Introduction to Compiler Design

Lesson 6:

Scanners, JLex Scanner Generator

JLex Scanner Generator

Declarative specification

tell what you want to scan, it will generate the rest

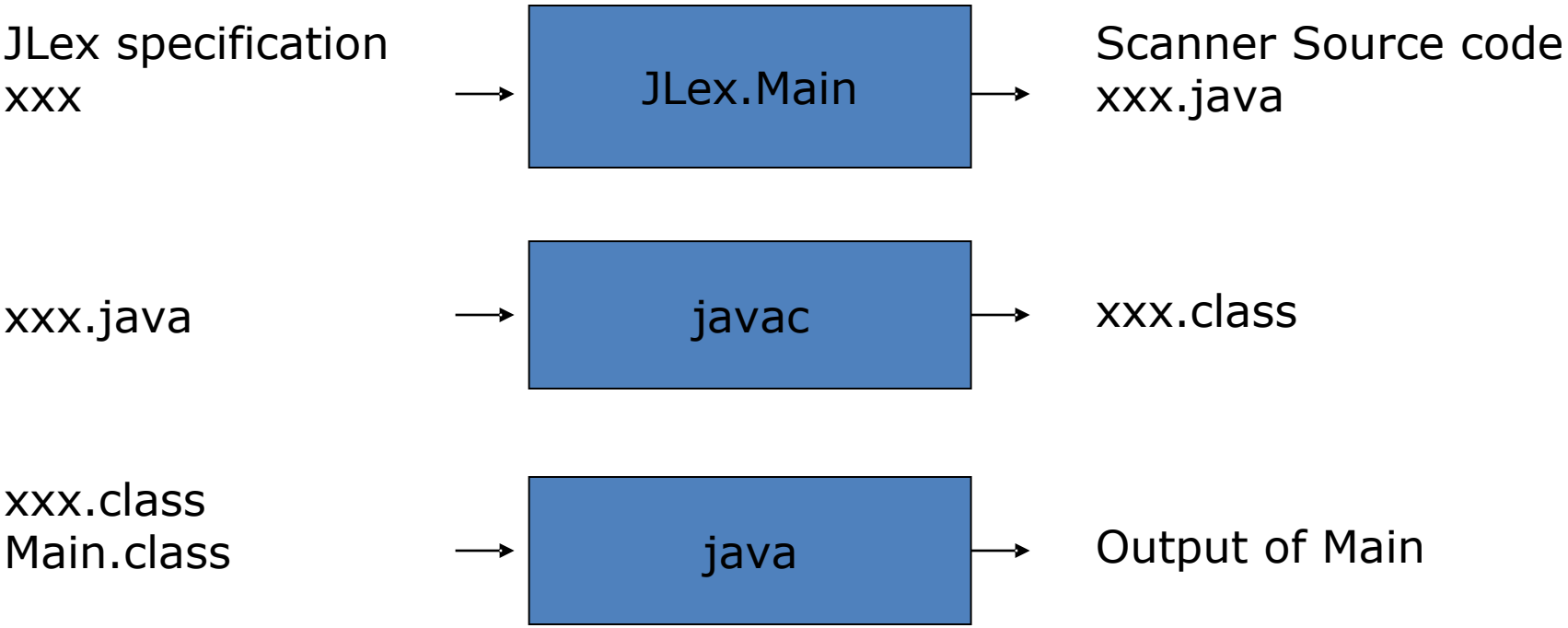
Input: set of regexps + associated actions

Inside a Xyz jlex file

Output: Java source code for a scanner

Xyz.java source code of scanner

JLex Scanner Generator



Yylex Class

```
class Yylex {

   …
   public Yylex(java.io.Reader i)…
   public Yylex(java.io.InputStream i)…
   …
   public <Type> next_token()…
   …
}
```

Regular Expression Rules

Regular expression

Pattern to be matched

{ action }

Java code to be executed
When pattern is matched

When the scanner's `next_token()` method is called, it repeats:

1/ Find the longest sequence of characters in the input
(starting with current character) that matches a pattern

2/ Perform the associated action.

next_token method

When the scanner's `next_token` method is called, it repeats:

1. Find the longest sequence of characters in the input (starting with current character) that matches a pattern

2. Perform the associated action.

until an action causes the next_token method to return.
If there are several patterns that match the same (longest) sequence of characters, then the first such pattern is considered to be matched (so the order of the patterns can be important).

If an input character is not matched in any pattern, the scanner throws an exception (so it is important to make sure that there can be no such unmatched characters, since it is not good to have a scanner that can "crash" on bad input).

Regular Expressions

- Most Characters match themselves

  abc

  ==

  while

- Characters in “” match themselves (even special characters)

  “abc”

  “==“

  “while”

  “a|b”

Regular Expressions

- Special Characters

  | means "or“

  * means zero or more instances of

  + means one or more instances of

  ? means zero or one instance of

  ( ) are used for grouping

  . means any character except newline

  \ means special escape character follows (\n, \t, \”, \\, etc.)

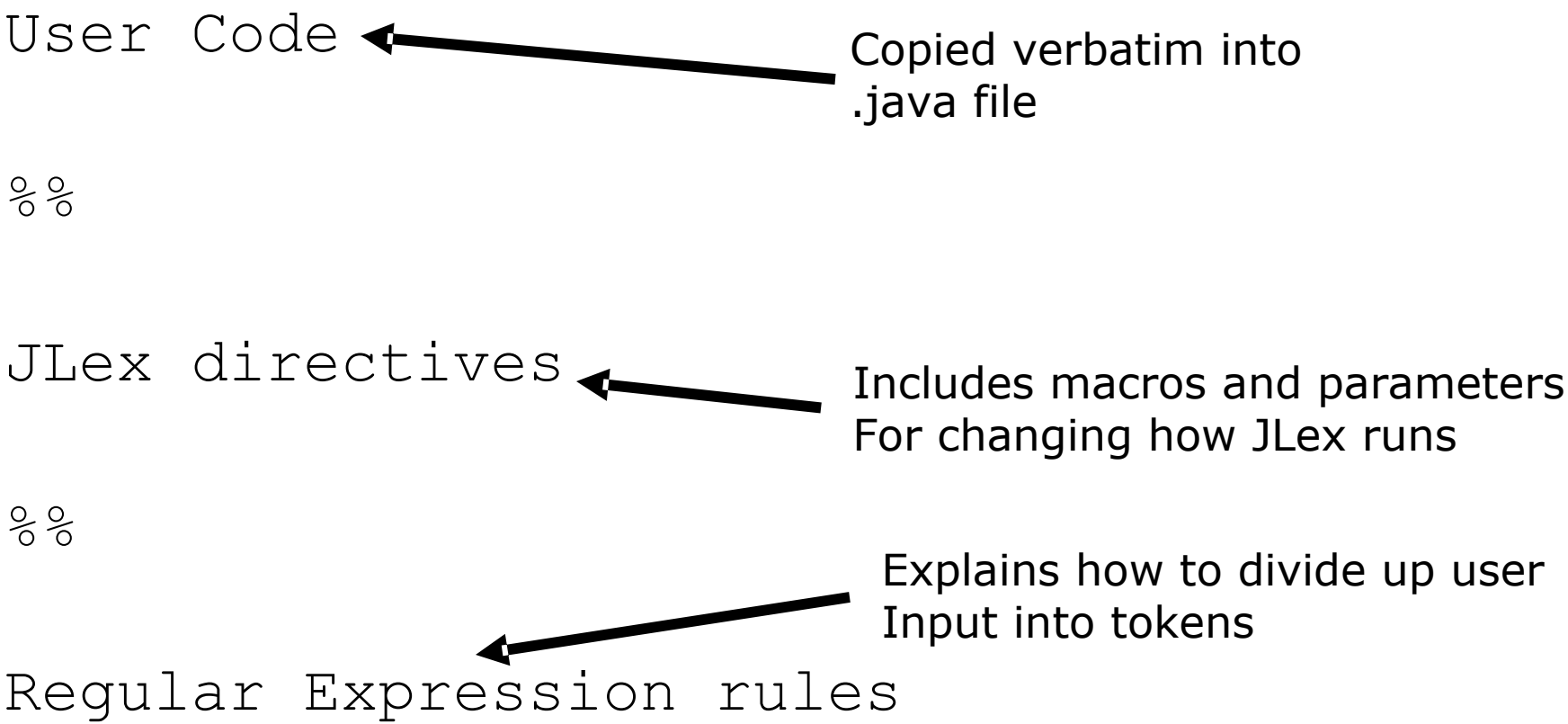
  ^ means only match at beginning of a line

  $ means only match at end of a line

Character Classes

- Characters in square brackets [] create a character class
- [a-z] matches any single lower-case character
- Special Characters in Character Classes:
  - - means range
  - ^ means negate the class (if at beginning)
  - \ escape character (same as before)
  - “” means match actual character (similar to \)
- Example Character Classes:
  - [a b] matches “a”, “ “, or “b”
  - [a”-”z] matches “a”, “-”, or “z”
  - [a\n] matches “a” or newline (\n)
  - [^a-z] matches anything except lowercase characters
- Whitespace outside character classes terminates the regular expression

JLex file


User Code
Copied verbatim into
.java file
%%
JLex directives
Includes macros and parameters
For changing how JLex runs
%%
Explains how to divide up user
Input into tokens
Regular Expression rules

JLex Directives

- Directives include
  - specifying the value that should be returned on end-of-file
  - specifying that line counting should be turned on
  - specifying that the scanner will be used with the Java parser generator java cup.
- The directives part also includes **macro definitions**.

Macro Definitions

The form of a macro definition is:

- name = regular-expression
- where name is any valid Java identifier, and regular-expression is any regular expression.

  DIGIT= [0-9]

  LETTER= [a-zA-Z]

  WHITESPACE= [\t\n]
- Using Macros
  - in a regular expression
  - In other macros (only use macros previous defined)
- Example Usage – Use curly braces {}

  {LETTER}({LETTER}|{DIGIT})*

Symbol	Meaning in RE	Meaning in Char Class
(	Matches with) to group sub-expressions.	Represents itself.
)	Matches with (to group sub-expressions.	Represents itself.
[	Begins a character class.	Represents itself.
]	Is illegal.	Ends a character class.
{	Matches with } to delimit a macro name.	Matches with } to delimit a macro name.
}	Matches with { to delimit a macro name.	Represents itself or matches with { to delimit a macro name.
"	Matches with " to delimit strings (only \ is special within strings).	Matches with " for a string of chars that belong to the char class. Only \" is special within the string.
\	Escapes special characters (n, t, etc). Also used unicode/hex/octal.	Escapes characters that are special inside a character class.
.	Matches any character except newline	Matches itself
|	Or	Matches itself
*	Kleene Closure	Matches itself
+	One or more matches	Matches itself
?	Zero or One matches	Matches itself
^	Matches only at beginning of line	Complements chars in class
$	Matches only at end of line	Matches itself
-	Matches ifself	Range of characters

```
//User Code Section (uninterpreted  java code)

%%

//Directives Section

DIGIT = [0-9]
LETTER = [a-zA-Z]
WHITESPACE = [\040\t\n]

%state SPECIALINTSTATE

//Configure for use with java CUP (Parser generator)
%implements java_cup.runtime.Scanner
%function next_token
%type java_cup.runtime.Symbol

//End of file behavior
%eofval{
System.out.println("All done");
return null;
%eofval}

//Turn on line counting
%line

%%

//Regular Expression rules
```

Macro definitions

State declaration

Rules Section

Format is <regex>{code} where regex is a regular expression for a single token

- can use macros from the directive sections in regex, surround with curly braces

Conventions

- chars represent themselves (except special characters)
- chars inside “” represent themselves (except \)

Regexp operators

- | * + ? () .

Character class operators

- - range
- ^ not
- \ escape

Rules Section

```
"="             { System.out.println(yyline + 1 + ": ASSIGN"); }
"+"             { System.out.println(yyline + 1 + ": PLUS"); }
"^"             { System.out.println(yyline + 1 + ": EXP"); }
"<"             { System.out.println(yyline + 1 + ": LT"); }
"+="             { System.out.println(yyline + 1 + ": INC"); }
"<="             { System.out.println(yyline + 1 + ": LEQ"); }
{WHITESPACE} { }
({LETTER}|"_")({DIGIT}|{LETTER}|"_")* {
                System.out.println(yyline+1 + ": ID " + yytext()));}
.               { System.out.println(yyline + 1 + ": badchar"); }
```

More Info On JLex

For a complete descritpion:

http://www.cs.princeton.edu/~appel/modern/java/JLex/