Module 03: CS-1319-1: Programming Language Design and Implementation (PLDI)

Lexical Analyzer Generator: Flex / Lex

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Module Objectives

- Understand Lexical Analysis
- Understand Flex Specification

Module Outline

1. Objectives & Outline
2. Lexical Analysis Outline
3. Flex Specification
   - Sample
   - Regular Expressions
   - Common Errors
   - Line Count Example
4. Interactive Flex
5. Flex-Bison Flow
   - Flex-Bison Build
6. Start Conditions
7. Summary

Lexical Analysis Outline

Dragon Book: Pages 109-114 (The Role of the Lexical Analyzer)
Dragon Book: Pages 116-125 (Specification of Tokens)
Dragon Book: Pages 147-151 (Finite Automata)
Dragon Book: Pages 152-166 (From Regular Expressions to Automata)

Lexical Analysis (LA): Tokenization

- **Input**
  - Stream of characters (Program Source):

    `count = count + 1;`

    OR: `\tcount␢=␢count␢+␢1;\n`
- **Output**
  - Stream of tokens. Every token is represented by:
    - ▷ Token Class: ID, ASSIGN_OP, ID, ADD_OP, ICONST, SEMICOLON
    - ▷ Token Attributes (optional)
      - – Pointer to Symbol Table Entry
      - – Value of the Literal
      - – Line #, Column #, and length of lexeme
    - ▷ Lexeme (optional): `"count"`, `"="`, `"count"`, `"+"`, `"1"`, `";"`
    - ▷ <ID, SYM1, "count">, <ASSIGN_OP>, <ID, SYM1, "count">, <ADD_OP>, <ICONST, 1, "1">, <SEMICOLON>
- **Notes**
  - LA consumes the white spaces (`␢`, `\t`, `\n`). Comments already stripped by CPP
  - Symbol Table is the side effect of Lexical Analysis - binds all subsequent stages

Lexical Analysis Algorithm

- RE[1] for every Token Class
- Convert Regular Expression to an NFA[2]
- Convert NFA to DFA[3]
- Lexical Action for every final state of DFA

Familiarity with Regular Expressions (RE), Non-Deterministic Finite Automata (NFA), Deterministic Finite Automata (DFA), and the algorithms for RE → NFA → DFA will be assumed in this module. If you have difficulties understanding these, you can get clarified during your DS.

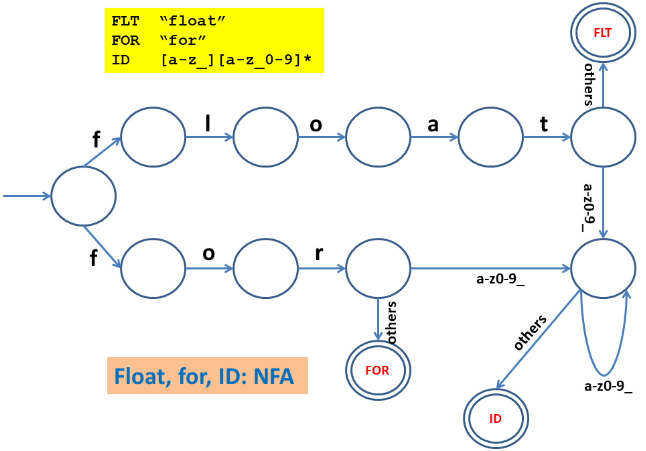
[1] Regular Expression

[2] Non-deterministic Finite Automata

[3] Deterministic Finite Automata

Lexical Analysis Algorithm

```
FLT   "float"
FOR   "for"
ID    [a-z_][a-z_0-9]*
```

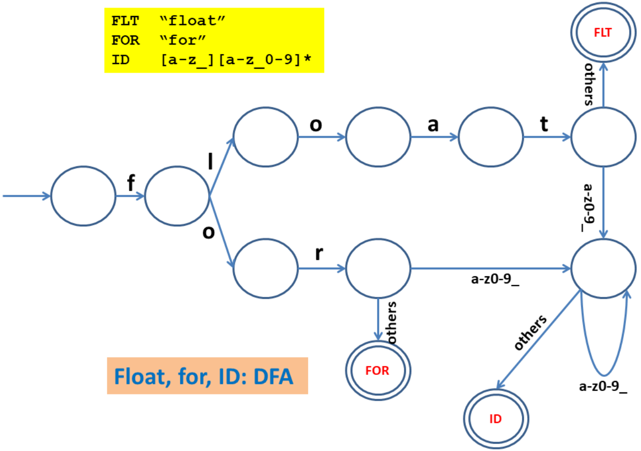


Float, for, ID: NFA

NFA Recognizer for keywords "float" & "for" and ids starting with 'float' or 'for' (restrictive). Transitions on 'others' are look-ahead while all others are consumption.

