# Contents

About the Author ..... xiii

About the Technical Reviewers ..... xv

Introduction ..... xvii

Chapter 1 Introducing JMX ..... 1

System and Resource Management Challenges ..... 1
JMX Overview ..... 4
    How JMX Works ..... 5
    Implementing JMX ..... 5
JMX Architecture ..... 6
    Instrumentation Level ..... 8
    Agent Level ..... 11
    Agents ..... 11
    MBean Servers ..... 11
    Distributed Services Level ..... 12
    Modular Server Architecture ..... 15
Writing Your First MBean ..... 16
Writing Your First Agent ..... 17
Summary ..... 20

Chapter 2 The Three-Level Model: Instrumentation and MBeans ..... 21

An MBean Primer ..... 22
Naming MBeans Using Object Names ..... 23
Standard MBeans ..... 24
Dynamic MBeans ..... 25
    Implementing the DynamicMBean Interface ..... 26
    Eliminating the DateTimeServiceMBean Interface ..... 26
    Implementing the DynamicMBean Methods ..... 28
Model MBeans ..... 35
Open MBeans ..... 35
MBean Notifications ..... 35
MBean Information and Metadata Classes ..... 37
    Adding Fields to Your MBean ..... 38
    Modifying the setDate and setTime Methods ..... 38

Modifying the stop and start Methods ..... 39
Enabling the MBean to Add and Remove Notification Listeners ..... 40
Modifying the mBeanInfo Object ..... 41
Creating the Notification Metadata Objects ..... 41
Summary ..... 42

Chapter 3 The Three-Level Model: Agents ..... 43

The Agent Level of JMX ..... 43
MBean Servers ..... 44
Opening Up the ServiceAgent ..... 45
Declaring an Effective Constructor ..... 46
Adding the addResource Method ..... 46
Adding the getResources Method ..... 48
Categorizing Resource Groups Using Domains ..... 49
Domain Names ..... 49
Uniquely Naming MBeans Using Key Properties ..... 49
Extending an Agent with Agent Services ..... 50
Dynamic MBean Loading ..... 50
Using Monitors to Track Changes ..... 52
Scheduling Notifications Using Timers ..... 58
The Relation Service ..... 65
Summary ..... 76

Chapter 4 MBean Servers ..... 79

Creating an MBean Server ..... 79
Finding an MBean Server ..... 79
MBean Server Delegate ..... 81
Modifying the Default MBean Server Implementation ..... 82
Naming and Registering MBeans ..... 82
Controlling MBean Registration ..... 84
MBean Registration Notifications ..... 85
MBean Server Queries ..... 86
Query Expressions ..... 87
Applying Query Expressions ..... 89
Methods for Defining Query Expressions ..... 93
MBean Proxies ..... 97
MBean Server Remote Communications ..... 98
Summary ..... 99

Chapter 5 Distributed Management System Design ..... 101

Management System Evolution ..... 101
History of Management Standards and Initiatives ..... 102
History of Management Designs ..... 107
Management Framework Patterns ..... 111
Specialized/Detached ..... 111
Centralized ..... 112
Hierarchical ..... 112
Distributed/Cooperative ..... 113
Manager/Agent Frameworks ..... 114
Managers ..... 114
Agents ..... 115
Manager and Agent Models and Roles ..... 116
Master Agents and Subagents ..... 118
Manager Domains ..... 119
Manager of Managers (MoMs) ..... 120
Managers and JMX ..... 121
Summary ..... 122

Chapter 6 The Three-Level Model and Distributed Services ..... 127

Clients and Servers Unite with Connectors ..... 128
Creating Connector Servers ..... 129
Publishing a Connector Server with Existing Infrastructures ..... 130
Creating Connector Clients ..... 131
Using a JMXConnectorFactory to Create a Connector Client ..... 131
Using a Connection Stub to Create a Connector Client ..... 131
Finding a Connector Server ..... 132
Finding Servers Using Connector Server Addresses ..... 132
Terminating Connections Between Clients and Servers ..... 133
The RMI Connector ..... 133
Mechanics of the RMI Connector ..... 133
JMX and Distributed Notification Events ..... 134
RMIConnector Notification Events ..... 135
Pluggable Object Wrapping ..... 136
The Generic Connector ..... 136
The Generic Connector Protocol ..... 137

