
Contents

PART ONE ■ OVERVIEW

Chapter 1 Introduction

- 1.1 What Operating Systems Do 4
- 1.2 Computer-System Organization 7
- 1.3 Computer-System Architecture 12
- 1.4 Operating-System Structure 19
- 1.5 Operating-System Operations 21
- 1.6 Process Management 24
- 1.7 Memory Management 25
- 1.8 Storage Management 26
- 1.9 Protection and Security 30
- 1.10 Kernel Data Structures 31
- 1.11 Computing Environments 35
- 1.12 Open-Source Operating Systems 43
- 1.13 Summary 47
- Exercises 49
- Bibliographical Notes 52

Chapter 2 Operating-System Structures

- 2.1 Operating-System Services 55
- 2.2 User and Operating-System Interface 58
- 2.3 System Calls 62
- 2.4 Types of System Calls 66
- 2.5 System Programs 74
- 2.6 Operating-System Design and Implementation 75
- 2.7 Operating-System Structure 78
- 2.8 Operating-System Debugging 86
- 2.9 Operating-System Generation 91
- 2.10 System Boot 92
- 2.11 Summary 93
- Exercises 94
- Bibliographical Notes 101

PART TWO ■ PROCESS MANAGEMENT

Chapter 3 Processes

- 3.1 Process Concept 105
- 3.2 Process Scheduling 110
- 3.3 Operations on Processes 115
- 3.4 Interprocess Communication 122
- 3.5 Examples of IPC Systems 130
- 3.6 Communication in Client–Server Systems 136
- 3.7 Summary 147
- Exercises 149
- Bibliographical Notes 161

Chapter 4 Threads

- 4.1 Overview 163
- 4.2 Multicore Programming 166
- 4.3 Multithreading Models 169
- 4.4 Thread Libraries 171
- 4.5 Implicit Threading 177
- 4.6 Threading Issues 183
- 4.7 Operating-System Examples 188
- 4.8 Summary 191
- Exercises 191
- Bibliographical Notes 199

Chapter 5 Process Synchronization

- 5.1 Background 203
- 5.2 The Critical-Section Problem 206
- 5.3 Peterson's Solution 207
- 5.4 Synchronization Hardware 209
- 5.5 Mutex Locks 212
- 5.6 Semaphores 213
- 5.7 Classic Problems of Synchronization 219
- 5.8 Monitors 223
- 5.9 Synchronization Examples 232
- 5.10 Alternative Approaches 238
- 5.11 Summary 242
- Exercises 242
- Bibliographical Notes 258

Chapter 6 CPU Scheduling

- 6.1 Basic Concepts 261
- 6.2 Scheduling Criteria 265
- 6.3 Scheduling Algorithms 266
- 6.4 Thread Scheduling 277
- 6.5 Multiple-Processor Scheduling 278
- 6.6 Real-Time CPU Scheduling 283
- 6.7 Operating-System Examples 290
- 6.8 Algorithm Evaluation 300
- 6.9 Summary 304
- Exercises 305
- Bibliographical Notes 311

Chapter 7 Deadlocks

- 7.1 System Model 315
- 7.2 Deadlock Characterization 317
- 7.3 Methods for Handling Deadlocks 322
- 7.4 Deadlock Prevention 323
- 7.5 Deadlock Avoidance 327
- 7.6 Deadlock Detection 333
- 7.7 Recovery from Deadlock 337
- 7.8 Summary 339
- Exercises 339
- Bibliographical Notes 346

PART THREE ■ MEMORY MANAGEMENT

Chapter 8 Main Memory

- 8.1 Background 351
- 8.2 Swapping 358
- 8.3 Contiguous Memory Allocation 360
- 8.4 Segmentation 364
- 8.5 Paging 366
- 8.6 Structure of the Page Table 378
- 8.7 Example: Intel 32 and 64-bit Architectures 383
- 8.8 Example: ARM Architecture 388
- 8.9 Summary 389
- Exercises 390
- Bibliographical Notes 394

Chapter 9 Virtual Memory

- 9.1 Background 397
- 9.2 Demand Paging 401
- 9.3 Copy-on-Write 408
- 9.4 Page Replacement 409
- 9.5 Allocation of Frames 421
- 9.6 Thrashing 425
- 9.7 Memory-Mapped Files 430
- 9.8 Allocating Kernel Memory 436
- 9.9 Other Considerations 439
- 9.10 Operating-System Examples 445
- 9.11 Summary 448
 - Exercises 449
 - Bibliographical Notes 461

PART FOUR ■ STORAGE MANAGEMENT

Chapter 10 Mass-Storage Structure

- 10.1 Overview of Mass-Storage Structure 467
- 10.2 Disk Structure 470
- 10.3 Disk Attachment 471
- 10.4 Disk Scheduling 472
- 10.5 Disk Management 478
- 10.6 Swap-Space Management 482
- 10.7 RAID Structure 484
- 10.8 Stable-Storage Implementation 494
- 10.9 Summary 496
 - Exercises 497
 - Bibliographical Notes 501

Chapter 11 File-System Interface

- 11.1 File Concept 503
- 11.2 Access Methods 513
- 11.3 Directory and Disk Structure 515
- 11.4 File-System Mounting 526
- 11.5 File Sharing 528
- 11.6 Protection 533
- 11.7 Summary 538
 - Exercises 539
 - Bibliographical Notes 541

