SER502 Project DevilsCode

Team 5

Hari Iyer
Pankaj Singh
Ting Yeu Yang
Mingfei Yang

Outlines

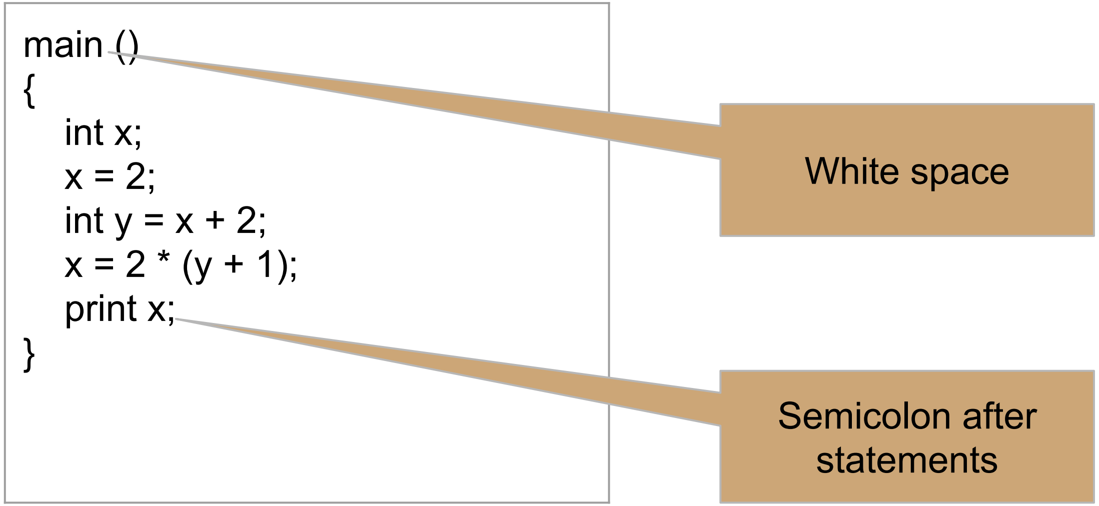
- Introduction
- Syntax & Grammar
- Lexical Analyzer & Parser
- Intermediate Code Generation
- Runtime

Introductions

- Designed language name: DevilsCode
- System: Ubuntu 16.04 LTS
- Tools:
    - Compiler: Python 3.5.2 and ANTLR 4.7
    - Runtime: Java SE 1.6
- Basic features:
    - Supports data types: integer and boolean
    - Supports while-loop
    - Supports if-else-statement
    - An output function to show results on console
    - Extension: .dvlc for source code and .ic for intermediate code

Syntax

- Code structure, declaration, assignment, and mathematical statements



```
main ()
{
    int x;
    x = 2;
    int y = x + 2;
    x = 2 * (y + 1);
    print x;
}
```

White space

Semicolon after statements

Syntax (cont’)

- while-loop statement

```
while (count > 5)
{
    print count;
    count = count + 1;
}
```

Does not support multiple conditions

Syntax (cont')

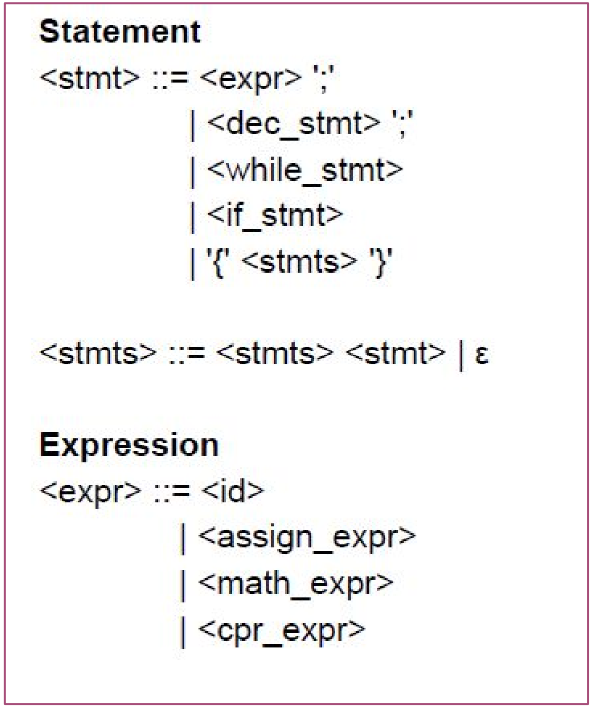
- if-else statement

```
if (age < 18)
{
    print 0;
}

if (age < 21)
{
    print 1;
}
else
{
    print 2;
}
```

