GPU Acceleration of the Stochastic Grid Bundling Method

Abstract

Pricing high-dimensional early-exercise option contracts is a great challenge in terms of computational cost, especially, when the dimensionality is increased drastically. In order to make it affordable, the use of GPGPU computing can be a suitable choice. This work describes the GPU implementation of the Stochastic Bundling Grid Method for pricing Bermudan options.

Introduction

In recent years, different Monte Carlo simulation techniques for pricing high-dimensional early-exercise option contracts appearing in computational finance were developed. One of the recent Monte Carlo pricing techniques is the Stochastic Bundling Grid Method (SGBM), proposed by Jain and Oosterlee [1] for pricing Bermudan options with several underlying assets. The method is a hybrid of regression- and bundling-based bundling-based approaches, and uses regressed value functions, together with bundling of the state space to approximate continuation values at different time steps. In this work (more details in [2]), we extend the method’s applicability by increasing the number of bundles and the problem dimensionality, which, together, also imply a drastic increase of the number of Monte Carlo paths. As the method becomes much more time-consuming then, we propose to parallelize the SGBM method taking advantage of the General-Purpose computing on Graphics Processing Units (GPGPU) paradigm. For this purpose, the CUDA tool, developed by Nvidia for their GPUs, is used. In order to get a significant improvement, we also present a new bundling technique for SGBM which is much more efficient on parallel hardware.

Parallel SGBM: GPU implementation

Since the SGBM method is based on two clearly separated parts, we perform the parallelization separately. First of all, the Monte Carlo grid generation is parallelized. As is well-known, Monte Carlo methods are very suitable for parallelization, because of characteristics like a high number of simulations and data independence. In this work, we extend the method’s applicability by increasing the number of bundles and the problem dimensionality, which, together, also imply a drastic increase of the number of Monte Carlo paths. As the method becomes much more time-consuming then, we propose to parallelize the SGBM method taking advantage of the General-Purpose computing on Graphics Processing Units (GPGPU) paradigm. For this purpose, the CUDA tool, developed by Nvidia for their GPUs, is used. In order to get a significant improvement, we also present a new bundling technique for SGBM which is much more efficient on parallel hardware.

Results

In Table 1, the execution times of pricing arithmetic basket Bermudan put options with SGBM are shown. We compare the method with different bundling techniques (original and equal-partitioning) and different implementations, sequential (in C) and parallel (in CUDA). With equal-partitioning, we can exploit better the GPU parallelism reaching a speedup of around 100 times for the 50-dimensional problem.

<table>
<thead>
<tr>
<th></th>
<th>Original</th>
<th>Equal-partitioning</th>
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<tbody>
<tr>
<td></td>
<td>5d</td>
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</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>C</td>
<td>591.91</td>
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<td>CUDA</td>
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<td>Speedup</td>
<td>17.10</td>
<td>8.48</td>
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</tbody>
</table>

Conclusions

In this work, we have presented an efficient implementation of the Stochastic Grid Bundling Method on a GPU architecture. By GPU parallelism, we can speed up the execution times when the number of bundles and the dimensionality increase. In addition, we have proposed a new bundling technique which is more efficient in terms of memory usage.

Footnote:

and parallelism. These two improvements enable the use of SGBM for more involved problems, like, for example, counterparty risk and CVA computations.

References


Álvaro Leitao (ESR9) and Cornelis W. Oosterlee
DIAM
TU Delft
Mekelweg 4, 2628 CD Delft
The Netherlands
A.LeitaoRodriguez@tudelft.nl
c.w.oosterlee@cwi.nl