Lexical Analysis Algorithm

```
FLT   "float"
FOR   "for"
ID    [a-z_][a-z_0-9]*
```



Float, for, ID: DFA

DFA Recognizer for keywords "float" & "for" and ids starting with 'float' or 'for' (restrictive). Transitions on 'others' are look-ahead while all others are consumption.

Lexical Analysis Rules

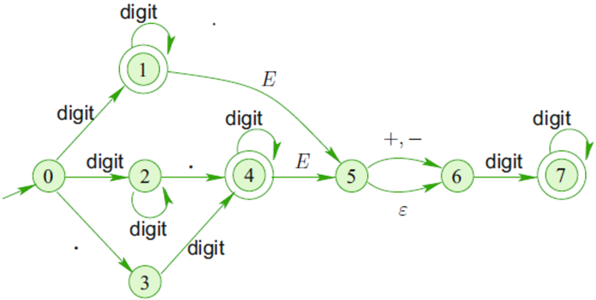
Identifier

$$
\begin{aligned}
id &\rightarrow letter\ (letter|\ digit) *\\
letter &\rightarrow \_ \mid A \mid B \mid C \mid \cdots \mid Z \mid a \mid b \mid c \mid \cdots \mid z\\
digit &\rightarrow 0 \mid 1 \mid 2 \mid \cdots \mid 9
\end{aligned}
$$

Numeric Constant

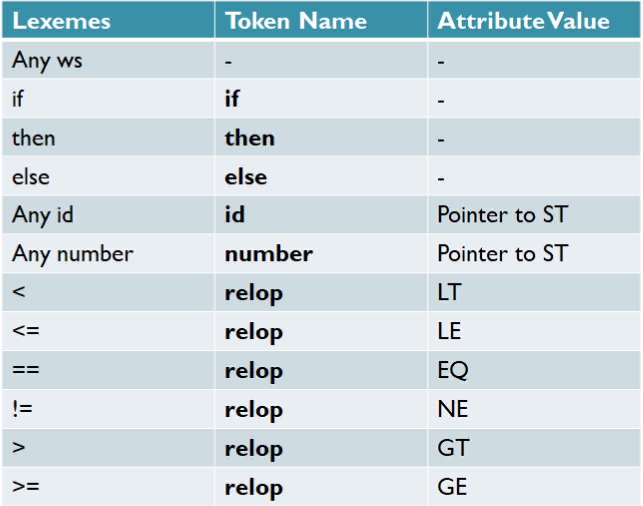
$$
\begin{aligned}
number &\rightarrow (digits \mid \epsilon)\ optFrac\ optExp\\
digit &\rightarrow 0 \mid 1 \mid 2 \mid \cdots \mid 9\\
digits &\rightarrow digit\ digit *\\
optFrac &\rightarrow .digits \mid \epsilon\\
optExp &\rightarrow (E\ (+ \mid - \mid \epsilon))\ digits \mid \epsilon
\end{aligned}
$$

FSM for Integer and Floating Point Constants



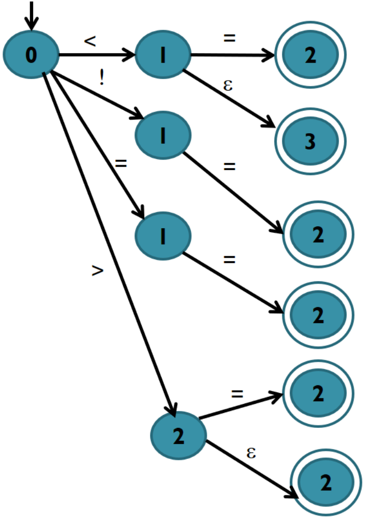
$$
\begin{array}{rcl}
\mathit{number} & \rightarrow & (\mathit{digits} \mid \epsilon)\ \mathit{optFrac}\ \mathit{optExp} \\
\mathit{digit} & \rightarrow & 0 \mid 1 \mid 2 \mid \cdots \mid 9 \\
\mathit{digits} & \rightarrow & \mathit{digit}\ \mathit{digit}\ * \\
\mathit{optFrac} & \rightarrow & .\mathit{digits} \mid \epsilon \\
\mathit{optExp} & \rightarrow & (E\ (+ \mid - \mid \epsilon))\ \mathit{digits} \mid \epsilon
\end{array}
$$

