PARALLEL AND DISTRIBUTED SEISMIC WAVE FIELD MODELING WITH COMBINED LINUX CLUSTERS AND GRAPHICS PROCESSING UNITS

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1. INTRODUCTION

Seismic wave filed modeling is an important part of seismic exploration and seismology. It can be used for various earthquake related analysis and during many stages of seismic investigations (e.g. [1]). Recently rapid progress in a full wave form seismic inversion methods has made these simulations even more important (e.g. [2]). But seismic wave filed modeling in complex geological media is one of the problems which are very time consuming even for modern supercomputers and clusters, not to mention about single processor machines. In past ten years limitations of a memory and a processor resources force geoscientists to use parallel computing methods. Now modern parallel machines of various types provide enough resources for typical simulations but time of computations and limited accessibility are still a problem. Fortunately, development in a computer based entertainment made graphics processing units (GPUs) very powerful parallel machines [3]. In some cases even a single GPU can be as effective as a middle class cluster. Rapid progress of the computer game market makes older but still very effective hardware solutions affordable in large quantities even for scientific institutions with limited budgets. This hardware can be used for the cheapest possible upgrade of typical PC clusters which are usually the base of computational resources of this kind of organizations. On the other hand some vendors of expensive dedicated cluster solutions like for example IBM introduced cluster units (IBM BladeCenter HC10) with NVIDA GPUs which support using them for a floating point computations. Combining a distributed cluster technology with a General-Purpose computation on GPUs (GPGPU) can make a cluster much more powerful and can make the most important week points of GPU - like limited memory and textures (matrices) sizes - less bothersome.

2. IMPLEMENTATION

In this work only free or open software solutions - like OpenGL with extensions - were used. These solutions are usually the best for academic projects because rules of usage are clear and constant which is not always true in the case of commercial software, even if one can use them without any additional costs. All test codes have been written in C (gcc or icc) and OpenGL shading language. For intra-cluster communication mpich implementation of MPI was used. In all test runs low end NVIDIA 5000, 6000 and 7000 series AGP adapters were used. Some additional tests were done for NVIDIA PCIE 8000 series and NVIDIA Quadro cards.

3. SELECTED RESULTS AND DISCUSSION

Proposed paper presents results and efficiency analysis of seismic wave filed modeling with typical finite difference algorithms and two kinds of decomposition. First is an ultra coarse grain decomposition which is the most natural way of decomposing data for GPGPU computations. In this method whole simulation for a single shoot point is calculated on one machine without communications with others. In this case time consuming communication between CPU and GPU memory is limited. Second analyzed method of decomposition was typical domain decomposition. This method is the easiest way of overcoming memory and texture size limitations. Efficiency of this decomposition is strongly affected by the previously mentioned problem with the communication between memories. Of course in case of typical multi shoot points modeling it is less efficient then the one-PC-one-shoot-point decomposition. It is especially visible for simple FD algorithms but for the most computationally intensive algorithms - when time of GPU computation is longer - the difference is much smaller.

Obtained preliminary results are very promising. For medium scale models (up to 10 millions grid points) and for complex FD schemes low end GPU is usually a dozen of times faster the Pentium 4 3.0 GHz CPU. In case of ultra coarse grain decomposition speed-ups for multi GPU computations were close to linear. In analyzed case domain decomposition was less effective but can be used for bigger models which do not fit into the limited GPU texture.

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4. REFERENCES

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