

CS & IT ENGINEERING

Data structure and
Programming

Arrays

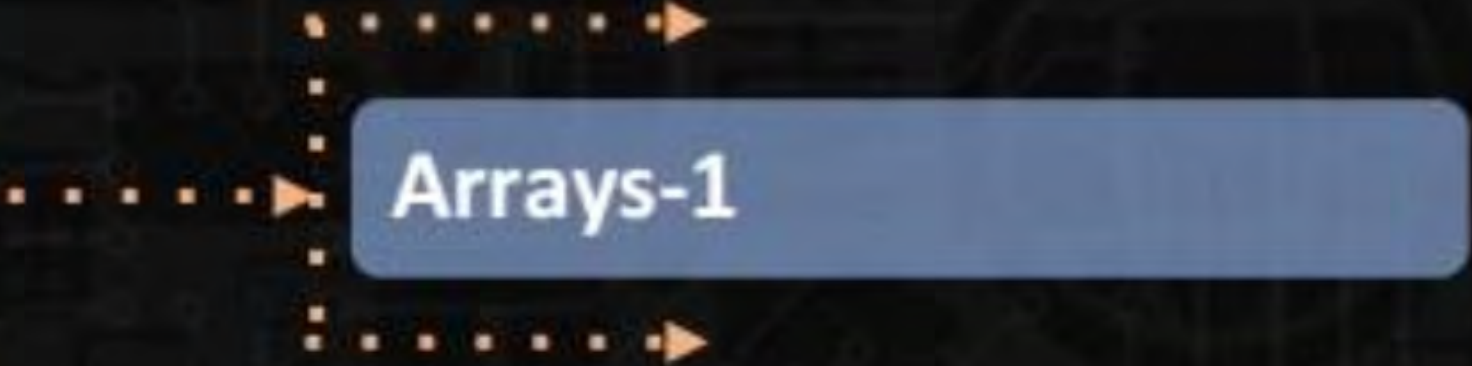
Lec- 01



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TOPICS TO BE
COVERED



Arrays-1

C-concept

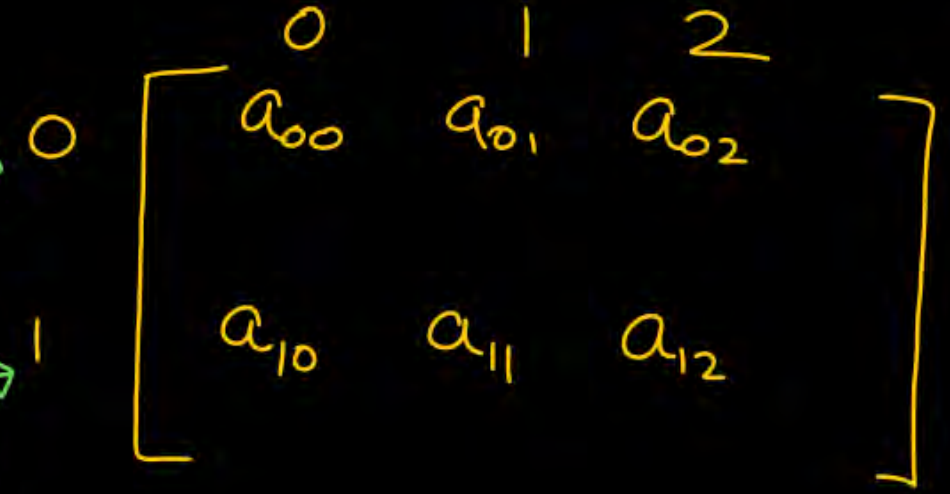
2-D array

int a[2][3];



row with index 0

row with index 1



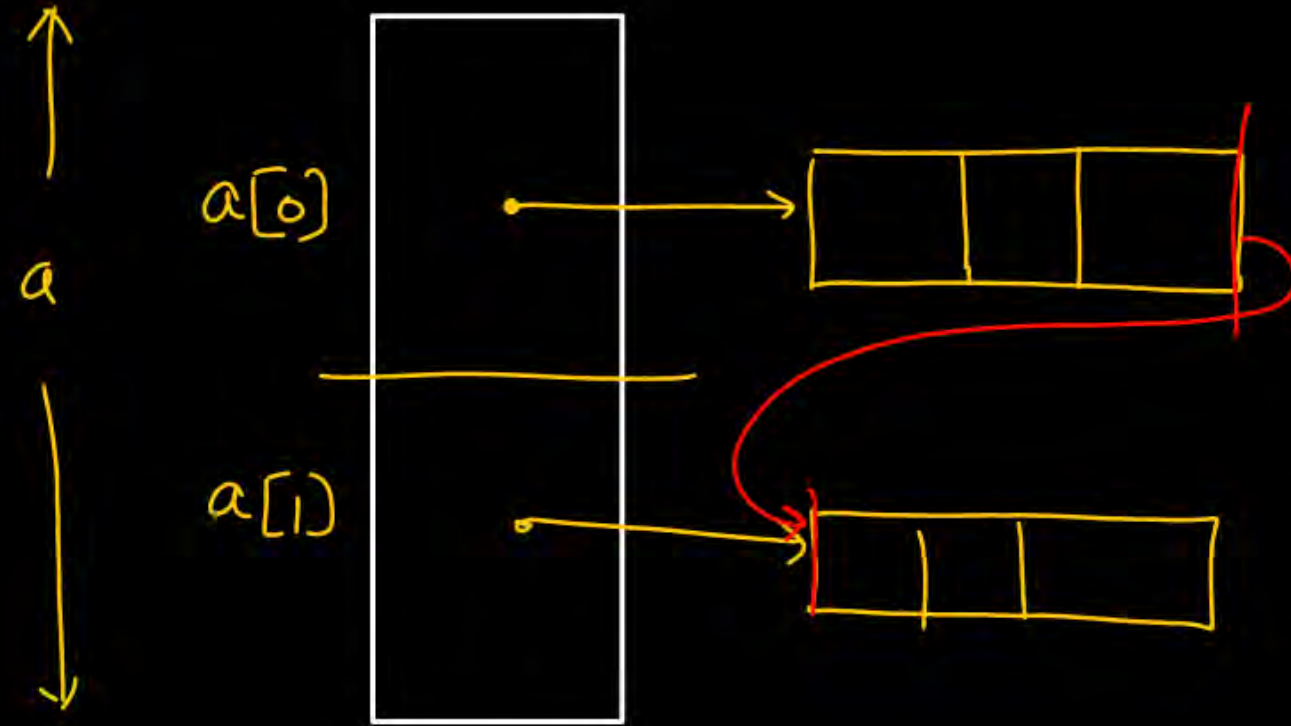
	0	1	2
0	a_{00}	a_{01}	a_{02}
1	a_{10}	a_{11}	a_{12}