Token Representation



Lexemes	Token Name	Attribute Value
Any ws	-	-
if	**if**	-
then	**then**	-
else	**else**	-
Any id	**id**	Pointer to ST
Any number	**number**	Pointer to ST
<	**relop**	LT
<=	**relop**	LE
==	**relop**	EQ
!=	**relop**	NE
>	**relop**	GT
>=	**relop**	GE

FSM for Logical Operators



return (**relop,** LE)

return (**relop,** LT)

return (**relop,** NE)

return (**relop,** EQ)

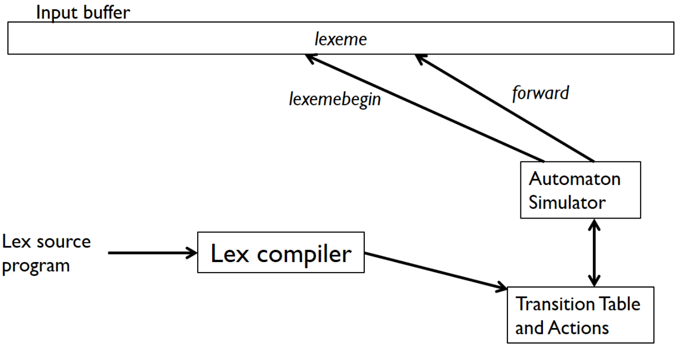
return (**relop,** GE)

return (**relop,** GT)

Flex Specification

Dragon Book: Pages 115-116 (Input Buffering)
Dragon Book: Pages 116-125 (Specification of Tokens)
Dragon Book: Pages 128-136 (Recognition of Tokens)
Dragon Book: Pages 140-146 (The Lexical Analyzer Generator Lex)
Flex, version 2.5

Flex Flow



Lex program → Transition table and actions → FA simulator

Our Sample for Flex

- This is a simple block with declaration and expression statements
- We shall use this as a running example

```
{
    int x;
    int y;
    x = 2;
    y = 3;
    x = 5 + y * 4;
}
```

Structure of Flex Specs

```
Declarations
%%
Translation rule
%%
Auxiliary functions
```

Flex Specs for our sample

- C Declarations and definitions
- Definitions of Regular Expressions
- Definitions of Rules & Actions
- C functions

```
%{
/* C Declarations and Definitions */
%}
 /* Regular Expression Definitions */
INT         "int"
ID          [a-z][a-z0-9]*
PUNC        [;]
CONST       [0-9]+
WS          [ \t\n]
/* Definitions of Rules \& Actions */
%%
{INT}       { printf("<KEYWORD, int>\n"); /* Keyword Rule */ }
{ID}        { printf("<ID, %s>\n", yytext); /* Identifier Rule & yytext points to lexeme */}
"+"         { printf("<OPERATOR, +>\n"); /* Operator Rule */ }
"*"         { printf("<OPERATOR, *>\n"); /* Operator Rule */ }
"="         { printf("<OPERATOR, =>\n"); /* Operator Rule */ }
"{"         { printf("<SPECIAL SYMBOL, {>\n"); /* Scope Rule */ }
"}"         { printf("<SPECIAL SYMBOL, }>\n"); /* Scope Rule */ }
{PUNC}      { printf("<PUNCTUATION, ;>\n"); /* Statement Rule */ }
{CONST}     { printf("<INTEGER CONSTANT, %s>\n",yytext); /* Literal Rule */ }
{WS}        /* White-space Rule */ ;
%%
/* C functions */
main() { yylex(); /* Flex Engine */ }
```

Flex I/O for our sample

I/P Character Stream

```
{
    int x;
    int y;
    x = 2;
    y = 3;
    x = 5 + y * 4;
}
```

