PROJECT REPORT

Compiler Construction Lab (CSL-323)

TARGET CODE GENERATION

BS(CS) – 5A

Group Members

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ABSTRACT

This project focuses on **target code generation**, transforming high-level programming constructs into equivalent and optimized C++ code. By leveraging lexical analysis, syntax analysis, and code generation, the system ensures semantic accuracy and efficiency. It enables developers to retain the abstraction of high-level languages while benefiting from C++'s performance and versatility. The generated C++ code is optimized for compilation and execution, maintaining functionality and structure while improving efficiency.

INTRODUCTION:

Target code generation is a process where source code written in one programming language is converted into another, often for better performance or compatibility. This project targets C++ as the output language, implementing a step-by-step approach:

1. **Lexical Analysis**: Tokenizing input code to identify keywords, operators, and constructs.
2. **Syntax Analysis**: Building an Abstract Syntax Tree (AST) to represent program logic.
3. **Code Generation**: Translating the AST into equivalent and optimized C++ constructs.
   The system ensures error handling, validation, and semantic preservation, making it a valuable tool for developers aiming to utilize C++'s efficiency while maintaining high-level abstraction.

PROBLEM STATEMENT:

The project is centered on developing a **target code generation tool** designed to convert source code from a high-level programming language (or a custom-defined language) into equivalent C++ code. This tool aims to accurately interpret the input, maintain its semantic and structural integrity, and generate syntactically correct and functionally equivalent C++ code.

Key Objectives

1. **Lexer Design**:
   Develop a lexer to scan the input source code and identify tokens, including keywords, operators, literals, and identifiers.
2. **Parser Implementation**:
   Construct a parser that organizes the identified tokens into an **Abstract Syntax Tree (AST)**, accurately representing the program's logical structure.
3. **Code Generation**:
   Create a code generator to transform the AST into optimized, readable, and compilable C++ code while preserving the functionality and logic of the input program.
4. **Error Handling**:
   Ensure robust mechanisms for identifying and handling syntax errors, unrecognized constructs, and invalid inputs, providing users with meaningful feedback.
5. **Testing and Validation**:
   Validate the tool's performance through comprehensive testing, ensuring the generated C++ code is consistent, correct, and suitable for compilation.

METHODOLOGY:

The methodology of the project includes:

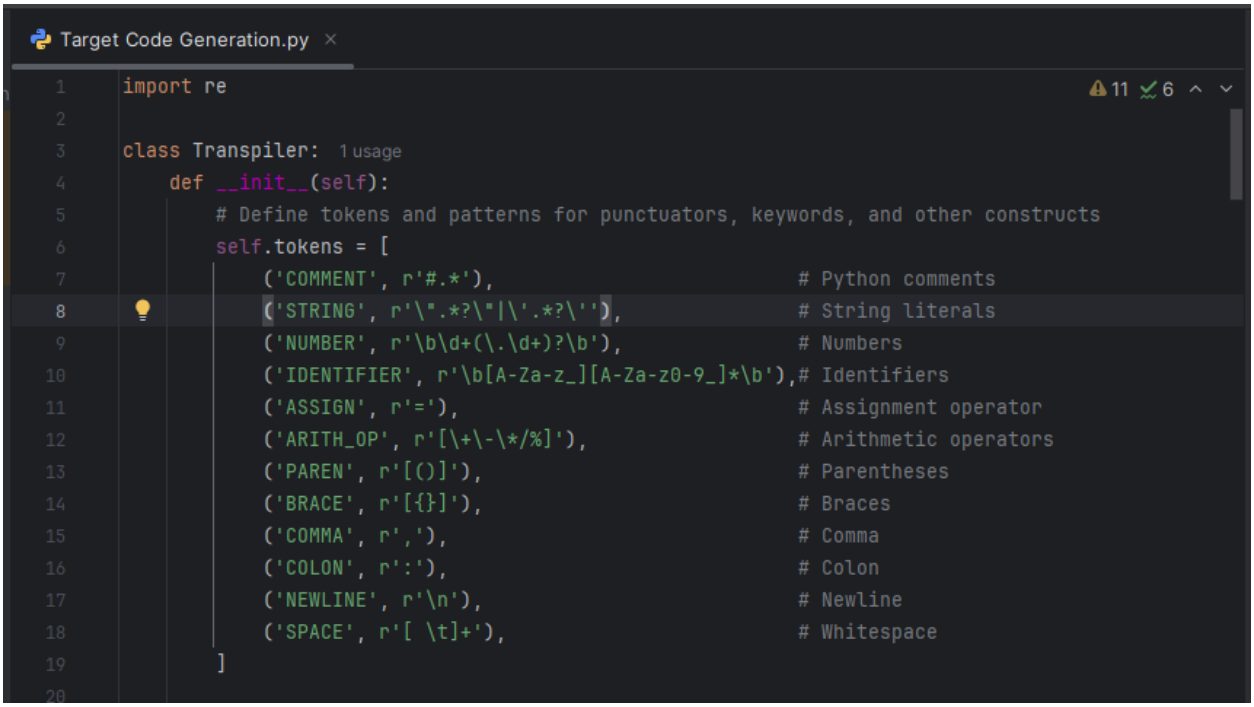
1. **Lexical Analysis**: Scans and tokenizes the input source code, identifying meaningful elements like keywords, variables, operators, and literals while flagging errors for invalid tokens.
2. **Syntax Analysis:** Constructs an Abstract Syntax Tree (AST) representing the hierarchical structure of the code and verifies its adherence to language grammar.
3. **Code Generation:** Maps AST components to equivalent C++ constructs, ensuring semantic accuracy and readability of the output.
4. **Testing and Validation:** The system is rigorously tested against various input cases to verify the correctness and efficiency of the generated code.

