

## Table of Content

|                                                                                             |    |
|---------------------------------------------------------------------------------------------|----|
| List of Figures.....                                                                        | 9  |
| List of Tables.....                                                                         | 13 |
| List of Acronyms.....                                                                       | 14 |
| List of Mathematical Symbols .....                                                          | 24 |
| Abstract .....                                                                              | 27 |
| Abstract (in German).....                                                                   | 29 |
| 1 Introduction .....                                                                        | 31 |
| 1.1 Categorization of Challenging Issues to be Investigated.....                            | 33 |
| 1.2 Identification of Research Goals.....                                                   | 34 |
| 1.3 The Book Structure.....                                                                 | 35 |
| 2 Evolution and Advances in Service Delivery with Network<br>Intelligence Enhancement ..... | 38 |
| 2.1 First Telephone Networks.....                                                           | 38 |
| 2.2 Common Channel Signaling Network.....                                                   | 39 |
| 2.3 Signaling System No.7 .....                                                             | 41 |
| 2.3.1 SS7 Architecture .....                                                                | 41 |
| 2.3.2 SS7 Protocol Layers.....                                                              | 44 |
| 2.4 SS7 Technologies for IN Services Performance Support.....                               | 47 |
| 2.4.1 IN Service Implementation Using SS7 with TCAP and INAP .....                          | 48 |
| 2.4.2 IN Service Implementation Using SS7 and a Modified TUP..                              | 50 |
| 2.5 Distribution of Intelligence .....                                                      | 51 |
| 2.5.1 Fundamentals of the OSI Model.....                                                    | 52 |
| 2.5.2 Distributed Processing Techniques.....                                                | 53 |
| 2.5.3 Aspects of a Distributed Network Intelligence .....                                   | 56 |
| 2.5.4 Diversity of Environments.....                                                        | 57 |
| 2.5.5 Methods for Intelligence Distributing .....                                           | 58 |
| 2.6 Platforms Supporting Distribution and Openness.....                                     | 62 |
| 2.6.1 IN Implementation – Hypothetical Travel Agency Service.....                           | 63 |
| 2.6.2 IN Service Platform Requirements .....                                                | 64 |
| 2.6.3 Open Service Platform Architecture .....                                              | 67 |
| 2.6.4 External Interfaces .....                                                             | 70 |
| 2.7 IN for Fixed/Mobile network Convergence (FMC) .....                                     | 72 |
| 2.7.1 General Regulatory Aspects .....                                                      | 73 |
| 2.7.2 E.164 Numbering Regulatory Aspects .....                                              | 74 |
| 2.7.3 Future Interworking .....                                                             | 76 |
| 2.8 Converged IN as a Single Platform for Telephony,<br>Multimedia, and Data Services.....  | 77 |

