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SCIENCE DIRECT®
Future Generation Computer Systems 21 (2005) 811–821
FGCS FUTURE GENERATION COMPUTER SYSTEMS
www.elsevier.com/locate/fgcs

Monte Carlo grid for financial risk management

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Received 8 October 2004; received in revised form 3 December 2004; accepted 16 December 2004
Available online 26 February 2005

Abstract

Due to reduced profitability, increased price competition, and strengthened regulation, financial institutions in all countries are now upgrading their financial analytics based on Monte Carlo simulation. In this article, we propose three key technologies, i.e., data protection, integrity, and deadline scheduling, which are indispensable to build a secure PC-grid for financial risk management. We constructed a PC-grid by scavenging unused CPU cycles of about 50 PCs under real office environment, and obtained the 80 times speed-up, namely, for 100,000 Monte Carlo scenarios, 95 h computation on a single server is reduced to 70 min. Finally, we discuss future research directions.

Keywords: Monte Carlo methods; Financial risk management; Basel II; Value at risk (VaR); Grid computing

1. Introduction

"We are on the verge of a new era of financial computing. The arrival of ever faster desktop computers, clustering technology, and the tools to utilize spare cpu cycles from a variety of sources . . . is making techniques which were previously considered to be prohibitively computationally expensive not only feasible, but the method of choice."

Peter Jäckel [3].

In the finance sector worldwide, risk management is now emerging as major business opportunity for several reasons. One is the structural increase in bankruptcies due to the recent recession hit at several leading countries including Japan. Another reason is that the enhanced competition between financial institutions worldwide has made the risk–return tradeoff from lending worse than ever. In recent years, interest margins or spreads, especially in the wholesale loan market, have become very thin. Also from the regulation side in the banking sector, the discussions on the Basel II Accord [1,8] have just converged to the completion in June 2004. The incentive for banks to develop advanced credit risk models is implied in the final agreement of the Accord.

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doi:10.1016/j.future.2004.12.003

From the technology side, advances in information technology have given financial institutions the opportunities to construct and test cutting-edge modeling techniques, since the mid-1990s, the use of internal models for the calculation of capital requirements for trading has been allowed by US regulations for certain large banks. In line of this movement, the value at risk (VaR) becomes the de facto standard to measure financial risks. Today, in computing market risk VaR, we have three choices: variance–covariance technique, historical simulation, and Monte Carlo simulation.

Monte Carlo simulation is widely used in financial applications such as derivative pricing and risk estimation [10]. In computing credit risk, the VaR is widely employed in software such as CreditMetrics, which is now the de facto standard worldwide, VaR is also employed in in-house risk management systems at large banks. However, its adoption is constrained by the fact that it is highly computer intensive. Sharing processing capacity is a seen as a promising possibility, and grid computing is becoming one of the hottest topic in the financial services sector. This creates a tremendous opportunity for the IT industry, not only to sell distributed computing solutions or components, but also to engage customers in discussions on technology-enabled business optimization.

Several financial institutions have already used grid technologies to speed-up their Monte Carlo computation related to risk management, for example, see [2,6]. To be precise, however, these technologies are clusters of servers or PCs, that is to say, the computing resources are dedicated for these computations. The focus of this paper is on PC-grid, which consists of hundreds or thousands of PCs on ordinary office floors of financial institutions, where end users or workers typically use them for their own work such as creating reports, word-processing or communicating with each other by e-mail.

In terms of total cost of ownership (TCO) reduction, financial institutions prefer PC-grid to larger servers. The biggest problem in such an application of grid technologies is the “security” of the PC-grid because business calculation or computing almost always deals with confidential data, and they also often have deadlines for reporting to managers or executives. Furthermore, the integrity of simulation results has to be guaranteed. This paper solves this crucial problem to provide key technologies, which transform a network of underutilized PCs to a secured PC-grid. Scavenging unused computing cycles, we will show significant speedup of Monte Carlo computations on a secure PC-grid consisting of about 50 PCs connected via LAN. The result is that financial institutions can perform their risk management computations more reliably and efficiently, but at a lower cost.

2. Problem description and project objective

This project stems from the real problem at NLI Research Institute, which is one of the top research institutes in the area of financial risk management technologies in Japan. They have their own in-house software based on Monte Carlo simulations for market and credit risk management [9]. It is now under operation for their parent company Nippon Life Insurance (Nissay), one of the biggest insurance companies in the world. This software system has already been licensed to several financial institutions in Japan.

One of the biggest problems with this risk management system is the slow convergence and the computational burden of Monte Carlo simulations involved in the calculation of VaRs, Tail-VaRs, and risk contributions for measuring market and credit risks of the total asset portfolios.

Another problem is that the NLI Research Institute consists of five divisions with in total 111 high-end PCs equipped with 2.4 GHz CPU and 1 GB memory, but their processing powers are almost untapped except for the use of e-mail and word processor. We should remark that these situations are very common across many financial institutions all over the world. However, just constructing a PC-grid by connecting these office PCs is not the solution. This is due to security consideration which are not present in scientific computation in general. We need to build a PC-grid using computing resource across all divisions, and also need to send confidential data restricted to one division to the other divisions (Fig. 1).

In order to solve these problems, this project had to provide the key technologies which transform less utilized many PCs to a secure PC-grid so that financial institutions can perform their business computations more reliably, more efficiently, and at a lower cost. The three key technologies are described as follows: