Extracted from:

Language Implementation Patterns

Create Your Own Domain-Specific and General Programming Languages

This PDF file contains pages extracted from Language Implementation Patterns, published by the Pragmatic Bookshelf. For more information or to purchase a paperback or PDF copy, please visit http://www.pragprog.com.

Note: This extract contains some colored text (particularly in code listing). This is available only in online versions of the books. The printed versions are black and white. Pagination might vary between the online and printer versions; the content is otherwise identical.

Copyright © 2010 The Pragmatic Programmers, LLC.

All rights reserved.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form, or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior consent of the publisher.



Language Implementation Patterns

Create Your Own Domain-Specific and General Programming Languages



Terence Parr



Many of the designations used by manufacturers and sellers to distinguish their products are claimed as trademarks. Where those designations appear in this book, and The Pragmatic Programmers, LLC was aware of a trademark claim, the designations have been printed in initial capital letters or in all capitals. The Pragmatic Starter Kit, The Pragmatic Programmer, Pragmatic Programming, Pragmatic Bookshelf and the linking g device are trademarks of The Pragmatic Programmers, LLC.

With permission of the creator we hereby publish the chess images in Chapter 11 under the following licenses:

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.2 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled "GNU Free Documentation License"

(http://commons.wikimedia.org/wiki/Commons:GNU Free Documentation License).

Every precaution was taken in the preparation of this book. However, the publisher assumes no responsibility for errors or omissions, or for damages that may result from the use of information (including program listings) contained herein.

Our Pragmatic courses, workshops, and other products can help you and your team create better software and have more fun. For more information, as well as the latest Pragmatic titles, please visit us at

http://www.pragprog.com

Copyright © 2010 Terence Parr.

All rights reserved.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form, or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior consent of the publisher.

Printed in the United States of America.

ISBN-10: 1-934356-45-X ISBN-13: 978-1-934356-45-6 Printed on acid-free paper. P1.0 printing, December 2009

Version: 2010-1-13

Contents

Ac	knowledgments		
Pr	eface		14
	What	to Expect from This Book	15
			16
	What to Expect from This Book How This Book Is Organized What You'll Find in the Patterns Who Should Read This Book How to Read This Book Languages and Tools Used in This Book Languages and Tools Used in This Book Language Applications Cracked Open 1.1 The Big Picture 1.2 A Tour of the Patterns 1.3 Dissecting a Few Applications 1.4 Choosing Patterns and Assembling Applications 2.1 Identifying Phrase Structure 2.2 Building Recursive-Descent Parsers 2.3 Parser Construction Using a Grammar DSL 2.4 Tokenizing Sentences P.1. Mapping Grammars to Recursive-Descent Recognizers P.2. LL(1) Recursive-Descent Lexer	17	
			17
			18
			19
I	Gett	ing Started with Parsing	21
1	Language Applications Cracked Open		22
	1.1	The Big Picture	22
	1.2	A Tour of the Patterns	24
	1.3	Dissecting a Few Applications	28
	1.4	Choosing Patterns and Assembling Applications	36
2	Basic Parsing Patterns		39
	2.1	Identifying Phrase Structure	40
	2.2	Building Recursive-Descent Parsers	42
	2.3	Parser Construction Using a Grammar DSL	44
	2.4	Tokenizing Sentences	45
	P.1	. Mapping Grammars to Recursive-Descent Recognizers	47
	P.2	. <i>LL(1)</i> Recursive-Descent Lexer	51
	P.3	. <i>LL(1)</i> Recursive-Descent Parser	56
	DΛ	II (b) Recursive-Descent Parser	61

3	Enha	nced Parsing Patterns	67
	3.1	Parsing with Arbitrary Lookahead	68
	3.2	Parsing like a Pack Rat	70
	3.3	Directing the Parse with Semantic Information	70
	P.5.	Backtracking Parser	73
		Memoizing Parser	80
	P.7.	Predicated Parser	86
II	Anal	yzing Languages	89
4	Build	ing Intermediate Form Trees	90
	4.1	Why We Build Trees	92
	4.2	Building Abstract Syntax Trees	94
	4.3	Quick Introduction to ANTLR	101
	4.4	Constructing ASTs with ANTLR Grammars	103
	P.8.	Parse Tree	107
	P.9.	Homogeneous AST	111
	P.10.	Normalized Heterogeneous AST	113
	P.11.	Irregular Heterogeneous AST	116
5	Walking and Rewriting Trees		
	5.1	Walking Trees and Visitation Order	119
	5.2	Encapsulating Node Visitation Code	122
	5.3	Automatically Generating Visitors from Grammars	124
	5.4	Decoupling Tree Traversal from Pattern Matching	127
		Embedded Heterogeneous Tree Walker	130
	P.13.	External Tree Visitor	133
		Tree Grammar	136
	P.15.	Tree Pattern Matcher	140
6	Track	king and Identifying Program Symbols	148
	6.1	Collecting Information About Program Entities	149
	6.2	Grouping Symbols into Scopes	151
	6.3	Resolving Symbols	156
		Symbol Table for Monolithic Scope	158
	P.17.	Symbol Table for Nested Scopes	163
7	Managing Symbol Tables for Data Aggregates		
	7.1	Building Scope Trees for Structs	173
	7.2	Building Scope Trees for Classes	175
		Symbol Table for Data Aggregates	178
	P.19.	Symbol Table for Classes	184

