High Performance Computing (HPC) Application Frameworks in Asset-Liability and Investment Risk Management

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Abstract:

Asset-Liability and Investment Risk Management is a crucial part of any Insurance company which offers Life, Annuity, Retirement and various other financial products to individuals or to institutions to match their financial commitments. The pricing of these products and investing the premiums or fees collected in a pool of suitable assets, involves very complex mathematical models and solutions projecting over different time horizons with multiple parameters like interest rates, asset returns etc. which leads into multi-scenario analysis. This paper tries to bring out various applications, which currently use the HPC in conjunction with efficient parallel algorithms to achieve the Asset-Liability match and Investment Risk Management in a typical insurance company. The paper also attempts to identify potential use of HPC in the various insurance companies ALM (Asset-Liability Management) framework.
Annotated Bibliography


   LI hong, LU Zhong-hua, CHI Xue-bin
   Supercomputing Center – Chinese Academy of Sciences,
   Beijing, China

   2010 Ninth International Symposium on Distributed Computing and Applications to Business, Engineering and Science

   The authors in this paper high lighted the High Performance Computing (HPC) Application Development in the financial area using the parallel algorithms.

   The time line comparison of the various methods currently available in China is a focus of the paper.


   Dr. Hans Moritsch
   (PhD Thesis) Institute of Software Technology and Interactive Systems, Vienna University of Technology – May, 2006

   The author presented the pricing models in parallel computing setup to speed up the Asset price of a given instrument.

   The author also talks about the optimization techniques of portfolio in order to manage the various risks (Credit, Interest rate risk, Liquidity, Currency risk etc.)

[3]  “Accelerating the Computation of Portfolios of Tranched Credit Derivative”

   Stephen Weston, Jean-Tristan Marin, James Spooner, Oliver Pell‡ and Oskar Mencer
The authors implemented the valuation of the tranches of Collateralized Default Obligations on Maxeler accelerated systems is over 30 times faster per cubic foot and per Watt than solutions using standard multi-core Intel Xeon processors.

The paper adopted the stochastic recover model in order to achieve the CDO tranches price.

[4] “Pricing Structured Equity Products on GPUs”

A. Bernemann, R. Schreyer,

K. Spanderen - Financial Engineering Equity Markets

WestLB AG Dusseldorf, Germany

The authors implemented the Pricing and Risk analysis on GPUs rather than CPUs to get the high performance at reduced costs.

Implementation of the hybrid pricing engine running on a GPU with 4 CPU Cores and CUDA code is built on top of QuantLib with C++ interface to CUDA. Simulations based on Monte Carlo for structured equity portfolio.


Herman Lam, NSF Center for High-Performance Reconfigurable Computing (CHREC) U. of Florida, Gregg Cooke – UBS Investment Bank


The authors focus is on the principal challenges and various opportunities for HPC in finance and how HPC Reconfigurable computing makes a major impact on the accelerating in complex model valuations.
The explicit parallelism using multicore and manycore CPU and GPU processors.


The authors talk about the semiautomation of “R” code with user-added OpenMP style program.

“R” is a language widely used by statistics and finance groups which links to the input data which makes high-performance computing with R imperative.


Xiang Tian and Khaled Benkrid

ACM Transactions on Reconfigurable Technology and Systems, Vol. 3, No. 4, Article 26, Pub. date: November 2010

Author talks about the variation of Monte Carlo simulation which is Quasi-Monte Carlo or also know as low-discrepancy numbers as random samples.

The paper presents the design and implementation of a massively parallelized Quasi-Monte Carlo simulation on a FPGA based supercomputer.

The paper also compares this implementation with the GPUs and GPP based architecture.

[8] “A Bioinspired Algorithm to Price Options”

Sameer Kumar, Ruppa K. Thulasiram, Parimala Thulasiraman

2008 ACM 978-1-60558-101-9/08/05
The authors used the ACO (Ant Colony Optimization) algorithms to price the derivative product Options. The Paper also establishes the best results for long-dated options whose performance can still be improved.

[9]
“Managing a Portfolio of Overlay Paths”

Daria Antonova, Arvind Krishnamurthy, Zheng Ma, Ravi Sundaram

2004 ACM 1-58113-801-6/04/0006

The authors use a set of paths to simulate the Portfolio Return Paths with the problem to solve the resource allocation issue on multiple paths.