PROJECT SCOPE:

The scope of the project includes:

1. **Language Support**: Transpilation of custom-defined languages or high-level languages such as Python, JavaScript, and Java.
2. **Core Constructs**: Support for variables, loops, conditionals, and functions.
3. **Error Handling**: Meaningful error detection and reporting.
4. **Testing**: Validation of lexer, parser, and code generation.

CODE:



Target Code Generation.py

```python
class Transpiler:  1 usage
    def __init__(self):
        # Compile token patterns
        self.token_regex = re.compile('|'.join(f'(?P<{name}>{pattern})' for name, pattern in self.tokens))

        # Supported languages and corresponding templates
        self.supported_languages = {
            'python': self.transpile_python_to_cpp,
            'javascript': self.transpile_javascript_to_cpp,
            'java': self.transpile_java_to_cpp
        }

    def tokenize(self, code):
        """Tokenize the input source code."""
        tokens = []
        for match in self.token_regex.finditer(code):
            token_type = match.lastgroup
            value = match.group(token_type)
            if token_type != 'SPACE' and token_type != 'COMMENT':  # Skip whitespace and comments
                tokens.append((token_type, value))
        return tokens
```

Target Code Generation.py

```python
class Transpiler:  1 usage

    def transpile_python_to_cpp(self, code):  1 usage
        """Transpile Python code to C++."""
        cpp_code = ["#include <iostream>", "#include <string>", "using namespace std;", "int main() {"]
        lines = code.split('\n')

        for line in lines:
            line = line.strip()
            if line.startswith('#'):
                cpp_code.append(f"    // {line[1:].strip()}")  # Convert Python comments to C++
            elif 'print' in line:
                # Handle print statements
                content = re.search( pattern: r'print\((.*)\)', line).group(1)
                cpp_code.append(f"    cout << {content.replace( __old: '.format(', __new: ' + ').replace( __old: ')', __new: '')} << endl;")
            elif '=' in line and '==' not in line:
                cpp_code.append(f"    auto {line};")  # Declare variables with `auto`
            elif line:
                cpp_code.append(f"    {line};")
```

Target Code Generation.py

```
3   class Transpiler:  1 usage
41      def transpile_python_to_cpp(self, code):  1 usage
58
59          cpp_code.append("    return 0;")
60          cpp_code.append("}")
61          return '\n'.join(cpp_code)
62
63      def transpile_javascript_to_cpp(self, code):  1 usage
64          """Transpile JavaScript code to C++."""
65          cpp_code = ["#include <iostream>", "#include <string>", "using namespace std;", "int main() {"]
66          lines = code.split('\n')
67
68          for line in lines:
69              line = line.strip()
70              if line.startswith('//'):
71                  cpp_code.append(f"    {line}")  # JavaScript comments remain the same
72              elif 'console.log' in line:
73                  # Handle console.log statements
74                  content = re.search( pattern: r'console\.log\((.*)\)', line).group(1)
75                  cpp_code.append(f"    cout << {content} << endl;")
```

