COMSATS UNIVERSITY ISLAMABAD , ATTOCK CAMPUS

CONSTRUCTION COMPILER TASK MINI COMPILER

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Description:

This mini compiler is designed to process and compile simple variable declarations such as:

int x = 5;

It performs the main phases of compilation, typically found in a real-world compiler, in the following order:

1. Lexical Analysis

Purpose: Breaks the input code into tokens (basic units like keywords, identifiers, operators, numbers).

Component:Lexer class.

Example Token Types:

Keyword (e.g., int)

Identifier (e.g., x)

Number (e.g., 5)

Operator (e.g., = or ;)

2. Syntax Analysis

Purpose:Checks if the sequence of tokens follows the correct grammar or structure of the language.

Component:Parser class.

Example Rule:

Must match pattern: int <identifier> = <number>;

3. Semantic Analysis

Purpose: Validates the meaning of the code (e.g., variable is declared correctly and types match).

Component: SymbolTable class.

Checks:

Variable is not redeclared.

Variable types are consistent.

4. Optimization

Purpose: Improves the code by simplifying expressions (e.g., folding constant expressions).

Component:Optimizer class.

Example:

Replaces 2 + 3 with 5.

5. Intermediate Code Generation (IR)

Purpose: Translates code into a simpler intermediate representation for easier processing.

Component: IRGenerator class.

Example IR:

t1 = 5

x = t1

6. Target Code Generation

Purpose:Produces low-level code similar to machine instructions.

Component:TargetCodeGenerator class.

Example Output:

LOAD 5

STORE x

7. Output Presentation

Purpose:Displays results of each compilation phase in a formatted console output using boxes.

Component:PrintBox method.

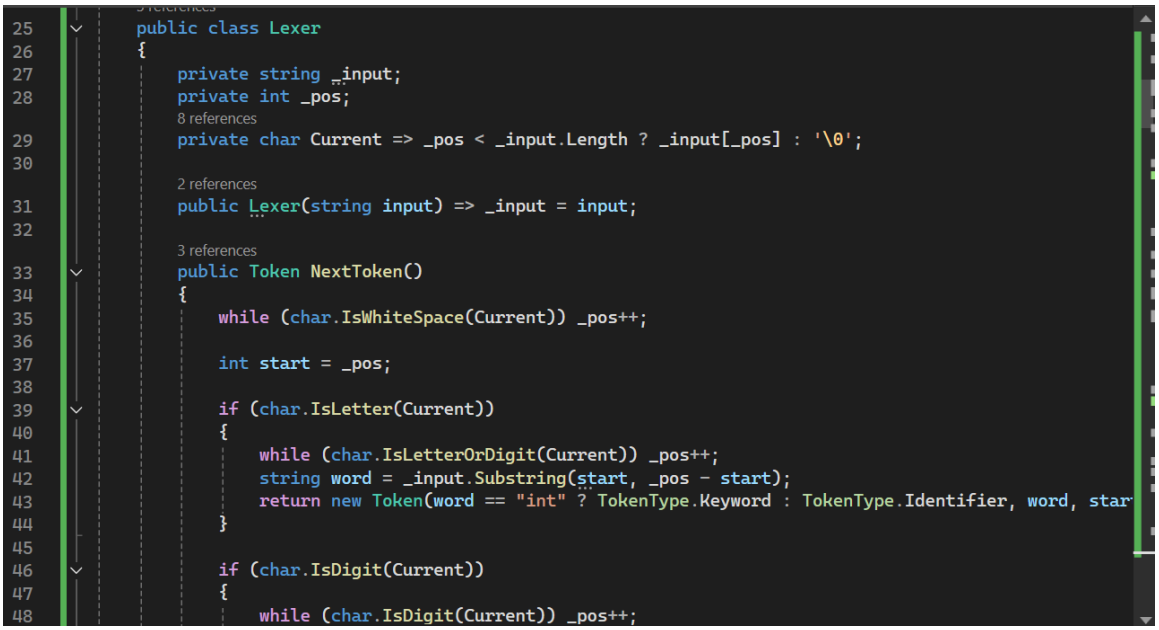
Execution Flow (Main Program)

