COMPUTATIONAL PERFORMANCE OF DSMC AND LBM CODES ON A RASPBERRY PI CLUSTER

Deepak S. Watvisave

Maharshi Karve Stree Shikshan Sanstha’s,
Cummins College of Engineering for Women,
Savitribai Phule Pune University,
Pune, India

e-mail: deepak.watvisave@cumminscollege.in

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Abstract. Computational performance of a parallel Direct Simulation Monte Carlo (DSMC) and Lattice Boltzmann Method (LBM) codes is evaluated on a 16 core Raspberry Pi cluster. Shock bubble interaction at rarefied conditions is analyzed with DSMC and Taylor-Green vortex decay is simulated with LBM. The speed-up is analysed by selecting 4, 8, 12 and 16 processors. The speed-up is observed to be proportional to the number of processors similar to a PC cluster. Temperature rise, low speed of data writing on SD card and low RAM are the issues, observed while running the simulations.

1 INTRODUCTION

Direct Simulation Monte Carlo (DSMC) and Lattice Boltzmann Method (LBM) codes can be parallelized with comparatively less effort than NSE codes. However, they require huge computational resources for simulations of real life size. Currently, ever demanding CFD computations are carried out on various heterogeneous platforms such as such as CPU/GPU with MPI, OpenMP or CUDA architectures. However, the cost of infrastructure and operation is considerable. The ARM architecture based platforms such as Raspberry Pi has become a very attractive low cost alternative to the above platforms. For exa-scale computing Raspberry Pi is one of the candidate due to its low cost and ease of operation. The implementation of MPI is exactly similar to a PC cluster. However, a limited RAM and data writing speeds are the major concerns to be addressed to tackle big problems on Pi cluster.

2 PROBLEM STATEMENT

A shock bubble interaction of dissimilar gases at rarefied conditions is to be carried out. The shock Mach number is 10 and the initial pressure is 0.001 bar. The bubble is of Helium gas and the shock is of Argon gas. The deformation of shock bubble is to be studied using DSMC method since at these flow conditions, NSE renders inaccurate results [1]. Number of molecules in the domain are 1.6 million. Another problem is Taylor-Green vortex decay simulations using LBM method [2]. Various number of nodes
are selected to gauge the computational performance. The objective of these simulations is to verify the speed-up achieved for above problems with 4, 8, 12, 16 processors and to test the quality of numerical results.

3 CONSTRUCTION OF PI CLUSTER and RESULTS

Figure 1 shows the arrangement of the cluster. The cluster consist of four Raspberry Pi 3B motherboards running on Raspbian. It is integrated with a desktop with Ubuntu 17.04. OpenMPI version 2.2 is loaded on Raspbian. The NFS file system is used for data sharing. The DSMC and LBM codes are written in C++/MPI. The cost of cluster is about 215 US dollars.

A small size LBM grid of 768 by 768 is selected to study the performance. For multi-processor simulations the bandwidth is 0.2 Gib/s. It is seen that as number of processors increases the run time decreases and however the speed is smaller for 4 cores when inter-communication between the processors is absent. A similar trend is observed for DSMC simulations. All the performance and physical results will be discussed in great detail in full paper.

4 CONCLUSIONS

The Raspberry Pi cluster showed a promising speed-up for the compute intensive simulations. However, the memory of the Pi board is not sufficient for the big simulations. The temperature rise of the processor is an issue and also the data transfer speed is less. With an increase in the on-board memory and an better cooling arrangement of processor, Raspberry Pi clusters can be used for bigger simulations over a longer time.

REFERENCES
