Problem set 2, MPI

TDT4200, Fall 2013

Deadline: 19.09.2013 at 22.00 Contact course staff ASAP if you cannot meet the deadline.

Evaluation: Graded, counts 10% of final grade

Delivery: Use It's Learning. Deliver exactly two files:

- *yourusername_ps2.pdf*, with answers to the theory questions
- *yourusername_code_ps2.*{*zip* |*tar.gz* |*tar*} containing only your modified versions of the files:
  - *main.c*
  - *global.h*
  - *jacobi.c*

General notes: All problem sets are to be done **INDIVIDUALLY**. Code must compile and run on `clustis3.idi.ntnu.no`. Do not run computationally heavy code on the login node. You should only make changes to the files indicated. Do not add additional files or thrid party code/libraries.

Part 1, Theory (25%)

Problem 1, MPI (5%)

a) Explain the difference between `MPI_Send()`, `MPI_Isend()` and `MPI_Ssend()`. (3%)

b) What is a communicator in MPI? What is the purpose of a cartesian communicator? (2%)

Problem 2, Interconnect (4%)

a) Mention three different interconnect topologies. Draw an example of each. (2%)

b) Show that the bisection width of a hypercube with p processors is $p/2$. (2%)

Problem 3, Amdahl and Gustafson (10%)

a) Using Amdahl's law, plot the speedup for programs with a serial fraction of 0.5, 0.2 and 0.1, for 1 to 2048 threads/cores. What are the maximum speedups that can be achieved? (2%)

b) Using Gustafson's law, plot the speedup for programs with a serial fraction of 0.5, 0.2 and 0.1, for 1 to 2048 threads/cores? (2%)

c) Explain the different results by explaining the difference between the serial fractions used in the two laws. (2%)

d) Assume a program is composed of two parts, A and B, where A is inherently serial, and B can be parallelized infinitely. On a sequential processor, the execution time of A is a, and the execution time of B is b, hence, the speedup on a parallel computer with p cores is:

$$S = \frac{T_{serial}}{T_{parallel}} = \frac{a+b}{a+\frac{b}{p}} \tag{1}$$

Define the serial fractions of Amdahl's and Gustafson's laws in terms of a, b and p. Use the definitions to derive Amdahl's and Gustafson's laws, starting from (1). (4%)

Problem 4, Domain decomposition (6%)

a) Given a 1024×1024 grid which should be divided into 64 equaly sized subdomains, what are the possible sizes of the subdomains? (2%)

b) Each subdomain is assigned to a processor, and the size of each grid element is 1 byte. For each of the possible subdomain sizes, calculate the total number of bytes that must be sent when a non-periodic border exchange with border thickness of 1 is performed. (4%)

Part 2, Code (75%)

Problem 1, Computational Fluid Dynamics/Jacobi method

In this task, you should complete the implementation of a Jacobi solver for a computational fluid dynamics program. In particular, you should complete the provided code by implementing the following functions.

- `jacobi()`
- `jacobi_iteration()`
- `create_types()`
- `gather_pres()`
- `exchange_borders()`
- `distribute_diverg()`

You might also have add aditional code and/or functions. You should only modify the files *main.c*, *global.h* and *jacobi.c*. Grading will be based on:

- Clearly written and commented code (15%)
- Code correctness (50%)
- Correct output (10%)

Additional neccessary details and information can be found in the recitation slides for this problemset.