Eleventh International Conference on Domain Decomposition Methods
Eleventh International Conference on Domain Decomposition Methods

Edited by CHOI-HONG LAI, PETTER E. BJØRSTAD, MARK CROSS AND OLOF WIDLUND
Contents

Preface ........................................................................................................... x

Part I: Theory ............................................................................................ 1

1 Domain Decomposition Methods for Non-Symmetric Problems
   (ACHDOU, JAPHET, LE TALLEC, NATAF, ROGIER, AND
   VIDRASCU ) ......................................................................................... 3

2 A Multigrid Method for the Complex Helmholtz Eigenvalue
   Problem (FRIESE, DEUFLHARD, AND SCHMIDT) ...................... 18

3 Optimal Convergence for Overlapping and Non-Overlapping
   Schwarz Waveform Relaxation (GANDER, HALPERN, AND
   NATAF) ............................................................................................ 27

4 Fast Integration Techniques in 3D Boundary Elements
   (GRAHAM, HACKBUSCH, AND SAUTER) ........................................ 37

5 A domain decomposition method with Lagrange multipliers for
   linear elasticity (KLAWONN AND WIDLUND) ................................. 49

6 Sparse Grid Spectral Methods and some Results from
   Approximation Theory (KUPKA) ..................................................... 57

7 On Schwarz Alternating Methods for the Incompressible
   Navier-Stokes Equations in N Dimensions (LUI) ......................... 65

8 An Iterative Substructuring Preconditioner for Collocation
   with Hermite Bicubics (MATEESCU AND RIBBENS) ............... 73

9 Preconditioning Operators for Elliptic Problems with Bad
   Parameters (NEPOMNYASHCHIK) .................................................. 82

10 Is there a curse of dimension for integration? (NOVAK) .............. 89
## CONTENTS

11 Interface Preconditioners and Multilevel Extension Operators (OSWALD) .................................................. 97

12 Robust Subspace Correction Methods for Thin Elastic Shells (OVTPHINIKOV AND XANTHIS) .......................... 105

13 V-cycle Multigrid Methods for Wilson Nonconforming Element (SHI AND XU) .............................................. 113

14 The FETI Method for Mortar Finite Elements (STEFANICA AND KLAUWN) .................................................. 121

15 Subspace Correction Methods for Convex Optimization Problems (TAI AND XU) ........................................... 130

16 Some Local and Parallel Properties of Finite Element Discretizations (XU AND ZHO) ............................... 140

### Part II: Algorithms

17 A Nonoverlapping Characteristic Domain Decomposition Method for Unsteady State Advection-Diffusion Equations (AL-LAWATIA AND WANG) .............................................. 151

18 An Explicit Multi-Model Compressible Flow Formulation Based on the Full Potential Equation and the Euler Equations on 3D Unstructured Meshes (CAI, PARASCHIVOIU, AND SARKIS) 159

19 Overlapping Schwarz Methods for Helmholtz's Equation (CASARIN AND WIDLUND) .................................... 178

20 Multilevel Spectral Partitioning of Unstructured Grids (CHAN, GO, AND ZOU) .............................................. 190

21 Quasi-Simultaneous Coupling for Wing and Aerofoil Flow (COENEN) ......................................................... 197

22 Domain Decomposition Methods for a System of Coupled Acoustic and Elastic Helmholtz Equations (CUMMINGS AND FENG) ........................................................................... 206

23 On the convergence of the generalized asynchronous multisplitting block two-stage relaxation methods for the large sparse systems of mildly nonlinear equations (EVANS AND BAI) ... 214

24 Domain Decomposition Capabilities for the Mortar Finite Volume Element Methods (EWING, LAZAROV, T. LIN, AND Y. LIN) ............................................................... 223
CONTENTS

25 FETI-H: a scalable domain decomposition method for high frequency exterior Helmholtz problems (FARHAT, MACEDO, AND TEZEAUR) .................................................. 231

26 Domain Decomposition with Local Fourier Bases applied to Frontal Polymerisation problems (GARBEY AND TROMEUR-DERVOUT) .................................................. 242

27 Lower Dimensional Interpolation in Overlapping Composite Mesh Difference Methods (GOOSSENS AND CAI) ........ 251

28 Domain Decomposition for Indefinite Weakly Singular Integral Equations (HEUER) .................................................. 260

29 Numerical Simulation of Wave Propagation Phenomena in Vocal Tract and Domain Decomposition Method (KAKO AND KANO) .................................................. 268

30 Optimal Shape of Pine for Sound Absorption in Water (KAWARADA AND SUITO) .................................................. 274

31 How Scalable is Domain Decomposition in Practice? (KEYES) 286

32 A non-overlapping DDM of Robin-Robin type for parabolic problems (LUBE, MÜLLER, AND OTTO) .................................................. 298

33 Communication Latency Hiding in a Parallel Conjugate Gradient Method (MCMANUS, JOHNSON, AND CROSS) 306

34 Implementational Aspects of Prewavelet Sparse Grid Methods (NIEDERMEIER AND ZIMMER) .................................................. 314

35 Comparison of three algorithms for nonlinear metal cutting problems (PALANSURIYA, LAI, IEROTHEOUS, PERICLEOUS, AND KEYES) .................................................. 322

36 Domain Decomposition Methods for the Steady Stokes Equations (RÖNQUIST) .................................................. 330

37 Domain Decomposition Methods for Parabolic Problems (SAMARSKII AND VABISHCHEVICH) .................................................. 341

38 An Asynchronous Space Decomposition Method (TAI AND TSENG) .................................................. 348

39 Viscous-Inviscid Interaction: Domain Decomposition Avant la Lettre (VELDMAN AND LAI) .................................................. 359
Part III: Applications

40 Domain decomposition for flow in porous media with fractures (ALBOIN, JAFFRÉ, ROBERTS, AND SERRES) ........................................ 371

41 Dynamic Load Balancing for Multi-Physical Modelling using Unstructured Meshes (ARAVINTHAN, JOHNSON, MCMANUS, WALSHAW, AND CROSS) ............................................................. 380

42 Domain Decomposition in High-Level Parallelization of PDE Codes (CAI) .................................................................................... 388

43 An overview on current multiphysics software strategies for coupled applications with interacting physics on parallel and distributed computers (CHOW AND ADDISON) ................................................. 396

44 A single-code software model for Multiphysics analysis-engine on parallel and distributed computers with the PHYSICA toolkit (CHOW, BAILEY, MCMANUS, ADDISON, AND CROSS) .............................................................. 402

45 Adaptive Multilevel FEM as Decisive Tools in the Clinical Cancer Therapy Hyperthermia (DEUFLHARD AND SEEBAESS) ....... 410

46 Sound Generation by Vortex-Blade Interactions (DJAMBAZOV, LAI, AND PERICLEOUS) ............................................................... 422

47 Analysis of Substructuring in a Metal Forming Process (MÜLLER AND ADAMIDIS) ................................................................. 430

48 The Parallel Solution of Early-exercise Asian Options with Stochastic Volatility (PARROTT AND CLARKE) ................................... 439

49 Efficient Mesh Partitioning For Adaptive HP Finite Element Meshes (PATRA AND KIM) ................................................................. 447

50 A FETI Solver for Corotational Nonlinear Problems (PIERSON AND LESOINNE) ................................................................. 456

51 Parallel Solution of General Sparse Linear Systems using PSPARSLIB (SAAD, KUZNETSOV, AND LO) ........................................ 464

52 Parallel Solvers for the Two-Group Neutron Diffusion Equations of Reactor Kinetics (SHEICHL) ...................................................... 476

53 Remarks on the implementation of the Generalized Neumann-Neumann algorithm (VIDRASCU) ...................................................... 484
Part IV: Student Papers 503

54 Scalability and load imbalance for domain decomposition based transport (WILDERS) ........................................ 494

55 Parallel implementation of the Spectral Element Method with Nonconforming Mesh (FENG AND MAVRIPLIS) .............. 505

56 NKS Methods for Compressible and Incompressible Flows on Unstructured Grids (KAUSHIK, KEYES, AND SMITH) .... 513

57 Block preconditioners for nonsymmetric saddle point problems (KRZYŻANOWSKI) .............................................. 521

58 Ordering techniques for convection dominated problems on unstructured three-dimensional grids (LE BORNE) .............. 529

