HyPER: Pricing Platform
Bringing Flexibility to Financial Option Pricing with hybrid FPGA/CPU Systems

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Background

Monte Carlo Simulation (Classical MC)
Euler-Maruyama Discretization:

\[ \Delta S_i = S_{i-1} + \mu S_{i-1} \Delta t + \sigma S_{i-1} \Delta W_i \]

Volatility correlation:

\[ \sigma \Delta W_i = \rho \sigma \Delta W_j + \sqrt{1-\rho^2} \Delta W_k \]

Multilevel Monte Carlo
Cheap initial estimate

Classical MC Path:

- \#steps = 4
- Cost = 120
- \#paths = 30

Monte Carlo Path:

- \#steps = 64
- \#paths = 50

Showing five samples of 2 and 6 with 10^3 time steps.

Mixed Precision Multilevel
Up to now using high precision:
- 13 bit Float: single, 32 bit Float

Selecting Optimal Bits

```
13 bit Float: single 
32 bit Float: double
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Towards an automatic approach

Selected p is parameter dependent \( \Rightarrow \) req. fast method

Increase p until Variance is < 100% of original value. Evaluate 100 samples. Repeat for all levels.

Very stable and fast \( \Rightarrow \) consistent overall 2.1x speedup

Using original p, \( \Rightarrow \) same accuracy as classical Multilevel

Architecture

Static Monte Carlo Price

- Random Number Generator
- Gaussian Transformation
- MC Step Generator

FPGA

- Features
- Path Dependent
- Payoff
- Efficient for high levels, but CPU too slow for e.g. Level 0

CPU

- Path Independent
- Mean
- Option Price

Platform-Based Design Methodology

Application Space
Financial Option Pricing

HyPER Platform (HW/SW)

Reconfigurable Hybrid Systems Architecture Space

ILO Optimizer: + Optimize Speed + Under Constraints

HyPER Configuration for each level

Platform Example: Zynq ZC702 + Power Measurement

Results

Flexibility

Classical MC

- CPU
- Mixed Precision

Multilevel MC

- CPU

HyPER

- CPU

Runtime in Minutes (pricing 100 options with 120 Watt at same accuracy)

- 3.8x
- 2.8x
- 2.1x
- 1.5x

http://ems.eit.uni-kl.de/

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