Keyword "else" is optional

Grammar

Original grammar rules → .g4 file for ANTLR input

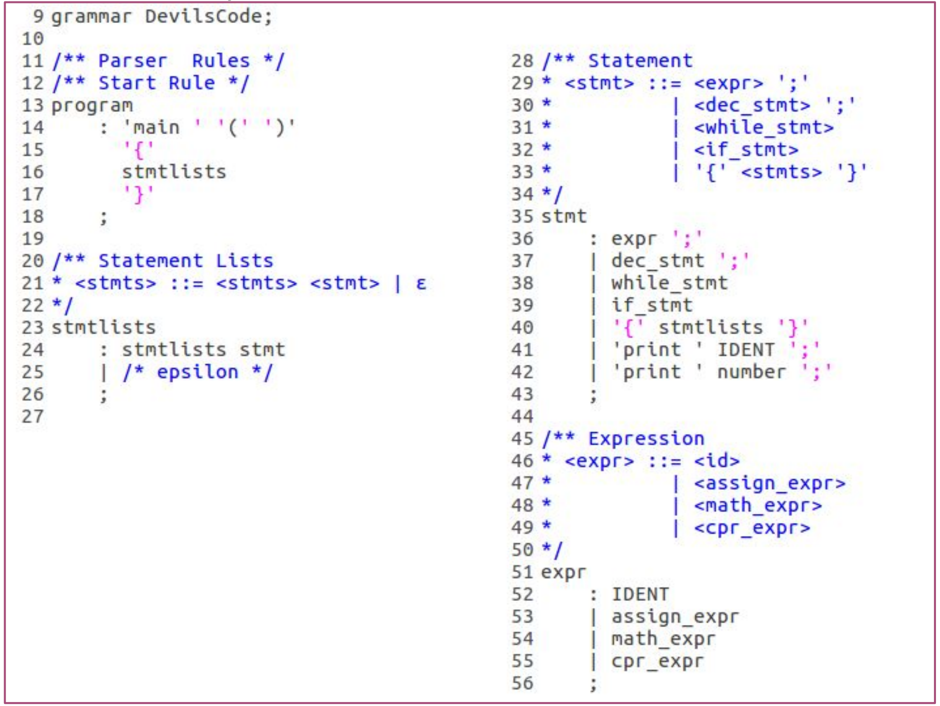


Statement

```
<stmt> ::= <expr> ';'
         | <dec_stmt> ';'
         | <while_stmt>
         | <if_stmt>
         | '{' <stmts> '}'

<stmts> ::= <stmts> <stmt> | ε
```

