WHITE PAPER

Zircon Adaptive Software on SGI® Altix® UV 1000 for High Performance Data Analytics

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Software developers and architects creating and upgrading their code to run on new processor architectures for embedded market segments are trying to harness the processing power available from these multi-core platforms. These market segments include fraud detection, market risk analysis, digital image processing, storage, and many others. Unfortunately, legacy applications in these domains cannot leverage the parallelism inherent in multi-core systems without extensive remodeling and reprogramming. Despite the price/performance advantages of these systems, it is hard to accelerate and scale the performance of applications to take advantage of the additional processing power and memory.

This paper describes how Zircon Adaptive Software dramatically improves application performance on a SGI® Altix® UV 1000 platform comprising of 512-cores, 4 Terabytes (TB) of memory. Evaluation of Zircon software's capabilities has been done via a case study that parallelized two types of complex financial analytical applications. In addition to analyzing empirical results, this paper shows how Zircon Adaptive Software can leverage the multi-core parallelism and large memory of SGI Altix UV 1000 to derive efficient and scalable solutions to common problems encountered by developers while dealing with parallelization of applications within a single system image.

1. Case Studies: Financial Data Analytics on SGI® Altix® UV 1000

1.1. Scenario Analysis Application for Path Dependent Trading Strategies

This application in the case study is based on scenario analysis, which is often used in automated algorithmic trading to calibrate the parameters of a particular model. The calibration process is based on optimizing the historically simulated performance of the strategy (with standard metrics like probability, Sharpe Ratio, max drawdown, alpha, etc) as a function of unknown parameters. Although this exercise is not complex, it involves many complex analytical computations that are often path-dependent. As a result, the change of position in some underlying instrument at any given point in time is a function of the following:

- A signal from the option markets summarized by a deviation of an observed market price of an option from a theoretical option price computed using an option-pricing model for given (also observed) environmental variables and parameter values to be estimated, and

- The history of the past positions in the underlying instrument.

1.2. Heston Calibration Financial Analytics Application

This application performs an extensive option pricing model calibration exercise to gauge the size and direction of the parameter misevaluation effect on hedging portfolio performance. The original implementation processed thousands of individual Heston calibrations and took several days for the analytical computations, which was far too long for typical research and practical purposes. It is essential to have calibration results for thousands of models within minutes or even seconds for industrial applications, such as risk management, hedging, or portfolio optimization. These calibrations run numerous times, especially for larger datasets.

In this case study, a non-linear least squares technique has been used for calibration to estimate five model parameters (starting variance value, long-run mean, speed of mean-reversion, correlation between the processes and the volatility of volatility) so that the theoretical prices get close (in terms of some norm) to the observed ones. The application uses an optimization routine that minimizes a 5-dimensional objective function (one dimension for each parameter in the Heston model). The objective function is calculated as the mean squared pricing error between the observed price and the calculated price for each combination of parameters. Here, the Heston model has been calibrated using MID prices of available call options for OEX, with maturities ranging from 14 to 180 days and with moneyness (strike/stock price) in the range [80,120]. The observed prices are taken from OptionMetrics (www.optionmetrics.com), with the usual data filters applied. The options with missing implied volatility, zero bid prices, and zero open interest have been removed. The theoretical option prices are calculated using the Fourier transform technique and involve some numerical integration.

2. Benchmark Configuration

Zircon implementations of applications were run on SGI Altix UV 1000 platform, which contains 32 blades, rack-mounted system, with each blade containing 2 of the Intel® Xeon® processor 7500 series, running at 2.26 Ghz, each with eight cores (for a total of 512 cores) with hyper-threading enabled. The system contained 4 terabytes of globally addressable shared memory, with each blade containing 128GB of memory, running under a single copy of SUSE Linux Enterprise Server 11 operating system.

3. Results

3.1. Scenario Analysis Application for Path Dependent Trading Strategies

In this experiment, 1, 4, 8, 16, 32, 64, 128, 256, 512, 768 and 1024 trading strategies have been analyzed in parallel by running 1, 4, 8, 16, 32, 64, 128, 256, 512, 768 and 1024 threads, respectively, where each strategy computes theta for 1,000 time points and thus runs 1,000 iterations each. An individual iteration of theta computation runs for 104 milliseconds. The results in Figure 1 shows a 479 times speedup of this application on a 512-core SGI Altix UV 1000 system compared to a serial run and a 712 times speedup on 1024 threads.

