Joshua Bloch

Updated for Java 9

Effective Java

Third Edition

Best practices for

...the Java Platform

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Joshua Bloch

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To my family: Cindy, Tim, and Matt

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Foreword

IF a colleague were to say to you, "Spouse of me this night today manufactures the unusual meal in a home. You will join?" three things would likely cross your mind: third, that you had been invited to dinner; second, that English was not your colleague's first language; and first, a good deal of puzzlement.

If you have ever studied a second language yourself and then tried to use it outside the classroom, you know that there are three things you must master: how the language is structured (grammar), how to name things you want to talk about (vocabulary), and the customary and effective ways to say everyday things (usage). Too often only the first two are covered in the classroom, and you find native speakers constantly suppressing their laughter as you try to make yourself understood.

It is much the same with a programming language. You need to understand the core language: is it algorithmic, functional, object-oriented? You need to know the vocabulary: what data structures, operations, and facilities are provided by the standard libraries? And you need to be familiar with the customary and effective ways to structure your code. Books about programming languages often cover only the first two, or discuss usage only spottily. Maybe that's because the first two are in some ways easier to write about. Grammar and vocabulary are properties of the language alone, but usage is characteristic of a community that uses it.

The Java programming language, for example, is object-oriented with single inheritance and supports an imperative (statement-oriented) coding style within each method. The libraries address graphic display support, networking, distributed computing, and security. But how is the language best put to use in practice?

There is another point. Programs, unlike spoken sentences and unlike most books and magazines, are likely to be changed over time. It's typically not enough to produce code that operates effectively and is readily understood by other persons; one must also organize the code so that it is easy to modify. There may be ten ways to write code for some task *T*. Of those ten ways, seven will be awkward, inefficient, or puzzling. Of the other three, which is most likely to be similar to the code needed for the task *T′* in next year's software release?

There are numerous books from which you can learn the grammar of the Java programming language, including *The Java™ Programming Language* by Arnold, Gosling, and Holmes, or *The Java™ Language Specification* by Gosling, Joy, yours truly, and Bracha. Likewise, there are dozens of books on the libraries and APIs associated with the Java programming language.

This book addresses your third need: customary and effective usage. Joshua Bloch has spent years extending, implementing, and using the Java programming language at Sun Microsystems; he has also read a lot of other people's code, including mine. Here he offers good advice, systematically organized, on how to structure your code so that it works well, so that other people can understand it, so that future modifications and improvements are less likely to cause headaches—perhaps, even, so that your programs will be pleasant, elegant, and graceful.

Guy L. Steele Jr.
Burlington, Massachusetts
April 2001

Preface

Preface to the Third Edition

IN 1997, when Java was new, James Gosling (the father of Java), described it as a "blue collar language" that was "pretty simple" [Gosling97]. At about the same time, Bjarne Stroustrup (the father of C++) described C++ as a "multi-paradigm language" that "deliberately differs from languages designed to support a single way of writing programs" [Stroustrup95]. Stroustrup warned:

> Much of the relative simplicity of Java is—like for most new languages—partly an illusion and partly a function of its incompleteness. As time passes, Java will grow significantly in size and complexity. It will double or triple in size and grow implementation-dependent extensions or libraries. [Stroustrup]

Now, twenty years later, it's fair to say that Gosling and Stroustrup were both right. Java is now large and complex, with multiple abstractions for many things, from parallel execution, to iteration, to the representation of dates and times.

I still like Java, though my ardor has cooled a bit as the platform has grown. Given its increased size and complexity, the need for an up-to-date best-practices guide is all the more critical. With this third edition of *Effective Java*, I did my best to provide you with one. I hope this edition continues to satisfy the need, while staying true to the spirit of the first two editions.

Small is beautiful, but simple ain't easy.

San Jose, California
November 2017

P.S. I would be remiss if I failed to mention an industry-wide best practice that has occupied a fair amount of my time lately. Since the birth of our field in the 1950's, we have freely reimplemented each others' APIs. This practice was critical to the meteoric success of computer technology. I am active in the effort to preserve this freedom [CompSci17], and I encourage you to join me. It is crucial to the continued health of our profession that we retain the right to reimplement each others' APIs.

