Annabel Z. Dodd

ESSENTIAL GUIDE to TELECOMMUNICATIONS

SIXTH EDITION

A Completely Revised Bestseller: Extensively Updated Coverage of Wi-Fi, LTE Advanced, SG, Broadband, Security Technologies, and the Competitive Landscape



PRAISE FOR THE ESSENTIAL GUIDE TO TELECOMMUNICATIONS, SIXTH EDITION

"Dodd's The Essential Guide to Telecommunications provides the history and context that make a fundamental underpinning of modern business more accessible to technologists and businesspeople alike. This new edition of her primer is an essential reference in the continuously evolving communications landscape."

—Tom Hopcroft, President and CEO, Mass Technology Leadership Council

"Annabel Dodd's book is a clear guide and big-picture view of technologies and industries. It is an up-to-date guide for anyone who wants to be familiar with important innovations and key technologies. This is truly an industry bible for mobile, Internet, and networking services."

—Hiawatha Bray, Technology Reporter, The Boston Globe

"Ms. Dodd's aptly titled The Essential Guide to Telecommunications has been my bible for all things telecom since my days as an AT&T transmission network engineer nearly twenty years ago. Exhaustively and meticulously researched, concisely written for lay folks and techs/engineers alike, this book aids me in my current role as an IT Support Technician II when discussing new technology with our telecommunications department. Thank you to Ms. Dodd for keeping us all current!"

—Todd Garbarini, IT Support Technician II Commvault Systems, Inc.

"The Essential Guide to Telecommunications is probably one of the most useful and well-written books on our telecom bookshelf. Annabel Z. Dodd does a great job of capturing a snapshot of the current telecom industry. Even those with little or no technical training should be able to understand the text. This is the perfect book for salespeople who want to learn more about the products and services they are selling, or for those who just want to keep up to date on the latest in telecom technology."

—William Van Hefner, President, Vantek Communications, Inc.

"Ms. Dodd continues to provide an excellent and thorough text on the telecommunications industry. As in her previous editions, she presents a good balance of technical and business-related information that is readily understandable by anyone with an interest in this key component of today's business environment. In her new edition, she has captured many of the recent changes in this dynamic field, which will affect every company in the years ahead. I strongly recommend her book to anyone who wants a better understanding of telecommunications."

—Joe McGrath, VP, Sage Pharmaceuticals, Inc.

Essential Guide to Telecommunications, The

Table of Contents

Cover

Half Title

Title Page

Copyright Page

Dedication

Contents

Preface

Acknowledgments

About the Author

Part I: Fundamentals, Data Centers, and IP PBXs

1 Computing and Enabling Technologies

Fiber-Optic and Copper Cabling

Fiber-Optic Cabling: Underpinning High-Speed Networks

Information Content Providers: Heavy Users of Fiber

Splitting Capacity of Individual Fiber Strands into Wavelengths

Fiber-Optic Cabling in Commercial Organizations

ChipsBuilding Blocks of the Digital Age

Machine Learning

Packetized Data

Per Packet Flexible Routing

Throughput

Deep Packet Inspection: Monitoring, Prioritizing, and Censoring Traffic

DPI in Organizations: Protecting Confidential Information



Governments Monitor: Terrorism, Web Access, and Unfavorable Comments

Carriers, Networks: Categorization and Billing

Traffic Shaping: Prioritizing Traffic

Compression

Streaming: Listening and Viewing without Downloading

Compression: The Engine behind TV over the Internet

Innovative Compression AlgorithmsFewer Bits, Higher-Quality Images

Using Codecs to Compress and Digitize Speech

Increasing Network Capacity via Multiplexing

Time-Division Multiplexing

Statistical Multiplexing: Efficient Utilization via Prioritization of Network Services

Using Protocols to Establish a Common Set of Rules

Protocols and Layers

Virtualization: Space, Cost, and Maintenance Efficiencies

Scalability and Energy Savings

VirtualizationEnabling Cloud Computing

Managing Virtualization

Managing Memory, Virtual Machines, and Disk Storage in Virtualized Data Centers

Containers: A Newer Form of Server Virtualization

The Cloud: Applications and Development at Providers Data Centers

Private vs. Public Cloud Service

Cloud Computing Fees

Rationale for Cloud Computing

Three Categories of Cloud ServicesLayers in the Cloud

Amazon: The Gorilla of Cloud Computing

Fewer IT Employees; Different SkillsDevOps

Compatibility with the Cloud

The EUU.S. Privacy Shield

Summary

Appendix

A Comparison between Analog and Digital Signaling

2 Data Centers and LANs, Storage, and IP Private Branch



Exchanges

Introduction

What Is a LAN?

