Electromagnetic Well Logs Simulated with the COMSOL® RF Module on a Cluster

D. Swaminathan[1], G. Minerbo[1], K. Pathak[1]

[1]Drilling and Production Group, Schlumberger, Houston, TX, USA

Abstract

Introduction

Computer simulations are widely used for the interpretation and inversion of electromagnetic measurements in well logging. Until recently, simulated logs have been computed with approximate 1D or 2D models. By using the COMSOL® RF Module installed on a cluster, we show that a full 3D finite-element simulated log can be obtained within an acceptable turnaround time.

Use of COMSOL Multiphysics® software

The model studied has triaxial antennas, one transmitter and two receiver antennas. It provides a basic representation of the induction arrays used in wireline logging or of the propagation arrays used in logging while drilling. The formation has anisotropic layers with arbitrary dipping orientation. Faults or fractures are represented by very thin layers. Figure 1 shows a log computed with COMSOL compared to an accurate solution for a case that has an analytic solution. The accuracy of the COMSOL results was acceptable but could be improved with finer meshing.

Each node in the cluster used for this study has 2 x Intel Sandy Bridge 10-core processors each, (total 20 cores), 96 GB RAM and 4 x 600 GB 10,000-RPM disks with InfiniBand® connection.

The model selected has approximately 5 million (complex-valued) degrees of freedom and requires 33 GB of memory. The calculations needed for each point of the simulated log are independent, so parallelism is easily achieved.

For parallel computation, we developed a wrapper script that allows the GUI to invoke the TORQUE scheduler to run jobs on the cluster.

Results

Figure 2 shows a conservative speedup of 4 times that can be achieved using 12 nodes. The simulated log had 50 sensor positions. The runs were split up into 3 days, and manually recombined. By parallelizing COMSOL parametric sweep feature, we get a convenient way of

computing simulated logs.

Figures used in the abstract

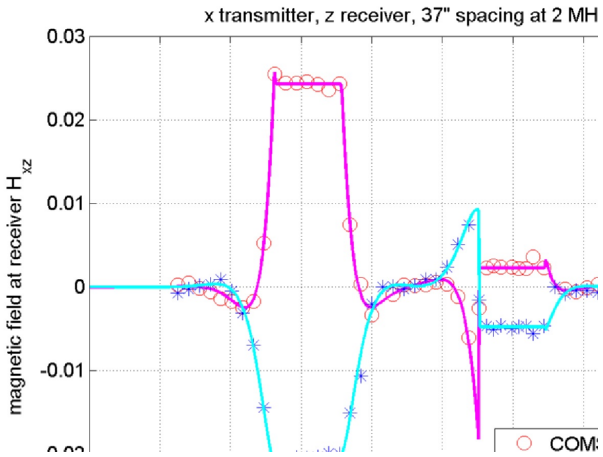

Figure 1: Simulated log computed by COMSOL® compared to the analytic solution. The transmitter magnetic moment is oriented along the x axis and normalized to unity. Hxz is the magnetic field [A/m] detected by a receiver oriented along the z axis at a distance of 37 inches from the transmitter.

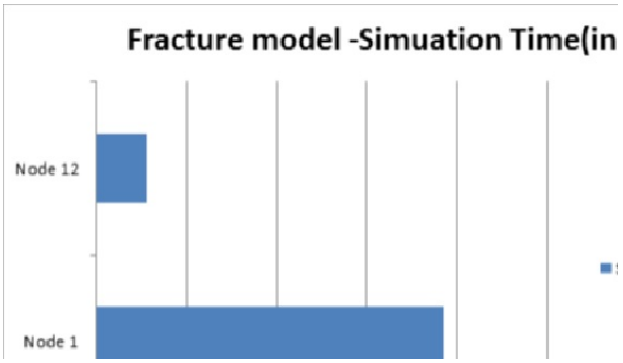

Figure 2: Time required to compute a simulated log using one node, or 12 nodes in parallel on a cluster.