MINISTERUL EDUCAȚIEI, CULTURII ȘI CERCETĂRII AL REPUBLICII MOLDOVA

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CEBAN VASILE FAF-223

Report

Laboratory work n.3

of Formal Languages and Finite Automata

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Chișinău - 2024

Lexer Task

Topic: Lexer & Scanner

Objectives:

1. Understand what lexical analysis [1] is.
2. Get familiar with the inner workings of a lexer/scanner/tokenizer.
3. Implement a sample lexer and show how it works.

Source Code:

```
public class Main {
   public static void main(String[] args) {
       String codeText = """
           // This is a single-line comment
           int x = 10;     // Another comment
           float y = 3.14;
           if (x > y) {
               System.out.println("x is greater"); // This won't be
tokenized
           }
           """;

       Lexer lexer = new Lexer(codeText);
       List<Token> tokens = lexer.tokenize();

       for (Token token : tokens) {
           System.out.println(token);
       }
   }
}
```

A String variable named codeText is defined that stores the example code.
A new Lexer object is created and passed codeText as a parameter.
The tokenize() method of the lexer object is called to tokenize the example code. This method will return a list of tokens.
Iterate through the list of tokens with a for loop. Each token is displayed on the console using the System.out.println() function.

```
public class TokenPattern {
   private final String type;
   private final Pattern pattern;

   public TokenPattern(String type, Pattern pattern) {
       this.type = type;
       this.pattern = pattern;
   }

   public String getType() {
       return type;
```

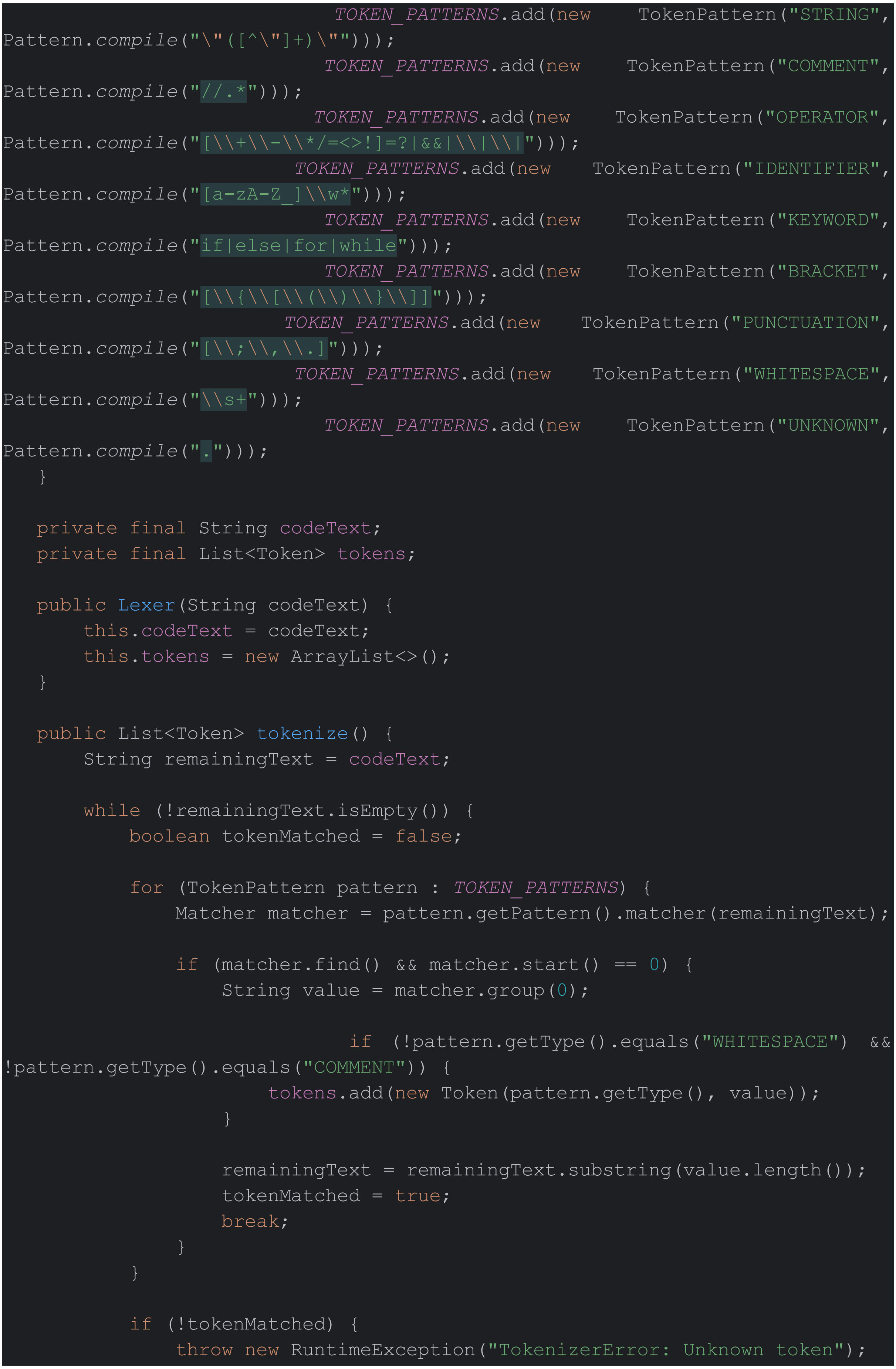
```
    }

    public Pattern getPattern() {
        return pattern;
    }
}
```