O/P Token Stream

```
<SPECIAL SYMBOL, {>
<KEYWORD, int> <ID, x> <PUNCTUATION, ;>
<KEYWORD, int> <ID, y> <PUNCTUATION, ;>
<ID, x> <OPERATOR, => <INTEGER CONSTANT, 2> <PUNCTUATION, ;>
<ID, y> <OPERATOR, => <INTEGER CONSTANT, 3> <PUNCTUATION, ;>
<ID, x> <OPERATOR, => <INTEGER CONSTANT, 5> <OPERATOR, +>
<ID, y> <OPERATOR, *> <INTEGER CONSTANT, 4> <PUNCTUATION, ;>
<SPECIAL SYMBOL, }>
```

- Every token is a doublet showing the token class and the specific token information
- The output is generated as one token per line. It has been rearranged here for better readability

Variables in Flex

`yylex()`	Flex generated lexer driver
`yyin`	File pointer to Flex input
`yyout`	File pointer to Flex output
`yytext`	Pointer to Lexeme
`yyleng`	Length of the Lexeme

Regular Expressions – Basic

Expr.	Meaning
x	Character x
.	Any character except newline
[xyz]	Any characters amongst x, y or z.
[a-z]	Denotes any letter from a through z
[^0-9]	Stands for any character which is not a decimal digit, including new-line
\x	If x is an a, b, f, n, r, t, or v, then the ANSI-C interpretation of \x. Otherwise, a literal x (used to *escape operators* such as *)
\0	A NULL character
\num	Character with octal value num
\xnum	Character with hexadecimal value num
"string"	Match the literal string. For instance "/*" denotes the character / and then the character *, as opposed to /* denoting any number of slashes
<<EOF>>	Match the end-of-file

Source: Flex Regular Expressions

Regular Expressions - Operators

Expr.	**Meaning**
(r)	Match an r; parentheses are used to override precedence
rs	Match the regular expression r followed by the regular expression s. This is called *concatenation*
r|s	Match either an r or an s. This is called *alternation*
{*abbreviation*}	Match the expansion of the abbreviation definition. Instead of:

```
%%
[a-zA-Z_][a-zA-Z0-9_]* return IDENTIFIER;
%%
```

Use

```
id [a-zA-Z_][a-zA-Z0-9_]*
%%
{id} return IDENTIFIER;
%%
```

Regular Expressions - Operators

Expr.	**Meaning**
	quantifiers
r*	zero or more r's
r+	one or more r's
r?	zero or one r's
For instance `-?([0-9]+|[0-9]*.[0-9]+([eE][-+]?[0-9]+)?)` matches C integer and floating point numbers.	
r{[num]}	num times r
r{min,[max]}	Anywhere from min to max (defaulting to no bound) r's
r/s	Match an r but only if it is followed by an s. This type of pattern is called *trailing context*. The text matched by s is included when determining whether this rule is the *longest match*, but is then returned to the input before the action is executed. So the action only sees the text matched by r. For example: Distinguish `DO1J=1,5` (a for loop where I runs from 1 to 5) from `DO1J=1.5` (a definition/assignment of the floating variable `DO1J` to `1.5`) in FORTRAN. To recognize its loop keyword, `DO`, one needs: `DO/[A-Z0-9]*=[A-Z0-9]*,`
^r	Match an r at the beginning of a line
r$	Match an r at the end of a line

Wrong Flex Specs for our sample

- Rules for ID and INT have been swapped.
- No keyword can be tokenized as keyword now.

```
%{
/* C Declarations and Definitions */
%}
 /* Regular Expression Definitions */
INT         "int"
ID          [a-z][a-z0-9]*
PUNC        [;]
CONST       [0-9]+
WS          [ \t\n]

%%
{ID}        { printf("<ID, %s>\n", yytext); /* Identifier Rule */}
{INT}       { printf("<KEYWORD, "int">\n"); /* Keyword Rule */ }
"+"         { printf("<OPERATOR, +>\n"); /* Operator Rule */ }
"*"         { printf("<OPERATOR, *>\n"); /* Operator Rule */ }
"="         { printf("<OPERATOR, =>\n"); /* Operator Rule */ }
"{"         { printf("<SPECIAL SYMBOL, {>\n"); /* Scope Rule */ }
"}"         { printf("<SPECIAL SYMBOL, }>\n"); /* Scope Rule */ }
{PUNC}      { printf("<PUNCTUATION, ;>\n"); /* Statement Rule */ }
{CONST}     { printf("<INTEGER CONSTANT, %s>\n",yytext); /* Literal Rule */ }
{WS}        /* White-space Rule */ ;
%%

main() {
    yylex(); /* Flex Engine */
}
```

Wrong Flex I/O for our sample

I/P Character Stream

```
{
    int x;
    int y;
    x = 2;
    y = 3;
    x = 5 + y * 4;
}
```

- Both `int`'s have been taken as `ID`!

