



**THE C++
STANDARD LIBRARY**

SECOND EDITION

A Tutorial and Reference

NICOLAI M. JOSUTTIS

The C++ Standard Library
Second Edition

This page intentionally left blank

The C++ Standard Library

A Tutorial and Reference

Second Edition

Nicolai M. Josuttis

◆◆ Addison-Wesley

Upper Saddle River, NJ • Boston • Indianapolis • San Francisco
New York • Toronto • Montreal • London • Munich • Paris • Madrid
Capetown • Sydney • Tokyo • Singapore • Mexico City

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 publisher was aware of a trademark claim, the designations have been printed with initial capital letters or in all capitals.

The author and publisher have taken care in the preparation of this book, but make no expressed or implied warranty of any kind and assume no responsibility for errors or omissions. No liability is assumed for incidental or consequential damages in connection with or arising out of the use of the information or programs contained herein.

The publisher offers excellent discounts on this book when ordered in quantity for bulk purchases or special sales, which may include electronic versions and/or custom covers and content particular to your business, training goals, marketing focus, and branding interests. For more information, please contact:

U.S. Corporate and Government Sales
(800) 382-3419
corpsales@pearsontechgroup.com

For sales outside the United States, please contact:

International Sales
international@pearson.com

Visit us on the Web: informit.com/aw

Library of Congress Cataloging-in-Publication Data

Josuttis, Nicolai M.

The C++ standard library : a tutorial and reference / Nicolai M. Josuttis.—2nd ed.
p. cm.

Includes bibliographical references and index.

ISBN 978-0-321-62321-8 (hardcover : alk. paper)

1. C++ (Computer program language) I. Title.

QA76.73.C153J69 2012

005.13'3-dc23

2011045071

Copyright © 2012 Pearson Education, Inc.

This book was typeset by the author using the \LaTeX document processing system.

All rights reserved. Printed in the United States of America. This publication is protected by copyright, and permission must be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. To obtain permission to use material from this work, please submit a written request to Pearson Education, Inc., Permissions Department, One Lake Street, Upper Saddle River, New Jersey 07458, or you may fax your request to (201) 236-3290.

ISBN-13: 978-0-321-62321-8

ISBN-10: 0-321-62321-5

Text printed in the United States on recycled paper at Edwards Brothers in Ann Arbor, Michigan.

First printing, March 2012

*To those who care
for people and mankind*

This page intentionally left blank

Contents

Preface to the Second Edition	xxiii
Acknowledgments for the Second Edition	xxiv
Preface to the First Edition	xxv
Acknowledgments for the First Edition	xxvi
1 About This Book	1
1.1 Why This Book	1
1.2 Before Reading This Book	2
1.3 Style and Structure of the Book	2
1.4 How to Read This Book	4
1.5 State of the Art	5
1.6 Example Code and Additional Information	5
1.7 Feedback	5
2 Introduction to C++ and the Standard Library	7
2.1 History of the C++ Standards	7
2.1.1 Common Questions about the C++11 Standard	8
2.1.2 Compatibility between C++98 and C++11	9
2.2 Complexity and Big-O Notation	10
3 New Language Features	13
3.1 New C++11 Language Features	13
3.1.1 Important Minor Syntax Cleanups	13
3.1.2 Automatic Type Deduction with <code>auto</code>	14
3.1.3 Uniform Initialization and Initializer Lists	15
3.1.4 Range-Based <code>for</code> Loops	17
3.1.5 Move Semantics and Rvalue References	19

