

---

# *NEXT GENERATION TELECOMMUNICATIONS NETWORKS, SERVICES, AND MANAGEMENT*

Edited by

**THOMAS PLEVYAK**

**VELI SAHIN**

IEEE Communications Society, *Sponsor*



**IEEE Press  
Series On  
Network  
Management**

Thomas Plevyak and Veli Sahin, *Series Editors*



**IEEE PRESS**



**A JOHN WILEY & SONS, INC., PUBLICATION**



*NEXT GENERATION  
TELECOMMUNICATIONS  
NETWORKS, SERVICES,  
AND MANAGEMENT*

IEEE Press  
445 Hoes Lane  
Piscataway, NJ 08854

**IEEE Press Editorial Board**

Lajos Hanzo, *Editor in Chief*

R. Abari	T. Chen	B. M. Hammerli
J. Anderson	T. G. Croda	O. Malik
S. Basu	M. El-Hawary	S. Nahavandi
A. Chatterjee	S. Farshchi	W. Reeve

Kenneth Moore, *Director of IEEE Book and Information Services (BIS)*

**Technical Reviewer**

Lakshmi Raman

**Books in the IEEE Press Series on Network Management**

*Telecommunications Network Management Into the 21st Century*,  
Co-Editors Thomas Plevyak and Salah Aidarous, 1994

*Telecommunications Network Management: Technologies and Implementations*,  
Co-Editors Thomas Plevyak and Salah Aidarous, 1997

*Fundamentals of Telecommunications Network Management*,  
by Lakshmi Raman, 1999

*Security for Telecommunications Management Network*,  
by Moshe Rozenblit, 2000

*Integrated Telecommunications Management Solutions*,  
by Graham Chen and Quinzhen Kong, 2000

*Managing IP Networks: Challenges and Opportunities*,  
Co-Editors Thomas Plevyak and the late Salah Aidarous, 2003

---

# *NEXT GENERATION TELECOMMUNICATIONS NETWORKS, SERVICES, AND MANAGEMENT*

Edited by

**THOMAS PLEVYAK**

**VELI SAHIN**

IEEE Communications Society, *Sponsor*



**IEEE Press  
Series On  
Network  
Management**

Thomas Plevyak and Veli Sahin, *Series Editors*



**IEEE PRESS**



A JOHN WILEY & SONS, INC., PUBLICATION

Copyright © 2010 by Institute of Electrical and Electronics Engineers. All rights reserved.

Published by John Wiley & Sons, Inc., Hoboken, New Jersey.  
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 Section 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, Inc., 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 750-4470, or on the web at [www.copyright.com](http://www.copyright.com). Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, (201) 748-6011, fax (201) 748-6008, or online at <http://www.wiley.com/go/permission>.

**Limit of Liability/Disclaimer of Warranty:** While the publisher and author have used their best efforts in preparing this book, they make no representations or warranties with respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives or written sales materials. The advice and strategies contained herein may not be suitable for your situation. You should consult with a professional where appropriate. Neither the publisher nor author shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

For general information on our other products and services or for technical support, please contact our Customer Care Department within the United States at (800) 762-2974, outside the United States at (317) 572-3993 or fax (317) 572-4002.

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

***Library of Congress Cataloging-in-Publication Data:***

Plevyak, Thomas.

Next generation telecommunications networks, services, and management /  
Thomas Plevyak, Veli Sahin.

p. cm.

ISBN 978-0-470-57528-4 (cloth)

1. Telecommunication systems—Forecasting. 2. Computer networks—Forecasting.

I. Sahin, Veli. II. Title.

TK5102.5.P59 2010

621.382—dc22

2009036488

Printed in the United States of America.

10 9 8 7 6 5 4 3 2 1

*The Editors and Authors  
Dedicate This Book to Their Families:  
The Cornerstone of Successful Societies*



# CONTENTS

*GUEST INTRODUCTIONS* xv

*EDITOR AND CONTRIBUTOR BIOGRAPHIES* xix

**CHAPTER 1** *CHANGES, OPPORTUNITIES, AND CHALLENGES* 1

---

*Veli Sahin and Thomas Plevyak*

- 1.1 Introduction 1
- 1.2 Scope 2
- 1.3 Changes, Opportunities, and Challenges 2
  - 1.3.1 Major Life Style Changes: Desktops, Laptops, and Now Handtops 2
  - 1.3.2 Major Network Infrastructure Changes 3
  - 1.3.3 Major Home Network (HN) Changes 4
  - 1.3.4 Major FCAPS Changes 4
  - 1.3.5 Major Regulatory Changes 5
  - 1.3.6 Service Aware Networks to Manage Expectations and Experiences 5
- 1.4 Major Management Challenges for a Value-Added Service: Triple Shift Service 7
- 1.5 The Grand Challenge: System Integration and Interoperability of Disjoined Islands 8
- 1.6 Some Examples of Management System Applications 10
  - 1.6.1 Event Correlation 10
  - 1.6.2 Hot Spot Identification and SMS Actions 11
  - 1.6.3 SLAs, Contracts, and Policy Management 12
    - 1.6.3.1 Service Assessment 12
    - 1.6.3.2 Contract Assessment 12
    - 1.6.3.3 Service and Contract Assurance 12
  - 1.6.4 SMS Integration with Planning and Engineering Systems 13
- 1.7 Overview of Book Organization and Chapters 13
- 1.8 References 14

**CHAPTER 2** *MANAGEMENT OF TRIPLE/QUADRUPLE PLAY SERVICES FROM A TELECOM PERSPECTIVE* 15

---

*Jean Craveur*

- 2.1 Introduction 15
- 2.2 Context of Triple/Quadruple Play for Telecom Operators 15
- 2.3 The Economic, Service, and Commercial Challenges 18
  - 2.3.1 General Conditions 18
  - 2.3.2 Service Offer Requirements 19
- 2.4 The Technical Challenge 20

