SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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<u>18CSC304J/ COMPLIER DESIGN</u>

<u>MINI PROJECT REPORT</u>

"Mini Compiler for If-Else and While Constructs in Python"

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AIM

To Create a mini python compiler using Lex and Yacc and to implement Mini compiler for if-else and while constructs in python

The steps to do this are:

- Tokenization
- Parsing
- Code generation
- Optimization

ABSTRACT

This project presents the development of a mini-compiler for the Python programming language. The compiler is designed to break down the input code into a series of tokens, parse the tokens to create an abstract syntax tree (AST), generate executable code from the AST, and apply various optimization techniques to improve the code's efficiency. The implementation of the mini-compiler uses a combination of regular expressions, parser generator tools, and code generation libraries to simplify the development process. This project aims to demonstrate the feasibility of creating a mini-compiler for Python and provides a foundation for further research and development in this area.

INTRODUCTION

To create a mini-compiler for Python, you'll need to break down the process into a few steps. Here's a general outline of the process:

1. Tokenization: The first step is to break down the input code into a series of tokens. Each token represents a single unit of meaning in the code, such as a keyword, an identifier, a literal value, or a punctuation symbol. You can use regular expressions to define the patterns for each type of token.

2. Parsing: Once you have a stream of tokens, the next step is to parse the code to create an abstract syntax tree (AST). The AST represents the structure of the code in a way that makes it easy to analyze and manipulate. You can use a parser generator tool like ANTLR or PLY to generate a parser based on a grammar specification.

3. Code generation: Once you have an AST, you can generate executable code from it. This involves translating the abstract syntax tree into actual Python code that can be executed by the interpreter. You can use a code generation library like CodeGen to simplify this process.

4. Optimization: Finally, you can apply various optimization techniques to the generated code to make it run more efficiently. This might involve performing constant folding, dead code elimination, or other optimizations.

Overall, creating a mini-compiler for Python can be a complex task, but with the right tools and techniques, it's certainly achievable. Good luck with your project!

ARCHITECTURE OF THE LANGUAGE

Python has a very flexible syntax and we have tried to incorporate as much as possible from our experience of using python into the grammar. But we have not taken care of semicolons, so a semicolon will result in an error while parsing. All lines of code terminate upon seeing a newline character. We have taken care of the following:

- If-Elif-Else and While constructs
- Print Statements
- pass, break and void returns
- Function definitions and Calls
- Lists
- All arithmetic operators and all boolean operators except standalone '!' ("!=" is taken care of)
- Single Line Comments (#)

Semantically we have checked the following :

- Whether any variable used on the RHS is defined and in the current scope or any Enclosing Scope of the current scope.
- Whether a variable being indexed is List
- Whether all expressions in the If and While Clauses are Boolean expressions

LITERATURE SURVEY

1. Lex and Yacc Doc by Tom Niemann
2. Official Bison Documentation : https://www.gnu.org/software/bison/manual/
3. Stackoverflow : https://stackoverflow.com/