of elements in row with index 0 = 3

of elements in row with index 1 = 3

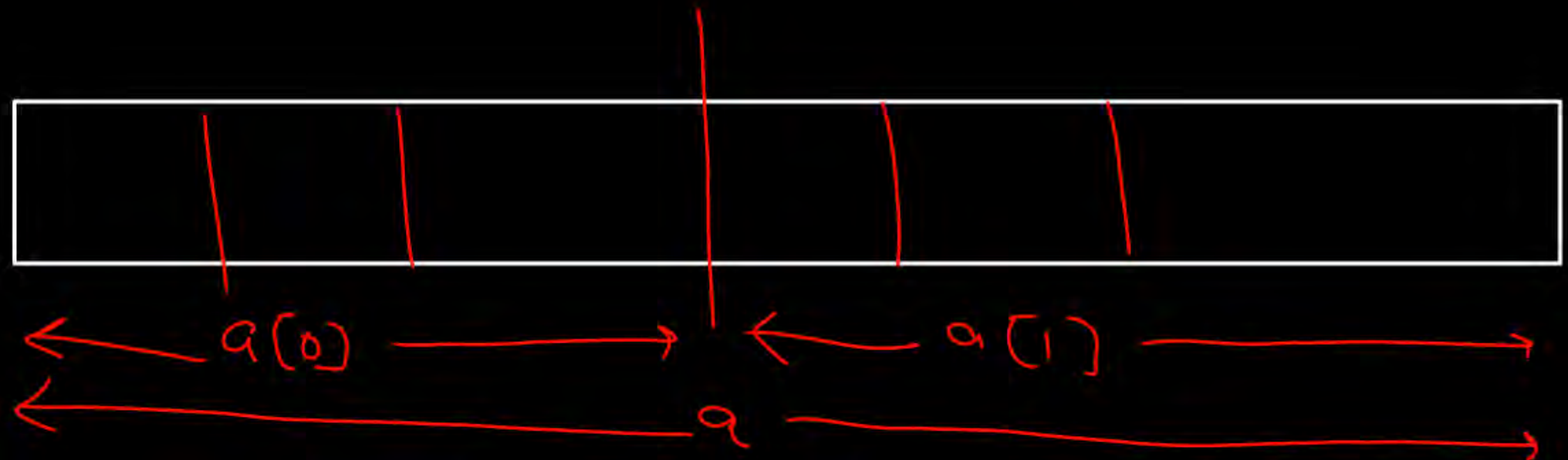
Every row, the no. of elements = 3 = no. of col.

`int a[2][3];`

$$\begin{matrix} & 0 & 1 & 2 \\ 0 & \begin{bmatrix} a_{00} & a_{01} & a_{02} \end{bmatrix} \\ 1 & \begin{bmatrix} a_{10} & a_{11} & a_{12} \end{bmatrix} \end{matrix}$$


row $a[0] \Rightarrow 3$

row $a[1] \Rightarrow 3$



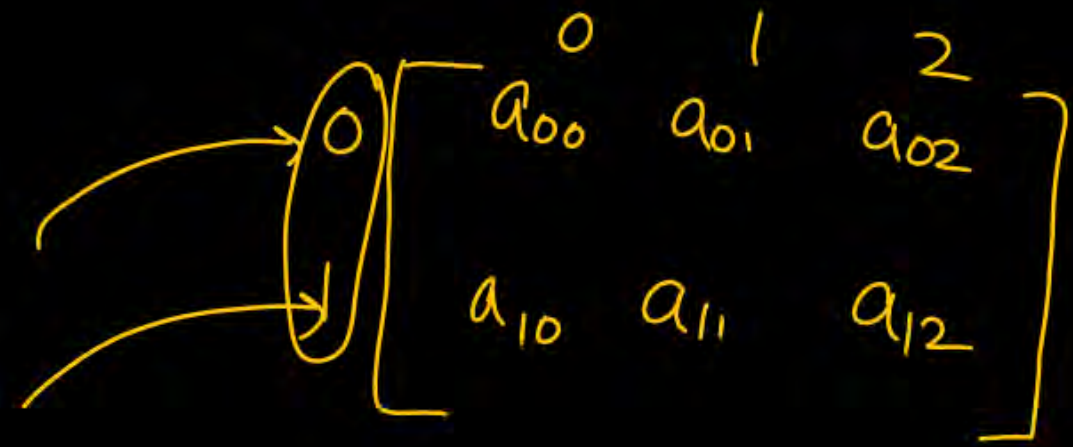
int a[2][3];



Each index/no. in this dim. represent 3 element

a[0] — 3

a[1] — 3



int a[3][4]

2-D array

Row-wise store

Column wise store

Row-major Order Column major order

	0	1	2	3
0	a_{00}	a_{01}	a_{02}	a_{03}
1	a_{10}	a_{11}	a_{12}	a_{13}
2	a_{20}	a_{21}	a_{22}	a_{23}

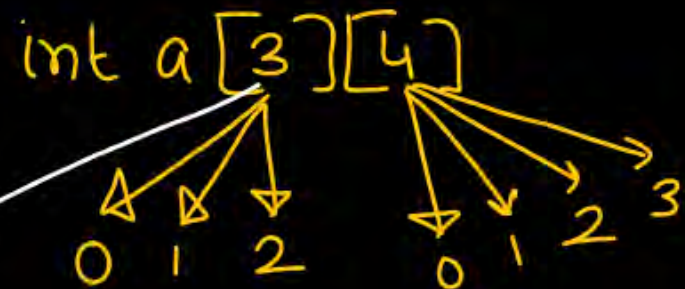
int a[3][4]

RMO

	0	1	2	3
0	a_{00}	a_{01}	a_{02}	a_{03}
1	a_{10}	a_{11}	a_{12}	a_{13}
2	a_{20}	a_{21}	a_{22}	a_{23}

row with index = 0 row with index = 1 → row with index = 2 →

a_{00}	a_{01}	a_{02}	a_{03}	a_{10}	a_{11}	a_{12}	a_{13}	a_{20}	a_{21}	a_{22}	a_{23}
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Σ 2 index = 4 element

add(a_{23})

row index

0	1	2	3
a_{00}	a_{01}	a_{02}	a_{03}
a_{10}	a_{11}	a_{12}	a_{13}
a_{20}	a_{21}	a_{22}	a_{23}

- ① How many rows already filled before row with index 2 = 2 rows
- ② No. of elements already filled before a_{23} in row with index 2 = 3 elements