2.4.1	The Technical Tool Box	21
2.4.1.1	Customer Equipment	21
2.4.1.2	Access Line and Aggregation/Backhaul Networks	21
2.4.1.3	Backbone Networks	22
2.4.1.4	Control Platform	22
2.4.1.5	Service Platform	22
2.4.1.6	IS Equipment	22
2.4.2	The Global Vision	23
2.4.2.1	Vision for an Overall Architecture Supporting Triple and Quadruple Play	23
2.4.3	Key Issues to Consider When Designing Network and IS Infrastructures for Triple and Quadruple Play	24
2.4.3.1	Convergence and Mutualization	25
2.4.3.2	Quality of Service (QoS)	25
2.4.4	Customer Premises Equipment (CPE) and Home Network	26
2.4.4.1	The Home Network Complexity	26
2.4.4.2	Distribution of Functions between Network and IS Platforms and Residential Gateways	27
2.4.4.3	The Home Network Paradox	27
2.4.4.4	The Home Device and Applications	28
2.4.5	Access Lines	28
2.4.6	Access Networks, Aggregation, and Backhauling	29
2.4.7	An Illustration of the Fixed Access Network Transformation from Internet Access Support to Triple Play Support	30
2.4.8	Backbone Networks	31
2.4.8.1	Content Delivery	32
2.4.9	Service and Resource Control	33
2.4.9.1	Core Control and Application Servers	33
2.4.9.2	Service Platforms	33
2.4.10	Information System	33
2.4.10.1	A Renovated IS Architecture for Triple/Quadruple/Multiple Play Business	35
2.4.10.2	The Customer Front-End	36
2.4.10.3	The Aggregation Layer	37
2.4.10.4	The Back-End	37
2.4.10.5	Order Management and Delivery	39
2.4.10.6	A Crucial Cooperation between IS, Network, and Service Platform	39
2.5	The Operational Challenge	40
2.5.1	Focus on the Service Management Center Function (SMC)	42
2.5.2	IS Tools for the SMCs	43
2.5.3	Operating IT and Service Platforms in Triple and Quadruple Play Contexts	44
2.5.4	Roles and Responsibilities of the Different Functions	45
2.5.5	New Skills in Operations	47
2.6	The Customer Experience in Broadband Triple Play	47
2.6.1	Definition of the Offerings	48
2.6.2	Distribution Channels	49
2.6.3	Relationship with the Local Operator	49

- 2.6.4 The Customer Journey 49
- 2.7 The Organizational Challenge 51
- 2.8 Conclusions 51
- 2.9 Acknowledgments 52
- 2.10 References 52
- 2.11 Suggested Further Reading 52

**CHAPTER 3** *MANAGEMENT OF TRIPLE/QUAD PLAY SERVICES  
FROM A CABLE PERSPECTIVE*

53

---

*David Jacobs*

- 3.1 Introduction 53
- 3.2 The HFC Network 55
  - 3.2.1 HFC Planning and Inventory 55
  - 3.2.2 HFC Network Maintenance 56
  - 3.2.3 HFC Network Upgrades 56
- 3.3 Digital TV 57
  - 3.3.1 Digital TV: Coding and Transmission of Analogue Information 58
  - 3.3.2 Network Information Table (NIT) 62
  - 3.3.3 DVB-SI Program Decoding 62
  - 3.3.4 ATSC-PSIP Program Decoding 62
  - 3.3.5 Conditional Access 63
  - 3.3.6 Out-of-Band Channels 64
  - 3.3.7 Digital Storage Media—Command and Control (DSM-CC) 64
  - 3.3.8 Switched Digital Video 65
  - 3.3.9 Enhanced TV/Interactive TV 67
    - 3.3.9.1 Enhanced TV Binary Interchange Format 69
  - 3.3.10 DOCSIS Set-Top Gateway 69
  - 3.3.11 Digital TV Head-End 70
  - 3.3.12 Integrated Receiver/Decoder or Set-Top Box 71
  - 3.3.13 Point of Deployment Module/CableCard 72
- 3.4 Data over Cable Service Interface Specification (DOCSIS) 73
  - 3.4.1 Physical Layer 74
  - 3.4.2 Data Link Layer 76
    - 3.4.2.1 Media Access Control (MAC) Sublayer 76
    - 3.4.2.2 Link Layer Security 78
    - 3.4.2.3 Logical Link Control (LLC) 79
  - 3.4.3 Network Layer 79
  - 3.4.4 Multicast Operation 80
  - 3.4.5 Cable Modem Start-up 80
  - 3.4.6 IP Detail Records 81
  - 3.4.7 DOCSIS Evolution 82
- 3.5 Cable Telephony 83
  - 3.5.1 Cable IP Telephony 84
    - 3.5.1.1 Network Control Signaling PacketCable 1.0 and 1.5 85
    - 3.5.1.2 Distributed Call Signaling 90
    - 3.5.1.3 Embedded MTA Start-up 90
    - 3.5.1.4 PacketCable 2.0 91
- 3.6 Wireless 96

