

# Contents

Preface.....	ix
<b>Chapter 1 NGN Standardization and QoS .....</b>	<b>1</b>
1.1 NGN in a Nutshell .....	2
1.1.1 Issues to Be Solved by NGN.....	3
1.1.2 Management Issues .....	4
1.2 Standardization Processes .....	5
1.2.1 Core Standardization Bodies .....	6
1.2.2 European Organizations .....	9
1.2.3 IETF .....	10
1.2.4 Timeline of Standards.....	12
1.3 Transport Layer QoS.....	20
1.3.1 Traditional View of Network Performance.....	20
1.3.2 NGN View at Transport Layer Performance .....	22
1.4 Application Layer QoS .....	24
1.4.1 Relation between Application and Transport Layers .....	24
1.4.2 Application Layer Performance.....	26
1.4.3 Performance Metrics.....	28
<b>Chapter 2 Passive Measurement Technology .....</b>	<b>31</b>
2.1 SNMP/MIB Technology .....	32
2.1.1 SNMP/MIB Principles .....	32
2.1.2 Client-Server Model .....	33
2.1.3 Network Devices and SNMP .....	34
2.1.4 Data Types Exchanged by SNMP.....	36
2.1.5 SNMP Communication Patterns .....	39
2.1.6 SNMP Timeline .....	43
2.2 NetFlow Technology .....	44
2.2.1 Traffic Collection Process.....	44
2.2.2 IP Flow Tuples.....	46
2.2.3 Overall Monitoring Architecture.....	48

<b>Chapter 3 Passive Measurement Tools.....</b>	51
3.1 Common Design Patterns in Monitoring Tools.....	53
3.1.1 Roles in Monitoring Process.....	53
3.1.2 Loosely Coupled Monitoring .....	54
3.1.3 Tightly Coupled Monitoring.....	56
3.1.4 Distribution of Load in Monitoring Systems.....	58
3.1.5 Specifics of SNMP .....	60
3.1.6 Specifics of NetFlow .....	62
3.2 SNMP-Based Tools.....	64
3.2.1 Basic Features of MRTG.....	64
3.2.2 Using PRTG .....	66
3.2.3 PRTG Output.....	68
3.2.4 Traffic Components of PRTG .....	70
3.3 NetFlow-Based Tools.....	72
3.3.1 NetFlow Compliance.....	73
3.3.2 top: the UNIX Tool .....	73
3.3.3 ntop: the Network top Tool .....	76
3.3.4 User Interface to ntop.....	77
3.3.5 Statistical Traffic Summaries.....	79
3.3.6 NetFlow Attributes of ntop .....	82
3.4 Contemporary Monitoring Realities .....	84
3.4.1 Example Practical Task .....	84
3.4.2 SNMP Mapping of the Example Scenario.....	86
3.4.3 NetFlow Mapping of the Example Scenario .....	87
3.4.4 Discussion of the Example Scenario.....	88
3.4.5 Technology Support of Existing Monitoring Targets.....	90
<b>Chapter 4 Active Measurement Technology .....</b>	93
4.1 Active Measurement Basics .....	94
4.1.1 Measurement in Management .....	94
4.1.2 IP Performance Metrics.....	97
4.1.3 The Scope of Active Measurements in this Book .....	99

4.2 Network Performance Metrics .....	99
4.2.1 Bottleneck Capacity .....	100
4.2.2 Available Bandwidth.....	100
4.2.3 Round Trip Time.....	101
4.2.4 End-to-End Jitter .....	102
4.3 Life of a Single Packet in the Path.....	102
4.3.1 Measurement Methodology .....	103
4.3.2 Shortcomings of Single-Packet Probing .....	106
4.4 Packet Pair Property .....	107
4.4.1 Measurement Methodology .....	107
4.4.2 Packet-Pair versus Single-Packet Techniques.....	109
4.5 Advanced Probe Designs .....	111
4.5.1 Piggyback Methods .....	111
4.5.2 Packet Trains .....	113
4.6 Routing Peculiarities .....	116
4.6.1 Directionality of Probing Path .....	116
4.6.2 Loose Coupling .....	116
4.6.3 Shared Topology .....	118
<b>Chapter 5 Active Measurement Methods.....</b>	<b>119</b>
5.1 Adaptive Capacity Measurement.....	119
5.1.1 Bottleneck Bandwidth Estimation.....	121
5.1.2 Online Variable Measurement .....	123
5.1.3 Histogram Based Performance Analysis.....	126
5.1.4 Validation Tests.....	132
5.1.5 Discussion of Measurement Methodology .....	138
5.2 Available Bandwidth Measurement .....	139
5.2.1 Probing Method .....	140
5.2.2 Method Evaluation .....	143
5.2.3 Discussion of Measurement Methodology .....	146

5.3 Lightweight Jitter Estimation.....	146
5.3.1 Estimation Model.....	147
5.3.2 Mining Examples .....	149
5.3.3 Discussion of Measurement Methodology .....	151
<b>Chapter 6 Active Measurement Boxes .....</b>	<b>153</b>
6.1 Standards, Tools, and Projects.....	155
6.1.1 Timeline of Standards and Tools.....	155
6.1.2 Tools and Performance Metrics .....	157
6.1.3 Major Measurement Projects.....	158
6.2 Test Traffic Measurement Box.....	159
6.2.1 Test Traffic Measurement Project.....	160
6.2.2 TTM Box as a Black Box .....	161
6.2.3 TTM Box Communications.....	161
6.2.4 Role of an Individual Box .....	163
6.3 QoS Boxes .....	165
6.3.1 QoSMetrics Box .....	166
6.3.2 QoSmetrics' Tools .....	167
<b>Chapter 7 Active Measurement in Context .....</b>	<b>173</b>
7.1 Management of Measurement Results.....	174
7.1.1 Problem Statement.....	175
7.1.2 Data Mining and Active Probing Results.....	176
7.1.3 Mining Method .....	178
7.1.4 Mining Examples .....	183
7.1.5 Discussion of Analysis Methodology .....	190
7.2 Topological Ramifications of Active Measurement .....	190
7.2.1 Problem Statement.....	191
7.2.2 Delay Properties of Community Networks .....	192
7.2.3 Topology Inference Algorithm .....	194
7.2.4 Discussion of Measurement and Analysis Methodology .....	201
<b>Bibliography .....</b>	<b>203</b>
<b>Index .....</b>	<b>207</b>