LAB : OpenMP
GNU Compiler Instructions

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Introduction

What you will learn

- How to compile Code (C and Fortran) with OpenMP
- How to parallelize code with OpenMP
  - Use the correct header declarations
  - Parallelize simple loops
- How to effectively hide OpenMP statements

What you will do

- Modify example code READ the CODE COMMENTS
- Compile and execute the example
- Compare the run-time of the serial codes and the OpenMP parallel codes with different scheduling methods

Accessing Lab Files

- If you do not have access to a TACC system, get and extract the following tar file on your own Linux system with these instructions:

- **From your browser download instructions and tar file:**

  http://www.tacc.utexas.edu/user-services/training/course-materials

  instructions: openmp_lab_gnu.pdf

  source files: openmp_lab_gnu.tar

- **Once you have downloaded the tar file, untar it.**

  ```
  tar -xvf ./openmp_lab_gnu.tar
  ```

- **Now change directory to the source files.**

  ```
  cd lab_openmp
  ```

Compiling

- All OpenMP statements are activated by the OpenMP flag:
  - Intel compiler: icc/ifort -openmp source.<c,F90>
  - PGI compiler: pgcc/pgf90 -mp source.<c,F90>
  - GNU compiler: gcc/gfortran - fopenmp -lm source.<c,F90>
- Compilation with the OpenMP flag (-openmp/-mp/-fopenmp):

  Activates OpenMP comment directives (…) :

  Fortran: !$OMP ...

  C: #pragma omp ...

  Enables the macro named _OPENMP

  #ifdef _OPENMP evaluates to true

  (Fortraners: use F90 suffix for auto preprocessing)

  Enables ”hidden” statements (Fortran only!)

  !$ ...

Exercises – Lab 1

- Exercise 1: Kernel check

  f_kernel.f90/c_kernel.c

  Kernel of the calculation (see exercise 2)

  Parallelize one Loop

- Exercise 2: Calculation of π

  f_pi.f90/c_pi.c

  Parallelize one Loop with a reduction

- Exercise 3: daxpy (a * x + b)

  f_daxpy.f90/c_daxpy.c

  Parallelize one Loop

Exercise I: π Integration Kernel Check

- cd exercise_1
- Codes: f_kernel.f90/c_kernel.c
- Number of intervals is varied (Trial loop)

Kernel

Trial Loop: itrial
Calculation of n and deltax
Loop over i
make sure area >0.0

1. Parallelize the code
2. Compile
3. Run with 1, 2, 4, 8 threads
   e.g. export OMP_NUM_THREADS=4
   ./a.out
4. Compare the timings

1. Parallelize the Loop over i :
   Use **omp parallel do/for**
   Set appropriate variables to private

2. Compile with:
   gfortran -fopenmp f_kernel.F90
   gcc -lm -fopenmp c_kernel.c

(This loads up the c math lib for "sqrt" function.)

- ✓ Timings decrease with more threads.
- ✓ If you execute with more threads than cores, the timings will NOT decrease. Why?

Exercise II: π Integration

- cd exercise_2
- Codes: f_pi.90/c_pi.c
- Number of intervals is varied (Trial loop)

π calculation

Trial Loop: itrial
Calculation of n and deltax
Loop over i

- Parallelize the code

1. Complete OpenMP statements
   - Initialization
   - omp get max threads
   - omp get thread num

1. Parallelize the Loop over **i** :
   Use **omp parallel do/for**
   with the default(none) clause

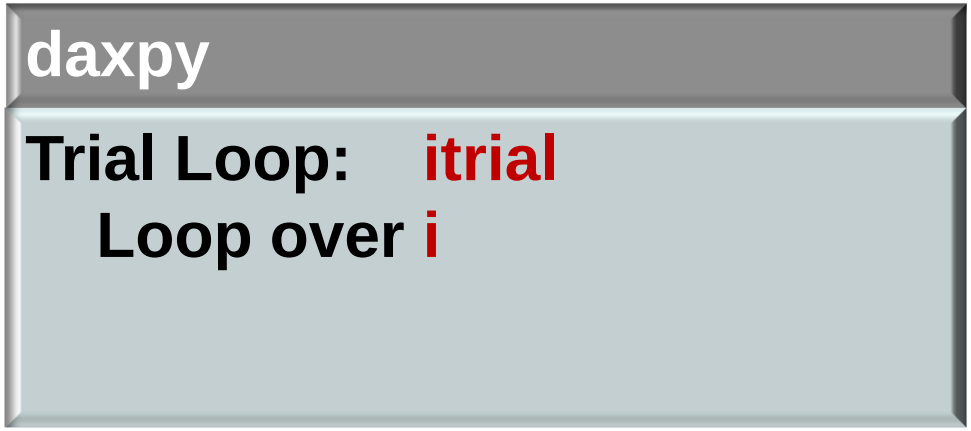
2. Compile with:
   make f_pi
   or
   make c_pi

3. Run with 1, 2, 4, 8 threads
   e.g. export OMP_NUM_THREADS=4
   ./c_pi or ./f_pi

4. Compare timings
   - ✓ Timings decrease with more threads
   - ✓ What is the scale up at 4 threads?.

Exercise III: daxpy

- cd exercise_3
- Codes: f_daxpy.f90/c_daxpy.c
- Number of intervals is varied (Trial loop)



1. Parallelize the Loop over **i** :
   Use **omp parallel do/for**
   with the default(none) clause

2. Compile with:
   make f_daxpy
   or
   make c_daxpy

- Parallelize the code

1. complete OpenMP statements
   - Initialization
   - omp get max threads

3. Run with 1 and 4

4. Compare timings
   - Why is performance only doubled?

✓ Hint: Parallel performance can be limited by memory bandwidth– what is happening for every daxpy operation? (Is there cache reuse?)