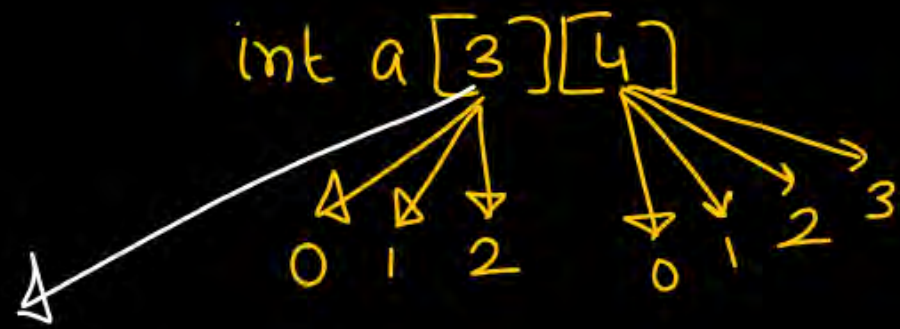
row with index = 0

row with index = 1

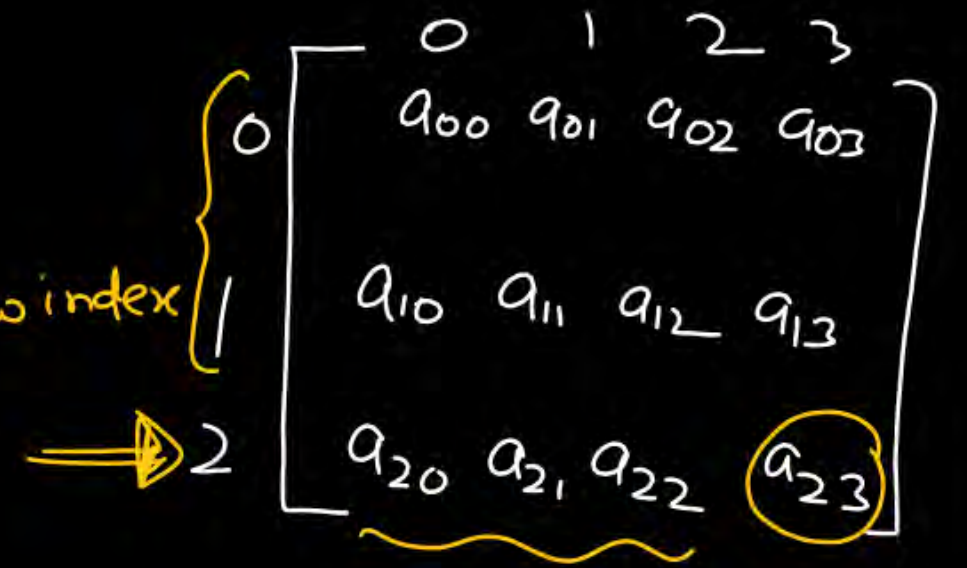
row with index = 2

<u>a_{00}</u>	<u>a_{01}</u>	<u>a_{02}</u>	<u>a_{03}</u>	<u>a_{10}</u>	<u>a_{11}</u>	<u>a_{12}</u>	<u>a_{13}</u>	<u>a_{20}</u>	<u>a_{21}</u>	<u>a_{22}</u>	<u>a_{23}</u>
----------------------------	----------------------------	----------------------------	----------------------------	----------------------------	----------------------------	----------------------------	----------------------------	----------------------------	----------------------------	----------------------------	----------------------------

1000



`add(a23)`

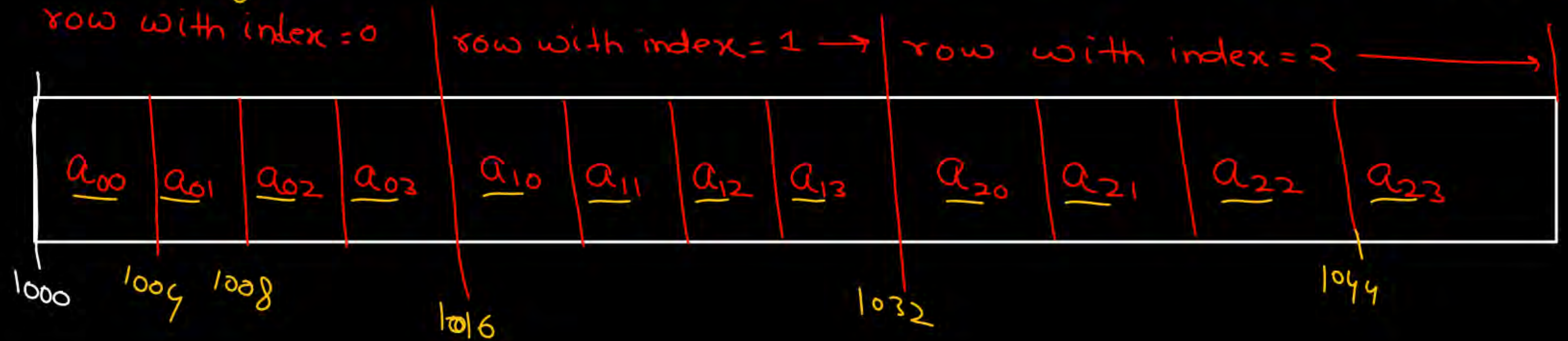


2 Rows $\Rightarrow 2 \times 4$

3 elements $\Rightarrow 3$

11 elements

No. of elem. already filled before `a23` $= 2 \times 4 + 3 = 11$ elements



$w = 4$ bytes

Memory already filled before $a_{23} = 11 \times 4 = 44$ bytes



$$1000 + 44 = 1044$$

add(a32)
 row index \swarrow \searrow col index
 int a[4][5]
 Each index = 5 elements
 w = 4 byte

3 rows

2 elem

	0	1	2	3	4
0	a ₀₀	a ₀₁	a ₀₂	a ₀₃	a ₀₄
1	a ₁₀	a ₁₁	a ₁₂	a ₁₃	a ₁₄
2	a ₂₀	a ₂₁	a ₂₂	a ₂₃	a ₂₄
3	a ₃₀	a ₃₁	a ₃₂	a ₃₃	a ₃₄

index = 0					row with index = 1					row with index = 2					index = 3				
a ₀₀	a ₀₁	a ₀₂	a ₀₃	a ₀₄	a ₁₀	a ₁₁	a ₁₂	a ₁₃	a ₁₄	a ₂₀	a ₂₁	a ₂₂	a ₂₃	a ₂₄	a ₃₀	a ₃₁	a ₃₂	a ₃₃	a ₃₄

1000

① How many row already filled before row with index 3 = row with index 0 to 2
 $= 2 - 0 + 1 = 3 \text{ rows}$

② Within row whose index is 3, the no. of elem. already filled before a₃₂ = col with index 0 to 1
 $= 1 - 0 + 1 = 2 \text{ elements}$

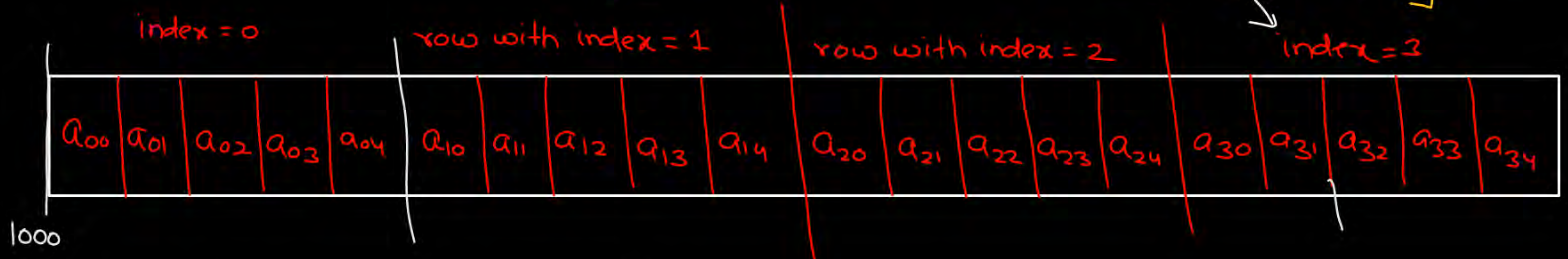
$w = 4 \text{ byte}$

$\text{add}(a_{32})$
row index \swarrow
col index \searrow
 $\text{int } a[4][5]$
Each index = 5 elements

2 elem

3 rows

	0	1	2	3	4
0	a_{00}	a_{01}	a_{02}	a_{03}	a_{04}
1	a_{10}	a_{11}	a_{12}	a_{13}	a_{14}
2	a_{20}	a_{21}	a_{22}	a_{23}	a_{24}
3	a_{30}	a_{31}	a_{32}	a_{33}	a_{34}



before $a_{32} \Rightarrow$ 3 rows & 2 ele already filled
 $\Rightarrow 3 \times 5 + 2 = 17$ elements are already filled
Memory already filled before $a_{32} = 17 \times 4 = 68 \text{ bytes}$

$$BA = 1000$$

add(a[1][1])

$$a \begin{bmatrix} -5 & 5 \end{bmatrix} \begin{bmatrix} -3 & 3 \end{bmatrix}$$

24. के ए

index = 7 element

A hand-drawn graph on a black background showing a coordinate plane. The x-axis is labeled from -3 to 3, and the y-axis is labeled from -5 to 5. Red arrows indicate a vector field. For $y \leq 0$, there are horizontal arrows pointing left from $x = -3$ to $x = -1$ and horizontal arrows pointing right from $x = 1$ to $x = 3$. For $y > 0$, there are no arrows drawn.