- 3.7 Cable Futures **97**
- 3.8 References **98**

**CHAPTER 4 NEXT GENERATION TECHNOLOGIES, NETWORKS, AND SERVICES 101**

---

*Bhumip Khasnabish*

- 4.1 Introduction **101**
- 4.2 Next Generation (NG) Technologies **102**
  - 4.2.1 Wireline NG Technologies **102**
    - 4.2.1.1 Fiber to the Premises (FTTP) **103**
    - 4.2.1.2 Long-Haul Managed Ethernet (over Optical Gears) **103**
  - 4.2.2 Wireless NG Technologies **104**
    - 4.2.2.1 Broadband Bluetooth and ZigBee **104**
    - 4.2.2.2 Personalized and Extended Wi-Fi **104**
    - 4.2.2.3 Mobile Worldwide Inter-operability for Microwave Access (M-WiMax) **105**
    - 4.2.2.4 Long Term Evolution (LTE) **106**
    - 4.2.2.5 Enhanced HSPA **106**
    - 4.2.2.6 Evolution Data Optimized (EVDO) and Ultra Mobile Broadband (UMB) **106**
    - 4.2.2.7 Mobile Ad Hoc Networking (MANET) and Wireless Mesh Networking (WMN) **106**
    - 4.2.2.8 Cognitive (and Software Defined) Radios and Their Interworking **107**
  - 4.2.3 Software and Server NG Technologies (Virtualization) **107**
- 4.3 Next Generation Networks (NGNs) **108**
  - 4.3.1 Transport Stratum **108**
  - 4.3.2 Service Stratum **110**
  - 4.3.3 Management **110**
    - 4.3.3.1 Fault Management **110**
    - 4.3.3.2 Configuration Management **110**
    - 4.3.3.3 Accounting Management **111**
    - 4.3.3.4 Performance Management **111**
    - 4.3.3.5 Security Management **111**
  - 4.3.4 Application Functions **112**
  - 4.3.5 Other Networks: Third-Party Domains **112**
  - 4.3.6 End-User Functions: Customer Premises Devices and Home Networks **113**
  - 4.3.7 Internet Protocol (IP): The NGN Glue **113**
    - 4.3.7.1 Internet Protocol version 4 (IPv4) **113**
    - 4.3.7.2 Internet Protocol version 6 (IPv6) **114**
    - 4.3.7.3 Mobile Internet Protocol version 6 (MIPv6) **114**
- 4.4 Next Generation Services **114**
  - 4.4.1 Software-Based Business Services **114**
  - 4.4.2 High-Definition (HD) Voices **115**
  - 4.4.3 Mobile and Managed Peer-to-Peer (M2P2P) Service **115**
  - 4.4.4 Wireless Charging of Hand-Held Device **115**
  - 4.4.5 Three-Dimensional Television (3D-TV) **116**
  - 4.4.6 Wearable, Body-Embedded Communications/Computing Including Personal and Body-Area Networks **116**
  - 4.4.7 Converged/Personalized/Interactive Multimedia Services **116**

4.4.8	Grand-Separation for Pay-per-Use Service	117
4.4.9	Mobile Internet for Automotive and Transportation	117
4.4.10	Consumer- and Business-Oriented Apps Storefront	117
4.4.11	Evolved Social Networking Service (E-SNS)	118
4.4.12	NG Services Architectures	118
4.4.13	Application Plane's Requirements to Support NG Services	120
4.4.14	Transport Plane's Requirements to Support NG Services	120
4.5	Management of NG Services	121
4.5.1	IP- and Ethernet-Based NG Services	121
4.5.2	Performance Management of NG Services	122
4.5.3	Security Management of NG Services	123
4.5.4	Device Configuration and Management of NG Services	123
4.5.5	Billing, Charging, and Settlement of NG Services	124
4.5.6	Faults, Overloads, and Disaster Management of NG Services	124
4.6	Next Generation Society	124
4.6.1	NG Technology-Based Humane Services	125
4.6.2	Ethical and Moral Issues in Technology Usage	125
4.7	Conclusions and Future Works/Trends	126
4.8	References	127

---

**CHAPTER 5 IMS AND CONVERGENCE MANAGEMENT**

129

*Keizo Kawakami, Kaoru Kenyoshi, and Toshiyuki Misu*

5.1	IMS Architecture	129
5.1.1	Serving CSCF (S-CSCF)	130
5.1.2	Proxy CSCF (P-CSCF)	131
5.1.3	Interrogating CSCF (I-CSCF)	132
5.2	IMS Services	133
5.2.1	Push to Talk over Cellular (PoC) Service	133
5.2.1.1	Service Authentication	133
5.2.1.2	Floor Information Management	133
5.2.1.3	Message Duplication and Transmission in 1-to-n Communication	133
5.2.2	IMS-Based FMC Service	134
5.2.2.1	CSCF	134
5.2.2.2	PDG	134
5.2.3	IMS-Based IPTV Service	134
5.3	QoS Control and Authentication	135
5.3.1	QoS Control in NGN	135
5.3.2	RACS	136
5.3.2.1	Functions Provided by RACS	136
5.3.2.2	Function Blocks Comprising RACS	137
5.3.3	Authentication in NGN	138
5.3.4	NASS	138
5.4	Network and Service Management for NGN	139
5.4.1	Introduction	139
5.4.2	Network Management Operation Requirements	141
5.4.3	Service Management Operation Requirements	142
5.4.4	Service Enhancement Requirements	143
5.4.5	B2B Realization Requirements	143

5.4.6	Compliance with Legal Restrictions Requirements	144
5.5	IMS Advantages	144
5.5.1	Reduction of Maintenance and Operating Cost	144
5.5.1.1	Reduction of Time Required for Introducing New Services (Time to Market)	145
5.5.1.2	Cost Merits	145
5.5.2	Roles of SDP and Development and Introduction of New Services	145
5.5.2.1	Positioning of SDP in NGN	145
5.5.2.2	Features of SDP	146
5.5.2.3	Examples of Application Servers	146
5.5.2.4	API	149
5.5.3	Services Implemented on NGN	150
5.5.3.1	Push to X	150
5.5.3.2	IPTV	151
5.5.3.3	IPTV Architectures	151
5.5.3.4	Advantages of NGN (IMS-based) IPTV	152
5.6	References	153
5.7	Suggested Further Reading	153

**CHAPTER 6** *NEXT GENERATION OSS ARCHITECTURE*

155

*Steve Orobec*

6.1	Introduction	155
6.2	Why Are Standards Important to OSS Architecture?	156
6.3	The TeleManagement Forum (TM Forum) for OSS Architecture	158
6.4	Other Standards Bodies	159
6.5	TM Forum's Enhanced Telecommunications Operations Map (eTOM)	159
6.5.1	Relationship to ITIL (Infrastructure Technology Information Library)	162
6.6	Information Framework	163
6.7	DMTF CIM (Distributed Task Force Management)	165
6.8	TIP (TM Forum's Interface Program)	166
6.9	NGOSS Contracts (aka Business Services)	167
6.10	MTOSI Case Study	170
6.10.1	Will Web Services and MTOSI Scale?	170
6.11	Representational State Transfer (REST)—A Silver Bullet?	176
6.12	Real Network Implementation of a Standard	177
6.13	Business Benefit	179
6.14	OSS Transition Strategies	181
6.15	ETSI TISPAN and 3GPP IMS	182
6.16	OSS Interaction with IMS and Subscriber Management (SuM)	183
6.17	NGN OSS Function/Information View Reference Model	187
6.18	Designing Technology-Neutral Architectures	189
6.19	UML and Domain Specific Languages (DSLs)	189
6.20	An Emerging Solution: The Domain Specific Language	192
6.21	From Model-Driven Architecture to Model-Driven Software Design	193
6.22	Other Standards Models (DMTF CIM, 3GPP, and TISPAN)	194
6.23	Putting Things Together: Business Services in Depth	195
6.24	Building a DSL-Based Solution	200
6.24.1	Problem Context	200
6.24.2	Proposed Initial Feature Content	200

