*flex*与*bison*(影印版)

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John Levine 著

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John R. Levine

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Preface

Flex and bison are tools designed for writers of compilers and interpreters, although they are also useful for many applications that will interest noncompiler writers. Any application that looks for patterns in its input or has an input or command language is a good candidate for flex and bison. Furthermore, they allow for rapid application prototyping, easy modification, and simple maintenance of programs. To stimulate your imagination, here are a few things people have used flex and bison, or their predecessors lex and yacc, to develop:

- The desktop calculator *bc*
- The tools *eqn* and *pic*, typesetting preprocessors for mathematical equations and complex pictures
- Many other "domain-specific languages" targeted for a particular application
- *PCC*, the Portable C Compiler used with many Unix systems
- Flex itself
- A SQL database language translator

Scope of This Book

Chapter 1, *Introducing Flex and Bison*, gives an overview of how and why flex and bison are used to create compilers and interpreters and demonstrates some simple applications including a calculator built in flex and bison. It also introduces basic terms we use throughout the book.

Chapter 2, *Using Flex*, describes how to use flex. It develops flex applications that count words in files, handle multiple and nested input files, and compute statistics on C programs.

Chapter 3, *Using Bison*, gives a full example using flex and bison to develop a fully functional desktop calculator with variables, procedures, loops, and conditional expressions. It shows the use of abstract syntax trees (ASTs), powerful and easy-to-use data structures for representing parsed input.

Chapter 4, *Parsing SQL*, develops a parser for the MySQL dialect of the SQL relational database language. The parser checks the syntax of SQL statements and translates them

into an internal form suitable for an interpreter. It shows the use of Reverse Polish Notation (RPN), another powerful form used to represent and interpret parsed input.

Chapter 5, *A Reference for Flex Specifications*, and Chapter 6, *A Reference for Bison Specifications*, provide detailed descriptions of the features and options available to flex and bison programmers. These chapters and the two that follow provide technical information for the now-experienced flex and bison programmer to use while developing flex and bison applications.

Chapter 7, *Ambiguities and Conflicts*, explains bison ambiguities and conflicts, which are grammar problems that keep bison from creating a parser from a grammar. It then develops methods that can be used to locate and correct such problems.

Chapter 8, *Error Reporting and Recovery*, discusses techniques that compiler or interpreter designers can use to locate, recognize, and report errors in the compiler input.

Chapter 9, *Advanced Flex and Bison*, covers reentrant scanners and parsers, Generalized Left to Right (GLR) parsers that can handle grammars that regular bison parsers can't, and interfaces to C++.

The *appendix* provides the complete grammar and a cross-reference for the SQL parser discussed in Chapter 4.

The *glossary* lists technical terms from language and compiler theory.

We presume you are familiar with C, because most examples are in C, flex, or bison, with a few in C++ and the remainder in SQL or the special-purpose languages developed within the text.

Conventions Used in This Book

The following conventions are used in this book:

Italic
: Used for new terms and concepts when they are introduced.

`Constant Width`
: Used for program listings, as well as within paragraphs to refer to program elements such as statements, classes, macros, states, rules, all code terms, and files and directories.

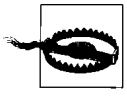
`Constant Bold`
: Shows commands or other text that should be typed literally by the user.

`Constant width italic`
: Shows text that should be replaced with user-supplied values or by values determined by context.

`$`
: is the shell prompt.

[]
surround optional elements in a description of program syntax. (Don't type the brackets themselves.)

This icon signifies a tip, suggestion, or general note.



This icon indicates a warning or caution.

Getting Flex and Bison

Flex and bison are modern replacements for the classic lex and yacc that were both developed at Bell Laboratories in the 1970s. Yacc was the first of the two, developed by Stephen C. Johnson. Lex was designed by Mike Lesk and Eric Schmidt (the same Eric Schmidt who now heads Google) to work with bison. Both lex and yacc have been standard Unix utilities since Seventh Edition Unix in the 1970s.

The GNU Project of the Free Software Foundation distributes bison, a foreward-compatible replacement for yacc. It was originally written by Robert Corbett and Richard Stallman. The bison manual is excellent, especially for referencing specific features. Bison is included with all common distributions of BSD and Linux, but if you want the most up-to-date version, its home page is:

http://www.gnu.org/software/bison/

BSD and the GNU Project also distribute *flex* (*F*ast *Lex*ical Analyzer Generator), "a rewrite of lex intended to fix some of that tool's many bugs and deficiencies." Flex was originally written by Jef Poskanzer; Vern Paxson and Van Jacobson have considerably improved it. Common distributions of BSD and Linux include a copy of flex, but if you want the latest version, it's now hosted at SourceForge:

http://flex.sourceforge.net/

This Book's Example Files

The programs in this book are available online as:

ftp://ftp.iecc.com/pub/file/flexbison.zip

They can be downloaded by any web browser or FTP client. The zip format file can be decoded by the popular freeware *unzip* utility on Unix-ish and Linux systems or opened as a compressed folder on Windows XP or newer.

The examples in the book were all tested with flex version 2.5.35 and bison 2.4.1.

Using Code Examples

This book is here to help you get your job done. In general, you may use the code in this book in your programs and documentation. You do not need to contact us for permission unless you're reproducing a significant portion of the code. For example, writing a program that uses several chunks of code from this book does not require permission. Selling or distributing a CD-ROM of examples from O'Reilly books does require permission. Answering a question by citing this book and quoting example code does not require permission. Incorporating a significant amount of example code from this book into your product's documentation does require permission.

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Table of Contents

CHAPTER 1

Introducing Flex and Bison

Flex and Bison are tools for building programs that handle structured input. They were originally tools for building compilers, but they have proven to be useful in many other areas. In this first chapter, we'll start by looking at a little (but not too much) of the theory behind them, and then we'll dive into some examples of their use.

Lexical Analysis and Parsing

The earliest compilers back in the 1950s used utterly ad hoc techniques to analyze the syntax of the source code of programs they were compiling. During the 1960s, the field got a lot of academic attention, and by the early 1970s, syntax analysis was a well-understood field.

One of the key insights was to break the job into two parts: *lexical analysis* (also called *lexing* or *scanning*) and *syntax analysis* (or *parsing*).

Roughly speaking, scanning divides the input into meaningful chunks, called *tokens*, and parsing figures out how the tokens relate to each other. For example, consider this snippet of C code:

```
alpha = beta + gamma ;
```

A scanner divides this into the tokens `alpha`, `equal sign`, `beta`, `plus sign`, `gamma`, and `semicolon`. Then the parser determines that `beta + gamma` is an expression, and that the expression is assigned to `alpha`.

Getting Flex and Bison

Most Linux and BSD systems come with flex and bison as part of the base system. If your system doesn't have them, or has out-of-date versions, they're both easy to install.

Flex is a Sourceforge project, at *http://flex.sourceforge.net/*. The current version as of early 2009 was 2.5.35. Changes from version to version are usually minor, so it's not essential to update your version if it's close to .35, but some systems still ship with version 2.5.4 or 2.5.4a, which is more than a decade old.

Bison is available from *http://www.gnu.org/software/bison/*. The current version as of early 2009 was 2.4.1. Bison is under fairly active development, so it's worth getting an up-to-date version to see what's new. Version 2.4 added support for parsers in Java, for example. BSD users can generally install a current version of flex or bison using the ports collection. Linux users may be able to find current RPMs. If not, flex and bison both use the standard GNU build process, so to install them, download and unpack the current flex and bison tarballs from the web sites, run `./configure` and then `make` to build each, then become superuser and `make install` to install them.

Flex and bison both depend on the GNU m4 macroprocessor. Linux and BSD should all have m4, but in case they don't, or they have an ancient version, the current GNU m4 is at *http://www.gnu.org/software/m4/*.

For Windows users, both bison and flex are included in the Cygwin Linux emulation environment available at *http://www.cygwin.com/*. You can use the C or C++ code they generate either with the Cygwin development tools or with native Windows development tools.

Regular Expressions and Scanning

Scanners generally work by looking for patterns of characters in the input. For example, in a C program, an integer constant is a string of one or more digits, a variable name is a letter followed by zero or more letters or digits, and the various operators are single characters or pairs of characters. A straightforward way to describe these patterns is *regular expressions*, often shortened to *regex* or *regexp*. These are the same kind of patterns that the editors ed and vi and the search program egrep use to describe text to search for. A flex program basically consists of a list of regexps with instructions about what to do when the input matches any of them, known as *actions*. A flex-generated scanner reads through its input, matching the input against all of the regexps and doing the appropriate action on each match. Flex translates all of the regexps into an efficient internal form that lets it match the input against all the patterns simultaneously, so it's just as fast for 100 patterns as for one.*

Our First Flex Program

Unix systems (by which I also mean Unix-ish systems including Linux and the BSDs) come with a word count program, which reads through a file and reports the number of lines, words, and characters in the file. Flex lets us write `wc` in a few dozen lines, shown in Example 1-1.

* The internal form is known as a deterministic finite automation (DFA). Fortunately, the only thing you really need to know about DFAs at this point is that they're fast, and the speed is independent of the number or complexity of the patterns.