$w = 2 \text{ byte}$

$BA = 1000$

$\text{add}(a[i][j])$

$$a \overset{5 - (-5) + 1}{[-5 \dots 5]} \overset{3 - (-3) + 1}{[-3 \dots 3]} \overset{11 \times 7}{} \quad \text{2nd dim 82}$$

index = 7 element

rows already

filled

$$= -5 \text{ to } 0$$

$$= 0 - (-5) + 1$$

$$= 6 \text{ rows}$$

	-3	-2	-1	0	1	2	3
-5	←		→				→
-4	←		→				→
-3	←		→				→
-2	←		→				→
-1	←		→				→
0	←		→				→
1							
2							
3							
4							
5							

$w = 2 \text{ byte}$

$BA = 1000$

$\text{add}(a[i][j])$

$$a \begin{matrix} 5 - (-5) + 1 & 3 - (-3) + 1 & 11 \times 7 \\ [-5..5] & [-3..3] \end{matrix}$$

अंश के 2

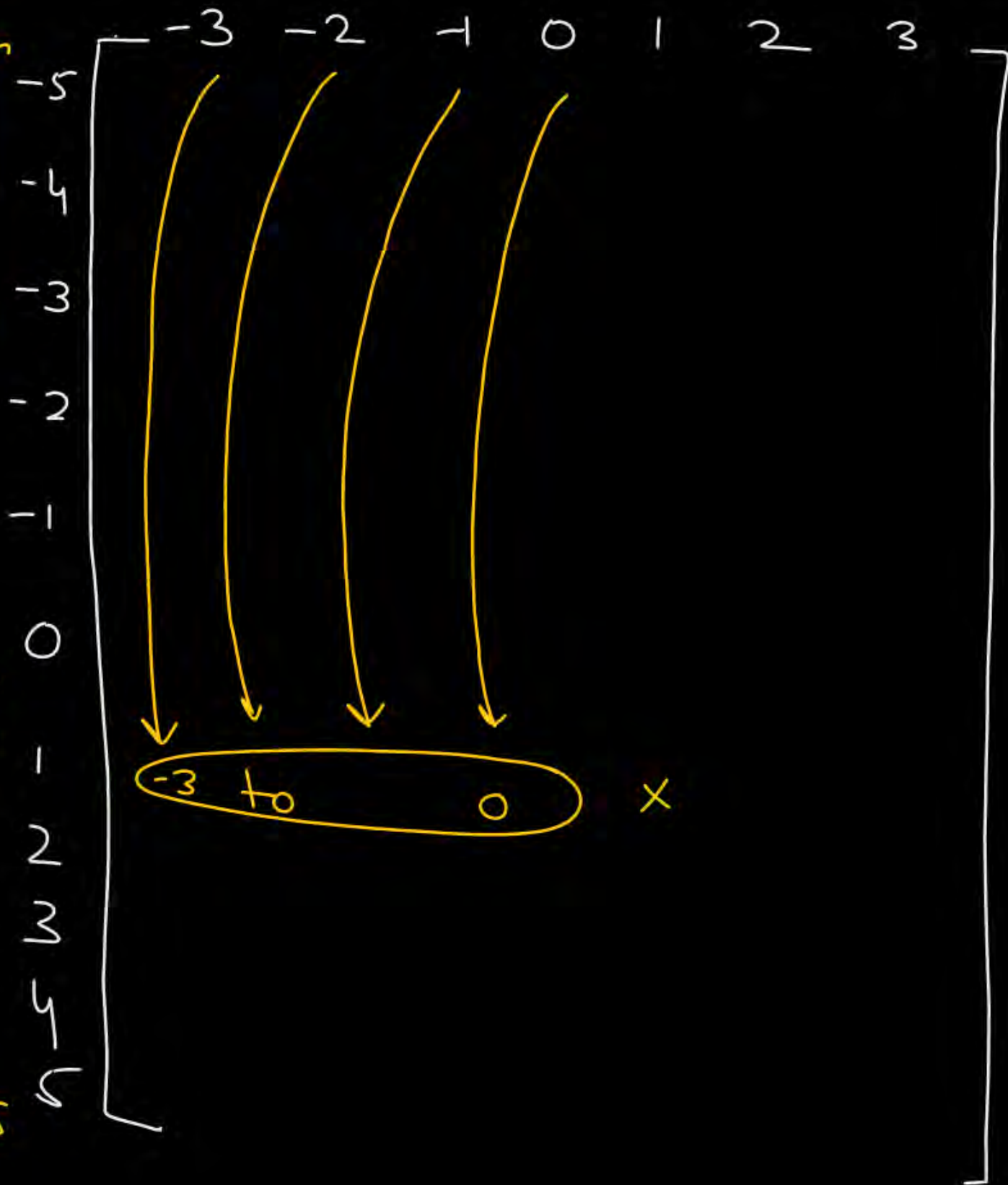
index = 7 element

within row with index 1

Elements already
filled before $a[i][j]$

= col. with index
-3 to 0

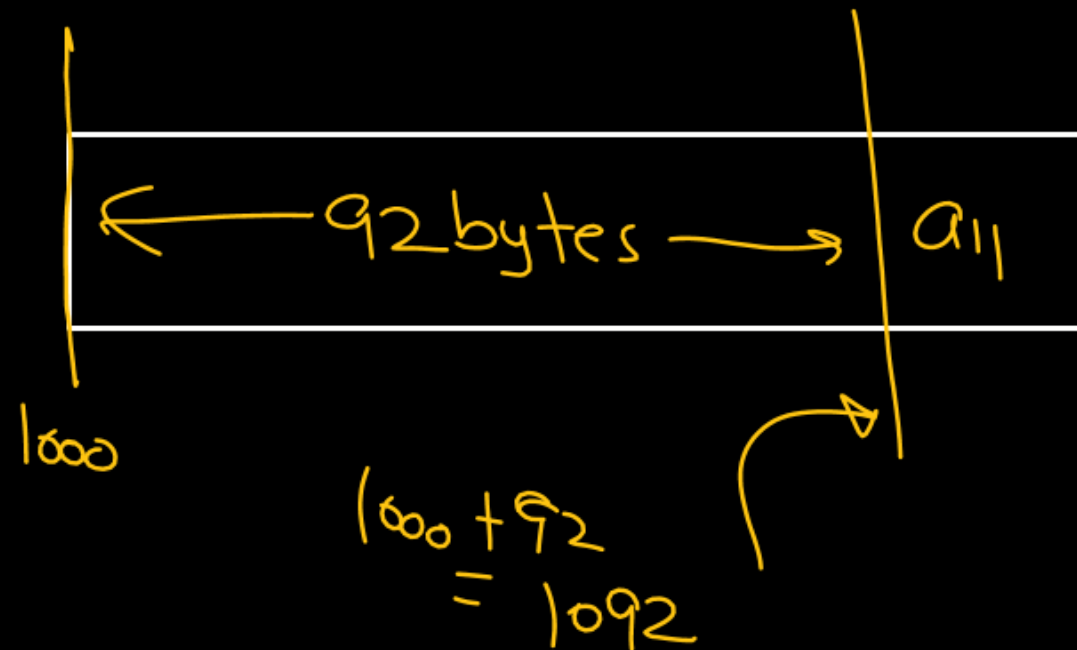
$0 - (-3) + 1 = 4 \text{ elements}$



After 6 rows & 4 elements a_{11} is stored

$$\begin{aligned}\text{Elem. already filled before } a_{11} &= 6 \times 7 + 4 \\ &= 46 \text{ elements}\end{aligned}$$

$$\begin{aligned}\text{Memory already filled before } a_{11} &= 46 \times 2 \\ &= 92 \text{ bytes}\end{aligned}$$