Preface to the Second Edition

A lot has happened to the Java platform since I wrote the first edition of this book in 2001, and it's high time for a second edition. The most significant set of changes was the addition of generics, enum types, annotations, autoboxing, and the for-each loop in Java 5. A close second was the addition of the new concurrency library, `java.util.concurrent`, also released in Java 5. With Gilad Bracha, I had the good fortune to lead the teams that designed the new language features. I also had the good fortune to serve on the team that designed and developed the concurrency library, which was led by Doug Lea.

The other big change in the platform is the widespread adoption of modern Integrated Development Environments (IDEs), such as Eclipse, IntelliJ IDEA, and NetBeans, and of static analysis tools, such as FindBugs. While I have not been involved in these efforts, I've benefited from them immensely and learned how they affect the Java development experience.

In 2004, I moved from Sun to Google, but I've continued my involvement in the development of the Java platform over the past four years, contributing to the concurrency and collections APIs through the good offices of Google and the Java Community Process. I've also had the pleasure of using the Java platform to develop libraries for use within Google. Now I know what it feels like to be a user.

As was the case in 2001 when I wrote the first edition, my primary goal is to share my experience with you so that you can imitate my successes while avoiding my failures. The new material continues to make liberal use of real-world examples from the Java platform libraries.

The first edition succeeded beyond my wildest expectations, and I've done my best to stay true to its spirit while covering all of the new material that was required to bring the book up to date. It was inevitable that the book would grow, and grow it did, from fifty-seven items to seventy-eight. Not only did I add twenty-three items, but I thoroughly revised all the original material and retired a few items whose better days had passed. In the Appendix, you can see how the material in this edition relates to the material in the first edition.

In the Preface to the First Edition, I wrote that the Java programming language and its libraries were immensely conducive to quality and productivity, and a joy to work with. The changes in releases 5 and 6 have taken a good thing and made it better. The platform is much bigger now than it was in 2001 and more complex, but once you learn the patterns and idioms for using the new features, they make your programs better and your life easier. I hope this edition captures my contin-

ued enthusiasm for the platform and helps make your use of the platform and its new features more effective and enjoyable.

San Jose, California
April 2008

Preface to the First Edition

In 1996 I pulled up stakes and headed west to work for JavaSoft, as it was then known, because it was clear that that was where the action was. In the intervening five years I've served as Java platform libraries architect. I've designed, implemented, and maintained many of the libraries and served as a consultant for many others. Presiding over these libraries as the Java platform matured was a once-in-a-lifetime opportunity. It is no exaggeration to say that I had the privilege to work with some of the great software engineers of our generation. In the process, I learned a lot about the Java programming language—what works, what doesn't, and how to use the language and its libraries to best effect.

This book is my attempt to share my experience with you so that you can imitate my successes while avoiding my failures. I borrowed the format from Scott Meyers's *Effective C++*, which consists of fifty items, each conveying one specific rule for improving your programs and designs. I found the format to be singularly effective, and I hope you do too.

In many cases, I took the liberty of illustrating the items with real-world examples from the Java platform libraries. When describing something that could have been done better, I tried to pick on code that I wrote myself, but occasionally I pick on something written by a colleague. I sincerely apologize if, despite my best efforts, I've offended anyone. Negative examples are cited not to cast blame but in the spirit of cooperation, so that all of us can benefit from the experience of those who've gone before.

While this book is not targeted solely at developers of reusable components, it is inevitably colored by my experience writing such components over the past two decades. I naturally think in terms of exported APIs (Application Programming Interfaces), and I encourage you to do likewise. Even if you aren't developing reusable components, thinking in these terms tends to improve the quality of the software you write. Furthermore, it's not uncommon to write a reusable compo-

nent without knowing it: You write something useful, share it with your buddy across the hall, and before long you have half a dozen users. At this point, you no longer have the flexibility to change the API at will and are thankful for all the effort that you put into designing the API when you first wrote the software.

My focus on API design may seem a bit unnatural to devotees of the new lightweight software development methodologies, such as *Extreme Programming*. These methodologies emphasize writing the simplest program that could possibly work. If you're using one of these methodologies, you'll find that a focus on API design serves you well in the *refactoring* process. The fundamental goals of refactoring are the improvement of system structure and the avoidance of code duplication. These goals are impossible to achieve in the absence of well-designed APIs for the components of the system.

No language is perfect, but some are excellent. I have found the Java programming language and its libraries to be immensely conducive to quality and productivity, and a joy to work with. I hope this book captures my enthusiasm and helps make your use of the language more effective and enjoyable.

