Applications of Pointers (1A)

Young Won Lim
10/2/18

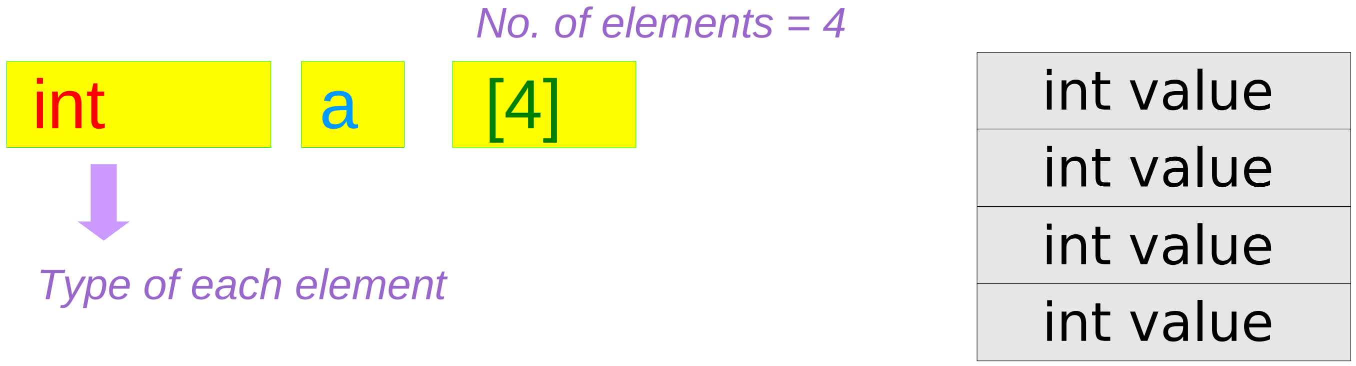
Please send corrections (or suggestions) to youngwlim@hotmail.com.
This document was produced by using LibreOffice.

Array of Pointers

Array of Pointers

```
int       a [4];

int *     b [4];
```

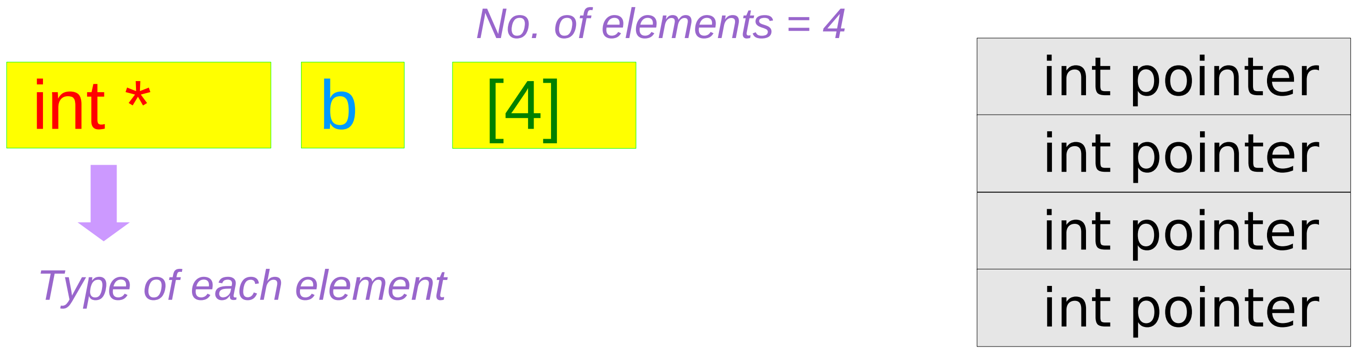


No. of elements = 4

int a [4]

Type of each element

int value
int value
int value
int value



No. of elements = 4

int * b [4]

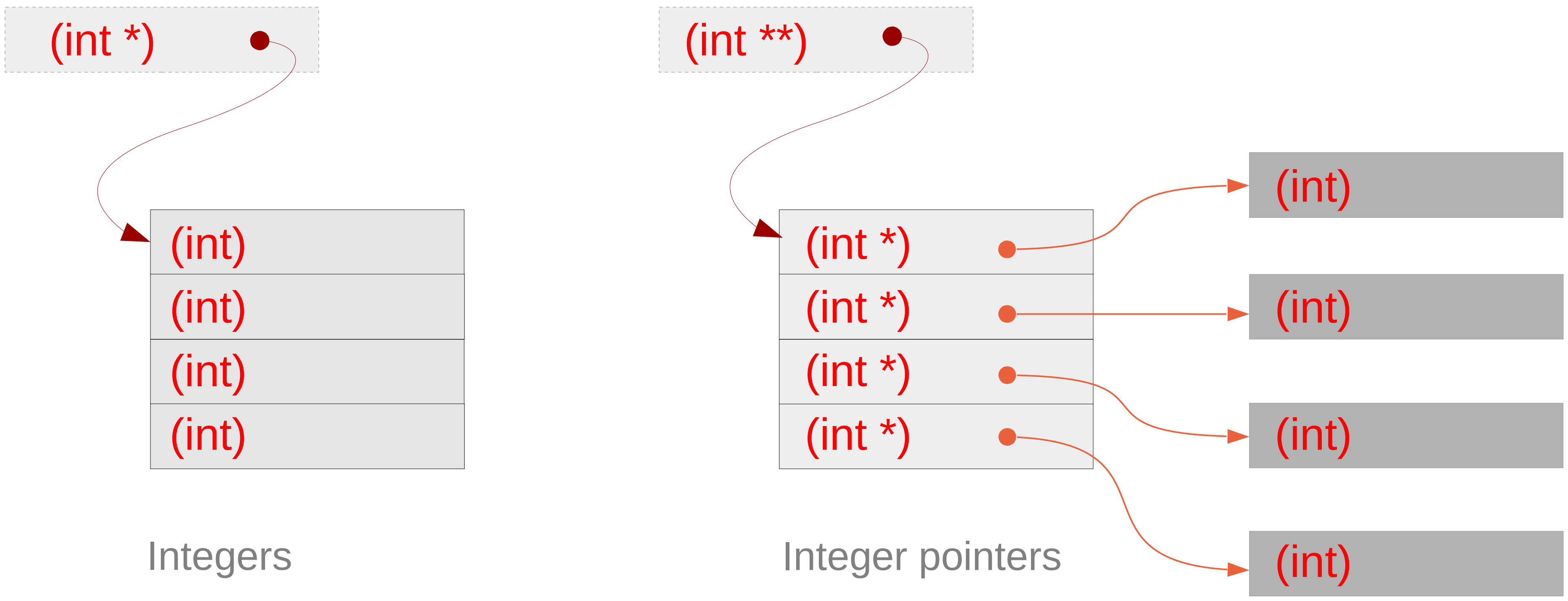
Type of each element

int pointer
int pointer
int pointer
int pointer

Array of Pointers – a type view

int a [4];

int * b [4];