THE CONTEXT FREE GRAMMAR

Grammar to Parse While And If Statements in Python

Grammar	Expression	Legend
StartDebugger	StartParse T_EndOfFile	T_Import : "import"
constant	T_Number | T_String	T_Print : "print"
T_ID	[_a-zA-Z][_a-zA-Z0-9]*	T_Pass : "pass"
term	T_ID | constant | list_index	T_If : "if"
list_index	T_ID T_OB constant T_CB	T_While : "while"
StartParse	T_NL StartParse | finalStatements T_NL StartParse | finalStatements T_NL	T_Break : "break"
basic_smt	pass_stmt | break_stmt | import_stmt | assign_stmt | bool_exp | arith_exp | print_stmt | return_stmt	T_And : "and"
arith_exp	term | arith_exp T_PL arith_exp |	T_Or : "or"
	arith_exp T_MN arith_exp |	T_Not : "not"
	arith_exp T_ML arith_exp |	T_Elif : "elif"
	arith_exp T_DV arith_exp |	T_Else : "else
	T_OP arith_exp T_CP	T_Def : "def"
ROP	T_GT | T_LT | T_ELT | T_EGT	T_In : "in"
bool_exp	bool_term | bool_term T_Or bool_term | arith_exp T_LT arith_exp | bool_term T_And bool_term	T_Cln : ":"
	arith_exp T_GT arith_exp | arith_exp T_ELT arith_exp | arith_exp T_EGT arith_exp | arith_exp T_In T_ID	T_GT : ">"
bool_term	bool_factor | arith_exp T_EQ arith_exp | T_True | T_False	T_LT : "<"
bool_factor	T_Not bool_factor | T_OP bool_exp T_CP	T_EGT : ">="
import_stmt	T_Import T_ID	T_ELT : "<="
assign_stmt	T_ID T_EQL arith_exp | T_ID T_EQL bool_exp | T_ID T_EQL func_call | T_ID T_EQL T_OB T_CB |	T_EQ : "=="
pass_stmt	T_Pass	T_NEQ : "!="
break_stmt	T_Break	T_True : "True"
return_stmt	T_Return	T_False : "False"
print_stmt	T_Print T_OP constant T_CP	T_PL : "+"
finalStatements	basic_stmt | cmpd_stmt | func_def | func_call	T_MN : "-"
cmpd_stmt	if_stmt | while_stmt	T_ML : "*"
if_stmt	T_If bool_exp T_Cln start_suite | T_If bool_exp T_Cln start_suite elif_stmts	T_DV : "/"
elif_stmts	T_Elif bool_exp T_Cln start_suite elif_stmts | else_stmt	T_OP : "("
else_stmt	T_Else T_Cln start_suite	T_CP : ")"
while_stmt	T_While bool_exp T_Cln start_suite	T_OB : "["
start_suite	basic_stmt | T_NL ID finalStatements suite	T_CB : "]"
suite	T_NL ND finalStatements suite | T_NL end_suite	T_Comma : ","
end_suite	DD finalStatements | DD |	T_EQL : "="
args	T_ID args_list |	T_NL : "\n"
args_list	T_Comma T_ID args_list |	T_String : String
call_list	T_Comma term call_list |	T_Number : Number
call_args	term call_list |	ND : Nodent
func_def	T_Def T_ID T_OP args T_CP T_Cln start_suite	ID : Indent
func_call	T_ID T_OP call_args T_CP	DD : Dedent
		T_EOF : End Of File

DESIGN STRATEGY

The Design Strategy we have implemented is that firstly, every links back to the Symbol Table. This means that the required nodes of the Abstract Syntax tree and a the required Quadruples in the Intermediate code have a link to the Symbol table. All the compiler generated Temporaries are also stored in the symbol table.

The Symbol Table stores 'Records' having 4 columns as you can see in the sample output, ie,

- ❖ Scope : Scope of each variable contained in record
- ❖ Name : Value/Name of each variable contained in record
- ❖ Type : Type of each variable contained in record
    - PackageName
    - Func_Name
    - Identifier
    - Constant
    - ListTypeID
    - ICGTempVar
    - ICGTempLabel
- ❖ Declaration : Line of Declaration of each variable contained in record
- ❖ Last Use Line

The scope is a function of Indentation depth and to make it unique we have a tuple of the scope of the parent and the current scope calculated using the Indentation depth.

For the Abstract Syntax Tree, We have 2 Types of Nodes, Leaf nodes and Internal nodes. The nodes can have variable number of children (0-3) depending upon the construct it represents. Take the example of the If-Else Statement,

If Condition CodeBlock Else

To display the AST, We take the AST and store it as a matrix of levels. As we can see in the sample output, we have printed each level of the AST. All Internal nodes also have a number enclosed in brackets next to them, which represents the number of children they have in the next level. Leaf nodes in the AST representing identifiers, constants, Lists, packages point to a record in the symbol table.

The Intermediate code is generated by recursively stepping through the AST. Each line is stored as a quadruple (Operation, Arg1, Arg2, Result) so that it we may easily optimize code in the following steps.

We Eliminate dead code, specifically unused variables in the whole program. For example, if we have the following lines of code:

a = 10

b = 10

c = a + b

And these 3 variables are not used on any other RHS, then these 3 lines of code are Eliminated during optimization. All the dead variables in the code are removed. We iterate through the Quads to do this.