Switches, Media, and Protocols in LANs

Layer 3 Switches Transmitting Data between Switches and Data Centers

Layer 2 SwitchesLinks to Nodes

Virtual Local Area Networks for Specialized Treatment

Protocols for Communications in LANs

Network Operating Systems

Data CentersCentralized Locations for Housing Applications

The Impact of Cloud Computing on Data Centers

Environmental Controls in Data Centers

Storage SystemsManaging Petabytes of Data

The Impact of Virtualized Hardware Failure

Managing Users Computers via Virtual Desktops

Access to the Internet and Other Broadband Networks via Routers

Software to Monitor LAN-Connected Devices

Monitoring LANsWhats Up? Whats Down?

IP PBXsVoice, Video, and Unifi ed Communications

IP Telephone SystemsVoice and Applications on LANs

IP TelephonyConverting Voice Signals to Digital Data

Voice QoS and Security

Assessing Network Quality by Using Voice Quality Measurements

Prioritizing Voice and Video on a Virtual Local Area Network

IP PBX Architecture

Media Gateways, Protocol Translation, and Signaling

Session Initiation ProtocolCompatible Trunks

Unified Communications, Contact Centers, and Video Conferencing

Integrating Conferencing, Instant Messaging, and E-Mail through UC

Desktop Video Conferencing

Video Conferencing

Immersive HD Video Conferencing

Communications Platform as a Service (CPaaS) vs. Hosted IP PBXs



Contact CentersEfficiencies for Incoming and Outgoing Communications

Voice Response UnitsRouting and Accessing Information via Touch-Tone or Speech

Appendix

Part II: Industry Overview and Regulations

3 Competition, Industry Structures, and Regulations

Introduction

The 1984 Breakup of AT&T

The Telecommunications Act of 1996

Costs and Competition for Cable TV Services in the United States

The Transformation of AT&T, CenturyLink, and Verizon into Conglomerates

AT&T, Verizon, CenturyLink and ComcastRecent Acquisitions

Cable TV ProvidersComcast, Charter, COX Communications, and Altice

Regulatory Issues

Utility Pole AttachmentsCritical for 5G

Universal Service and Rate of Return

Decreasing ICC Payments for Connecting TrafficGradually Being Reduced

Alternate Connect America Model

Lifeline Subsidies for Low-Income Residents

Media Consolidation Issues

Spam CallsRobocalls

Legislation to Protect the Privacy of Minors

Lobbying Efforts to Influence Regulations

The State of the IndustryConsolidation via Mergers

Competition to Telephone, Mobile, and Cable TV Companies

Mobile Operators

Consolidation of Mobile Providers

Selling Wholesale Network Services

Other Competitors to Broadband ProvidersOverbuilders

Agents

ResellersMobile Virtual Network Operators

Non-Traditional Competitors: Alphabet, Apple, Amazon, Facebook, Twitter, Snapchat, and Microsoft