- 6.24.2.1 Desired Inputs **200**
- 6.24.2.2 Desired Outputs **201**
- 6.24.3 Open-source Tool Environments **201**
- 6.25 Final Thought **205**
- 6.26 Bibliography **205**

---

**CHAPTER 7** *MANAGEMENT OF WIRELESS AD HOC AND SENSOR NETWORKS* **207**


---

*Mehmet Ulema*

- 7.1 Introduction **207**
- 7.2 Overview **208**
  - 7.2.1 Wireless Ad Hoc Networks **209**
  - 7.2.2 Wireless Sensor Networks **210**
  - 7.2.3 Wireless Ad Hoc Networks vs. Sensor Networks **211**
  - 7.2.4 Network Management Aspects and Framework **212**
- 7.3 Functional and Physical Architectures **213**
- 7.4 Logical Architectures **214**
- 7.5 Information Architectures **216**
  - 7.5.1 Manager-Agent Communication Models **217**
  - 7.5.2 Management Interfaces and Protocols **223**
  - 7.5.3 Structure of Management Information and Models **223**
  - 7.5.4 Others **228**
- 7.6 Summary and Conclusions **228**
- 7.7 References **229**

---

**CHAPTER 8** *STRATEGIC STANDARDS DEVELOPMENT AND NEXT GENERATION MANAGEMENT STANDARDS* **231**


---

*Michael Fargano*

- 8.1 Introduction **231**
  - 8.1.1 General Drivers for Standards **232**
  - 8.1.2 Management Standards History **232**
- 8.2 General Standards Development Process **233**
  - 8.2.1 Key Attributes of Standards Development Process **234**
  - 8.2.2 General SDO/Forum Types and Interactions **235**
  - 8.2.3 General Standards Development and Coordination Framework **235**
    - 8.2.3.1 Project Execution and Cross-Organization Interactions and Handoff Points **238**
- 8.3 Management SDO/Forum Categories **239**
  - 8.3.1 General Network/Service SDO/Forum **239**
  - 8.3.2 Specific Network/Service SDO/Forum **239**
  - 8.3.3 Information Technology SDO/Forum **239**
  - 8.3.4 Management-Standards Focused SDO/Forum **240**
- 8.4 Principles, Frameworks, and Architecture in Management Standards **240**
  - 8.4.1 Principles and Concepts in Management Standards Development **240**
  - 8.4.2 Frameworks and Architecture **241**
- 8.5 Strategic Framework for Management Standards Development **244**
  - 8.5.1 Strategic Questions for Standards Engagement Determination **244**
  - 8.5.2 Strategic Progression of Standards Work **245**
  - 8.5.3 Strategic Human Side of Standards Development **245**

**xiv** CONTENTS

8.6 Sampling of NGN Management Standards Areas and SDO/Forums 245

8.7 Summary and Conclusions 248

8.7.1 Chapter Summary 248

8.7.2 General Standards Development Process 248

8.7.3 Management SDO/Forum Categories 248

8.7.4 Principles, Frameworks, and Architecture in Management Standards 248

8.7.4.1 Principles 248

8.7.4.2 Frameworks and Architecture 249

8.7.5 Strategic Framework for Management Standards Development 249

8.7.5.1 Strategic Progression of Standards Work 249

8.7.5.2 Strategic Human Side of Standards Development 249

8.7.6 Key Lessons Learned for Strategic NGN Management Standards Development 250

8.7.7 Challenges and Trends 250

8.8 References 250

**CHAPTER 9** *FORECAST OF TELECOMMUNICATIONS NETWORKS  
AND SERVICES AND THEIR MANAGEMENT (WELL)  
INTO THE 21ST CENTURY*

253

---

*Roberto Saracco*

9.1 Have We Reached the End of the Road? 254

9.2 “Glocal” Innovation 257

9.3 Digital Storage 259

9.4 Processing 261

9.5 Sensors 262

9.6 Displays 263

9.7 Statistical Data Analyses 265

9.8 Autonomic Systems 267

9.9 New Networking Paradigms 268

9.10 Business Ecosystems 270

9.11 Internet in 2020 274

9.12 Communication in 2020 (or Quite Sooner) 276

9.13 References 280

*INDEX*

281

---

## *GUEST INTRODUCTION*

Rapid progress in information and communications technology (ICT) induces improved and new telecommunications services and contributes greatly to society in general and to vendors and network and service providers. In addition to existing services such as telephony or leased line services, spread of the Internet, the Internet Protocol (IP) phone, and new communications services like IPTV are making great progress with the development of digital subscriber lines (DSL) and high-speed communications technologies like fiber to the home (FTTH). Furthermore, with the deployment of Next Generation Networks (NGNs), development of still newer services is anticipated. Construction of NGNs, in accordance with standards specified by international standardization organizations and feasibility studies and investigations, have begun in Japan and many countries around the world. The amount of information that a user can exchange has been expanding exponentially. Services can be used simultaneously (anywhere, anytime, and any device) and seamlessly with the development of broadband wireless access technology in NGN. Moreover, since service and application functions are separated and transport functions are independent from access technologies such as xDSL, FTTH, WiFi, WiMAX, Third Generation (3G), and Long Term Evolution (LTE), services of fixed and mobile communications are also unified. Furthermore, since the service and application functions consist of several common components, cooperation with third party applications becomes easier, resulting in practical use of various kinds of existing communications services (e.g., IT-based services and broadcasting services). Simultaneously, network reliability and security are also improving with the development of related technologies. In summary, NGN creates a new market by offering new services and rejuvenates markets such as career, enterprise, IT, and broadcasting businesses with new business models.

Maintaining the outstanding aspects of the existing network, NGN aims at larger scale, higher quality, and greater reliability. NGN is considered the biggest turning point in the history of communications. Although the present Internet provides services very conveniently for a user, the design of the Internet as a social infrastructure is inadequate. NGN can apply the technology of the Internet, can realize service level agreements (SLAs) and can provide mission-critical services. Users can choose high-price services for mission critical systems, medium-price services with high security, and low-price services as seen with the existing Internet. Wide-area client/server systems, which have high investment cost, were difficult to realize but will become realizable in NGN with the availability of super-mass storage systems. These allow integrated servers using the high-quality network services offered by NGN. As services spread for individual subscribers using NGN, IPTV, and voice over data, with development of NGN, a higher-definition video can be provided inexpensively.

