Fr. Conceicao Rodrigues College of Engineering
Department of Computer Engineering

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Class : T.E. (Computer - A)
Subject Name : System Programming and Compiler Construction
Subject Code : (CPC601)

Practical No:	3
Title:	To generate an Intermediate code.
Date of Performance:	25/02/2025
Date of Submission:	21/03/2025
Roll No:	9913
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Evaluation:

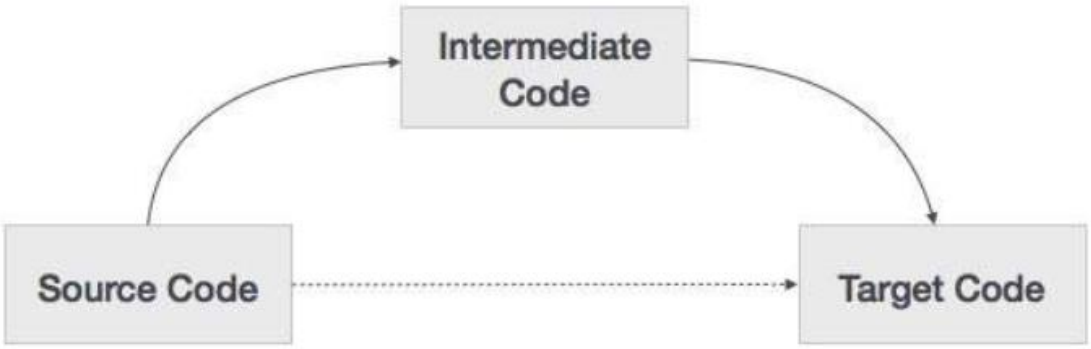
Sr. No	Rubric	Grade
1	Time Line (2)	
2	Output(3)	
3	Code optimization (2)	
4	Postlab (3)	

Signature of the Teacher :

Experiment No 3

Aim : To generate an Intermediate code.

Description:



- If a compiler translates the source language to its target machine language without having the option for generating intermediate code, then for each new machine, a full native compiler is required.
- Intermediate code eliminates the need of a new full compiler for every unique machine by keeping the analysis portion same for all the compilers.
- The second part of compiler, synthesis, is changed according to the target machine.
- It becomes easier to apply the source code modifications to improve code performance by applying code optimization techniques on the intermediate code.

- ## Three-Address Code

  Intermediate code generator receives input from its predecessor phase, semantic analyzer, in the form of an annotated syntax tree. That syntax tree then can be converted into a linear representation, e.g., postfix notation. Intermediate code tends to be machine independent code. Therefore, code generator assumes to have unlimited number of memory storage (register) to generate code.
- For example:

```
a = b + c * d;
```

- The intermediate code generator will try to divide this expression into sub-expressions and then generate the corresponding code.

```
r1 = c * d;
r2 = b + r1;
a = r2
```

- r being used as registers in the target program.
- A three-address code has at most three address locations to calculate the expression. A three-address code can be represented in two forms : quadruples and triples.

Quadruples

Each instruction in quadruples presentation is divided into four fields: operator, arg1, arg2, and result. The above example is represented below in quadruples format:

Op	arg_1	arg_2	result
*	c	d	r1
+	b	r1	r2
+	r2	r1	r3
=	r3		a

Triples

Each instruction in triples presentation has three fields : op, arg1, and arg2.The results of respective sub-expressions are denoted by the position of expression. Triples represent similarity with DAG and syntax tree. They are equivalent to DAG while representing expressions.

Op	arg_1	arg_2
*	c	d
+	b	(0)
+	(1)	(0)
=	(2)	

Triples face the problem of code immovability while optimization, as the results are positional and changing the order or position of an expression may cause problems.

Indirect Triples

This representation is an enhancement over triples representation. It uses pointers instead of position to store results. This enables the optimizers to freely re-position the sub-expression to produce an optimized code.

CODE:

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <ctype.h>

#define MAX_LEN 100

typedef enum { ID, NUM, PLUS, MINUS, MULT, DIV, ASSIGN, LBRACKET, RBRACKET, LPAREN, RPAREN, END, ERROR } TokenType;

typedef struct {
    TokenType type;
    char lexeme[MAX_LEN];
} Token;

typedef struct {
    char op[10], arg1[MAX_LEN], arg2[MAX_LEN], result[MAX_LEN];
} Quadruple;

typedef struct {
    char op[10], arg1[MAX_LEN], arg2[MAX_LEN];
} Triple;

char *input;
int pos = 0, tempVar = 0, quadIdx = 0, tripleIdx = 0;
Token token;
Quadruple quads[MAX_LEN];
Triple triples[MAX_LEN];

char* create_temp() {
    char* temp = (char*)malloc(10);
    sprintf(temp, "t%d", tempVar++);
```

```
    return temp;
}

void fetch_token() {
    while (input[pos] && isspace(input[pos])) pos++;
    if (!input[pos]) { token.type = END; strcpy(token.lexeme, "EOF"); return; }

    if (isalpha(input[pos])) {
        int i = 0;
        while (isalnum(input[pos])) token.lexeme[i++] = input[pos++];
        token.lexeme[i] = '\0';
        token.type = ID;
    } else if (isdigit(input[pos])) {
        int i = 0;
        while (isdigit(input[pos])) token.lexeme[i++] = input[pos++];
        token.lexeme[i] = '\0';
        token.type = NUM;
    } else {
        switch (input[pos++]) {
            case '+': token.type = PLUS; strcpy(token.lexeme, "+"); break;
            case '-': token.type = MINUS; strcpy(token.lexeme, "-"); break;
            case '*': token.type = MULT; strcpy(token.lexeme, "*"); break;
            case '/': token.type = DIV; strcpy(token.lexeme, "/"); break;
            case '=': token.type = ASSIGN; strcpy(token.lexeme, "="); break;
            case '[': token.type = LBRACKET; strcpy(token.lexeme, "["); break;
            case ']': token.type = RBRACKET; strcpy(token.lexeme, "]"); break;
            case '(': token.type = LPAREN; strcpy(token.lexeme, "("); break;
            case ')': token.type = RPAREN; strcpy(token.lexeme, ")"); break;
             default: token.type = ERROR; token.lexeme[0] = input[pos - 1]; token.lexeme[1] =
'\0';
        }
    }
}
```

```
void generate_quad(char* op, char* arg1, char* arg2, char* result) {
    strcpy(quads[quadIdx].op, op);
    strcpy(quads[quadIdx].arg1, arg1);
    strcpy(quads[quadIdx].arg2, arg2);
    strcpy(quads[quadIdx].result, result);
    quadIdx++;
}

void generate_triple(char* op, char* arg1, char* arg2) {
    strcpy(triples[tripleIdx].op, op);
    strcpy(triples[tripleIdx].arg1, arg1);
    strcpy(triples[tripleIdx].arg2, arg2);
    tripleIdx++;
}

char* parse_expression();

char* parse_factor() {
    char *res;
    if (token.type == ID) {
        res = strdup(token.lexeme);
        fetch_token();
        if (token.type == LBRACKET) {
            fetch_token();
            char* index = parse_expression();
            if (token.type != RBRACKET) { printf("Syntax Error: Expected ']'\n"); exit(1); }
            fetch_token();
            char* temp = create_temp();
            generate_quad("[]", res, index, temp);
            generate_triple("[]", res, index);
            free(res);
            free(index);
```

```
            return temp;
        }
        return res;
    } else if (token.type == NUM) {
        res = strdup(token.lexeme);
        fetch_token();
        return res;
    } else if (token.type == LPAREN) {
        fetch_token();
        res = parse_expression();
        if (token.type != RPAREN) { printf("Syntax Error: Expected ')'\n"); exit(1); }
        fetch_token();
        return res;
    }
    printf("Syntax Error: Unexpected token %s\n", token.lexeme);
    exit(1);
}

char* parse_term() {
    char* left = parse_factor();
    while (token.type == MULT || token.type == DIV) {
        TokenType op = token.type;
        fetch_token();
        char* right = parse_factor();
        char* temp = create_temp();
        generate_quad(op == MULT ? "*" : "/", left, right, temp);
        generate_triple(op == MULT ? "*" : "/", left, right);
        free(left);
        free(right);
        left = temp;
    }
    return left;
}
```

```
char* parse_expression() {
    char* left = parse_term();
    while (token.type == PLUS || token.type == MINUS) {
        TokenType op = token.type;
        fetch_token();
        char* right = parse_term();
        char* temp = create_temp();
        generate_quad(op == PLUS ? "+" : "-", left, right, temp);
        generate_triple(op == PLUS ? "+" : "-", left, right);
        free(left);
        free(right);
        left = temp;
    }
    return left;
}

int main() {
    char buffer[MAX_LEN];
    printf("Enter an arithmetic expression: ");
    fgets(buffer, sizeof(buffer), stdin);
    buffer[strcspn(buffer, "\n")] = '\0';
    input = buffer;
    pos = tempVar = quadIdx = tripleIdx = 0;

    fetch_token();
    char* left = parse_factor();
    if (token.type != ASSIGN) { printf("Syntax Error: Expected '='\n"); exit(1); }
    fetch_token();
    char* right = parse_expression();
    generate_quad("=", right, "", left);
    generate_triple("=", right, "");
    free(left);
```

```
    free(right);

    printf("\nThree-Address Code:\n");
    for (int i = 0; i < quadIdx; i++) {
        printf("%s = %s %s %s\n", quads[i].result, quads[i].arg1, quads[i].op, quads[i].arg2);
    }

    printf("\nTriples:\n");
    printf("| Index | Op  | Arg1  | Arg2  |\n");
    printf("|-------|-----|-------|-------|\n");
    for (int i = 0; i < tripleIdx; i++) {
        printf("| %5d | %-3s | %-5s | %-5s |\n", i, triples[i].op, triples[i].arg1, triples[i].arg2);
    }

    printf("\nQuadruples:\n");
    printf("| Index | Op  | Arg1  | Arg2  | Result |\n");
    printf("|-------|-----|-------|-------|--------|\n");
    for (int i = 0; i < quadIdx; i++) {
        printf("| %5d | %-3s | %-5s | %-5s | %-6s |\n", i, quads[i].op, quads[i].arg1, quads[i].arg2,
quads[i].result);
    }

    return 1;
}
```

OUTPUT:

```
PS C:\Users\Mark Lopes\Desktop\college\Sem_6\spcc\exp_3> .\a.exe
Enter an arithmetic expression: a = b+3*c

Three-Address Code:
t0 = 3 * c
t1 = b + t0
a = t1 =

Quadruples:
| Index | Op  | Arg1  | Arg2  | Result |
|-------|-----|-------|-------|--------|
|     0 | *   | 3     | c     | t0     |
|     1 | +   | b     | t0    | t1     |
|     2 | =   | t1    |       | a      |

Triples:
| Index | Op  | Arg1  | Arg2  |
|-------|-----|-------|-------|
|     0 | *   | 3     | c     |
|     1 | +   | b     | t0    |
|     2 | =   | t1    |       |
PS C:\Users\Mark Lopes\Desktop\college\Sem_6\spcc\exp_3>
```

Post Lab Question

1. **Write the intermediate code generated for ----**

   while (a<b) do

   If (c< d) then

   X= y+z

   Else

   X= y-z

2. **Write the intermediate code generated for ----**

   switch E

   Begin

   case V_1 : S_1

   case V_2 : S_2

   ….

   default: S_n

   end

SPCC Postlab 3

Q.1

```
L1: if a>b goto L4
L2: if c>ed goto L3
        t1 = y+3
        x = t1
        goto L5
L3      t2 = y-3
        x = t2
L5: goto L4
L4: exit
```

Q.2

~~L1=~~

```
if t1 == v1 goto L1
if t2 == v2 goto L2

goto L1
L1: S1
    goto Lend
L2: S2
    goto Lend
... (remaining cases)
Ld: Sn

Lend: exit
```