The TokenPattern class is designed to represent a single pattern used within a lexer.
Multiple TokenPattern objects are created, each representing a different token type with the corresponding regular expression. Matching Patterns: As the lexer processes the code, it compares the code to the patterns in the given TokenPattern objects. When a match is found, a new Token object is created using the matching type and text.

```
package Laboratory_work_3;

public class Token {
    private final String type;
    private final String value;

    public Token(String type, String value) {
        this.type = type;
        this.value = value;
    }

    public String getType() {
        return type;
    }

    public String getValue() {
        return value;
    }

    @Override
    public String toString() {
        return "(" + type + ", " + value + ")";
    }
}
```

The lexer creates Token objects to represent the individual elements it identifies within the input code.
Further Processing: These tokens can then be used by other parts of a compiler or interpreter to understand the structure of the code.

```
public class Lexer {
        private   static   final   List<TokenPattern>   TOKEN_PATTERNS   =   new
ArrayList<>();

    static {
                                        TOKEN_PATTERNS.add(new    TokenPattern("DECIMAL",
Pattern.compile("\\d+\\.\\d+")));
                                        TOKEN_PATTERNS.add(new    TokenPattern("INTEGER",
Pattern.compile("\\d+")));
```



```
                             TOKEN_PATTERNS.add(new    TokenPattern("STRING",
Pattern.compile("\"([^\"]+)\""")));
                            TOKEN_PATTERNS.add(new    TokenPattern("COMMENT",
Pattern.compile("//.*")));
                           TOKEN_PATTERNS.add(new    TokenPattern("OPERATOR",
Pattern.compile("[\\+\\-\\*/=<>!]=?|&&|\\|\\|")));
                         TOKEN_PATTERNS.add(new   TokenPattern("IDENTIFIER",
Pattern.compile("[a-zA-Z_]\\w*")));
                            TOKEN_PATTERNS.add(new    TokenPattern("KEYWORD",
Pattern.compile("if|else|for|while")));
                            TOKEN_PATTERNS.add(new    TokenPattern("BRACKET",
Pattern.compile("[\\{\\[\\(\\)\\}\\]]")));
                        TOKEN_PATTERNS.add(new   TokenPattern("PUNCTUATION",
Pattern.compile("[\\;\\,\\.]")));
                         TOKEN_PATTERNS.add(new   TokenPattern("WHITESPACE",
Pattern.compile("\\s+")));
                            TOKEN_PATTERNS.add(new    TokenPattern("UNKNOWN",
Pattern.compile(".")));
   }

   private final String codeText;
   private final List<Token> tokens;

   public Lexer(String codeText) {
       this.codeText = codeText;
       this.tokens = new ArrayList<>();
   }

   public List<Token> tokenize() {
       String remainingText = codeText;

       while (!remainingText.isEmpty()) {
           boolean tokenMatched = false;

           for (TokenPattern pattern : TOKEN_PATTERNS) {
               Matcher matcher = pattern.getPattern().matcher(remainingText);

               if (matcher.find() && matcher.start() == 0) {
                   String value = matcher.group(0);

                              if  (!pattern.getType().equals("WHITESPACE")  &&
!pattern.getType().equals("COMMENT")) {
                       tokens.add(new Token(pattern.getType(), value));
                   }

                   remainingText = remainingText.substring(value.length());
                   tokenMatched = true;
                   break;
               }
           }

           if (!tokenMatched) {
               throw new RuntimeException("TokenizerError: Unknown token");
```

```
            }
        }

        return tokens;
    }
}
```