Software as a Service (SaaS), using NGN will develop for business users. A reliable SaaS solution can be offered with security and SLA features that guarantee quality-of-service to each user of NGN. NGN will be ubiquitous. If information from rain sensors deployed all over a country is transmitted via NGN and processed and analyzed by a server, accurate weather forecasts will become reality. NGN will connect the medical systems of an area. If a doctor and residents can share medical information via the service of “virtual visits” by medical specialists in remote areas then we can offer medical consultation, medical checkup, etc. If a mobile IP network with an access speed of 100Mbps is available, the distinction between mobile and fixed networks will diminish. NGN applications can be common to mobile networks and fixed networks. The wide area client/server system, which unifies mobile and fixed networks, will be completed by 2012. NEC Corporation has advanced communications and computers (C&C) as a concept, marrying communications and computers. NEC has been working on research and development of the future architectures realizing long-term C&C goals and views NGN as the field that realizes the philosophy of C&C.

This book aims at deepening the understanding of NGNs, services, service management technologies, Operations Support Systems (OSS), cable services, IP Multimedia System (IMS) and convergence services, ad hoc networks, sensor networks, etc. The book provides detailed explanations of latest technology trends. I am pleased and honored to provide the introduction to this book, which will promote your understanding and construction of NGN. I believe that an important benefit of NGN is further fullness to society and personal lives. I also believe that NGN further expands economic activities and can contribute to ecosystems by, for example, measuring climate change and global warming via efficient network deployment and management.

*Botaro Hirosaki*  
*Senior Executive Vice President and Board Member, NEC*

---

## *GUEST INTRODUCTION*

To say that we live in the information age is, of course, a cliché, and a 20-year-old cliché, at that. But the fact that it is a cliché doesn't make it any less true. Communications networks developed over the last two decades have profoundly changed how we carry out our everyday lives—how we exchange information, engage in commerce, form relationships, entertain ourselves, protect ourselves, create art, learn, and work. The convergence of communications and computing, long anticipated, is now a fact.

The “modern” communications industry is actually more than 130 years old. For almost all of that history, the industry's goal has been the reliable delivery of a particular kind of analog signal—first speech, then music, then video—over links and networks established for *only that signal*. It is only since the two-pronged emergence of the Internet and mobile telephone networks that we have been able to glimpse the splendid opportunities made possible by multimedia networks operating over a diversity of channels—wireless, wireline, and cable—delivering a wide array of content to an assortment of devices, including PCs, notebooks, TVs, mobile phones, and PDAs.

But as communications networks have become more complex and the services offered over those networks have become more diverse and numerous, the problem of managing networks has become profound. Different types of data mean different requirements in terms of latency, quality-of-service, and security. Different types of communications media mean significantly different operating environments in terms of delay, reliability, and bandwidth efficiency. Fortunately, the Telecommunications Management Network (TMN) model offers system designers a framework for interconnectivity across heterogeneous networks. It is an architecture that enables network management and provides a “handle” to engineers and computer scientists seeking to design products and services that will become part of the information infrastructure.

This book goes beyond the Network Management Layer (NML) of TMN to the Service Management Layer (SML) and business frameworks. As new services and “apps” are rolled out every day—new ways to use your smartphone or your home network that you have not yet envisioned—the challenge of managing those new capabilities, efficiently and securely, and their solutions, are addressed in this book. Its chapters describe some of the latest multimedia services offered by the telecom and cable industries and provide insight into how they are best managed. It looks ahead to IP-based next-generation telecommunications networks, services, and management, as well as ad hoc and sensor networks. This book offers a vision of how pervasive, heterogeneous, and converged multimedia networks will be deployed and managed well into the 21st century.

What role will academia play in this evolutionary (and, sometimes, revolutionary) process? It will be a fundamentally important role. Universities will continue to educate the designers, managers, and implementers of these networks and carry out the long-term, basic research that will help enable the next generation of networks. As teachers, we have the obligation to make sure that graduating electrical and computer engineers and computer scientists understand the fundamental properties of heterogeneous information networks. As researchers, we have the opportunity to use our tools—modeling, analysis, simulation—and our imaginations, to fashion better networks and to manage them more efficiently, securely, and robustly.

*Thomas Fuja*  
*Chair, Electrical Engineering, University of Notre Dame*

*Peter Kilpatrick*  
*McCloskey Dean of Engineering, University of Notre Dame*

---

## *EDITOR AND CONTRIBUTOR BIOGRAPHIES*

**Jean Craveur** presently heads the France Telecom Group Transverse Mission and is in charge of preparing the group networks transformation from PSTN to NGN/IMS. He has previously steered, in France Telecom, the IT and Network overall architecture and strategy department and headed the R&D center on core network. He held several responsibilities in international telecommunication organizations: as a member of the International Experts Group, which wrote the first CCITT N°7 signaling specifications; as chairman of the CEPT and ETSI Subtechnical Committee, which issued the roaming architecture and signaling for the GSM system; as chairman of the “Network Group” of the European Cooperation on ISDN; and, finally, as vice chairman of the ETSI Technical Committee on Signalling Protocol and Switching. He was also one of the vice presidents for Europe in the TINA Consortium. Jean Craveur has published several papers related to signaling and telecommunication networks in telecommunication reviews and presented in the International Switching Symposium (ISS). He graduated from Ecole Nationale Supérieure de l’Aéronautique et de l’Espace (SUP’AERO) and holds a masters in economic science from Université des Sciences Sociales in Toulouse and a diploma in automatic and complex systems from Ecole Nationale Supérieure de l’Aéronautique et de l’Espace.

