

Contents

Foreword xv

Preface xix

Acknowledgments xxvii

Part I Introduction to the UPnP Architecture 1

Chapter 1 It Just Works 3

Why the UPnP Standard? 4

The Foundation for Home Networking 4

What Is the UPnP Standard? 5

User Scenarios 6

Watching a Movie 7

Home Maintenance 7

Key Themes 8

The UPnP Forum 8

A Brief History of UPnP 9

The Committees of the UPnP Forum 10

Steering Committee 10

Technical Committee 10

Marketing Committee 10

Working Committees 10

Security and the UPnP Architecture 13

The UPnP Security Working Committee 13

The SSDP Service Bug 14

The UPnP Implementer's Corporation 15
Summary 16

Chapter 2 UPnP Concepts 17

Terminology 17
UPnP Phases 21
 Addressing 23
 Description 23
 Discovery 23
 Control 24
 Eventing 24
 Presentation 24
The UPnP Object Model 24
 The Device 25
 The Service 25
 Events and Subscriptions 28
 The Built-in Web Server 31
The UPnP Stack 31
 Point-to-Point Communication 32
 Multicast Communication 32
 Addressing Protocols 32
Summary 33

Chapter 3 The Technical Foundation 35

Uniform Resource Identifiers 35
 Uniform Resource Locators 36
 Uniform Resource Names 36
 The UPnP Architecture and URIs 36
IP Multicast 37
 The Host Group 37
 Network Infrastructure Support for IP Multicast 38
 The Reach of UPnP Network Traffic 38
 UPnP and IP Multicast 39
Hypertext Transfer Protocol 1.0 40
 HTTP Request/Response Model 40
 Structure of HTTP Transactions 40
 Initial Request Line 41
 HTTP Status Codes—Initial Response Line 41
 Header Lines 42
 The Message Body 43
 Sample HTTP Exchange 43
HTTP 1.1 44
 Host: Header 45
 Accepting Absolute URLs 45
 Chunked Transfer-Encoding 45

Persistent Connections and the “Connection:close” Header	47
The “100 Continue” Response	47
Caching	48
Client and Server Requirements	49
HTTP over UDP—HTTPMU and HTTPU	50
The MX Request Header	50
The S (Sequence) General Header	51
The AL (Alternate Location) General Header	51
The “*” Request URI	52
Extensible Markup Language	52
XML Documents	53
The Document Prolog	53
XML Elements	56
XML Attributes	57
CDATA Sections	57
XML and UPnP	57
The Document Object Model	58
The Tree Structure	58
DOM Levels	58
DOM Objects	59
DOM and UPnP	60
Summary	60

Part II UPnP Protocols 63

Chapter 4 Addressing 65

Addressing Challenges	66
Dynamic Host Configuration Protocol	66
Acquiring a Lease	67
Renewing a Lease	68
Releasing a Lease	69
Auto-IP	69
Address Selection	69
Resolving Address Conflicts	70
Ad-Hoc Networks	70
Limitations	71
Steps in UPnP Device Addressing	71
1. Try to Obtain an Address via DHCP	71
2. Failing DHCP, Proceed with Auto-IP	72
Summary	74

Chapter 5 Discovery 75

The Discovery Problem	76
Service Discovery Solution	76
Design Decisions	76

- Simple Service Discovery Protocol 78
 - Service Identification 78
 - Communication Model 79
 - Discovery Requests and Presence Announcements 80
 - Network Transport 81
- SSDP Discovery Request 81
- SSDP Discovery Response 84
- Presence Announcements 87
 - Device Available: ssdp:alive 89
 - Device Unavailable: ssdp:bye-bye 91
 - Expiration Information and Cache Control 91
- Summary 92

Chapter 6 Description 93

- UPnP's Description Phase 94
- Description Document Standards 95
- UPnP Device Description Document 97
 - Basic Device Information 98
- UPnP Service Description Documents 103
- Retrieving Device and Service Descriptions 108
- Validity of the Information in Description Documents 110
- Summary 110

Chapter 7 Control 111

- Remote Procedure Calls 112
- The Simple Object Access Protocol 113
 - SOAP Namespaces 114
- The SOAP Message Envelope 115
 - The SOAP Header Element 115
 - The SOAP Body Element 115
- SOAP Encoding Rules 116
- Conventions for SOAP over HTTP 117
 - The SOAP HTTP Request 117
 - The SOAP HTTP Response 119
 - SOAP Exceptions 120
- The Control URL 121
- Action Request 122
- Action Response 124
 - Action Error Response 126
- QueryStateVariable 127
- Summary 128

Chapter 8 Eventing 129

- Events in a Distributed System 129
 - Publisher/Subscriber Model 130

General Event Notification Architecture	131
The Communication Transport	131
HTTP Methods and Headers	132
Using GENA with UPnP Devices	132
Service Description and Evented State Variables	134
The UPnP Template Language for Eventing	135
Moderation of Events	136
Event Keys	137
Subscription Processes/Mechanics/Examples	137
Subscriber List	137
Subscribing to Events	138
Renewing a Subscription	141
Canceling a Subscription	143
Cancellation Response	145
Event Messages	145
Event Keys	146
The NOTIFY Message	147
The NOTIFY Message Response	149
Summary	150

