Parallel strategies for the three-dimensional reconstruction of biological specimens

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Abstract. In general, image processing programs are roughly based on three stages: data input, computer data processing and data output. The key point in this kind of programs is the workflow management in order to obtain the best performance on heterogeneous computer clusters or grids. Computer technology trends lead us to consider a 2-level hierarchical architecture on the new computer systems, i.e., a first level among distributed nodes and a second level among cores inside of each node. In this way, an easy and effective dynamic load balancing strategy for applications based on image processing has been proposed in this paper. Hybrid parallel programming (combining MPI for node level and OpenMP for core level) and on-demand strategies on each level have been of paramount importance to minimize the number of communications among nodes and the number of idle cores. Our strategy of dynamic load balancing has been tested for a biological application, the three-dimensional reconstruction of cellular specimens. Several experiments have been tested on dedicated and simulated non-dedicated, homogeneous and simulated heterogeneous computer cluster under HPC Europa project at Edinburgh Parallel Computing Center in Scotland.

Keywords: dynamic load balancing, hybrid parallel computing, electron tomography

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Introduction

Given the fast advance of the computer technologies, it is easy to find a computer cluster that combines a few new and fast nodes with a lot of “old” and slow nodes [1]. We take into account this situation in our work, and we exploit all the possibilities of the slowest node for getting the homogeneity of the system and thus the lowest execution times. Two paramount relevance issues for the developers of the program are what is the architectural design of the distributed system and how the users will access to the computational resources, i.e., if they will access of exclusive (dedicated use) or shared (non-dedicated use) form. It will lead to answer questions as how to get the computational power of each node, how to distribute the workload among the nodes or when to do the balancing. That is an arduous task, if we have into account that they have to develop not only the application but also they have to consider and incorporate strategies as static or dynamic load balancing, data migration, balancing decision, etc.

Our first hybrid (MPI/PThreads) parallel algorithm is called BAHPTomo (Balancing Adaptative algorithm for Heterogeneous Parallel systems in Tomography). The proposed algorithm has two steps. During the first step, the program evaluates the performance of each node in the distributed system. In the second step, the node 0 chooses the best cores to run the parallel program and it does a final distribution of balanced workload among different nodes.

In order to evaluate the algorithm efficiency described above, other reconstruction parallel algorithms were implemented:
- Parallel algorithm based on pure MPI with on demand strategy for load balancing.
- Parallel algorithm base on MPI/Pthreads without load balancing in which the criterion for the workload distribution is according to the number of cores on each node.

Working at EPCC

Our aim is to get different hybrid parallel implementations for our reconstruction program which could be stable under non-predictable changes of the system performance. In this way, the main objectives of our work at EPCC were the following:
1) Implementing new hierarchical load balancing techniques which take into account static methods...
on the node level (MPI level) and dynamic methods on the core level (PThreads or OpenMP level) [5,6,7,8].

2) Finding different ways to simulate the workload imbalance in order to test our programs, given that the supercomputer Hector stayed in Edinburgh Parallel Computing Centre is completely homogeneous.

3) Compare and evaluate the behaviour of our new load balancing techniques against pure MPI or PThread algorithms.

Future work

Our next work consists on the 3D reconstruction of cellular specimens in non-dedicated heterogeneous computational systems. New hybrid algorithms will be implemented and new load balancing criteria must be studied. We will propose solutions at three complicated points as they are: the core selection for each multicore node of the heterogeneous cluster, synchronism points to rebalance the workload among nodes and the data migration among nodes.

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References


