CD 12 marks ct3

Compiler Design (SRM Institute of Science and Technology)

UNIT-4

PART-C

1. What is three Address code? what is its type? how is it implemented?

(c) Intermediate Code Representation:

In the analysis - synthesis model of a comp. the front-end of a compiler translates a source program into an independent intermediate code. then the back-end of the compiler uses this I.C to generate the target code.

Three Address code: (Seq. of 3 Address Statement)

→ Statement involving more than 3 references (2 operands, 1 results)

⇒ $x = y$ op. z x, y, z → will have address (memory location)

→ Sometimes less than 3 references called as 3-Address code.

Representation of 3 Add. code.
- → Quadruples
- → triples
- → indirect triples

Eg: $a + b * c + d$ → 3. Add. code form of IC

temporary variables
$T_1 = b * c$
$T_2 = a + T_1$
$T_3 = T_2 + d$

→ generated by compiler for implementing code optimization

→ 3 A.C to represent any statement

Quadruples

each instructions into 4 diff fields

→ op. arg1, arg2, result.

→ internal code of the operator

→ Storing 2 operands

Storing result.

Triples

Representation

→ References to instructions are made

→ Temporary variables of not used.

Indirect triples.

→ enhancement over triples Representation

→ Additional instructions, to point the pointer to triples

→ uses optimizers to easily re-position to optimized code.

Eg: $a + b \times c / e \uparrow f + b \times a$.

$T_1 = e \uparrow f$
$T_2 = b \times c$
$T_3 = T_2 / T_1$
$T_4 = b \times a$
$T_5 = a + T_3$
$T_6 = T_5 + T_4$

Char:

→ generated by compiler for implementing code optimization

→ 3 Addresses to represent

→ implemented as a record with Add. field.

2. Using Backpatching, generate an intermediate code for A < B OR C < D AND P < Q

→ Backpatching process of fulfilling unspecified info.

→ It uses semantic actions during the process of code generation

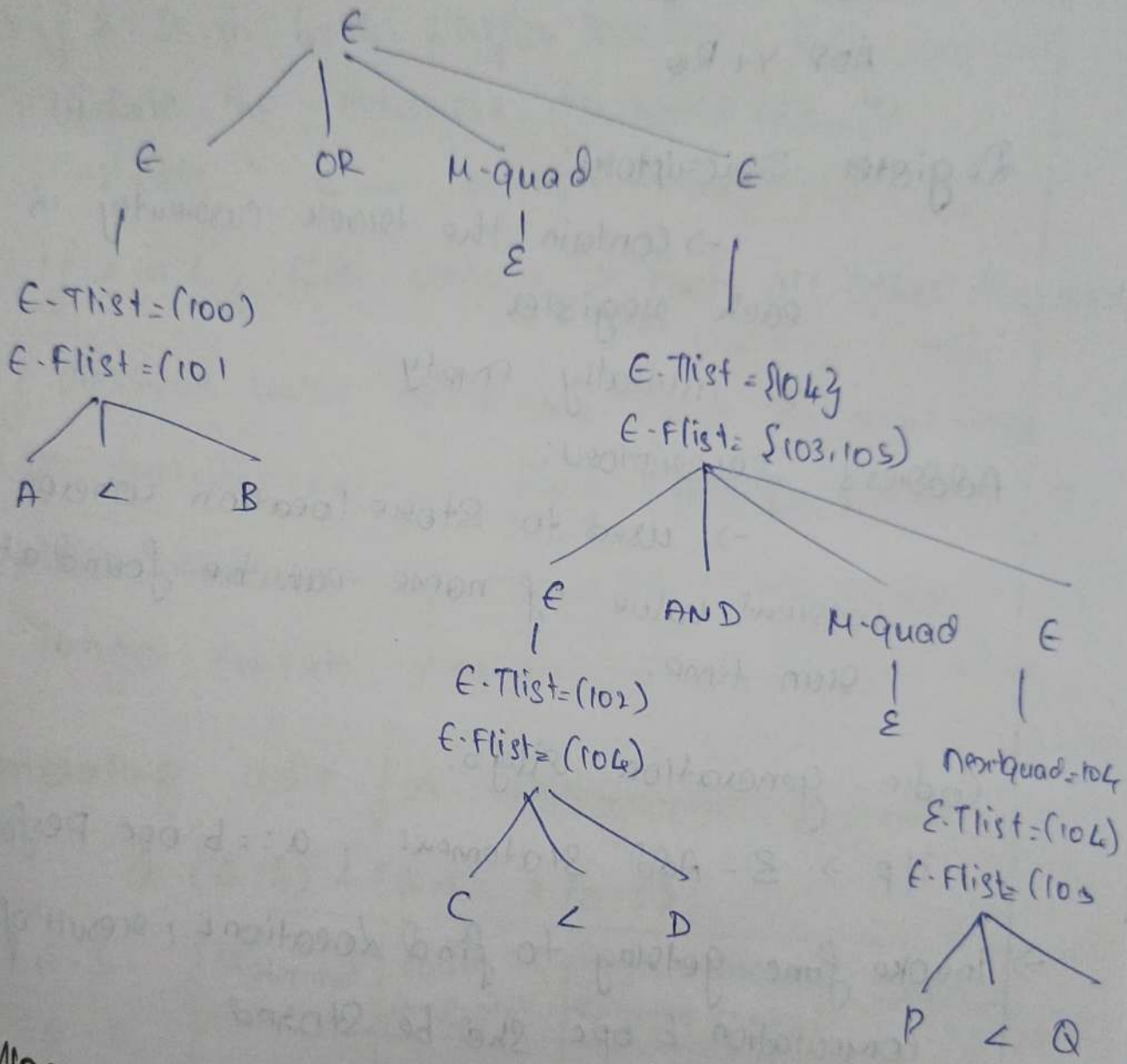
Steps: 1) generation of the production table

2) we have to find the TAC (Three-A-C) for the gn by backpatching

A < B OR C < D AND P < Q

100	if A < B goto 106	Backpatch (E1.Flist, 102
101	goto 102	E.Tlist = {100, 104}
102	if C < D goto 104	E.Flist = {103, 105}
103	goto 107	
104	OR if P < Q goto 106	Backpatch (E1.Tlist, 104)
105	goto 107	AND M.quad = next quad
		E.Tlist := {104}
106 :	(true)	E.Flist = {103, 105}
107 :	(false)	

3) Make parse tree for ~~[illegible]~~ exp.



3. ~~[illegible]~~ Algo in code generation with eg:

Code generator: Converts the intermediate representation of source code into a form that can be readily executed by machine

Eg:

MOV X, R0

ADD Y, R0

Register Descriptors:

→ Contain the track currently in each register

→ initialy empty.

Address Descriptors:

→ used to store location where current value of name can be found at run time.

Code-generation Algo.

i/p → 3-Add statement, a := b opc performs Ad

→ invoke func. getreg to find location L, result of computation b opc shd be stored

→ Address description for y to determine y'.

→ if value of y in memory & prefer register y'

→ if not, generate instruction MOV y', L to place a copy of y in L.

→ generate OP z', L, z' → current location.

→ if z is in both prefer location, then update the Address descriptor of x to indicate x is in location L.

→ if x in L, then remove x from all other descriptor

→ if current value of y or z have no next uses or not live on exit from the block

→ After execution of x := y op z those no longer contain y or z

generating code for Assignment Statement

d: (a-b) + (a-c) + (a-c)

3-A-Co

t := a - b

u := a - c

v := t + u

d := v + u

Statement	Code generated	Register Discriptor register empty	Address descriptor
t := a-b	MOV a, R0 SUB b, R0	R0 contain t	t in R0
u := a-c	MOV a, R1 SUB c, R1	R0 contains t R1 contains u	t in R0 u in R1
v := t+u	ADD R1, R0	R0 contains u R1 contains u	v in R1 u in R1
d := v+u	ADD R1, R0 MOV R0, d	R0 contains d	d in R0 d in R0 & memory

D: (a - b) * (a - c) + (a - c)

t1 := a - b	t1 := a - b	t1 := a - b
t2 := a - c	t2 := a - c	t2 := a - c
t3 := t1 * t2	t3 := t1 * t2	t3 := t1 * t2
t4 := a - c		t4 := t2
D := t3 + t4		D := t3 + t4

4. Various methods for translating Boolean exp.

→ Boolean exp have 2 primary purposes

→ Compute logical values (but conditional exp)

→ Composed of boolean operators.

Methods:

2 principal methods.

→ To encode T & F numerically & to evaluate a boolean exp to an arithmetic.

→ 1 - T , 0 - F

→ Implementing boolean exp in flow-control statements

⇒ Numerical representation.

Expression evaluate from L to R. as arith. exp.

Eg: a or b and not c → (TAC)

t1 := not c

t2 := b and t1

t3 := a or t2

Relational exp :- if a<b then 1 else 0.

100: if a<b goto 103 101: t := 0

102: goto 104

103: t := 1

104:

⇒ Short circuit code:

→ can convert boolean to TAC without generating code for any of the boolean op.

→ AKA short circuit / jumping code.

→ can evaluate bool. exp without code.

a<b or c<d and e<f.

100: if a < b goto

103 101: t1 := 0

102: goto 104 103: t1 := 1

104: if c < d goto

107 105: t2 := 0

106: goto 108

107: t2 := 1

108: if e < f goto 111 109: t3 := 0

110: goto 112

111: t3 := 1

112: t4 := t2 & t3

113: t5 := t1 or t4

⇒ flow-of control statements:

translation of bool. to TAC in context of if, if-then-else, while.

S → if E then S_1

| if E then S_2 else S_2

| while E do S_1

E → Boolean exp to be translated

S → allows control to flow

S.next → translation after S.code.

PART-C UNIT 5

Source code → [Frontend] → [Intermediate code] → [code generation] → target code

1. Optimization tech:

4m/12

→ Eliminating the unwanted code lines

→ Rearranging the statement of code.

Ad:

Optimized code ⇒ faster execution speed, memory efficiency, better performance.

*Compile time evaluation: Shifting of computations from runtime to compile time

↳ folding: Computation of constant is done at compile time instead of execution time.

$L = (22/7) * 2.$

↳ Const Propagation: value of the variable is replaced.

$Pi = 2.14$, $r = 15$ $Pi * r_1 \times r_2$.

*Loop-invariant Computation

→ Moving some part of code outside the loop & placing it just before entering in loop.

Eg: while (i <= max-1)
{
sum = sum + a[i];
}

=> n = max - 1;
while (i <= n)
{ sum = sum + a[i];
}

* Strength reduction:

-> the strength of certain operator is higher (i.e * than +) if higher replaced by lower

Eg. for (i=1; i<=50; i++)
{...
count = i * 7;
...
}

=> temp = 7;
for (i=1; i<=50; i++)
{...
count = temp;
temp = temp + 7;
}

* Dead code elimination:

a value is said to be dead, if the value contained init is never been seen

Ex: i = j
...
x = i ± 10;
...

=> i = 0;
if (i = 1)
{ a = x + 5;
}

* Common Subexpression elimination:

→ appearing repeatedly in the prog. which is computed previously.

```
t1 = 4 * i                    t1 = 4 * i
t2 = n[t1]                    t2 = n[t1]
t3 = 4 * j          =>        t3 = 4 * j
t4 = 4 * i                    t5 = n;
t5 = n;                       t6 = b[t1] + t5
t6 = b[t4] + t5
```

* Copy propagation:

→ Used of one variable instead of another

Eg: x = Pi

. . .

area = x * r * r;

→ area = Pi * r * r.

* Code Movement.

→ reduce the size of code & frequency of execution of code. to obtain time complexity.

Eg:
```
for (i=0 ; i<=10 ; i++)
{ x = y * 5,
. . .
k = (y * 5) + 50;
}
```

=>

```
z = y * 5
for (i=0; i<=10; i++)
{ x = z;
. . .
k = z + 50;
}
```

* Loop Optimization:

→ code optimization performed on inner loop

→ code Motion, unrolling, fusion.

→ loop invariant method

→ induction variable & strength reduction.

Data flow Analysis: 4m

→ flow of Data in Control flow graph.

→ With the help of Analysis, optimization can be done.

→ tech how Data flows through Prog.

Types:

→ Reaching Definitions Analysis:

→ the pt in prog where Definition reaches the particular use of variable / exp

→ Live variable Analysis:

→ value for some future computation

→ Available expression Analysis:

value has been computed & reused.

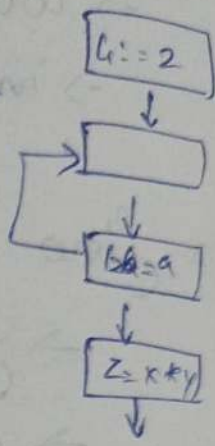
→ Const propagation Analysis:

→ tracks the particular value is const.

Ad: improved code quality.
Better error Detection.
increased understanding of prog. Behaviour

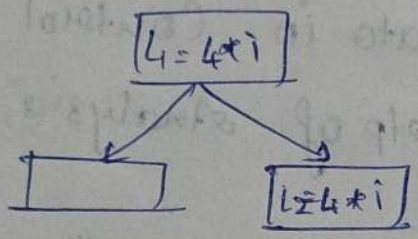
Basic terminologies.

Definition pt, evaluation pt, reference pt.



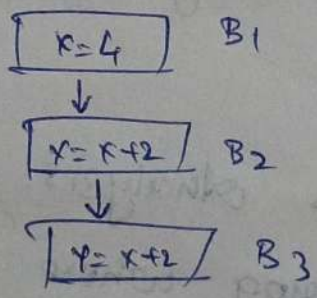
Data flow properties

* Available exp:

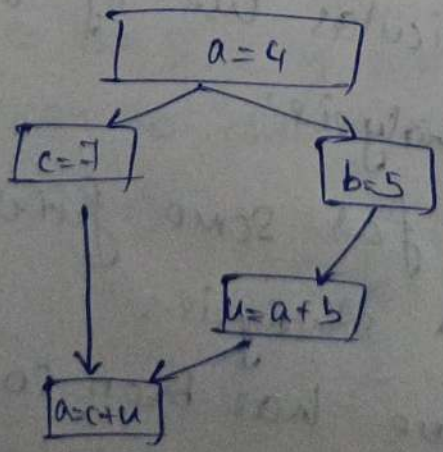


E.P

* Reaching Definition



* Live Variable



* Busy Exp:

busy along a path if its evaluation exist along the path.

Peephole optimization :- 4m

→ type of code optimization performed on a small part of code.

→ small set of instructions in a segment of code

⇒ objectives

↳ to improve performance, memory footprint, code size

⇒ optimization tech.

* Redundant load & store elimination.
  ↳ redundancy elimination.

```
y = x + 5          y = x + 5;
i = y        =>    w = i * 3;
z = i
w = z * 3
```

* Const folding: → simplified by users itself.

  x = 2*3; → x = 6.

* Strength Reduction: higher execution time Replaced by lower.

  y = x * 2

  y = x + x; or y = x << 1;

* null sequences: useless op. Deleted.

  a := a + 0; a := a | 0;

  a := a * 1; a := a & 1;

* Combine operation : several op are replaced by a single equivalent op.

* Deadcode Elimination: A part of code which can never be executed