PETER C. BRILLINGER
DORON J. COHEN

Introduction to Data Structures and Non-Numeric Computation

PRENTICE-HALL SERIES IN AUTOMATIC COMPUTATION

INTRODUCTION TO DATA STRUCTURES AND NON-NUMERIC COMPUTATION

Featuring the WATFOR and WATFIV Compilers

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To Cathy and Rina

PREFACE

This textbook contains material for an intermediate course on Data Structures and Applications in Computer Science. It assumes a basic knowledge of computer programming, with an emphasis on the FORTRAN language as it is implemented with the WATFOR and WATFIV compilers.

The book provides a comprehensive discussion of data representations and data structures, followed by a detailed study of operations and applications with character strings, linearly linked lists, graphs, and trees. Included is a consideration of algorithms for traversing trees and implementing recursive routines with the use of push-down stacks. This in-depth study of techniques takes the mystery out of list processing by teaching the basic methods usually used by high-level list processing languages. The book concludes with an elementary discussion of programming language translation, covering syntactic analysis, object code generation, and macro processors.

We have addressed this book not only to students at educational institutions but also to industry-oriented programming personnel. Emphasizing techniques and mechanics rather than theory, the book teaches methods and internal representations. Although

FORTRAN was not originally designed for non-numerical programming, many programmers have nonetheless found it a comfortable language for doing so. The book treats this subject in a formal and rigorous manner. To our knowledge, this approach is relatively novel and has not been adopted in previous textbooks.

The FORTRAN language is utilized only as a convenient tool for illustrating the techniques and procedures that are usually implemented in machine language. By using FORTRAN as if it were the actual machine language, the book simplifies the explanation and removes the need for unnecessary details that usually make such techniques difficult to teach or comprehend. The reader, once exposed to the basic concepts and ideas, can proceed to transfer them to other programming languages.

This textbook is the fifth edition of a set of notes originally written by Doron J. Cohen and based on his experience in teaching courses in Non-Numerical Applications in Computer Science at the University of Waterloo during the years 1968 - 1972. During this period, these notes were used at several universities as a sequel to the text FORTRAN IV WITH WATFOR AND WATFIV (written by P. Cress, P. Dirksen, and J.W. Graham, and published by Prentice-Hall).

We are very indebted to Donald F. Weir of the University of Waterloo for his numerous suggestions and invaluable assistance in proof-reading various versions of the manuscript, testing examples on the computer, preparing rough drafts of

exercises, and constructing the index. We are also grateful to H. Boom of the University of Alberta for his contributions to the earlier versions of the notes. Finally, we would like to express our sincere thanks to Mrs. Susan Hopkins for her excellent typing of the manuscript.

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INTRODUCTION TO DATA STRUCTURES AND NON-NUMERIC COMPUTATION

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