The Center for Research on Parallel Computation

Perspective on Parallel Computing

This book is aimed at students and practitioners of technical computing who need to understand both the promise and practice of high performance and parallel computing. It can be used as a resource by both computer science and application researchers. The book and its associated Web site can be used in computational science and parallel computing education and training. The principal goal of this book is to make it easy for those entering the field of parallel computing with a good background in applications or computational science to understand the technologies available and how to apply them.

Over the last ten years, while the CRPC has been at the forefront of research on parallel computation, the field has matured significantly. The authors of the individual chapters each describe the field from their experiences in this time of great change. In the process, they cover key contributions from researchers both within and outside the CRPC. The book is aimed at the users of high performance systems whose architectures span the range of small desktop SMP's and PC clusters to high-end supercomputers costing $100 M or more. The book sets context within this scenario and describes the external forces from the Internet to the HPCC Presidential Initiative that have brought this to pass.

For the most part, the book focuses on software technologies and numerical algorithms, along with the large-scale applications enabled by them. In each area, the text contains a general discussion of the state of the field followed by detailed descriptions of key technologies or methods. In some cases, such as MPI for message passing, this is the dominant approach. In others, such as the discussion of problem solving environments, the authors choose systems representing key concepts in an emerging area.

The book is organized into five sections. In the first, the field is summarized starting with the national scene. This is followed by overviews of the driving application requirements and the current status of hardware architectures, software technologies, and numerical algorithms. The next three sections describe applications, software technologies, and numerical algorithms in detail. The final section discusses futures from both a technology and application perspective. There is a related Web site with a set of community resources, CRPC papers, and links to other sites of interest.

The application section is designed to help new users learn if and how high performance techniques can be applied in their area. It consists of an overview of the process by which one identifies appropriate software and algorithms and of the issues involved in implementation. Some twenty vignettes of parallel systems in different areas, which briefly describe successful approaches to use, illustrate these general comments. These examples have been chosen to cover a broad range of both scientific areas and numerical approaches. This overview material is complemented by three in-depth studies in the areas of computational fluid dynamics, environmental engineering, and astrophysical particle simulations. The applications are cross-referenced to the following sections, which cover in depth the needed software technologies and algorithms.

The computer technologies section will discuss the progress made on a variety of software technologies, including message passing libraries, run-time libraries for parallel computing such as class libraries for HPC++, languages like HPF and HPC++, performance analysis and tuning tools such as Pablo, high-level programming systems, and problem-solving environments. The goal of this section is to provide a survey of progress with hints to the user that will help in selecting the right technology for use in a given application.

The numerical algorithms section will discuss parallel numerical algorithms for a variety of problems in science and engineering including linear algebra, continuous and discrete optimization, and simulation. Each chapter will cover a different algorithmic area. The goal here is to serve as a resource for the application developer seeking good algorithms for difficult problems.

The final section of the book is a discussion of important future problems for the high performance science and engineering community, including distributed computing in a grid environment.