3.1.6	New String Literals	23
3.1.7	Keyword <code>noexcept</code>	24
3.1.8	Keyword <code>constexpr</code>	26
3.1.9	New Template Features	26
3.1.10	Lambdas	28
3.1.11	Keyword <code>decltype</code>	32
3.1.12	New Function Declaration Syntax	32
3.1.13	Scoped Enumerations	32
3.1.14	New Fundamental Data Types	33
3.2	Old “New” Language Features	33
3.2.1	Explicit Initialization for Fundamental Types	37
3.2.2	Definition of <code>main()</code>	37
4	General Concepts	39
4.1	Namespace <code>std</code>	39
4.2	Header Files	40
4.3	Error and Exception Handling	41
4.3.1	Standard Exception Classes	41
4.3.2	Members of Exception Classes	44
4.3.3	Passing Exceptions with Class <code>exception_ptr</code>	52
4.3.4	Throwing Standard Exceptions	53
4.3.5	Deriving from Standard Exception Classes	54
4.4	Callable Objects	54
4.5	Concurrency and Multithreading	55
4.6	Allocators	57
5	Utilities	59
5.1	Pairs and Tuples	60
5.1.1	Pairs	60
5.1.2	Tuples	68
5.1.3	I/O for Tuples	74
5.1.4	Conversions between <code>tuples</code> and <code>pairs</code>	75
5.2	Smart Pointers	76
5.2.1	Class <code>shared_ptr</code>	76
5.2.2	Class <code>weak_ptr</code>	84
5.2.3	Misusing Shared Pointers	89
5.2.4	Shared and Weak Pointers in Detail	92
5.2.5	Class <code>unique_ptr</code>	98

5.2.6	Class <code>unique_ptr</code> in Detail	110
5.2.7	Class <code>auto_ptr</code>	113
5.2.8	Final Words on Smart Pointers	114
5.3	Numeric Limits	115
5.4	Type Traits and Type Utilities	122
5.4.1	Purpose of Type Traits	122
5.4.2	Type Traits in Detail	125
5.4.3	Reference Wrappers	132
5.4.4	Function Type Wrappers	133
5.5	Auxiliary Functions	134
5.5.1	Processing the Minimum and Maximum	134
5.5.2	Swapping Two Values	136
5.5.3	Supplementary Comparison Operators	138
5.6	Compile-Time Fractional Arithmetic with Class <code>ratio<></code>	140
5.7	Clocks and Timers	143
5.7.1	Overview of the Chrono Library	143
5.7.2	Durations	144
5.7.3	Clocks and Timepoints	149
5.7.4	Date and Time Functions by C and POSIX	157
5.7.5	Blocking with Timers	160
5.8	Header Files <code><cstdlib></code> , <code><stdlib.h></code> , and <code><cstring></code>	161
5.8.1	Definitions in <code><cstdlib></code>	161
5.8.2	Definitions in <code><stdlib.h></code>	162
5.8.3	Definitions in <code><cstring></code>	163
6	The Standard Template Library	165
6.1	STL Components	165
6.2	Containers	167
6.2.1	Sequence Containers	169
6.2.2	Associative Containers	177
6.2.3	Unordered Containers	180
6.2.4	Associative Arrays	185
6.2.5	Other Containers	187
6.2.6	Container Adapters	188
6.3	Iterators	188
6.3.1	Further Examples of Using Associative and Unordered Containers	193
6.3.2	Iterator Categories	198

6.4	Algorithms	199
6.4.1	Ranges	203
6.4.2	Handling Multiple Ranges	207
6.5	Iterator Adapters	210
6.5.1	Insert Iterators	210
6.5.2	Stream Iterators	212
6.5.3	Reverse Iterators	214
6.5.4	Move Iterators	216
6.6	User-Defined Generic Functions	216
6.7	Manipulating Algorithms	217
6.7.1	“Removing” Elements	218
6.7.2	Manipulating Associative and Unordered Containers	221
6.7.3	Algorithms versus Member Functions	223
6.8	Functions as Algorithm Arguments	224
6.8.1	Using Functions as Algorithm Arguments	224
6.8.2	Predicates	226
6.9	Using Lambdas	229
6.10	Function Objects	233
6.10.1	Definition of Function Objects	233
6.10.2	Predefined Function Objects	239
6.10.3	Binders	241
6.10.4	Function Objects and Binders versus Lambdas	243
6.11	Container Elements	244
6.11.1	Requirements for Container Elements	244
6.11.2	Value Semantics or Reference Semantics	245
6.12	Errors and Exceptions inside the STL	245
6.12.1	Error Handling	246
6.12.2	Exception Handling	248
6.13	Extending the STL	250
6.13.1	Integrating Additional Types	250
6.13.2	Deriving from STL Types	251
7	STL Containers	253
7.1	Common Container Abilities and Operations	254
7.1.1	Container Abilities	254
7.1.2	Container Operations	254
7.1.3	Container Types	260

