Preface

Optimization has become a versatile tool in a wide array of application areas, ranging from manufacturing and information technology to the social sciences. Methods for solving optimization problems are equally numerous and provide a large reservoir of problem-solving technology. In fact, there is such a variety of methods that it is difficult to take full advantage of them. They are described in different technical languages and are implemented in different software packages. Many are not implemented at all. It is hard to tell which one is best for a given problem, and there is too seldom an opportunity to combine techniques that have complementary strengths.

The ideal would be to bring these methods under one roof, so that they and their combinations are all available to solve a problem. As it turns out, many of them share, at some level, a common problem-solving strategy. This opens the door to integration—to the design of a modeling and algorithmic framework within which different techniques can work together in a principled way.

This book undertakes such a project. It deals primarily with the unification of mathematical programming and constraint programming, since this has been the focus of most recent research on integrated methods. Mathematical programming brings to the table its sophisticated relaxation techniques and concepts of duality. Constraint programming contributes its inference and propagation methods, along with a powerful modeling approach. It is possible to have all of these advantages at once, rather than being forced to choose between them. Continuous global optimization and heuristic methods can also be brought into the framework.

The book is intended for those who wish to learn about optimization from an integrated point of view, including researchers, software developers, and practitioners. It is also for postgraduate students interested in a unified treatment of the field. It is written as an advanced textbook, with exercises, that develops optimization concepts from the ground up. It takes an interdisciplinary approach that presupposes mathematical sophistication but no specific knowledge of either mathematical programming or constraint programming.

The choice of topics is guided by what is relevant to understanding the principles behind popular linear, mixed integer, and constraint programming solvers—and more importantly, integrated solvers of the present and foreseeable future. On the mathematical programming side, it presents the basic theory of linear and integer programming, cutting planes, Lagrangean and other types of duality, mixed integer modeling, and polyhedral relaxations for a wide range of combinatorial constraints. On the constraint programming side it discusses constraint propagation, domain filtering, consistency, global constraints, and modeling techniques. The material ranges from the classical to the very recent, with some results presented here for the first time.

The ideas are tied together by a search-infer-and-relax algorithmic framework, an underlying theory of inference and relaxation duality, and the use of metaconstraints (a generalization of global constraints) for modeling.

The first edition of the book was published only four years ago, but the field has moved ahead. This second edition expands, reorganizes, and updates the earlier edition in several ways. The examples that began the first book now occupy a separate chapter, followed by two new chapters. A chapter on optimization basics makes the book more nearly self-contained. A second new chapter on duality presents a stronger case for its centrality and provides conceptual background for the search chapter that follows, which is much expanded. The chapter on inference covers additional global constraints, and the dictionary of metaconstraints in the final chapter has been enlarged. The material throughout has been updated and elaborated where appropriate, resulting in some 170 new references.

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