DATA STUCTURE
(Programming)

Array :-

array pointer

$\underbrace{\text{int a[10]}}_{\text{declaration}} = \underbrace{\{10, 20, 30, \ldots\ldots 100\}}_{\text{intialization}}$ (1D - array)

type

array size

data

a	10	20	30	40	50	60	70	80	90	100
index	0	1	2	3	4	5	6	7	8	9

a[5] ⟶ accesing data of 5th index element of array 'a'.

& a[5] ⟶ return address of that element

refrence operator

*(& a[5]) ⟶ return data of refrenced address

Q. a = { 55, ... 125 } ; Base Add = 1000

index

Size of an element = 10

Find LOC(a[119]) ?

$n = 125 - 55 + 1 = 71$

$$LOC = 1000 + (119 - 55)\,10$$

$$= \underline{1640}$$

Q. $a = [-125, -124, \ldots\ldots +125]$ BA = 0 , S = 1

Find LOC(a[-3])

$$LOC = 0 + (-3 + 125) \times 1 = \underline{122}$$

NOTE :-

a[LB, ..., UB] , BA , S

Lower Bound

upper Bound

Base Add

Size of each element

$$LOC(a[i]) = BA + (i - LB) * S$$

- By defalt, array index start from zero, not from one because there is ~~there is~~ no need to calculate offset value.

$i - LB$ when $LB = 0$

$i - 0 = i$ (no need to perform SUB opn)

(2-D Array):-

int a[4][3] ;

- 4: no. of rows → {1 – 4}
- 3: no. of columns → {1 – 3}

a

$$\begin{array}{c|ccc} & 1 & 2 & 3 \\ \hline 1 & a_{11} & a_{12} & a_{13} \\ 2 & a_{21} & a_{22} & a_{23} \\ 3 & a_{31} & a_{32} & a_{33} \\ 4 & a_{41} & a_{42} & a_{43} \end{array}$$

Matrix Representation

Total memory slots = $m \times n$
$= 4 \times 3 = 12$

a → 1000

00	02	04	06	08	10	12	14	16	18	20	22
a_{11}	a_{12}	a_{13}	a_{21}	a_{22}	a_{23}	a_{31}	a_{32}	a_{33}	a_{41}	a_{42}	a_{43}
0	1	2	3	4	5	6	7	8	9	10	11

Memory representation (Row major order)

$$\text{LOC}(a[4][3]) = 1000 + [(4-1)(3) + (3-1)] \times 2$$
$$= 1000 + [9 + 2] \times 2$$
$$= \underline{\underline{1022}}$$

NOTE:- (row-major order)

$$\text{LOC}(a[m][n]) = \underbrace{BA}_{\text{Base Add.}} + [(m - \overset{\text{LB of row}}{1})(\underbrace{c}_{\text{no. of columns } \cancel{\text{size}}}) + n - \overset{\text{LB of column}}{1}] \times \underbrace{S}_{\text{size of each elements}}$$

(int = 2)

Q. $A = \{25 \ldots 500,\ 125 \ldots 300\}$; $BA = 500$

$S = 10\ B$

Find $Loc(A[350][200])$

$$Loc = BA + [(m - LB_r)(c) + (n - LB_c)]\ S$$

$$= 500 + [(350-25)(176) + (200-125)]\ 10$$

$$= 500 + [57200 + 75]\ 10$$

$$= 573250\ B$$

Q. $A = \{-75 \ldots -25,\ -575 \ldots -200\}$; $BA = 0$

$S = 1\ B$

Find $Loc(A[-30][-175])$

$$Loc = 0 + [(-30+75)(376) + (-175+575)] \times 1$$

$$= 0 + [16920 + 400]$$

$$= 17320$$

(3-D Array):-

$$A\Big[\underbrace{9\ldots15}_{7},\ \underbrace{3\ldots\ldots20}_{18},\ \underbrace{7\ldots17}_{11}\Big]\ ;\quad BA = 1000\ ;\ S = 10$$

na — no. of 2D array; nr — no. of row; nc — no. of colum

$$\text{LOC}_{A[i][j][k]} = BA + \Big[(i-LB_1)(n_r \times n_c) + (j-LB_2)(n_c) + (k-LB_3)\Big]\times S$$

row major

$$\text{LOC}_{A[13][15][12]} = 1000 + \Big[(13-9)(18\times11) + (15-3)(\cancel{18}) + (12-7)\Big]\times10$$

$$= 1000 + \Big[792 + \overset{132}{\cancel{216}} + 5\Big]\times10$$

$$= 10290$$

$$\text{LOC } A[i][j][k] = BA + \Big[(i-LB_1)(n_r\times n_c) + (k-LB_3)(n_r) + (j-LB_2)\Big]\times S$$