7.2	Arrays	261
7.2.1	Abilities of Arrays	261
7.2.2	Array Operations	263
7.2.3	Using arrays as C-Style Arrays	267
7.2.4	Exception Handling	268
7.2.5	Tuple Interface	268
7.2.6	Examples of Using Arrays	268
7.3	Vectors	270
7.3.1	Abilities of Vectors	270
7.3.2	Vector Operations	273
7.3.3	Using Vectors as C-Style Arrays	278
7.3.4	Exception Handling	278
7.3.5	Examples of Using Vectors	279
7.3.6	Class <code>vector<bool></code>	281
7.4	Deque	283
7.4.1	Abilities of Deques	284
7.4.2	Deque Operations	285
7.4.3	Exception Handling	288
7.4.4	Examples of Using Deques	288
7.5	Lists	290
7.5.1	Abilities of Lists	290
7.5.2	List Operations	291
7.5.3	Exception Handling	296
7.5.4	Examples of Using Lists	298
7.6	Forward Lists	300
7.6.1	Abilities of Forward Lists	300
7.6.2	Forward List Operations	302
7.6.3	Exception Handling	311
7.6.4	Examples of Using Forward Lists	312
7.7	Sets and Multisets	314
7.7.1	Abilities of Sets and Multisets	315
7.7.2	Set and Multiset Operations	316
7.7.3	Exception Handling	325
7.7.4	Examples of Using Sets and Multisets	325
7.7.5	Example of Specifying the Sorting Criterion at Runtime	328

7.8	Maps and Multimaps	331
7.8.1	Abilities of Maps and Multimaps	332
7.8.2	Map and Multimap Operations	333
7.8.3	Using Maps as Associative Arrays	343
7.8.4	Exception Handling	345
7.8.5	Examples of Using Maps and Multimaps	345
7.8.6	Example with Maps, Strings, and Sorting Criterion at Runtime	351
7.9	Unordered Containers	355
7.9.1	Abilities of Unordered Containers	357
7.9.2	Creating and Controlling Unordered Containers	359
7.9.3	Other Operations for Unordered Containers	367
7.9.4	The Bucket Interface	374
7.9.5	Using Unordered Maps as Associative Arrays	374
7.9.6	Exception Handling	375
7.9.7	Examples of Using Unordered Containers	375
7.10	Other STL Containers	385
7.10.1	Strings as STL Containers	385
7.10.2	Ordinary C-Style Arrays as STL Containers	386
7.11	Implementing Reference Semantics	388
7.12	When to Use Which Container	392
8	STL Container Members in Detail	397
8.1	Type Definitions	397
8.2	Create, Copy, and Destroy Operations	400
8.3	Nonmodifying Operations	403
8.3.1	Size Operations	403
8.3.2	Comparison Operations	404
8.3.3	Nonmodifying Operations for Associative and Unordered Containers	404
8.4	Assignments	406
8.5	Direct Element Access	408
8.6	Operations to Generate Iterators	410
8.7	Inserting and Removing Elements	411
8.7.1	Inserting Single Elements	411
8.7.2	Inserting Multiple Elements	416
8.7.3	Removing Elements	417
8.7.4	Resizing	420