Bindings to Lookup Services ..... 140
Lookup Attributes ..... 141
Summary of Environment Parameters ..... 142
Service Templates ..... 144
Summary ..... 148

Chapter 7 JMX Connectors ..... 151

Establishing a JMX Remote Connection ..... 151
MBean Server Operations Through a Connection ..... 152
Terminating a Connection ..... 153
Connecting to Connector Servers Using Connector Server Addresses ..... 153
Creating a Connector Server ..... 154
The RMI Connector ..... 155
Using RMI Transports ..... 156
Mechanics of the RMI Connector ..... 156
Connecting to an RMI Connector Server ..... 159
The Generic Connector ..... 160
The Pluggable Transport Protocol ..... 160
Customizing Serialization Using Pluggable Object Wrapping ..... 161
Defining a New Transport ..... 163
Summary of Environment Parameters ..... 164
Describing JMX Services Using Service Templates ..... 167
Summary ..... 167

Chapter 8 Remote Lookup ..... 169

Finding a Server ..... 169
Publishing a Server ..... 170
How to Connect to an RMI Connector Server ..... 170
Bindings to Lookup Services ..... 171
General Principles ..... 171
Using the Service Location Protocol ..... 175
Using the Jini Network Technology ..... 180
Using the Java Naming and Directory Interface (LDAP Back End) ..... 185
Summary ..... 193

Chapter 9 JMX Clients ..... 197

Connector Clients ..... 197
Finding a Connector Server ..... 197
Looking Up a JMX Service URL with SLP ..... 198

Looking Up a JMX Connector Stub from the Jini Lookup Service ..... 199
Looking Up a JMX Service URL from an LDAP Server ..... 201
Establishing a Connection ..... 202
JMXConnectorFactory ..... 202
Connection Stubs ..... 203
Connecting to an RMI Connector Server ..... 203
MBean Server Operations Through a Connection ..... 204
Distributed Notifications ..... 204
Adding Remote Listeners ..... 204
Filters and Handbacks ..... 205
Removing Listeners ..... 206
Terminating a Connection ..... 207
Abnormal Termination ..... 207
Creating a Connector Client ..... 208
Mechanics of the RMI Connector ..... 208
The Generic Connector Protocol ..... 208
Summary ..... 211

Chapter 10 Security ..... 213

Connector Server Security ..... 213
Subject Delegation ..... 214
Using the JMXAuthenticator Interface ..... 214
Basic Security with the RMI Connector ..... 215
How Security Affects the RMI Connector Protocol ..... 215
Implementing Tighter Security ..... 216
Security and the Generic Connector ..... 216
Handshake and Profile Message Exchanges ..... 217
Using the SASL Message Class ..... 226
Using Fine-Grained Security with Connector Servers ..... 229
Summary ..... 234

Chapter 11 JMX in the Industry ..... 237

AdventNet ..... 237
Agent Toolkit Java Edition ..... 237
ManageEngine JMX Studio ..... 239
BEA Systems ..... 239
WebLogic Server ..... 239
IBM ..... 241
WebSphere Application Server ..... 241
Emerging Technologies Toolkit ..... 242
JMX Bridge ..... 242

IONA Technologies ..... 242
Orbix E2A Application Server Platform ..... 243
IONA Administrator ..... 243
XMLBus ..... 244
JBoss ..... 245
JMX4Ant ..... 246
Tomcat ..... 247
The JMX Proxy Servlet ..... 247
XMOJO ..... 248
MX4J ..... 248
MC4J Management Console ..... 249
MC4J Layout ..... 250
MC4J and JBoss ..... 251
MC4J and WebLogic ..... 251
MC4J and Tomcat ..... 251
Summary ..... 251

Chapter 12 A Summary of JMX ..... 253

Instrumentation, Agents, and Distributed Services ..... 253
MBean Servers ..... 254
Designs of Distribution ..... 256
Distributed Services and Remote Access ..... 259
Connectors ..... 259
Connector Server Addresses ..... 260
Protocol Message Exchanges ..... 261
Remote Notification Events ..... 262
Remote Agent and Server Lookup ..... 262
Remote Clients ..... 263
Security ..... 264
Industry Appeal ..... 265
Conclusion ..... 266

Index ..... 267