Integers

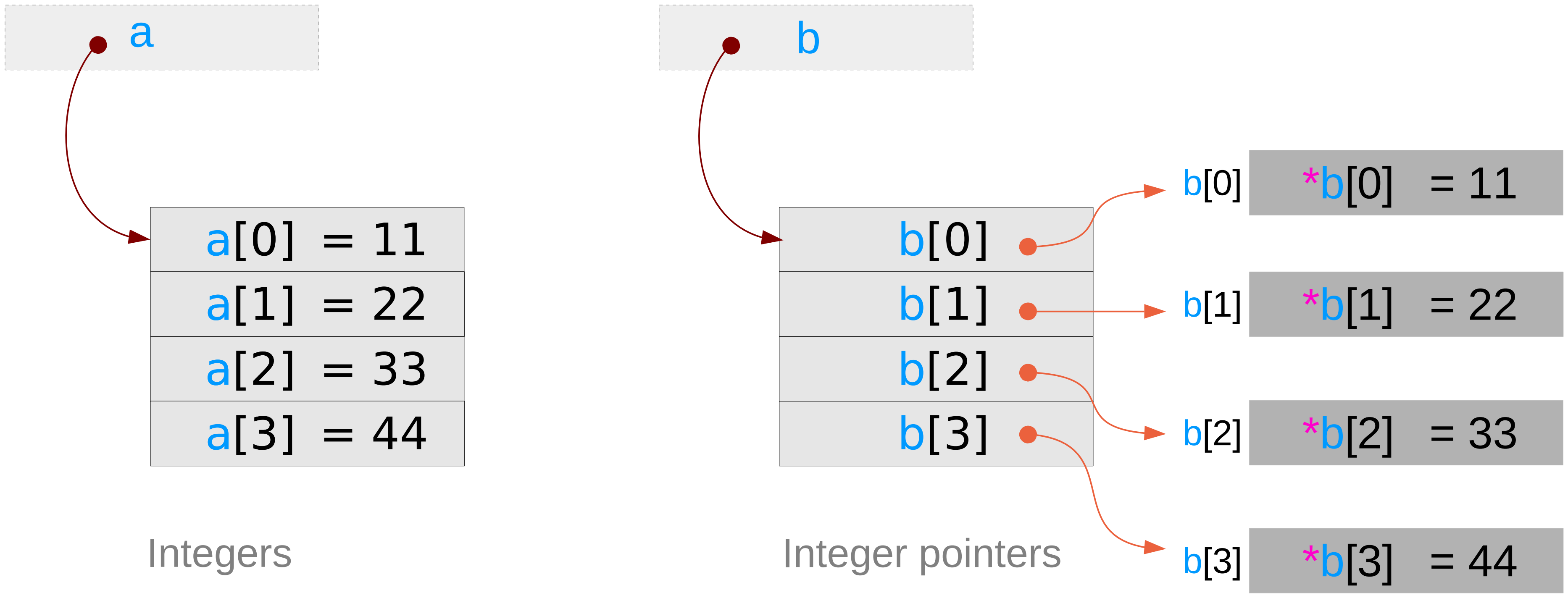
Integer pointers

taking actual memory locations

Array of Pointers – a variable view

int a [4];

int * b [4];



a

a[0] = 11
a[1] = 22
a[2] = 33
a[3] = 44

Integers

b

b[0]
b[1]
b[2]
b[3]

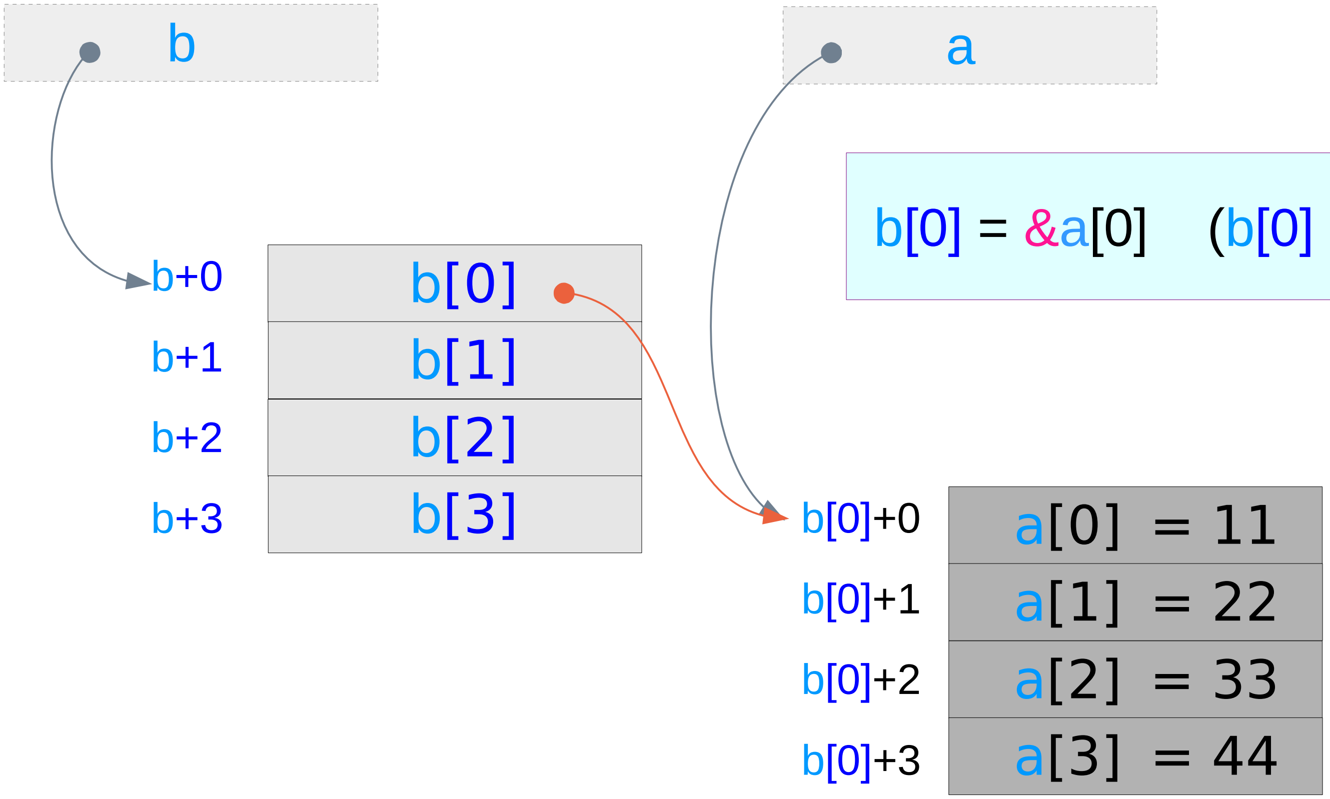
Integer pointers

b[0] *b[0] = 11
b[1] *b[1] = 22
b[2] *b[2] = 33
b[3] *b[3] = 44

Array of Pointers – assigning a **1-d** array name

```
int *    b [4];
```

```
int      a [4];
```



b[0] = &a[0]   (b[0] = a)

