Modern Compiler Implementation in Java
Second Edition

This textbook describes all phases of a compiler: lexical analysis, parsing, abstract syntax, semantic actions, intermediate representations, instruction selection via tree matching, dataflow analysis, graph-coloring register allocation, and runtime systems. It includes good coverage of current techniques in code generation and register allocation, as well as the compilation of functional and object-oriented languages, which is missing from most books. The most accepted and successful techniques are described concisely, rather than as an exhaustive catalog of every possible variant. Detailed descriptions of the interfaces between modules of a compiler are illustrated with actual Java classes.

The first part of the book, Fundamentals of Compilation, is suitable for a one-semester first course in compiler design. The second part, Advanced Topics, which includes the compilation of object-oriented and functional languages, garbage collection, loop optimization, SSA form, instruction scheduling, and optimization for cache-memory hierarchies, can be used for a second-semester or graduate course.

This new edition has been rewritten extensively to include more discussion of Java and object-oriented programming concepts, such as visitor patterns. A unique feature is the newly redesigned compiler project in Java for a subset of Java itself. The project includes both front-end and back-end phases, so that students can build a complete working compiler in one semester.

Andrew W. Appel is Professor of Computer Science at Princeton University. He has done research and published papers on compilers, functional programming languages, runtime systems and garbage collection, type systems, and computer security; he is also author of the book *Compiling with Continuations.* He is a designer and founder of the Standard ML of New Jersey project. In 1998, Appel was elected a Fellow of the Association for Computing Machinery for "significant research contributions in the area of programming languages and compilers" and for his work as editor-in-chief (1993–97) of the *ACM Transactions on Programming Languages and Systems,* the leading journal in the field of compilers and programming languages.

Jens Palsberg is Associate Professor of Computer Science at Purdue University. His research interests are programming languages, compilers, software engineering, and information security. He has authored more than 50 technical papers in these areas and a book with Michael Schwartzbach, *Object-oriented Type Systems.* In 1998, he received the National Science Foundation Faculty Early Career Development Award, and in 1999, the Purdue University Faculty Scholar award.

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Contents

Preface

This book is intended as a textbook for a one- or two-semester course in compilers. Students will see the theory behind different components of a compiler, the programming techniques used to put the theory into practice, and the interfaces used to modularize the compiler. To make the interfaces and programming examples clear and concrete, we have written them in Java. Another edition of this book is available that uses the ML language.

Implementation project. The "student project compiler" that we have outlined is reasonably simple, but is organized to demonstrate some important techniques that are now in common use: abstract syntax trees to avoid tangling syntax and semantics, separation of instruction selection from register allocation, copy propagation to give flexibility to earlier phases of the compiler, and containment of target-machine dependencies. Unlike many "student compilers" found in other textbooks, this one has a simple but sophisticated back end, allowing good register allocation to be done after instruction selection.

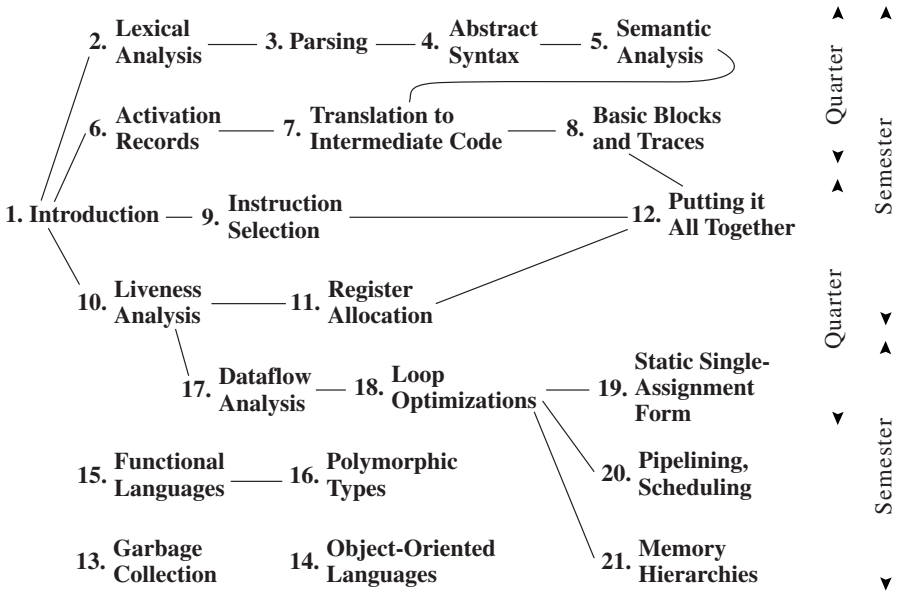
This second edition of the book has a redesigned project compiler: It uses a subset of Java, called MiniJava, as the source language for the compiler project, it explains the use of the parser generators JavaCC and SableCC, and it promotes programming with the Visitor pattern. Students using this edition can implement a compiler for a language they're familiar with, using standard tools, in a more object-oriented style.

Each chapter in Part I has a programming exercise corresponding to one module of a compiler. Software useful for the exercises can be found at
http://uk.cambridge.org/resources/052182060X (outside North America);
http://us.cambridge.org/titles/052182060X.html (within North America).

Exercises. Each chapter has pencil-and-paper exercises; those marked with a star are more challenging, two-star problems are difficult but solvable, and

the occasional three-star exercises are not known to have a solution.

Course sequence. The figure shows how the chapters depend on each other.



- A one-semester course could cover all of Part I (Chapters 1–12), with students implementing the project compiler (perhaps working in groups); in addition, lectures could cover selected topics from Part II.
- An advanced or graduate course could cover Part II, as well as additional topics from the current literature. Many of the Part II chapters can stand independently from Part I, so that an advanced course could be taught to students who have used a different book for their first course.
- In a two-quarter sequence, the first quarter could cover Chapters 1–8, and the second quarter could cover Chapters 9–12 and some chapters from Part II.

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