8		cing Static Typing Rules	198
		Computing Static Expression Types	201
		Automatic Type Promotion	210
		Enforcing Static Type Safety	218
	P.23.	Enforcing Polymorphic Type Safety	225
Ш	Build	ling Interpreters	233
9	Building High-Level Interpreters		
	9.1	Designing High-Level Interpreter Memory Systems	235
	9.2	Tracking Symbols in High-Level Interpreters	237
	9.3	Processing Instructions	239
	P.24.	Syntax-Directed Interpreter	240
	P.25.	Tree-Based Interpreter	245
10	Build	ing Bytecode Interpreters	25 4
	10.1	Programming Bytecode Interpreters	256
	10.2	Defining an Assembly Language Syntax	258
	10.3	Bytecode Machine Architecture	260
		Where to Go from Here	265
		Bytecode Assembler	267
		Stack-Based Bytecode Interpreter	274
	P.28.	Register-Based Bytecode Interpreter	282
IV	Tran	slating and Generating Languages	291
11	Trans	slating Computer Languages	292
	11.1	Syntax-Directed Translation	2 94
	11.2	Rule-Based Translation	295
	11.3	Model-Driven Translation	297
	11.4	Constructing a Nested Output Model	305
		Syntax-Directed Translator	309
	P.30.	Rule-Based Translator	315
	P.31.	Target-Specific Generator Classes	321
12		rating DSLs with Templates	325
	12.1	Getting Started with StringTemplate	326
	12.2	Characterizing StringTemplate	329
	12.3	Generating Templates from a Simple Input Model	330
	12.4	Reusing Templates with a Different Input Model	333

	12.5	Using a Tree Grammar to Create Templates	336
	12.6	Applying Templates to Lists of Data	343
	12.7	Building Retargetable Translators	349
13	Putti	ng It All Together	360
	13.1	Finding Patterns in Protein Structures	360
	13.2	Using a Script to Build 3D Scenes	361
	13.3	Processing XML	362
	13.4	Reading Generic Configuration Files	364
	13.5	Tweaking Source Code	365
	13.6	Adding a New Type to Java	366
	13.7	Pretty Printing Source Code	367
	13.8	Compiling to Machine Code	368
A	Bibliography		370
	Index		372

The Pragmatic Bookshelf

The Pragmatic Bookshelf features books written by developers for developers. The titles continue the well-known Pragmatic Programmer style and continue to garner awards and rave reviews. As development gets more and more difficult, the Pragmatic Programmers will be there with more titles and products to help you stay on top of your game.

Visit Us Online

Language Implementation Patterns' Home Page

http://pragprog.com/titles/tpdsl

Source code from this book, errata, and other resources. Come give us feedback, too!

Register for Updates

http://pragprog.com/updates

Be notified when updates and new books become available.

Join the Community

http://pragprog.com/community

Read our weblogs, join our online discussions, participate in our mailing list, interact with our wiki, and benefit from the experience of other Pragmatic Programmers.

New and Noteworthy

http://pragprog.com/news

Check out the latest pragmatic developments, new titles and other offerings.

Buy the Book

If you liked this eBook, perhaps you'd like to have a paper copy of the book. It's available for purchase at our store: progprog.com/titles/tpdsl.

Contact Us

Online Orders: www.pragprog.com/catalog
Customer Service: support@pragprog.com
Non-English Versions: translations@pragprog.com
Pragmatic Teaching: academic@pragprog.com/catalog
translations@pragprog.com/catalog

academic@pragprog.com/catalog

translations@pragprog.com

academic@pragprog.com/catalog

pragmatic Teaching: translations@pragprog.com/catalog

academic@pragprog.com

Author Proposals: pragprog.com/catalog

Contact us: 1-800-699-PROG (+1 919 847 3884)