8.8	Special Member Functions for Lists and Forward Lists	420
8.8.1	Special Member Functions for Lists (and Forward Lists)	420
8.8.2	Special Member Functions for Forward Lists Only	423
8.9	Container Policy Interfaces	427
8.9.1	Nonmodifying Policy Functions	427
8.9.2	Modifying Policy Functions	428
8.9.3	Bucket Interface for Unordered Containers	429
8.10	Allocator Support	430
8.10.1	Fundamental Allocator Members	430
8.10.2	Constructors with Optional Allocator Parameters	430
9	STL Iterators	433
9.1	Header Files for Iterators	433
9.2	Iterator Categories	433
9.2.1	Output Iterators	433
9.2.2	Input Iterators	435
9.2.3	Forward Iterators	436
9.2.4	Bidirectional Iterators	437
9.2.5	Random-Access Iterators	438
9.2.6	The Increment and Decrement Problem of Vector Iterators	440
9.3	Auxiliary Iterator Functions	441
9.3.1	<code>advance()</code>	441
9.3.2	<code>next()</code> and <code>prev()</code>	443
9.3.3	<code>distance()</code>	445
9.3.4	<code>iter_swap()</code>	446
9.4	Iterator Adapters	448
9.4.1	Reverse Iterators	448
9.4.2	Insert Iterators	454
9.4.3	Stream Iterators	460
9.4.4	Move Iterators	466
9.5	Iterator Traits	466
9.5.1	Writing Generic Functions for Iterators	468
9.6	Writing User-Defined Iterators	471

10 STL Function Objects and Using Lambdas	475
10.1 The Concept of Function Objects	475
10.1.1 Function Objects as Sorting Criteria	476
10.1.2 Function Objects with Internal State	478
10.1.3 The Return Value of <code>for_each()</code>	482
10.1.4 Predicates versus Function Objects	483
10.2 Predefined Function Objects and Binders	486
10.2.1 Predefined Function Objects	486
10.2.2 Function Adapters and Binders	487
10.2.3 User-Defined Function Objects for Function Adapters	495
10.2.4 Deprecated Function Adapters	497
10.3 Using Lambdas	499
10.3.1 Lambdas versus Binders	499
10.3.2 Lambdas versus Stateful Function Objects	500
10.3.3 Lambdas Calling Global and Member Functions	502
10.3.4 Lambdas as Hash Function, Sorting, or Equivalence Criterion	504
11 STL Algorithms	505
11.1 Algorithm Header Files	505
11.2 Algorithm Overview	505
11.2.1 A Brief Introduction	506
11.2.2 Classification of Algorithms	506
11.3 Auxiliary Functions	517
11.4 The <code>for_each()</code> Algorithm	519
11.5 Nonmodifying Algorithms	524
11.5.1 Counting Elements	524
11.5.2 Minimum and Maximum	525
11.5.3 Searching Elements	528
11.5.4 Comparing Ranges	542
11.5.5 Predicates for Ranges	550
11.6 Modifying Algorithms	557
11.6.1 Copying Elements	557
11.6.2 Moving Elements	561
11.6.3 Transforming and Combining Elements	563
11.6.4 Swapping Elements	566
11.6.5 Assigning New Values	568
11.6.6 Replacing Elements	571

11.7	Removing Algorithms	575
11.7.1	Removing Certain Values	575
11.7.2	Removing Duplicates	578
11.8	Mutating Algorithms	583
11.8.1	Reversing the Order of Elements	583
11.8.2	Rotating Elements	584
11.8.3	Permuting Elements	587
11.8.4	Shuffling Elements	589
11.8.5	Moving Elements to the Front	592
11.8.6	Partition into Two Subranges	594
11.9	Sorting Algorithms	596
11.9.1	Sorting All Elements	596
11.9.2	Partial Sorting	599
11.9.3	Sorting According to the <i>n</i> th Element	602
11.9.4	Heap Algorithms	604
11.10	Sorted-Range Algorithms	608
11.10.1	Searching Elements	608
11.10.2	Merging Elements	614
11.11	Numeric Algorithms	623
11.11.1	Processing Results	623
11.11.2	Converting Relative and Absolute Values	627
12	Special Containers	631
12.1	Stacks	632
12.1.1	The Core Interface	633
12.1.2	Example of Using Stacks	633
12.1.3	A User-Defined Stack Class	635
12.1.4	Class <code>stack<></code> in Detail	637
12.2	Queues	638
12.2.1	The Core Interface	639
12.2.2	Example of Using Queues	640
12.2.3	A User-Defined Queue Class	641
12.2.4	Class <code>queue<></code> in Detail	641
12.3	Priority Queues	641
12.3.1	The Core Interface	643
12.3.2	Example of Using Priority Queues	643
12.3.3	Class <code>priority_queue<></code> in Detail	644

