

OLIVER C. IBE



FUNDAMENTALS OF DATA COMMUNICATION NETWORKS

WILEY

WHAT EVERY ELECTRICAL ENGINEERING STUDENT AND TECHNICAL PROFESSIONAL NEEDS TO KNOW ABOUT DATA EXCHANGE ACROSS NETWORKS

While most electrical engineering students learn how the individual components that make up data communication technologies work, they rarely learn how the parts work together in complete data communication networks. In part, this is due to the fact that until now there have been no texts on data communication networking written for undergraduate electrical engineering students. Based on the author's years of classroom experience, *Fundamentals of Data Communication Networks* fills that gap in the pedagogical literature, providing readers with a much-needed overview of all relevant aspects of data communication networking, addressed from the perspective of the various technologies involved.

The demand for information exchange in networks continues to grow at a staggering rate, and that demand will continue to mount exponentially as the number of interconnected IoT-enabled devices grows to an expected twenty-six billion by the year 2020. Never has it been more urgent for engineering students to understand the fundamental science and technology behind data communication, and this book, the first of its kind, gives them that understanding. To achieve this goal, the book:

- Combines signal theory, data protocols, and wireless networking concepts into one text
- Explores the full range of issues that affect common processes such as media downloads and online games
- Addresses services for the network layer, the transport layer, and the application layer
- Investigates multiple access schemes and local area networks with coverage of services for the physical layer and the data link layer
- Describes mobile communication networks and critical issues in network security
- Includes problem sets in each chapter to test and fine-tune readers' understanding

Fundamentals of Data Communication Networks is a must-read for advanced undergraduates and graduate students in electrical and computer engineering. It is also a valuable working resource for researchers, electrical engineers, and technical professionals.

OLIVER C. IBE, ScD, is a Professor of Electrical Engineering and the Associate Dean of Engineering for Undergraduate Studies at the University of Massachusetts, Lowell, Massachusetts, USA. He has sixteen years of experience in the telecommunication industry including stints as Chief Technology Officer and cofounder of Sineria Networks, and the Director of Network Architecture at both Spike Broadband Systems and Adaptive Broadband Corporation. Dr. Ibe has published numerous books on the subjects of telecommunication technologies and applied probability.

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Oliver C. Ibe

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Fundamentals of Data Communication Networks

Preface

There are many books on data communication networks, and so one would ask why write another one. Almost all the books written so far are written for graduate students. The few that are written for an undergraduate audience are aimed at business students who need to understand the buzzwords that they will be encountering in the marketing and sale of data communication equipment. There is no book written for undergraduate electrical engineering students who study the different components of the data communication technologies in isolation. Thus, this book grew out of the following observations:

1. While electrical and computer engineering students study how to build filters in circuit theory class and Fourier analysis, sampling theorem, and modulation in signal and systems, no concerted effort is made to combine these topics into one system that they can relate to.
2. In this information age, most undergraduate electrical and computer engineering students do not know what an IP address is, how to design a data network, or how domain name system (DNS) works.
3. While every student uses a mobile device, most undergraduate engineering students in general and undergraduate electrical and computer engineering students in particular do not know what 2G, 3G, and 4G networks are. To them these are mere buzzwords.
4. Data security is a very important issue and still many undergraduate electrical and computer engineering students do not understand the basic concepts of data security.

This book seeks to address these issues and grew out of the lecture notes for a class with a similar title as this book that I have been teaching in the Department of Electrical and Computer Engineering at the University of Massachusetts Lowell. Most of the students are juniors and seniors who have taken signals and systems, calculus II, and circuit theory I.

The book is organized along the seven-layer framework of the open systems interconnection (OSI) model, which is a conceptual hierarchical model that specifies the communication functions of each layer in a communication system. The lowest layer of the hierarchy is called the physical layer (or Layer 1), while the highest layer is called the application layer (or Layer 7). Specifically, Chapter 1 gives an overview of data communication networks, including how they are classified, and a discussion of the OSI model. Chapter 2 discusses the lowest layer of the OSI model, which is the physical layer (or Layer 1). The different topics covered in signals and systems as well as circuit theory are discussed, including Fourier series, Fourier transform, the different multiplexing and modulation schemes, sampling theorem, different media types, and channel impairments.