GoogleA Search Conglomerate that Morphed into a Multi-Function Software Company

AmazonFrom Online Book Sales and Cloud Services to On-Ground Grocery Stores

FacebookAn Influential Social Network

SnapchatA Visual Social Network App

MicrosoftOffice Productivity, Operating System Software, Cloud Hosting, and Xbox

Twitter

Apple

Appendix

Part III: Managing Broadband Networks and Broadband Network Services

4 Managing Broadband Networks

Introduction

The Public Network

Core NetworksBetween Cities and Continents

Software Defined Networks to Manage Traffic Surges

Network Function VirtualizationArchitecture

Submarine Network Systems

Bandwidth Capabilities in Carrier Networks

Carrier Gigabit Ethernet

Optical Transport NetworksCarrying Multiple Types of Traffic

Optical Transport Networks and SDN and NFV

Transporting Movies and TV in the Core

Using Headends to Receive and Transmit Programming

Hub Sites

Middle-Mile Networks

Last-Mile Access Networks

Adding Capacity to Access Networks

Legacy Circuit-Switching Service

Transitioning Customers to Voice over Internet Protocol and Fiber

Digital Subscriber Line Access Multiplexers

Passive Optical Networks



Sharing Fiber CapacityPON Architecture

PON StandardsGigabit Ethernet

Access Networks in Cable Operators Networks

Using Cable Modems to Access the Internet

The Cable Modem Handshake

Using Set-Top Boxes to Interface to Cable TV

Using Cable Modem Termination Systems for IP Traffic

Supporting More Video via Set-Top Boxes

Cable Modem Standards Transition to Higher Speeds

Transitioning from Asymmetric to Symmetric Channels

Full Duplex DOCSIS 3.1Symmetric Speeds

Telecommunications Services in National Emergencies

Planning to Insure Reliability and Sustainability

Internet Security and Sustainability

Signaling

An Overview of Signaling

Interconnecting Carriers and Providing Secure Space for Equipment in Co-Location Facilities

Appendix

5 Broadband Network Services

Introduction

Disagreement within the FCC over the Definition of Broadband

VoIP Calling Services over Broadband

Residential vs. Enterprise Services

Lower-Priced, Flexible Consumer VoIP Services Adopted by Enterprises

VoIP for Very Small Organizations

The Impact of VoIP and Wi-Fi on Traditional Carriers

The Demarcation Point at Which Telephone Companies Wire Trunks

Multi-Protocol Label Switching for Interoffice Connections

MPLS Virtual Private NetworkA Managed Service

Routes and Security on MPLS

MPLS Implementation



MPLS for Multinational Locations

Prioritizing Traffic via Classes of Service

IP Virtual Private Networks over the Internet

Using IP VPNs between OfficesLess Costly than MPLS

Adding Security on Traffic Sent over IP VPNs

Security Protocols on Access to IP VPNs

Deploying Firewalls to Protect against Malicious Attacks

Managed Services

Managed Services Rather than Dumb Pipe Providers

Managed ServicesFor a Variety of Functions

Digital Subscriber LineDistance Limitations; Operates on Copper Cabling

How DSL Technology Works

DSL Limitations

Carrier Gigabit Ethernet

Carrier Gigabit Ethernet Flexibility and Scalable Speeds

Dedicated Wavelengths

T1 and T3: Services Largely Replaced by Higher-Capacity Broadband

Network Topology on Dedicated, Private Lines

Dedicated Private LinesFor Greater Security

Network TopologiesThe View from Above

Direct Dedicated Interconnections to the Cloud

Session Initiation ProtocolOut-of-Band Signaling

Wide Area Software Defi ned Networks for Enterprises

Network BackupsProtection from Outages

Appendix

Part IV: The Internet and Cellular Networks

6 The Internet

Introduction

What Is the Internet?

