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Spanning Trees and Optimization Problems

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Preface

The research on spanning trees has been one of the most important areas in algorithm design. People who are interested in algorithms will find this book informing and inspiring. The new results are still accumulating, and we try to make it clear the whole picture of the current status and future developments.

This book is written for graduate or advanced undergraduate students in computer science, electrical engineering, industrial engineering, and mathematics. It is also a good reference for professionals.

Our motivations for writing up this book:

1. To the best of our knowledge, there is no book totally dedicated to the topics of spanning trees.

2. Our recent progress in spanning trees reveals a new line of investigation.

3. Designing approximation algorithms for spanning tree problems have become an exciting and important field in theoretical computer science.

4. Besides numerous network design applications, spanning trees have also been playing important roles in newly established research areas, such as biological sequence alignments, and evolutionary tree construction.

This book is a general, and rigorous text on algorithms for spanning trees. It covers the full spectrum of spanning tree algorithms from classical computer science to modern applications. The selected topics in this book makes it an excellent handbook on algorithms for spanning trees. At the end of every chapter, we report related work and recent progress.

We first explain general properties of spanning trees. We then focus on three categories of spanning trees, namely, minimum spanning trees, shortest-paths trees, and optimum routing cost spanning trees. We also show how to balance the tree costs. Besides the theoretical description of the methods, many examples are used to illustrate the ideas behind. Moreover, we demonstrate some applications of these spanning trees. We explore in details some other interesting spanning trees, including maximum leaf spanning trees and minimum diameter spanning trees. In addition, Steiner trees and evolutionary trees are also discussed. We close this book by summarizing other important problems related to spanning trees.

Writing a book is not as easy as we thought at the very beginning of this project. We have tried our best to make it consistent and correct. However, it's a mission impossible for imperfect authors to produce a perfect book.

Should you find any mathematical, historical, or typographical errors, please kindly let us know.

We are extremely grateful to our mentor Chuan Yi Tang, who always makes the subject of algorithms exciting and beautiful in his superb lectures. His guidance and suggestions throughout this study were indispensable. We also thank our colleagues in the weekly theory-group seminar hosted by Richard Chia-Tung Lee and Chuan Yi Tang.

We thank Vineet Bafna, Giuseppe Lancia, and R. Ravi for their collaborations on the minimum routing cost spanning tree problem. We thank Tao Jiang and Howard Karloff for suggesting the merger of two different works at the early stage of our investigation. We thank the anonymous reviewers for their valuable comments.

It has been a pleasure working with CRC Press in the development of this book. We are very proud to have this book included in the CRC series on Discrete Mathematics and its Applications edited by Kenneth H. Rosen. Ken also provided critical reviews and invaluable information for which we are grateful. We thank Sunil Nair for his final approval of our proposal. Richard O'Hanley was the first to inform us to think about the possibility of publishing a book at CRC Press. Robert B. Stern then handled the proposal review and contract arrangements in a perfect and efficient way. Bob also proposed many constructive suggestions throughout the project. Jamie B. Sigal helped us with both production and permissions issues, and his gentle reminders kept us moving on in a right pace.

Finally, we thank our families for their love, patience, and encouragement. We thank our wives — Mei-Ling Cheng and Pei-Ju Tsai, and our sons — Ming-Hsuan Wu and Leo Liang Chao for tolerating our absent-mindedness during the writing of this book. We promise to work less than 168 hours a week by not taking on a new grand project immediately.

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Symbol Description

Z^+	the set of all positive integers
Z_0^+	the set of all nonnegative integers
$\|S\|$	the cardinality of a set S
$G = (V, E, w)$	a graph G with vertex set V, edge set E, and edge weight function $w : E \rightarrow Z_0^+$
$V(G)$	the vertex set of graph G
$E(G)$	the edge set of graph G
$w(G)$	the total length of edges in $E(G)$, i.e., $\sum_{e \in E(G)} w(e)$
$SP_G(u, v)$	a shortest path between vertices u and v on graph G
$d_G(u, v)$	the distance (shortest path length) between u and v on G, i.e., $w(SP_G(u, v))$
$d_G(v, U)$	the minimum distance from vertex v to any vertex in U, i.e., $\min_{u \in U}\{d_G(v, u)\}$
$\bar{G}$	the metric closure of a graph G
$D_G(v, U)$	the maximum distance from vertex v to any vertex in U, i.e., $\max_{u \in U}\{d_G(v, u)\}$
$G - e$	the graph obtained by removing edge e from G
$G + e$	the graph obtained by inserting edge e into G
$G \backslash e$	the resulting graph after contracting e in G
$parent(v)$	the parent of a vertex v in a rooted tree
n	the number of vertices of the input graph
m	the number of edges of the input graph