CHAPTER 5  Representing Numerical Data  136

5.0  Introduction  137
5.1  Unsigned Binary and Binary-Coded Decimal Representations  138
5.2  Representations for Signed Integers  141
     Sign-and-Magnitude Representation  141
     Nine's Decimal and 1's Binary Complementary Representations  143
     Ten's Complement and 2's Complement  149
     Overflow and Carry Conditions  152
     Other Bases  153
     Summary of Rules for Complementary Numbers  153
5.3  Real Numbers  154
     A Review of Exponential Notation  154
     Floating Point Format  156
     Normalization and Formatting of Floating Point Numbers  158
     A Programming Example  161
     Floating Point Calculations  162
     Floating Point in the Computer  164
     Conversion between Base 10 and Base 2  166
5.4  Programming Considerations  167
     Summary and Review  168  For Further Reading  169
     Key Concepts and Terms  169  Reading Review Questions  169
     Exercises  170

PART THREE
COMPUTER ARCHITECTURE AND HARDWARE OPERATION  176

CHAPTER 6  The Little Man Computer  178

6.0  Introduction  179
6.1  Layout of the Little Man Computer  179
6.2  Operation of the LMC  181
6.3  A Simple Program  182
6.4  An Extended Instruction Set  184
6.5  The Instruction Cycle  187
6.6  A Note Regarding Computer Architectures  190
     Summary and Review  190
     Key Concepts and Terms  191  Reading Review Questions  191
     Exercises  191
CHAPTER 7  The CPU and Memory  194

7.0 Introduction  195
7.1 The Components of the CPU  196
7.2 The Concept of Registers  197
7.3 The Memory Unit  200
The Operation of Memory  200
Memory Capacity and Addressing Limitations  204
Primary Memory Characteristics and Implementation  205
7.4 The Fetch–Execute Instruction Cycle  207
7.5 Buses  210
Bus Characteristics  210
7.6 Classification of Instructions  214
Data Movement Instructions (LOAD, STORE, and Other Moves)  215
Arithmetic Instructions  217
Boolean Logic Instructions  218
Single Operand Manipulation Instructions  218
Bit Manipulation Instructions  218
Shift and Rotate Instructions  218
Program Control Instructions  219
Stack Instructions  220
Multiple Data Instructions  223
Other Instructions  224
7.7 Instruction Word Formats  224
7.8 Instruction Word Requirements and Constraints  226
Summary and Review  229  For Further Reading  229
Key Concepts and Terms  230  Reading Review Questions  230
Exercises  231

CHAPTER 8  CPU and Memory: Design, Enhancement, and Implementation  234

8.0 Introduction  235
8.1 CPU Architectures  236
Overview  236
Traditional Modern Architectures  237
8.2 CPU Features and Enhancements  238
Introduction  238
Fetch–Execute Cycle Timing Issues  239
A Model for Improved CPU Performance  241
Scalar and Superscalar Processor Organization  245
8.3 Memory Enhancements  248
CHAPTER 8  The Compleat Modern Superscalar CPU  254
  8.4 The Compleat Modern Superscalar CPU  254
  8.5 Multiprocessing  256
  8.6 A Few Comments on Implementation  260
Summary and Review  260  For Further Reading  261
Key Concepts and Terms  262  Reading Review Questions  262
Exercises  263

CHAPTER 9  Input/Output  266

  9.0 Introduction  267
  9.1 Characteristics of Typical I/O Devices  268
  9.2 Programmed I/O  273
  9.3 Interrupts  275
     Servicing Interrupts  275
     The Uses of Interrupts  277
     Multiple Interrupts and Prioritization  282
  9.4 Direct Memory Access  286
  9.5 I/O Controllers  289
Summary and Review  291  For Further Reading  292
Key Concepts and Terms  292  Reading Review Questions  292
Exercises  293

CHAPTER 10  Computer Peripherals  294

  10.0 Introduction  295
  10.1 The Hierarchy of Storage  296
  10.2 Solid-State Memory  298
  10.3 Magnetic Disks  299
     Disk Arrays  306
  10.4 Optical Disk Storage  307
  10.5 Magnetic Tape  309
  10.6 Displays  310
     Basic Display Design  310
     Graphical Processing Units (GPUs)  312
     Liquid Crystal Display Technology  316
     OLED Display Technology  317
  10.7 Printers  317
     Laser Printers  319
     Inkjet Printers  320
  10.8 User Input Devices  320
CHAPTER 13 Ethernet and TCP/IP Networking 400

13.0 Introduction 401
13.1 TCP/IP, OSI, and Other Communication Protocol Models 402
13.2 Program Applications Versus Network Applications 406
13.3 The Physical and Data Link Layers 407
   The Physical Layer 408
   The Data Link Layer 408
   Hub-Based Ethernet 410
   Switched Ethernet 411
   Wireless Ethernet (Wi-Fi) 411
13.4 The Network Layer 413
13.5 The Transport Layer 416
13.6 IP Addresses 421
   IPv4 and DHCP 421
   IPv6 425
13.7 Domain Names and DNS Services 425
13.8 Quality of Service 430
13.9 Network Security 431
   Physical and Logical Access Restriction 432
   Encryption 432
13.10 Alternative Protocols 433
   A Comparison of TCP/IP and OSI 433
   Other Protocol Suites and Components 434
   SCSI Over IP 434
   Cellular Technology 435
   MPLS 435
   SONET/SDH 436
   Frame Relay 436

