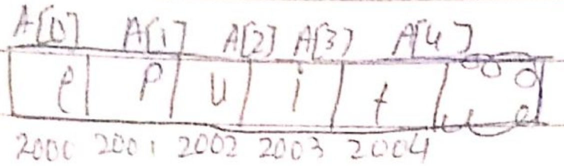
Array index formula computation

Array - Contiguous Memory allocation

char A



~~A[l : u]~~

Index Formula

A[l : u]

upper bound

lower bound

No of element = U - l + 1

A [0:4] No of element = 4 - 0 + 1 = 5

0 = l

4 = u

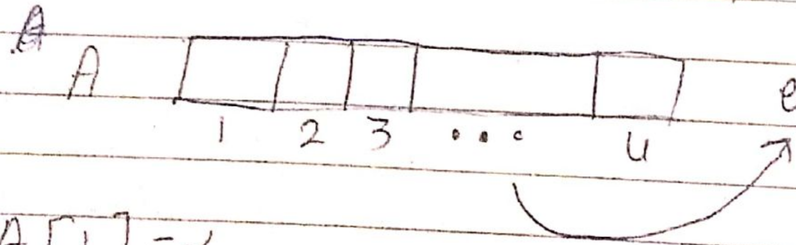
One Dimensional Array

A [l:u]

A [L: U]

l => Index

Assumption: $\boxed{\begin{array}{l} l = 1 \\ \text{Every element Storage} = 1\text{Byte} \end{array}}$



ellipses

$A[1] = \alpha$

$A[2] = \alpha + 1$

$A[3] = \alpha + 2$

$|$

$A[i] = \alpha + (i - 1)$

$i = i - L + 1$

$= \alpha + (i - L + \cancel{1} - \cancel{1})$

$\alpha + i - L$

Assumption If Storage byte N

$\Rightarrow A[i] = \alpha + (i-L) \times N$

Q Consider a One dimensional array $A[-2:10]$ If base adress of array is 1000 find out adress of $A[7]$ if every element requires 4 bytes

$\alpha + (i-L) \times N$

$1000 + (7+2) \times 4$

$1000 + 36 = 1036$

2-D Array $\Rightarrow$

$A[L_1 : U_1 , L_2 : U_2]$

int A[5][3]

Rows = $U_1 - L_1 + 1$ Collumn = $U_2 - L_2 + 1$

Q Given $A[-1:7, -2:10]$

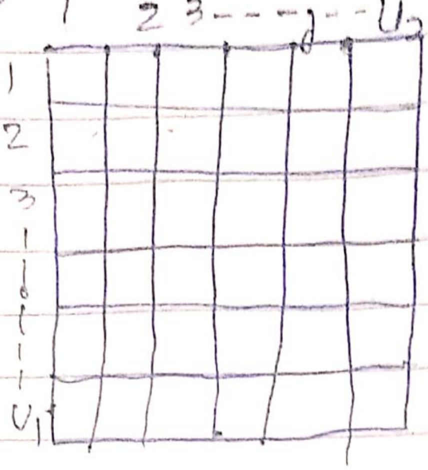
Find no of rows
collumns
& elements

Rows = $7+1+1 = 9$

Collum = $10+2+1 = 13$

No of ellement = 117

Row measure Order



Address of

$A[1,1] = \alpha$

$A[1,2] = \alpha+1$

$A[1,3] = \alpha+2$

$A[1,U_2] = \alpha+(U_2-1)$

$A[2,1] = \alpha+U_2$

$A[3,1] = \alpha+2U_2$

$A[4,1] = \alpha+3U_2$

$A[i,1] = \alpha+(i-1)u_2$

$A[i,2) = \alpha+(i-1)U_2+1$

$A[i,j] = \alpha+(i-1)u_2+(j-1)$

Removing assumption

$i \rightarrow i-L_1+1$

$j \rightarrow j-L_2+1$

$U_2 \rightarrow U_2-L_2+1$

Removing second assumption

$A[i][j] = \alpha+[(i-L_1)(U_2-L_2+1)+(j-L_2)]\times N$

~~Collumn Measure Order~~

↓↓↓

Q Given a 2D array $A[-1:7, -2:10]$ Find out address of element $a[5][5]$ if base adress of array be 7000 and each element requires 6 bytes for storage