column major

SO,

$$\text{LOC}_{A[13][15][12]} = 1000 + \Big[(13-9)(18\times11) + (15-3) + (12-7)(18)\Big]\times10$$

$$= 1000 + \Big[792 + 12 + 90\Big]\times10$$

$$= \underline{9940}$$

(Lower Traingular Matrix) :-

$A[1 \ldots 4, 1 \ldots 4] \Rightarrow$

$$\begin{array}{c|cccc} & 1 & 2 & 3 & 4 \\ \hline 1 & a_{11} & 0 & 0 & 0 \\ 2 & a_{21} & a_{22} & 0 & 0 \\ 3 & a_{31} & a_{32} & a_{33} & 0 \\ 4 & a_{41} & a_{42} & a_{43} & a_{44} \end{array}$$

zeros

non zeros

No. of non-zeros = a_{11} ———— 1

$a_{21}\ a_{22}$ ———— 2

$a_{31}\ a_{32}\ a_{33}$ ———— 3

$a_{41}\ a_{42}\ a_{43}\ a_{44}$ ———— 4

$= 1 + 2 + 3 + \cdots n$

$= \left(\dfrac{n(n+1)}{2}\right)$

- To store these type of array efficiently, store only non-zero elements.

for $n=4$, no. of slots $= \dfrac{4(4+1)}{2} = 2 \times 5 = \underline{10}$

a_{11}	a_{21}	a_{22}	a_{31}	a_{32}	a_{33}	a_{41}	a_{42}	a_{43}	a_{44}
0	1	2	3	4	5	6	7	8	9

$$\text{LOC}(A[i][j]) = \begin{cases} 0 & \text{if } i < j \\ BA + \left(\underbrace{\frac{i(i-1)}{2}}_{\text{Sum of } (i-1) \text{ rows}} + (j-1) \right) \times S \end{cases}$$

row major

so,

$$\text{LOC}(A[4][3]) = 1000 + \left(\frac{4(3)}{2} + (3-1) \right) \times 2$$

$$= 1000 + (6+2)(2)$$

$$= 1016$$

Q. Consider a Lower triangular matrix: (row major order)

$A[25 \ldots 95, \; 25 \ldots 95]$; $BA = 1000$, $S = 10$ B

$n_r = 71 \qquad n_c = 71$

Find $\text{LOC}(A[85][70])$

$i = 85 - 25 + 1 = 61$

$j = 85 - 70 + 1 = 16$

$$\text{LOC}(A[85][70]) = 1000 + \left(\frac{60(61)}{2} + 15 \right) 10$$

$$= 1000 + (1830 + 15)\, 10$$

$$= 18450 + 1000$$

$$= 19450$$

$$\text{LOC}[i][j] = \begin{cases} 0 & \text{if } i<j \\ \cancel{BA + \left[(i-1) + \frac{j(j-1)}{2}\right] \times S} & \\ BA + \left[\frac{n(n+1)}{2} - \frac{(n-j+1)(n-j+2)}{2} + (i-j)\right] \times S & \end{cases}$$

column major order

Q. $A[25 \ldots 95,\ 25, \ldots 95]$; $BA = 0$; $S = 5$;

$n_r = 71$ $\quad n_c = 71$

Find $\text{LOC}(A[85][50])$

$$\frac{(95-50+1)(95-50+2)}{2}$$

$$\text{LOC}(A[85][50]) = 0 + \left[\frac{71 \times 72}{2} - \cancel{\frac{(26)(27)}{2}} + 15\right] \times 5$$

$$= [2556 - 351 + 15] \times 5$$

$$= \underline{\underline{11075}}$$

(Z-matrix) :-

$$\begin{array}{c|cccc} & 1 & 2 & 3 & 4 \\ \hline 1 & a_{11} & a_{12} & a_{13} & a_{14} \\ 2 & 0 & 0 & a_{23} & 0 \\ 3 & 0 & a_{32} & 0 & 0 \\ 4 & a_{41} & a_{42} & a_{43} & a_{44} \end{array}$$

no. of non-zero elements $= n + n + n - 2$

$= (3n-2)$

n	1	1	. . . . . .	1	n

first row $\qquad\qquad$ last row

~~row-major~~ :- n - 1 - 1 - 1 - . . . . 1 - 1 - n

$$\cancel{Loc(A[50][23])} \overset{50 \times 50}{} = BA + (n + (50-1))$$

First-row	Last-row	Diagonal
n	n	$n-2$

Loc(a[i][j])

(i) if i == I row

$$(Loc = BA + j - LB)$$

(ii) if i == Last-row

$$(Loc = BA + n + j - LB)$$

(iii) (Loc = BA + 2n + Column work)