To take care of the Indentation based code structure and scoping we have implemented a stack and we use 3 tokens. The top of the stack always points to the current indentation value, if that value on scanning the next line, doesn't change, it implies that we're in the same scope and hence, we return the token 'ND', i.e, 'No-dent'. If the value increases, it means we are entering a sub-scope and we return the token 'ID' , i.e. 'Indent' and finally, if the value decreases, it means we're returning to one of the enclosing scope and we return 'DD', i.e. 'Dedent'.

For Error Handling, Whenever the parser encounters an error, It prints the Line no and column number of the error. We also display the following errors:

- Identifier Not declared in scope
- Identifier Not Indexable

All Comments are removed from the code before parsing

CODE

```
%{
#include <string.h>
#include "y.tab.h"
#define stack_size 100
#define DEBUG 1

int yycolumn = 1;
int startFlag = 1;

#define YY_USER_ACTION yylloc.first_line = yylloc.last_line = yylineno;                \
    yylloc.first_column = yycolumn; yylloc.last_column = yycolumn + yyleng - 1;      \
    yycolumn += yyleng;


static int sp=0, stack [stack_size];

static void debug(const char *X)
{
#ifdef DEBUG
if(startFlag)
{
printf("----------------------------------Token Sequence--------------------------\n1 ");
startFlag=0;
}

if(strcmp(X, "NL")==0)
{
printf("T_%s\n%d ", X, yylineno);
}
else
{
printf("T_%s ", X);
}
#endif
}
static void push (int i)
{
        if (++sp<stack_size) stack[sp]= i;
        else {printf ("error: stack overflow\n"); exit(1);}
```

```
}

int pop ()
{
			if (sp>-1) return stack[sp--];
			else {printf ("error: stack underflow\n"); exit(1);}
}

int top()
{
if(sp>-1) return stack[sp];
else return 1;
}

static int indent_depth(const char *K)
{
int len = strlen(K), i, tab_count=1;
for(i=0; i< len ; i++)
{
if(K[i]=='\t')
{
tab_count++;
}
else
{
printf("Nope");
break;
}
}
return tab_count;
}
int depth = 1;

%}
%option yylineno
whitespace [ ]
Multiline_comment \'\'\'.+\'\'\'
%%

[\t]*			{
depth = indent_depth(yytext);
//				printf("Depth : %d ",  depth);
```

```
if(depth < top())
{
while (depth < top()) pop();
yylval.depth = depth;
debug("DD");
return DD;
}

if(depth == top())
{
debug("ND");
yylval.depth = depth;
return ND;
}
if(depth > top())
{
push(depth);
debug("ID");
yylval.depth = depth;
return ID;
}

}

"import" {debug("IMPT"); return T_Import;}
"print"  {debug("Print"); return T_Print;}
"pass" {debug("Pass"); return T_Pass;}
"if" {debug("If"); return T_If;}
"in" {debug("In"); return T_In;}
"while" {debug("While"); return T_While;}
"break" {debug("Break"); return T_Break;}
"and" {debug("And"); return T_And;}
"or" {debug("Or"); return T_Or;}
"not" {debug("Not"); return T_Not;}
"elif" {debug("Elif"); return T_Elif;}
"else" {debug("Else"); return T_Else;}
"def" {debug("Def"); return T_Def;}
"return" {debug("Return"); return T_Return;}
":" {debug("Cln"); return T_Cln;}
">" {debug("GT"); return T_GT;}
"<" {debug("LT"); return T_LT;}
">=" {debug("EGT"); return T_EGT;}
```

```
"<=" {debug("ELT"); return T_ELT;}
"==" {debug("EQ"); return T_EQ;}
"!=" {debug("NEQ"); return T_NEQ;}
"True" {debug("True"); return T_True;}
"False" {debug("False"); return T_False;}
"+" {debug("PL"); return T_PL;}
"-" {debug("MN"); return T_MN;}
"*" {debug("ML"); return T_ML;}
"/" {debug("DV"); return T_DV;}
"(" { debug("OP"); return T_OP;}
")" {debug("CP"); return T_CP;}
"[" {debug("OB"); return T_OB;}
"]" {debug("CB"); return T_CB;}
"," {debug("Comma"); return T_Comma;}
"=" {debug("EQL"); return T_EQL;}
"list" {debug("List"); return T_List;}
[0-9]+ {yylval.text = strdup(yytext); debug(yylval.text); return T_Number;}
[_a-zA-Z][_a-zA-Z0-9]* {yylval.text = strdup(yytext); debug(yylval.text); return T_ID;}
\"([^\"\n])*\" {yylval.text = strdup(yytext); debug(yylval.text); return T_String;}
\'([^\'\n])*\' {yylval.text = strdup(yytext); debug(yylval.text); return T_String;}
"#"([a-z]|[0-9]|[A-Z]|" ")* {}
{whitespace} {}
"\n" {yycolumn=1; debug("NL"); return T_NL;}
<<EOF>> {debug("EOF"); return T_EndOfFile;}
```