$\alpha = 7000$ $U_1 = 7$, $U_2 = 10$

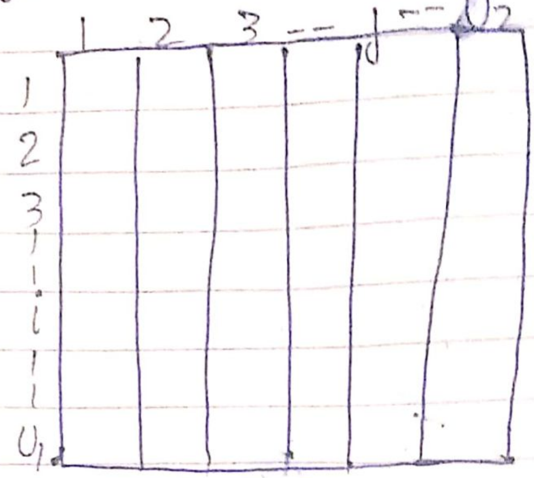
$i=5$, $j=5$ $L_1=-1$, $L_2=-2$

$A[i][j] = 7000+(6(13)+(7)] \times 6$

$7000 + 85\times6$

2D Array Collumn Measure Order

Assumption
$i=1, j=1$
$=1$



$A[1,1] = \alpha$

$A[2,1] = \alpha+1$

$A[3,1] = \alpha+2$

$A[U_1,1] = \alpha + (U_1 - 1)$

$A[1,2] = \alpha + U_1$

$A[1,3] = \alpha + 2U_1$

$A[1,4] = \alpha + 3U_1$

$A[1,j] = \alpha + (j-1)U_1$

$A[2,j] = \alpha + (j-1)U_1 + 1$

$A[3,j] = \alpha + (j-1)U_1 + 2$

$A[i,j] = \alpha + (j-1)U_1 + (i-1)$

Rumoving assumption

$j \rightarrow j - L_2 + 1$

$i \rightarrow i - L_1 + 1$

$U_1 \rightarrow U_1 - L_1 + 1$

$A[i,j] = \alpha + (j-L_2)(U_1 - L_1 + 1) + (i - L_1)$

Removing 2^nd assumption

$\alpha + [(j-L_2)(U_1 - L_1 + 1) + (i-L_1)] \times N$

$7000 + [7(9) + (6)] \times 6$

$7000 + 69 \times 6$

$7000 + 414 = 7414$

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Given an ~~array~~ collumn measure order, array $A[0:7, 3:20]$. Find address of element $A[4][11]$. Given base address 10054 and each element requires 11 byte for storage.

