Preface

Domain decomposition, a form of divide-and-conquer for mathematical problems posed over a physical domain, as in partial differential equations, is the most common paradigm for large-scale simulation on massively parallel distributed, hierarchical memory computers. In domain decomposition, a large problem is reduced to a collection of (typically many) smaller problems, each of which is easier to solve computationally than the un-decomposed problem, and most or all of which can be solved independently and concurrently. Typically, it is necessary to iterate over the collection of smaller problems, and much of the theoretical interest in domain decomposition algorithms lies in ensuring that the number of iterations required is very small. Indeed, the best domain decomposition methods share with their cousins, multigrid methods, the property that the total computational work is linearly proportional to the size of the input data, or that the number of iterations required is at most logarithmic in the number of degrees of freedom of individual subdomains. Algorithms whose work requirements are linear in the size of the input data in this context are said to be "optimal". Optimal domain decomposition algorithms are now known for many, but certainly not all, important classes of problems that arise science and engineering. Much of the practical interest in domain decomposition algorithms lies in extending the classes of problems for which optimal algorithms are known. Domain decomposition algorithms can be tailored to the properties of the physical system as reflected in the mathematical operators, the number of processors available, and even to specific architectural parameters, such as cache size and the ratio of memory bandwidth to floating point processing rate.

Since the first meeting was held in Paris in 1987, the International Conference on Domain Decomposition Methods is the only regularly occurring international forum dedicated to interdisciplinary technical interactions between theoreticians and practitioners working in the creation, analysis, software implementation, and application of domain decomposition methods. The conferences have now been held in twelve countries in the Far East, Europe, the Middle East, and North America. To date, there are essentially no real alternatives to domain decomposition as a strategy for parallelization on petascale computers and beyond, with hundreds of thousands or even millions of processor cores. Domain decomposition has proved to be an ideal paradigm not only for execution on advanced architecture computers, but also for the development of reusable, portable software. The most complex operation in a typical domain decomposition method is the application of a preconditioner that carries out in each subdomain steps nearly identical to those required to apply a conventional preconditioner to the global domain. Hence software developed for the global problem can readily be adapted to the local problem, instantly presenting wealth of "legacy" scientific code to be harvested for parallel implementations. Furthermore, since the majority of data sharing between subdomains in domain decomposition codes occurs in two archetypal communication operations – ghost point updates in overlapping zones between neighboring subdomains, and global reduction operations, as in forming an inner product – domain decomposition methods map readily onto optimized, standardized message-passing environments, such as MPI. Finally, it should be noted that domain decomposition is often a natural paradigm for the modeling community. Physical systems are often decomposed into two or more contiguous subdomains based on phenomenological considerations, such as the importance or negligibility of viscosity or reactivity, or any other feature, and the subdomains are discretized accordingly, as independent tasks. This physically-based domain decomposition may be mirrored in the software engineering of the corresponding code,and leads to threads of execution that operate on contiguous subdomain blocks, which can either be further subdivided or aggregated to the granularity of an available parallel computer, and have the correct topological and mathematical characteristics for scalability. Much of the reputation of this conference series results from the close interaction between experts in mathematics, computer science, and large scale computational science in various application areas.

The present volume contains a selection of 83 papers presented at the 20th International Conference on Domain Decomposition, DD20, hosted by the Center for Computational Mathematics at the University of California at San Diego, held at the San Diego Supercomputer Center on the UCSD campus during the week of February 9–13, 2011. The conference featured 16 plenary lectures delivered by leaders in the field, 18 minisymposiums, as well as contributed talks and a poster session. In addition, Olof Widlund gave an introductory short course on Domain Decomposition on Sunday February 8 to a packed room of more than forty participants in the Center for Computational Mathematics, a short walk from the San Diego Supercomputer Center. Attending the regular conference during the week were 199 scientists from 21 countries, giving a total of 173 presentations, which accentuates the international scope and relevance of this meeting. To add a unique local flavor to the UCSD meeting, three special plenary talks were scheduled for Tuesday, given by world-renowned local UCSD computational scientists in fields spanning computational chemistry to galaxy collision simulation. In addition to the scientific talks during the day throughout the week, participants gathered for a poster session with wine and cheese in the early evening on Monday, and the plenary speakers gathered for a small dinner in Del Mar on Tuesday evening. The Scientific Committee met with the local organizing committee and discussed plans for the next conference in the series on Wednesday evening, aided by samplings from local San Diego micro-breweries.

The large conference banquet for all the participants was held in the UCSD Faculty Club on Thursday evening, and the conference came to a close at noon on Friday.

For further information, we recommend the homepage of International Domain Decomposition Conferences, www.ddm.org, maintained by Martin Gander. This site features free online access to the proceedings of all previous DD conferences, information about past and future meetings, as well as bibliographic and personal information pertaining to domain decomposition. A bibliography with all previous proceedings is provided below, along with some major review articles es and monographs. (We apologize for unintentional omissions to our necessarily incomplete list.) No attempts have been made to supplement this list with the larger and closely related literature of multigrid and general iterative methods, except for the books by Hackbusch and Saad, which have significant domain decomposition components.

The editors wish to thank all members of the International Scientific Committee for Domain Decomposition Conferences, chaired by Ralf Kornhuber, for their help in setting the scientific direction of this conference. We are also grateful to the organizers of the minisymposia for shaping the profile of the scientific program and attracting high-quality presentations. The local organizers were Randolph Bank and Michael Holst, aided by Rob Falgout, David Keyes, Rich Lehoucq, and Jinchao Xu. We gratefully acknowledge administrative assistance from the San Diego Computer Center (SDSC) and the California Institute for Telecommunications and Information Technology (CalIT2).

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Randolph E. Bank
University of California, San Diego, USA

Michael J. Holst
University of California, San Diego, USA

Olof B. Widlund
Courant Institute, New York, USA

Jinchao Xu
Pennsylvania State University, USA

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Contents

Part III Contributed Presentations