Preface

In this volume, leading representatives from major algorithmic areas of large-scale scientific computing survey their fields, with an emphasis on parallelism.

Beginning with the highly developed algorithmic foundation of linear algebra — dense and sparse, direct and iterative, inhomogeneous equation systems and eigensystems, the reader is led through algorithms more directly rooted in partial differential equations — of domain decomposition and multi-level type, then through algorithms motivated by specialized transformations of the PDEs or their corresponding integral equation forms — FFTs, multiresolution methods, and multipole methods. Techniques for working in the parallel environment — partitioning, performance debugging, and benchmarking — are the subjects of the final three chapters. In most of these areas, opportunities for parallelism have been known for some time, and substantial experience leading to existing (and forthcoming) software is described herein.

Multiresolution and multipole methods, being the newest areas of algorithmic research represented here, are less developed in parallel. These methods are challenging to parallelize since they transform PDE problems with relatively uniform data parallelism into problems with much less uniformity in the data access patterns. Unlike FFTs, but like adaptive PDE methods, multiresolution and multipole methods have data access patterns which are themselves data-dependent. They thus vastly reduce the computational complexity and storage, relative to the original formulation, at the price of more complex data structures, with which parallel algorithmicists and systems software designers will have increasingly to deal.

This book arose out of a **Workshop on Parallel Numerical Algorithms**, hosted by the Institute for Computer Applications in Science and Engineering (ICASE), and the NASA Langley Research Center, in Hampton, VA, May 23–25, 1994, and attended by approximately eighty people from academia, government laboratories, and industry. ICASE's charter mission in 1972 remains today — to explore novel computer environments (vector in the 1970's; parallel in the 1990's) for scientific computing. To quote the announcement:

> The objective of this workshop is to acquaint developers of high-performance applications codes based on partial differential equations or integral equations with the state of the art in core areas of algorithms and the parallel computational environment, and to engage representative experts from the algorithms community in discussions about their applicability. The parallel challenge in large computational fluid dynamics, computational structural mechanics, and computational electricity and magnetism problems is the implicit solution process. Hence, these applications areas meet in a common algorithmic core. However, results on model problems are often not transferable. The workshop will promote more useful development and more rapid integration of parallel algorithms in high-performance applications.

The practical focus of the workshop dictated two distinctives relative to general compendia of parallel algorithmic research: coverage of techniques more directly associated with the operators of partial differential and integral equations than with their matrix representations alone, and an emphasis on medium-granularity parallelism approachable through traditional programming languages.

The two most important criteria in the selection of speakers for the workshop were their substantial contributions to large-scale numerical computation in both the algorithmic literature and in software implementation, and their reputation for clarity of presentation. The written contributions contained herein focus on the main ideas, point to extensions, and conclude with valuable bibliographies. Several of the authors used their invitation to participate as an opportunity to undertake a unified and updated overview, which nonspecialists will appreciate. The chapters on nonsymmetric eigensolvers, multigrid, multipole, and partitioning — still rapidly developing areas algorithmically — were all completed shortly before press time. The earlier submitted chapters on generally more codified topics have been updated bibliographically at press time. The links to electronic archives in the introduction further extend the coverage of this book, in space and time.

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