Features of the Internet

Protocols Used on the Internet

The Impact of CapacityThe Availability of Broadband Networks



Using Search Engines to Unleash Vast Stores of Information

Search EnginesMathematical Algorithms and Page Ranking

Internet2A Non-Commercial Outgrowth of the Internet

Streaming A Disruptive Technology

Growth in Streaming

Easier Set-Up and Increased Internet Uptake

Accessing StreamingConnected TVs, Game Consoles, and Mobile Devices

Set-Top Boxes for OTT Streams

Keeping and Attracting SubscribersThe Criticality of Content

A Snapshot of Companies that Offer Streaming

Ad Revenue on Streaming Services

Streaming Worldwide

Ease of Use and Technological Enablers

Pay-TVSkinny Bundles Plus Streaming on Set-Top Boxes

Technical Challenges

The Structure of the Internet

Edge Routers

Aggregation Routers in Core Networks

Ensuring Reliability in the Core and Edge

Enhancing Internet Performance by Using Content Delivery Networks

Exchanging Data at Peering Points

Address Structures

Tracking and Managing Top-Level Domains

Transitioning to IPv6

Security: Connected, Ubiquitous NetworksVulnerable to Malicious Hackers

Methods Hackers Use to Attack and Infiltrate Networks

The Five Rs of Information Security

Cyber Terrorism between Countries

Privacy

Web Site Tracking, Connected Devices, and Free Search Engines

The Impact of E-Commerce

Combining Online Services with On-Site Stores



Fostering Civic Participation and EngagementOnline Forums

Town E-Mail Lists to Keep Communities Informed

Network Neutrality

The Issues Surrounding Network Neutrality

The Digital Divide: Bandwidth, Skills, and Computers

Internet Pricing and Competition

Intranets and Extranets

Intranets

ExtranetsSaving Money on Customer Service

7 Mobile and Wi-Fi Networks

Introduction

Spectrum for Wireless NetworksA Critical Asset

Cellular StructuresThe Foundation of Mobile Networks

The Division of Airwaves into Frequencies

The Characteristics of Short and Long Wavelengths

Spectrum Blocks

Using Auctions to Allocate Spectrum

Profits from Unused Spectrum on the Secondary Market

Synchronizing Spectrum Internationally

Mitigating Interference

Unlicensed Spectrum for Super Wi-Fi

RoamingUsing Mobile Devices in Other Networks

More Efficient 4th Generation Digital Networks

3G TechnologiesIncompatible Standards

Early LTE Implementations

LTEThe First True 4th Generation Cellular Protocol

4G LTEDesigned to Transmit Data and Voice in IP Packets

LTE Capacity

LTE Cell Sites Additional Functionality

BackhaulConnecting Cell Sites and Core Networks

Elements of LTE Infrastructure

The Three Elemental Functions of the LTE IP Core



Databases in the LTE Evolved Packet Core

Voice over LTEPacketized Voice

Accessing Applications and VoLTEThe IP Multimedia Subsystem

Connections to Customers and Mobile Networks via the Cell Site, Towers, and Mobile Switches

Heterogeneous NetworksArchitecture for Densely Trafficked Areas

Frequency- and Time-Division Air Interfaces in LTE

4G Multiple-Input Multiple-Output Antennas

The LTE Orthogonal Frequency-Division Multiplexing Air Interface

5G Mobile NetworksSmall Cells; Additional Capacity

Massive MIMO Antennas for 5G Networks

5G New Radio Service and 5G Applications

C-RAN Centralized or Cloud-Based Radio Access Networks in 5G Networks

Interoperability and Fall Back on 5G Mobile Networks

Device Compatibility A Multi-Year Gap

Killing Lost or Stolen Portable Computers Using GPS

The Internet of Things (IoT)

Information and Privacy on IoT Services

Unmanned Aircraft; DronesMilitary and Commercial Applications

Battery Life

Applications and Services

Mobile Payments

Machine-to-Machine Communications between Devices with Embedded Radios

Using Prepaid Mobile Services

Wi-Fi Standards, Architecture, and Their Use in Cellular Networks

The 802.11 Wi-Fi Standard

A Deeper Dive into Wi-Fi Standards

Wi-Fi Architecture in Enterprises

Mesh NetworksEvery Device to Every Device: Controller-Less Architecture

Devices on Wi-Fi NetworksAccess Points and Controllers

Securing Wi-Fi NetworksWPA3

Using Wi-Fi to Offload Traffic from Congested Mobile Networks

SatellitesGeosynchronous and Low Earth Orbiting



Satellite Networks

Low Earth Orbiting SatellitesFewer Delays; More Satellites; 200 to 1,200 Miles High

High-Frequency Satellite Service within Airplanes for Internet Access

Appendix

Glossary

Α

В

С

D

Ε

F

G

Н

L

J

ᆫ

М

Ν

0

Р

Q

R

S

Т

U

٧

W Z Index