O/P Token Stream

```
<SPECIAL SYMBOL, {>
<ID, int> <ID, x> <PUNCTUATION, ;>
<ID, int> <ID, y> <PUNCTUATION, ;>
<ID, x> <OPERATOR, => <INTEGER CONSTANT, 2> <PUNCTUATION, ;>
<ID, y> <OPERATOR, => <INTEGER CONSTANT, 3> <PUNCTUATION, ;>
<ID, x> <OPERATOR, => <INTEGER CONSTANT, 5> <OPERATOR, +>
<ID, y> <OPERATOR, *> <INTEGER CONSTANT, 4> <PUNCTUATION, ;>
<SPECIAL SYMBOL, }>
```

Count Number of Lines – Flex Specs

```
/* C Declarations and definitions */
%{
    int charCount = 0, wordCount = 0, lineCount = 0;
%}

/* Definitions of Regular Expressions */
word   [^ \t\n]+                              /* A word is a seq. of char. w/o a white space */

/* Definitions of Rules \& Actions */
%%
{word}    { wordCount++; charCount += yyleng; /* Any character other than white space */ }
[\n]      { charCount++; lineCount++;         /* newline character */ }
.         { charCount++;                      /* space and tab characters */ }
%%

/* C functions */
main() {
    yylex();
    printf("Characters: %d Words: %d Lines %d\n",charCount, wordCount, lineCount);
}
```

Count Number of Lines – lex.yy.c

```
char *yytext;
int charCount = 0, wordCount = 0, lineCount = 0; /* C Declarations and definitions */
/* Definitions of Regular Expressions & Definitions of Rules & Actions */
int yylex (void) { /** The main scanner function which does all the work. */
// ...
    if ( ! (yy_start) ) (yy_start) = 1;    /* first start state */
    if ( ! yyin ) yyin = stdin;
    if ( ! yyout ) yyout = stdout;
// ...
    while ( 1 ) {        /* loops until end-of-file is reached */
// ..
     yy_current_state = (yy_start);
yy_match: // ...
yy_find_action: // ...
do_action:
        switch ( yy_act ) { /* beginning of action switch */
            case 0: /* must back up */ // ...
            case 1: { wordCount++; charCount += yyleng; } YY_BREAK
            case 2: { charCount++; lineCount++; } YY_BREAK
            case 3: { charCount++; } YY_BREAK
            case 4: ECHO; YY_BREAK
            case YY_STATE_EOF(INITIAL): yyterminate();
            case YY_END_OF_BUFFER:
            default: YY_FATAL_ERROR("fatal flex scanner internal error--no action found" );
        } /* end of action switch */
    } /* end of scanning one token */
} /* end of yylex */
main() { /* C functions */
    yylex();
    printf("Characters: %d Words: %d Lines %d\n",charCount, wordCount, lineCount);
}
```

Interactive Flex

Flex, version 2.5

Modes of Flex Operations

Flex can be used in two modes:

- **Non-interactive**: Call `yylex()` only once. It keeps spitting the tokens till the end-of-file is reached. So the actions on the rules do not have `return` and falls through in the `switch` in `lex.yy.c`.
  This is convenient for small specifications. But does not work well for large programs because:
  - Long stream of spitted tokens may need a further tokenization while processed by the parser
  - At times tokenization itself, or at least the information update in the actions for the rules, may need information from the parser (like pointer to the correctly scoped symbol table)
- **Interactive**: Repeatedly call `yylex()`. Every call returns one token (after taking the actions for the rule matched) that is consumed by the parser and `yylex()` is again called for the next token. This lets parser and lexer work hand-in-hand and also eases information interchange between the two.