Summary and Review 436 For Further Reading 437
Key Concepts and Terms 437 Reading Review Questions 438
Exercises 439
CHAPTER 14 Communication Channel Technology 442

14.0 Introduction 443
14.1 Communication Channel Technology 444
14.2 The Fundamentals of Signaling Technology 447
   Analog Signaling 448
   Digital Signaling 456
   Modems 461
14.3 Transmission Media and Signaling Methods 462
14.4 Alternative Technologies 464
   Cellular Technology 464
   Wi-Fi 466
   Bluetooth 466

Summary and Review 467 For Further Reading 468
Key Concepts and Terms 468 Reading Review Questions 469
Exercises 470

PART FIVE
THE SOFTWARE COMPONENT 474

CHAPTER 15 Operating Systems: An Overview 476

15.0 Introduction 477
15.1 The Barebones Computer System 478
15.2 The Operating Systems Concept: An Introduction 479
15.3 Services and Facilities 485
   User Interface and Command Execution Services 486
   File Management 487
   Input/Output Services 489
   Process Control Management 489
   Memory Management 490
   Scheduling and Dispatch 491
   Secondary Storage Management 493
   Network and Communications Support Services 494
   Security and Protection Services 494
   System Administration Support 495
15.4 Organization 499
15.5 Types of Computer Systems 502

Summary and Review 506 For Further Reading 506
Key Concepts and Terms 507 Reading Review Questions 507
Exercises 508
CONTENTS XV

CD, DVD, and Flash Drive Allocation 566
17.5 File Systems, Volumes, Disks, Partitions, and Storage Pools 566
17.6 The Directory Structure 569
   Tree-Structured Directories 570
   Acyclic-Graph Directories 573
17.7 Network File Access 576
17.8 Storage Area Networks 578
17.9 File Protection 578
17.10 Journaling File Systems 581

Summary and Review 581 For Further Reading 582
Key Concepts and Terms 582 Reading Review Questions 583
Exercises 584

CHAPTER 18 The Internal Operating System 586

18.0 Introduction 587
18.1 Fundamental OS Requirements 588
   Example: A Simple Multitasking Operating System 590
18.2 Starting the Computer System: The Bootstrap 592
18.3 Processes and Threads 595
   Process Creation 597
   Process States 598
   Threads 600
18.4 Basic Loading and Execution Operations 600
18.5 CPU Scheduling and Dispatching 601
   High-Level Scheduler 601
   Dispatching 603
   Nonpreemptive Dispatch Algorithms 605
   Preemptive Dispatch Algorithms 606
18.6 Memory Management 608
   Memory Partitioning 608
18.7 Virtual Storage 610
   Overview 610
   Pages and Frames 610
   The Concept of Virtual Storage 616
   Page Faults 617
   Working Sets and the Concept of Locality 619
   Page Sharing 620
   Page Replacement Algorithms 620
   Thrashing 624
   Page Table Implementation 624
   Segmentation 626
   Process Separation 627
18.8 Secondary Storage Scheduling 627
   First-Come, First-Served Scheduling 627
   Shortest Distance First Scheduling 628
   Scan Scheduling 628
   n-Step c-Scan Scheduling 628

18.9 Network Operating System Services 629
   OS Protocol Support and Other Services 629

18.10 Other Operating System Issues 632
   Deadlock 632
   Other Issues 632

18.11 Virtual Machines 634
   Summary and Review 636  For Further Reading 636
   Key Concepts and Terms 637  Reading Review Questions 638
   Exercises 639

Bibliography 645
Index 657

SUPPLEMENTARY CHAPTERS

On the Web at www.wiley.com/college/englander

SUPPLEMENTARY CHAPTER 1  An Introduction to Digital Computer Logic

  S1.0 Introduction
  S1.1 Boolean Algebra
  S1.2 Gates and Combinatorial Logic
  S1.3 Sequential Logic Circuits
  Summary and Review  For Further Reading
  Key Concepts and Terms  Reading Review Questions
  Exercises

SUPPLEMENTARY CHAPTER 2  System Examples

  S2.0 Introduction
  S2.1 Hardware Examples
     The x86 Family
     The POWER Family
     The IBM System 360/370/390/zSeries Family
  S2.2 Operating System Examples
     The Microsoft Windows Family
     UNIX and Linux
     The IBM z/OS Operating System
S2.3 Networking Examples
Google
Summary and Review For Further Reading
Key Concepts and Terms Reading Review Questions
Exercises

SUPPLEMENTARY CHAPTER 3 Instruction Addressing Modes

S3.0 Introduction
S3.1 Register Addressing
S3.2 Alternatives to Absolute Addressing
S3.3 Alternatives to Direct Addressing
    Immediate Addressing
    Indirect Addressing
    Register Indirect Addressing
    Indexed Addressing
    Indirect Indexed and Indirect Indexed Addressing
Summary and Review For Further Reading
Key Concepts and Terms Reading Review Questions
Exercises

SUPPLEMENTARY CHAPTER 4 Programming Tools

S4.0 Introduction
S4.1 Program Editing and Entry
S4.2 The Concept of Program Translation
S4.3 Assembly Language and the Assembler
    Operation of the Assembler
    Assembly Language Formats
    Features and Extensions
    Relocatability
S4.4 Program Language Description and Rules
    A Description of Written English
    Programming Language Rules
    Computer Language Descriptions
    The Compilation Process
    Interpreters
S4.5 Linking and Loading
S4.6 Debuggers
Summary and Review For Further Reading
Key Concepts and Terms Reading Review Questions
Exercises