Target Code Generation.py

```
3   class Transpiler:  1 usage
63      def transpile_javascript_to_cpp(self, code):  1 usage
76              elif 'let ' in line or 'var ' in line or 'const ' in line:
77                  line = line.replace('let ', 'auto ').replace('var ', 'auto ').replace('const ', 'auto ')
78                  cpp_code.append(f"    {line};")
79              elif line:
80                  cpp_code.append(f"    {line};")
81
82          cpp_code.append("    return 0;")
83          cpp_code.append("}")
84          return '\n'.join(cpp_code)
85
86      def transpile_java_to_cpp(self, code):  1 usage
87          """Transpile Java code to C++."""
88          cpp_code = ["#include <iostream>", "#include <string>", "using namespace std;"]
89          lines = code.split('\n')
90
```

Target Code Generation.py

```
class Transpiler:  1 usage
    def transpile_java_to_cpp(self, code):  1 usage

        for line in lines:
            line = line.strip()
            if line.startswith('//'):
                cpp_code.append(f"    {line}")  # Java comments remain the same
            elif line.startswith('System.out.println'):
                # Handle System.out.println statements
                content = re.search( pattern: r'System\.out\.println\((.*)\)', line).group(1)
                cpp_code.append(f"    cout << {content} << endl;")
            elif 'int ' in line or 'double ' in line or 'String ' in line:
                cpp_code.append(f"    {line};")
            elif line:
                cpp_code.append(f"    {line};")

        cpp_code.append("    return 0;")
        cpp_code.append("}")
        return '\n'.join(cpp_code)
```

Target Code Generation.py

```
class Transpiler:  1 usage
    def transpile(self, language, source_code):  1 usage
        """Main transpiler function."""
        language = language.lower()
        if language not in self.supported_languages:
            raise ValueError(f"Unsupported language: {language}")

        transpile_function = self.supported_languages[language]
        return transpile_function(source_code)


# Main execution
if __name__ == "__main__":
    print("Welcome to the Language-to-C++ Transpiler!")
    print("This tool allows you to convert code written in Python, JavaScript, or Java into equivalent C++ code.")
    print("Supported languages: Python, JavaScript, Java.")

    while True:
        input_language = input("Enter the input language (or type 'exit' to quit): ").strip()
        if input_language.lower() == 'exit':
            break
```

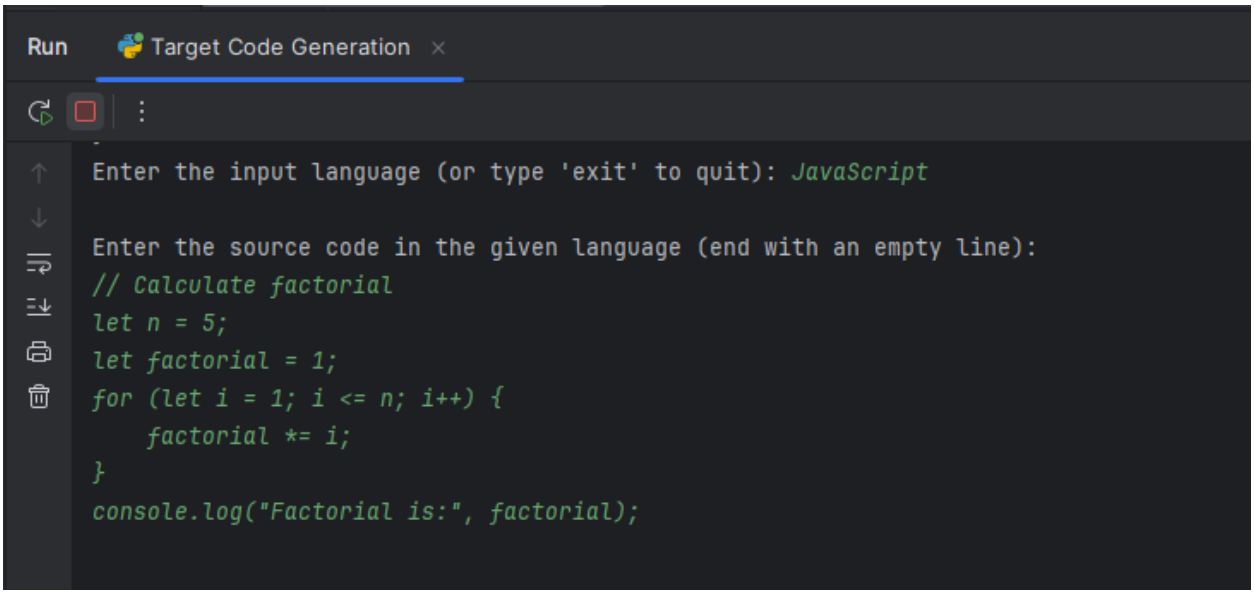
Target Code Generation.py

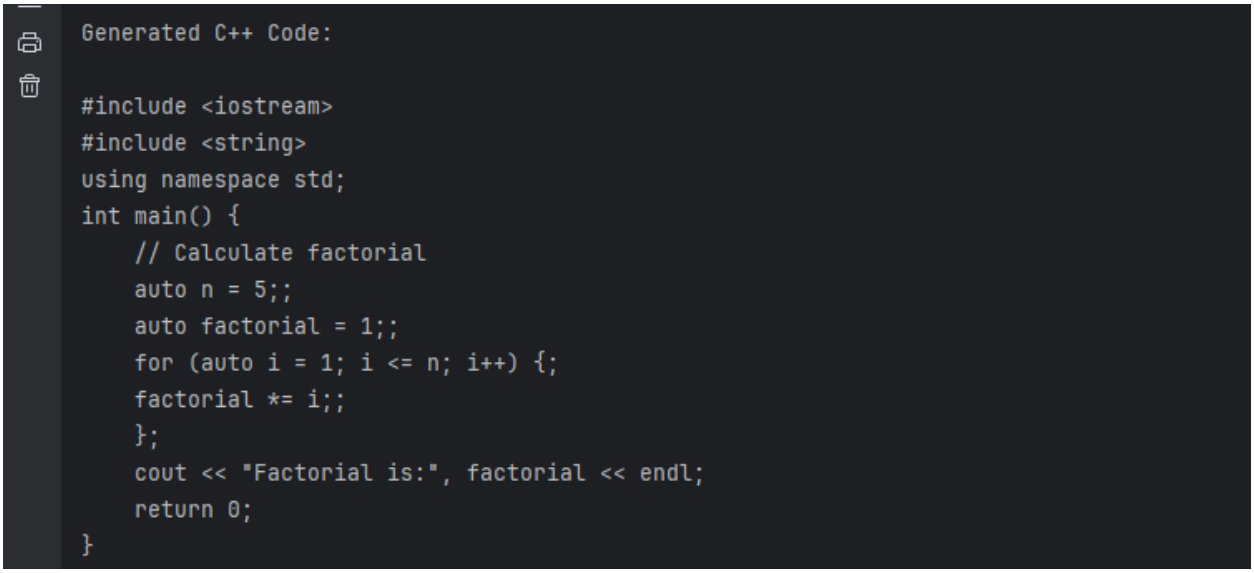
```
128
129         print("\nEnter the source code in the given language (end with an empty line):")
130         source_code = []
131         while True:
132             line = input()
133             if line.strip() == "":
134                 break
135             source_code.append(line)
136
137         source_code = "\n".join(source_code)
138
139         try:
140             transpiler = Transpiler()
141             generated_cpp_code = transpiler.transpile(input_language, source_code)
142             print("\nGenerated C++ Code:\n")
143             print(generated_cpp_code)
144         except Exception as e:
145             print(f"\nError: {e}")
146
147     print("\nThank you for using the Language-to-C++ Transpiler! Have a great day! 😊")
148
```