Flex Specs (non-interactive) for our sample

- C Declarations and definitions
- Definitions of Regular Expressions
- Definitions of Rules & Actions
- C functions

```
%{
/* C Declarations and Definitions */
%}
 /* Regular Expression Definitions */
INT         "int"
ID          [a-z][a-z0-9]*
PUNC        [;]
CONST       [0-9]+
WS          [ \t\n]
/* Definitions of Rules \& Actions */
%%
{INT}       { printf("<KEYWORD, int>\n"); /* Keyword Rule */ }
{ID}        { printf("<ID, %s>\n", yytext); /* Identifier Rule */}
"+"         { printf("<OPERATOR, +>\n"); /* Operator Rule */ }
"*"         { printf("<OPERATOR, *>\n"); /* Operator Rule */ }
"="         { printf("<OPERATOR, =>\n"); /* Operator Rule */ }
"{"         { printf("<SPECIAL SYMBOL, {>\n"); /* Scope Rule */ }
"}"         { printf("<SPECIAL SYMBOL, }>\n"); /* Scope Rule */ }
{PUNC}      { printf("<PUNCTUATION, ;>\n"); /* Statement Rule */ }
{CONST}     { printf("<INTEGER CONSTANT, %s>\n",yytext); /* Literal Rule */ }
{WS}        /* White-space Rule */ ;
%%
/* C functions */
main() { yylex(); /* Flex Engine */ }
```

Flex Specs (interactive) for our sample

```
%{
#define    INT         10
#define    ID          11
#define    PLUS        12
#define    MULT        13
#define    ASSIGN      14
#define    LBRACE      15
#define    RBRACE      16
#define    CONST       17
#define    SEMICOLON   18
%}

INT        "int"
ID         [a-z][a-z0-9]*
PUNC       [;]
CONST      [0-9]+
WS         [ \t\n]

%%
{INT}   { return INT; }
{ID}    { return ID; }
"+"     { return PLUS; }
"*"     { return MULT; }
"="     { return ASSIGN; }
"{"     { return LBRACE; }
"}"     { return RBRACE; }
{PUNC}  { return SEMICOLON; }
{CONST} { return CONST; }
{WS}    {/* Ignore
            whitespace */}
%%
```

```
main() { int token;
    while (token = yylex()) {
        switch (token) {
            case INT: printf("<KEYWORD, %d, %s>\n",
                token, yytext); break;
            case ID: printf("<IDENTIFIER, %d, %s>\n",
                token, yytext); break;
            case PLUS: printf("<OPERATOR, %d, %s>\n",
                token, yytext); break;
            case MULT: printf("<OPERATOR, %d, %s>\n",
                token, yytext); break;
            case ASSIGN: printf("<OPERATOR, %d, %s>\n",
                token, yytext); break;
            case LBRACE: printf("<SPECIAL SYMBOL, %d, %s>\n",
                token, yytext); break;
            case RBRACE: printf("<SPECIAL SYMBOL, %d, %s>\n",
                token, yytext); break;
            case SEMICOLON: printf("<PUNCTUATION, %d, %s>\n",
                token, yytext); break;
            case CONST: printf("<INTEGER CONSTANT, %d, %s>\n",
                token, yytext); break;
        }
    }
}
```

– Input is taken from `stdin`. It can be changed by opening the file in `main()` and setting the file pointer to `yyin`.
– When the lexer will be integrated with the YACC generated parser, the `yyparse()` therein will call `yylex()` and the `main()` will call `yyparse()`.

Flex I/O (interactive) for our sample

I/P Character Stream

```
{
    int x;
    int y;
    x = 2;
    y = 3;
    x = 5 + y * 4;
}
```

```
#define    INT          10
#define    ID           11
#define    PLUS         12
#define    MULT         13
#define    ASSIGN       14
#define    LBRACE       15
#define    RBRACE       16
#define    CONST        17
#define    SEMICOLON    18
```

O/P Token Stream

```
<SPECIAL SYMBOL, 15, {>
<KEYWORD, 10, int>
<IDENTIFIER, 11, x>
<PUNCTUATION, 18, ;>
<KEYWORD, 10, int>
<IDENTIFIER, 11, y>
<PUNCTUATION, 18, ;>
<IDENTIFIER, 11, x>
<OPERATOR, 14, =>
<INTEGER CONSTANT, 17, 2>
<PUNCTUATION, 18, ;>
<IDENTIFIER, 11, y>
<OPERATOR, 14, =>
<INTEGER CONSTANT, 17, 3>
<PUNCTUATION, 18, ;>
<IDENTIFIER, 11, x>
<OPERATOR, 14, =>
<INTEGER CONSTANT, 17, 5>
<OPERATOR, 12, +>
<IDENTIFIER, 11, y>
<OPERATOR, 13, *>
<INTEGER CONSTANT, 17, 4>
<PUNCTUATION, 18, ;>
<SPECIAL SYMBOL, 16, }>
```

- Every token is a triplet showing the token class, token manifest constant and the specific token information.