Expression

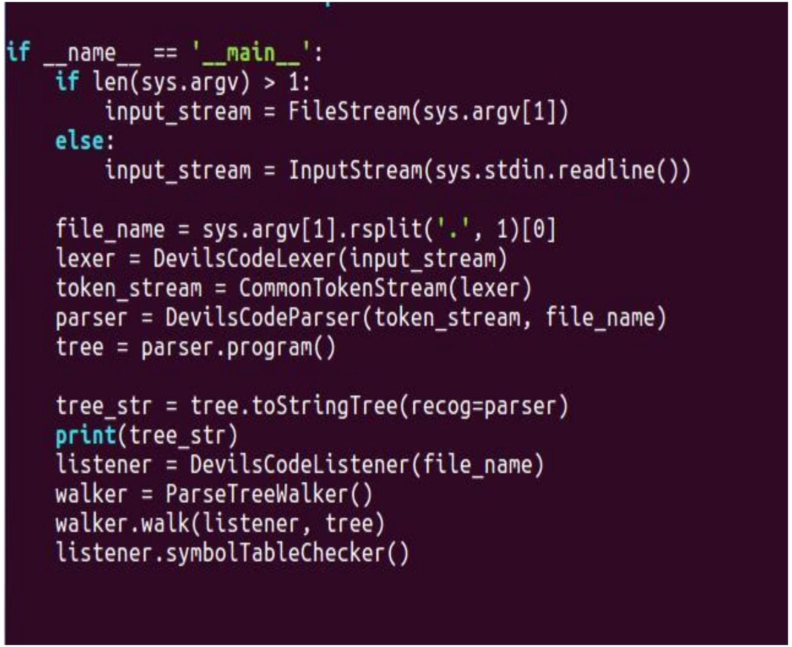
```
<expr> ::= <id>
         | <assign_expr>
         | <math_expr>
         | <cpr_expr>
```



```
grammar DevilsCode;

/** Parser  Rules */
/** Start Rule */
program
    : 'main ' '(' ')'
      '{'
      stmtlists
      '}'
    ;

/** Statement Lists
* <stmts> ::= <stmts> <stmt> | ε
*/
stmtlists
    : stmtlists stmt
    | /* epsilon */
    ;

/** Statement
* <stmt> ::= <expr> ';'
*            | <dec_stmt> ';'
*            | <while_stmt>
*            | <if_stmt>
*            | '{' <stmts> '}'
*/
stmt
    : expr ';'
    | dec_stmt ';'
    | while_stmt
    | if_stmt
    | '{' stmtlists '}'
    | 'print ' IDENT ';'
    | 'print ' number ';'
    ;

/** Expression
* <expr> ::= <id>
*            | <assign_expr>
*            | <math_expr>
*            | <cpr_expr>
*/
expr
    : IDENT
    | assign_expr
    | math_expr
    | cpr_expr
    ;
```

Lexical Analysis

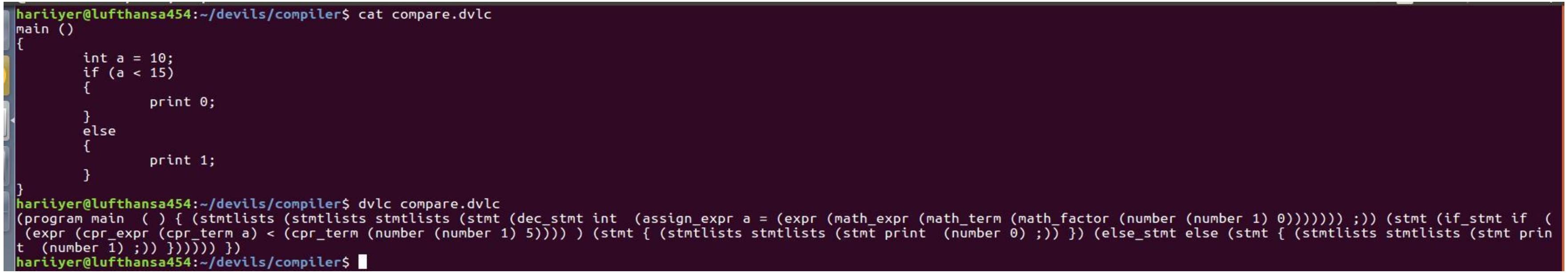
- ANTLR - Translates Grammar to Lexer and Parser
- DevilsCode Input
- Lexical Rules
- Keywords and Literals Validation
- Error Reporting



```
if __name__ == '__main__':
    if len(sys.argv) > 1:
        input_stream = FileStream(sys.argv[1])
    else:
        input_stream = InputStream(sys.stdin.readline())

    file_name = sys.argv[1].rsplit('.', 1)[0]
    lexer = DevilsCodeLexer(input_stream)
    token_stream = CommonTokenStream(lexer)
    parser = DevilsCodeParser(token_stream, file_name)
    tree = parser.program()

    tree_str = tree.toStringTree(recog=parser)
    print(tree_str)
    listener = DevilsCodeListener(file_name)
    walker = ParseTreeWalker()
    walker.walk(listener, tree)
    listener.symbolTableChecker()
```

Parsing

- Parser generated from the Rules
- Consumes TokenStream from Lexer
- Analyze Code for its Grammatical Structure
- program() as Entry Point to the Code
- Generates Parse Tree



```
hariiyer@lufthansa454:~/devils/compiler$ cat compare.dvlc
main ()
{
        int a = 10;
        if (a < 15)
        {
                print 0;
        }
        else
        {
                print 1;
        }
}
hariiyer@lufthansa454:~/devils/compiler$ dvlc compare.dvlc
(program main  ( ) { (stmtlists (stmtlists stmtlists (stmt (dec_stmt int  (assign_expr a = (expr (math_expr (math_term (math_factor (number (number 1) 0))))))) ;)) (stmt (if_stmt if  (
 (expr (cpr_expr (cpr_term a) < (cpr_term (number (number 1) 5)))) ) (stmt { (stmtlists stmtlists (stmt print  (number 0) ;)) }) (else_stmt else (stmt { (stmtlists stmtlists (stmt prin
t  (number 1) ;)) }))))) })
hariiyer@lufthansa454:~/devils/compiler$ 
```

Parse Tree

- Syntactic Structure of the Program
- Precursor to Intermediate Code
- Listener enables Parse Tree Traversal
- getChild() and getParent() for depth-traversals
- Example:

Code:

```
        main ()
        {
                int i = 1;
                i = i + 120;
                print i;
        }
```

Parse Tree:

(program main ( ) { (stmtlists (stmtlists (stmtlists stmtlists (stmt (dec_stmt int (assign_expr i = (expr (math_expr (math_term (math_factor (number 1))))))) ;)) (stmt (expr (assign_expr i = (expr (math_expr (math_expr (math_term (math_factor i))) + (math_term (math_factor (number (number (number 1) 2) 0))))))) ;)) (stmt print i ;)) })

Intermediate Code Generation

Intermediate Code Format

- Similar to Assembly language
- Output Format: **Line Number** + **Keyword** (+ **Argument**)
- **Keywords**:
    - START/STOP: Mark the beginning and the end of source program
    - BEGIN/END: Mark the beginning and the end of statement block (i.e. { stmt })
    - DEC: Mark the variable declaration, takes two arguments
    - ASSN: Mark the assignment expression, takes two arguments
    - ADD/SUB/MUL/DIV: Mark the arithmetic operations takes two arguments
    - SML/SMLEQL/GTR/GTREQL/EQL: Mark the comparison operations, two args
    - IF/ELSE: Mark the beginning of certain condition statement
    - LOOP: Mark the beginning of iteration statement
    - PRINT: Mark the print statement, takes one argument
    - GOTO: Mark the branch target, takes one argument

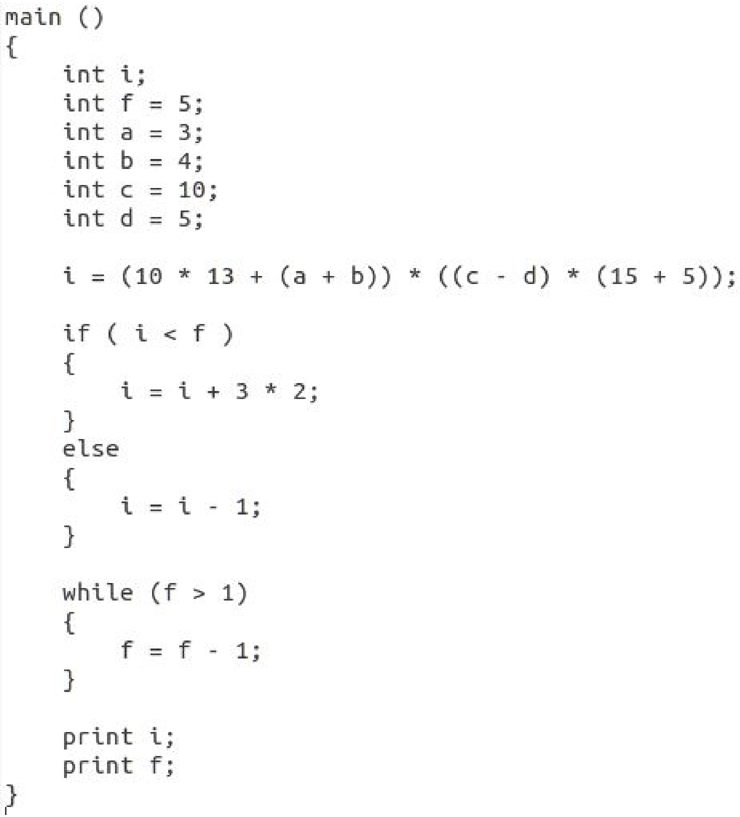
Generation Procedure

- Intermediate Code is generated by traversing parse tree
- Implemented in DevilsCodeListener.py, which is used for traversal
    - For each Non-terminal NT in grammar rules, ANTLR will generate two functions inside Listener named “enterNT” and “exitNT”
    - Certain code is written into the file when “entering” or “exiting” one node
        - Entering: “enterNT” function is called when visiting this node
        - Exiting: “exitNT” function is called after traversal of all children of this node
- Enter functions are usually used to generate intermediate code with START, BEGIN, DEC, SML/SMLEQL/GTR/GTREQL/EQL, PRINT, IF/ELSE, LOOP
- Exit functions are usually used to generate intermediate code with STOP, END, ADD/SUB/MUL/DIV, ASSN, GOTO

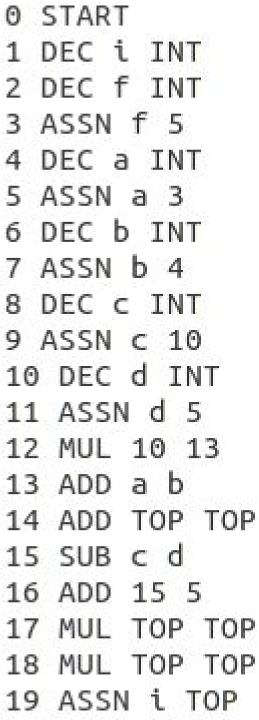
Data Structure Used in Generation Procedure

- Stack
  - Temporary values storage
  - Nested loops handling
  - Matching else with the nearest if
  - Branch target handling

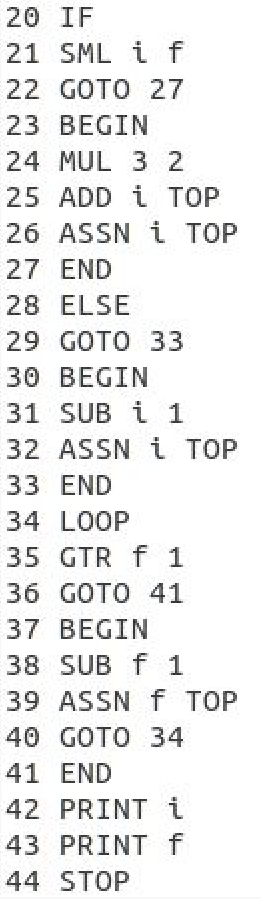
Sample



```
main ()
{
    int i;
    int f = 5;
    int a = 3;
    int b = 4;
    int c = 10;
    int d = 5;

    i = (10 * 13 + (a + b)) * ((c - d) * (15 + 5));

    if ( i < f )
    {
        i = i + 3 * 2;
    }
    else
    {
        i = i - 1;
    }

    while (f > 1)
    {
        f = f - 1;
    }

    print i;
    print f;
}
```



```
0 START
1 DEC i INT
2 DEC f INT
3 ASSN f 5
4 DEC a INT
5 ASSN a 3
6 DEC b INT
7 ASSN b 4
8 DEC c INT
9 ASSN c 10
10 DEC d INT
11 ASSN d 5
12 MUL 10 13
13 ADD a b
14 ADD TOP TOP
15 SUB c d
16 ADD 15 5
17 MUL TOP TOP
18 MUL TOP TOP
19 ASSN i TOP
```



```
20 IF
21 SML i f
22 GOTO 27
23 BEGIN
24 MUL 3 2
25 ADD i TOP
26 ASSN i TOP
27 END
28 ELSE
29 GOTO 33
30 BEGIN
31 SUB i 1
32 ASSN i TOP
33 END
34 LOOP
35 GTR f 1
36 GOTO 41
37 BEGIN
38 SUB f 1
39 ASSN f TOP
40 GOTO 34
41 END
42 PRINT i
43 PRINT f
44 STOP
```

DevilsCode Runtime

- Implemented in Java language
- Requires Java 1.6 or higher to support runtime
- Whole code is packaged a jar file and exported
- Command to execute runtime separately

```
java -jar DevilsCodeRuntime [intermediate code filename]
```

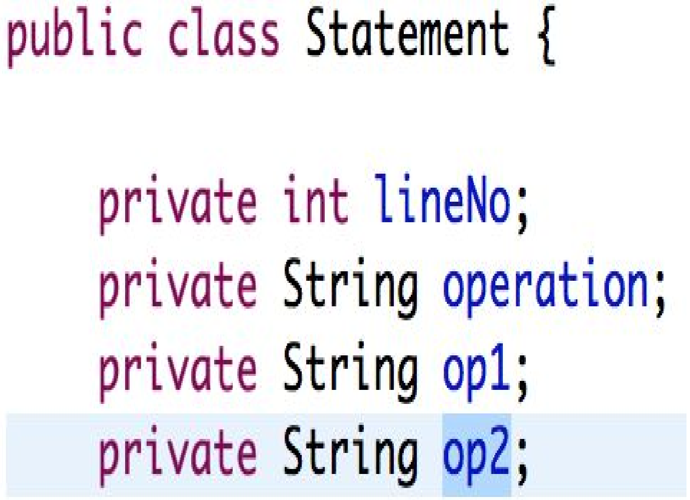
DevilsCode Runtime

Reads intermediate code as a list of statements

- Reads intermediate code from file
- Stores the code in the form of List of statements
- Executes each statement one by one

Statements

- Each statement has at max 4 components
  - Line Number : represent index in the list
  - Operation : a keyword with special meaning to runtime e.g. ASSN to assign values
  - Operand1 : variable or data value required by operation
  - Operand2 : variable or data value required by operation
- Variables are stored in a Map with name as key and its state as value
- Two separate Maps are used for integer and boolean



```
public class Statement {


    private int lineNo;
    private String operation;
    private String op1;
    private String op2;
```

Arithmetic and Boolean Operations

- All supported Arithmetic operations have 2 operands e.g.

  ADD a b

  Which means a+b; where a and b are integer variables

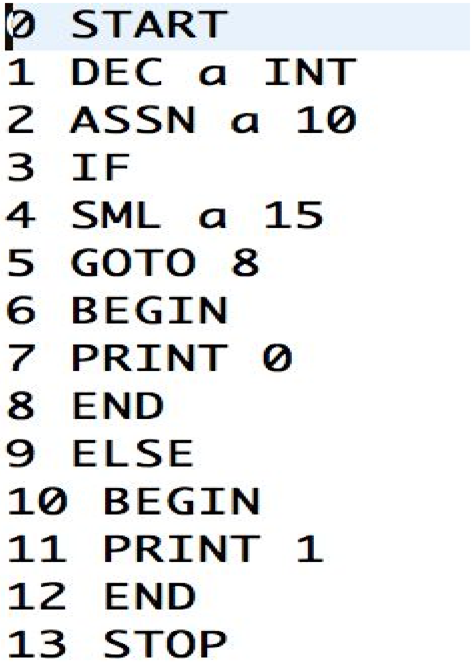
- Stores the result in intStack with last value pushed at the TOP
- During assignment TOP is popped from stack and assigned to variables

