

CONTENTS

Preface xiii

Chapter 0 Reader's Guide 1

- 0.1 Outline of the Book 2
- 0.2 A Roadmap for Readers and Instructors 3
- 0.3 Internet and Web Resources 4

PART ONE BACKGROUND 6

Chapter 1 Computer System Overview 7

- 1.1 Basic Elements 8
- 1.2 Processor Registers 9
- 1.3 Instruction Execution 12
- 1.4 Interrupts 15
- 1.5 The Memory Hierarchy 26
- 1.6 Cache Memory 29
- 1.7 I/O Communication Techniques 33
- 1.8 Recommended Reading and Web Sites 36
- 1.9 Key Terms, Review Questions, and Problems 37
- Appendix 1A Performance Characteristics of Two-Level Memory 39
- Appendix 1B Procedure Control 46

Chapter 2 Operating System Overview 50

- 2.1 Operating System Objectives and Functions 51
- 2.2 The Evolution of Operating Systems 55
- 2.3 Major Achievements 64
- 2.4 Developments Leading to Modern Operating Systems 77
- 2.5 Microsoft Windows Overview 80
- 2.6 Traditional UNIX Systems 90
- 2.7 Modern UNIX Systems 93
- 2.8 Linux 94
- 2.9 Recommended Reading and Web Sites 100
- 2.10 Key Terms, Review Questions, and Problems 101

PART TWO PROCESSES 105

Chapter 3 Process Description and Control 107

- 3.1 What is a Process? 108
- 3.2 Process States 111
- 3.3 Process Description 126
- 3.4 Process Control 135
- 3.5 Execution of the Operating System 140
- 3.6 Security Issues 143
- 3.7 UNIX SVR4 Process Management 147

vi CONTENTS

- 3.8 Summary 152
- 3.9 Recommended Reading 153
- 3.10 Key Terms, Review Questions, and Problems 153
Programming Project One Developing a Shell 157
- Chapter 4 Threads, SMP, and Microkernels 160**
 - 4.1 Processes and Threads 161
 - 4.2 Symmetric Multiprocessing (SMP) 175
 - 4.3 Microkernels 179
 - 4.4 Windows Vista Thread and SMP Management 185
 - 4.5 Solaris Thread and SMP Management 190
 - 4.6 Linux Process and Thread Management 195
 - 4.7 Summary 198
 - 4.8 Recommended Reading 198
 - 4.9 Key Terms, Review Questions, and Problems 199
- Chapter 5 Concurrency: Mutual Exclusion and Synchronization 206**
 - 5.1 Principles of Concurrency 207
 - 5.2 Mutual Exclusion: Hardware Support 216
 - 5.3 Semaphores 219
 - 5.4 Monitors 232
 - 5.5 Message Passing 239
 - 5.6 Readers/Writers Problem 245
 - 5.7 Summary 249
 - 5.8 Recommended Reading 250
 - 5.9 Key Terms, Review Questions, and Problems 251
- Chapter 6 Concurrency: Deadlock and Starvation 262**
 - 6.1 Principles of Deadlock 263
 - 6.2 Deadlock Prevention 272
 - 6.3 Deadlock Avoidance 273
 - 6.4 Deadlock Detection 279
 - 6.5 An Integrated Deadlock Strategy 281
 - 6.6 Dining Philosophers Problem 282
 - 6.7 UNIX Concurrency Mechanisms 286
 - 6.8 Linux Kernel Concurrency Mechanisms 289
 - 6.9 Solaris Thread Synchronization Primitives 295
 - 6.10 Windows Vista Concurrency Mechanisms 298
 - 6.11 Summary 302
 - 6.12 Recommended Reading 302
 - 6.13 Key Terms, Review Questions, and Problems 303

PART THREE MEMORY 309

- Chapter 7 Memory Management 311**
 - 7.1 Memory Management Requirements 312
 - 7.2 Memory Partitioning 315
 - 7.3 Paging 326
 - 7.4 Segmentation 330

- 7.5 Security Issues 331
- 7.6 Summary 335
- 7.7 Recommended Reading 335
- 7.8 Key Terms, Review Questions, and Problems 336
- Appendix 7A Loading and Linking 339

Chapter 8 Virtual Memory 345

- 8.1 Hardware and Control Structures 346
- 8.2 Operating System Software 365
- 8.3 UNIX and Solaris Memory Management 383
- 8.4 Linux Memory Management 389
- 8.5 Windows Vista Memory Management 391
- 8.6 Summary 394
- 8.7 Recommended Reading and Web Sites 395
- 8.8 Key Terms, Review Questions, and Problems 396
- Appendix 8A Hash Tables 400

PART FOUR SCHEDULING 404

Chapter 9 Uniprocessor Scheduling 405

- 9.1 Types of Scheduling 406
- 9.2 Scheduling Algorithms 410
- 9.3 Traditional UNIX Scheduling 432
- 9.4 Summary 434
- 9.5 Recommended Reading 434
- 9.6 Key Terms, Review Questions, and Problems 435
- Appendix 9A Response Time 438
- Appendix 9B Queuing Systems 440
- Programming Project Two The HOST Dispatcher Shell 447*

Chapter 10 Multiprocessor and Real-Time Scheduling 452

- 10.1 Multiprocessor Scheduling 453
- 10.2 Real-Time Scheduling 466
- 10.3 Linux Scheduling 481
- 10.4 UNIX FreeBSD Scheduling 485
- 10.5 Windows Vista Scheduling 487
- 10.6 Summary 490
- 10.7 Recommended Reading 490
- 10.8 Key Terms, Review Questions, and Problems 491