Chapter 9 Presentation 151

The UPnP Presentation Page	151
Getting a Device's Presentation Page	152
Presentation Page Requirements	152
HTML/HTTP-based Presentation	153
Implementation Choices	154
Localization	155
Language Tags	156
Accept-Language and Content-Language Headers	157
Character Encodings	157
Summary	159

Part III Developing a UPnP Device 161

Chapter 10 Introducing the UPnP Super Toaster 163

Who Needs a New Toaster?	164
Physical Product Description	164
Software Requirements Specification	165
Introduction	165
Information Description	165
Functional Description	167
Summary	171

Chapter 11 Choosing a UPnP SDK 173

What to Look For	173
The Implementations	174

Allegro Software	174
Atinav Incorporated	174
Lantronix	175
Metro Link	175
Microsoft	175
Siemens	176
Intel	176
The Choice for This Example: The Intel SDK	176
Installation	177
Source Tree	181
Using the Intel SDK in Your Applications	182
Linking With the Library	182
Where to Go for Help	182
Intel® Tools for UPnP Technologies	184
Summary	186

Chapter 12 Adding Device Discovery 187

Problem Description	187
UPnP Device Description	188
Device Implementer Responsibilities	188
UPnP Namespace Requirements	189
Mapping our Requirements	189
Device Namespace	190
URLBase	193
The Super Toaster Device	193
Super Toaster Services	195
The Complete Device Description Document	199
Device Registration	201
Cleaning Up	209
What about the IP Address?	212
Programmatic Description Document Creation	217
Intel Tools for UPnP Technologies	217
Summary	225

Chapter 13 Defining Device Services 227

Introduction	227
Service Characteristics	229
Service Description Documents	230
UPnP Data Types	230
Super Toaster SCPDs	232
Lifetime Statistics Service	232
Toaster Control Service	240
Supporting Service Action Invocation	244
Multiple Out Parameters	259
The Complete Service Action Handlers	261

	Intel Tools for UPnP Technology	274
	Summary	281
Chapter 14	Handling Subscriptions and Events	283
	Problem Description	283
	UPnP Service Subscriptions	284
	Event Subscription URL	285
	Subscription Semantics	286
	Subscription Events	288
	UPnP Super Toaster	290
	Toaster Status SCPD	291
	Implementation	292
	Upnp_Subscription_Request	295
	The API	297
	The Code	300
	Super Toaster Improvements	306
	Lifetime Statistics	306
	Toaster Control Service	310
	Alternate APIs	311
	Intel Tools for UPnP Technology	313
	Summary	317
Chapter 15	Creating Device Presentation Pages	319
	Problem Description	319
	UPnP Presentation Pages	319
	Presentation URL	320
	Localization	321
	Creating a Presentation Page	322
	Viewing the Presentation Page	322
	Dynamic Presentation Page Creation	324
	Using the DOM	324
	Copy and Paste	334
	Advanced Topics	340
	Invoking Actions	340
	Server Scripts	341
	Summary	341
Chapter 16	Putting It All Together	343
	The Four Steps of Device Development	343
	Device Description	343
	Device Services	344
	Subscriptions and Eventing	345
	Presentation	346
	Advanced Topics	346
	Embedded Devices	346
	Other Stuff	348

- Using the MAC Address for the Device UDN 350
- Updating the Device Description Document 351
- Testing with Device Validator 355
 - Device Spy Trick 356
- Summary 356

Part IV Advanced Topics 357

Chapter 17 UPnP Audio/Video 359

- Problem Statement 359
- UPnP A/V Architecture Overview 360
 - A_ARG_TYPE 362
 - LastChange 362
- UPnP A/V Media Server 363
 - ContentDirectory Service 363
 - ConnectionManager Service 368
 - AVTransport Service 370
- UPnP A/V Media Renderer 375
 - ConnectionManager Service 375
 - RenderingControl Service 376
 - AVTransport Service 380
- UPnP A/V Control Point 381
- End User Scenario: Audio Playback 382
- Summary 383

Chapter 18 Adding UPnP A/V Support to the Super Toaster 385

- Super Duper Toaster 385
- Ground Rules 386
- Writing the Code 393
 - Connection Manager Service 397
 - AVTransport Service 402
- Intel Tools for UPnP Technology 411
- Summary 411

Chapter 19 Developing Control Point Applications 413

- Problem Description 413
- UPnP Control Point Applications 414
 - Discovery 416
 - Invoking Actions 420
 - Subscriptions and Eventing 423
- Advanced Topics 431
- Summary 432

Part V	Future Topics	433
Chapter 20	Simple Control Protocol	435
	Why SCP?	435
	SCP Device Architecture	436
	Communication Subsystem	436
	Application Subsystem	436
	SCP Discovery	437
	SCP Logical Device Model	438
	SCP and UPnP Differences	441
	Property Routes and Subscriptions	442
	Event Source Property	443
	Security	443
	SCP and UPnP Interoperability	444
	SCP SDK	445
	Summary	447
Part VI	The Appendixes	449
Appendix A	UPnP API Quick Reference	451
Appendix B	References	457
Glossary		463