Introduction to High Performance Computing (IN4049)

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Time: Every Friday 13:45 – 16:45 from 17 Sep. 2021

Location: Lecture Hall L (building EEMCS); Zoom Meeting (Meeting ID: 910 0159 2946, Passcode: 436240)

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1 Introduction

MPI is undoubtedly the most popular programming model for distributed platforms such as clusters and supercomputers. The lab exercises will be performed on the DAS-5 computer. The emphasis will be on designing efficient parallel algorithms and on the performance optimization. The score of the lab course will count for 50% of the final grade. At the end, a final report should be handed ib, which contains answers and measurements questions, it should also include a final version of the code. The score will be determined based on discussions and optimizations etc.

1.1 MPI Introduction

This small "Hello world" exercise will guide you into the MPI world from the scratch. If you are a newbie in MPI, you should not skip it.

2 Exercise

There are 3 separate exercises [1] [2] to give you hand on experience in high performance programming and you can optimize the code in a step-by-step manner.

- ◊ (1) Poisson solver: This exercise will teach you program an fairly complex application-Poisson kernel and let you learn to use MPI mechanisms. Thereafter, you are supposed to do experiment with your parallelized code on DAS5.
- ◇ (2) Finite elements simulation.
- ◇ (3) The eigenvalue solution by Power Method on GPU programming.

[1] The exercise specifications and the initial code can be downloaded from brightspace
[2] You can also download this electronic instruction copy from brightspace.

3 How to Use the Parallel Platform

- ◊ DAS5 is used as the parallel computing platform. Server Name: fs3.das5.tudelft.nl. For more details about DAS5, please refer to http://www.cs.vu.nl/das5/.
- ◊ If you are working at home, please connect the TUD VPN for the first step. For more details about VPN, please refer to https://www.tudelft.nl/en/ it-manuals/vpn-openvpn/.
- ◊ Linux user: Use *ssh* to connect to this server with the provided username and password: *ssh username@fs3.das5.tudelft.nl*
- ◊ Windows user (All the lab computers are Windows): Open software PuTTY to connect: hostname: *fs3.das5.tudelft.nl*, port: *22*
  Click connect. Input your username, press ENTER, input your password.
  Note that you can change your password on fs0 of DAS5:
  ssh username@fs0.das5.cs.vu.nl.
  But it takes around half a day before your new password is activated.
- ◊ Use the modules prun and openmpi as follows:
  module load prun
  module load openmpi/gcc
  Note that if you do not want to input these command lines each time you can log onto the server, and use an editor to append these lines to your local .bashrc file.
- ◊ Use vi, vim or gedit (gedit is easier for newers) for editing: *vi filename.c* or *gedit filename.c*. If you are not familiar with it, type,e.g, man vi or vi -h to get the tips, or you can just search for information from internet.
- ◊ Compilation
  mpicc -o filename1 filename1.c
  Note that the source code is in filename1.c, and the result (The executable file) will be in filename1 (indicated by the -o option, 'o' for 'output'). **Be careful** that a typo mpicc -o filename1.c filename1 can result in that your c program is overwritten and lost.
- ◊ Run the program
  prun -v -np X -Y -sge-script $*PRUN_ETC/prun-openmpi ./PROGRAM*
  X: number of nodes you want to use;
  Y: number of cores you want to use on each X node (default is one);
  PROGRAM: the name of the program;
- ◇ Follow Steps into the MPI World! in the "Helloworld" example.

4 Requirements

- ◊ The course work must be submitted in the form of a final report containing all your answers to all the questions in the three exercises.
- ◊ Any figures, analysis, and tools, illustrating or demonstrating your answers, will be beneficial for your overall grades.
- ◇ Each of you must complete the final report independently.
- ◊ Reports should have the following on the front cover: your name(s), student number(s), email address(s), and submission date.

- Please email your assignments to *T.Deng or A.N.Vasulkar*; also print your reports (no tedious source code) and hand in it to our office, later please send us an email to check we have received or not. This is to make sure that your report is not lost due to some people carelessly.
- Submission Deadline: February 1st 2022.

5 Assistance

In the 1st lab course (17th Sept, 2021) we will have a lecture with hybrid format from 13:45 – 16:45 to give a brief instruction about accessing DAS-5 and help make the first successful connection. After that, we will have Lab exercise every Friday from 13:45 – 16:45 to provide assistance. When you have any questions/suggestions about the lab course, you can contact us via our email address: t.deng@tudelft.nl or A.N.Vasulkar@tudelft.nl or you may drop by office, Mekelweg 4, 2628 CD. Office 5.130.

6 Grading Rules

The following rules will be followed to grade your assignments.

- The base grade for satisfying the answers of three exercises are: Poisson solver **(**2.0), Finite elements simulation **(**1.0) and eigenvalue solution by Power Method on GPU **(**2.0). You will get a grade of 5.0 points when you finish all the basic questiones.
- Multiple of 0.5 points will be added to your total grade (until 10.0), according to the shining points (e.g., performance analysis, optimmization, discussion and nice figures).