Service Provision

Technologies for Next Generation Communications

Edited by

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Contents

List of Contributors **xv**

Preface **xvii**

Part I: Network Support for Services **1**

1 Introduction and Context **3**

Kenneth J. Turner, Evan H. Magill and David J. Marples

1.1 Communications Services 3
1.2 Network Support for Services 4
1.3 Building and Analyzing Services 4
1.4 The Future of Services 6

2 Multimedia Technology in a Telecommunications Setting **7**

Alistair McBain

2.1 Definition of Multimedia 8
2.2 Market Drivers for Multimedia 9
2.2.1 User expectations 9
2.2.2 Need for new revenue streams 10
2.2.3 Effect of the Internet 10
2.2.4 Content 10
2.2.5 Increasing mobility 11
2.2.6 Converged networks 11
2.2.7 Charging for multimedia services 11
2.2.8 Public network performance 12
2.2.9 Ensuring Quality of Service (QoS) 13
2.3 Standards for Multimedia Services 13
2.3.1 International Telecommunications Union (ITU) 13
2.3.2 Internet Engineering Task Force (IETF) 14
2.3.3 International Organization for Standardization (ISO) 15
2.3.4 The Open Mobile Alliance (OMA) 18
2.3.5 Proprietary standards 18

2.4 Multimedia Services and their Constituent Media Components 19
2.4.1 Media components 19
2.4.2 Attributes of a multimedia connection 21
2.4.3 Examples of multimedia services 23
2.5 Interworking between Multimedia and Traditional Voice 25
2.6 Terminal Equipment and User Interfaces 26
2.7 The Future 27

3 Call Processing **29**

Graham M. Clark and Wayne Cutler
3.1 The Beginnings of Call Processing 29
3.2 Key Attributes of Call Processing Systems 30
3.2.1 User and network interfaces 31
3.2.2 Number translation and route selection 32
3.2.3 User subscription data 34
3.2.4 Resource and switch control 34
3.2.5 Generation of call recording data 35
3.3 Switch Architectures and Call Models 36
3.3.1 Half call model 36
3.3.2 Three segment model 37
3.3.3 Multi-segment model 37
3.3.4 Mobile switches 39
3.3.5 Implementation of call models 41
3.4 Switch-Based Services 42
3.4.1 PSTN services 42
3.4.2 ISDN services 43
3.4.3 Feature interaction 43
3.5 Call Processing for Intelligent Networks 44
3.5.1 Triggering 44
3.5.2 Service switching 44
3.5.3 The IN and feature interaction 45
3.5.4 The IN and mobility 45
3.6 Softswitches 45
3.6.1 Softswitch definition 46
3.6.2 Capabilities 48
3.6.3 Developments 49
3.7 Future 51

4 Advanced Intelligent Networks **53**

Robert Pinheiro and Simon Tsang
4.1 History of the Intelligent Network (IN/AIN) 53
4.2 Intelligent Network Architecture 55
4.2.1 AIN and ITU-T IN architectures 55
4.2.2 Differences between AIN (USA) and ITU-T (International) Intelligent Network architectures 60

4.3 Components of IN Service Delivery 60
4.3.1 Service Switching Point 60
4.3.2 Service Control Point 65
4.3.3 Intelligent Peripherals (Specialized Resource Points) 66
4.4 Intelligent Network Services 66
4.4.1 Service examples 66
4.4.2 ITU-T CS 1 services 68
4.5 Assessment of Intelligent Networks 68
4.6 Future of Intelligent Networks 70

5 Basic Internet Technology in Support of Communication Services 73

Marcus Brunner
5.1 Introduction 73
5.1.1 Overview 73
5.1.2 The Internet standardization process 74
5.2 Transport Service Quality in the Internet 75
5.2.1 Plain old IP 75
5.2.2 Integrated Services 76
5.2.3 Differentiated Services 78
5.2.4 Multi-Protocol Label Switching (MPLS) 82
5.3 Internet Telephony 83
5.3.1 PSTN versus Internet 84
5.3.2 Session Initiation Protocol (SIP) 84
5.3.3 Media transport protocols (RTP, RTCP) 86
5.3.4 SIP services 86
5.4 Directory-Enabled Networks (DEN) 87
5.5 Open Services Gateway Initiative 88
5.6 Active Networks 89
5.7 Conclusion 92

6 Wireless Technology 93

James M. Irvine
6.1 Introduction 93
6.2 Cellular Systems 95
6.2.1 Introduction – the cellular principle 95
6.2.2 2G systems 96
6.2.3 Early data services 96
6.2.4 2.5G systems 97
6.2.5 3G services 97
6.2.6 3G technologies 98
6.2.7 Handover and location management 100
6.2.8 Mobile networks 101
6.2.9 Location technologies 104

