DIMACS
Series in Discrete Mathematics and Theoretical Computer Science

Volume 16

Quadratic Assignment and Related Problems

DIMACS Workshop
May 20–21, 1993

Panos M. Pardalos
Henry Wolkowicz
Editors

American Mathematical Society

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Foreword

This DIMACS volume on Quadratic Assignment and Related Problems contains refereed versions of papers from a workshop held at DIMACS May 20–21, 1993. The workshop was sponsored by DIMACS, through grants from the National Science Foundation and the New Jersey Commission on Science and Technology.

We especially thank the workshop organizers, Panos Pardalos and Henry Wolkowicz, for organizing the workshop, which brought together so many outstanding participants in this field.

Diane L. Souvaine, Acting Director, DIMACS
Robert Tarjan, Co-Director, DIMACS
Michael Saks, Associate Director, DIMACS

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Preface

In the last decade we have seen a dramatic increase in the size of NP-hard combinatorial optimization problems that can be solved in practice. This is due to advances in data structures, new algorithmic developments and major advances in computer hardware. It is not unusual today to solve large-scale combinatorial problems, such as maximum clique problems on graphs with thousands of vertices and millions of edges, or traveling salesman problems with several thousands of cities. There is an exception in the class of combinatorial optimization problems, the quadratic assignment problem (QAP), which is still considered to be of large-scale when $n > 20$, where n is the problem dimension.

Given a set $\mathcal{N} = \{1, 2, \ldots, n\}$ and $n \times n$ matrices $F = (f_{ij})$ and $D = (d_{kl})$, the quadratic assignment problem (QAP) can be stated as follows:

$$\min_{p \in \Pi_{\mathcal{N}}} \sum_{i=1}^{n} \sum_{j=1}^{n} f_{ij} d_{p(i)p(j)},$$

where $\Pi_{\mathcal{N}}$ is the set of all permutations of $\mathcal{N}$. One of the major applications of the QAP is in location theory where the matrix $F = (f_{ij})$ is the flow matrix, i.e. f_{ij} is the flow of materials from facility i to facility j, and $D = (d_{kl})$ is the distance matrix, i.e. d_{kl} represents the distance from location k to location l. The cost of simultaneously assigning facility i to location k and facility j to location l is $f_{ij} d_{kl}$. The objective is to find an assignment of all facilities to all locations (i.e. a permutation $p \in \Pi_{\mathcal{N}}$), such that the total cost of the assignment is minimized. With an appropriate choice of the flow matrix, the traveling salesman problem is a special class of QAP. Other applications include scheduling, manufacturing, the backboard wiring problem in electronics, parallel and distributed computing, and statistical data analysis. The term "quadratic" comes from the reformulation of the problem as an optimization problem with a quadratic objective function.

From the computational complexity point of view the QAP is one of the most difficult problems to solve, as it is in the class of NP-hard problems. Currently, solving general problems of size $n > 20$ is still considered intractable. This problem continues to be very interesting and stimulating both from computational and theoretical points of view.

On May 20–21, 1993, a workshop on "Quadratic Assignment and Related Problems", hosted by the Center for Discrete Mathematics and Theoretical Computer Science (organized by P. M. Pardalos and H. Wolkowicz), was held at Rutgers University. Participants from different countries gave the meeting an international component. The workshop was a success because it fostered many interactions between researchers from academia and industry. The editors also hope that this volume will lead to continuing developments in the important area of nonlinear assignment problems.

The workshop on QAP focussed on recent computational approaches and applications. About twenty invited speakers presented results on new techniques and applications. The techniques included eigenvalue estimates and reduction techniques for lower bounds, parallelization, genetic algorithms, polyhedral approaches, greedy and adaptive search algorithms. The applications included graph bandwidth problems, telecommunications network design, load balancing, VLSI design, data association problems, and multidimensional assignment problems. This volume comprises a collection of research papers invited for presentation at the workshop.

We are indebted to DIMACS for their help in organizing the workshop and in arranging the publication of the proceedings. We would also like to take this opportunity to thank the participants of the workshop, the authors, the anonymous referees, and the American Mathematical Society for helping us produce this volume.

Panos M. Pardalos and Henry Wolkowicz

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