Q RMO $a[-5 \dots 5][-7 \dots 7]$

$W = 4$ bytes

BA = 1000

add($a[1][3]$)

How many index
already filled in
this dim

$= -5$ to 0

$= 0 - (-5) + 1$

$= 6$



6×15

Each index/No.
in this dim $\Rightarrow 15$ elem.

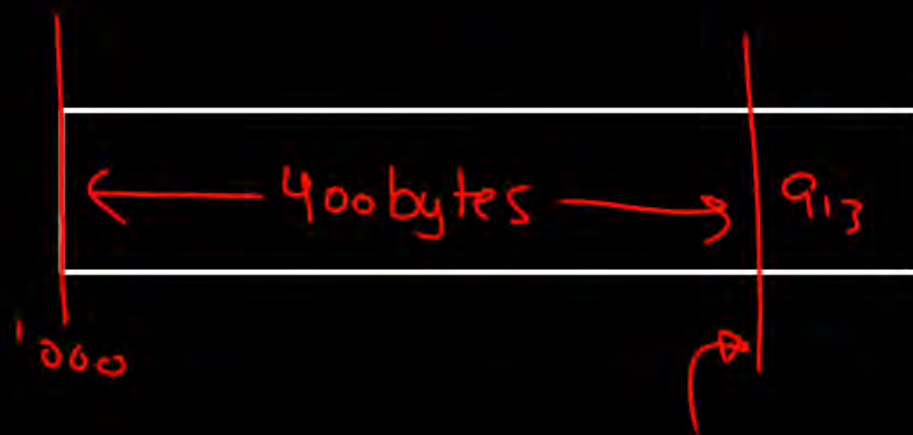
-7 to 2

$2 - (-7) + 1$

$= 10$ elem

Total element already filled $= 6 \times 15 + 10$
 $= 100$ elem.