6.2.10 Mobile satellite systems 104
6.2.11 Market trends 105
6.3 Private Mobile Radio 107
6.4 Broadcast 108
6.5 Local wireless 109
6.5.1 Introduction 109
6.5.2 Bluetooth and ZigBee 109
6.5.3 Cordless technologies 110
6.5.4 WLL 110
6.5.5 Fixed Broadband Wireless Access or WiMax 111
6.5.6 WLAN 111
6.5.7 Public access WLAN or Wi-Fi 111
6.5.8 Ultra-Wide Band 112
6.6 The Future of Wireless 112

Part II: Building and Analyzing Services 113

7 Service Management and Quality of Service 117

Pierre C. Johnson
7.1 Overview 117
7.2 What is Service Management? 118
7.2.1 Service Management historically 118
7.2.2 Service Management evolution 118
7.3 Service Level Agreements 119
7.4 Quality of Service 120
7.4.1 What is Quality of Service? 120
7.4.2 QoS attributes 120
7.4.3 Typical QoS trade-offs 121
7.4.4 Human factors and QoS 122
7.4.5 Service types as a function of QoS 122
7.4.6 QoS targets summarized 125
7.4.7 QoS in overload 126
7.4.8 QoS in failure conditions 128
7.4.9 QoS exceptions 128
7.4.10 QoS trends 129
7.5 Further Reading 129

8 Securing Communication Systems 131

Erich S. Morisse
8.1 Introduction 131
8.2 Cryptosystems 131
8.2.1 Symmetric key ciphers 132
8.2.2 Public key ciphers 133

8.2.3 Key management 134
8.2.4 Hashes 135
8.3 Authentication 135
8.3.1 Passwords 135
8.3.2 One-time passwords 136
8.3.3 Encryption key pairs 137
8.3.4 Biometrics 137
8.3.5 Digital signatures 137
8.3.6 Anonymity 138
8.4 Access Control 139
8.4.1 IP network permissions 140
8.4.2 Symmetric key encryption 141
8.4.3 Public key encryption 141
8.5 Security in Practice – Digital Cash 142
8.5.1 Design requirements 142
8.5.2 Purchasing protocol 143
8.5.3 Coin validity 143
8.5.4 Anonymity 144
8.5.5 Transferability 145
8.5.6 Divisibility 145
8.5.7 Revocability 146
8.6 Future 146
8.7 Further Reading 146

9 Service Creation 149

Munir Cochinwala, Chris Lott, Hyong Sop Shim and John R. Wullert II
9.1 Overview 149
9.2 Introduction 149
9.2.1 What is service creation? 149
9.2.2 Historical perspective 150
9.2.3 Simplifying service creation 151
9.2.4 Service creation in multiple networks 151
9.3 Services in the Public Switched Telephone Network 151
9.3.1 Example services 151
9.3.2 Intelligent Network architecture 152
9.3.3 Telephony creation environments 153
9.3.4 Integrated services 155
9.4 Internet-Based Data and Communication Services 156
9.4.1 Service architecture 156
9.4.2 The World Wide Web as a service platform 156
9.4.3 Service integration 157
9.4.4 Web services 158
9.5 Integrated Services 161
9.5.1 Challenges for an integrated network 161
9.5.2 Research trends 163

9.6 Service Introduction 164
9.6.1 Service support infrastructure 164
9.7 Conclusion 165
9.8 Further Reading 165

10 Service Architectures 167

Gordon S. Blair and Geoff Coulson
10.1 Introduction and Motivation 167
10.2 Early Developments 168
10.3 Current Architectures 170
10.3.1 RM-ODP – a meta-framework for distributed computing 170
10.3.2 Specific distributed object technologies 175
10.3.3 From objects to components 179
10.4 Applying the Technologies 182
10.4.1 The OMG's Telecommunications Domain Task Force 182
10.4.2 Middleware technology in open service provision 183
10.4.3 Middleware technology in programmable networking environments 184
10.5 Meeting Future Challenges 184
10.5.1 Emerging challenges 184
10.5.2 Emerging solutions 186
10.6 Conclusion 187

11 Service Capability APIs 189

John-Luc Bakker and Farooq Anjum
11.1 Introduction 189
11.2 Telecommunications Information Network Architecture 191
11.2.1 The TINA architecture 192
11.2.2 TINA and the service capability APIs 193
11.3 Java APIs for The Integrated Network 194
11.3.1 Call control in JAIN 196
11.3.2 Hands-on 198
11.4 The Parlay APIs 198
11.4.1 History 198
11.4.2 Motivation 199
11.4.3 Architecture 200
11.4.4 Procedure 201
11.4.5 Overview of Parlay APIs 202
11.4.6 Hands-on 210
11.5 Parlay X Web Services 210
11.5.1 Motivation 210
11.5.2 Architecture 211

11.5.3 Framework 211
11.5.4 The Parlay X Web services 213
11.5.5 Observations 214
11.6 Conclusion 214
11.7 Further Reading 215