Flex-Bison Flow

Managing Symbol Table

```
%{
    struct symbol {
        char *name;
        struct ref *reflist;
    };
    struct ref {
        struct ref *next;
        char *filename;
        int flags;
        int lineno;
   };

   #define NHASH 100
   struct symbol symtab[NHASH];
   struct symbol *lookup(char *);
   void addref(int, char*, char*, int);
%}
```

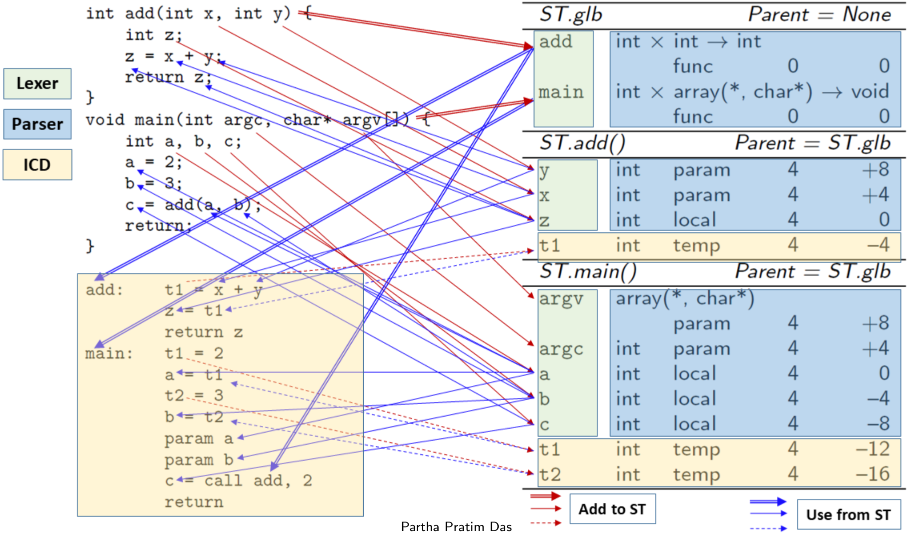
Example of Symbol Tables

```
int add(int x, int y) {
    int z;
    z = x + y;
    return z;
}
void main(int argc, char* argv[]) {
    int a, b, c;
    a = 2;
    b = 3;
    c = add(a, b);
    return;
}
```

```
add:    t1 = x + y
        z = t1
        return z
main:   t1 = 2
        a = t1
        t2 = 3
        b = t2
        param a
        param b
        c = call add, 2
        return
```

ST.glb				*Parent* = *None*
add	int × int → int			
		func	0	0
main	int × array(*, char*) → void			
		func	0	0
ST.add()				*Parent* = *ST.glb*
y	int	param	4	+8
x	int	param	4	+4
z	int	local	4	0
t1	int	temp	4	–4
ST.main()				*Parent* = *ST.glb*
argv	array(*, char*)			
		param	4	+8
argc	int	param	4	+4
a	int	local	4	0
b	int	local	4	–4
c	int	local	4	–8
t1	int	temp	4	–12
t2	int	temp	4	–16

Example of Symbol Tables



Lexer

Parser

ICD

```
int add(int x, int y) {
    int z;
    z = x + y;
    return z;
}
void main(int argc, char* argv[]) {
    int a, b, c;
    a = 2;
    b = 3;
    c = add(a, b);
    return;
}
```

```
add:    t1 = x + y
        z = t1
        return z
main:   t1 = 2
        a = t1
        t2 = 3
        b = t2
        param a
        param b
        c = call add, 2
        return
```

ST.glb				*Parent = None*
add	int × int → int			
		func	0	0
main	int × array(*, char*) → void			
		func	0	0

ST.add()				*Parent = ST.glb*
y	int	param	4	+8
x	int	param	4	+4
z	int	local	4	0
t1	int	temp	4	−4

ST.main()				*Parent = ST.glb*
argv	array(*, char*)			
		param	4	+8
argc	int	param	4	+4
a	int	local	4	0
b	int	local	4	−4
c	int	local	4	−8
t1	int	temp	4	−12
t2	int	temp	4	−16