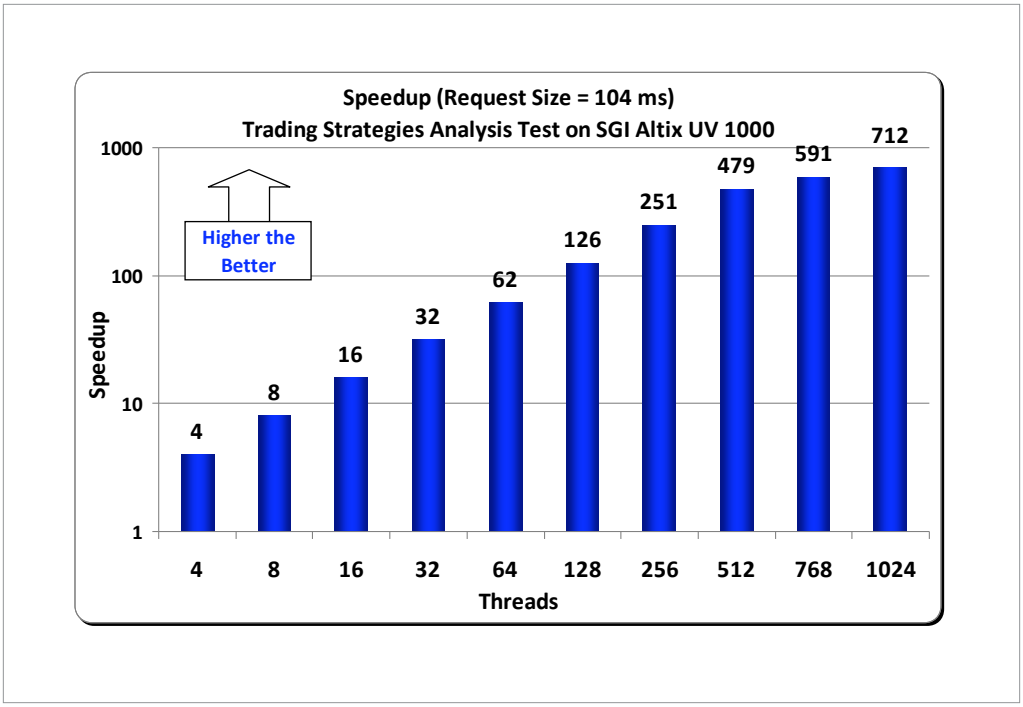

Figure 1: Speedup: Trading Strategy Analysis Application

3.2. Heston Calibration Financial Analytics Application

In this experiment, the elapsed time for several runs of the Heston Calibration Financial Analytics Application has been run by increasing the number of worker threads from 1 to 1024 on a hyper-threaded 512 core SGI Altix UV 1000 system. Figure 2 shows that the Zircon implementation of the Heston Calibration application takes 24 hours and 24 minutes to calibrate 34,400 models when run on a single core of an SGI Altix UV 1000 system. However, the application runs only in 3 mins on 512 physical cores showing a 500 times improvement and a near-linear scalability, whereas, it runs only in 2 mins 11 secs, while using 1024 threads, a further improvement of 40% due to hyperthreading.