12 Formal Methods for Services **217**

Kenneth J. Turner
12.1 What is a Formal Method? 217
12.1.1 Nature 217
12.1.2 Benefits and costs 218
12.1.3 Concepts and terminology 219
12.2 Classification of Formal Methods 220
12.2.1 Model-based 221
12.2.2 Logic 221
12.2.3 State-based 222
12.2.4 Algebraic 222
12.2.5 Structural 223
12.3 Formal Methods for Communications Services 223
12.3.1 OSI (Open Systems Interconnection) 223
12.3.2 ODP (Open Distributed Processing) 225
12.3.3 Other kinds of service 227
12.4 Formal Methods for Telecommunications Services 227
12.4.1 Model-based 228
12.4.2 Logic 228
12.4.3 State-based 229
12.4.4 Algebraic 229
12.4.5 Structural 230
12.5 Evaluation of Formal Methods for Services 231
12.5.1 Results 231
12.5.2 Prospects 232

13 Feature Interaction: Old Hat or Deadly New Menace? **235**

Evan H. Magill
13.1 Overview 235
13.2 Introduction 236
13.3 Feature Interaction in POTS 237
13.4 Response of the Communications Community 241
13.4.1 Response of researchers 241
13.4.2 Response of operators 243
13.4.3 Response of vendors 243
13.5 Regulatory Changes 244
13.6 Technological Changes 244
13.7 Future Services, Old Interactions 246

13.8 Future Services, Future Interactions 247
13.9 Future Services, More Complex Interactions 249
13.10 New Challenges, New Opportunities 249
13.11 Summary 250

Part III: The Future of Services **251**

14 Advances in Services **253**

James T. Smith
14.1 Introduction 253
14.2 Service Convergence 254
14.2.1 Metcalfe's Law 255
14.2.2 Sustaining service convergence 255
14.2.3 Disruptive service convergence 256
14.2.4 Finding common ground 256
14.3 Context: Putting Communications in Perspective 257
14.3.1 One simple example 257
14.3.2 Where is this thing called context? 258
14.3.3 A context logistics problem 258
14.3.4 Context management: the basics 259
14.3.5 Context management: a historical perspective 260
14.3.6 The end game: converged services through context 261
14.4 Context: the next killer service feature 262
14.4.1 Presence: personalized context management 262
14.4.2 Wireless meets presence management 264
14.5 Sharing Service Context 265
14.5.1 Messaging: a historical perspective 265
14.5.2 Messaging in all its flavors 266
14.5.3 Intelligent messaging 267
14.6 SIP: The Oil that makes Context flow 268
14.7 Discovering Service Context 269
14.7.1 Discovery characterized 269
14.7.2 Device discovery pot pourri 270
14.7.3 Discovering and interpreting location 271
14.7.4 Discovery not limited to physical entities 271
14.7.5 Negotiation extends discovery 272
14.8 The New Converged Home Network 273
14.8.1 The current state of affairs 273
14.8.2 Great opportunities for service convergence 274
14.9 Conclusion 277

15 Evolving Service Technology **279**

Peter Martin and Stephen Corley
15.1 Introduction 279

15.2 Software Agents 279
15.2.1 Introduction 279
15.2.2 Software Agents for service engineering 281
15.2.3 Discussion 284
15.3 Constraint Satisfaction 285
15.3.1 Introduction 285
15.3.2 Constraint Satisfaction for service engineering 285
15.3.3 Discussion 287
15.4 Artificial Neural Networks 288
15.4.1 Introduction 288
15.4.2 Artificial Neural Networks for service engineering 289
15.4.3 Discussion 290
15.5 Genetic Programming for Service Creation 290
15.5.1 Introduction 290
15.5.2 Genetic Programming for service creation 294
15.5.3 Discussion 297
15.6 Conclusions 297
15.6.1 Summary of evolving technologies 297
15.6.2 Barriers to the adoption of evolving technologies 298
15.6.3 Outlook for evolving technologies 298
15.7 Further Reading 298

16 Prospects 301

David J. Marples, Kenneth J. Turner and Evan H. Magill
16.1 Introduction 301
16.2 Technical Changes 301
16.2.1 Wireless service innovation 302
16.2.2 Fixed line service innovation 303
16.2.3 Service delivery 304
16.3 Service Environments 304
16.3.1 Location 304
16.3.2 Structure 305
16.3.3 Migration 306
16.4 Market Changes 308
16.4.1 Vehicle 308
16.4.2 Home 308
16.4.3 Personal Area Network 310
16.5 Commercial Changes 311
16.5.1 The Open Source movement 311
16.5.2 The role of copyright 312
16.5.3 Safety and security 313
16.6 And Finally . . . 313

Appendix 1 Abbreviations **315**

Appendix 2 Glossary **325**

Appendix 3 Websites **331**

Bibliography **333**

Index **359**

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Preface

Subject of this Book

Communications is a very broad subject. At one time, a distinction might have been made between computer communications (data networking) and telecommunications (public voice networking). However these two domains are rapidly converging, with the same network technologies being used to support data, voice, video, and other media.

Communications services provide useful facilities to end-users. Services therefore take a user-oriented rather than network-oriented view. Services are the financial basis of communications since they are directly responsible for operator revenues. The major developments in communications technology during the past decade have been driven by the services that can be sold to customers; technology in itself is not of interest to end-users. Operators also differentiate themselves in a highly competitive market by the services that they sell. A sound understanding of services is thus vital for anyone working in the communications domain.