**Michael Fargano** has broad telecommunications industry leadership responsibility and is the current Industry Standards Program Manager at Qwest Communications International. His career spans more than 25 years and is grounded in leadership in many successful telecommunications R&D projects, advanced systems architecture and engineering projects, and standards projects such as AIN, TMN, 3G wireless, NGN, emergency services, and security management at several well-known and respected telecommunications companies/departments such as Bell Labs, Bellcore, US WEST Advanced Technologies, and Qwest. In addition, he has been an adjunct instructor at several institutions and universities including Bell Labs, Stevens Tech, University of Denver, and University of Colorado, covering a wide variety of engineering topics including telecommunications network management and standards. He was chairman of several standards committees and is a sought-after leader in standards development, for which he was honored with several industry awards including the ANSI Meritorious Service Award and ATIS Leadership in Standards Development Award. He also holds several patents. He graduated in 1980 from a special simultaneous bachelor/master program in general engineering and electrical engineering at the Stevens Institute of Technology. He also holds an advanced business/technology management graduate certification from the University of Denver–Daniels College of Business, with a specialty in Strategic Program Management.

**David Jacobs** is chief technical officer in the Amdocs Broadband, Cable & Satellite Division with responsibility for driving Amdocs products strategy for Cable MSOs and Satellite operators who provide next generation services to residential and commercial customers. He joined Amdocs following the acquisition of Jacobs Rimell by Amdocs in April 2008. As co-founder and CTO of Jacobs Rimell, he was responsible for the company's technology and product direction, enabling it to become one of the leading providers of customer-centric fulfillment solutions for the cable industry. Previously, he spent 11 years with Reuters in a number of senior roles, culminating in the deployment of a global frame relay infrastructure and one of the world's first global IP extranets for the delivery of Reuters' information services. He holds a BSc in electrical and electronics engineering from Middlesex Polytechnic, London and a Full Tech City and Guilds Certificate in Telecommunications. He holds two U.S. patents and contributed to a third.

**Keizo Kawakami** is a project manager in the Network Management Systems Division of the Network Software Operations Unit of NEC. He joined NEC in 1989 and he has been engaged in software development of mobile, satellite, and fixed networks management systems for 15 years. He is now in charge of strategic planning and development of service and management solutions for mobile and fixed operators. He is a principal contact of the TeleManagement Forum (TMF) in NEC.

**Kaoru Kenyoshi** is a chief manager in the first Carrier Solutions Operations Unit of NEC. He joined NEC in 1984. He has been engaged in software development for ISDN switching systems and B-ISDN for 10 years. From 1995 to 2000, he worked as a manager in the planning division for switching systems and was in charge of strategic planning for services and products of switching systems for the carrier market. From 2000 to 2006, he worked as a general and chief manager in the sales and solution department for fixed and mobile networks. He is now in charge of promotion of NGN and IPTV solutions for fixed and mobile operators. He is very involved in standardization activities and is leader of the IPTV Network Architecture Sub-working Group and member of the Strategy Committee of TTC in Japan and one of the vice chairman of ITU-T SG11.

**Bhumip Khasnabish**, PhD, is a Senior Member of IEEE and a Distinguished Lecturer of the IEEE Communications Society (ComSoc). He is a Director in the Standards Development and Industry Relations Division of ZTE USA Inc. with responsibility to set direction, goal, and strategy of the Company for Next Generation Voice over IP (VoIP) and peer-to-peer (P2P) multimedia services. Previously, Bhumip was a Distinguished MTS of Verizon Network & Technology in Waltham, MA, USA. He is the founding chair of the recently created ATIS Next Generation Carrier Interconnect (NG-CI) Task Force. Bhumip also founded MSF Services Working Group, and led the world's first IMS-based IPTV Interop during GMI08. At Verizon, he focused on NGN and Carrier Interconnection projects related to delivering enhanced multimedia services. He also represented Verizon in the Standards activities of MSF and ATIS NG-CI. An Electrical Engineering graduate of the University of Waterloo and the University of Windsor (both in Ontario, Canada),

Bhumip previously worked at Bell-Northern Research (BNR) Ltd. in Ottawa, Ontario, Canada. While at BNR he initially designed, implemented, and then led the implementation of trunking and traffic management software modules for BNR's flagship Passport® multi-service switching product. Dr. Khasnabish has authored/co-authored numerous patents, books, chapters, technical reports, Industry Standards contributions, and articles for various international archival journals, magazines, and referenced conference proceedings. His recent book entitled, "*Implementing Voice over IP*" [ISBN: 0-471-21666-6] is currently in its second printing. Previously, he edited/co-edited "*Multimedia Communications Networks: Technologies and Services*" [ISBN-10: 0890069360, ISBN-13: 978-0890069363], and many Special Issues of *IEEE Network*, *IEEE Wireless Communications*, *IEEE Communications Magazines*, and the *Journal of Network and Systems Management (JNSM)*. He is also a member of the Board of Editors of the JNSM, and an adjunct faculty member of Brandeis University, Bentley University, and Northeastern University.

**Toshiyuki Misu** is a chief manager of the Network Software Operations Unit, NEC Corporation. Since he joined NEC, he has been engaged in software development of digital switching systems, Intelligent Networks, VoIP, IMS/NGN, and Service Delivery Platform. He is now in charge of NGN Service Promotion and Service API Standardization. From 1991 to 1992, he was a visiting researcher of CTR (Center for Telecommunications Research), Columbia University.

**Steve Orobec** is British Telecom's (BT) lead OSS standards manager and enterprise architect. The focus of his work is in the TM Forum, where he is the leader of the architecture harmonization team. He also leads the BT OSS team in ETSI TISPAN Working Group 8, collaborating with 3GPP to specify IMS/NGN management systems and solutions for integrating them into OSS. He has also represented BT at ITU Study Group 4 meetings. He has worked in all parts of the software lifecycle from validation and test, software development, solution design, and architecture during his 17 years at BT. He reports at director level and co-ordinates his activities to ensure that BT's requirements are represented in the TM Forum and that TM Forum standards are utilized in BT's OSS. He is currently responsible for developing an automated, standards-based OSS management solution that will reduce BT's OSS costs and increase agility. He holds a degree in physics and astrophysics from Leicester University.

