COMPUTAÇÃO DE ALTO DESEMPENHO

2021/2022

Project 2 - MPI

The study of celestial bodies motions, subjects to gravitational interactions of each other's, is an hard problem. The general problem is described as the N-Body problem, were each one is subject to the forces from all the other over time, considering the mass and initial velocity of these bodies. The solution of these differential equations can be approximated by numerical integration where the system is simulated as time passes in very small time steps. You can find the description of this problem in several places, including Wikipedia[1]. Also in Chapter 7 of the recommended book[2] there is an introduction and solution for this problem that you should use for this project.

The objective is to implement a parallel solution for this problem using MPI and evaluate its scalability with the number of processes. A sequential version is provided based on the "basic solution" described in [2] (note that it ignores the Physics constants and units). In that book, you can also find a description of a MPI based version, that you can use as reference. In this code, the data structures used are just arrays to simplify your communication using MPI.

Requirements:

1. (65%) Implement a MPI version:
    a. Identify the hotspot of this solver and parallelize that part (see **section 7.1** of Pacheco's book)
    b. It may be useful to read MPI documentation and examples about MPI_Send, MPI_Receive, MPI_Bcast, MPI_Scater, MPI_Gather, MPI_Allgather, etc. [3,4,5]
    c. Develop and test in your computer or in node14 from cluster.di.fct.unl.pt
    d. Evaluate your final version changing the number of processes. Present the speedup for 1, 2, 4, 8, and 16 processes. For this, run in batch mode on a dedicated node from the Bulbasaur ones. Example: run 4 processes in one of the Bulbasaur nodes:
    `oarsub -l {"cluster='bulbasaur'"}/nodes=1 "mpirun -n 4 nbodympi"`

2. (10%) Evaluate using two nodes (/nodes=2):
    a. Run with 17, 24 and 32 processes
    For a reliable execution use the mpirun command like this:
    `"mpirun **--mca btl_tcp_if_include bond0** -n 32 nbodympi"`

3. (25%) Write a report (max of 5 pages A4 11pt font) that presents:
    a. Description of your approach(s)
    b. Relevant implementation details
    c. Your evaluation results (include graphs)
    d. An analysis and interpretation of these results (if you used two nodes, explain that results)

    Suggestion: use a Latex ACM or IEEE conference template.

Other relevant optimizations (like implementing the "reduced solver") may also be accounted in the final grade.

[1] n-body problem, Wikipedia, https://en.wikipedia.org/wiki/N-body_problem
[2] An Introduction to Parallel Programming (Second Edition), Chapter 7, Peter Pacheco, Matthew Malensek
[3] Open MPI v4.1.2 documentation, https://www.open-mpi.org/doc/current/
[4] MPI Documentation, RookieHPC, https://www.rookiehpc.com/mpi/docs/
[5] MPI Tutorials, https://mpitutorial.com/tutorials/