The focus of the book is on technical issues. It deals with the technologies that support the development of services, as well as the networking aspects needed to support services. Commercial issues are important, such as pricing and selling communications services, but are not the subject of this book.

Aim of this Book

The aim of this book is therefore to present the broad sweep of developments in communications services. Because of the breadth of the subject, it can be difficult even for practitioners to understand what is happening outside their own specialist niches. Rapid technological changes also make it difficult to keep abreast. To fully understand current developments would require participation in many standards organizations, would need monitoring of many projects, and would necessitate many hours of reading emerging standards (many of them hard to come by except for committee members). This book aims to alleviate much of the difficulty by bringing together in one place the combined expertise of the contributors.

The book is designed to help anyone with a technical interest in communications services. This includes communications engineers, strategists, consultants, managers, educators and students. Although the book is written for the practicing engineer, it would also be suitable for self-study or as part of a graduate course on communications. It is assumed that the reader has a computing background and a general knowledge of communications.

Book Structure

The book has been divided up into self-contained topics. Each chapter can therefore be read in isolation. Although there is a logical progression in the book, chapters can be read in any order. The book can therefore be used for familiarization with the field, reading the chapters

in the order written; the book can also be used for reference, reading individual chapters for more depth on particular topics.

However certain topics such as call processing, quality of service, service architecture, and feature interaction tend to be recurring themes. They are touched on where relevant, but can be studied in more depth in the specialist chapters on these topics.

Part I (Network Support for Services) considers how networks support communications services. *Chapter 1 (Introduction and context)* sets the scene for the whole book. It overviews the nature of communications services and the approaches taken to developing them. *Chapter 2 (Multimedia technology in a telecommunications setting)* explains how communications services have grown rapidly to include multimedia as a central provision. The issues surrounding multimedia are explored, presenting the key standards that support multimedia services. *Chapter 3 (Call processing)* explains the major aspects of call processing. A variety of call models is introduced, along with switch-based services. Call processing is explained for (advanced) intelligent networks and softswitches. *Chapter 4 (Advanced Intelligent Networks)* explains the origins of intelligent networks and the motivation for their development. The architecture and major functions are presented for the (Advanced) Intelligent Network. A variety of Intelligent Network services is introduced, including internationally standardized services and service features. *Chapter 5 (Basic Internet technology in support of communication services)* introduces the main areas in which Internet technology impacts service provision. Approaches to Internet Quality of Service are discussed. A topical solution for Internet Telephony is explored. Directory-enabled Networks are described as a means of achieving better management interoperability. Home Networks and Active Networks are discussed as examples of emerging Internet-based networks. *Chapter 6 (Wireless technology)* reviews a range of wireless solutions supporting a variety of different geographical areas. The evolution of cellular systems is traced through the first, second and third generations, with particular emphasis on the emerging Third Generation mobile systems. Other wireless systems addressed include broadcast networks and local wireless networks.

Part II (Building and analyzing services) considers the architecture, creation, development, and analysis of services. *Chapter 7 (Service Management and Quality of Service)* focuses on the management of services, using Service Level Agreements and Quality of Service as the basis. Mechanisms are discussed in depth for managing and monitoring Quality of Service. *Chapter 8 (Securing communication systems)* deals with the important question of security as it affects services. The basic principles of cryptography are explained, along with the kinds of threat to which communications systems are subject. Mechanisms are introduced for authentication, non-repudiation, and access control. Digital cash is used as a case study to illustrate how security issues arise and are dealt with. *Chapter 9 (Service creation)* examines service creation as pioneered in the (Advanced) Intelligent Network. The Telcordia SPACE system is used as a concrete example of a Service Creation Environment. Service creation is also considered for Internet services such as Internet Telephony and the Web. The important topics of service integration and service introduction are discussed. *Chapter 10 (Service architectures)* starts by reviewing two early efforts relevant to service architecture standardization: Open Systems Interconnection and the Distributed Computing Environment. The evolution of distributed services is then discussed in the context of subsequent standards: Open Distributed Processing, the Telecommunications Information Networking Architecture, and the Common Object Request Broker Architecture. The chapter also highlights the increasing importance of the middleware paradigm for service provision. *Chapter 11 (Service capability APIs)* focuses

closely on specific programming interfaces for creating services: the Telecommunications Information Networking Architecture, Java APIs for The Integrated Network, and various Parlay APIs. *Chapter 12 (Formal methods for services)* explains the nature of a formal method, and how it can be used to help service design. As examples, it is explained how services were formalized for Open Systems Interconnection and Open Distributed Processing. General classes of formal method are discussed for modeling communications services. *Chapter 13 (Feature interaction: old hat or deadly new menace?)* explores feature interaction in general, and in the context of telephony. Reactions to the problem are presented from the perspective of researchers, operators, and vendors. The changing nature of feature interaction is discussed in the context of how services are evolving.

