Performance Analysis of GS2 Plasma Turbulence Code

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Introduction

GS2 [1] is an open source gyrokinetic simulation code used to study turbulence in plasma, one application is for fusion experiments. It is a gyrokinetic flux tube initial value and eigenvalue solver and is written in Fortran and parallelised with MPI.

Performance analysis was performed under the Performance Optimisation and Productivity Centre of Excellence (POP) using a methodology to narrow down underlying causes of inefficiency. After an initial analysis changes were made by the developers based upon the recommendations. The refactored code was further analysed with two inputs variants, this comparison is presented below. Performance Analysis was performed using the BSC tools Extrae and Paraver [2].

Methodology

POP efficiency metrics give an overview of how well the parallelisation of the application works and how efficiently the hardware is used [3]. The metrics are organised in a hierarchy and give a detailed overview of the performance of an application in a very condensed form. An ideal network is defined as instantaneous data transfer.

![Image of Efficiency Metrics](https://pop.co.uk/sites/default/files/pop_files/metrics.png)

Metrics are percentages where 0% is low, 80-85% is the cut off for good performance and 100% is ideal performance.

Analysis

A single GS2 timestep for this analysis included the following phases:
1) Nonlinear Advance (N)
2) Linear Advance (L)
3) Field Solver (F)
4) Second Linear Advance (L)
5) Iteration
6) Print

The analysis was performed on 2304 MPI ranks on the ARCHER UK Supercomputer. The main input variables are:

(ntheta, ngauss, nspec, nx, ny, nstep, field, layout) = (26, 5, 8, 2, 24, 24, 100, gf, yxles)

Two versions of data were distributed as follows. How five of the dimensions of the gyrokinetic distribution function are distributed across the MPI ranks was varied.

```
Right (default) 3 2 24 8 2
Square          3 8 6 8 2
```

![Communication matrix for 120 ranks for a) right and b) square split domains.](https://pop.co.uk/sites/default/files/pop_files/metrics.png)

Communication matrix for 120 ranks for a) right and b) square split domains. Coloured by number of messages sent between partners, light green are fewer and dark blue more messages.

Considerably more point-to-point messages are sent with the right split domain than the square split domain. The pattern is related to the input parameters for the domain decomposition.

Conclusions

The square split domain was the most efficient split tested and around twice as fast as the default data distribution.

1. Communication is the key bottleneck, specifically the amount of data transferred and the complexity of the communication patterns.
2. Further investigation of the impact of data distribution with different inputs to determine an optimal configuration for runs is required
3. This work clearly demonstrates there is a large scope for improvement to the communication in GS2

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