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Guide: OpenMP on AWS

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Abstract

This is a guideline document to show the necessary actions to set up and use `gcc` to evaluate its OpenMP support on Ubuntu (16.04).

Requirements

- **First you should have followed the Guide "First Access to AWS"**. It is assumed you already have an AWS account and a key pair, and you are familiar with the AWS EC2 environment.
- We strongly recommend an instance with at least 4 vCPUs to be able to evaluate parallel implementation. The results in this guide have been obtained on a **t2.2xlarge** instance with 8 vCPUs, which is the instance type recommended in the homework assignment.
- The files needed to do the exercises are available for download from **Canvas**.

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1. Install gcc

- Install `gcc` via the toolchain PPA

```
$ sudo apt-get install software-properties-common
$ sudo add-apt-repository ppa:ubuntu-toolchain-r/test
$ sudo apt-get update
$ sudo apt-get install gcc
```

- To check the `gcc` installation is successful run following command in the terminal

```
$ gcc -v
```

2. Verify OpenMP Support

This section includes a simple session aimed at verifying the OpenMP support provided by the gcc compiler.

- Use `lscpu` to visualize the number of CPUs and cores of the system.

```
$ lscpu
Architecture:          x86_64
CPU op-mode(s):        32-bit, 64-bit
Byte Order:            Little Endian
CPU(s):                8
On-line CPU(s) list:   0-7
Thread(s) per core:    1
Core(s) per socket:    8
Socket(s):             1
NUMA node(s):          1
Vendor ID:             GenuineIntel
CPU family:            6
Model:                 63
Model name:            Intel(R) Xeon(R) CPU E5-2676 v3 @ 2.40GHz
Stepping:              2
CPU MHz:               2400.072
…
```

- Upload to the VM the `omp_sc.c`, compile it with the `-fopenmp` flag, and run the code with different numbers of cores.

```
$ gcc -fopenmp omp_sc.c -o omp_sc
$ export OMP_NUM_THREADS=8
$ time ./omp_sc
```

- Upload to the VM the `omp_mm.c` code with the OpenMP parallelization of `seq_mm.c`, compile it with the `-fopenmp` flag, and run the code with a growing number of cores.

```
$ ulimit -s 64000

$ gcc -O3 -fopenmp omp_mm.c -o omp_mm_O3
$ export OMP_NUM_THREADS=1
$ time ./omp_mm_O3 > output

real    0m47.568s
user    0m47.512s
sys     0m0.057s


$ export OMP_NUM_THREADS=2
$ time ./omp_mm_O3 > output

real    0m25.851s
user    0m49.879s
sys     0m0.048s


$ export OMP_NUM_THREADS=4
$ time ./omp_mm_O3 > output

real    0m13.981s
user    0m50.533s
sys     0m0.076s


$ export OMP_NUM_THREADS=8
$ time ./omp_mm_O3 > output

real    0m7.910s
user    0m50.586s
sys     0m0.092s
```

There are two important considerations from previous results:

- An OpenMP program in one thread runs slower than its sequential version, because the parallelized version introduces an overhead associated with the setup of the runtime environment and the creation of the thread. Moreover the compiler may not be able to as aggressively optimise the parallel code as the serial code.
- In order to measure times we must use real time and not cpu time, which adds the time consumed by the process in all CPUs. See that CPU times are the same for any number of threads.
- This code ends with a write to file part that limits the speedup (Amdahl law). In our particular case this sequential part takes 1.8 seconds approximately. If we only consider the parallel part we achieve a linear speedup.

4. Automatic Parallelization

gcc brings a simple automatic parallelization:

- Upload `seq_mm.c`, `timing.c`, `timing.h` to the VM
- Use the automatic parallelization flag `-ftree-parallelize-loops=8` to generate a parallel version of `seq_mm.c`

```
$ gcc -O3 -DUSE_CLOCK -ftree-parallelize-loops=8 seq_mm.c  timing.c -o seq_mm_ap
$ time ./seq_mm_ap > output

real    0m7.960s
user    0m50.891s
sys     0m0.084s
```

Stop your instances when are done for the day to avoid incurring charges
Terminate them when you are sure you are done with your instance