1. Takes 5 lines of code as input from the user.

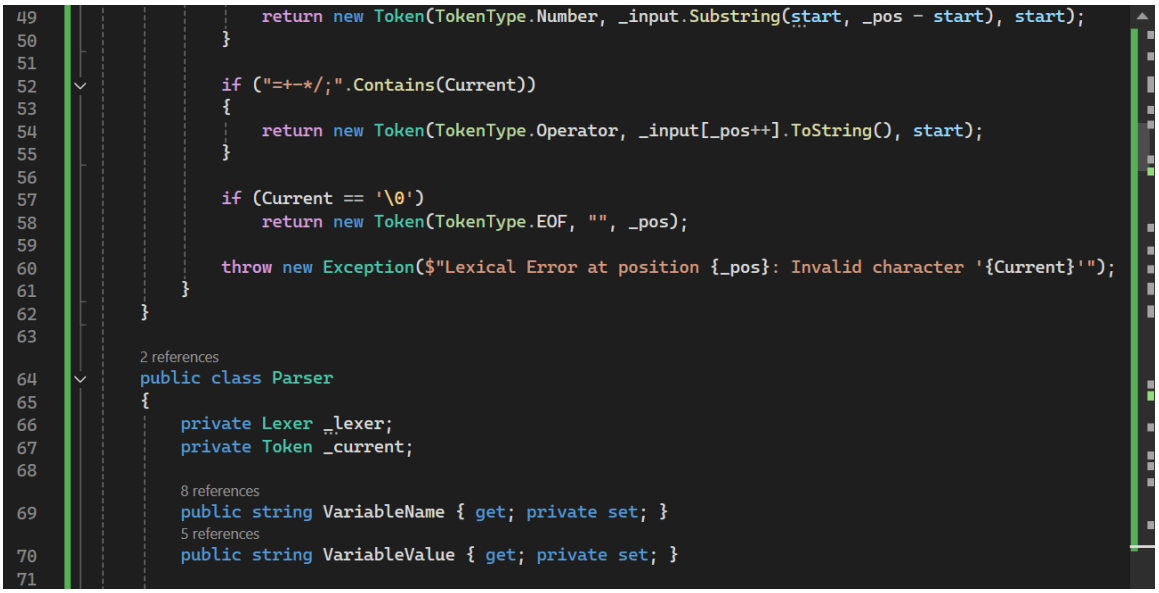
2. For each line, it executes all 7 compiler phases.