Part III (The future of services) looks at the evolution of communications services and their supporting technologies. *Chapter 14 (Advances in services)* examines factors such as convergence and context that are driving new kinds of service. Presence-based services, messaging services, and service discovery are considered, all augmented by wireless connectivity. Home-based services are also discussed in depth. *Chapter 15 (Evolving service technology)* explores new techniques being used to create communications services: software agents, constraint satisfaction, Artificial Neural Networks, and Genetic Programming. *Chapter 16 (Prospects)* rounds off the book by evaluating the approaches developed for communications services. It discusses trends in the kinds of service that will be deployed and how they will be created. A mid- to long-term projection is presented of how services will evolve.

Appendix 1 Abbreviations collects in one place the major acronyms used throughout the book.

Appendix 2 Glossary briefly defines some key terms used in the book.

Appendix 3 Websites covers the major online sources for organizations discussed in the book, such as standardization bodies and trade associations.

Finally, the *Bibliography* gives details of all articles referenced throughout the book, and provides further reading for more detailed study.

Reviewers

Most chapters were reviewed by contributors to the book. However, a number of other individuals reviewed drafts of some chapters. The editors warmly thank the following: Daniel Amyot (University of Ottawa, Canada), Derek Atkins, Lynne Blair (Lancaster University, UK), Chris Brightman (Telcordia Technologies, USA), Elaine Bushnik (Consultant), Mario Kolberg (University of Stirling, UK), Stan Moyer (Telcordia Technologies, USA), Stephan Reiff-Marganiec (University of Stirling, UK), Mark Ryan (University of Birmingham, UK), Carron Shankland (University of Stirling, UK), Richard Sinnott (National E-Science Centre, UK), Charlie Woloszynski (Telcordia Technologies, USA).

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Part I

Network Support for Services

This part of the book considers how networks support communications services. The chapters deal with the impact on networking of multimedia, call processing, (Advanced) Intelligent Networks, the Internet, and wireless technology.

Chapter 1 (Introduction and context) sets the scene for the whole book. It begins by introducing the nature of communications services. The field of communications services is explored using the structure of the book as a roadmap. Network support for services is discussed, showing how aspects such as traditional telephony, Intelligent Networks, wireless telephony, the Internet and multimedia have developed. Techniques for building and analyzing services are reviewed. Several service architectures have been standardized, along with Application Programming Interfaces. Service creation and associated analytic methods are presented. New developments in services and service technologies give a glimpse into the future of communications services.

Chapter 2 (Multimedia technology in a telecommunications setting) explains how communications services have grown rapidly from simple telegraphy to a wide range of present-day services. Multimedia underlies may of these new services. The nature of multimedia is introduced, along with the market drivers for multimedia services. Issues surrounding multimedia include charging mechanisms and Quality of Service support. Key standards for multimedia services are reviewed, mainly those developed by the International Telecommunications Union, the Internet Engineering Task Force, and the International Organization for Standardization. The main elements of multimedia services are introduced. Quality of Service issues are then discussed. Typical multimedia services are presented as examples. Interworking is covered between multimedia services and traditional voice services. Multimedia aspects of terminal devices and user interfaces are explored. The chapter concludes with a brief review of future developments in multimedia services.

Chapter 3 (Call processing) opens with an historical review of call processing in telephone switching. Key aspects of call processing are then explained: interfaces, number translation, route selection, user preferences, resource control, and call data recording. A variety of call models is introduced, ranging from a simple half call model, through multi-segment models, to the more complex models required in mobile communication. Switch-based services are discussed for the Public Switched Telephone Network and for the Integrated Services Digital Network. Problems due to feature interaction are mentioned briefly. Call processing is investigated for (Advanced) Intelligent Networks. By way of comparison, the approach taken by

softswitches is also explained in detail. The chapter closes with an evaluation of call processing and how it is likely to develop in future years.

Chapter 4 (Advanced Intelligent Networks) explains the origins of Intelligent Networks and the motivation for their development. Closely related but differing approaches are discussed for the Advanced Intelligent Network designed by Bellcore (now Telcordia Technologies) and the Intelligent Network standards from the International Telecommunications Union. The architecture and major functions are presented for the (Advanced) Intelligent Network. The key factor is the separation of switching from service control. The structured architecture and specialized functions ensure a modular approach. For example, it is explained how four separate planes deal with different levels of abstraction: the service plane, the global functional plane, the distributed functional plane, and the physical plane. The major elements of the architecture are discussed: the Service Switching Point and its associated call models, the Service Control Point, and the Intelligent Peripheral. A variety of Intelligent Network services is introduced, including internationally standardized services and service features. The chapter is rounded off by an evaluation of Intelligent Networks and their future evolution.

Chapter 5 (Basic Internet technology in support of communication services) introduces the main areas in which Internet techniques impact service provision: the Internet itself, Internet telephony, Directory-Enabled Networks, Home Networks, and Active Networks. Approaches to Internet Quality of Service are discussed, particularly Integrated Services, Differentiated Services, and Multi-Protocol Label Switching. Issues surrounding Internet telephony are explored, with the Session Initiation Protocol and its supporting protocols serving as a topical example. Directory-Enabled Networks are a means of achieving better interoperability at the level of management data. Internet technology in the home is discussed through the example of the Open Services Gateway initiative. The approach of Active Networking is considered as a significant advance in how networks can be made more programmable and more flexible. The chapter ends with a summary of how various Internet technologies are already playing a vital role in service provision.

