High Speed 3D Hybrid Elastic Seismic Modeling

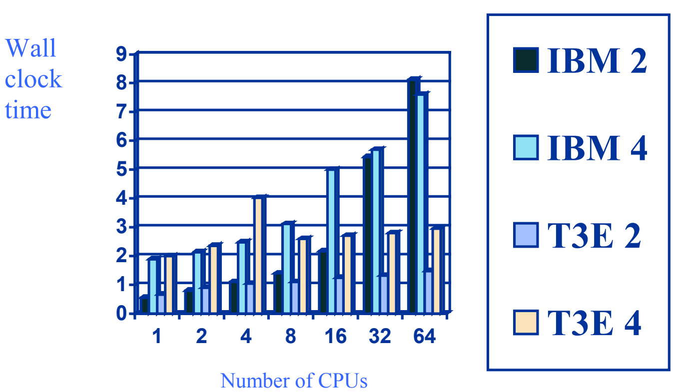
V. A. Korneev and C. Rendleman

Research Objectives

The best tool for understanding and, imaging complex structure and long offset data is an accurate fully elastic 3D algorithm. The applications of such algorithms are many fold including survey design, hypothesis testing, AVO evaluation, wave field interpretation, generation of test data sets for testing of new migration algorithms and as forward calculation engines in 3D prestack migration algorithms and new full waveform inversion algorithms. While such algorithms have been developed, uniform grid sampling produces costly over sampling of high velocity regions and unnecessarily small time integration steps in low velocity regions. Thus, the scale of the computer resources required to model the entire geologic section, from source locations to the depths of interest, with a fully elastic representation is prohibitive. In addition, the discretization of high contrast boundaries such as the salt-sediment interface can produce high-energy diffraction events in the modeled data, which are often difficult to completely suppress even in processing. There is a critical need for an algorithm which can accurately model and image all of the elastic effects occurring in complex structure while at the same time being efficient enough to be run on clusters of available workstations in a reasonable time.

Approach

We develop an efficient 3D elastic forward modeling algorithm that will address these requirements. There are two critical concepts that will provide for a significant improvement in computation efficiency and accuracy over what is currently available. First is the decomposition of the original three-dimensional model into parts (subdomains) where wave propagation will be computed using the optimal spatial parameterization for each particular subdomain. The second critical concept is the use of 4^{th} order in time scheme as opposed to 2^{nd} order scheme used elsewhere. The use of subdomains in finite difference (FD) modeling has several major advantages over current single domain algorithms. First, this approach allows fine girding to be used only in the low velocity regions (sea water, loosely compacted sediments) where it is required and allow courser girding in the higher velocity regions (salt, deep sediments). The innovative 4^{th} order in space differencing scheme allows to improve accuracy of time differencing, and, therefore to increase a of time differencing step for the expense of extra computation within a single node. Since inter SPU communication speed is a major bottleneck for parallel data processing flow the 4 th order scheme allows to increase a computation to communication ratio improving the effectiveness of parallel computations. The 4^{th} order time differencing scheme does not affect memory usage compare to 2nd order scheme. It also requires special formulation of absorbing boundary conditions, which are under development.



This graph summarizes a set of runs with the number of computational zones increasing linearly with the number of processors. Perfect scaling results would have zero slope. The Cray T3E times are pretty good. The IBM SP show a reduction in parallel performance with increasing numbers of processors. The performance loss is less severe for the 4th order scheme than for the 2^{nd} order scheme. IBM has slower interprocessor communications: lower bandwidth and higher latency. Run time reported is wall clock time. Cray T3E shows very efficient processor usage for both second and fourth order schemes. Fourth order schemes show slower degradation of parallel performance with increasing problems size.

The new variable grid subdomain FD algorithm is designed for parallel cluster computing using a message passing interface technique.

Funding
Project has started in April 2000. This work is supported by U.S. Department of Energy (DOE) under contract No. DE-AC03-76SF00098. Funding is provided in the frame of DOE Gas and Oil Partnership Program**.**GX Technologies and Burlington Resources provide in kind contribution.