COMP528: Assignment 4

1. Overview and Requirements

This assignment requires knowledge of parallel programming and use of profiling will help you achieve a highly performant implementation. Marks are split between the coding and the report.

You are provided with a serial code to approximate the interactions and movements of a number of particles. This could range from gas atoms, or chemical molecules, right up to astrophysical bodies. We will however ignore quantum and relativistic effects. For simplicity, we have considered a 2D problem (along x- and y-axes but ignoring z-axis).

The code has number of timesteps during which we consider each body in turn. For which, the forces acting on it due to the other bodies are calculated (Newton's Equation) and this will determine the change in velocity and position. We repeat this for all bodies, such we then have a set of new velocities. We then update each body with its new position. We repeat this whole process for a number of timesteps. (Since we do not model collisions, we have to also catch if distances between bodies is too small such that the acceleration would become infinite.)

You are required to parallelise this code using MPI and OpenMP. It is suggested you use MPI ranks for each body, and that you parallelise the calculation of the forces using OpenMP, but you are free to choose the granularity (how many MPI processes and how many OpenMP threads). You should also use compiler reports and/or a profiler to determine if there are any optimisations to apply eg for improved vectorisation. You may parallelise any aspect of the code.

The code provided has a fixed number (5000) bodies for a fixed number (100) timesteps. Your parallel implementation should be capable of scaling both these by several factors of 10 (but you do not need to run such larger models) and your report should discuss how MPI and OpenMP would support this, highlighting any limitations.

All compilations should be done using the Intel compiler and with the -O2 optimisation flag. Timings given in the report should be the 'real' element of (the equivalent of) "time ./a.out". Timings should only include output of data after the final timestep, which may be redirected to a file.

Your submission must include:

- A 2 page report comprising:
  - Discussion of parallelisation strategy (10% of marks)
  - Discussion of accuracy and performance compared to the provided serial version, including the optimum granularity (#MPI process, #OpenMP threads) (30%)
  - Discussion of how you examined compiler reports and/or profiled the code, what you learned and how (if appropriate) you implemented what you learned (20%)
  - Discussion on scaling your code to model galaxy formation (10%)
- A single C code containing MPI and OpenMP parallelisation (30%)

DEADLINE & SUBMISSION

The deadline is 4pm, FRIDAY 14 December 2018 and this time you will need to submit via VITAL. All reports will be checked via TurnItIn and University policies apply regarding plagiarism, collusion and fabrication of data.

[ENDS]