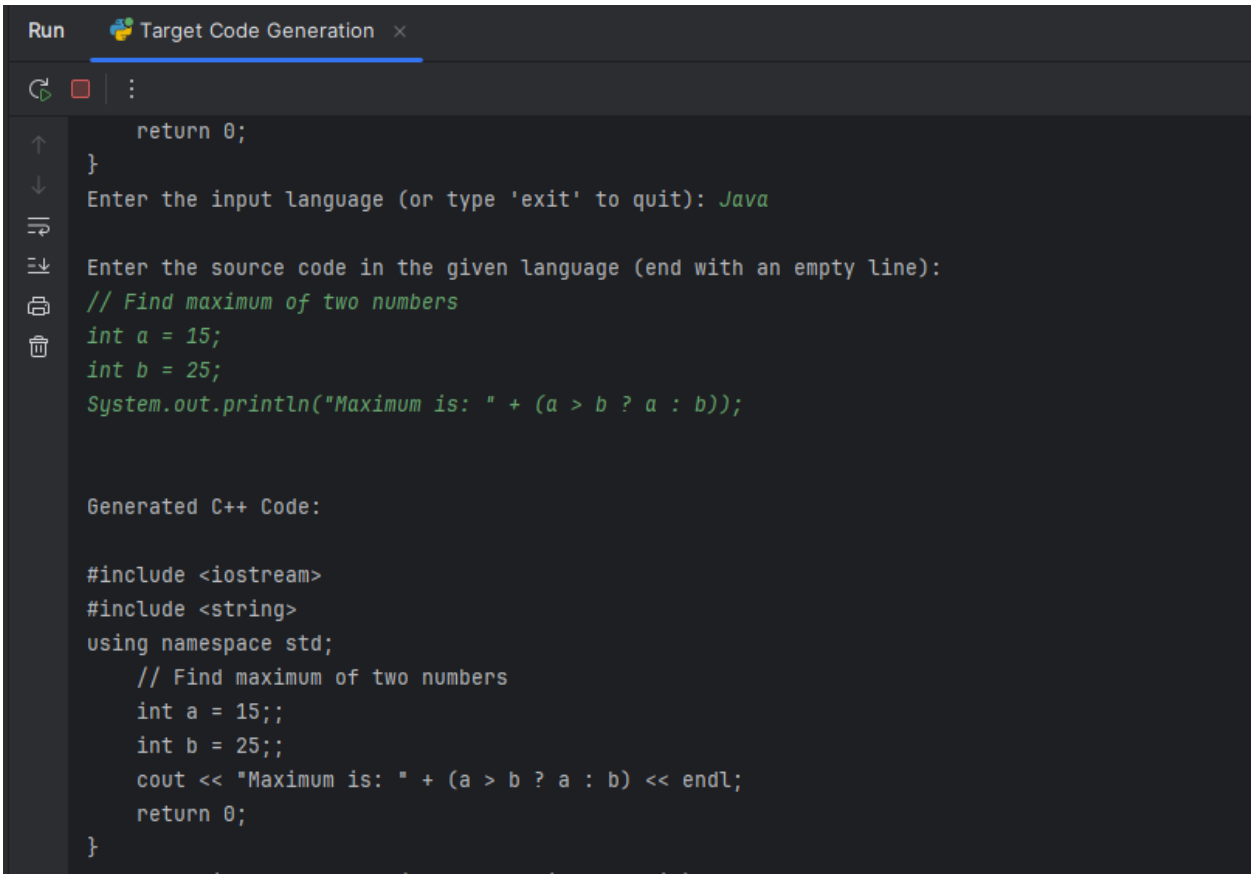
OUTPUT:

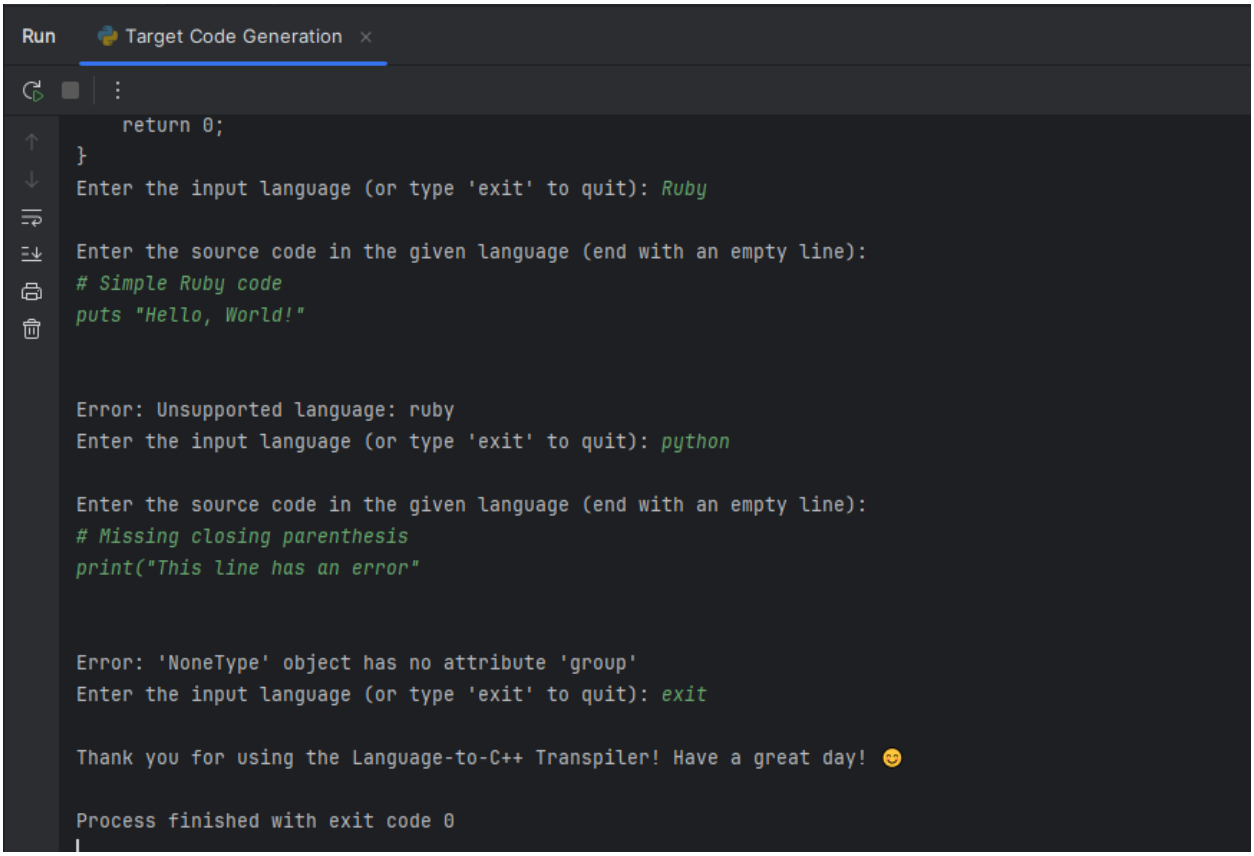
Run Target Code Generation

```
Welcome to the Language-to-C++ Transpiler!
This tool allows you to convert code written in Python, JavaScript, or Java into equivalent C++ code.
Supported languages: Python, JavaScript, Java.
Enter the input language (or type 'exit' to quit): Python

Enter the source code in the given language (end with an empty line):
# Calculate the sum
a = 10
b = 20
print("Sum is:", a + b)


Generated C++ Code:

#include <iostream>
#include <string>
using namespace std;
int main() {
    // Calculate the sum
    auto a = 10;
    auto b = 20;
    cout << "Sum is:", a + b << endl;
    return 0;
}
```


Run
Target Code Generation
Enter the input language (or type 'exit' to quit): JavaScript
Enter the source code in the given language (end with an empty line):
// Calculate factorial
let n = 5;
let factorial = 1;
for (let i = 1; i <= n; i++) {
factorial *= i;
}
console.log("Factorial is:", factorial);


Generated C++ Code:
#include <iostream>
#include <string>
using namespace std;
int main() {
// Calculate factorial
auto n = 5;;
auto factorial = 1;;
for (auto i = 1; i <= n; i++) {;
factorial *= i;;
};
cout << "Factorial is:", factorial << endl;
return 0;
}


Run
Target Code Generation
return 0;
}
Enter the input language (or type 'exit' to quit): Java
Enter the source code in the given language (end with an empty line):
// Find maximum of two numbers
int a = 15;
int b = 25;
System.out.println("Maximum is: " + (a > b ? a : b));
Generated C++ Code:
#include <iostream>
#include <string>
using namespace std;
// Find maximum of two numbers
int a = 15;;
int b = 25;;
cout << "Maximum is: " + (a > b ? a : b) << endl;
return 0;
}



FUTURE DEVELOPMENT:

Future enhancements for the project include:

1. **Object-Oriented Support**: Add support for classes, objects, and inheritance.
2. **Advanced Features**: Include exception handling, external libraries, and additional language constructs.
3. **Optimizations**: Improve generated C++ code efficiency.
4. **User Interface**: Create a GUI for ease of use.
5. **Extended Language Support**: Expand to more high-level languages.

CONCLUSION:

The project successfully demonstrates target code generation by converting high-level constructs into C++ while preserving functionality. It showcases the core principles of lexical analysis, syntax analysis, and code generation. Future advancements will focus on adding features, optimizing performance, and supporting additional programming languages.