Delivering Voice over IP Networks

Second Edition

Daniel Minoli Emma Minoli



Wiley Publishing, Inc.



Publisher: Robert Ipsen
Editor: Margaret Eldridge
Assistant Editor: Adaobi Obi
Managing Editor: Angela Smith
New Media Editor: Brian Snapp
Text Design & Composition: North Market Street Graphics

Designations used by companies to distinguish their products are often claimed as trademarks. In all instances where John Wiley & Sons, Inc., is aware of a claim, the product names appear in initial capital or ALL CAPITAL LETTERS. Readers, however, should contact the appropriate companies for more complete information regarding trademarks and registration.

This text is printed on acid-free paper. ⊚

Copyright © 2002 by Dan Minoli, Emmanuelle Minoli. All rights reserved.

Published by Wiley Publishing, Inc., Indianapolis, Indiana

Published simultaneously in Canada.

No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning or otherwise, except as permitted under Sections 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 750-4744. Requests to the Publisher for permission should be addressed to the Legal Department, Wiley Publishing, Inc., 10475 Crosspointe Blvd., Indianapolis, IN 46256, (317) 572-3447, fax (317) 572-4447, E-mail: permcoordinator@wiley.com.

This publication is designed to provide accurate and authoritative information in regard to the subject matter covered. It is sold with the understanding that the publisher is not engaged in professional services. If professional advice or other expert assistance is required, the services of a competent professional person should be sought.

Library of Congress Cataloging-in-Publication Data:

Minoli, Daniel

Delivering voice over IP networks / Dan Minoli, Emma Minoli.— 2nd ed. p. cm.

ISBN 0-471-38606-5

1. Internet telephony. 2. TCP/IP (Computer network protocol). 3. Digital telephone systems. 4. Computer networks. 5. Data transmission sytems. I. Minoli, Emma. II. Title.

TK5105.8865 .M57 2002 621.385—dc21

2002071368

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic versions. For more information about Wiley products, visit our web site at www.wiley.com.

Printed in the United States of America.

10 9 8 7 6 5 4 3 2 1



Contents

PREFACE	xiii	
ACKNOW	LEDGMENT	xv
About the Authors		xvi

Chapter 1: Introduction and Motivation

- 1.1 Introduction
- 1.2 Drivers for Voice over IP

THE NEGATIVE DRIVERS 12

1.3 Approaches for IP-Based Voice Systems

Voice Servers Approach 15

IP VOICE AND VIDEO PHONES 18

1.4 The Future 18

References 18

Chapter 2: An Overview of IP, IPOATM, MPLS, and RTP 21

- 2.1 Introduction 21
- 2.2 Internet Protocol

THE ROLE OF THE IP

IP ROUTING 26

IP Datagrams 29

SUPPORT OF VOICE AND VIDEO IN ROUTERS 32

IP VERSION 6 (IPv6)

- 2.3 IP OVER ATM (IPOATM) 36
- 2.4 BASIC SYNOPSIS OF MPLS

MPLS FORWARDING/LABEL-SWITCHING MECHANISM

MPLS Label-Distribution Mechanism 43

- 2.5 REAL-TIME TRANSPORT PROTOCOL (RTP)
- 2.6 RTP CONTROL PROTOCOL (RTCP) 50
- 2.7 STREAM CONTROL TRANSMISSION PROTOCOL (SCTP)



2.8 ATM QoS Mechanisms 54
Quality of Service Parameters 56
QoS Classes 57
References 59
Notes 61

Chapter 3: Issues in Packet Voice Communication 63

3.1 Introduction 63

Scope 64

SUMMARY OF RESULTS 65

3.2 Traffic Models 66

Introduction 66

Speech Events 66

Speaker Models 67

Call Origination Model 72

3.3 Performance Criteria 74

RESULTS OF SUBJECTIVE STUDIES 74

SMOOTHNESS CRITERIA 76

3.4 Link Model 78

Introduction 79

Model Description 79

3.5 Results 84

Properties of the Delay Distribution 84

FINITE-BUFFER CASE 86

EFFECT OF SPEECH MODELS 88

OPTIMAL PACKET LENGTH 90

Transient Behavior 92

3.6 Conclusion 95

References 96

Chapter 4: Voice Technologies for Packet-Based Voice Applications 101

4.1 Introduction 101

GENERAL OVERVIEW OF SPEECH TECHNOLOGY 101

Waveform Coding 102

Vocoding (Analysis/Synthesis) in the Frequency Domain 107

4.2 G.727: ADPCM FOR PACKET NETWORK APPLICATIONS 111

INTRODUCTION 111

ADPCM ENCODER PRINCIPLES 114

ADPCM Decoder Principles 121



4.3 Example of Application 123 References 123 Notes 123

Chapter 5: Technology and Standards for Low-Bit-Rate Vocoding Methods 125

5.1 Introduction 125

Overview 127

VOCODER ATTRIBUTES 128

LINEAR PREDICTION ANALYSIS-BY-SYNTHESIS (LPAS) CODING 130

5.2 Introduction to G.729 and G.723.1 133

Differentiations 133

STANDARDIZATION PROCESS 134

STANDARDIZATION INTERVAL 135

5.3 G.723.1 136

INTRODUCTION 136

ENCODER/DECODER 136

5.4 G.728 138

LD-CELP ENCODER 139

LD-CELP DECODER 140

5.5 G.729 140

ENCODER 141

Decoder 143

5.6 Example of Applications 145

H.263 VIDEO CODING FOR LOW-BIT-RATE COMMUNICATION 145

H.324 Multimedia Communication 146

H.323 MULTIMEDIA COMMUNICATIONS STANDARD FOR LANS AND ENTERPRISE

Networks 148

References 150

Notes 151

Chapter 6: Voice over IP and the Internet 153

6.1 Introduction 153

6.2 IP/Internet Background 157

INTERNET PROTOCOL SUITE 157

THE INTERNET 157

6.3 VOICE TRANSMISSION AND APPROACHES IN ATM, FRAME RELAY, AND IP 162

ATM 162

Frame Relay 164

IP 164



DOCKET

Explore Litigation Insights



Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time** alerts and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.

