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Front cover: Separation of a joint direct attack munition (JDAM) from a McDonnell Douglas (now Boeing) FA-18C Hornet multi-role fighter showing the airspeed distibution. Reproduced from Figure 1.6 on page 17, for further detail see: U. Tremel, "Parallel Unstructured Adaptive Remeshing for Moving Boundary Problems", PhD Thesis, Swansea University, Wales, 2005. Back cover: Pressure distribution for the same simulation. Reproduced from Figure 1.7 on page 18, for further details see U. Tremel, *ibid.*

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Contents

Preface

This volume comprises the Invited Lectures presented at *The First International Conference on Parallel, Distributed and Grid Computing for Engineering*, held at the Pollack Mihály Faculty of Engineering, University of Pécs, Hungary, 6-8 April, 2009.

Mihály Pollack (1773-1855) was one of the most outstanding architects of Hungarian neo-classicism. He studied in Austria, spent two years in Italy and finally arrived at Budapest in 1798. He worked for several years in Pest and from 1808 was a member of the Hungarian Beautifying Committee. He planned several private and public buildings, including the Theatre and Assemby Rooms in Warsaw, and participated in the reconstruction of the cathedral in Pécs. One of his most significant designs is the Hungarian National Museum in Budapest completed during 1846. The Faculty of Engineering includes a wide range of engineering disciplines and architecture - so the faculty's name rightly commemorates the leading neo-classical architect of Central Europe from the first half of the ninteenth century: Mihály Pollack.

The University of Pécs is the successor of the first Hungarian university, established by Louis the Great in 1367. Between 1970 and 1995, the Pollack Mihály College of Engineering was a separate institute; but in 1995 it joined as an engineering college to become part of the University of Pécs. Finally, in 2004, it became the Faculty of Engineering of the University of Pécs.

Each year since 2006, the Faculty of Engineering has organised advanced courses for PhD students and researchers with an interest in High Performance Computing. In addition, High Performance Computing has been well represented in the presentations made at the International Symposiums in Engineering, held annually, in the Faculty, for young researchers and PhD students. The University is currently embarking on the construction of a new Science Building which will house a regional High Performance Computing Centre. It was therefore felt particularly appropriate to hold *The First International Conference on Parallel, Distributed and Grid Computing for Engineering* at the Pollack Mihály Faculty of Engineering. The conference also provided a perfect opportunity to discuss the theoretical and practical problems in the development of a new MSc course in *Engineering Informatics*, at the Pollack Mihály Faculty of Engineering, where one of the specialisations will be High Performance Computing in Engineering.

We would like to thank key members of the Faculty who have helped us with the realisation of this conference: Dr Bálint Bachmann (Dean of the Faculty), Dr Tibor Kukai (Vice Dean) and Dr Ella Regina Pais (Vice Dean). We are grateful for their enthusiam and encouragement of this and other aspects of the development of

engineering informatics and high performace computing in the Faculty.

The first chapter in this book was originally presented by Professor Hassan as the opening plenary lecture at the conference. It is concerned with the parallelisation of an unstructured adaptive mesh generator with a parallel computational fluid dynamics solver. It is shown how these parallel computational techniques may be used for the efficient analysis of industrial fluid-flow problems. The chapter demonstrates a moving boundary approach which adapts the boundary and permits mesh movement. These techniques enable a wide range of engineering problems such as fluid-fluid or fluid-structure interaction to be efficiently simulated.

In next two chapters the developments in processors and computer architectures are reviewed. In the first of these chapters, Professor Vinter discusses the Von Neumann bottleneck and how it may be overcome. He highlights the trade-off between bandwidth and latency; and then discusses three next generation processors and their programming. Finally he considers some applications. In Chapter 3, Professor Resch takes up the same theme, by considering trends in computer architectures. Amongst others he raises the issues of speed and scalability. These two chapters present key issues in the computer science aspects which were of interest to the conference.

The next five chapters review different aspects of grid computing. Professor Kacsuk, shows middleware and application level integration techniques for service and desktop grids in Chapter 4. He then describes his vision for the development of a World Wide Grid. In Chapter 5, Professor Gentzsch describes the use of grid and cloud portals. He demonstrates how reliable, standardised tools for managing data can be developed. In Chapter 6, Dr Dolenc provides an alternative vision of the computing environment for the Web 2.0 era including grid technology, cloud computing and software as a service. In Chapters 7 and 8, Professor Paprzycki and his colleagues discuss many aspects of the development, job scheduling and resource management of grids.

In Chapter 9, Dr Knottenbelt and his co-workers describe their recent research relating to the development of *PIPE2* a Petri net tool, which provides performance tree query design capabilities through a graphical user interface and a natural language query builder. The application of performance trees is demonstrated with respect to an on-line transaction system.

The next four chapters are concerned with parallel solution methods for engineering problems. In Chapter 10, Dr Kruis reviews the domain decomposition technique for finite element problems called the finite element tearing and interconnecting method. Next, in Chapter 11, Professor Tromeur-Devout, describes the development of the Schwarz domain decomposition method for non separable operators, where the convergence is accelerated by an Aitken process which is not based on the mesh property. In Chapter 12, Professor Jimack and his colleagues describe their recent work on the development of implicit, adaptive, multi-grid solvers for three-dimensional, non-linear and time-dependent phase-change problems that require parallel computations. In Chapter 13, Professor Gravvanis reviews a range of parallel pre-conditioned iterative methods and parallel inverse algorithms for the solution of sparse matrices generated by finite element problems.

The final eight chapters are concerned with applications of parallel, distributed and grid computing to engineering problems. First, in Chapter 14, Professor Morgan and colleagues considers large scale electromagnetic simulations; and then in Chapter 15, Dr Slone and colleagues explore the scalabilty issues relating to dynamic fluid structure interaction problems. In Chapter 16, Dr Sternel and Professor Shäfer discuss the issues relating to large scale computational fluid dynamics calculations; and in Chapter 17, Professor Chetverushkin considers the use of high performance computing in a range of industrial applications. In Chapter 18, Dr Khan and Dr Muhamad Amin decribe how monitoring and other data may be integrated within a structural analysis grid enabling the support of analysis, design and monitoring of engineering structures. In Chapter 19, Professors Boucard and Champaney present efficient strategies for fictional contact problems while in Chapter 20, Professor Yamada describes a system for the parallel distributed seismic analysis of a nuclear power plant. The final chapter by Professors Cognard and Verpeaux describes techniques for the solution of a wide class of structural non-linear problems.

The chapters of this book therefore represent the interdisciplinary nature of this research field where true progress can only be made by the interaction of computer scientists, mathematicians, engineers and scientists. We hope that the conference has acted as a further stimulus to collaboration.

We would like to take the opportunity of thanking all the authors of the chapters in this book for their co-operation and collaboration during the realisation of this book. Without their keen attention and efforts there would not have been a conference and this book would not have been published.

The contributed papers from the conference are published in: Proceedings of the First International Conference on Parallel, Distributed and Grid Computing for Engineering, B.H.V. Topping and P. Iványi, (Editors), Civil-Comp Press, Stirlingshire, Scotland, 2009.

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