12.4	Container Adapters in Detail	645
12.4.1	Type Definitions	645
12.4.2	Constructors	646
12.4.3	Supplementary Constructors for Priority Queues	646
12.4.4	Operations	647
12.5	Bitsets	650
12.5.1	Examples of Using Bitsets	651
12.5.2	Class <code>bitset</code> in Detail	653
13	Strings	655
13.1	Purpose of the String Classes	656
13.1.1	A First Example: Extracting a Temporary Filename	656
13.1.2	A Second Example: Extracting Words and Printing Them Backward	660
13.2	Description of the String Classes	663
13.2.1	String Types	663
13.2.2	Operation Overview	666
13.2.3	Constructors and Destructor	667
13.2.4	Strings and C-Strings	668
13.2.5	Size and Capacity	669
13.2.6	Element Access	671
13.2.7	Comparisons	672
13.2.8	Modifiers	673
13.2.9	Substrings and String Concatenation	676
13.2.10	Input/Output Operators	677
13.2.11	Searching and Finding	678
13.2.12	The Value <code>npos</code>	680
13.2.13	Numeric Conversions	681
13.2.14	Iterator Support for Strings	684
13.2.15	Internationalization	689
13.2.16	Performance	692
13.2.17	Strings and Vectors	692
13.3	String Class in Detail	693
13.3.1	Type Definitions and Static Values	693
13.3.2	Create, Copy, and Destroy Operations	694
13.3.3	Operations for Size and Capacity	696
13.3.4	Comparisons	697
13.3.5	Character Access	699
13.3.6	Generating C-Strings and Character Arrays	700

13.3.7	Modifying Operations	700
13.3.8	Searching and Finding	708
13.3.9	Substrings and String Concatenation	711
13.3.10	Input/Output Functions	712
13.3.11	Numeric Conversions	713
13.3.12	Generating Iterators	714
13.3.13	Allocator Support	715
14	Regular Expressions	717
14.1	The Regex Match and Search Interface	717
14.2	Dealing with Subexpressions	720
14.3	Regex Iterators	726
14.4	Regex Token Iterators	727
14.5	Replacing Regular Expressions	730
14.6	Regex Flags	732
14.7	Regex Exceptions	735
14.8	The Regex ECMAScript Grammar	738
14.9	Other Grammars	739
14.10	Basic Regex Signatures in Detail	740
15	Input/Output Using Stream Classes	743
15.1	Common Background of I/O Streams	744
15.1.1	Stream Objects	744
15.1.2	Stream Classes	744
15.1.3	Global Stream Objects	745
15.1.4	Stream Operators	745
15.1.5	Manipulators	746
15.1.6	A Simple Example	746
15.2	Fundamental Stream Classes and Objects	748
15.2.1	Classes and Class Hierarchy	748
15.2.2	Global Stream Objects	751
15.2.3	Header Files	752
15.3	Standard Stream Operators << and >>	753
15.3.1	Output Operator <<	753
15.3.2	Input Operator >>	754
15.3.3	Input/Output of Special Types	755