IMPLEMENTATION DETAILS

The Symbol table uses two Structures,

```
typedef struct record
{
        char *type;
        char *name;
        int decLineNo;
        int lastUseLine;
} record;
typedef struct STable
{
        int no;
        int noOfElems;
        int scope;
        record *Elements;
        int Parent;
} STable;
```

The “record” structure represents each record in the symbol table. Each symbol table can contain a maximum of “MAXRECST” records, MAXRECST is a macro.

The “STable” structure represents one symbol table. A new Symbol table is made for every scope. A Maximum of “MAXST” symbol tables and hence scopes can exist, MAXST is a macro.

The Abstract Syntax Tree uses one structure,

```
typedef struct ASTNode
    {
        int nodeNo;
        /*Operator*/
```

```
        char *NType;
        int noOps;
        struct ASTNode** NextLevel;
        /*Identifier or Const*/
        record *id;
    } node;
```

This ASTNode structure takes care of both leaf nodes as well as Internal "Operator" Nodes. The respective values are set depending upon the type of node. Each node can have 0-3 children. We print the AST by first storing it in a Matrix of Order "MAXLEVELS" x "MAXCHILDREN" and printing the matrix Levelwise. This Matrix, is a matrix of pointers to the AST. The "noOps" element of the Node gives the number of children of that node.

The Three-Address Code is represented and stored as Quads that are given by the Structutre,

```
typedef struct Quad
    {
        char *R;
        char *A1;
        char *A2;
        char *Op;
        int I;
    } Quad;
```

The last element, the integer 'I', is used during code optimization. All the Three-Address codes are stored as Quads in an array of Quads. There can be a maximum of "MAXQUADS" quadruples.

For the dead code elimination we continously loop through the code till no more code can be eliminated. To check if a quadruple represnts dead code we see if the result parameter/element of that quad appears as any arguments to any other subsequent quads which have not been eliminated, If not, we consider that quad to represent dead code and mark the element 'I' with the value "-1".

The scope checking is handled by recursively stepping through enclosing scopes and finding the most recent definition of the variable. If no definition is found, we print the error.

Lastly, To compile the code and execute the code we have provided a makefile.

If you wish to only see the AST,

```
lex grammar.l
yacc -dv grammarAST.y
gcc lex.yy.c y.tab.c -g -ll -o TestAST.out
./TestAST.out < InputFile.txt
```

If you wish to only see the Intermediate code and Optimization

```
lex grammar.l
yacc -dv grammarICG.y
gcc lex.yy.c y.tab.c -g -ll -o TestICG.out
./TestICG.out < InputFile.txt
```

The makefile provided comipiles the “grammar.y” file and prints everything.
./Test.out < Input.txt