Chapter 6 (Wireless technology) introduces the main aspects of wireless networks. It reviews a range of wireless solutions supporting a variety of different areas: personal, local, suburban, rural, and global. Cellular systems are a major technology, and their evolution is traced through the first, second, and third generations. As the evolving standard, the goals and challenges of Third Generation mobile technology are discussed in detail. Important considerations in cellular networks include handover, location management, network architecture, location technologies, satellite systems, and market trends. Private Mobile Radio and Broadcast networks are also discussed to round out the picture. Local wireless networks are explored: Bluetooth, cordless technologies such as the Digital Enhanced Cordless Telecommunications, Wireless Local Loop, and Wireless Local Area Networks. The chapter finishes with an evaluation of wireless technologies and their future prospects.

1

Introduction and Context

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1.1 Communications Services

The term 'service' is a very broad one. An everyday sense of the word is assistance for someone else, e.g. a booking service or a delivery service. The same general meaning carries over into technical domains such as communications. As will be seen throughout the book, services appear in many forms. The following examples illustrate the richness and diversity of communications services:

- audio services such as telephony, audio-conferencing, mobile telephony, recorded weather forecasts, voice-controlled flight enquiries, online music;
- image services such as facsimile, video-conferencing, video-on-demand, streaming video;
- distributed data services such as file sharing, meeting schedulers, electronic whiteboards, online gaming, electronic newspapers, storage area networks;
- Web-based services such as travel booking, mobile Web access, e-business, e-commerce, e-learning, e-medicine.

This is a growing list. The big advantage of communications services is that they can be delivered to users wherever they are, whenever they want.

Communications services provide facilities to end-users. They therefore focus on the end-user view rather than the network view. A service is thus an abstraction of the underlying network, including its protocols and resources. As an example, consider the Plain Old Telephone Service. The subscriber simply expects to dial other subscribers and speak to them. This simple service is easy to understand and to describe. However, it requires a very complex infrastructure in the telephone network to make it work. This is completely invisible to the end-user. In fact, the hallmark of an effective service is that its users need know nothing about how it is realized.

Communications services often have a distinct commercial aspect: a service is something that is packaged and sold to customers. A telephone subscriber, for example, might pay for a call answering service or a call forwarding service. What a marketing person might call

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a service could correspond to a number of individual technical services. For example, someone who pays for a charge-card service might also benefit from bulk call discounts, itemized billing and short-code dialing – all individual services from a technical perspective.

Services provide the primary income for network operators, so they lie at the financial heart of the communications sector. Operators and suppliers invest heavily in support for accurate billing of service use. Services and tariffs are also vital for operators to differentiate themselves in what is an increasingly competitive market.

The following sections provide an overview of communications services, using the chapters of this book as a routemap.

1.2 Network Support for Services

A study of the timeline for communications systems (see Chapter 2) will show that communications services have grown extremely rapidly in the past 150 years. Data services (telegraphy) were followed by voice services (telephony), audio services (radio), image services (facsimile), video services (TV), text services (telex), mobile services (paging, telephony), Internet services (email, file transfer, remote access, telephony), and Web-based services (just about anything prefixed with 'e-'). Many services were initially supported by specialized networks. However, the convergence of computing and communications has meant that new services can be supported over existing networks, and that current services can be provided over shared networks. IP-based networks, using standards from the Internet Protocol family, are emerging as a common infrastructure for many communications services. Even broadcast wireless services such as radio and TV may succumb to this trend.

Telephony has been the driver for many service developments. The advent of Stored Program Control telephone exchanges (see Chapter 3) made it practicable to do much more than merely establish an end-to-end path. More flexible call handling was introduced in the 1980s. However, the intermingling of basic switching (establishing an end-to-end path) and additional services (such as free numbers) made it difficult to develop and maintain new services. With the standardization of Intelligent Networks in the 1990s (see Chapter 4), a clean separation was obtained between switching and services. Signaling emerged as an important issue in its own right, allowing advanced services to be built using more sophisticated control mechanisms.

In parallel, the Internet has been developing since the 1970s. Unlike telephone networks, which are primarily voice-oriented, the Internet began with data as its main focus. However, the increasing digitization of nearly all signals has allowed voice to be carried with almost the same ease (see Chapter 5). Indeed the Internet has shown itself appropriate for carrying many kinds of media. It is significant that many traditional telephony developers are now building networks using Internet technologies as a common infrastructure for voice, image, and data.

However, mobile communication (see Chapter 6) has provided a new impetus for telephony developments. The early analogue networks for mobile telephony have also progressed to digital form. Third Generation networks will exhibit a significant element of Internet technology in their design.

