The Flex Scanner Generator

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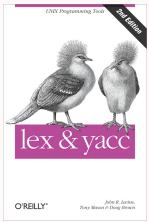
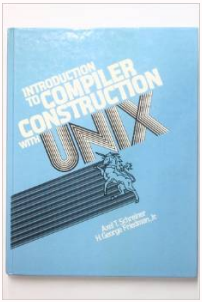
Brian A. Malloy



1. Text Books

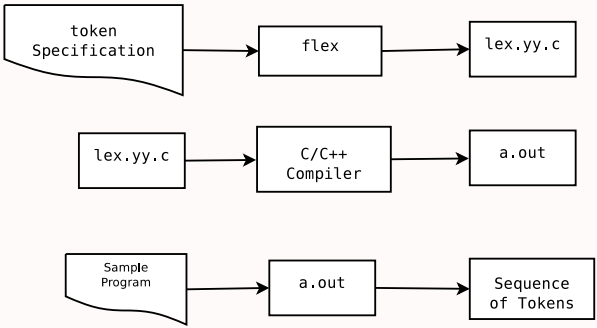

Unix Text Processing Tools
flex & bison
O'REILLY
John Levine


INTRODUCTION TO COMPILER CONSTRUCTION WITH UNIX

2. Overview

- Historically, parsing was broken into phases; scanning and parsing were the first 2 phases.
- The scanner provided a sequence of tokens to the parser by reading characters from the input stream and building the tokens.
- flex is a scanner generator
- flex reads a spec describing the tokens, and then generates a scanner.

2.1. Scanner Generation

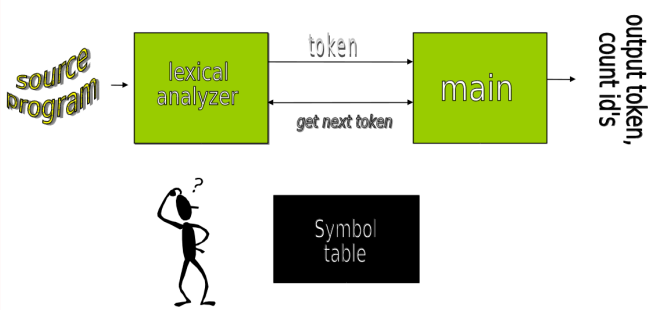


2.2. How it works

- flex generates yylex, a C fn that implements a DFA, based on the flex specification
- yylex reads from stdin and returns a number (token) associated with the matched pattern.
- To match more than one pattern, call yylex repeatedly (yylex returns 0 at eof):

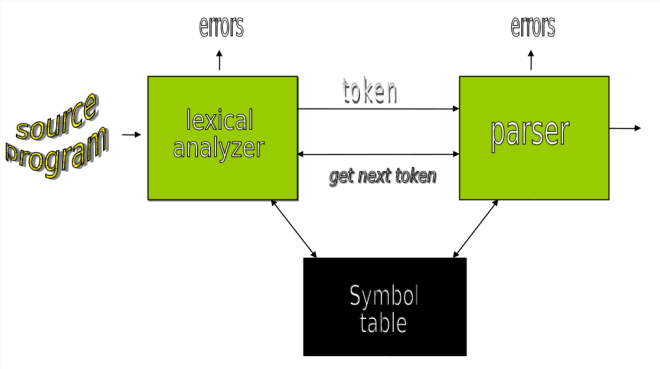
```
int main() {
  int token = yylex();
  while ( token ) {
    std::cout << "token: " << token << std::endl;
    token = yylex();
  }
}
```


2.3. Works with main or parser



2.4. Works with main or parser

- flex recognizes regular expressions.
- Need bison to recognize language constructs



2.5. Lexical Analysis (scanner)

- Usually first phase in compilation
- Also used in editors, query language, testing, ...
- Approaches to building a scanner:
  - Write it by hand,
  - use a tool,
  - Incorporate into parser.




2.6. Tasks in Lexical Analysis

- Find extraneous chars,
- store names in symbol table,
- strip white space,
- recognize tokens.

2.7. yywrap()

- called on eof by yylex;
  - if yywrap returns 1, then flex terminates;
  - Otherwise, flex makes another pass.

```
int yywrap() {
  std::cout << "terminating flex" << std::endl;
  return 1;
}
```

2.8. Makefile to use flex in debug mode

```
CCC = g++
LEX = flex
CXXFLAGS=-g -W -Wall -std=c++11 -Weffc++ -Wextra -O0

LEXFLAGS = -Wno-unused
FLEXDEBUG = -d
OBJS = main.o lex.yy.o

run: $(OBJS)
    $(CCC) $(CFLAGS) -o run $(OBJS)
main.o: main.cpp
    $(CCC) $(CFLAGS) -c main.cpp
lex.yy.c: scan.l
    $(LEX) $(FLEXDEBUG) -i scan.l
lex.yy.o: lex.yy.c
    $(CCC) $(CFLAGS) $(LEXFLAGS) -c lex.yy.c
```

2.9. Reading from a file

```
#include <iostream>
#include <fstream>

void main(int argc, char * argv[]) {
  if (argc != 2) {
    cout << "usage: " << argv[0] << "<filename>\n";
  }
  FILE * infile; // Must use C-style I/O
  infile = fopen(argv[1], "r");
  if (!infile) {
    cout << "Could not open: " <<  argv[1] << endl;
  }
  yyin = infile;
  yylex();
}
```

3. Flex Sections

```
%{
  C/C++ code
%}
Scanner declarations

%%
Token definitions and semantic actions

%%
C/C++ subroutines
(need prototype in C/C++ code section
```

4. Regular Expressions

Flex characters have special meanings:

1. . matches any single char except newline
2. [] character class, matches any char w/in brackets; if first char is $\wedge$ it matches any char except those in bracket.
3. $\wedge$ matches the beginning of a line as first char in regular expr.
4. $ matches the end of line as last char
5. \ escapes metacharacters
6. * matches 0 or more
7. + matches 1 or more
8. ? matches 0 or 1 occurrence
9. | is alternation

10. () group
    ****
11. {} if numbers, specifies how many ($A\{1,3\}$ matches 1 to 3 consecutive A's), and ($A\{2\}$ matches 2 consecutive A's)
12. (?s:pattern) apply option s while interpreting pattern. Options include:
    - $i \Rightarrow$ case insensitive;
    - $-i \Rightarrow$ case sensitive
13. `(?# comment )` $\Rightarrow$ comments in specs




Some Pattern Examples:

```
%{
#include <iostream>
%}
letter      [a-zA-Z]

%%
ab              { cout << "Matching ab" << :endl;          }
(?i:c)          { cout << "upper or lower case c" << endl; }
(?-i:d)         { cout << "only lower case d" << endl;     }
(?-i:E)         { cout << "only upper case E" << endl;     }
{letter}*       { cout << "Matching 'letter'" << endl;     }
(?#: this is a commment)
.               { /* matches everything except \n */ }
```

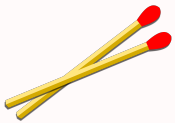
4.1. RE Examples

a+b+	1 or more a's, followed by 1 or more b's
a|b	either an a or a b
x	the character x
`[abc]`	a, b, or c
`[0-9]+`	an integer
`[-+]?[0-9]+`	integer with opt sign (- must come 1st)
`[ \t\n]`	whitespace
`[mM]`	use this rather than (?i:m)
{*word*}	whatever *word* is defined as
∧r	an r, only at begin of line
r$	an r, only at end of line
r{3}	exactly 3 r's
r{1,3}	1 to 3 r's
r{2,}	2 or more r's

5. Ambiguity

- If multiple patterns match a given input:
  - Match longest string,
  - In case of tie, match first pattern in specification.

```
%%
[0-9]+    { std::cout << "matched 9" << std::endl; }
9         { std::cout << "no way!" << std::endl; }
```



6. Start States

- Permits control of what gets matched when
- \x defines the start state
- When scanner is in a state, it can only match the patterns specified in that state.
- Can define as many start states as needed
- The macro BEGIN switches states
- BEGIN(INITIAL) or BEGIN(0) return to start state

6.1. C Comments

```
%x COMMENT

%%
"/*"            { BEGIN(COMMENT); ++comments; }
<COMMENT>"*/"   { BEGIN(0); do_newline(); }
<COMMENT>\n     { do_newline(); }
<COMMENT>.      { ; }
```

7. Debugging Flex

- The -d flag tells flex to go into debug mode:
  `flex -d scan.l`
- Flex will then print the rules that are matched:

```
for a+b+ on line 12, and \n on line 14:

aaab
--accepting rule at line 12 ("aaab")
match: aaab
--accepting rule at line 14 ("
")
```