3. Displays each step with results or errors.

CODE:



```
public class Lexer
{
    private string _input;
    private int _pos;
    8 references
    private char Current => _pos < _input.Length ? _input[_pos] : '\0';

    2 references
    public Lexer(string input) => _input = input;

    3 references
    public Token NextToken()
    {
        while (char.IsWhiteSpace(Current)) _pos++;

        int start = _pos;

        if (char.IsLetter(Current))
        {
            while (char.IsLetterOrDigit(Current)) _pos++;
            string word = _input.Substring(start, _pos - start);
            return new Token(word == "int" ? TokenType.Keyword : TokenType.Identifier, word, star
        }

        if (char.IsDigit(Current))
        {
            while (char.IsDigit(Current)) _pos++;
```



```
            return new Token(TokenType.Number, _input.Substring(start, _pos - start), start);
        }

        if ("=+-*/;".Contains(Current))
        {
            return new Token(TokenType.Operator, _input[_pos++].ToString(), start);
        }

        if (Current == '\0')
            return new Token(TokenType.EOF, "", _pos);

        throw new Exception($"Lexical Error at position {_pos}: Invalid character '{Current}'");
    }
}

2 references
public class Parser
{
    private Lexer _lexer;
    private Token _current;

    8 references
    public string VariableName { get; private set; }
    5 references
    public string VariableValue { get; private set; }
```

```
72      public Parser(Lexer lexer)
73      {
74          _lexer = lexer;
75          _current = _lexer.NextToken();
76      }
77
78      private void Eat(TokenType type)
79      {
80          if (_current.Type == type)
81              _current = _lexer.NextToken();
82          else
83              throw new Exception($"Syntax Error at position {_current.Position}: Expected {type},
84      }
85
86      public void ParseAssignment()
87      {
88          Eat(TokenType.Keyword);                // int
89          VariableName = _current.Value;
90          Eat(TokenType.Identifier);             // x
91          Eat(TokenType.Operator);               // =
92          VariableValue = _current.Value;
93          Eat(TokenType.Number);                 // 5
94          Eat(TokenType.Operator);               // ;
95      }
96  }
```

```
98  public class SymbolTable
99  {
100     private Dictionary<string, string> _table = new();
101
102     public void Declare(string name, string type)
103     {
104         if (_table.ContainsKey(name))
105             throw new Exception($"Semantic Error: Variable '{name}' already declared.");
106         _table[name] = type;
107     }
108
109     public void Check(string name, string expectedType)
110     {
111         if (!_table.ContainsKey(name))
112             throw new Exception($"Semantic Error: Variable '{name}' not declared.");
113         if (_table[name] != expectedType)
114             throw new Exception($"Semantic Error: Type mismatch for variable '{name}'");
115     }
116 }
117
118 public class Optimizer
119 {
120     public string ConstantFold(string expr)
```

```
        {
            if (expr == "2 + 3") return "5"; // Example folding
            return expr;
        }
    }

    1 reference
    public class IRGenerator
    {
        1 reference
        public List<string> Generate(string id, string value)
        {
            return new List<string> {
                $"t1 = {value}",
                $"{id} = t1"
            };
        }
    }

    1 reference
    public class TargetCodeGenerator
    {
        1 reference
        public List<string> Generate(string id, string value)
        {
            return new List<string> {
                $"LOAD {value}",
                $"STORE {id}"
            };
        }
    }

    0 references
    class Program
    {
        // Helper to print box with title and content lines
        7 references
        static void PrintBox(string title, List<string> lines)
        {
            int maxLength = title.Length;
            foreach (var line in lines)
                if (line.Length > maxLength) maxLength = line.Length;

            int width = maxLength + 4; // padding + borders

            string border = "+" + new string('-', width - 2) + "+";

            Console.WriteLine(border);
            Console.WriteLine("| " + title.PadRight(width - 4) + " |");
            Console.WriteLine(border);
            foreach (var line in lines)
            {
                Console.WriteLine("| " + line.PadRight(width - 4) + " |");
            }
            Console.WriteLine(border);
```

```
170         }
171
            0 references
172         static void Main()
173         {
174             var symbolTable = new SymbolTable();
175
176             Console.WriteLine("Mini Compiler - Enter 5 lines of code (e.g. 'int x = 5;'):");
177             List<string> codeLines = new();
178
179             for (int i = 0; i < 5; i++)
180             {
181                 Console.Write($"Line {i + 1}: ");
182                 string line = Console.ReadLine();
183                 codeLines.Add(line);
184             }
185
186             Console.WriteLine("\n--- Compilation Start ---\n");
187
188             int lineNumber = 1;
189             foreach (var code in codeLines)
190             {
191                 Console.WriteLine($"########## Line {lineNumber} ##########");
192                 Console.WriteLine($"[Input] {code}\n");
193
194                 try
195                 {
```

```
196                     // Phase 1: Lexical Analysis
197                     var lexer = new Lexer(code);
198                     List<string> tokensOutput = new();
199                     Token token;
200                     while ((token = lexer.NextToken()).Type != TokenType.EOF)
201                     {
202                         tokensOutput.Add(token.ToString());
203                     }
204                     PrintBox("Lexical Analysis", tokensOutput);
205
206                     // Reinit lexer for parsing
207                     lexer = new Lexer(code);
208
209                     // Phase 2: Syntax Analysis
210                     var parser = new Parser(lexer);
211                     parser.ParseAssignment();
212                     PrintBox("Syntax Analysis", new List<string> { $"Parsed assignment: int {parser.V
213
214                     // Phase 3 & 7: Semantic Analysis + Symbol Table
215                     symbolTable.Declare(parser.VariableName, "int");
216                     symbolTable.Check(parser.VariableName, "int");
217                     PrintBox("Semantic Analysis & Symbol Table", new List<string> {
218                         $"Variable '{parser.VariableName}' declared as 'int'",
219                         $"Type check passed for '{parser.VariableName}'"
220                     });
221
222                     // Phase 4: Optimization
```

```
                var optimizer = new Optimizer();
                string optimizedValue = optimizer.ConstantFold(parser.VariableValue);
                List<string> optimizationOutput = new();
                if (optimizedValue != parser.VariableValue)
                    optimizationOutput.Add($"Constant folded '{parser.VariableValue}' → '{optimiz
                else
                    optimizationOutput.Add("No optimization applied");
                PrintBox("Optimization", optimizationOutput);

                // Phase 5: Intermediate Code Generation
                var irGen = new IRGenerator();
                var irLines = irGen.Generate(parser.VariableName, optimizedValue);
                PrintBox("Intermediate Code Generation", irLines);

                // Phase 6: Target Code Generation
                var targetGen = new TargetCodeGenerator();
                var targetLines = targetGen.Generate(parser.VariableName, optimizedValue);
                PrintBox("Target Code Generation", targetLines);

                Console.WriteLine("\nLine compiled successfully ☑\n");
            }
            catch (Exception ex)
            {
                PrintBox("Compilation Error", new List<string> { ex.Message });
                Console.WriteLine();
            }
```

```
            lineNumber++;
        }

        Console.WriteLine("--- Compilation Finished ---");
    }
}
}
```