**Thomas Plevyak** is a past president of the IEEE Communications Society (ComSoc). He has served as ComSoc's editor-in-chief of *IEEE Communications Magazine*, director of publications, and Member-at-Large of the Board of Governors. Mr. Plevyak is an IEEE Fellow for contributions to the field of Network Management. He is a Distinguished Member of Technical Staff in Verizon's Network & Technology organization, currently responsible for domestic and international wireline and wireless operations and network management standards. He holds a BS in engineering from the University of Notre Dame, an MS in engineering from the University of Connecticut, a certificate from the Bell Laboratories Communications Development Training (CDT) program and an MS in advanced management from Pace University. He is co-editor of *Telecommunications Network*

*Management into the 21st Century*, as well as a series of six books in the field of network management. He is the author of many technical publications and holds two U.S. patents.

**Veli Sahin**, Ph.D., is senior director of Business Development at NEC Corporation of America in Irving, Texas. Previously, he held management and leadership positions at Bell Laboratories, Bellcore, Samsung, and Marconi. He has been working in the area of Telecommunications Networks for over 25 years. His current interest includes Next Generation Networks (NGN), IP Multimedia Subsystems (IMS), Triple/Quad Play Services, IPTV Services, development of TMN-based management systems and wireline/wireless national and global information infrastructures for the 21st century. Dr. Sahin has over 100 internal and external publications, is co-author of an IEEE Press book chapter and co-editor of the IEEE Press Book Series on Network Management. He received an MS and PhD (multi-hop packet radio networks) in computer science and an MS in electrical engineering at Polytechnic University, Brooklyn, New York. He also received a BS in electronics engineering at Istanbul Technical University, Istanbul, Turkey. He received IEEE/IFIP The Salah Aidarous Memorial Award in 2008 for his contributions to IT and Telecommunications Network Management. He was general chair of the 1998 and 2002 Network Operations and Management Symposium, co-founder and first chair of the IEEE ComSoc Technical Committee on Information Infrastructure (from 1995 to 1998), and chair of the IEEE ComSoc Technical Committee on Network Operations and Management (from 1998 to 2000). Dr. Sahin was also a member of the editorial board and/or advisory board of several respected journals. He is currently MSF Board Member and also project leader for the NEC MSF and Verizon VIF Interoperability Testing (IOT) activities.

**Roberto Saracco** holds a bachelor's degree in computer science, a master's degree in math, and a postdoctoral degree in physics. He joined Telecom Italia in 1971, contributing to the development of the first SPC system in Italy. Through the years he worked on data transmission, switching, and network management. In the last 10 years he has worked on the economic side of telecommunications, creating and directing a research group at the Future Centre in Venice. Author of many papers and nine books in the field of telecommunications, with the last five on the topic of living and communicating in the next decade, he has worked on the foresight Panel of the European Commission, charged to imagine the Internet beyond 2020. He is currently director of Telecom Italia Future Centre, in Venice, and co-chair of the Edge-Core group of the Communications Future Program of MIT. He is a senior member of IEEE ComSoc, serving in many roles, including TC secretary, NM chair, and vice president of Membership Relations. He is currently ComSoc's director for Sister- and Related-Societies.

He received the Salah Aidarous Award in 2005 for his contribution to network management and the 2007 Donald McLellan Meritorious Service Award for his contribution to strengthening the Communications Society presence worldwide.

**Mehmet Ulema** is a professor at the Computer Information Systems Department at Manhattan College, New York. Previously, he held management and technical

positions in Daewoo Telecom, Bellcore (now Telcordia), AT&T Bell Laboratories, and Hazeltine Corporations. He has numerous publications in various international conferences and journals. He holds two patents. He gave a number of talks and tutorials on Network management and wireless networks. He is on the editorial board of the IEEE Transactions on Network and Service Management, the ACM Wireless Network Journal, and the Springer Journal of Network and Services Management. He is an active Senior Member of IEEE. He served as the chair and co-founder of the IEEE Communications Society's Information Infrastructure Technical Committee. Previously he served as the chair of the Radio Communications Technical Committee. He is involved in a number of major IEEE conferences as technical program chair (Globecom 2009, ICC 2006, CCNC 2004, NOMS 2002, ISCC 200). He was a general chair of NOMS 2008. He received MS & Ph.D. in Computer Science at Polytechnic University, Brooklyn, New York. U.S.A. He also received BS & MS degrees at Istanbul Technical University, Turkey.



# *CHANGES, OPPORTUNITIES, AND CHALLENGES*

*Veli Sahin and  
Thomas Plevyak*

## **1.1 INTRODUCTION**

---

Never have telecommunications operations and network management been so important. Never has it been more important to move away from practices that date back to the very beginning of the telecommunications industry. Building and connecting systems internally at low cost, on an as-needed basis, and adding software for supporting new networks and services without an overall architectural design will not be cost effective for the future. Defining operations and network management requirements at the 11th hour for new technologies, networks, and services deployments must also change. Planning and deployment of all aspects of telecommunications leading to Next Generation Networks (NGN) and services must be done in unison to achieve effective and timely results.

The need for new approaches can be seen everywhere in the global telecommunications industry. Competition in telecommunications can turn players into victims if functional and cost-effective operations and network management requirements are not deployed quickly. Technology advancements in this field have been enormous. Operations and network management technologies make new approaches a reality in designing NGN services.

The point of departure for architected network management systems will be NGN and services. Points of departure can't be expected to initially play out with incrementally lowest cost. There can be initial added costs, but the operations and network management setting put in place will make the next network and service less costly, with more rapid implementation than would otherwise have been the case. Telecommunications network and service providers will find themselves on a fully competitive playing field.

## 1.2 SCOPE

---

This book discusses NGN architectures, technologies, and services introduced in the last decade, such as Triple Play / IPTV [1] and services that are expected to become increasingly deployed in the coming decade such as Time Shift TV (TSTV), network Private Video Recording (nPVR), multi-screen video services, triple-shift services, location- and presence-based services, blended and converged services, etc.

In addition, this book also focuses on the Service Management Layer (SML) of the Telecommunications Management Network (TMN) [2]. In the past 30-plus years, the global industry spent considerable time and resources developing Element Management Systems (EMSs), Network Management Systems (NMSs), and Business Management Systems (BMSs). Changes in life style (expectations, viewing habits, calling habits, shopping habits, etc.), technologies, and the competitive business environment are now moving the industry to pay attention to Service Management Systems (SMSs).