1.3 Building and Analyzing Services

As communications services have become more widespread and more vital, Quality of Service (see Chapter 7) has become a major issue – particularly for services such as audio and video

that must respect real-time constraints despite the volume of data. For commercial use, Service Level Agreements are now commonplace as a means of defining the standard of service that the customer should expect. This in turn requires mechanisms for monitoring and controlling Quality of Service.

Information pervades all modern organizations, and has significant commercial value. Protecting it through physical security is relatively straightforward. However, widespread distributed access through communications services poses many new kinds of threat (see Chapter 8). Sophisticated protocols have been developed for securely distributing information, authenticating this information and its users, and providing accurate records of how information is manipulated and used. Even the ordinary user needs such mechanisms to allow safe online payment and to protect personal information.

Communications services are typically very complex to design and to maintain. Techniques and tools for service creation were first developed for telephony services (see Chapter 9). Service Creation Environments have tended to be vendor-specific, making it difficult to re-use the design of a service with another kind of switch (end office or exchange). Although Intelligent Networks have helped to improve portability, telephony services remain rather specialized and switch-specific. There is hope, however, that Internet-based services will be more portable.

Several standardization efforts have focused on architectures to support services (see Chapter 10). The standards for Open Systems Interconnection were developed to support interoperability in a heterogeneous networking environment. Open Systems Interconnection also defined a Basic Reference Model that gave prominence to communications services. A further architecture was standardized for Open Distributed Processing, dealing with distributed systems and not just networking. The service concept is also important in Open Distributed Processing, but takes a more general form.

Client-server approaches have emerged as a common basis for providing communications services. The Distributed Computing Environment is an example of middleware as an infrastructure supporting distributed communications services. The Common Object Request Broker Architecture was developed for distributed interworking, including legacy systems that need to interoperate with new systems.

Pragmatic, industry-led developments have also included Application Programming Interfaces for communications services (see Chapter 11). The Telecommunications Information Networking Architecture was explicitly designed around communications services as a central element. Microsoft's Telephony Application Programming Interface exposed communications interfaces so that more complex services could be built. Several similar interfaces were designed by other manufacturers. The general approach has been exploited in Computer–Telephony Integration and in call centers. The widespread use of Java led to the definition of Java APIs for The Integrated Network.

The Parlay Group pioneered the concept of opening up networks to third party service provision. Traditionally, services have been provided *within* the core of networks. This has several advantages, including service provision by a single authority that can exercise tight control over quality and reliability. Increasingly, services are being provided at the *edge* of networks. These services may be offered by third parties. However, it is becoming feasible for end-users to define their own services. This is close to the Internet philosophy, where the core of the network is deliberately kept simple in order to provide scalable, high-volume data transfer. In an Internet view, services are mainly provided in the end systems.

Communications services are often complex, and need to interwork across heterogeneous systems. It is therefore important that the services be defined precisely and, if possible, be checked for accuracy. Formal methods (see Chapter 12) have been used for this kind of task. Several Formal Description Techniques have been standardized in the context of communications systems. Communications services have attracted the use of a number of formal methods. Some of this work has been architectural in nature, most has focused on service specification, and some has investigated rigorous analysis of services.

A particular form of service analysis deals with service compatibility – the so-called feature interaction problem (see Chapter 13). A modern switch will typically contain code for hundreds of features (the building blocks of services). Unfortunately, it is very difficult to design features that do not interfere with each other. As the number of features grows, the risk of unexpected interference rises. Both formal and informal methods have been developed to detect and resolve such interference. Although feature interaction has been studied extensively in traditional telephony, the issue arises in other domains and is likely to be problematic in newer kinds of communications service.

1.4 The Future of Services

Users are increasingly contactable wherever they are: in the office, at home, on the move, at leisure. They receive communications via fixed-line phone, cellular phone, voicemail, pager, facsimile, email, PC, and PDA. A major growth area in recent years has been instant messaging: the user is notified of 'buddies' who are online and available to chat. Presence-based services, availability control, and wireless connectivity (see Chapter 14) are becoming the major drivers in anytime, anywhere communication. Services for the home are also becoming a reality. Home Network technologies and the Open Services Gateway initiative are allowing end-users and third parties to provide new services in the home.

New approaches to service provision are also gaining ground (see Chapter 15). Software agents are already common as a means of supporting users in local and distributed information retrieval and processing. Constraint satisfaction is a general-purpose technique, but has also been found useful in dealing with conflict among services. Artificial Neural Networks have been applied to many problems of a pattern recognition character, including applications in communications. Genetic Programming is an optimization technique that has also been applied to communications services.

Despite the high-tech industry downturn of the early 2000s, it is clear that communications services will continue to grow dramatically (see Chapter 16). A number of trends are already evident. Services will become a lot more of everything: more widespread, more complex, more personal, more programmable, more pervasive, more interlinked, more dispersed. It is hoped that the readers of this book will be encouraged to contribute towards the development of future communications services.

