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Selected parallel optimization methods for financial management under uncertainty ☆

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Abstract

A review of some of the most important existing parallel solution algorithms for stochastic dynamic problems arising in financial planning is the main focus of this work. Optimization remains the most difficult, time and resource consuming part of the process of decision support for financial planning under uncertainty. However, other parts of a specialized decision support system (DSS) are also briefly outlined to provide appropriate background.

Finally, financial modeling is but one of the possible application fields of stochastic dynamic optimization. Therefore the same fairly general methods described here are also useful in many other contexts.

Authors hope that the overview of this application field may be of interest to readers concerned with development of parallel programming paradigms, methodology and tools. Therefore special care was taken to ensure that the presentation is easily understandable without much previous knowledge of theory and methods of operations research. © 2000 Published by Elsevier Science B.V. All rights reserved.

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1. Introduction

Large-scale optimization methods, especially for structured problems, such as dynamic, stochastic and stochastic dynamic problems, have long been known for their extreme requirements on computer memory and computing power. Each significant increase in available processing power, and especially the advent of parallel computers, was seen as a chance to solve new important and difficult classes of optimization problems. Yet one cannot help noticing the discrepancy between the availability of parallel computers in numerous research centers as well as commercial institutions and the availability of specialized optimization software able to utilize those vast resources.

This is not caused by the lack of appropriate parallel algorithms: those have been proliferating for more than a decade now (not to mention the parallel methods that came before the time of parallel computers). One can enumerate decomposition-based approaches like [2,14,18,24,29,31,33], data parallel algorithms [20,21,32] and even specializations of general optimization methods for solution of a structured problem, like [7,34]. Some generic parallel optimization algorithmic paradigms have also been developed a relatively long time ago (see, e.g., [8,9]). The authors believe that one of the causes for the slow development of practical parallel optimization systems is the difficulty of implementing even a conceptually simple and inherently parallel method using the parallel programming tools of today. In fact, it is immediately apparent to the reader of most of the works listed above, that a parallel implementation was only mentioned as a possible future course of research (e.g., [7]), or that some *sequential* implementation was produced and simulations of parallel execution were performed (e.g., [21,31]). Eventually, after years of hard work new publications appear in which successful truly parallel implementations are described (e.g., [1,4,13,35]). Sometimes the parallel implementations fail to materialize at all.

While parallel optimization methods are likely to be the single most important factor in the development of a parallel financial management DSS, there are even more difficult implementation issues that have to be faced when designing an application which is considerably more complex.

In the following we will use our DSS currently under development as part of the authors' on-going research [12,27], as an example of a complex application which consists of many non-trivial, possibly highly parallel components, each working on a structured set of data. The individual structures present at consecutive stages of data processing result from the different (sometimes unrelated) mathematical models and methods adopted. Each structure is best defined and operated on using a distinct collection of symbols and representations typical for the mathematical method. The transition from one form to the other can be seen as one of the major sources of difficulty of parallel implementation.

We believe that such an overview of the field may be of interest to everyone concerned with development of parallel programming paradigms, methodology and tools.

In Section 2 the financial management optimization problem will be outlined, while in Section 3 we shall provide a brief description of the structure of the DSS.