

## Table of Contents

Introduction	xxii
1 The Network Management World Must Change: Why Should You Care?	2
Introduction	2
The Industry Has Changed: What Are the Trends?	6
Existing Network Management Practices and Related Limitations	24
Data Modeling Is Key for Automation	39
Interview with the Experts	48
Summary	52
References in This Chapter	53
Endnotes	53
2 Data Model—Driven Management	56
The Beginning: A New Set of Requirements	56
Network Management Is Dead, Long Live Network Management	59
YANG: The Data Modeling Language	61
The Management Architecture	69
Data Model—Driven Management Components	70
The Encoding (Protocol Binding and Serialization)	74
The Server Architecture: Datastore	77
The Protocols	78
The Programming Language	85
Telemetry	86
The Bigger Picture: Using NETCONF to Manage a Network	86
Interview with the Experts	91
Summary	93
References in This Chapter	93
Endnotes	94
3 YANG Explained	96
Introduction	96
Describe Your World of Data	96
Describing Possible Events	113
Separating Configuration from Operational Data	117
Constraints Keep Things Meaningful	122
Augmenting, Extending, and Possibly Deviating	142
Network Management Datastore Architecture (NMDA)	149
Interview with the Expert	154
Summary	156
References in This Chapter	157
4 NETCONF, RESTCONF, and gNMI Explained	158
Introduction	158
NETCONF	158
RESTCONF	190
OpenConfig and gNMI	214
Interview with the Expert	225
Summary	227

References in This Chapter	227
5 Telemetry Explained	230
Introduction	230
Data Model—Driven Telemetry	230
Moving Away from SNMP to Telemetry	232
Telemetry Use Cases	235
Telemetry Components	236
Telemetry Standard Mechanisms	242
Interview with the Experts	249
Summary	252
References in This Chapter	253
Endnotes	253
6 YANG Data Modeling Developments in the Industry	256
Introduction	256
The Beginning: The IETF	256
Embracing YANG Throughout the Industry	263
The OpenConfig YANG Model	268
Industry Coordination Is Required	270
Interoperability Testing	272
Implementing More Than One YANG Model for a Specific Functionality	274
Interview with the Expert	275
Summary	278
References in This Chapter	279
Endnotes	279
7 Automation Is as Good as the Data Models, Their Related Metadata, and the Tools: For the Network Architect and Operator	282
Introduction	282
Getting to Know the Structure of a YANG Module	283
Finding the Right Modules Using the YANG Catalog	287
Interacting with Devices	299
Interview with the Experts	331
Summary	335
Endnotes	335
8 Automation Is as Good as the Data Models, Their Related Metadata, and the Tools: For the Module Author	336
Introduction	336
Designing Modules	336
Understanding Your Module's Impact	349
Interview with the Expert	350
Summary	352
Endnotes	352
9 Automation Is as Good as the Data Models, Their Related Metadata, and the Tools: For the Application Developer	354
Introduction	354
Working with YANG Modules	355
Interacting with the Network	366

Making YANG Language Native 373  
Interview with the Expert 380  
Summary 381  
Endnotes 382  
10 Using NETCONF and YANG 384  
Introduction 384  
So the Story Goes 385  
Top-Down Service Model 386  
Bottom-Up Device Templates 392  
Service Logic Connecting the Dots 394  
Setting Up NETCONF on a Device 398  
Discovering What's on a Device 400  
Managing Services 405  
Manager Synchronization with Devices 413  
Network-Wide Transactions 417  
Interview with the Experts 425  
Summary 428  
11 YANG Model Design 430  
Introduction 430  
Modeling Strategy 430  
YANG Modeling Tips 433  
Common YANG Mistakes 443  
Backward Compatibility 457  
Interview with the Experts 460  
Summary 462