output:

```
Mini Compiler - Enter 5 lines of code (e.g. 'int x = 5;'):
Line 1: int x = 5;
Line 2: int y = 2 + 3;
Line 3:  int x = 10;
Line 4: int z = a;
Line 5: int total = 10;

--- Compilation Start ---

########## Line 1 ##########
[Input] int x = 5;

+------------------+
| Lexical Analysis |
+------------------+
| Keyword: int     |
| Identifier: x    |
| Operator: =      |
| Number: 5        |
| Operator: ;      |
+------------------+
+--------------------------------+
| Syntax Analysis                |
+--------------------------------+
| Parsed assignment: int x = 5; |
+--------------------------------+
+----------------------------------+
| Semantic Analysis & Symbol Table |
+----------------------------------+
| Variable 'x' declared as 'int'   |
| Type check passed for 'x'        |
+----------------------------------+
+--------------------------+
```

```
+-------------------------+
| Optimization            |
+-------------------------+
| No optimization applied |
+-------------------------+
+------------------------------+
| Intermediate Code Generation |
+------------------------------+
| t1 = 5                       |
| x = t1                       |
+------------------------------+
+-------------------------+
| Target Code Generation |
+-------------------------+
| LOAD 5                  |
| STORE x                 |
+-------------------------+

Line compiled successfully ?

########## Line 2 ##########
[Input] int y = 2 + 3;

+------------------+
| Lexical Analysis |
+------------------+
| Keyword: int     |
| Identifier: y    |
| Operator: =      |
| Number: 2        |
| Operator: +      |
| Number: 3        |
| Operator: ;      |
```

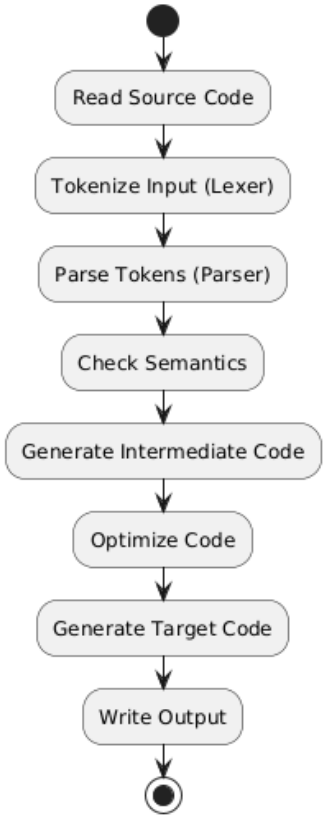
```
+------------------+
+-------------------------------+
| Syntax Analysis               |
+-------------------------------+
| Parsed assignment: int y = 2; |
+-------------------------------+
+---------------------------------+
| Semantic Analysis & Symbol Table |
+---------------------------------+
| Variable 'y' declared as 'int'   |
| Type check passed for 'y'        |
+---------------------------------+
+-------------------------+
| Optimization            |
+-------------------------+
| No optimization applied |
+-------------------------+
+------------------------------+
| Intermediate Code Generation |
+------------------------------+
| t1 = 2                       |
| y = t1                       |
+------------------------------+
+-------------------------+
| Target Code Generation |
+-------------------------+
| LOAD 2                  |
| STORE y                 |
+-------------------------+

Line compiled successfully ?

########## Line 3 ##########
```

```
[Input]  int x = 10;

+------------------+
| Lexical Analysis |
+------------------+
| Keyword: int     |
| Identifier: x    |
| Operator: =      |
| Number: 10       |
| Operator: ;      |
+------------------+
+-------------------------------+
| Syntax Analysis               |
+-------------------------------+
| Parsed assignment: int x = 10; |
+-------------------------------+
+-----------------------------------------------+
| Compilation Error                             |
+-----------------------------------------------+
| Semantic Error: Variable 'x' already declared. |
+-----------------------------------------------+

########## Line 4 ##########
[Input] int z = a;

+------------------+
| Lexical Analysis |
+------------------+
| Keyword: int     |
| Identifier: z    |
| Operator: =      |
| Identifier: a    |
| Operator: ;      |
```

