Seismic Processing with Tricon's Tsunami Suite Accelerated by Starbridge Hypercomputing

Tricon, Starbridge and Essential Seismic Solutions (ESS) have partnered to provide seismic data processing customers with the highest performance, most accurate imaging solutions available. Using field programmable gate array (FPGA) technology, the price performance of seismic imaging solutions will improve by more than a factor of one hundred.

Tricon currently offers the ESS Tsunami Imaging Suite, which implements the Kirchhoff prestack time and depth migration algorithms on Linux clusters of up to five hundred CPUs. Running in a cluster environment, Tsunami images data up to seven times faster than other widely used software applications.

Current methods to increase processing throughput depend mainly on creating larger clusters. This approach incurs high electrical and air conditioning costs, requires a large administration staff, takes up ever-increasing amounts of space, and ultimately provides a diminishing return on investment as clusters grow larger.

Tricon and ESS have turned to Hypercomputing® for an unprecedented speed-up and cost reduction of the seismic imaging process. Hypercomputing uses FPGAs to reduce the time required to perform highly compute-intensive algorithms. Starbridge is the only company providing large-scale, high-end FPGA Hypercomputer accelerator boards, as well as the ability to port seismic algorithms in a time-efficient manner.

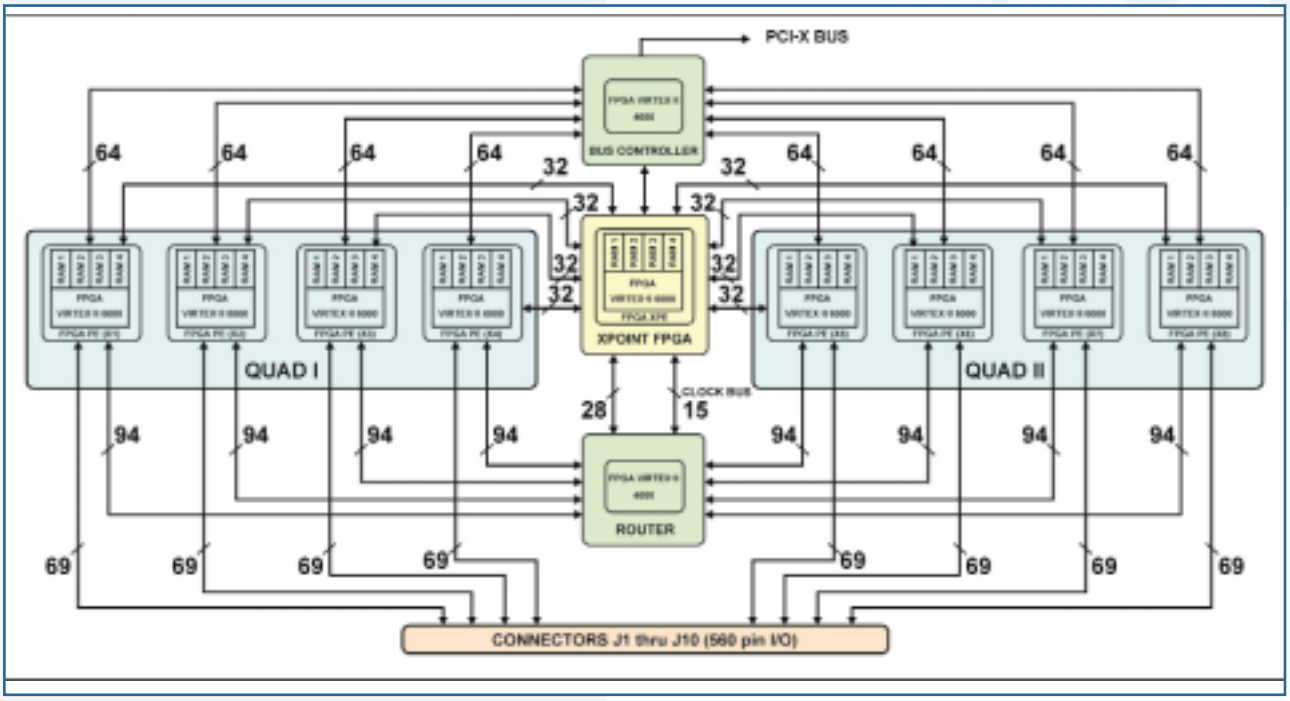
FPGA Background

An FPGA is a reconfigurable (i.e. programmable) chip that can be configured in a fraction of a second to create optimized hardware for particular computations. FPGAs used in the Hypercomputer are high-end Xilinx chips, comprising more than six million gates each. Once programmed, the resulting special purpose chips make optimal use of all available circuitry to run a specified algorithm. General purpose CPUs, by contrast, are capable of running many different applications, but with very low hardware resource utilization. Imaging algorithms running on clusters of Intel CPUs leave a large percentage of the chip's hardware resources idle, resulting in wasteful, inefficient use of expensive and power-hungry equipment.

The Starbridge Hypercomputer

Starbridge has created a powerful reconfigurable FPGA-based accelerator board that will run compute-intensive code orders of magnitude faster than is possible on traditional distributed Linux clusters. This significant speed advantage is due to the highly parallel nature of FPGA hardware, which is exploited by specifically tailored parallel code written using the Starbridge FPGA development environment, Viva®. Instead of performing one calculation per clock cycle per cluster CPU, the Hypercomputer can perform tens of thousands of calculations per clock cycle on a single accelerator board.

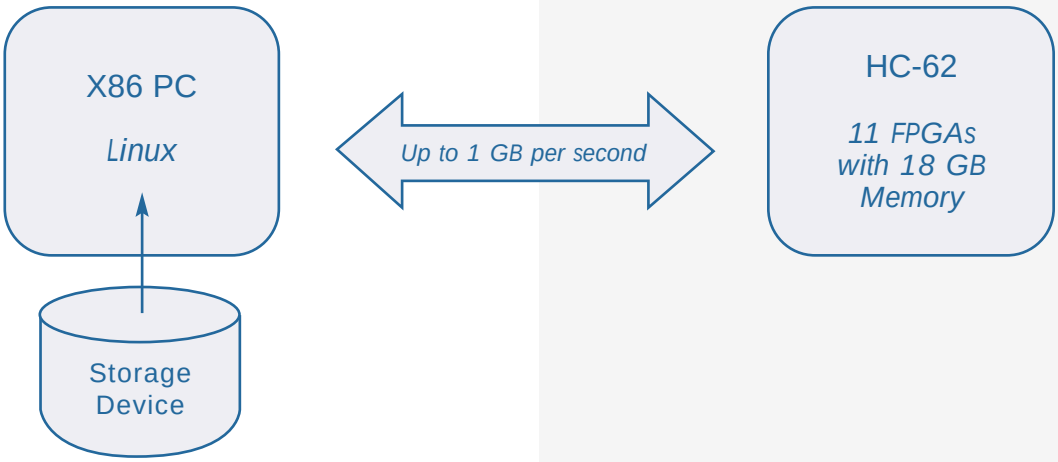
HC-62 Board Diagram



The Starbridge Hypercomputer HC-62 contains eight FPGAs used for computation, and three additional FPGAs that perform routing, switching, and bus communication.

The HC-62 board plugs into a PCI-X slot in a motherboard on a standard Linux PC or server. A single Intel chip, running Linux, runs the user interface and the less computationally intensive parts of the application. A high-speed data interconnect streams data from the Linux system into the FPGAs.

4U Cabinet



Time Migration and Finite Difference Wave Equation Algorithms

The pre-stack time migration was chosen as the first application because of its simplicity and widespread use in the industry.

The finite difference wave equation will allow us to deliver the first truly economic implementation of the full wave equation. The user will no longer need to drastically limit the frequency range or dip limit of the image to achieve suitable run times. In addition, it creates the possibility of outputting full depth gathers instead of a simple stack, enabling the use of the wave equation for velocity analysis and AVO work.

Hypercomputing and Tsunami Uses Patent Pending Technology

Starbridge and ESS have identified the most compute-intensive portions of the Tsunami imaging applications. These computational pipelines have been ported to run on the Hypercomputer. Many pipelines of computation are implemented on a single FPGA, with each pipeline producing multiple imaging results per clock cycle. Implementation of the Tsunami Imaging Suite™ in Starbridge's Viva software language for implementation on Starbridge's FPGA-based Hypercomputers is patent pending technology developed by ESS in cooperation with Starbridge.

In contrast, the Intel chip has only one pipeline, and can only produce an imaging result once every one hundred clock cycles for even the least expensive algorithm.

Cluster vs. Hypercomputer—Price/Performance

The acquisition cost of the HC-62 Hypercomputer is comparable to a PC cluster of approximately 150 CPUs. However, it can deliver the same seismic imaging performance as more than five thousand Intel CPUs.

The Hypercomputer fits into a single 4U cabinet, greatly reducing space requirements. It drastically reduces power consumption–only five hundred watts of power, in comparison with the more than five hundred thousand watts of power consumed by four thousand CPUs. Accordingly, air conditioning requirements are proportionally reduced. System administration effort is reduced, and system reliability is increased proportionally to the number of systems employed.

Hypercomputers are linearly scalable. Adding a second Hypercomputer will double the level of total performance for imaging applications.

Until now, FPGAs have generally not been successfully exploited in the seismic imaging industry. Historically, programming FPGAs has been an extremely

laborious and time-consuming process, requiring a low-level design language such as VHDL or Verilog. Alterations to algorithms implemented in an FPGA—such as changes in trace length, different sized output volumes, or different sized do-loops—required painstaking reprogramming by this same process. In seismic data processing, a completely new FPGA chip design would be required for each new data set, an effort requiring months of work.

Starbridge's patent pending Viva programming language greatly simplifies this process by allowing programmers to create reusable libraries of functions that can be easily modified and extended, similar to the way C++ objects are modified and extended. The core seismic imaging algorithms can be implemented to take advantage of the inherent parallelisms in FPGA technology, and can be converted from C or FORTRAN to Viva.

Using Viva, core algorithms can be programmed to achieve orders of magnitude performance increases. Additionally, these core algorithms can be dynamically altered to accommodate different data sizes or user parameters without any software redesign. Users simply run the software as they do today on the cluster, and the application reprograms the FPGA based on the current job and set of parameters.

Availability

The pre-stack time migration application is expected to be available for purchase in the first quarter of 2004. The finite difference wave equation should be available by the second quarter of 2004.

The list price for the HC-62 with eight FPGAs is approximately $350,000. Systems with fewer FPGAs are available at a lower price.

The Partners

TRICON Geophysics, Inc. is a leading supplier of Seismic Processing and Imaging services, Integrated Reservoir Studies, Attribute Analysis, Visualization and Data Archival Services. The company is staffed by highly trained and experienced geoscientists, Tricon provides conventional seismic processing, prestack time and depth imaging, for land, marine and transition zone projects on a world wide basis.

For more information go to www.tricongeophysics.com.

Star Bridge Systems, Inc. is a High Performance Computing company that provides an innovative highly parallel FPGA-based accelerator, resulting in orders of magnitude performance increases for many computationally intensive problems, including geophysics, biosciences, signal processing, and cryptography.

For more information go to www.starbridgesystems.com.

Essential Seismic Solutions (ESS) is the creator of the Tsunami Imaging Suite, a leading-edge seismic imaging application.

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