Add to ST

Use from ST

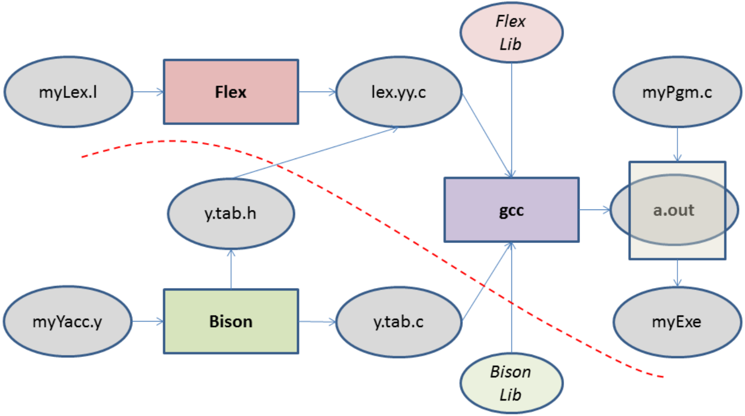
First Flex Program

```
$ flex myLex.l
$ cc lex.yy.c -ll
$ ./a.out
...
$
```

Check the flex library name in your system. You may need:

```
$ flex myLex.l
$ cc lex.yy.c -lfl
$ ./a.out
...
$
```

Flex-Bison Flow



Start Conditions

Flex, version 2.5

Start Condition in Flex

Flex provides a mechanism for conditionally activating rules. Any rule whose pattern is prefixed with <sc> will only be active when the scanner is in the start condition named sc. For example,

```
<STRING>[^"]*               { /* eat up the string body ... */
                             ...
                             }
```

will be active only when the scanner is in the STRING start condition, and

```
<INITIAL,STRING,QUOTE>\.  { /* handle an escape ... */
                             ...
                             }
```

will be active only when the current start condition is either INITIAL, STRING, or QUOTE.

Source: https://ftp.gnu.org/old-gnu/Manuals/flex-2.5.4/html_node/flex_11.html

Start Condition in Flex - Specs

- *Declaration*: Declared in the definitions section of the input
- `BEGIN` *Action*: A start condition is activated using the `BEGIN` action. Until the next `BEGIN` action is executed, rules with the given start condition will be active and rules with other start conditions will be inactive
- *Inclusive Start Conditions*: Use unindented lines beginning with '%s' followed by a list of names. If the start condition is inclusive, then rules with no start conditions at all will also be active
- *Exclusive Start Conditions*: Use unindented lines beginning with '%x' followed by a list of names. If it is exclusive, then only rules qualified with the start condition will be active

  A set of rules contingent on the same exclusive start condition describe a scanner which is independent of any of the other rules in the flex input. Because of this, exclusive start conditions make it easy to specify mini-scanners which scan portions of the input that are syntactically different from the rest (for example, comments)

Source: https://ftp.gnu.org/old-gnu/Manuals/flex-2.5.4/html_node/flex_11.html

Start Condition in Flex - Example

The set of rules:

```
%s example
%%
<example>foo   do_something();
bar            something_else();
```

is equivalent to

```
%x example
%%
<example>foo           do_something();
<INITIAL,example>bar   something_else();
```

Without the <INITIAL,example> qualifier, the bar pattern in the second example wouldn't be active (that is, couldn't match) when in start condition example. If we just used <example> to qualify bar, though, then it would only be active in example and not in `INITIAL`, while in the first example it's active in both, because in the first example the example start condition is an inclusive (%s) start condition.

Source: https://ftp.gnu.org/old-gnu/Manuals/flex-2.5.4/html_node/flex_11.html

Handling Comments

```
%x comment
%%
int line_num = 1;

"/*"                    BEGIN(comment);

<comment>[^*\n]*        /* eat anything that's not a '*' */
<comment>"*"+[^*/\n]*   /* eat up '*'s not followed by '/'s */
<comment>\n             ++line_num;
<comment>"*"+"/"        BEGIN(INITIAL);
```

Source: https://ftp.gnu.org/old-gnu/Manuals/flex-2.5.4/html_node/flex_11.html

Module Summary

- Lexical Analysis process is introduced
- Flex specification for Lexical Analyzer generation is discussed in depth
- Flow of Flex and Bison explained
- Special Flex feature of Start Condition discussed