2

Multimedia Technology in a Telecommunications Setting

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Since the opening of the first telegraphy networks in the middle of the 19th century many additional telecommunications services have been developed, with new ones continuing to be added. The resulting explosion of telecommunications services over time is illustrated in Figure 2.1, which maps some of the key services onto a timeline for telecommunications. It can be observed that not only are the numbers of services increasing, they are also becoming more complex with additional audio, video, and data content. This trend looks set to continue into the future, with advances in technology being harnessed to ensure that greater functionality is delivered with greater user friendliness.

Historically, each new service has been supported by a single medium ('monomedia') that is often carried on a dedicated network infrastructure, leading to what is sometimes referred to as a 'stove pipe' network architecture. This is clearly not a sustainable approach as ever more new services emerge in the future, especially since the nature of many of these new services is impossible to predict.

The solution is to move away from the 'dedicated network per service' approach towards so-called converged networks that are capable of supporting a range of services on a common network infrastructure. In turn, this approach eases the introduction of services that are amalgams of distinct services, such as voice and video, that were previously unrelated and supported on separate networks. The word 'multimedia' has emerged to describe such new complex services.

This chapter explores the impact that multimedia is having on telecommunications services. It starts by considering definitions for multimedia. Then it examines the market drivers that are creating the demand for these new services. A short overview of the appropriate standards is given, leading to a review of the components that make up multimedia services, using some common services as examples. The need to interwork with traditional services, notably voice, is emphasized. The chapter concludes with some thoughts on multimedia terminal equipment and future trends. It should be remembered that multimedia services and technologies are still evolving, so this chapter can present only a snapshot of current activities.

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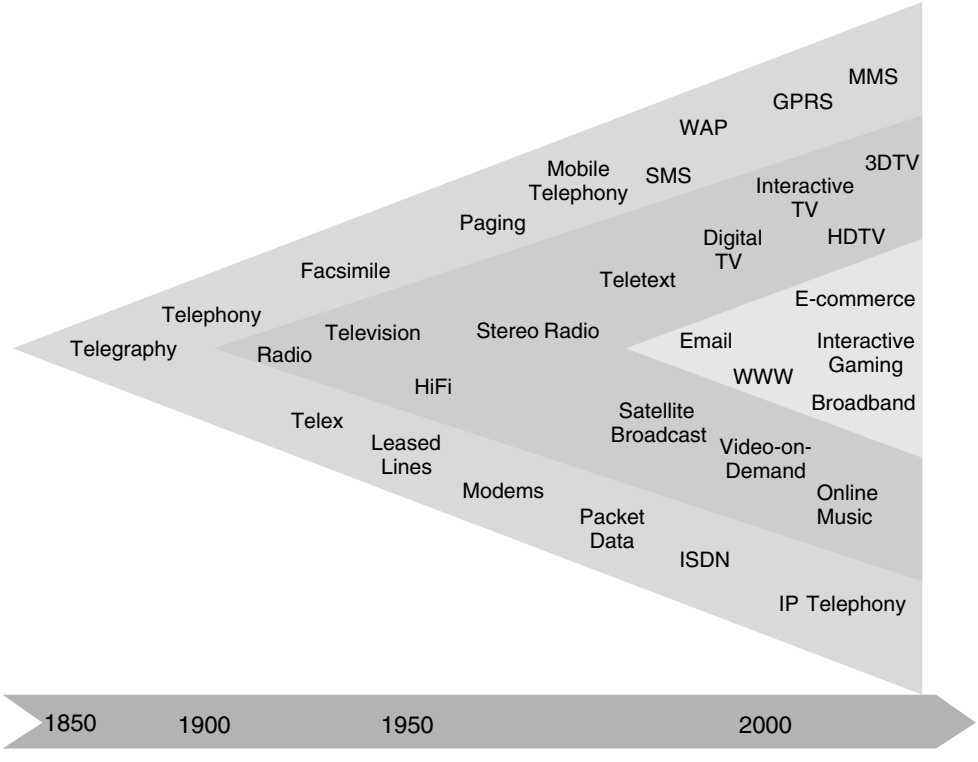

Figure 2.1 Growth of telecommunications services.

2.1 Definition of Multimedia

'Multimedia' has become a very popular concept over recent years, but the term is used very loosely. A generally accepted definition of multimedia is the combination of two or more different media types, one of these usually being audio. The popular image of a multimedia call is video telephony involving the use of voice and video. Voice and data, for example a virtual whiteboard, is another common combination.

In passing, it can be observed that there are many alternative definitions for 'multimedia' given in the literature, for example (Whyte 1995):

> *'Multimedia communications, through a range of technologies, including communication over a distance, aspires to provide a rich and immediate environment of image, graphics, sound, text and interaction, which assists in decision-making or environmental involvement'.*

A more formal definition is provided by the Telecommunications Sector of the International Telecommunications Union (ITU-T) in Recommendation I.113. This defines a multimedia service as '*a service in which the interchanged information consists of more than one type, such as text, graphics, sound, image and video*' (ITU 1997a).

ITU-T Recommendation F.700 (ITU 2000a) considers multimedia services from both end-user and network provider viewpoints: