Finite-Difference Methods for Option Pricing

An option is a tradable financial security whose value depends on the value of the underlying asset. The task of option pricing is to find the price of the option given the underlying asset and market conditions.

Crank-Nicolson Method

An iterative implicit-explicit method, the Crank-Nicolson method is used for solving the Black-Scholes equation. It uses the heat equation to solve the PDE using finite-difference methods.

Monte Carlo Based Value-at-Risk Analysis

With the proliferation of algorithmic trading, derivative usage and highly leveraged hedge funds, Value-at-Risk is an increasingly important metric for financial institutions.

Parallelization & Results

This research is supported in part by an Intel Ph.D. Fellowship. This research is also supported in part by Microsoft (Award #242683) and Intel (Award #248894) funding and by matching funding by U.C. Discovery (Award #DIG07-10227).

Quantitative Finance High Level Overview

Instrument Models

Market Conditions

Pricing, Value at Risk

Portfolio

Strategy

Trade

- Input Data (general parameter information)
- Algorithms/Routines
- Input Data (specific to user)

Instrument

Models

Market

Price Feed

Price

Value at Risk

Portfolio

Strategy

Trade

- Input Data (general parameter information)
- Algorithms/Routines
- Input Data (specific to user)

Parallel Computing Lab, Intel

Core Scaling

SIMD-Level
- Unroll the Gauss-Seidel iteration loop
- Reuse registers
- Efficient gather/scatter

Core-level
- Embarassingly-parallel - map one option per core

Speedup

1 Option
128 Options

Larrabee

Nehalem

Intra-day Risk Analysis

Typical four-step process in Monte Carlo simulation, each step can be customized with alternative implementations. Important computation pattern in Our Pattern Language.

Monte Carlo Based Value-at-Risk Analysis

In collaboration with Matthew Dixon, University of California, Davis

Performance optimized using a three-levels approach comprised of problem reformulation, module selection and implementation styling.

148x speedup on same platform

Potential Future Exposure Analysis

In collaboration with the Center for Innovative Financial Technologies, UC Berkeley

- Billions of instrument must be priced overnight
- Challenge lies in developing software architectures that are efficient, scalable, and maintainable
- Working with one of the top financial data provider to architect their risk analytics engine