  ASSN c TOP

- Similar procedure is implemented for boolean operation

Branching Operation

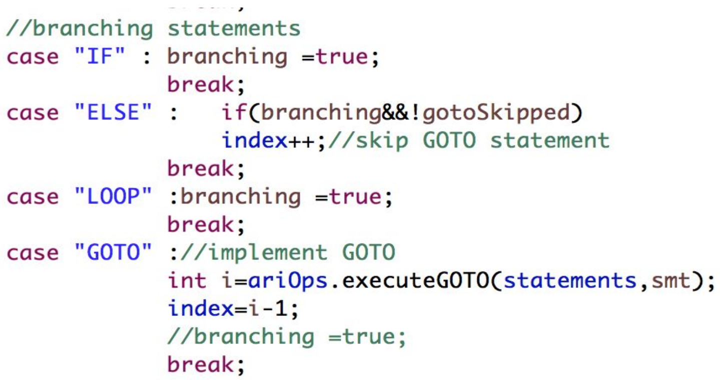
- IF and ELSE marks the branching statement
- IF will be followed by a condition statement
- Condition will be evaluated and if it is true we skip the next statement else continue
- Next Statement is GOTO line_number ; it sets the index to a new lineNumber and the runtime jumps to start executing from there (i.e. END of IF block)
- For ELSE statement, runtime checks if the condition was false then skip GOTO statement otherwise continue



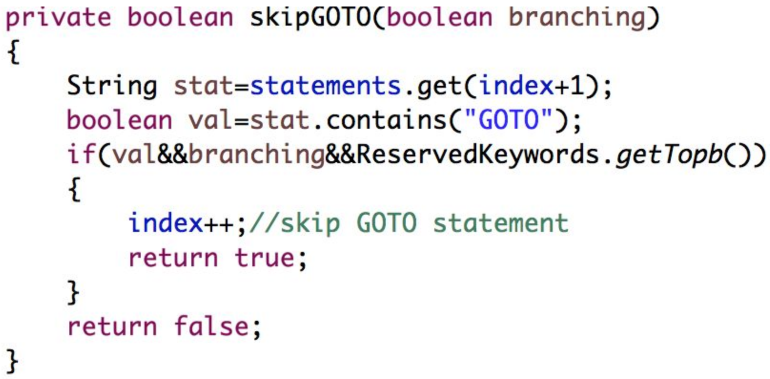
```
0 START
1 DEC a INT
2 ASSN a 10
3 IF
4 SML a 15
5 GOTO 8
6 BEGIN
7 PRINT 0
8 END
9 ELSE
10 BEGIN
11 PRINT 1
12 END
13 STOP
```

LOOP Operation

- LOOP statement marks the looping block
- LOOP will be followed by a condition statement
- Condition will be evaluated and if it is true we skip the next statement else continue
- Next Statement is GOTO line_number ; it sets the index to a new lineNumber and the runtime jumps to start executing from there (i.e. END of LOOP block)
- Before the end of Loop block there is another GOTO statement which makes runtime come back at the LOOP statement.