|          |                                                                                       |     |
|----------|---------------------------------------------------------------------------------------|-----|
| 2.8.1    | Service Classification .....                                                          | 77  |
| 2.8.2    | Unified Service Content and Call Control Model .....                                  | 78  |
| 2.9      | IN Services Behaviour Modeling .....                                                  | 80  |
| 2.9.1    | Performance Analysis of Different Traffic Flow Processes ...                          | 80  |
| 2.9.2    | Performance Modeling of Telecommunication Networks .....                              | 86  |
| 2.9.3    | Finite Source Models.....                                                             | 88  |
| 2.9.4    | Intelligent Network Analysis by Closed Queueing Model .....                           | 95  |
| 2.9.5    | M/M/2/K/K System for Large IN.....                                                    | 108 |
| 2.10     | Chapter Contributions Summarizing .....                                               | 113 |
| <b>3</b> | <b>Service Integration Aspects by the IN and IP Networks</b>                          |     |
|          | Convergence .....                                                                     | 117 |
| 3.1      | Integration Drivers and Enablers.....                                                 | 117 |
| 3.1.1    | Objectives .....                                                                      | 117 |
| 3.1.2    | Enablers and New Perspectives .....                                                   | 118 |
| 3.1.3    | Network Configuration and Major Feature Requirements ...                              | 119 |
| 3.1.4    | Interfaces and Protocols.....                                                         | 119 |
| 3.1.5    | Prototype .....                                                                       | 119 |
| 3.1.6    | Evolutional Increase of Intelligence to IP networks .....                             | 119 |
| 3.1.7    | Outlook .....                                                                         | 120 |
| 3.2      | IN/IP Convergence - Standardization and Research Work .....                           | 120 |
| 3.2.1    | PSTN/Internet Interworking (PINT) .....                                               | 121 |
| 3.2.2    | PSTN/IN Requesting Internet Service (SPIRITS) .....                                   | 123 |
| 3.2.3    | PARLAY .....                                                                          | 124 |
| 3.2.4    | IN/CORBA Interworking .....                                                           | 126 |
| 3.2.5    | Telecommunications and Internet Protocol Harmonization<br>Over Networks (TIPHON)..... | 128 |
| 3.2.6    | ITU SG-11, SG-16 and H.323 .....                                                      | 130 |
| 3.2.7    | JAIN .....                                                                            | 131 |
| 3.2.8    | Computer-Telephony Integration.....                                                   | 133 |
| 3.3      | Call Models for Converged Networks .....                                              | 136 |
| 3.3.1    | Call Models Description.....                                                          | 137 |
| 3.3.2    | IN Call Model Mappings .....                                                          | 138 |
| 3.3.3    | IN/SIP Architecture .....                                                             | 139 |
| 3.4      | Service Control for Voice and Data Networks .....                                     | 141 |
| 3.4.1    | Call Control .....                                                                    | 142 |
| 3.4.2    | Messaging Control .....                                                               | 142 |
| 3.5      | JAIN APIs for Converged Networks .....                                                | 143 |
| 3.5.1    | JAIN SS7 APIs .....                                                                   | 144 |
| 3.5.2    | JAIN IP APIs .....                                                                    | 145 |
| 3.5.3    | JAIN APIs for IN/IP Convergence .....                                                 | 146 |
| 3.6      | Services that can be Recognized as Converged.....                                     | 148 |
| 3.6.1    | Overall Services Description .....                                                    | 149 |

|       |                                                                                      |     |
|-------|--------------------------------------------------------------------------------------|-----|
| 3.6.2 | IN Service Requests towards IP Networks .....                                        | 150 |
| 3.6.3 | IN Service Request from IP Networks .....                                            | 163 |
| 3.7   | PINT and SPIRITS Protocols for Converged Services Support .....                      | 173 |
| 3.7.1 | PINT Protocol .....                                                                  | 173 |
| 3.7.2 | SPIRITS Protocol .....                                                               | 177 |
| 3.7.3 | PINT and SPIRITS Protocols Mirror Images of Integration .....                        | 182 |
| 3.8   | Converged Network Services Modeling .....                                            | 190 |
| 3.8.1 | Scenarios for Services Interworking in .....                                         |     |
|       | Converged Networks .....                                                             | 191 |
| 3.8.2 | Signaling and Control for Different Scenarios .....                                  | 194 |
| 3.8.3 | Modeling of the First Scenario .....                                                 | 196 |
| 3.8.4 | Modeling of the Second Scenario Using M/G/1 System .....                             | 196 |
| 3.8.5 | Modeling the Third Scenario Using M/E <sub>2</sub> /1 system .....                   | 202 |
| 3.8.6 | Systems in Tandem M/G/1+ G/M/1 – the Fourth Scenario<br>Model .....                  | 208 |
| 3.8.7 | Systems M/E <sub>2</sub> /1 + H <sub>2</sub> /E <sub>2</sub> /1 for Scenario 5 ..... | 214 |
| 3.9   | Assessment and Modeling Results Summarizing .....                                    | 225 |
| 4     | Conclusions .....                                                                    | 229 |
| 5     | References .....                                                                     | 233 |