Chapter 12 File-System Implementation

- 12.1 File-System Structure 543
- 12.2 File-System Implementation 546
- 12.3 Directory Implementation 552
- 12.4 Allocation Methods 553
- 12.5 Free-Space Management 561
- 12.6 Efficiency and Performance 564
- 12.7 Recovery 568
- 12.8 NFS 571
- 12.9 Example: The WAFL File System 577
- 12.10 Summary 580
 - Exercises 581
 - Bibliographical Notes 585

Chapter 13 I/O Systems

- 13.1 Overview 587
- 13.2 I/O Hardware 588
- 13.3 Application I/O Interface 597
- 13.4 Kernel I/O Subsystem 604
- 13.5 Transforming I/O Requests to Hardware Operations 611
- 13.6 STREAMS 613
- 13.7 Performance 615
- 13.8 Summary 618
 - Exercises 619
 - Bibliographical Notes 621

PART FIVE ■ PROTECTION AND SECURITY

Chapter 14 Protection

- 14.1 Goals of Protection 625
- 14.2 Principles of Protection 626
- 14.3 Domain of Protection 627
- 14.4 Access Matrix 632
- 14.5 Implementation of the Access Matrix 636
- 14.6 Access Control 639
- 14.7 Revocation of Access Rights 640
- 14.8 Capability-Based Systems 641
- 14.9 Language-Based Protection 644
- 14.10 Summary 649
- Exercises 650
- Bibliographical Notes 652

Chapter 15 Security

- 15.1 The Security Problem 657
- 15.2 Program Threats 661
- 15.3 System and Network Threats 669
- 15.4 Cryptography as a Security Tool 674
- 15.5 User Authentication 685
- 15.6 Implementing Security Defenses 689
- 15.7 Firewalling to Protect Systems and Networks 696
- 15.8 Computer-Security Classifications 698
- 15.9 An Example: Windows 7 699
- 15.10 Summary 701
- Exercises 702
- Bibliographical Notes 704

PART SIX ■ ADVANCED TOPICS

Chapter 16 Virtual Machines

- 16.1 Overview 711
- 16.2 History 713
- 16.3 Benefits and Features 714
- 16.4 Building Blocks 717
- 16.5 Types of Virtual Machines and Their Implementations 721
- 16.6 Virtualization and Operating-System Components 728
- 16.7 Examples 735
- 16.8 Summary 737
- Exercises 738
- Bibliographical Notes 739

Chapter 17 Distributed Systems

- 17.1 Advantages of Distributed Systems 741
- 17.2 Types of Network-based Operating Systems 743
- 17.3 Network Structure 747
- 17.4 Communication Structure 751
- 17.5 Communication Protocols 756
- 17.6 An Example: TCP/IP 760
- 17.7 Robustness 762
- 17.8 Design Issues 764
- 17.9 Distributed File Systems 765
- 17.10 Summary 773
- Exercises 774
- Bibliographical Notes 777

PART SEVEN ■ CASE STUDIES

Chapter 18 The Linux System

- 18.1 Linux History 781
- 18.2 Design Principles 786
- 18.3 Kernel Modules 789
- 18.4 Process Management 792
- 18.5 Scheduling 795
- 18.6 Memory Management 800
- 18.7 File Systems 809
- 18.8 Input and Output 815
- 18.9 Interprocess Communication 818
- 18.10 Network Structure 819
- 18.11 Security 821
- 18.12 Summary 824
- Exercises 824
- Bibliographical Notes 826

Chapter 19 Windows 7

- 19.1 History 829
- 19.2 Design Principles 831
- 19.3 System Components 838
- 19.4 Terminal Services and Fast User Switching 862
- 19.5 File System 863
- 19.6 Networking 869
- 19.7 Programmer Interface 874
- 19.8 Summary 883
- Exercises 883
- Bibliographical Notes 885

Chapter 20 Influential Operating Systems

- 20.1 Feature Migration 887
- 20.2 Early Systems 888
- 20.3 Atlas 895
- 20.4 XDS-940 896
- 20.5 THE 897
- 20.6 RC 4000 897
- 20.7 CTSS 898
- 20.8 MULTICS 899
- 20.9 IBM OS/360 899
- 20.10 TOPS-20 901
- 20.11 CP/M and MS/DOS 901
- 20.12 Macintosh Operating System and Windows 902
- 20.13 Mach 902
- 20.14 Other Systems 904
- Exercises 904
- Bibliographical Notes 904

PART EIGHT ■ APPENDICES

Appendix A BSD UNIX

- A.1 UNIX History A1
- A.2 Design Principles A6
- A.3 Programmer Interface A8
- A.4 User Interface A15
- A.5 Process Management A18
- A.6 Memory Management A22
- A.7 File System A24
- A.8 I/O System A32
- A.9 Interprocess Communication A36
- A.10 Summary A40
- Exercises A41
- Bibliographical Notes A42

Appendix B The Mach System

B.1 History of the Mach System	B1	B.6 Memory Management	B18
B.2 Design Principles	B3	B.7 Programmer Interface	B23
B.3 System Components	B4	B.8 Summary	B24
B.4 Process Management	B7	Exercises	B25
B.5 Interprocess Communication	B13	Bibliographical Notes	B26