Memory already filled $= 100 \times 4 = 400$ byte



$1000 + 400$
 $= 1400$

$a[-5..5][-7..7]$

a_{13}

rows already

filled

$-5 \text{ to } 0$
 $= 0 - (-5) + 1$
 $= 6 \text{ rows}$

\Rightarrow

-5
 -4
 -3
 -2
 -1
 0
 1
 2
 3
 4
 5

-7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7

a_{13}

$a[M][N]$

$\text{add}(a_{ij})$

① rows already filled before row with index

$i = 0 \text{ to } i-1$

$= i - 1 - 0 + 1$

$= i \text{ Rows}$

\Downarrow

$i \times N$
elements

(index)
② within i th row, elements already filled before a_{ij}

$= \text{col with index}$

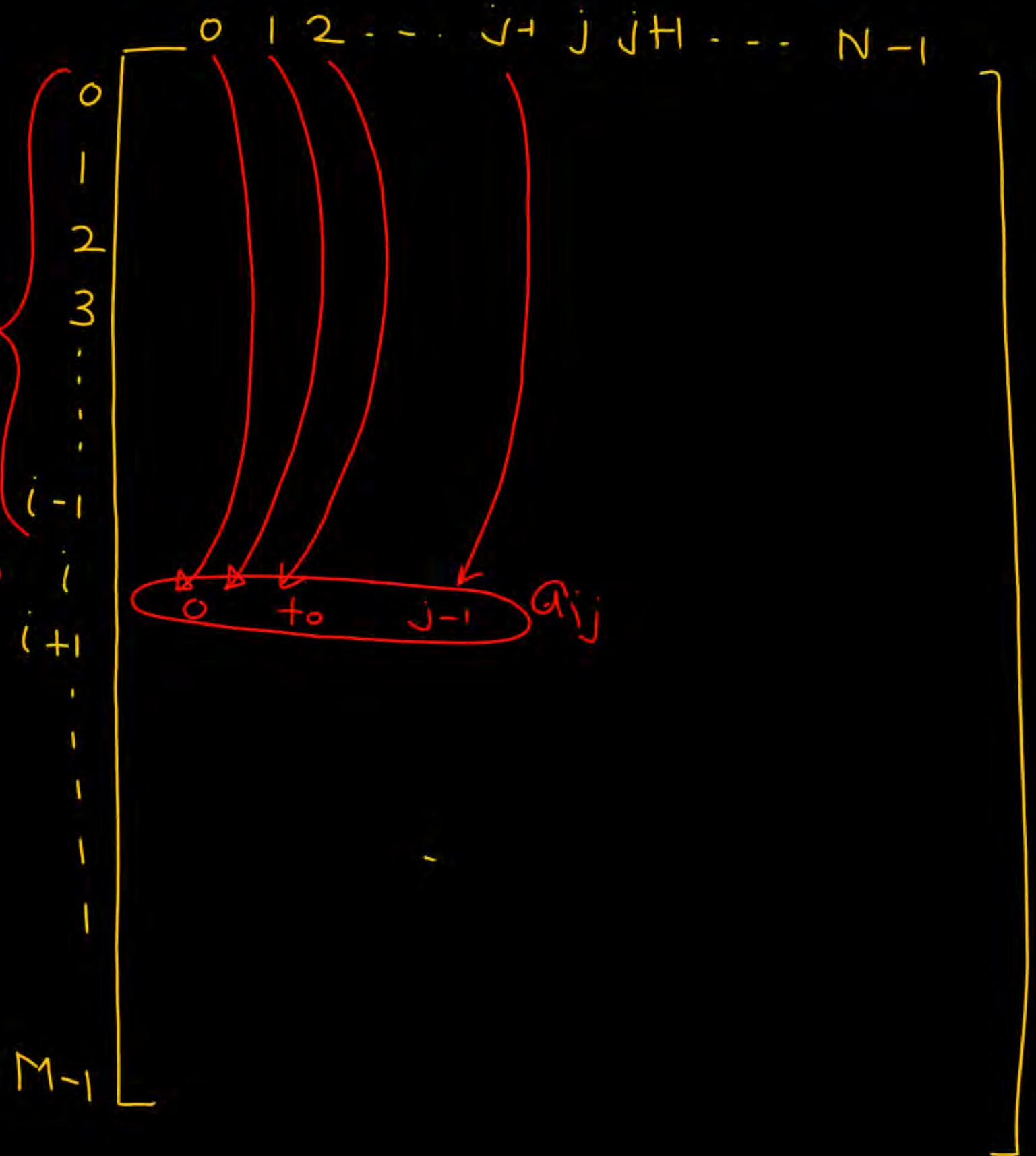
$0 \text{ to } j-1$

$= j - 1 - 0 + 1$

$= j \text{ elements}$

rows already filled

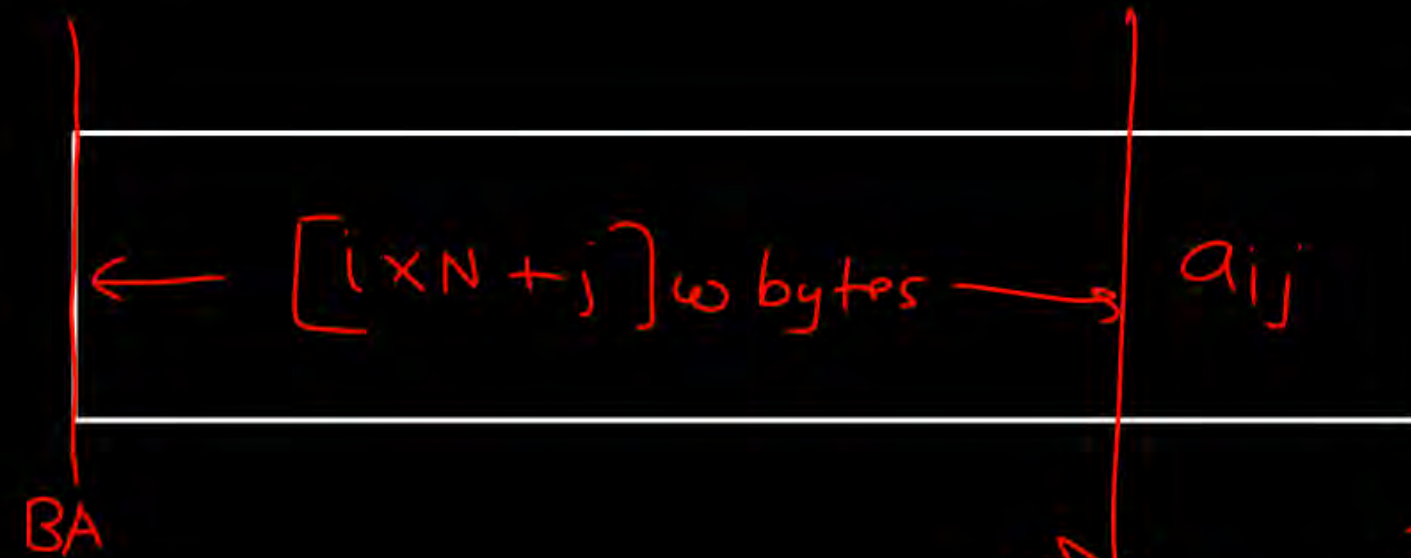
\Rightarrow



Total elem. already filled $= [i \times N + j]$

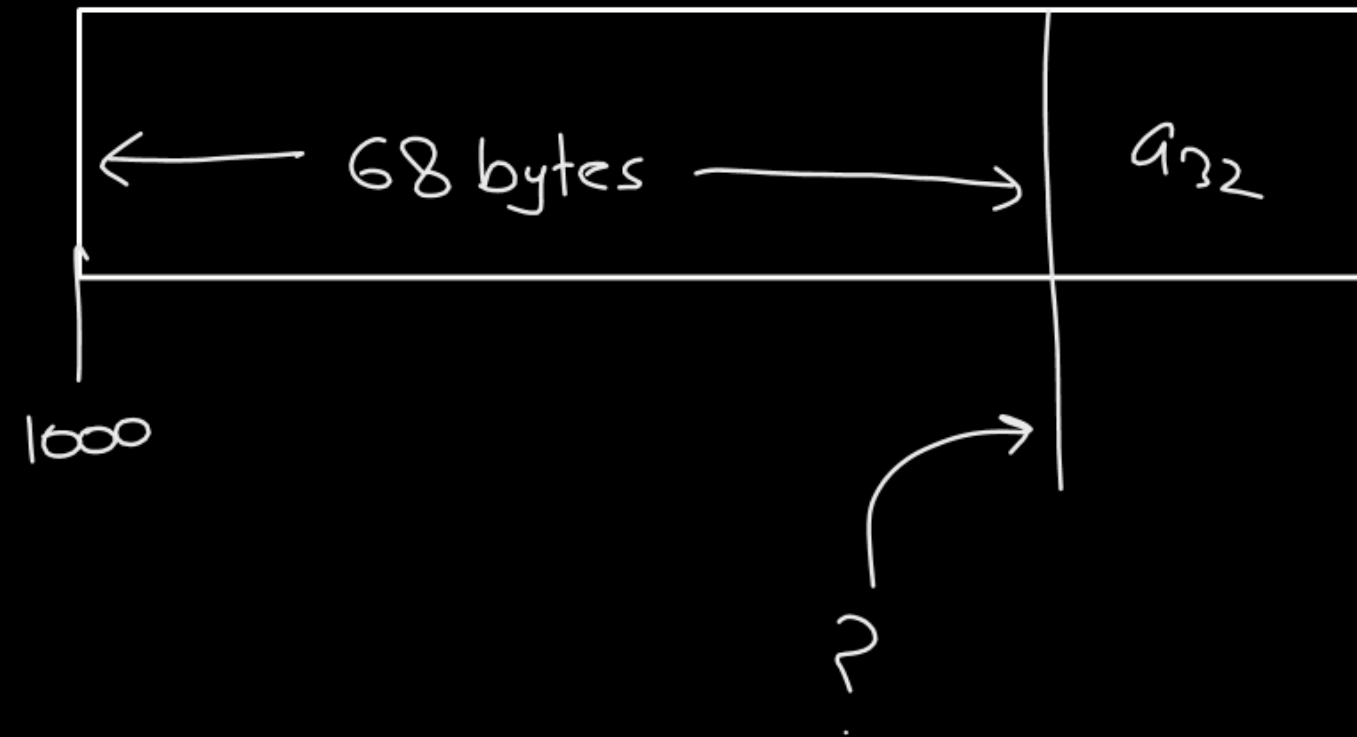
Size of each = w bytes

Memory already filled = $[i \times N + j] \times w$ bytes



$$\text{add}(a_{ij}) = \text{BA} + (i \times N + j) \times w$$

स्टैक 22 जगह है



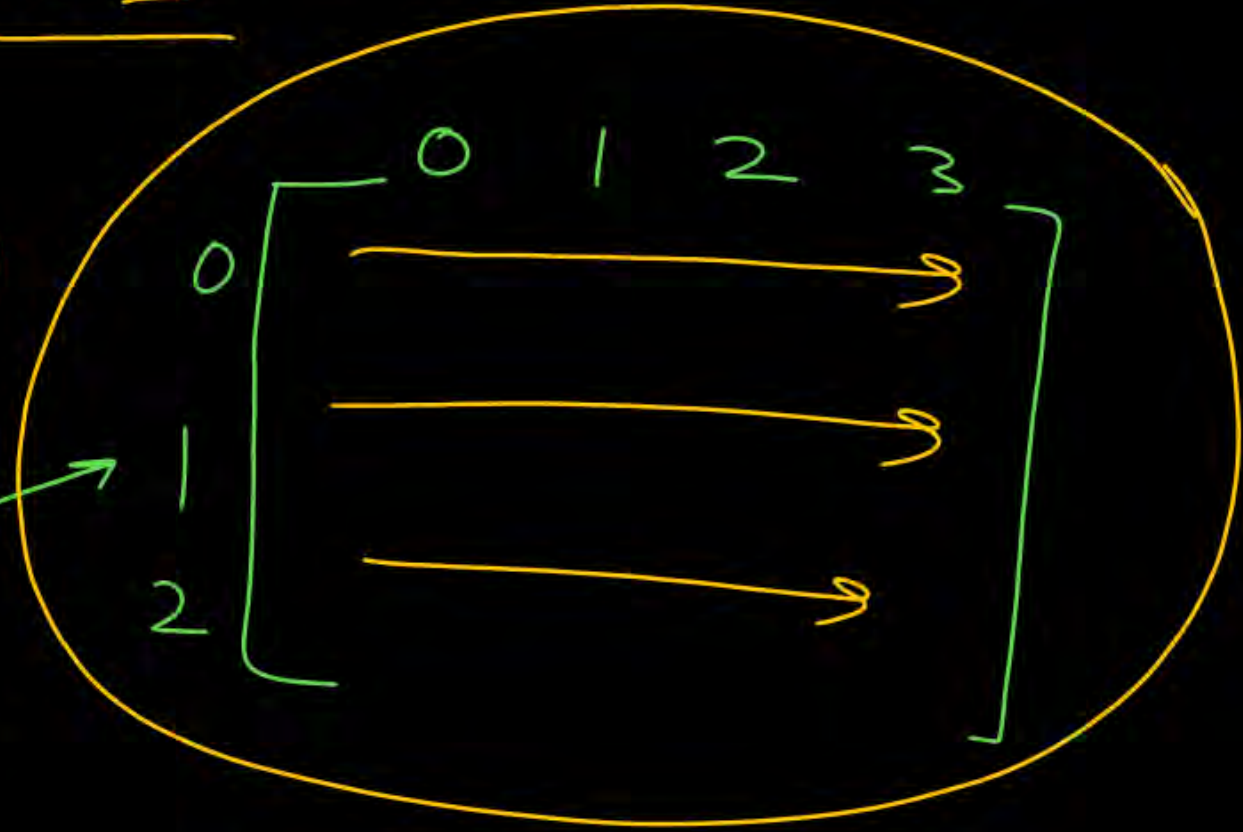
$$\Rightarrow 1000 + 68 = 1068$$

3-D Array

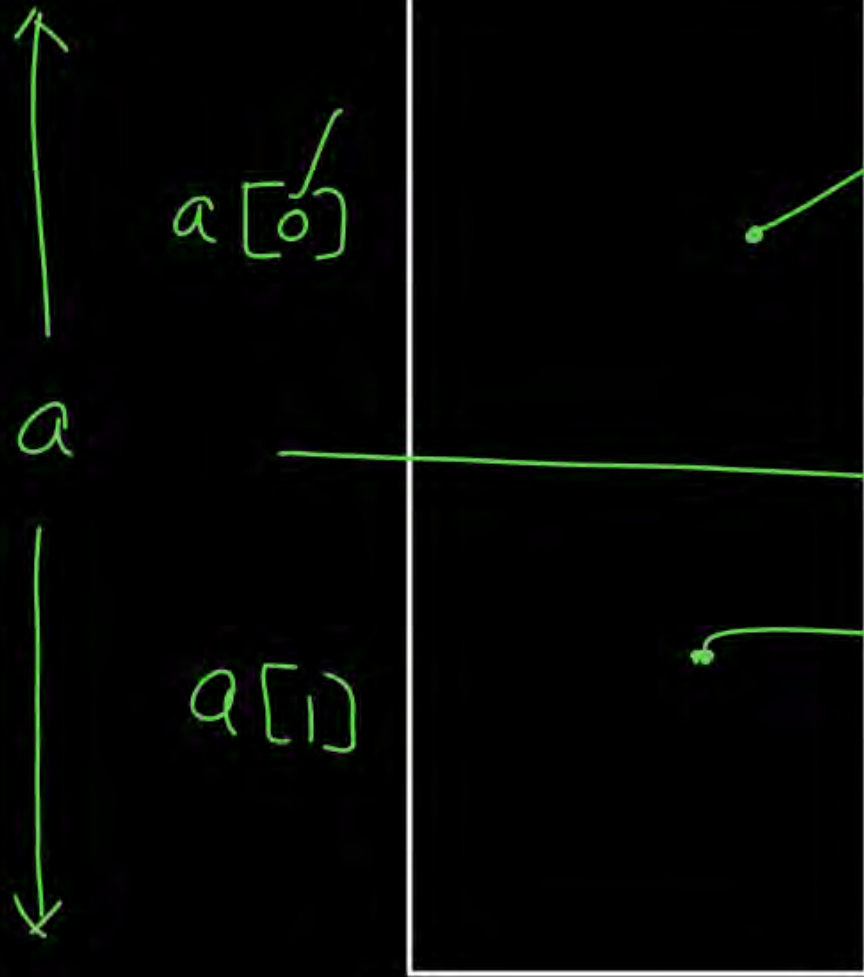
int a[2][3][4]

0 1

2-D array



a₀₀
a₀₁
a₀₂



$$\begin{array}{c} a[2][3][4] \\ \hline \text{dim} \end{array} \rightarrow$$

int a[3][4][5]

Every index in
this dimension
represent

$= 4 \times 5$

element

Every index/No.
in this dimension
represent

$= 5$ elements

Q

RMO

~~int~~

$w = 4$ byte

BA = 1000

add (a 2 2 3)

0 to 1

$1 - 0 + 1$

= 2

⇓

$2 \times 3 \times 5$

