

NICKLAUS WIRTH

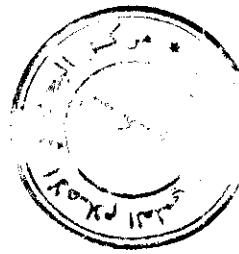
Algorithms +  
Data  
Structures =  
Programs

PRENTICE-HALL  
SERIES IN  
AUTOMATIC  
COMPUTATION

BIBLIOTHEQUE DU CERIST

BIBLIOTHEQUE DU CERIST

C 1548



**ALGORITHMS +**

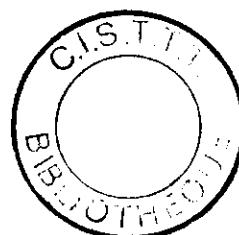
**DATA STRUCTURES =**

**PROGRAMS**

**NIKLAUS WIRTH**

*Eidgenossische Technische Hochschule  
Zurich, Switzerland*

BIBLIOTHEQUE DU CERIST



**PRENTICE-HALL, INC.**

ENGLEWOOD CLIFFS, N.J.

BIBLIOTHEQUE DU CERIST

## CONTENTS

PREFACE x

DECLARATION xv

### 1 FUNDAMENTAL DATA STRUCTURES 1

- 1.1 Introduction 1
- 1.2 The Concept of Data Type 4
- 1.3 Primitive Data Types 6
- 1.4 Standard Primitive Types 8
- 1.5 Subrange Types 10
- 1.6 The Array Structure 11
- 1.7 The Record Structure 16
- 1.8 Variants of Record Structures 20
- 1.9 The Set Structure 23
- 1.10 Representation of Array, Record, and Set Structures 29
  - 1.10.1 Representation of Arrays* 30
  - 1.10.2 Representation of Record Structures* 32
  - 1.10.3 Representation of Sets* 33
- 1.11 The Sequential File Structure 34
  - 1.11.1 Elementary File Operators* 37
  - 1.11.2 Files with Substructure* 39
  - 1.11.3 Texts* 41
  - 1.11.4 A File Editing Program* 49

## **2** SORTING 56

- 2.1 Introduction 56
- 2.2 Sorting Arrays 59
  - 2.2.1 *Sorting by Straight Insertion* 60
  - 2.2.2 *Sorting by Straight Selection* 63
  - 2.2.3 *Sorting by Straight Exchange* 65
  - 2.2.4 *Insertion Sort by Diminishing Increment* 68
  - 2.2.5 *Tree Sort* 70
  - 2.2.6 *Partition Sort* 76
  - 2.2.7 *Finding the Median* 82
  - 2.2.8 *A Comparison of Array Sorting Methods* 84
- 2.3 Sorting Sequential Files 87
  - 2.3.1 *Straight Merging* 87
  - 2.3.2 *Natural Merging* 92
  - 2.3.3 *Balanced Multiway Merging* 99
  - 2.3.4 *Polyphase Sort* 104
  - 2.3.5 *Distribution of Initial Runs* 116

## **3** RECURSIVE ALGORITHMS 125

- 3.1 Introduction 125
- 3.2 When Not to Use Recursion 127
- 3.3 Two Examples of Recursive Programs 130
- 3.4 Backtracking Algorithms 137
- 3.5 The Eight Queens Problem 143
- 3.6 The Stable Marriage Problem 148
- 3.7 The Optimal Selection Problem 154

## **4** DYNAMIC INFORMATION STRUCTURES 162

- 4.1 Recursive Data Types 162
- 4.2 Pointers or References 166
- 4.3 Linear Lists 171
  - 4.3.1 *Basic Operations* 171
  - 4.3.2 *Ordered Lists and Re-organizing Lists* 174
  - 4.3.3 *An Application: Topological Sorting* 182
- 4.4 Tree Structures 189
  - 4.4.1 *Basic Concepts and Definitions* 189
  - 4.4.2 *Basic Operations on Binary Trees* 198
  - 4.4.3 *Tree Search and Insertion* 201

4.4.4	<i>Tree Deletion</i>	210
4.4.5	<i>Analysis of Tree Search and Insertion</i>	211
4.4.6	<i>Balanced Trees</i>	215
4.4.7	<i>Balanced Tree Insertion</i>	216
4.4.8	<i>Balanced Tree Deletion</i>	222
4.4.9	<i>Optimal Search Trees</i>	226
4.4.10	<i>Displaying a Tree Structure</i>	232
4.5	Multiway Trees	242
4.5.1	<i>B-Trees</i>	245
4.5.2	<i>Binary B-Trees</i>	257
4.6	Key Transformations (Hashing)	264
4.6.1	<i>Choice of a Transformation Function</i>	266
4.6.2	<i>Collision Handling</i>	266
4.6.3	<i>Analysis of Key Transformation</i>	271

## 5 LANGUAGE STRUCTURES AND COMPILERS 280

5.1	Language Definition and Structure	280
5.2	Sentence Analysis	283
5.3	Constructing a Syntax Graph	288
5.4	Constructing a Parser for a Given Syntax	291
5.5	Constructing a Table-Driven Parsing Program	295
5.6	A Translator from BNF into Parser-Driving Data Structures	299
5.7	The Programming Language PL/0	307
5.8	A Parser for PL/0	311
5.9	Recovering from Syntactic Errors	320
5.10	A PL/0 Processor	331
5.11	Code Generation	344

## APPENDICES

### A THE ASCII CHARACTER SET 351

### B PASCAL SYNTAX DIAGRAMS 352

### SUBJECT INDEX 359

### INDEX OF PROGRAMS 365