15.4	State of Streams	758
15.4.1	Constants for the State of Streams	758
15.4.2	Member Functions Accessing the State of Streams	759
15.4.3	Stream State and Boolean Conditions	760
15.4.4	Stream State and Exceptions	762
15.5	Standard Input/Output Functions	767
15.5.1	Member Functions for Input	768
15.5.2	Member Functions for Output	771
15.5.3	Example Uses	772
15.5.4	sentry Objects	772
15.6	Manipulators	774
15.6.1	Overview of All Manipulators	774
15.6.2	How Manipulators Work	776
15.6.3	User-Defined Manipulators	777
15.7	Formatting	779
15.7.1	Format Flags	779
15.7.2	Input/Output Format of Boolean Values	781
15.7.3	Field Width, Fill Character, and Adjustment	781
15.7.4	Positive Sign and Uppercase Letters	784
15.7.5	Numeric Base	785
15.7.6	Floating-Point Notation	787
15.7.7	General Formatting Definitions	789
15.8	Internationalization	790
15.9	File Access	791
15.9.1	File Stream Classes	791
15.9.2	Rvalue and Move Semantics for File Streams	795
15.9.3	File Flags	796
15.9.4	Random Access	799
15.9.5	Using File Descriptors	801
15.10	Stream Classes for Strings	802
15.10.1	String Stream Classes	802
15.10.2	Move Semantics for String Streams	806
15.10.3	char* Stream Classes	807
15.11	Input/Output Operators for User-Defined Types	810
15.11.1	Implementing Output Operators	810
15.11.2	Implementing Input Operators	812
15.11.3	Input/Output Using Auxiliary Functions	814

15.11.4	User-Defined Format Flags	815
15.11.5	Conventions for User-Defined Input/Output Operators	818
15.12	Connecting Input and Output Streams	819
15.12.1	Loose Coupling Using <code>tie()</code>	819
15.12.2	Tight Coupling Using Stream Buffers	820
15.12.3	Redirecting Standard Streams	822
15.12.4	Streams for Reading and Writing	824
15.13	The Stream Buffer Classes	826
15.13.1	The Stream Buffer Interfaces	826
15.13.2	Stream Buffer Iterators	828
15.13.3	User-Defined Stream Buffers	832
15.14	Performance Issues	844
15.14.1	Synchronization with C's Standard Streams	845
15.14.2	Buffering in Stream Buffers	845
15.14.3	Using Stream Buffers Directly	846
16	Internationalization	849
16.1	Character Encodings and Character Sets	850
16.1.1	Multibyte and Wide-Character Text	850
16.1.2	Different Character Sets	851
16.1.3	Dealing with Character Sets in C++	852
16.1.4	Character Traits	853
16.1.5	Internationalization of Special Characters	857
16.2	The Concept of Locales	857
16.2.1	Using Locales	858
16.2.2	Locale Facets	864
16.3	Locales in Detail	866
16.4	Facets in Detail	869
16.4.1	Numeric Formatting	870
16.4.2	Monetary Formatting	874
16.4.3	Time and Date Formatting	884
16.4.4	Character Classification and Conversion	891
16.4.5	String Collation	904
16.4.6	Internationalized Messages	905

17 Numerics	907
17.1 Random Numbers and Distributions	907
17.1.1 A First Example	908
17.1.2 Engines	912
17.1.3 Engines in Detail	915
17.1.4 Distributions	917
17.1.5 Distributions in Detail	921
17.2 Complex Numbers	925
17.2.1 Class <code>complex<></code> in General	925
17.2.2 Examples Using Class <code>complex<></code>	926
17.2.3 Operations for Complex Numbers	928
17.2.4 Class <code>complex<></code> in Detail	935
17.3 Global Numeric Functions	941
17.4 Valarrays	943
18 Concurrency	945
18.1 The High-Level Interface: <code>async()</code> and Futures	946
18.1.1 A First Example Using <code>async()</code> and Futures	946
18.1.2 An Example of Waiting for Two Tasks	955
18.1.3 Shared Futures	960
18.2 The Low-Level Interface: Threads and Promises	964
18.2.1 Class <code>std::thread</code>	964
18.2.2 Promises	969
18.2.3 Class <code>packaged_task<></code>	972
18.3 Starting a Thread in Detail	973
18.3.1 <code>async()</code> in Detail	974
18.3.2 Futures in Detail	975
18.3.3 Shared Futures in Detail	976
18.3.4 Class <code>std::promise</code> in Detail	977
18.3.5 Class <code>std::packaged_task</code> in Detail	977
18.3.6 Class <code>std::thread</code> in Detail	979
18.3.7 Namespace <code>this_thread</code>	981
18.4 Synchronizing Threads, or the Problem of Concurrency	982
18.4.1 Beware of Concurrency!	982
18.4.2 The Reason for the Problem of Concurrent Data Access	983
18.4.3 What Exactly Can Go Wrong (the Extent of the Problem)	983
18.4.4 The Features to Solve the Problems	987