59 Domain decomposition and parallel processing in microwave applicator design. (MALAN AND METAXAS) .................. 537

60 On the Choice of Krylov Methods and Preconditioners for a Domain Decomposed Iterative Solution of the Exterior Helmholtz Problem (PUPPÍN MACEDO) .......................... 543

61 Overlapping Methods with Perfectly Matched Layers for the Solution of the Helmholtz Equation (TOSELLI) .................. 551

62 Parallel multi-grid for turbulent reacting flow simulations (TWERDA, VERWEIJ, PEETERS, AND BAKKER) .............. 558

63 Parallel Domain Decomposition for Reaction-Diffusion Problems (VOLFOVSKY AND BERCOVIER) ........................ 568

64 FETI domain decomposition algorithms for sensitivity analysis in contact shape optimization (VÍT VONDRAK, ZDENĚ K DOSTÁL, AND RASMUSSEN) ........................................ 576
Preface

This volume represents the Proceedings of the Eleventh International Conference on Domain Decomposition Methods for Science and Engineering held at the University of Greenwich - Avery Hill Campus, July 20th - 24th, 1998.

This almost annual conference series has now become a major event in Applied Mathematics and Computational Science. At this 11th Conference, there were two to three parallel sessions being run daily and a total of six mini-symposia addressing various aspects of this subject involving both theory and applications. There were also sixteen invited presentations delivered by internationally well known scientists. Some of these invited presentations are included in this volume.

A new feature at this Conference was a Graduate Student Paper Competition. There were thirteen graduate student papers at the final competition being heard by the entire conference and examined by the Judging Committee which consisted of M Cross, I G Graham, J E Roberts, O Widlund and J Xu. Prizes were offered covering international return flights to attend the Conference.

In addition to the invited and student presentations, there were a total 102 mini-symposium and contributed talks. Many presentations represented an interdisciplinary view of the subject with papers ranging from the use of advanced computer architectures to the development of related software tools, from the theoretical formulation to the design of robust algorithms and from engineering to medical science applications.

The participants who have their papers presented at the Conference were invited to submit their manuscripts for the Proceedings. All submitted manuscripts have gone through a reviewing process. Keynote speakers were invited to submit manuscripts of 12 pages for each article. Speakers for contributed sessions and mini-symposia were invited to submit manuscripts of 8 pages for each article. We believe that the traditional partitioning of the Proceedings into Theory, Algorithms, and Applications still works well for the present volume. We have also included a new section with Student Papers. Papers in each section are alphabetically ordered as according to the first author in the author list of each paper.

The Conference was organised by M Cross (Greenwich), K Chen (Liverpool), A Craig (Durham), M G Everett (Greenwich), I G Graham (Bath), C - H Lai (Greenwich), and K A Pericleous (Greenwich) with the help from the three European Affair Advisors, P Deuflhard (ZIB - Berlin), J Periaux (Dassault), and J E Roberts (INRIA). The technical direction of the Conference was provided by the Scientific Committee which consisting of P E Bjørstad, J H Bramble, T F Chan, P Deuflhard,
R Glowinski, R Hoppe, H Kawarada, D E Keyes, Yu Kuznetsov, J Periaux, O Pironneau, Z - C Shi, O Widlund, and J Xu. The Conference received support from the Engineering and Physical Sciences Research Council (UK), the American Pacific Technology Group (Hong Kong), and the University of Greenwich.

We wish to thank the Conference Secretary, Mrs F Barkshire, for her enormous hard work towards the success of the Conference. We are also grateful to the organisers of the mini-symposia for attracting high quality presentations. Timely production of these Proceedings has only been possible through the cooperation of the authors and numerous referees. The editors wish to thank the effort of all referees and the quick response from the contributors to the editors regarding comments and modifications of their manuscripts.

The web page http://dd11.gre.ac.uk contains the complete programme of the Conference and an electronic version of these Proceedings. The Official Domain Decomposition Web site is http://www.ddm.org, from which further details for future conferences, previous conference proceedings, and the present proceedings may be obtained.

Choi-Hong Lai  
Greenwich, UK

Petter Bjarstad  
Bergen, Norway

Mark Cross  
Greenwich, UK

Olof Widlund  
New York, USA