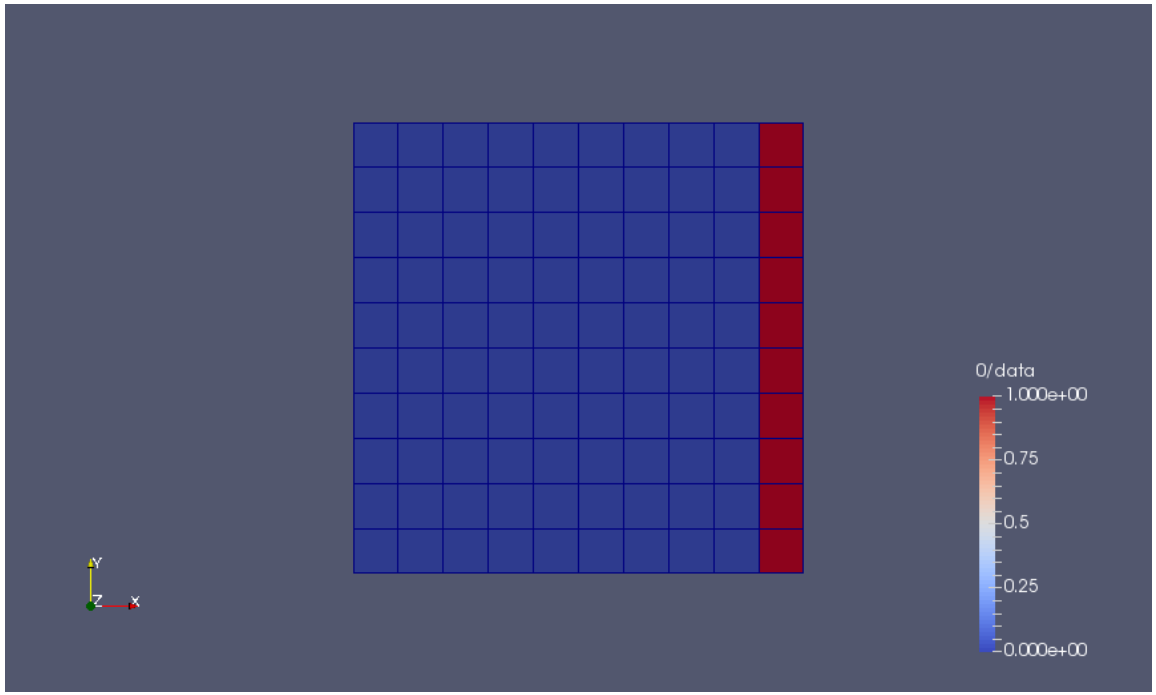
Using the OpenMP v4.5 `target` directives for off-loading to an accelerator.

Example	Source
Target in C	`target/target_c.c`

Jacobi

The Jacobi method for stencil-based iterative solvers. The example is for a 3D diffusion equation.

Example	Source
Fortran	`jacobi`



- Load the HDF5 module for I/O.

  ```
  compute80 ~$ module load tools/hdf5-1.8.15-intel
  ```

- Compile the serial jacobi program

  ```
  compute80 ~$ make
  ```

- Execute the program with a $100 \times 100 \times 100$ domain and 1000 iterations. These are the deafults in the `input.nl` file.

  ```
  compute80 ~$ ./jacobi -i input.nl
  ```

Questions?

Online Survey

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