18.5	Mutexes and Locks	989
18.5.1	Using Mutexes and Locks	989
18.5.2	Mutexes and Locks in Detail	998
18.5.3	Calling Once for Multiple Threads	1000
18.6	Condition Variables	1003
18.6.1	Purpose of Condition Variables	1003
18.6.2	A First Complete Example for Condition Variables	1004
18.6.3	Using Condition Variables to Implement a Queue for Multiple Threads	1006
18.6.4	Condition Variables in Detail	1009
18.7	Atomics	1012
18.7.1	Example of Using Atomics	1012
18.7.2	Atomics and Their High-Level Interface in Detail	1016
18.7.3	The C-Style Interface of Atomics	1019
18.7.4	The Low-Level Interface of Atomics	1019
19	Allocators	1023
19.1	Using Allocators as an Application Programmer	1023
19.2	A User-Defined Allocator	1024
19.3	Using Allocators as a Library Programmer	1026
	Bibliography	1031
	Newsgroups and Forums	1031
	Books and Web Sites	1032
	Index	1037

This page intentionally left blank

Preface to the Second Edition

I never thought that the first edition of this book would sell so long. But now, after twelve years, it's time for a new edition that covers C++11, the new C++ standard.

Note that this means more than simply adding new libraries. C++ has changed. Almost all typical applications of parts of the library look a bit different now. This is not the result of a huge language change. It's the result of many minor changes, such as using rvalue references and move semantics, range-based `for` loops, `auto`, and new template features. Thus, besides presenting new libraries and supplementary features of existing libraries, almost all of the examples in this book were rewritten at least partially. Nevertheless, to support programmers who still use "old" C++ environments, this book will describe differences between C++ versions whenever they appear.

I learned C++11 the hard way. Because I didn't follow the standardization as it was happening I started to look at C++11 about two years ago. I really had trouble understanding it. But the people on the standardization committee helped me to describe and present the new features as they are intended to be used now.

Note, finally, that this book now has a problem: Although the book's size grew from about 800 to more than 1,100 pages, I still can't present the C++ standard library as a whole. The library part of the new C++11 standard alone now has about 750 pages, written in very condensed form without much explanation. For this reason, I had to decide which features to describe and in how much detail. Again, many people in the C++ community helped me to make this decision. The intent was to concentrate on what the average application programmer needs. For some missing parts, I provide a supplementary chapter on the Web site of this book, <http://www.cppstdlib.com>, but you still will find details not mentioned here in the standard.

The art of teaching is not the art of presenting everything. It's the art of separating the wheat from the chaff so that you get the most out of it. May the exercise succeed.

- [Why Didn't They Ask Evans? for free](#)
- [read Obsessed \(Peter Zak, Book 4\)](#)
- [Eat, Read, Love: A Cookbook book](#)
- [read The Warrior King \(The Seer King Trilogy, Book 3\) online](#)
- [Guerrilla Marketing For Dummies book](#)
- [CCNA Security Lab Manual for free](#)

- <http://jaythebody.com/freebooks/The-Ghost-and-the-Documents-Reviewer--A-Mystery-Novella.pdf>
- <http://test.markblaustein.com/library/Obsessed--Peter-Zak--Book-4-.pdf>
- <http://patrickvincitore.com/?ebooks/Children-Playing-Before-a-Statue-of-Hercules.pdf>
- <http://nexson.arzamaszev.com/library/Beasts-and-Super-Beasts.pdf>
- <http://nexson.arzamaszev.com/library/Guerrilla-Marketing-For-Dummies.pdf>
- <http://paulczajak.com/?library/Black-Horse-Creek.pdf>