Chapters 3–5 discuss topics related to the data link layer or Layer 2. Chapter 3 discusses data link layer protocols. Chapter 4 discusses techniques called multiple access schemes that are used to access data communication networks, while Chapter 5 discusses local area networks that use Layer 2 protocols.

Chapters 6 and 7 discuss the network layer or Layer 3. Chapter 6 discusses IP addressing, while Chapter 7 discusses how information is sent from source to destination, a process that is called routing. Different routing protocols are discussed, where a protocol is a defined set of rules that ensure an effective communication.

Chapters 8 and 9 discuss the transport layer or Layer 4. Chapter 8 discusses two protocols that were defined in the early days of the Internet. These are the transmission control protocol (TCP) and the user datagram protocol (UDP). These two protocols were defined when the Internet, which is a data communication network, was expected to be used mainly for non-real-time applications. Thus, they are optimized for file transfers. With the Internet being used for both traditional non-real-time applications and new real-time applications such as streaming video and voice over IP, two new transport-layer protocols have been defined to deal with this new environment. These protocols are the stream control transmission protocol (SCTP) and the datagram congestion control protocol (DCCP), and they are discussed in Chapter 9.

Chapter 10 discusses two protocols that are used in the highest layer called the application layer. These are the dynamic host configuration protocol (DHCP) and the DNS.

Chapter 11 provides an introduction to mobile communication networks. It discusses the different generations of the mobile communication network called 1G, 2G, 3G, 4G, and 5G networks, where 1G stands for first-generation network, 2G stands for second-generation network, and so on.

Finally, Chapter 12 gives an introduction to network security. It discusses the security threats that are encountered in a data communication network and the steps used to overcome them. There are exercises at the end of each chapter.

We have been able to cover these chapters in one semester, but the instructor is free to skip some chapters that they believe that the students are not equipped to handle. However, it is strongly recommended that Chapters 1 through 9 be covered, while Chapters 10–12 will be covered when time permits.

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Lowell, Massachusetts

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Contents

Preface *xv*

Acknowledgments *xix*

1	Overview of Data Communication Networks	1
1.1	Introduction	1
1.2	Data Communication Network Model	1
1.3	Classification of Data Communication Networks	3
1.3.1	Transmission Method	3
1.3.2	Data Flow Direction	3
1.3.3	Network Topology	4
1.3.4	Geographical Coverage	7
1.3.5	Transmission Medium	8
1.3.6	Data Transfer Technique	8
1.3.7	Network Access Technique	9
1.3.8	Media Sharing Technique	9
1.4	Data Network Architecture	11
1.4.1	The OSI Protocol Reference Model	11
1.4.2	The Internet Architecture	12
1.5	Summary	14
2	Physical Layer	17
2.1	Introduction	17
2.2	Classification of Signals	17
2.3	Periodic Signals	18
2.4	Fourier Analysis of Periodic Signals	18
2.4.1	Reconstructing a Function from its Fourier Series	20
2.4.2	Fourier Analysis of Even and Odd Functions	21
2.4.3	Parseval's Theorem	22
2.4.4	Complex Form of Fourier Series	23

2.5	Fourier Transform of Nonperiodic Signals	23
2.6	Filters	24
2.7	Line Coding	26
2.8	Modulation	28
2.8.1	Trigonometric Refresher Course	30
2.8.2	Amplitude Modulation	31
2.8.2.1	Overmodulation and Distortion	34
2.8.2.2	Single-Sideband Suppressed-Carrier Amplitude Modulation	34
2.8.3	Frequency Modulation	36
2.8.4	Phase Modulation	38
2.9	Sampling Theorem	38
2.9.1	Analyzing Impulse Train Sampling	39
2.9.2	Reconstruction of the Continuous-Time Signal	40
2.9.3	Statement of the Sampling Theorem	42
2.9.4	Proof of the Sampling Theorem	42
2.10	Analog-to-Digital Conversion: From PAM to PCM	44
2.10.1	Pulse Code Modulation	44
2.10.2	Quantization Noise	45
2.11	Basic Digital Modulation Schemes	46
2.11.1	Amplitude-Shift Keying	46
2.11.2	Frequency-Shift Keying	47
2.11.3	Phase-Shift Keying	48
2.12	Media Sharing Schemes	50
2.12.1	Frequency Division Multiplexing	50
2.12.1.1	Wavelength Division Multiplexing	52
2.12.2	Time Division Multiplexing	52
2.12.2.1	Synchronous Versus Asynchronous TDM	52
2.13	Modems	54
2.14	Transmission Media	54
2.14.1	Twisted Pair	55
2.14.2	Coaxial Cable	55
2.14.3	Optical Fiber	56
2.14.3.1	Fiber Modes	58
2.14.4	Wireless Medium	59
2.15	Channel Impairments	61
2.15.1	Attenuation	61
2.15.2	Noise	61
2.15.2.1	Concept of Decibel	63
2.15.2.2	Signal-to-Noise Ratio	64
2.15.3	Distortion	65
2.15.4	Equalization	66
2.16	Summary	68

3	Data Link Layer Protocols	73
3.1	Introduction	73
3.2	Framing	73
3.3	Bit Stuffing	74
3.4	Flow Control	74
3.4.1	The Stop-and-Wait Protocol	75
3.4.2	The Sliding Window Flow Control	75
3.5	Error Detection	76
3.5.1	Parity Checking	76
3.5.2	Two-Dimensional Parity	77
3.5.3	Cyclic Redundancy Checking	78
3.6	Error Control Protocols	80
3.6.1	Stop-and-Wait ARQ	81
3.6.2	Go-Back- <i>N</i> ARQ	81
3.6.3	Selective Repeat ARQ	82
3.7	Data Link Control Protocols	82
3.7.1	High-level Data Link Control	83
3.7.1.1	HDLC Frame Format	84
3.7.1.2	Control Field Format	85
3.7.2	Point-to-Point Protocol	86
3.7.2.1	PPP Components	87
3.7.2.2	PPP Frame Format	87
3.7.2.3	PPP Link Control	88
3.8	Summary	89
4	Multiple Access Schemes	91
4.1	Introduction	91
4.2	Multiplexing Schemes Revisited	92
4.2.1	FDM	93
4.2.2	TDM	93
4.2.3	CDM	93
4.3	Orthogonal Access Schemes	93
4.3.1	FDMA	94
4.3.2	TDMA	94
4.3.3	CDMA	95
4.4	Controlled Access Schemes	96
4.4.1	Centralized Polling	96
4.4.2	Token Passing	96
4.4.3	Service Policies	96
4.5	Random Access Schemes	97
4.5.1	Aloha System	97
4.5.2	Slotted Aloha	98
4.5.3	CSMA	98

4.5.4	CSMA/CD	99
4.5.4.1	Why Listen While Transmitting in CSMA/CD	100
4.5.5	CSMA/CA	102
4.6	Summary	102
5	Local Area Networks	105
5.1	Introduction	105
5.2	Ethernet	105
5.2.1	Ethernet Frame Structure	106
5.2.2	IEEE 802.3 LAN Types	107
5.2.3	Ethernet Topologies	108
5.2.4	LAN Switching	110
5.2.5	Classification of Ethernet Switching	111
5.2.6	Frame Forwarding Methods	112
5.2.6.1	Store-and-Forward Switching	112
5.2.6.2	Cut-Through Switching	113
5.2.6.3	Fragment-Free Switching	113
5.2.7	Highest Layer used for Forwarding	113
5.2.7.1	Layer 2 Switching	114
5.2.7.2	Layer 3 Switching	114
5.2.7.3	Layer 4 Switching	115
5.3	Virtual LANs	115
5.3.1	Advantages of VLANs	115
5.3.2	Types of VLANs	117
5.3.2.1	Port-Based VLAN	117
5.3.2.2	MAC Address-Based VLAN	118
5.3.2.3	Protocol-Based VLANs	119
5.3.3	VLAN Tagging	120
5.3.4	Comments	121
5.4	Gigabit Ethernet	122
5.4.1	Frame Bursting	123
5.5	Wireless LANs	123
5.5.1	IEEE 802.11b WLAN	125
5.5.2	IEEE 802.11a WLAN	125
5.5.3	IEEE 802.11g WLAN	125
5.5.4	Architecture of the IEEE 802.11 WLAN	126
5.5.5	Ad Hoc Mode Deployment	126
5.5.6	Infrastructure Mode Deployment	126
5.5.7	IEEE 802.11 WLAN Timers	127
5.5.8	IEEE 802.11 WLAN Operation	127
5.5.9	DCF Mechanism	128
5.5.10	PCF Mechanism	128
5.5.11	Range and Data Rate Comparison in the PCF Environment	129