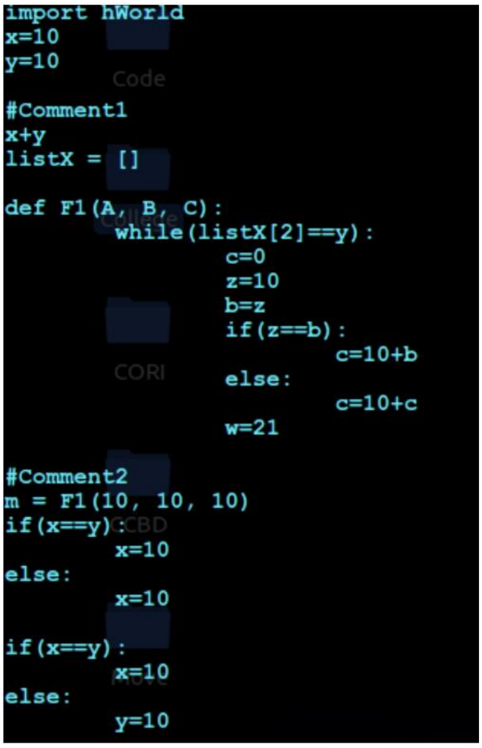
RESULTS AND SHORTCOMINGS

The result achieved is that we have a mini compiler which parses grammar corresponding to basic python syntax and generates finally, an optimized intermediate representation.

The areas where our mini compiler falls short are,

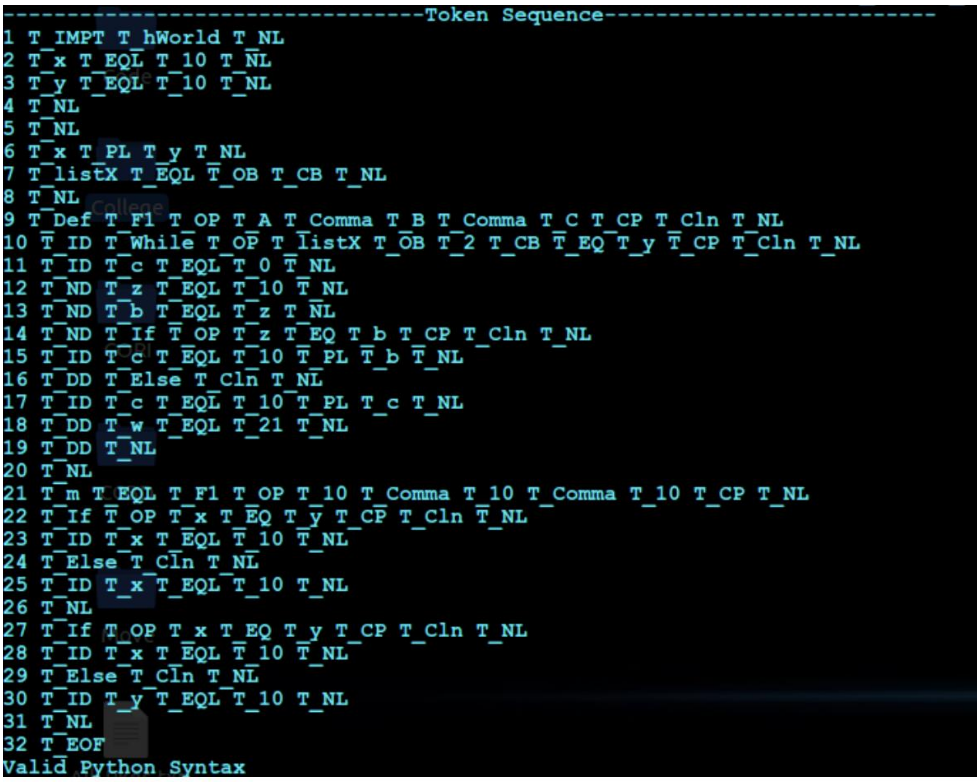
- Doesn’t handle semi colon.
- Only one very basic optimization is implemented that does not reduce code density by a huge margin.
- The Program has a few memory leaks, although mast of them have been taken care of.

SNAPSHOTS



```
import hWorld
x=10
y=10

#Comment1
x+y
listX = []

def F1(A, B, C):
        while(listX[2]==y):
                c=0
                z=10
                b=z
                if(z==b):
                        c=10+b
                else:
                        c=10+c
                w=21

#Comment2
m = F1(10, 10, 10)
if(x==y):
        x=10
else:
        x=10

if(x==y):
        x=10
else:
        y=10
```