index
filled

= 0 to 1

= $1 - 0 + 1$

= 2

⇓

2×5

index

= 0 to 2

$2 - 0 + 1$

= 3 elements

a [3] [3] [5]

Σ 2 index

= 3×5

Σ 2 index

= 5

Total ele = $2 \times 3 \times 5 + 2 \times 5 + 3$

= 43 elements

Total memory
filled = $43 \times 4 = 172$ bytes

$1000 + 172$

1172

← 172 bytes →

$w = 2 \text{ byte}$
 $BA = 1000$

$A[-5 \dots 5] [-3 \dots 3] [-5 \dots 5]$

$\text{add}(A[0, 0, 0])$

Every
index
 $= 7 \times 11$

Every
index $= 11$

Total elements already filled

$$= (5 \times 7 \times 11 + 3 \times 11 + 5)$$

$$= 423 \text{ elements}$$

Memory already filled

$$= 423 \times 2$$

$$= 846 \text{ bytes}$$

1000



$$\Rightarrow 1000 + 846 = 1846$$

index filled $= -5 \text{ to } -1$
 $= -1 - (-5) + 1$
 $= 5$

\Downarrow
 $5 \times 7 \times 11$

index filled $= -3 \text{ to } -1$
 $= -1 - (-3) + 1$
 $= 3$

\Downarrow
 3×11

index filled $= -5 \text{ to } -1$
 $= -1 - (-5) + 1$
 $= 5$

$w = 2 \text{ bytes}$
 $BA = 1000$

$A[-5..5][-\overset{\textcircled{21}}{10}..\overset{\textcircled{7}}{10}][-\overset{\textcircled{7}}{3}..\overset{\textcircled{11}}{3}][-\overset{\textcircled{11}}{5}..5]$

$\text{add}(A_{0213})$

$21 \times 7 \times 11$

7×11

11

Total elements

$$= 5 \times 21 \times 7 \times 11$$

$$+ 12 \times 7 \times 11$$

$$+ 4 \times 11$$

$$+ 8$$

$$= 105 \times 11 \times 7 \Rightarrow 735 \times 11$$

$$+ 88 \times 11$$

$$+ 8$$

$$= 9061 \text{ elem.}$$

$$\begin{array}{r} 1 \\ 8230 \\ 823 \\ \hline 9053 \\ +8 \\ \hline 9061 \\ \hline 823 \times 11 \\ +8 \end{array}$$