PART FIVE INPUT/OUTPUT AND FILES 494

Chapter 11 I/O Management and Disk Scheduling 495

- 11.1 I/O Devices 496
- 11.2 Organization of the I/O Function 497
- 11.3 Operating System Design Issues 501
- 11.4 I/O Buffering 504
- 11.5 Disk Scheduling 507
- 11.6 RAID 514

viii CONTENTS

- 11.7 Disk Cache 523
 - 11.8 UNIX FreeBSD I/O 526
 - 11.9 Linux I/O 529
 - 11.10 Windows Vista I/O 533
 - 11.11 Summary 536
 - 11.12 Recommended Reading 536
 - 11.13 Key Terms, Review Questions, and Problems 538
- Appendix 11A Disk Storage Devices 540

Chapter 12 File Management 521

- 12.1 Overview 552
- 12.2 File Organization and Access 558
- 12.3 File Directories 562
- 12.4 File Sharing 567
- 12.5 Record Blocking 568
- 12.6 Secondary Storage Management 570
- 12.7 File System Security 578
- 12.8 UNIX File Management 580
- 12.9 Linux File Management 587
- 12.10 Windows Vista File System 591
- 12.11 Summary 597
- 12.12 Recommended Reading 597
- 12.13 Key Terms, Review Questions, and Problems 598

PART SIX EMBEDDED SYSTEMS 601

Chapter 13 Embedded Operating Systems 602

- 13.1 Embedded Systems 603
- 13.2 Characteristics of Embedded Operating Systems 605
- 13.3 eCOS 607
- 13.4 TinyOS 622
- 13.5 Recommended Reading and Web Sites 630
- 13.6 Key Terms, Review Questions, and Problems 631

PART SEVEN SECURITY 634

Chapter 14 Computer Security Threats 635

- 14.1 Computer Security Concepts 636
- 14.2 Threats, Attacks, and Assets 638
- 14.3 Intruders 643
- 14.4 Malicious Software Overview 647
- 14.5 Viruses, Worms, and Bots 651
- 14.6 Rootkits 661
- 14.7 Recommended Readings and Web Sites 663
- 14.8 Key Terms, Review Questions, and Problems 664

Chapter 15 Computer Security Techniques 667

- 15.1 Authentication 668
- 15.2 Access Control 675
- 15.3 Intrusion Detection 680
- 15.4 Malware Defense 686
- 15.5 Dealing with Buffer Overflow Attacks 692
- 15.6 Windows Vista Security 697
- 15.7 Recommended Readings and Web Sites 701
- 15.8 Key Terms, Review Questions, and Problems 703

PART EIGHT DISTRIBUTED SYSTEMS 707**Chapter 16 Distributed Processing, Client/Server, and Clusters 710**

- 16.1 Client/Server Computing 711
- 16.2 Distributed Message Passing 722
- 16.3 Remote Procedure Calls 724
- 16.4 Clusters 728
- 16.5 Windows Vista Cluster Server 733
- 16.6 Sun Cluster 735
- 16.7 Beowulf and Linux Clusters 738
- 16.8 Summary 740
- 16.9 Recommended Reading 740
- 16.10 Key Terms, Review Questions, and Problems 742

APPENDICES**Appendix A Topics in Concurrency 744**

- A.1 Mutual Exclusion: Software Approaches 745
- A.2 Race Conditions and Semaphores 751
- A.3 A Barbershop Problem 758
- A.4 Problems 764

Appendix B Object-Oriented Design 765

- B.1 Motivation 766
- B.2 Object-Oriented Concepts 767
- B.3 Benefits of Object-Oriented Design 772
- B.4 CORBA 772
- B.5 Recommended Reading and Web Site 776

Appendix C Programming and Operating System Projects 777

- C.1 Animations and Animation Projects 778
- C.2 Simulations 779
- C.3 Programming Projects 780
- C.4 Research Projects 782
- C.5 Reading/Report Assignments 782

x CONTENTS

- C.6** Writing Assignments 782
- C.7** Documentation Projects 783
- C.8** BACI and Nachos 783

ONLINE CHAPTERS AND APPENDICES

Chapter 17 Networking

- 17.1** The Need for a Protocol Architecture
- 17.2** The TCP/IP Protocol Architecture
- 17.3** Sockets
- 17.4** Linux Networking
- 17.5** Summary
- 17.6** Recommended Reading and Web Sites
- 17.7** Key Terms, Review Questions, and Problems
- Appendix 17A The Trivial File Transfer Protocol

Chapter 18 Distributed Process Management

- 18.1** Process Migration
- 18.2** Distributed Global States
- 18.3** Distributed Mutual Exclusion
- 18.4** Distributed Deadlock
- 18.5** Summary
- 18.6** Recommended Reading
- 18.7** Key Terms, Review Questions, and Problems

Appendix D The Complexity of Algorithms

Appendix E Standards Organizations

- E.1** The Importance of Standards
- E.2** Standards and Regulation
- E.3** Standards-Setting Organizations

Appendix F Cryptographic Algorithms

- F.1** Symmetric Encryption
- F.2** Public-Key Cryptography
- F.3** Secure Hash Functions

Appendix G The International Reference Alphabet

Appendix H BACI: The Ben-Ari Concurrent Programming System

- H.1** Introduction
- H.2** BACI
- H.3** Examples of BACI Programs
- H.4** BACI Projects
- H.5** Enhancements to the BACK System

Appendix I Sockets: A Programmer's Introduction

- I.1** Versions of Sockets
- I.2** Sockets, Socket Descriptors, Ports, and Connections

- I.3 The Client/Server Model of Communication
- I.4 Sockets Elements
- I.5 Stream and Datagram Sockets
- I.6 Run-Time Program Control
- I.7 Remote Execution of a Windows Console Application

Glossary 785

References 795

Index 813