$L_1 = 0$, $U_1 = 7$, $i = 4$

$L_2 = 3$, $U_2 = 20$, $j = 11$

$\alpha + [(j - L_2)(U_1 - L_1 + 1) + (i - L_1)] \times N$

$10054 + [8(8) + 4] \times 11$

$10054 + 68 \times 11$

$10054 \quad 748$

10802

3 D Array

~~Row measure order~~

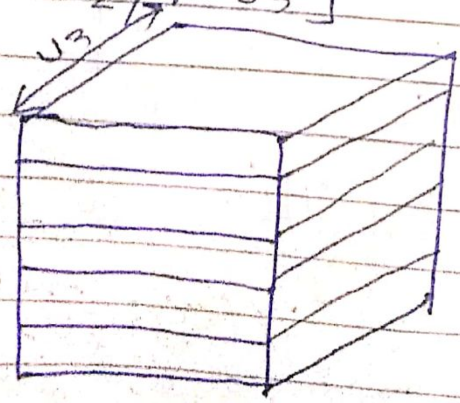
$A[L_1 : U_1, L_2 : U_2, L_3 : U_3]$

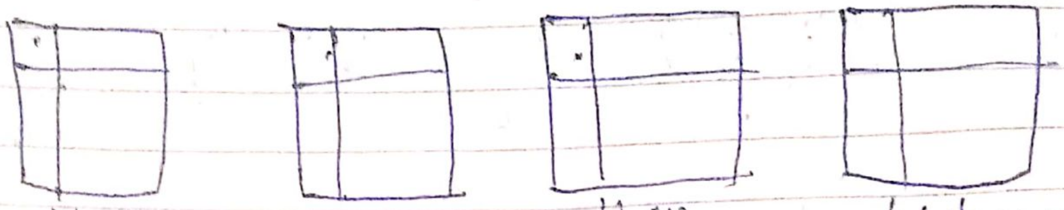
Assumption

$L_1, L_2, L_3 = 1$

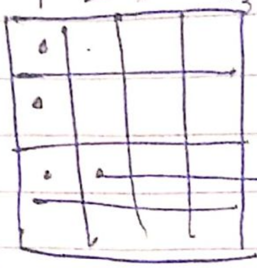
Storage space = 1

$A[1:U_1, 1:U_2, 1:U_3]$





Row measure



$A[1,1,1] = \alpha$

$A[2,1,1] = \alpha + U_2 \times U_3$

$A[3,1,1] = \alpha + 2(U_2, U_3)$

$A[i,1,1] = \alpha + (i-1)U_2U_3$

$A[i,2,1] = \alpha + (i-1)U_2U_3 + U_3$

$A[i,3,1] = \alpha + (i-1)U_2U_3 + 2U_3$

$A[i,j,1] = \alpha + (i-1)U_2U_3 + (j-1)U_3$

$A[i,j,2] = \alpha + (i-1)U_2U_3 + (j-1)U_3 + 1$

$A[i,j,3] = \alpha + (i-1)U_2U_3 + (j-1)U_3 + 2$

$A[i,j,k] = \alpha + (i-1)U_2U_3 + (j-1)U_3 + (k-1)$

Removing assumption

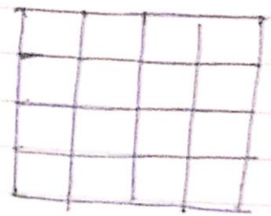
$i = i - L_1 + 1$, $j = j - L_2 + 1$, $k = k - L_3 + 1$

$U_1 = U_1 - L_1 + 1$; $U_2 = U_2 - L_2 + 1$, $U_3 = U_3 - L_3 + 1$

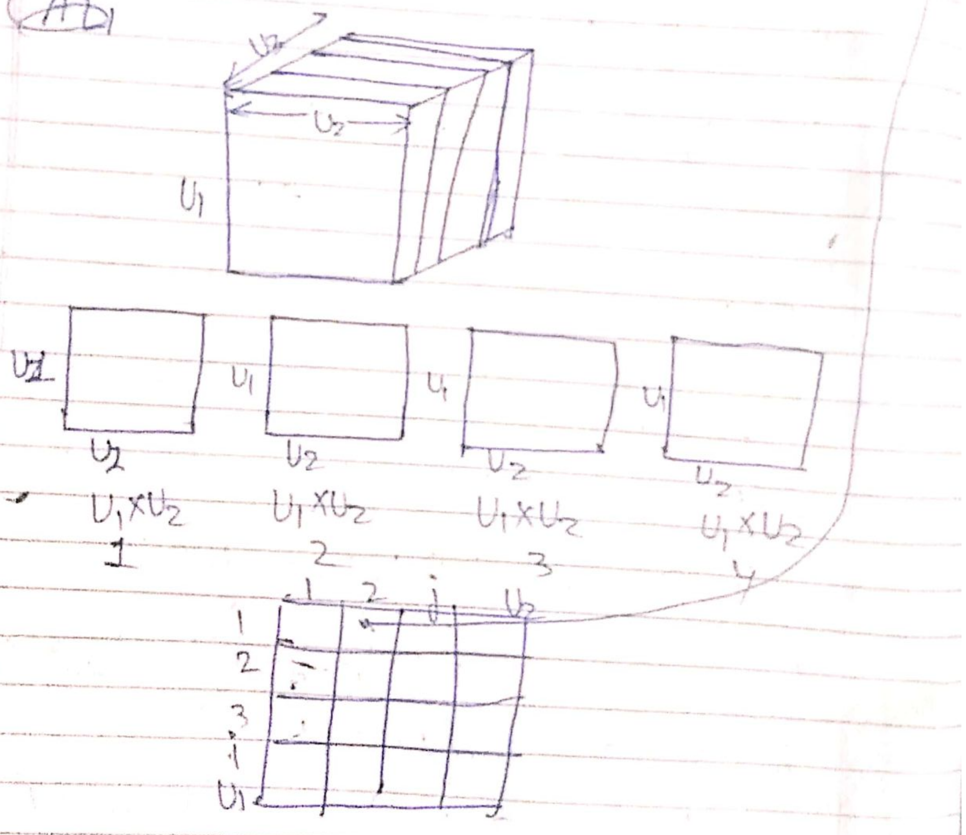
Removing 2nd

$A[i][j][k] = \alpha + [(i-L_1)(U_2-L_2+1)(U_3-L_3+1)$
$+ (j-L_2)(U_3-L_3+1) + k-L_3$

Collumn Measure



AE1



$A[1,1,1] = \alpha$

N $\quad A[1,1,2] = \alpha + U_1 U_2$

$A[1,1,3] = \alpha + 2(U_1 U_2)$

$A[1,1,k] = \alpha + (k-1)(U_1 U_2)$

$\rightarrow A[1,2,k] = \alpha + (k-1)(U_1 U_2) + U_1$

$A[1,3,k] = \alpha + (k-1)(U_1 U_2) + 2U_1$

$A[1,j,k] = \alpha + (k-1)(U_1 U_2) + (j-1)U_1$

$A[2,j,k] = \alpha + (k-1)(U_1 U_2) + (j-1)U_1 + 1$

$A[i,j,k] = \alpha + (k-1)U_1 U_2 + (j-1)U_2 + (j-1)$

Removing assumption

$i = i - L_1 + 1, \quad j = j - L_2 + 1, \quad k = k - L_3 + 1$

$U_1 = U_1 - L_1 + 1, \quad U_2 = U_2 - L_2 + 1, \quad U_3 = U_3 - L_3 + 1$

$$\alpha + \left[(k-L_3)(U_1 - L_1 + 1)(U_2 - L_2 + 1) + (j-L_2)(U_1 - L_1 + 1) + (i - L_1)\right] \times N$$

Given a 3D array $A[-1:7, 2:6, 4:12]$

$A[2,6,6]$

$i = 2$	$BA = 2^{10}$	$L_1 = -1$	$U_1 = 7$
$j = 6$	$N = 4$	$L_2 = 2$	$U_2 = 6$
$k = 6$		$L_3 = 4$	$U_3 = 12$

$2^{10} + [(2)(9)(5) + (3)(5) + 4] \times 4$

$2^{10}\ [90 + 15 + 4] \times 4$

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$2^{10} + 109 \times 4$

$2^{10} + 436$

$1024 + 436$

$\underline{1460}$

Row measure

$1024 + [(3)(5)(9) + (4)(9) + 2] \times 4$

$1024 + [135 + 36 + 2] \times 4$

$1024 + 143 \times 4$

$1024 + \cancel{572}\ 692$

$\cancel{1596}\ 1716$

105
38
43

135
38
173
692

N.To 1 step/2

$N = 10$

$\frac{N}{2}$ 10

5

$\frac{N}{4}$

$\frac{N}{8}$

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Formula

$A[i] = \alpha + (i-1) \times N$

⇒ Row major

$A[i,j] = \alpha + [(i-L_1)(U_2-L_2+1) + (j-L_2)] \times N$

⇒ Collum measure

$A[i,j] = \alpha + [(j-L_2)(U_1-L_1+1) + (i-L_1)] \times N$

With assumptions

⇒ Row magor order

$A[i,j,k] = \alpha + [(i-1)U_2U_3 + (j-1)U_3 + (k-1)]$

⇒ Collumn measur

$A[i,j,k] = \alpha + (k-1)U_1U_2 + (j-1)U_1 + (i-1)$

⇒ ~~Row~~ N Dimension $A[L_1:U_1, L_2:U_2, L_3:U_3, -- L_n:U_N]$

⇒ Row measure $A[1:U_1; 1:U_2, 1:U_3, ---, 1:N)$

$i_1, i_2, i_3 --- i_n$

$A[i_1, i_2, i_3, --- i_N] = \alpha + (i_1-1)U_2U_3 -- U_N$

$+ (i_2-1)U_3U_4 -- U_N + (i_3-1)U_4U_5 -- U_N + +$

$(i_{N-1}-1)U_N + (i_N-1)$

⇒ Collumn Measure

$A[i_1, i_2, i_3, --- i_N] = \alpha + [(i_n-1)U_1U_2 --- U_{N-1} + (i_{n-1}-1)U_1U_2 -- U_{N-2}$

$+ (i_{n-2}-1)U_1U_2 -- U_{N-3} + ---- (i_2-1)U_1 + (i_1-1)]$

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Q Given a 3D array

$A[-1:6, 0:8, -2:9]$

$A[2,4,6]$

Base adress of array is 2^{14} and every element requires 4 byte for sto[rage]

8192×2
16384

$i = 2$, $k = 6$, $L_2 = 0$, $U_1 = 6$, U_3
$j = 4$, $L_1 = -1$, $L_3 = -2$, $U_2 = 8$

Row order

$A[i,j,k] = \alpha + [(i_1 - 1) U_2 U_3 + (j-1) U_3 + (k-1)]$

$\alpha + [(i - L_1)(U_2 - L_2 + 1)(U_3 - L_3 + 1) + (j - L_2)(U_3 - L_3 + 1) + (k - L_3)]$

$\alpha + [(3)(9)(12) + (4)(12) + (8)] \times 4$

$108 \times 3 = 324$

$2^{14} + [324 + 48 + 8] \times 4$

$[380] \times 4$

$16384 + 1520$

$\underline{17904}$

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Collumn Order

$$A[i,j,k] = \alpha + [(k-L_3)(U_1-L_1+1)(U_2-L_2+1) + (j-L_2)(U_1-L_1+1) + (i-L_1)] \times N$$

$$[8(8)(9) + (4)(8) + (3)] \times 4$$

$$16384 + [576 + 32 + 3] \times 4$$

$$16384 + [611] \times 4$$

$$16384 + 2444$$

$$18828$$ Ans