Cupertino, California
April 2001

Acknowledgments

Acknowledgments for the Third Edition

I thank the readers of the first two editions of this book for giving it such a kind and enthusiastic reception, for taking its ideas to heart, and for letting me know what a positive influence it had on them and their work. I thank the many professors who used the book in their courses, and the many engineering teams that adopted it.

I thank the whole team at Addison-Wesley and Pearson for their kindness, professionalism, patience, and grace under extreme pressure. Through it all, my editor Greg Doench remained unflappable: a fine editor and a perfect gentleman. I'm afraid his hair may have turned a bit gray as a result of this project, and I humbly apologize. My project manager, Julie Nahil, and my project editor, Dana Wilson, were all I could hope for: diligent, prompt, organized, and friendly. My copy editor, Kim Wimpsett, was meticulous and tasteful.

I have yet again been blessed with the best team of reviewers imaginable, and I give my sincerest thanks to each of them. The core team, who reviewed most every chapter, consisted of Cindy Bloch, Brian Kernighan, Kevin Bourrillion, Joe Bowbeer, William Chargin, Joe Darcy, Brian Goetz, Tim Halloran, Stuart Marks, Tim Peierls, and Yoshiki Shibata, Other reviewers included Marcus Biel, Dan Bloch, Beth Bottos, Martin Buchholz, Michael Diamond, Charlie Garrod, Tom Hawtin, Doug Lea, Aleksey Shipilëv, Lou Wasserman, and Peter Weinberger. These reviewers made numerous suggestions that led to great improvements in this book and saved me from many embarrassments.

I give special thanks to William Chargin, Doug Lea, and Tim Peierls, who served as sounding boards for many of the ideas in this book. William, Doug, and Tim were unfailingly generous with their time and knowledge.

Finally, I thank my wife, Cindy Bloch, for encouraging me to write, for reading each item in raw form, for writing the index, for helping me with all of the things that invariably come up when you take on a big project, and for putting up with me while I wrote.

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I give special thanks to Doug Lea and Tim Peierls, who served as sounding boards for many of the ideas in this book. Doug and Tim were unfailingly generous with their time and knowledge.

I thank my manager at Google, Prabha Krishna, for her continued support and encouragement.

Finally, I thank my wife, Cindy Bloch, for encouraging me to write, for reading each item in raw form, for helping me with Framemaker, for writing the index, and for putting up with me while I wrote.

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I thank Patrick Chan for suggesting that I write this book and for pitching the idea to Lisa Friendly, the series managing editor; Tim Lindholm, the series technical editor; and Mike Hendrickson, executive editor of Addison-Wesley. I thank Lisa, Tim, and Mike for encouraging me to pursue the project and for their superhuman patience and unyielding faith that I would someday write this book.

I thank James Gosling and his original team for giving me something great to write about, and I thank the many Java platform engineers who followed in James's footsteps. In particular, I thank my colleagues in Sun's Java Platform Tools and Libraries Group for their insights, their encouragement, and their support. The team consists of Andrew Bennett, Joe Darcy, Neal Gafter, Iris Garcia, Konstantin Kladko, Ian Little, Mike McCloskey, and Mark Reinhold. Former members include Zhenghua Li, Bill Maddox, and Naveen Sanjeeva.

I thank my manager, Andrew Bennett, and my director, Larry Abrahams, for lending their full and enthusiastic support to this project. I thank Rich Green, the VP of Engineering at Java Software, for providing an environment where engineers are free to think creatively and to publish their work.

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Numerous colleagues, inside and outside Sun, participated in technical discussions that improved the quality of this book. Among others, Ben Gomes, Steffen Grarup, Peter Kessler, Richard Roda, John Rose, and David Stoutamire contributed useful insights. A special thanks is due Doug Lea, who served as a sounding board for many of the ideas in this book. Doug has been unfailingly generous with his time and his knowledge.

I thank Julie Dinicola, Jacqui Doucette, Mike Hendrickson, Heather Olszyk, Tracy Russ, and the whole team at Addison-Wesley for their support and professionalism. Even under an impossibly tight schedule, they were always friendly and accommodating.

I thank Guy Steele for writing the Foreword. I am honored that he chose to participate in this project.

Finally, I thank my wife, Cindy Bloch, for encouraging and occasionally threatening me to write this book, for reading each item in its raw form, for helping me with Framemaker, for writing the index, and for putting up with me while I wrote.