The problem of computing a set of paths and the relative amounts of data conveyed through them in order to provide the desired level of performance for data streams.

[10]
“Monte Carlo Methods: A Computational Pattern for Our Pattern Language.”

Jike Chong, Ekaterina Gonina, Kurt Keutzer

2010 ACM 978-1-4503-0127-5

The authors talk about the computation and the independent component with boundaries of parallelization.

The paper also talks about the Monte Carlo methods for software programming patterns and focuses on the numerical data perspectives.

[11]

Hari Subramoni, Gregory Marsh, Sundeep Narravula, Ping Lai, and Dhabaleswar K. Panda
This paper appears in: High Performance Computational Finance, 2008. WHPCF 2008. Workshop on Issue Date : 16-16 Nov. 2008 On page(s): 1 – 8

The Authors give an over view of the Advanced Message Queuing Protocol (AMQP)

The messaging is key for any financial institution involved in trading. The response time is critical and authors benchmark the time over various messaging protocols.

[12]
“High-Performance Computing on Wall Street”

Brad Spiers and Denis Wallez, Bank of America Merrill Lynch

This presentation focus on the HPC in financial service industry due to emergency of various complex products.

Talks about the Exotic Options and Derivatives, which require very high computational power for pricing due to complex mathematical models.

[13]
“The Development of Computational Technology and Its Use in Finance”

WU Qianjiao, LAN Rong

This paper appears in: Education Technology and Computer Science (ETCS), 2010 Second International Workshop on Issue Date : 6-7 March 2010 Volume : 1 On page(s): 643 - 646

Authors discuss multiple computing models on different computer architectures.

The authors show the problem of the effective financial supervision and high speed financial product pricing, were solved by Distributed and Parallel Computing.

[14]
“HEDGING BEYOND DURATION AND CONVEXITY”

Jian Chen, Michael C. Fu

The authors use of PCA analytics (Principal Component analysis) is used rather than traditional Duration, Convexity to capture the interest rate risks.

The perturbation analysis is derived by using Monte Carlo simulations.

[15] “PRICING DERIVATIVE SECURITIES IN INCOMPLETE MARKETS”

Sergey Sarykalin, Stan Uryasev


The authors proposed algorithms to price the American and European Options in incomplete market.

The authors show the numerical performance of the algorithms with options on future contracts in natural gas market.

[16] “Multithreaded Algorithms for Pricing a Class of Complex Options”


This paper appears in: Parallel and Distributed Processing Symposium., Proceedings 15th International Issue Date: Apr 2001 On page(s): 6 pp.

This paper studies the multithreaded algorithms for pricing the American Style Options.

Explained the relative complexities and their performance of the algorithms. Binomial lattice discussed.

[17] “A multistage stochastic programming algorithm suitable for parallel computing”

Jorgen Blomvall


The paper discusses and solves for the nonlinear node-separable convex objective with the algorithm proposed in the paper.
The Primal interior point method algorithm proposed in the paper was implemented on low-budget parallel computer where the author observed perfect linear speedup and very good scalability of the algorithm.

[18] “Cost vs. Performance of VaR on Accelerator Platforms”

**Mukul Majmudar , Ciprian Docan , Manish Parashar**

WHPCF ’09, November 15, 2009 Portland, Oregon, USA
2009 ACM 978-1-60558-716-5/09/11

The authors discuss the parallelization of VaR (Value at Risk) and the cost on various parallel platforms.

Accelerated Platforms like NVIDIA CUDA and IBM Cell BE, Amazon EC2 and MPI were discussed in the paper.

[19] “High-performance computing in Finance The last 10 years and the next”

**Stavros A. Zenios**

Parallel Computing, Volume 25, Issues 13-14, December 1999, Pages 2149-2175

Author discusses the past 2 decades of Computing (Supercomputers and Massive Parallel computers) which revolutionized several industries.

The author in this paper focus 3 major developments. Monte Carlo Simulations, Value at Risk (VaR) and security pricing as the main points on parallel computers.


**Xi Yang, Jacek Gondzio , Andreas Grothey**

School of Mathematics and Maxwell Institute for Mathematical Sciences
The authors discuss the Asset-Liability Model with a new strategy for controlling risk of under-funding management programs.

The basis model includes the multiperiod decisions which are also called Portfolio Rebalance and deals with usual uncertainty of Investments.