Internet access, cellphones, laptops, and DVRs are integral to our lives today. How many of us can live a day without them? Daily personal and business lives are completely dependent on telecommunications services. End-to-end management of those services and Quality-of-Service (QoS) management and identification and management of Quality-of-Experience (QoE) metrics are very important to improve standards of living and increase productivity. Examples of QoE are quality-of-picture, channel switching time, easy use of user interface/programming guide, request response time, etc.

This is the seventh book in the IEEE Network Management Series. It follows the same approach as the first book in the series, *Telecommunications Network Management into the 21<sup>st</sup> Century*, published in 1994 [2], and the second, *Telecommunications Network Management Technologies and Implementations*, published in 1998 [3]. It is an orchestrated set of original chapters, written expressly for the book by a team of global subject experts. This is a technical reference book and graduate textbook.

## 1.3 CHANGES, OPPORTUNITIES, AND CHALLENGES

---

This section briefly discusses major changes and how service providers (SPs) and SMS vendors use this as an opportunity to develop solutions that address expectations of their customers. SPs work to offer new services such as IPTV, multi-screen, triple-shift, blended and converged services, etc. Vendors and SPs work to provide new SMS applications to manage those new services.

Today's users want to communicate, watch, shop and make payments, etc. anytime, anywhere, and with any device. This is a major paradigm shift and has major impact in designing NGNs and services as well as management systems.

### 1.3.1 Major Life Style Changes: Desktops, Laptops, and Now Handtops

We all know how personal computers (PCs) have changed our lives during the last two decades. First, we started with desktop PCs and then started using more and

more laptop PCs, especially in last 10 years or so. Laptops allow us to carry our PC with us anywhere we go and use it. With wireless and mobile Internet access, users access the Internet anywhere and anytime. We can send and receive e-mails and exchange files at any time, from anywhere. Voice applications allow us to call and talk with anyone in the world who has a PC or a phone. PC-to-PC calls are free and PC-to-phone calls cost less than traditional calls.

Many of our traditional daily habits have been changing too—watching, calling, shopping, making payments, and many more. These changes affect the way we do business in many industries.

It wasn't so long ago that we watched a movie, a video, or a program just using the TV and made phone calls using only wireline phones. Today, we also use PCs to watch programs and wireless phones to make a great many of our phone calls. In more and more families and businesses, wireline phones are used for special cases (conference calls, interviews, other business calls, etc.). Increasingly, people do not have wireline phones. They use their cell phones. They watch TV programs using their laptops and/or "handtops." Handtops are mini personal computers such as iPhones and BlackBerry phones. Even though we refer to them as phones, they are small laptops, used to access the Internet, send/receive e-mails, make phone calls, etc. Millions use the Internet to shop, pay their bills online and manage their bank accounts. As a result, security management (SM) has risen to become a first priority concern.

In the future, user-generated content (UGC) will play a major role in designing NGNs, service, and management systems.

### 1.3.2 Major Network Infrastructure Changes

The first major network infrastructure change was to shift from time-division multiplexing (TDM) to statistical multiplexing. NGNs are now based on packet switching technologies rather than TDM. Internet Protocol (IP) became the winner. Today, NGNs are becoming IP-based packet-switched networks, end-to-end, including backbone, metro, and access networks. This is important because it caused a paradigm shift in Fault, Configuration, Accounting, Performance, and Security (FCAPS) operations and network management applications and in SP concerns, which we will discuss later in this section.

The second major change is the use of more and more wireless and mobile technologies in NGNs. Billions of cellphones are in use worldwide, and the number will continue to grow. The concept of telecommunicating (via phone or e-mail) and Internet access at any time and any place has become a reality.

The third major change is just starting and will be rapidly taking place in the next few years. This change is IP Multimedia Subsystems (IMS)-based signaling and control to replace traditional signaling systems. IMS will provide an end-to-end platform to offer most new services and, therefore, will eliminate current silos. With IMS signaling and control, many advanced location- and presence-based services will become a cost-effective reality. IMS is also expected to solve the problem of rapid introduction of new services at less cost. Details of IMS can be found in Chapter 5.

Finally, development and deployment of Service Delivery Platforms (SDPs) with open Application Programming Interfaces (APIs) for third-party application

development will have major affects in introducing next-generation advanced services quickly and in more cost effective ways.

### 1.3.3 Major Home Network (HN) Changes

Residential customer premises networks, also called Home Networks (HNs), are now becoming extensions of SPs' networks.

Home connectivity is evolving from narrowband to broadband. SPs have deployed the technology needed to offer larger bandwidth with cable, xDSL, or fiber technologies. The Internet has been a major driver for evolution to broadband, creating a new experience for customers and offering new services, such as fast Internet browsing, video-on-demand (VoD), online shopping and banking, and digital video recording (DVR), while providing broadband connectivity among many devices at home such as PCs, TVs, Set Top Box (STBs), DVRs, residential gateways (RGs) / home gateways (HG), game consoles, etc.

The main drivers for home networking that exist today are as follows:

1. As media become increasingly digital in nature (online music and video, digital photos etc.), consumers want to share content and listen to or display it on other, more consumer-friendly devices such as TVs, etc. This requires customers to connect their digital content storage devices (e.g., PCs, MP3 players, private video recorders (PVRs), and digital cameras/camcorders) to their entertainment systems over a home network.
2. More and more customers want to use digital voice and video. This is due mainly to the attractive price using triple play services. These new voice and video services should be capable of being received on a range of mobile consumer devices (laptops, mobile phones, etc.).
3. Devices such as laptops that are WiFi-enabled are encouraging consumers to access the Internet, work, and/or watch videos wherever it is convenient in the home.

Management and control of home networks have become a strategic challenge for SPs all over the world. Problems in home networks affect QoS and customers' experiences. Therefore, all SPs have been developing strategies to provide RGs / HGs as part of their triple play services.

### 1.3.4 Major FCAPS Changes

As stated previously, FCAPS stands for Fault Management (FM), Configuration Management (CM), Accounting Management (AM), Performance Management (PM) and Security Management (SM). Readers who are not familiar with basic FCAPS functions should read the FCAPS sections in [2] or brief further details in Chapter 4.

In the past, when networks were based on circuit switching, FM was a first-priority application, followed by CM, AM, PM, and SM. PM and SM functions were considered to have least priority in circuit switched/TDM networks. FCAPS has