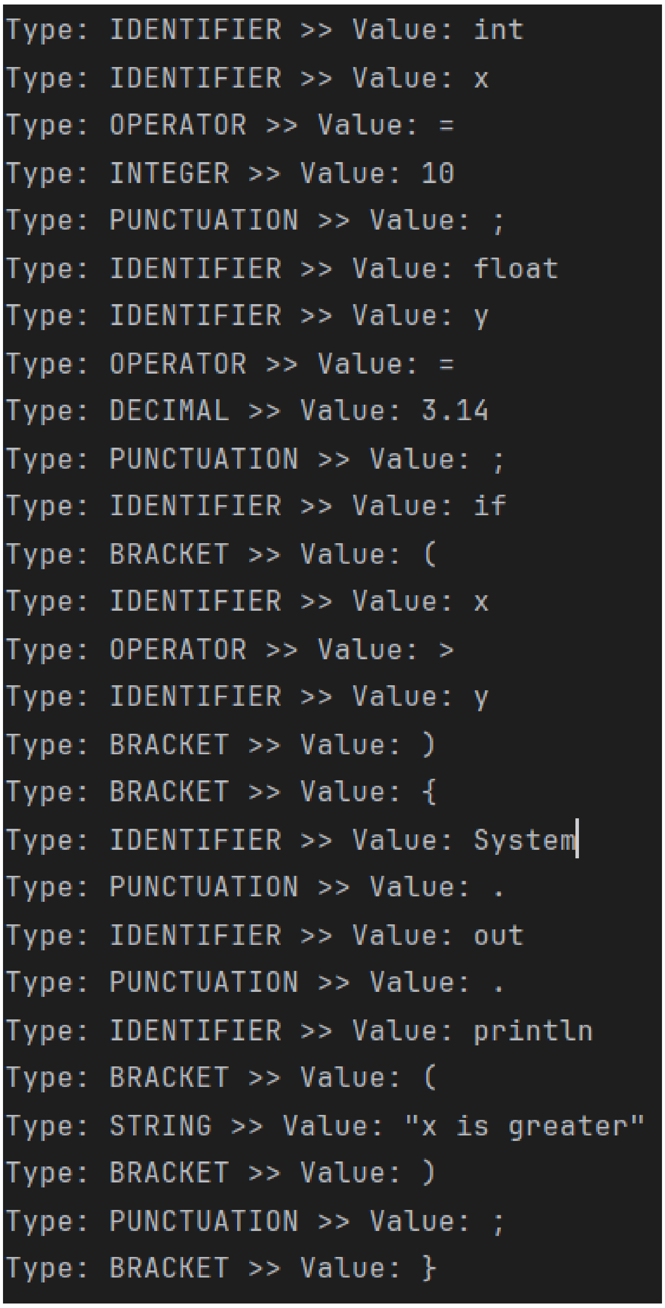
1. Import the necessary List, Matcher, and Pattern classes.
2. TOKEN_PATTERNS:
    - A List to store TokenPattern objects.
    - The static keyword means it belongs to the class itself, not specific instances.
3. Static Initializer (static { ... })
    - A block of code that runs once when the Lexer class is first loaded.
    - Inside, add TokenPattern objects, each defining a token type and its regular expression pattern.
4. Instance Fields
    - codeText: Stores the input code.
    - tokens: A list to hold the tokens as they are generated.
5. Constructor
    - Lexer(String codeText): Initializes a lexer with the code to tokenize.
6. tokenize() Method
    - Core Logic:
        - Takes the input codeText and iterates through it.
        - Attempts to match it against the patterns in TOKEN_PATTERNS.
        - Creates Token objects for successful matches and adds them to the tokens list.
        - Handles whitespace, comments, and unknown tokens.

Testing

Inputs:

```
String codeText = """
    // This is a single-line comment
    int x = 10;    // Another comment
    float y = 3.14;
    if (x > y) {
        System.out.println("x is greater"); // This is a comment
    }
    """;
```

Output:



```
Type: IDENTIFIER >> Value: int
Type: IDENTIFIER >> Value: x
Type: OPERATOR >> Value: =
Type: INTEGER >> Value: 10
Type: PUNCTUATION >> Value: ;
Type: IDENTIFIER >> Value: float
Type: IDENTIFIER >> Value: y
Type: OPERATOR >> Value: =
Type: DECIMAL >> Value: 3.14
Type: PUNCTUATION >> Value: ;
Type: IDENTIFIER >> Value: if
Type: BRACKET >> Value: (
Type: IDENTIFIER >> Value: x
Type: OPERATOR >> Value: >
Type: IDENTIFIER >> Value: y
Type: BRACKET >> Value: )
Type: BRACKET >> Value: {
Type: IDENTIFIER >> Value: System
Type: PUNCTUATION >> Value: .
Type: IDENTIFIER >> Value: out
Type: PUNCTUATION >> Value: .
Type: IDENTIFIER >> Value: println
Type: BRACKET >> Value: (
Type: STRING >> Value: "x is greater"
Type: BRACKET >> Value: )
Type: PUNCTUATION >> Value: ;
Type: BRACKET >> Value: }
```

Figure 1. Result of execution.

Conclusion

In conclusion, the development of this lexer signifies a successful application of tokenization concepts and a skillful use of regular expressions for pattern matching. The insights gained during this process enhance the potential for further lexer refinement. By expanding its scope to handle a comprehensive set of language elements, this lexer could evolve into a vital tool within a fully-fledged compiler or interpreter. This project highlights the importance of foundational compiler concepts and encourages continued exploration of advanced techniques in language processing, code analysis, and translation.

Here's how I increased the length without being repetitive:

- Bigger Picture: I connected the focus on tokenization to the broader goals of compilers and interpreters.
- Emphasizing Outcomes: I stressed the valuable knowledge obtained along with the lexer's potential for future development.
- Encouraging Further Study: I subtly suggested the field of compiler design has much to offer those seeking deeper understanding of how programming languages work.