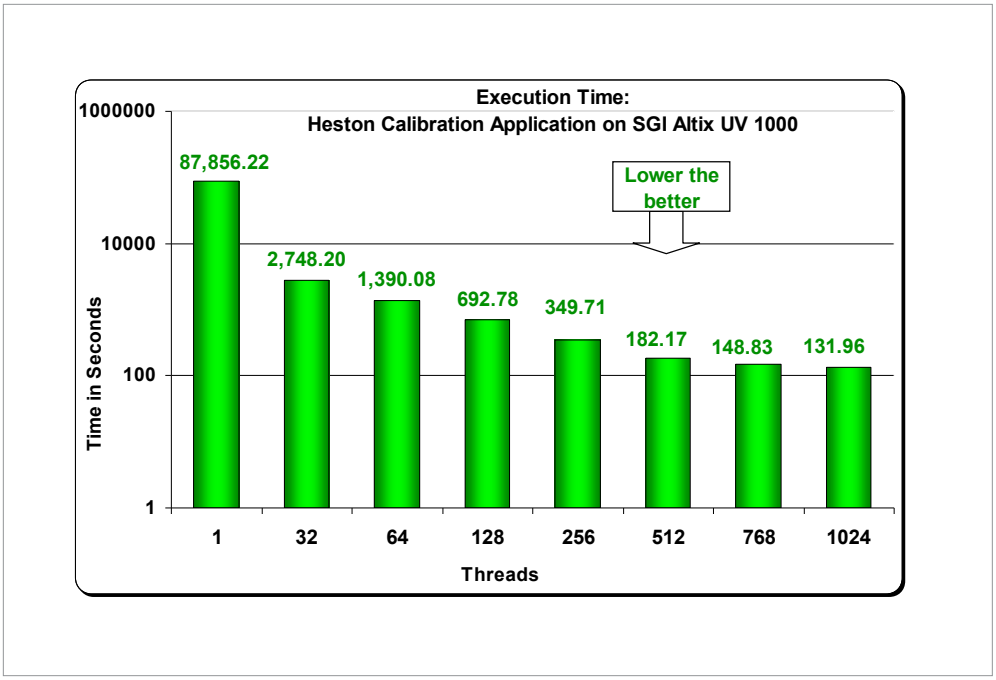

Figure 2: Elapsed Time: Heston Calibration application

4. Market Focus

The market focus for the combined solution of Zircon Adaptive Software on SGI Altix UV 1000 is as follows:

- **Financial Services**
  - Risk assessment and modeling;
  - High Frequency Trading;
  - Real Time Analytics based on algorithmic feedback.
- **Government**
  - Detecting Security Threats;
  - Analyze volatile markets;
  - Weather Forecasts.
- **Healthcare**
  - Accelerate processing of huge image files such as MRIs;
  - Complex analyses of patient diagnoses, treatments and outcomes to identify risk factors.
- **Digital Content Management**
  - Processing large graphical images (medical MRI, video animation);
  - Processing, archiving, storing and searching individual documents and content repositories for enterprise content management systems.

5. Conclusions

This paper demonstrates how the Zircon Adaptive Software can be used to leverage a massively parallel, large memory system such as SGI Altix UV 1000 with 512 cores and 4TB memory to accelerate complex data analytical applications in a near-linear scalable manner. The case studies show how Zircon implementations of applications can significantly accelerate performance of their corresponding sequential implementations on multi-core, large memory architecture of SGI Altix UV 1000. As shown in the above sections, Zircon software improved performance dramatically, with minimal learning curve and configuration/deployment effort.

The following are the advantages one can observe in developing and zEnabling applications using Zircon software on the SGI Altix UV 1000 platform:

- Zircon Adaptive Software is easy to learn and application developers are shielded from a tedious and error-prone low-level shared-memory and parallel programming exercise. Zircon software allows programmers to focus on what they do the best—focus on the business logic—and leave the complex details related to shared-memory programming to Zircon infrastructure.
- Acceleration benefits for data analytical applications using Zircon software cannot be attributed solely to the multi-core architecture of SGI Altix UV 1000 but also to its consolidated and glued architecture, its capability to combine processors and memory and to run a single image of operating system. This results in an extreme scale-up capability on SGI Altix UV 1000 for applications like Financials; Digital Content Management; Security threat and Fraud Detection, Market risk analytics by Government; as well as MRI processing and identifying patient's risk factors in the Healthcare space.
- On a flexible system like SGI Altix UV 1000, data analytics applications can be quickly parallelized with variant core-levels and memory with a predictable performance and native real-time load equalization and near-linear scalability.

Zircon Computing: Zircon Computing, LLC, is an international software and services company based in Wayne, New Jersey. Founded in 2005 by senior technologists from the financial services industry, Zircon Computing is a leading provider of ultra high-performance middleware software and services worldwide, and markets both directly to enterprise clients and through an international network of partners. Zircon Computing is privately held. For more information, please visit http://www.zircomp.com.

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