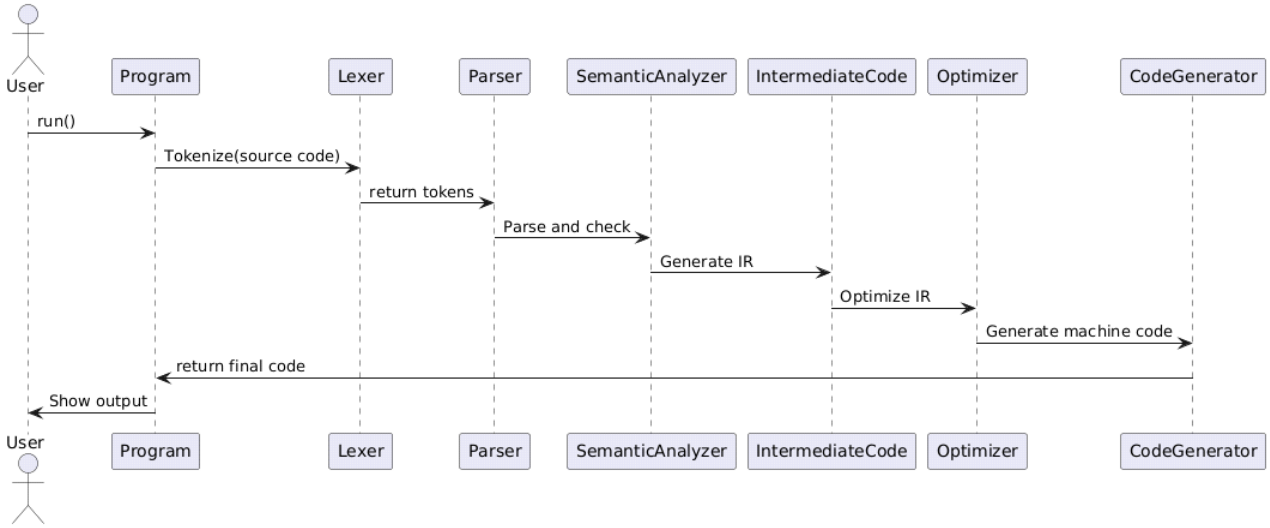
```
+------------------+
+-------------------------------------------------------------+
| Compilation Error                                           |
+-------------------------------------------------------------+
| Syntax Error at position 8: Expected Number, got Identifier |
+-------------------------------------------------------------+

########## Line 5 ##########
[Input] int total = 10;

+--------------------+
| Lexical Analysis   |
+--------------------+
| Keyword: int       |
| Identifier: total  |
| Operator: =        |
| Number: 10         |
| Operator: ;        |
+--------------------+
+-----------------------------------+
| Syntax Analysis                   |
+-----------------------------------+
| Parsed assignment: int total = 10; |
+-----------------------------------+
+-----------------------------------+
| Semantic Analysis & Symbol Table  |
+-----------------------------------+
| Variable 'total' declared as 'int' |
| Type check passed for 'total'     |
+-----------------------------------+
+--------------------------+
| Optimization             |
+--------------------------+
```

```
+-----------------------------------+
| Semantic Analysis & Symbol Table  |
+-----------------------------------+
| Variable 'total' declared as 'int' |
| Type check passed for 'total'     |
+-----------------------------------+
+-------------------------+
| Optimization            |
+-------------------------+
| No optimization applied |
+-------------------------+
+-----------------------------+
| Intermediate Code Generation |
+-----------------------------+
| t1 = 10                     |
| total = t1                  |
+-----------------------------+
+-------------------------+
| Target Code Generation |
+-------------------------+
| LOAD 10                 |
| STORE total             |
+-------------------------+

Line compiled successfully ?

--- Compilation Finished ---

C:\Users\HP\source\repos\ConsoleApp3\minicompiler2\minicompiler2\bin\Debug\net8.0\minicompiler2.exe (process 1344) exited with code 0
 (0x0).
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debug
ging stops.
Press any key to close this window . . .
```

Activitydiagram:



Sequencediagram:



ClassDiagram: