Covered Topics Under UNIT-3 of "CD- COMPILER DESIGN (KIT-052)"

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CD: UNIT-3

Syntax-Directed Translation

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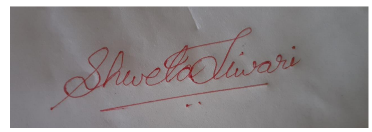

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TOPIC On : UNIT-3

3 Address Code for Array Reference(1-D Array and 2-D Array)

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Under On: Syntax-Directed Translation

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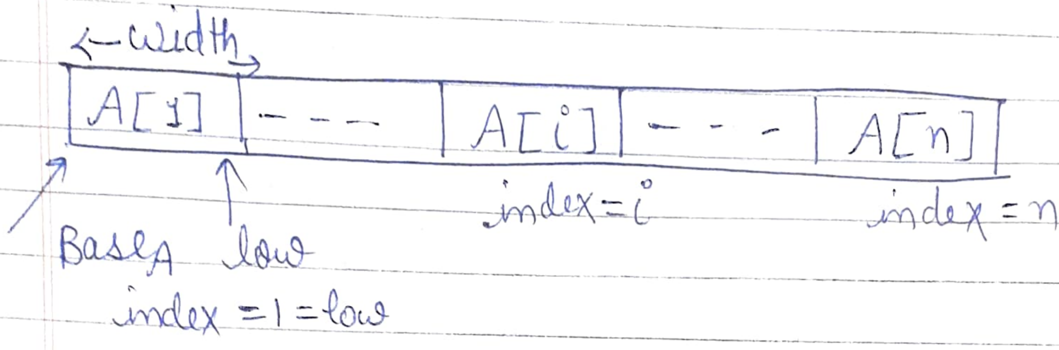
Three Address Code [Array Reference]

(1.) Three Address Code for One D Array

→ let us consider one D array A.



$Base_A$ = Address of starting location of array A.

width = width of each array element in bytes.

low = Index of first array element

$\boxed{\text{So, low} = 1 \text{ By default}}$

$$\text{Location of } A[i] = Base_A + (i - low) * width$$

$$= (Base_A - low * width) + (i * width)$$

$$= \underbrace{(address_A - width)}_{t_2} + \underbrace{(i * width)}_{t_1}$$

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$A[i] = t_2[t_1]$

Example (eg:):-

← 8 bytes →	← 8 →	← 8 →	← 8 →
A[1]	A[2]	A[3]	A[5]

8 16 24 32 40

given
$\boxed{\text{width} = 8 \text{ bytes}}$

Location of A[3]

$= \text{Base}_A + (i - \text{low}) * \text{width}$

given ⇒ $\text{Base}_A = 8$

$i = \text{index} = 3.$
$\text{low} = 1$
$\text{width} = 8$

$= 8 + (3-1) * 8$
$= 8 + 16$
$= 24$

⇒ Convert following into 3- Address Code

Eg:- $a[i] = 20$

width = 8 bytes

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3-address code is

$a[i] = 10$

$t_2[t_1] = 10$

$t_1 = i \times width \quad = i \times 4$

$t_2 = address_A - width \quad = address_{(a)} - 4$

$t_2[t_1] = 10$

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3-Address Code for 2D Array

2D Array

As we know that 3-address code for 1D array is

$$\boxed{A[i] = Base_A + (i - low) * width}$$

Similarly the 3-address code for 2D array is,

$$\boxed{A[i,j] = Base_A + ((i - low_1) \times n_2 + j - low_2) * width}$$

$$= Base_A + i \times n_2 \times width - low_1 \times n_2 \times width + j \times width - low_2 \times width$$

$$= \underbrace{(i \times n_2 + j) * width}_{t_1} + \underbrace{Base_A - (low_1 \times n_2 + low_2) * width}_{t_2}$$

$$\boxed{A[i,j] = t_2[t_1]}$$

$Base_A$ = Address of starting location of array

low_1, low_2 = Index of 1st row, and 1st column.

n_2 = no. of elements in each column

eg → A → 30×30
row × col.

width = width of ith row and jth column.

Ques- * Convert the following into 3 address code.

add = 0;
i = 1
j = 1
add = add + a[i,j] + b[j,i]

where a and b are array of size 20×20 and there are 4 bytes per word.

Answer $low_1 = low_2 = 1$; $n_1 \times n_2 = 20 \times 20$;
width = 4 byte;

for $a[i,j] = t_2[t_1]$

$t_2 = Base_A - (low_1 \times n_2 + low_2) \times width$
$= address_A - (1 \times 20 + 1) \times 4$

$address_A - 164$

$t_1 = (i \times n_2 + j) \times width$

$t_1 = (i \times 20 + j) \times 4$

for $B[j, i] = t_4[t_3]$

$t_3 = (j \times 20 + i) \times 4$

$= \cancel{\otimes}$

$t_4 = address_B - (low_1 \times n_2 + low_2) \times width$

$= address_B - (1 \times 20 + 1) \times 4$

$t_4 = address_B - 164$

1. $add = 0$	~~12. t_8~~
2. $i = 1$	12. $t_4 = address_A - 164$
3. $j = 1$	13. $t_6 = t_4[t_3]$
4. $t_1 = i \times 20$	14. $t_7 = t_5 + t_7$
5. $t_1 = t_1 + j$	15. $t_8 = add + t_7$
6. $t_1 = t_1 \times 4$	16. $add = t_8$.
7. $t_2 = address_A - 164$	
8. $t_5 = t_2[t_1]$	
9. $t_3 = j \times 20$	
10. $t_3 = t_3 + i$	
11. $t_3 = t_3 \times 4$	

Answer

3-Address Code for 2D Array

2D Array

As we know that 3-address code for 1D array is

$$\boxed{A[i] = Base_A + (i - low) * width}$$

Similarly the 3-address code for 2D array is,

$$\boxed{A[i,j] = Base_A + ((i - low_1) \times n_2 + j - low_2) * width}$$

$$= Base_A + i \times n_2 \times width - low_1 \times n_2 \times width + j \times width - low_2 \times width$$

$$= \underbrace{(i \times n_2 + j) * width}_{t_1} + \underbrace{Base_A - (low_1 \times n_2 + low_2) * width}_{t_2}$$

$$\boxed{A[i,j] = t_2[t_1]}$$

$Base_A$ = Address of starting location of array

low_1, low_2 = Index of 1st row, and 1st column.

n_2 = no. of elements in each column

eg → A → 30 × 30
row × col.

width = width of ith row and jth column.

Ques - Convert the following into 3 address code.

add = 0;
i = 1
j = 1
add = add + a[i,j] + b[j,i]

where a and b are array of size 20×20 and there are 4 bytes per word.

Answer $low_1 = low_2 = 1$; $n_1 \times n_2 = 20 \times 20$;
width = 4 byte;

for a[i,j] = $t_2[t_1]$

$t_2 = Base_A - (low_1 \times n_2 + low_2) \times width$
$= address_A - (1 \times 20 + 1) \times 4$

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$address_A - 84$

$t_1 = (i \times n_2 + j) \times width$

$t_1 = (i \times 20 + j) \times 4$

for $B[j,i] = t_4[t_3]$

$t_3 = (j \times 20 + i) \times 4$

$= \cancel{Q}$

$t_4 = address_B - (low_1 \times n_2 + low_2) \times width$

$= address_B - (1 \times 20 + 1) \times 4$

$t_4 = address_B - 84$

1. add = 0	12.
2. i = 1	12. $t_4 = address_A - 84$
3. j = 1	13. $t_6 = t_4[t_3]$
4. $t_1 = i \times 20$	14. $t_7 = t_5 + t_7$
5. $t_1 = t_1 + j$	15. $t_8 = add + t_7$
6. $t_1 = t_1 \times 4$	16. add = t_8.
7. $t_2 = address_A - 84$	
8. $t_5 = t_2[t_1]$	
9. $t_3 = j \times 20$	
10. $t_3 = t_3 + i$	
11. $t_3 = t_3 \times 4$	Answer

Example on 3-Address Code of 2-D Array

$c[a[i,j]] = b[i,j] + c[a[i,j]] + d[i+j]$

where a and b are array of size 30×40 and c and d are array of size 20. There are 4 bytes per word and $low_1 = low_2 = 1$.

$l_1 = low_1$, $l_2 = low_2$

$w =$ width

Answer

$a[i,j] = t_2[t_1]$ $\quad$ $t_9[t_8]$

$$= \underbrace{(i \times n_2 + j) \times w}_{t_1} + \underbrace{address_a - (l_1 \times n_2 + l_2) \times w}_{t_2}$$

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$$= (i \times 40 + j) \times 4 + \text{address}_a - (1 \times 40 + 1) \times 4$$

$$= (i \times 40 + j) \times 4 + \text{address}_a - (41 \times 4)$$

$$= \underbrace{(i \times 40 + j) \times 4}_{t_1} + \underbrace{\text{address}_a - 164}_{t_2}$$

t_8 t_9

$b[i,j] = t_6[t_5]$.

$$b[i,j] = \underbrace{(i \times 40 + j) \times 4}_{t_5} + \underbrace{\text{address}_b - 164}_{t_6}$$

* same as a[i,j] b[i,j] because is size same

1D ~~Arr~~ Array

$A[i] = t_2[t_1]$

$t_1 = i \times w$

$t_2 = \text{address}_A - w$

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1. $t_1 = i \times 40$

2. $t_1 = t_1 + j$

3. $t_1 = t_1 \times 40$

4 $t_2 = address_a - 164$

5 $t_3 = t_2[t_1]$ ---- $c[t_3]$

otherwise
$t_4 = t_3 \times 4$
$c[t_3] = t_4[t_3]$ equat.

6 $t_3 = t_3 \times 4$

7 $t_4 = address_c - 4$ ---- $c[a[i,j]]$

8 $t_4' = t_4[t_3]$

9 $t_5 = i \times 40$

10 $t_5 = t_5 + j$

11 $t_5 = t_5 \times 40$

12 $t_6 = address_b - 164$

13 $t_7 = t_6[t_5]$ —— $b[i,j]$

14 $t_8 = i \times 40$

15 $t_8 = t_8 + j$

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16. $t_8 = t_8 \times 4$

17. $t_9 = \text{address}_a - 164$

18. $t_{10} = t_9[t_8]$ ---- $c[t_{10}]$ $t_{11}[t_{10}]$

19. $t_{10} = t_{10} \times 4$

20 $t_{11} = \text{address}_c - 4$

21 $t_{12} = t_{11}[t_{10}]$ $c[a[i,j]]$

22 $t_{13} = i+j$

23 $t_{13} = t_{13} \times 4$

24 $t_{14} = \text{address}_d - 4$

25 $t_{15} = t_{14}[t_{13}]$ --- $d[i+j]$ $\parallel$ $t_{14}[t_{13}]$

26 $t_{16} = t_7 + t_{12}$

27 $t_{17} = t_{16} + t_{15}$

28 $t_4' = t_{17}$

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