Token Sequence



```
--------------------------------Token Sequence--------------------------
1 T_IMPT T_hWorld T_NL
2 T_x T_EQL T_10 T_NL
3 T_y T_EQL T_10 T_NL
4 T_NL
5 T_NL
6 T_x T_PL T_y T_NL
7 T_listX T_EQL T_OB T_CB T_NL
8 T_NL
9 T_Def T_F1 T_OP T_A T_Comma T_B T_Comma T_C T_CP T_Cln T_NL
10 T_ID T_While T_OP T_listX T_OB T_2 T_CB T_EQ T_y T_CP T_Cln T_NL
11 T_ID T_c T_EQL T_0 T_NL
12 T_ND T_z T_EQL T_10 T_NL
13 T_ND T_b T_EQL T_z T_NL
14 T_ND T_If T_OP T_z T_EQ T_b T_CP T_Cln T_NL
15 T_ID T_c T_EQL T_10 T_PL T_b T_NL
16 T_DD T_Else T_Cln T_NL
17 T_ID T_c T_EQL T_10 T_PL T_c T_NL
18 T_DD T_w T_EQL T_21 T_NL
19 T_DD T_NL
20 T_NL
21 T_m T_EQL T_F1 T_OP T_10 T_Comma T_10 T_Comma T_10 T_CP T_NL
22 T_If T_OP T_x T_EQ T_y T_CP T_Cln T_NL
23 T_ID T_x T_EQL T_10 T_NL
24 T_Else T_Cln T_NL
25 T_ID T_x T_EQL T_10 T_NL
26 T_NL
27 T_If T_OP T_x T_EQ T_y T_CP T_Cln T_NL
28 T_ID T_x T_EQL T_10 T_NL
29 T_Else T_Cln T_NL
30 T_ID T_y T_EQL T_10 T_NL
31 T_NL
32 T_EOF
Valid Python Syntax
```

Abstract Syntax Tree

```
------------------------Abstract Syntax Tree-------------------------
NewLine(2)
import(1) NewLine(2)
hWorld  =(2) NewLine(2)
      x  10  =(2) NewLine(2)
         y  10  +(2) NewLine(2)
            x  y  listX  NewLine(2)
                   Func_Name(3) NewLine(2)
                   F1  Ā, B, C  BeginBlock(2) =(2) NewLine(2)
                            While(2) EndBlock  m  Func_Call(2) If(3) If(3)
                                     ==(2) BeginBlock(2̄) F1  10, 10, 10  ==(2) BeginBlock(2) Else(1) ==(2) BeginBlock(2) Else(1)
                                                 ListIndex(2) y  =(2) Next(2) x  y  =(2) EndBlock  BeginBlock(2) x  y  =(2) EndBlock  BeginBlock(2)
                                                                    listX  2  c  0  =(2) Next(2) x  10  =(2) EndBlock  x  10  =(2) EndBlock
                                                                                             z  10  =(2) Next(2) x  10  y  10
                                                                                                      b  z  If(3) EndBlock
                                                                                                                 ==(2) BeginBlock(2) Else(1)
                                                                                                                 z  b  =(2) EndBlock  BeginBlock(2)
                                                                                                                           c  +(2) =(2) EndBlock(1)
                                                                                                                            10  b  c  +(2) =(2)
                                                                                                                                10  c  w  21
```

Intermediate Code

```
import hWorld
T2 = 10
x = T2
T5 = 10
y = T5
T8 = x
T9 = y
T10 = T8 + T9
Begin Function F1
T15 = listX[2]
T16 = y
T17 = T15 == T16
L0: If False T17 goto L1
T18 = 0
c = T18
T21 = 10
z = T21
T24 = z
b = T24
T27 = z
T28 = b
T29 = T27 == T28
If False T29 goto L2
T30 = 10
T31 = b
T32 = T30 + T31
c = T32
goto L3
L2: T37 = 10
T38 = c
T39 = T37 + T38
c = T39
T42 = 21
w = T42
L3: goto L0
L1: End Function F1
Push Param 10
Push Param  10
Push Param  10
(T63)Call Function F1, 3
Pop Params for Function F1, 3
m = T63
T66 = x
T67 = y
T68 = T66 == T67
If False T68 goto L6
T69 = 10
x = T69
goto L7
L6: T74 = 10
x = T74
L7: T81 = x
T82 = y
T83 = T81 == T82
If False T83 goto L8
T84 = 10
x = T84
goto L9
L8: T89 = 10
y = T89
```

```
------------------------------All Quads--------------------------------
0       import  hWorld  -       -
1       =       10      -       T2
2       =       T2      -       x
3       =       10      -       T5
4       =       T5      -       y
5       =       x       -       T8
6       =       y       -       T9
7       +       T8      T9      T10
8       BeginF  F1      -       -
9       =[]     listX   2       T15
10      =       y       -       T16
11      ==      T15     T16     T17
12      Label   -       -       L0
13      If False        T17     -       L1
14      =       0       -       T18
15      =       T18     -       c
16      =       10      -       T21
17      =       T21     -       z
18      =       z       -       T24
19      =       T24     -       b
20      =       z       -       T27
21      =       b       -       T28
22      ==      T27     T28     T29
23      If False        T29     -       L2
24      =       10      -       T30
25      =       b       -       T31
26      +       T30     T31     T32
27      =       T32     -       c
28      goto    -       -       L3
29      Label   -       -       L2
30      =       10      -       T37
31      =       c       -       T38
32      +       T37     T38     T39
33      =       T39     -       c
34      =       21      -       T42
35      =       T42     -       w
36      Label   -       -       L3
37      goto    -       -       L0
38      Label   -       -       L1
39      EndF    F1      -       -
40      Param   10      -       -
41      Param    10     -       -
42      Param    10     -       -
43      Call    F1      3       T63
44      =       T63     -       m
45      =       x       -       T66
46      =       y       -       T67
47      ==      T66     T67     T68
48      If False        T68     -       L6
49      =       10      -       T69
50      =       T69     -       x
51      goto    -       -       L7
52      Label   -       -       L6
53      =       10      -       T74
54      =       T74     -       x
55      Label   -       -       L7
56      =       x       -       T81
57      =       y       -       T82
58      ==      T81     T82     T83
59      If False        T83     -       L8
60      =       10      -       T84
61      =       T84     -       x
62      goto    -       -       L9
63      Label   -       -       L8
64      =       10      -       T89
65      =       T89     -       y
66      Label   -       -       L9
-----------------------------------------------------------------------
```

Optimized Code (Quads Removed)

```
--------------------------------All Quads------------------------------
0        import   hWorld   -        -
1        =        10       -        T2
2        =        T2       -        x
3        =        10       -        T5
4        =        T5       -        y
8        BeginF   F1       -        -
9        =[]      listX    2        T15
10       =        y        -        T16
11       ==       T15      T16      T17
12       Label    -        -        L0
13       If False          T17      -        L1
14       =        0        -        T18
15       =        T18      -        c
16       =        10       -        T21
17       =        T21      -        z
18       =        z        -        T24
19       =        T24      -        b
20       =        z        -        T27
21       =        b        -        T28
22       ==       T27      T28      T29
23       If False          T29      -        L2
24       =        10       -        T30
25       =        b        -        T31
26       +        T30      T31      T32
27       =        T32      -        c
28       goto     -        -        L3
29       Label    -        -        L2
30       =        10       -        T37
31       =        c        -        T38
32       +        T37      T38      T39
33       =        T39      -        c
36       Label    -        -        L3
37       goto     -        -        L0
38       Label    -        -        L1
39       EndF     F1       -        -
40       Param    10       -        -
41       Param     10      -        -
42       Param     10      -        -
43       Call     F1       3        T63
45       =        x        -        T66
46       =        y        -        T67
47       ==       T66      T67      T68
48       If False          T68      -        L6
49       =        10       -        T69
50       =        T69      -        x
51       goto     -        -        L7
52       Label    -        -        L6
53       =        10       -        T74
54       =        T74      -        x
55       Label    -        -        L7
56       =        x        -        T81
57       =        y        -        T82
58       ==       T81      T82      T83
59       If False          T83      -        L8
60       =        10       -        T84
61       =        T84      -        x
62       goto     -        -        L9
63       Label    -        -        L8
64       =        10       -        T89
65       =        T89      -        y
66       Label    -        -        L9
-----------------------------------------------------------------------
```

All Symbol Tables

```
----------------------------All Symbol Tables----------------------------
Scope    Name     Type            Declaration     Last Used Line
(0, 1)   hWorld   PackageName     1               1
(0, 1)   10       Constant        2               3
(0, 1)   x        Identifier      2               27
(0, 1)   y        Identifier      3               27
(0, 1)   listX    ListTypeID      7               10
(0, 1)   F1       Func_Name       9               9
(0, 1)   T2       ICGTempVar      -1              -1
(0, 1)   T5       ICGTempVar      -1              -1
(0, 1)   T8       ICGTempVar      -1              -1
(0, 1)   T9       ICGTempVar      -1              -1
(0, 1)   T10      ICGTempVar      -1              -1
(0, 1)   T15      ICGTempVar      -1              -1
(0, 1)   T16      ICGTempVar      -1              -1
(0, 1)   T17      ICGTempVar      -1              -1
(0, 1)   L0       ICGTempLabel    -1              -1
(0, 1)   L1       ICGTempLabel    -1              -1
(0, 1)   T18      ICGTempVar      -1              -1
(0, 1)   T21      ICGTempVar      -1              -1
(0, 1)   T24      ICGTempVar      -1              -1
(0, 1)   T27      ICGTempVar      -1              -1
(0, 1)   T28      ICGTempVar      -1              -1
(0, 1)   T29      ICGTempVar      -1              -1
(0, 1)   L2       ICGTempLabel    -1              -1
(0, 1)   T30      ICGTempVar      -1              -1
(0, 1)   T31      ICGTempVar      -1              -1
(0, 1)   T32      ICGTempVar      -1              -1
(0, 1)   L3       ICGTempLabel    -1              -1
(0, 1)   T37      ICGTempVar      -1              -1
(0, 1)   T38      ICGTempVar      -1              -1
(0, 1)   T39      ICGTempVar      -1              -1
(0, 1)   T42      ICGTempVar      -1              -1
(0, 1)   T63      ICGTempVar      -1              -1
(0, 1)   T66      ICGTempVar      -1              -1
(0, 1)   T67      ICGTempVar      -1              -1
(0, 1)   T68      ICGTempVar      -1              -1
(0, 1)   L6       ICGTempLabel    -1              -1
(0, 1)   T69      ICGTempVar      -1              -1
(0, 1)   L7       ICGTempLabel    -1              -1
(0, 1)   T74      ICGTempVar      -1              -1
(0, 1)   T81      ICGTempVar      -1              -1
(0, 1)   T82      ICGTempVar      -1              -1
(0, 1)   T83      ICGTempVar      -1              -1
(0, 1)   L8       ICGTempLabel    -1              -1
(0, 1)   T84      ICGTempVar      -1              -1
(0, 1)   L9       ICGTempLabel    -1              -1
(0, 1)   T89      ICGTempVar      -1              -1
(0, 2)   2        Constant        10              10
(0, 2)   10       Constant        21              21
(0, 2)   m        Identifier      21              21
(1, 3)   0        Constant        11              11
(1, 3)   c        Identifier      11              11
(1, 3)   10       Constant        12              12
(1, 3)   z        Identifier      12              14
(1, 3)   b        Identifier      13              15
(1, 3)   21       Constant        18              18
(1, 3)   w        Identifier      18              18
(2, 4)   10       Constant        15              15
(2, 4)   c        Identifier      15              17
(2, 16)  10       Constant        17              17
(2, 16)  c        Identifier      17              17
(1, 4)   10       Constant        23              23
(1, 4)   x        Identifier      23              23
(1, 8)   10       Constant        25              25
(1, 8)   x        Identifier      25              25
(1, 16)  10       Constant        28              28
(1, 16)  x        Identifier      28              28
(1, 32)  10       Constant        30              30
(1, 32)  y        Identifier      30              30
```

CONCLUSION

In Conclusion, A Compiler for Python was implemented. In addition to the constructs specified, the basic python constructs were implemented and function definitions and calls were supported.

The compiler also reports the basic errors and gives the line number and column number.

The Intermediate code was represented by quads which was later optimized to remove dead code.

FURTHER ENHANCEMENTS

The Compiler can be further enhanced by adding,

- Support for ‘For’ Loops
- Better Memory Management
- More efficient optimization techniques
- Semantic analysis for Parameter Matching
- Error Recovery