$-5 \text{ to } -1$

$$= -1 - (-5) + 1$$

$$= 5$$

\Downarrow

$5 \times 21 \times 7 \times 11$
elem

$-10 \text{ to } 1$

$$= 1 - (-10) + 1$$

$$= 12$$

\Downarrow

$12 \times 7 \times 11$

$-3 \text{ to } 0$

$$= 0 - (-3) + 1$$

$$= 4$$

\Downarrow

4×11

$-5 \text{ to } 2$

$$= 2 - (-5) + 1$$

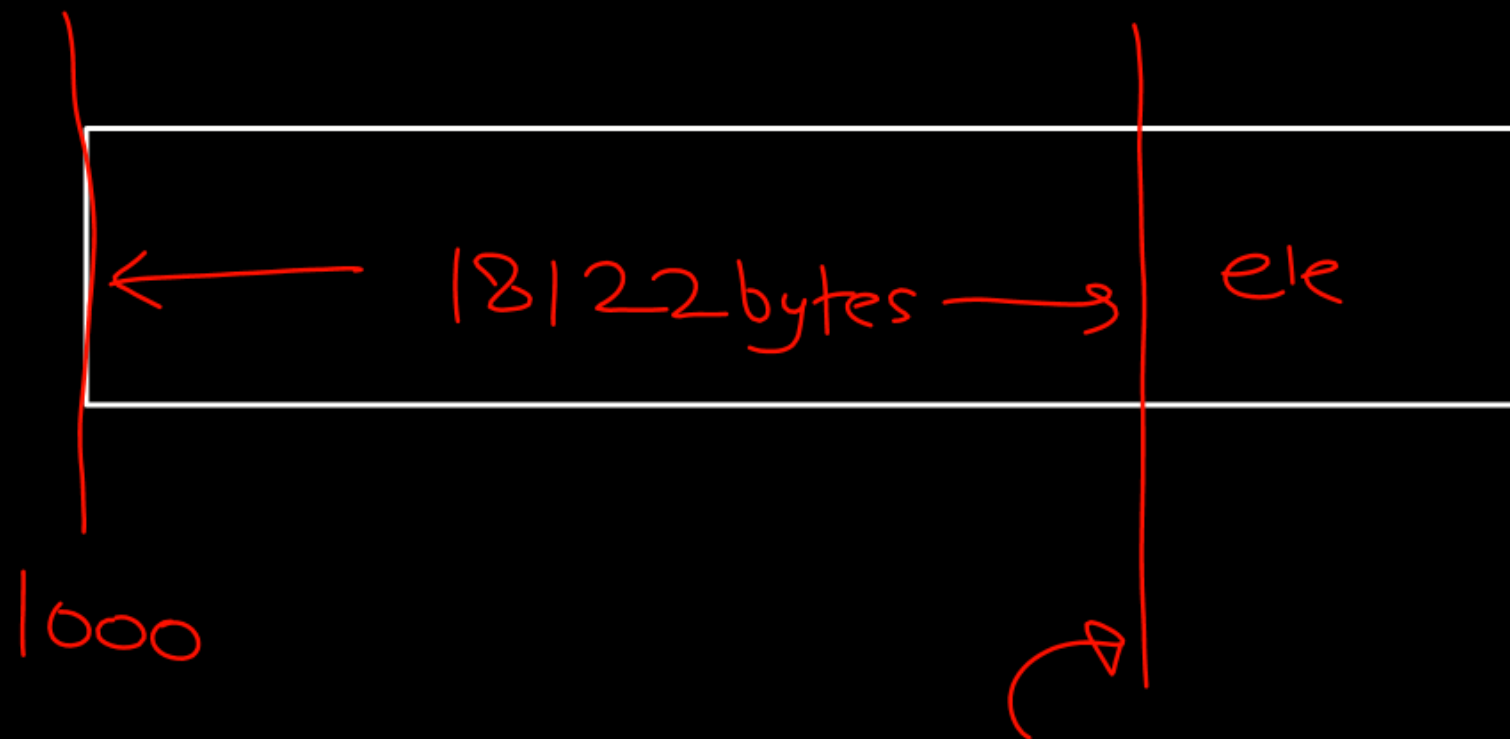
$$= 8$$

Ex Programmer
RMO CMO

$$\text{Memory} = 9061 \times 2 \\ \Rightarrow 18122 \text{ bytes}$$

RMO
↓
2-D ✓

Page fault
Cache
↓
Hit miss



19122

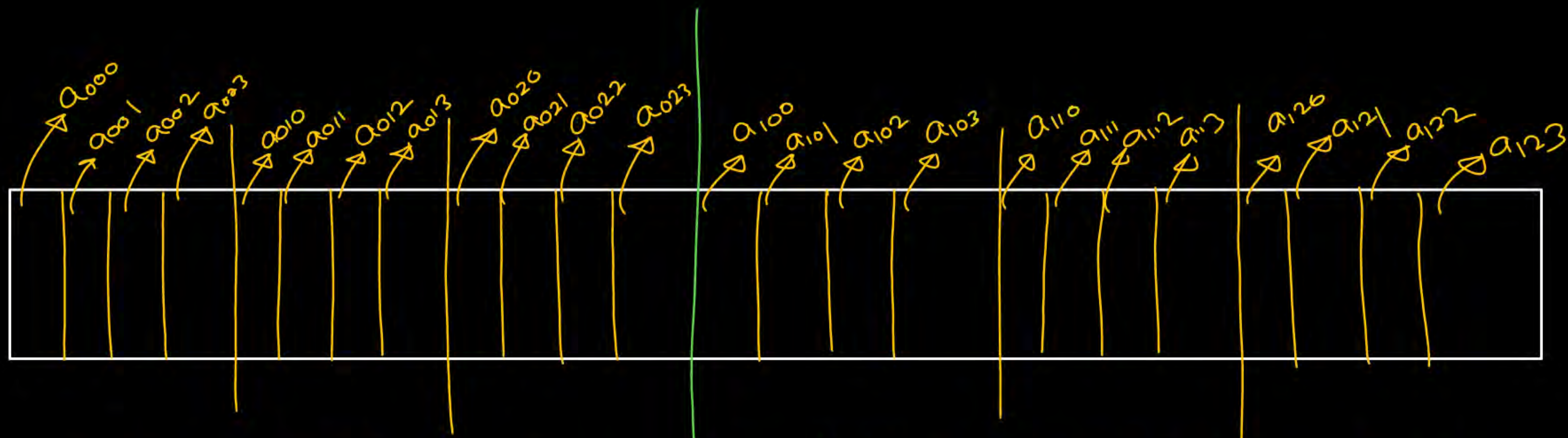


Diagram illustrating the indexing of the 2D array a :

- Row $a[0]$ contains elements $a[0][0], a[0][1], a[0][2], \dots$
- Row $a[1]$ contains elements $a[1][0], a[1][1], a[1][2], \dots$
- Row $a[2]$ contains elements $a[2][0], a[2][1], a[2][2], \dots$

The array is organized into three groups of 4 columns each, corresponding to rows $a[0]$, $a[1]$, and $a[2]$.

000, 001, 002, 003
010, 011, 012, 013
020, 021, 022, 023

100, 101, 102, 103,
110, 111, 112, 113
120, 121, 122, 123