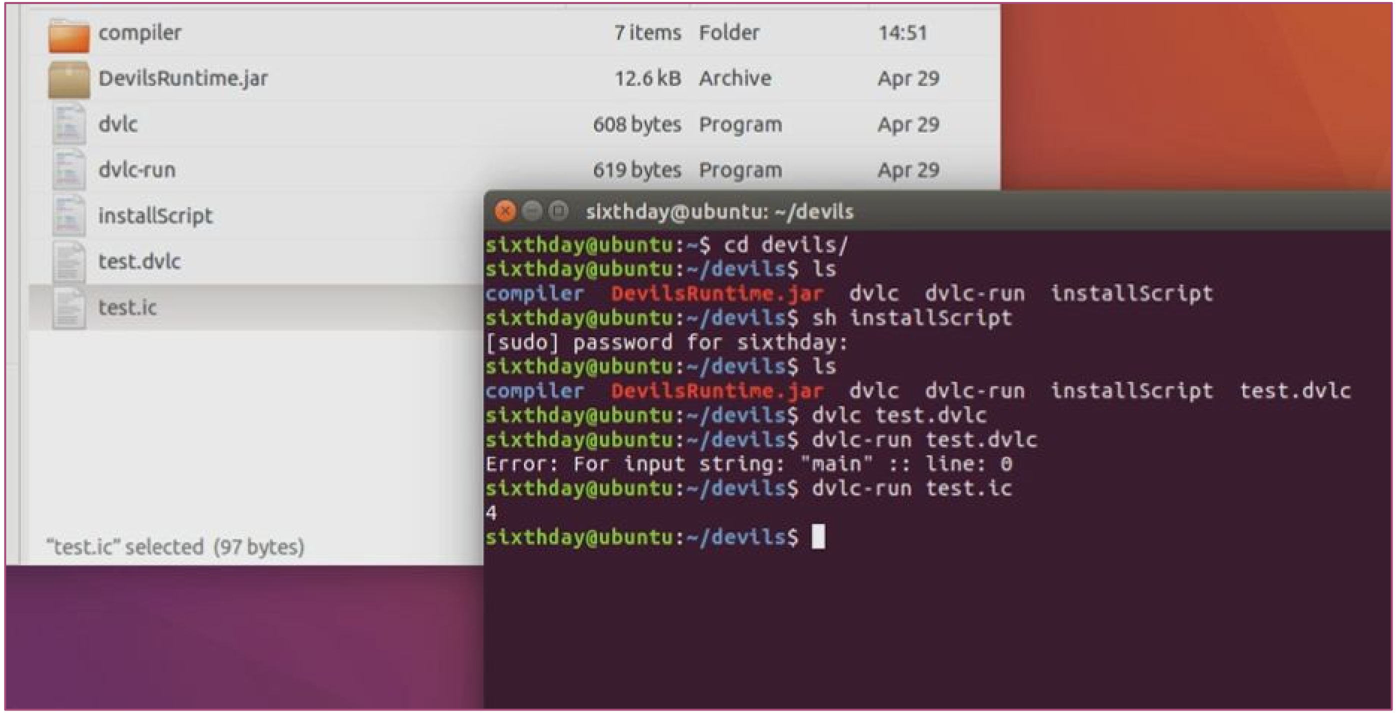


```
//branching statements
case "IF" : branching =true;
            break;
case "ELSE" :   if(branching&&!gotoSkipped)
                index++;//skip GOTO statement
            break;
case "LOOP" :branching =true;
            break;
case "GOTO" ://implement GOTO
            int i=ariOps.executeGOTO(statements,smt);
            index=i-1;
            //branching =true;
            break;
```



```
private boolean skipGOTO(boolean branching)
{
    String stat=statements.get(index+1);
    boolean val=stat.contains("GOTO");
    if(val&&branching&&ReservedKeywords.getTopb())
    {
        index++;//skip GOTO statement
        return true;
    }
    return false;
}
```

Execute Compiler and Runtime



compiler	7 items	Folder	14:51
DevilsRuntime.jar	12.6 kB	Archive	Apr 29
dvlc	608 bytes	Program	Apr 29
dvlc-run	619 bytes	Program	Apr 29
installScript			
test.dvlc			
test.ic			

“test.ic” selected (97 bytes)

```
sixthday@ubuntu:~$ cd devils/
sixthday@ubuntu:~/devils$ ls
compiler  DevilsRuntime.jar  dvlc  dvlc-run  installScript
sixthday@ubuntu:~/devils$ sh installScript
[sudo] password for sixthday:
sixthday@ubuntu:~/devils$ ls
compiler  DevilsRuntime.jar  dvlc  dvlc-run  installScript  test.dvlc
sixthday@ubuntu:~/devils$ dvlc test.dvlc
sixthday@ubuntu:~/devils$ dvlc-run test.dvlc
Error: For input string: "main" :: line: 0
sixthday@ubuntu:~/devils$ dvlc-run test.ic
4
sixthday@ubuntu:~/devils$ 
```