Array of Pointers – an extended dimension

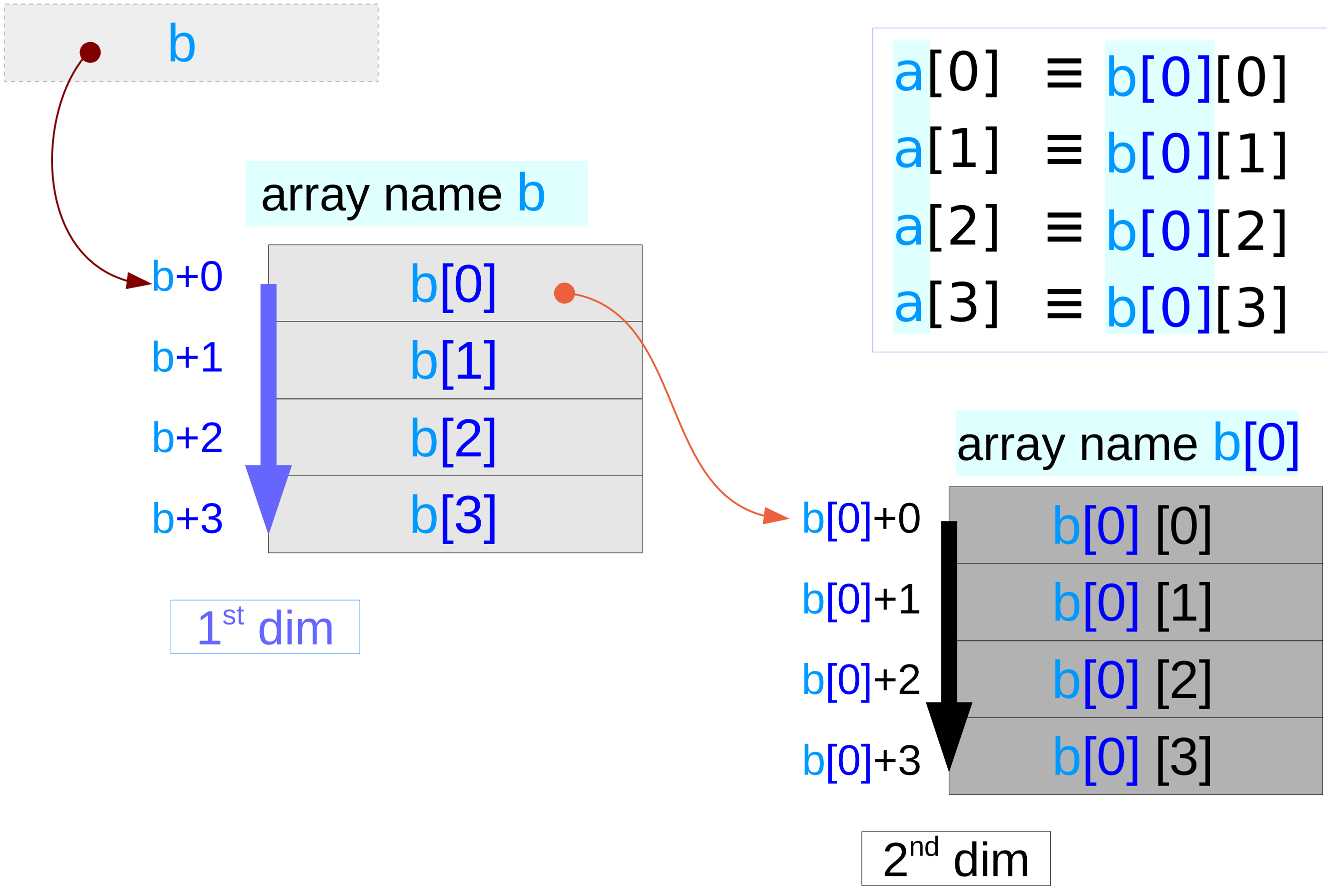
```
int *     b [4];
```

assignment

b[0] = a

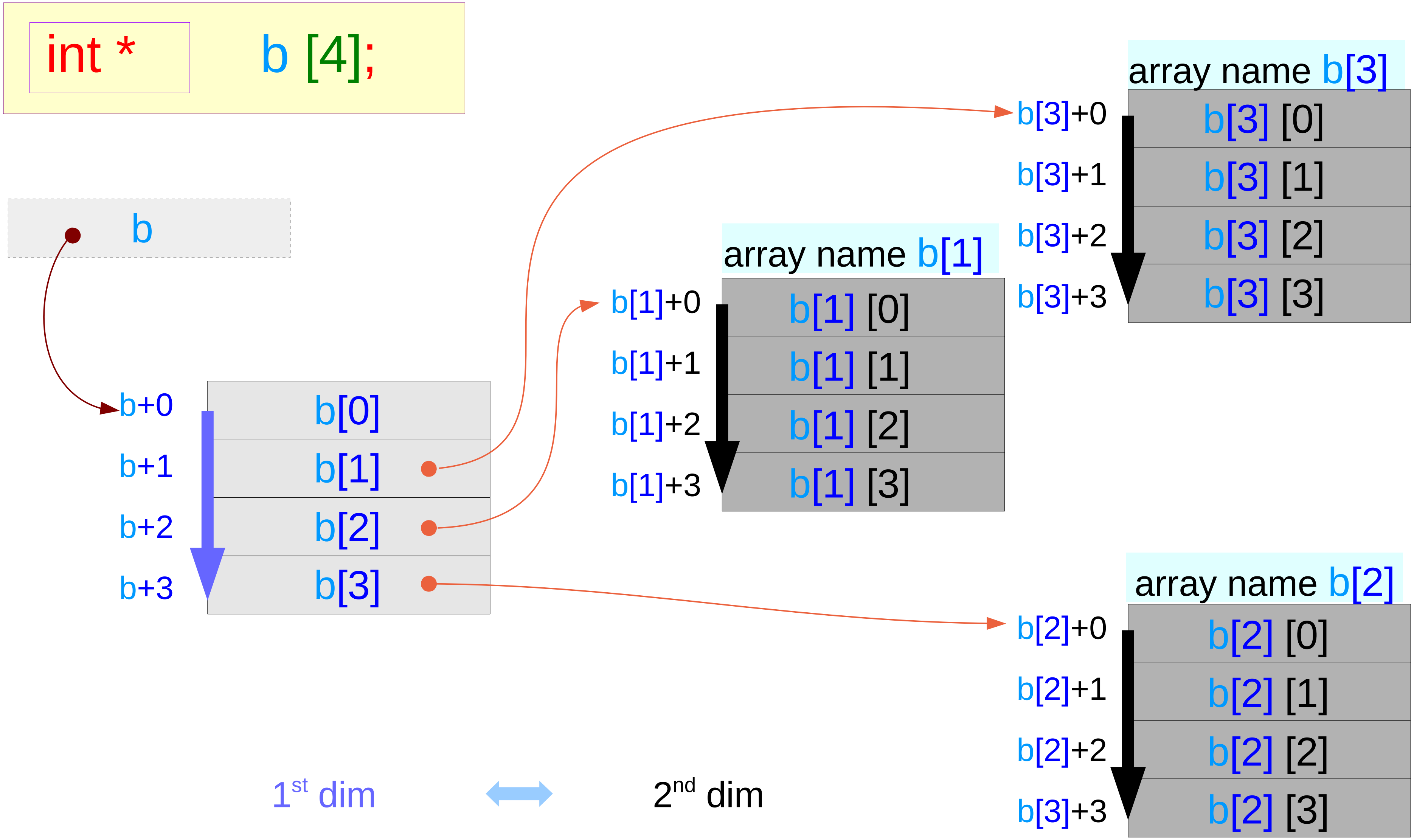
equivalence

a[0]	≡	b[0][0]	≡	*(*(b+0)+0)
a[1]	≡	b[0][1]	≡	*(*(b+0)+1)
a[2]	≡	b[0][2]	≡	*(*(b+0)+2)
a[3]	≡	b[0][3]	≡	*(*(b+0)+3)



Array of Pointers – assigning other **1-d** array names

```
int *      b [4];
```



2-d access of a **1-d** array – using a pointer array

```
int *      b [4];
```

```
int        a [4*4];
```

```
b[0] = &a[0*4]    (b[0] = a+  0)
b[1] = &a[1*4]    (b[1] = a+  4)
b[2] = &a[2*4]    (b[2] = a+  8)
b[3] = &a[3*4]    (b[3] = a+12)
```

2-d access of a **1-d** array

```
b[i][j]      ≡ *(*(b+i)+j)

a[i*4+j]  ≡ *(a + i*4+j)
```

1-d access of a **1-d** array

3-d access of a 1-d array – using pointer arrays

```
int        a [4*4*4];
int *      b [4*4];
int **     c [4];
```

→

```
a[i]          ≡ *(a+i)
b[i][j]       ≡ *(*(b+i)+j)
c[i][j][k]    ≡ *(*(*(c+i)+j)+k)
```

```
*(b+i) = b[i]    ↔    a

*(c+i) = c[i]    ↔    b
```

3-d access of a **1-d** array – pointer array assignment

```
int       a [4*4*4];
int *     b [4*4];
int **    c [4];
```

```
a[i]       ≡ *(a+i)
b[i][j]    ≡ *(*(b+i)+j)
c[i][j][k] ≡ *(*(*(c+i)+j)+k)
```

```
for (i=0; i<4; ++i)
    c[i] = &b[i*4];

for (i=0; i<4; ++i)
    b[i] = &a[i*4]
```

3-d access of a **1-d** array

```
c[i][j][k] ≡
a[i*M*N+j*N+k] ≡
a[(i*M + j)*N+k]
```

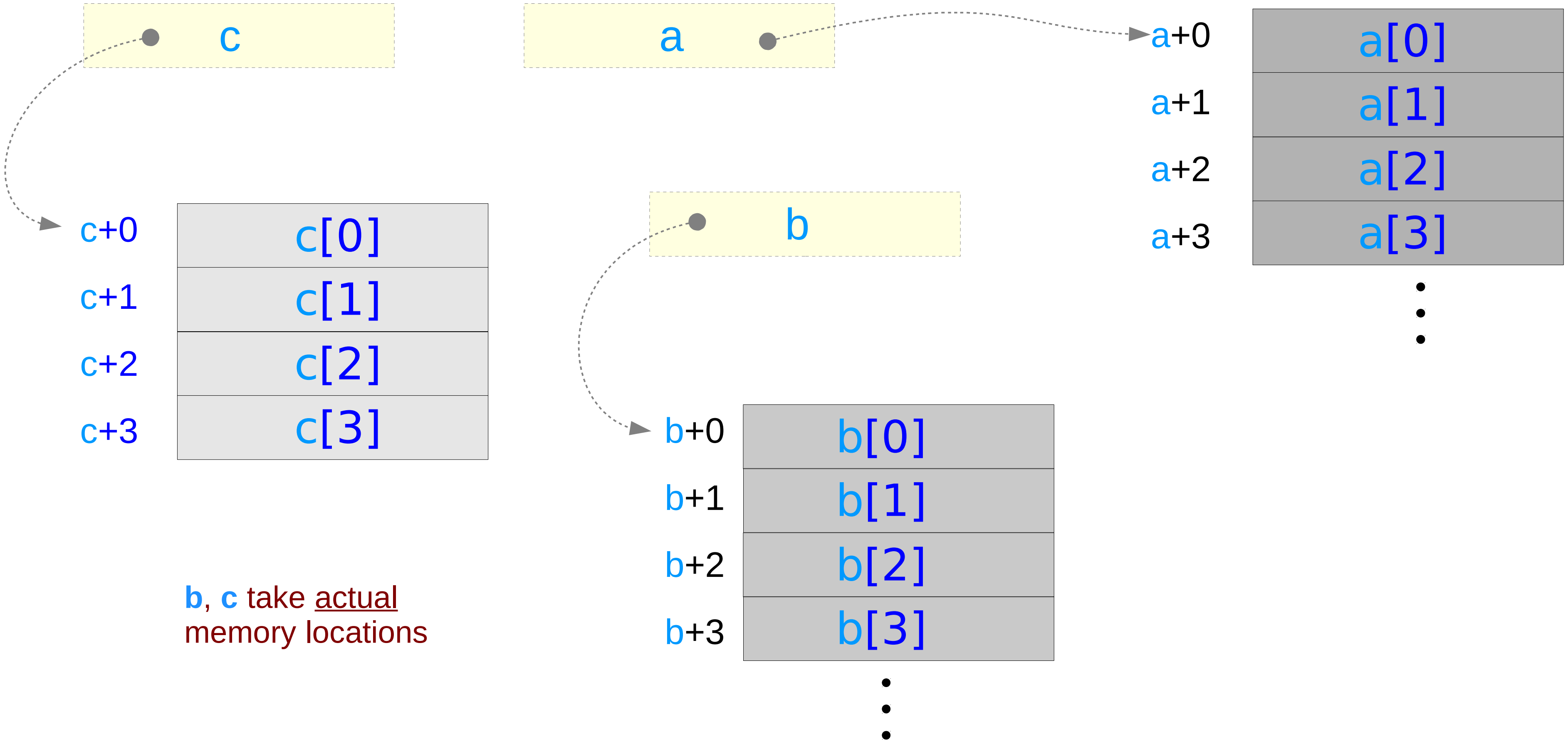
1-d access of a **1-d** array

Initialization of pointer arrays b and c

3-d Array – using pointer arrays **b**, **c**

```
int **    c [4];
int *     b [4*4];
```

```
int       a [4*4*4];
```

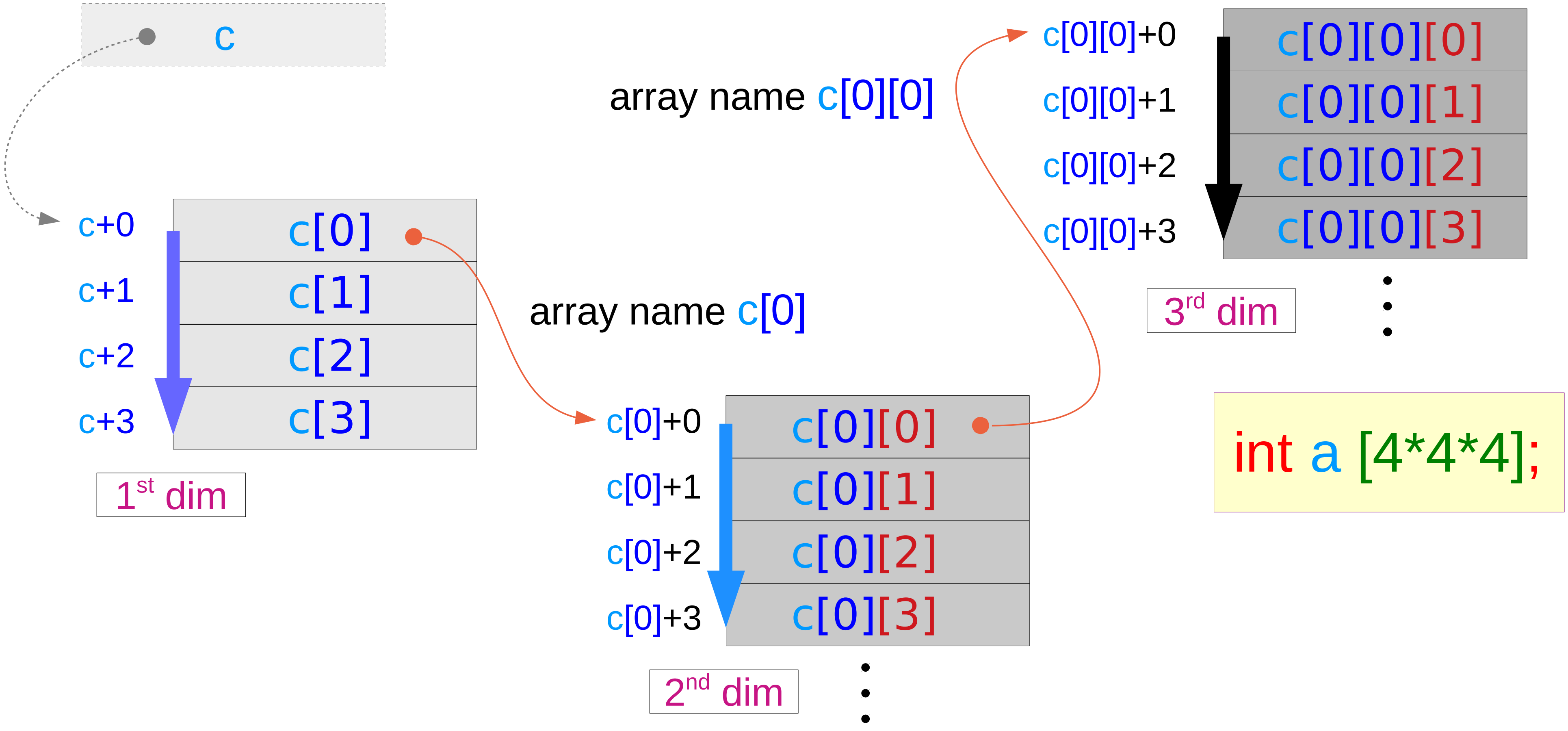


b, **c** take actual memory locations

3-d Array – pointer arrays extend dimensions

```
int **    c [4];
int *     b [4*4];
```

```
c[0] = b;      (c[0] = &b[0];)
b[0] = a;      (b[0] = &a[0];)
```



```
int a [4*4*4];
```

Using recursive pointers and brackets

c[i][j][k]	➡	*(c[i][j] +k)	X[k] = *(X+k)
*(c[i][j] +k)	➡	*(*(c[i] +j) +k)	Y[j] = *(Y+j)
((c[i] +j) +k)	➡	*(*(*(c +i) +j) +k)	Z[i] = *(Z+i)

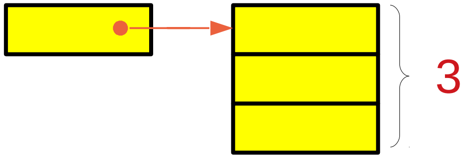
c[i][j][k]	⬌	*(*(*(c+i)+j)+k)

Initializing two **1-d** pointer arrays **b**, **c**

```
int     a [2*3*4];
int*    b [2*3];
int**   c [2];
```

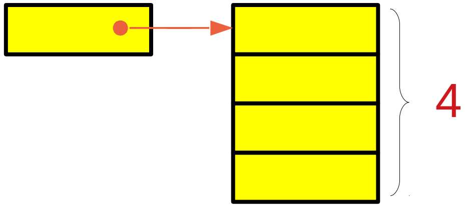
```
c[0] = &b[0*3];
c[1] = &b[1*3];
```

```
int c[2];
int b[2*3];
```



```
b[0] = &a[0*4];
b[1] = &a[1*4];
b[2] = &a[2*4];
b[3] = &a[3*4];
b[4] = &a[4*4];
b[5] = &a[5*4];
```

```
int b[2*3];
int a[2*3*4];
```



Initialization of pointer arrays – a general case

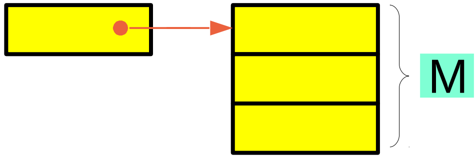
```
int      a [L*M*N];
```

```
int*     b [L*M];
int**    c [L];
```

pointer arrays b, c

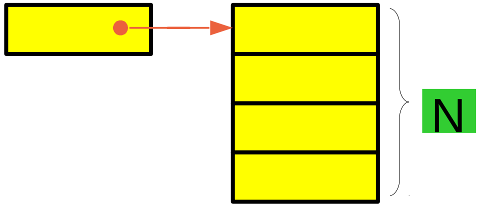
```
int **     c[L];
int *      b[L*M];
```

```
for (i=0; i<L; ++i)
      c[i] = &b[i*M];
```



```
int *      b[L*M];
int        a[L*M*N];
```

```
for (j=0; j<L*M; ++j)
      b[j] = &a[j*N];
```

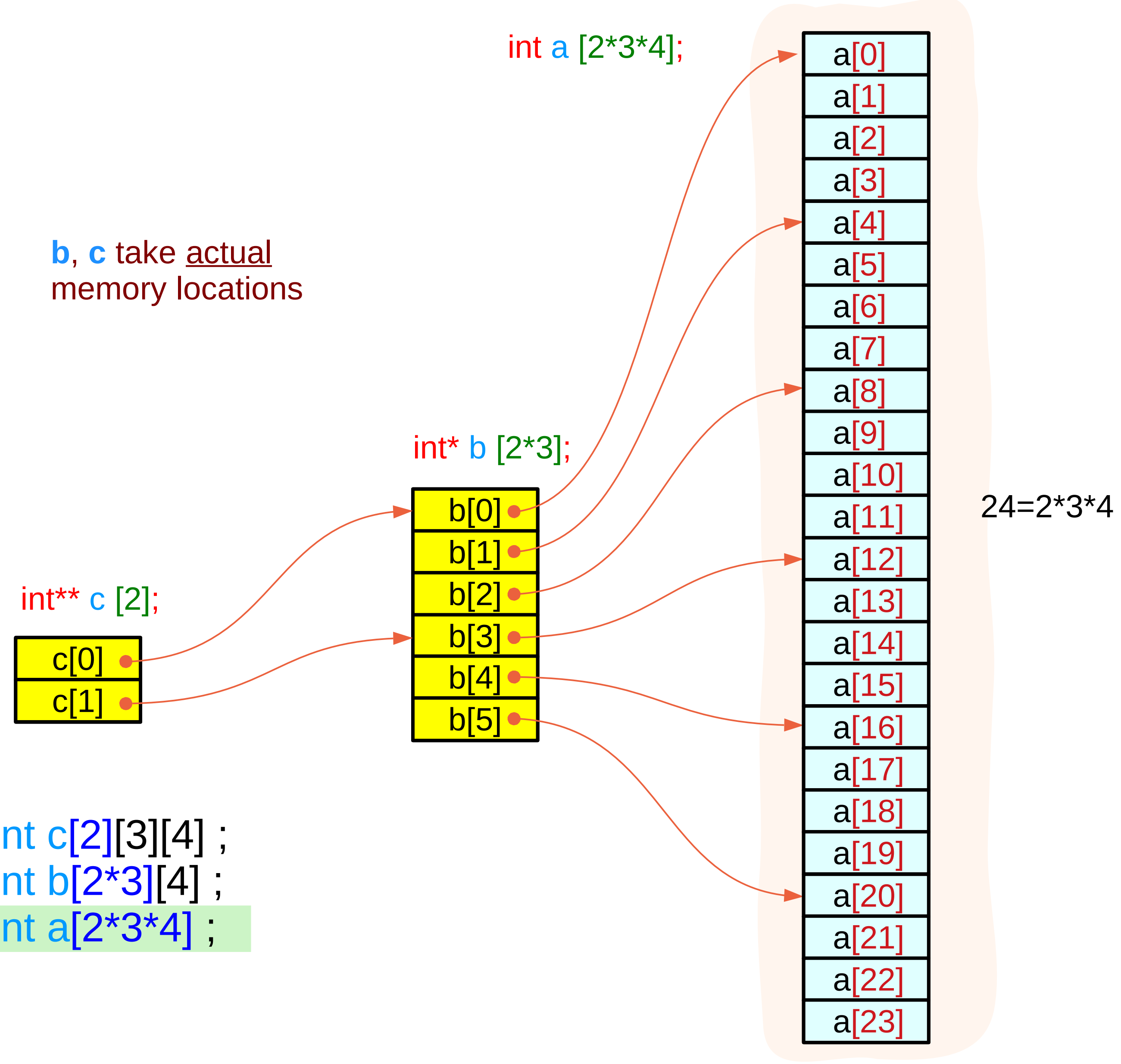


```
int      c [L][M][N];
```

Accessing the array **a** as a **1-d** array

```
int      a [2*3*4];
int*     b [2*3];
int**    c [2];
```

```
int      a [24];
```



b, **c** take <u>actual</u> memory locations

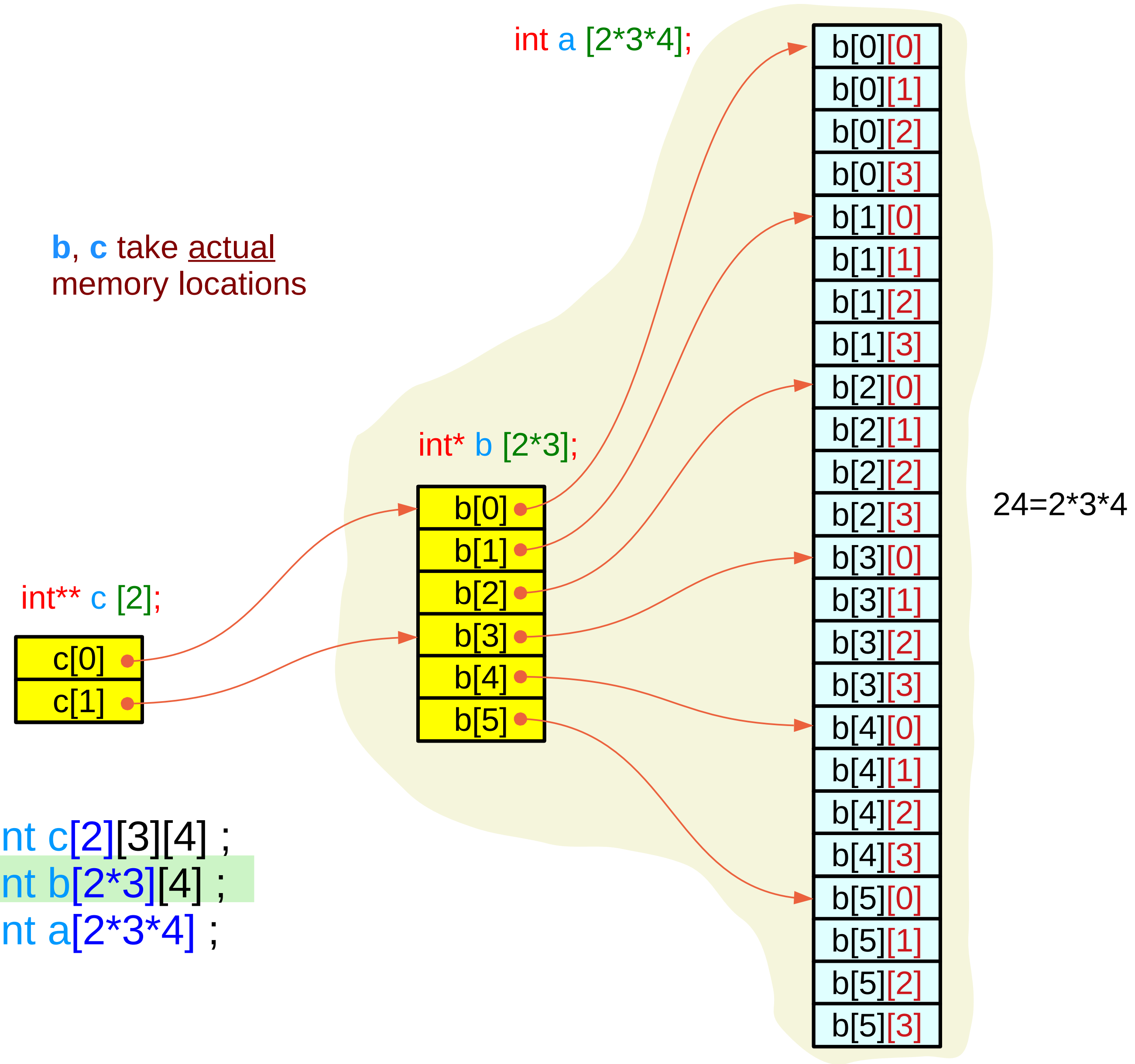
```
c[i][j][k]   ≡ *(*(*(c+i)+j)+k)     int c[2][3][4] ;
b[i][j]      ≡ *(*(b+i)+j)          int b[2*3][4] ;
a[i]         ≡ *(a+i)               int a[2*3*4] ;
```

Accessing the array **a** as a **2-d** array using **b**

```
int     a [2*3*4];
int*    b [2*3];
int**   c [2];
```

```
int     b [6][4];
```

b, **c** take actual memory locations



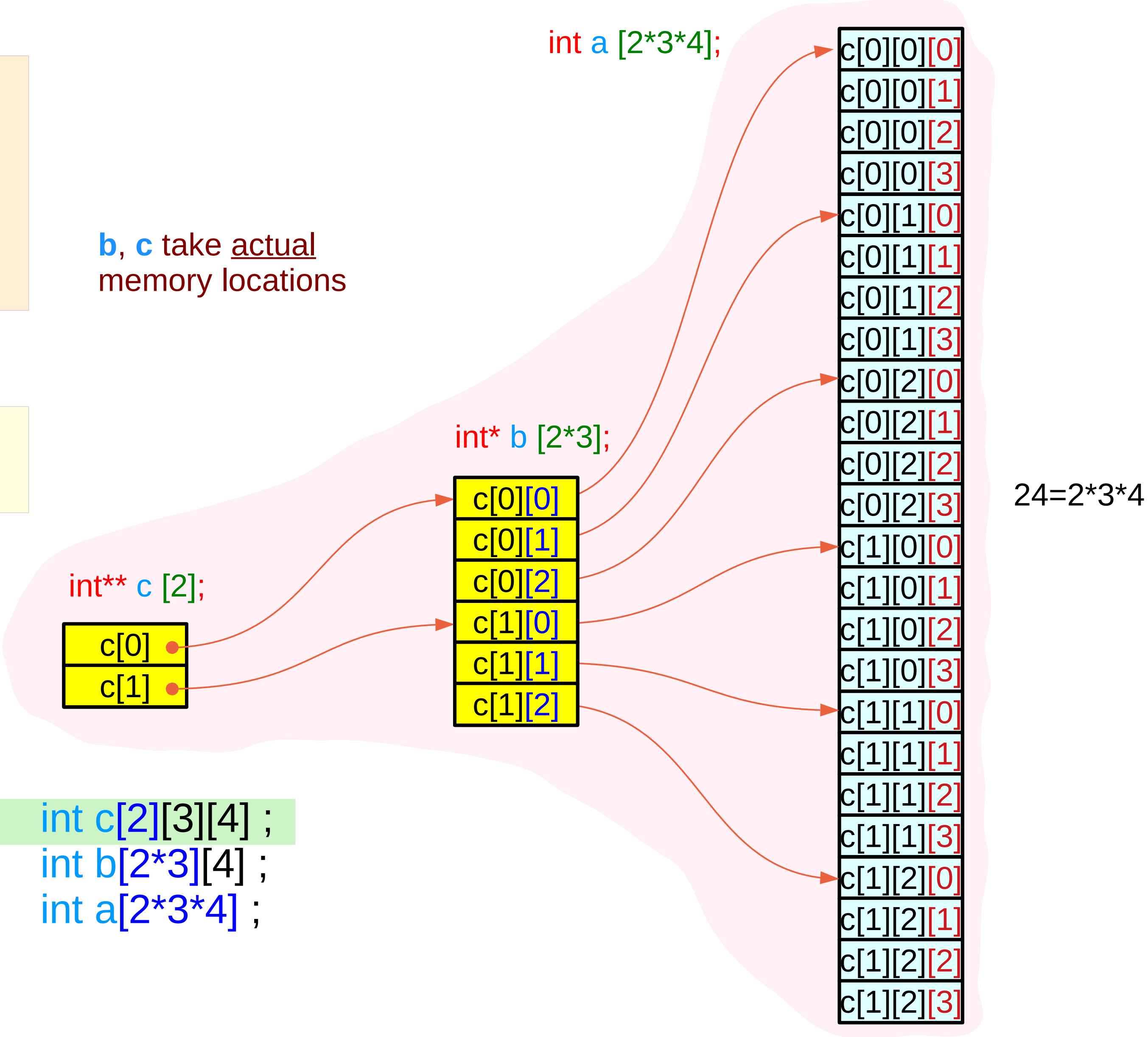
c[i][j][k]	≡ *(*(*(c+i)+j)+k)	int c[2][3][4] ;
b[i][j]	≡ *(*(b+i)+j)	int b[2*3][4] ;
a[i]	≡ *(a+i)	int a[2*3*4] ;

Accessing the array **a** as a **3-d** array using **c**

```
int     a [2*3*4];
int*    b [2*3];
int**   c [2];
```

```
int     c [2][3][4];
```

b, **c** take actual memory locations



c[i][j][k]	≡ *(*(*(c+i)+j)+k)	int c[2][3][4] ;
b[i][j]	≡ *(*(b+i)+j)	int b[2*3][4] ;
a[i]	≡ *(a+i)	int a[2*3*4] ;

Array names of **2-d** and **1-d** sub-arrays

```
int      a [2*3*4];
int*     b [2*3];
int**    c [2];
```

```
int      c [2][3][4];
```

c[0] array name of a 2-d array [M][N]
c[1] array name of a 2-d array [M][N]

```
                                      starting elements
    c[0][0][0] = a[0*M*N]             &c[0][0][0] = c[0][0]
    c[1][0][0] = a[1*M*N]             &c[1][0][0] = c[1][0]
```

c[0][0] array name of a 1-d array [N]
c[0][1] array name of a 1-d array [N]
c[0][2] array name of a 1-d array [N]
c[1][0] array name of a 1-d array [N]
c[1][1] array name of a 1-d array [N]
c[1][2] array name of a 1-d array [N]

```
                                      starting elements
    c[0][0][0] = a[(0*M+0)*N]         &c[0][0][0] = c[0][0]
    c[0][1][0] = a[(0*M+1)*N]         &c[0][1][0] = c[0][1]
    c[0][2][0] = a[(0*M+2)*N]         &c[0][2][0] = c[0][2]
    c[1][0][0] = a[(1*M+0)*N]         &c[1][0][0] = c[1][0]
    c[1][1][0] = a[(1*M+1)*N]         &c[1][1][0] = c[1][1]
    c[1][2][0] = a[(1*M+2)*N]         &c[1][2][0] = c[1][2]
```

Starting element Index

```
int     a [L*M*N];
int*    b [L*M];
int**   c [L];
```

```
int     c [L][M][N];
```

L=2	i=0
	i=1
		i*3*4 = 0
		i*3*4 = 12

M=3	j=0
	j=1
	j=2
		j*4 = 0
		j*4 = 4
		j*4 = 8

N=4	k=0
	k=1
	k=2
	k=3
		k*1= 0
		k*1= 1
		k*1= 2
		k*1= 3

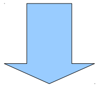
```
c[0][0][0] = a[ 0]        0
c[1][0][0] = a[12]        12

c[0][0][0] = a[ 0]         0+0
c[0][1][0] = a[ 4]         0+4
c[0][2][0] = a[ 8]         0+8
c[1][0][0] = a[12]        12+0
c[1][1][0] = a[16]        12+4
c[1][2][0] = a[20]        12+8
```

c[0][0][0]	a[0]
c[0][0][1]	a[1]
c[0][0][2]	a[2]
c[0][0][3]	a[3]
c[0][1][0]	a[4]
c[0][1][1]	a[5]
c[0][1][2]	a[6]
c[0][1][3]	a[7]
c[0][2][0]	a[8]
c[0][2][1]	a[9]
c[0][2][2]	a[10]
c[0][2][3]	a[11]
c[1][0][0]	a[12]
c[1][0][1]	a[13]
c[1][0][2]	a[14]
c[1][0][3]	a[15]
c[1][1][0]	a[16]
c[1][1][1]	a[17]
c[1][1][2]	a[18]
c[1][1][3]	a[19]
c[1][2][0]	a[20]
c[1][2][1]	a[21]
c[1][2][2]	a[22]
c[1][2][3]	a[23]

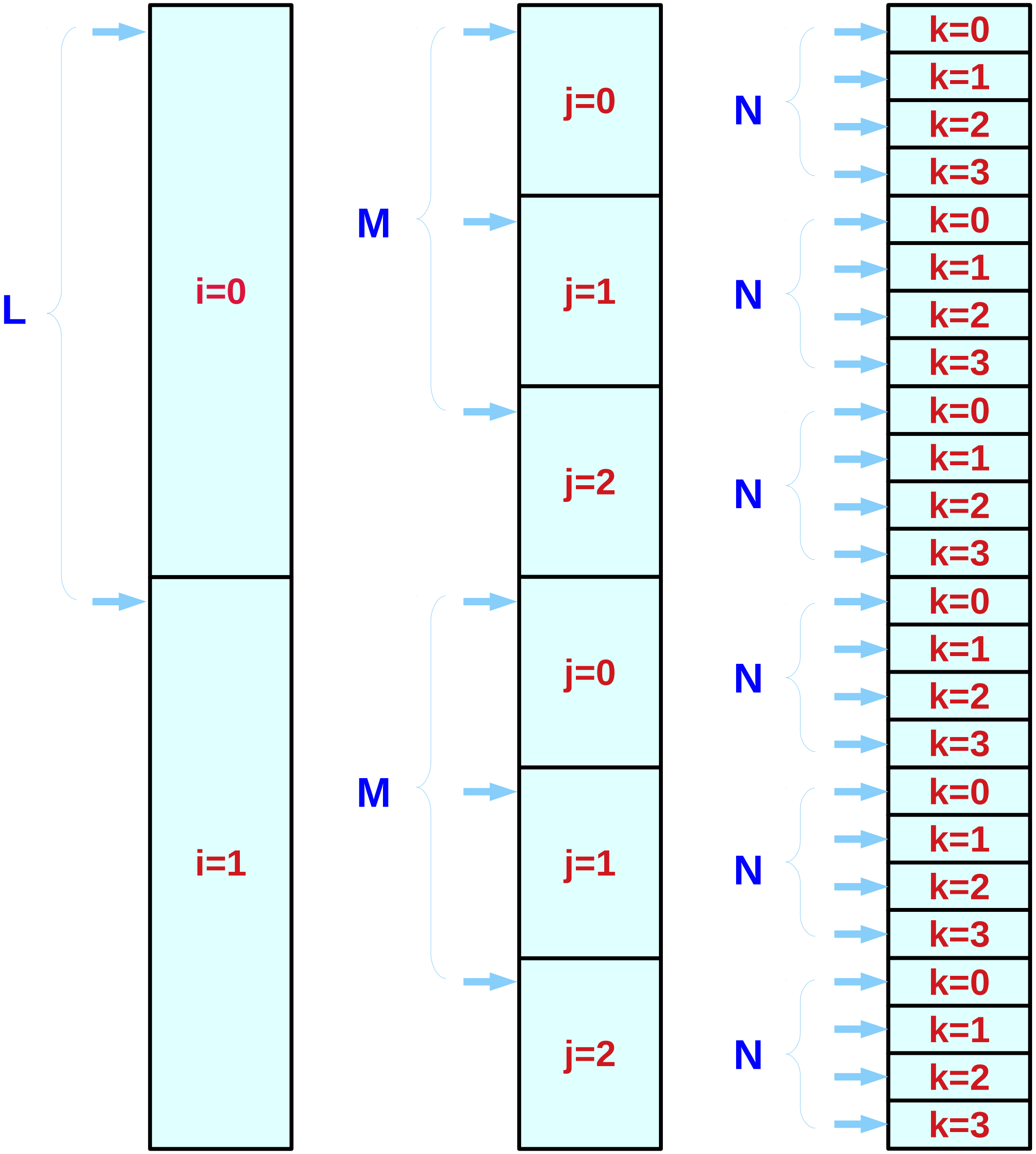
L, M, N – the number of index values

```
int     a [L*M*N];
int*    b [L*M];
int**   c [L];
```



```
int     c [L][M][N];
```

L	M	N
i [0..L-1]	j [0..M-1]	k [0..N-1]

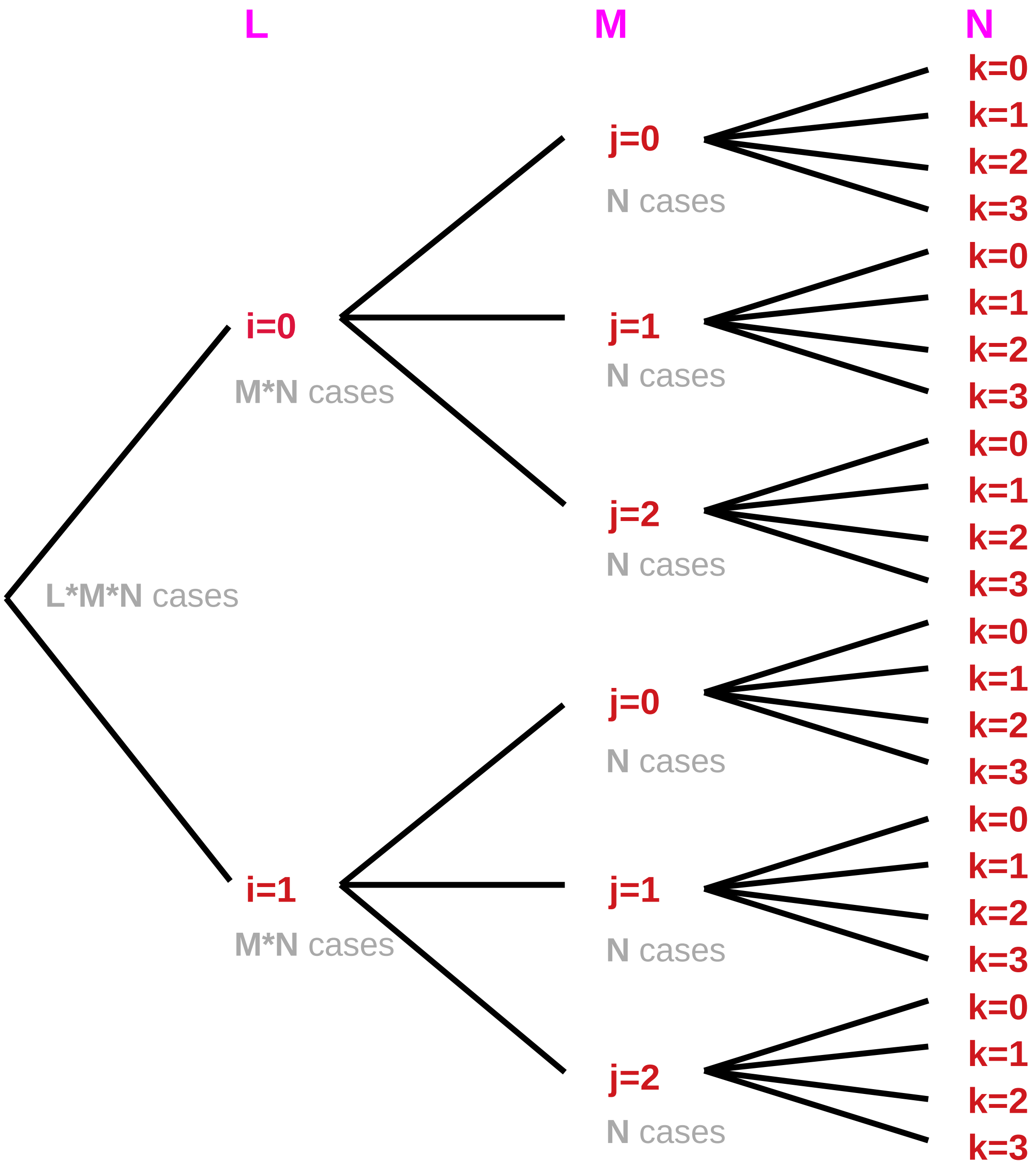


Index value tree – all possible combinations

```
int     a [L*M*N];
int*    b [L*M];
int**   c [L];
```

```
int     c [L][M][N];
```

L	M	N
i [0..L-1]	j [0..M-1]	k [0..N-1]



L

M

N

L*M*N cases

i=0

M*N cases

j=0

N cases

k=0 k=1 k=2 k=3

j=1

N cases

k=0 k=1 k=2 k=3

j=2

N cases

k=0 k=1 k=2 k=3

i=1

M*N cases

j=0

N cases

k=0 k=1 k=2 k=3

j=1

N cases

k=0 k=1 k=2 k=3

j=2

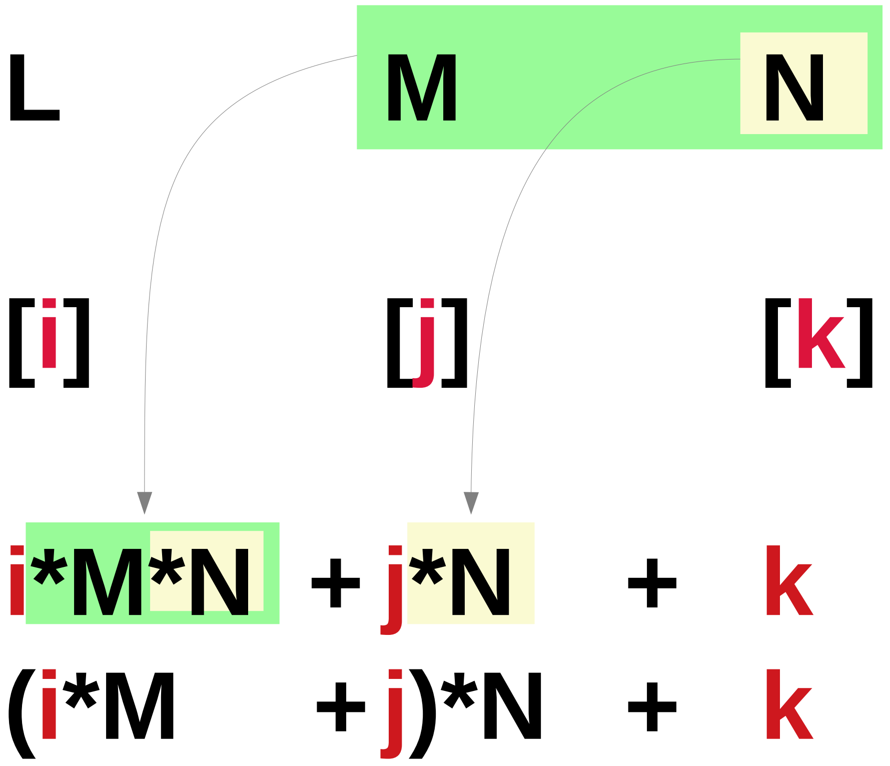
N cases

k=0 k=1 k=2 k=3

Converting a **3-d** index into a **1-d** index

```
int      a [L*M*N];
int*     b [L*M];
int**    c [L];
```

```
int      c [L][M][N];
```



L M N

[i] [j] [k]

i*M*N + j*N + k

(i*M + j)*N + k

L	M	N
i [0..L-1]	j [0..M-1]	k [0..N-1]
i*M*N	j*N	k

3-d and 1-d accesses (recursive pointers vs. brackets)

```
c[i] = &b[i*M];
b[j] = &a[j*N];
```

→

```
c[i][j][k]    ≡    a[i*M*N + j*N + k]
              ≡    a[(i*M + j)*N + k]
```

```
int **    c[L];
int *     b[L*M];

for (i=0; i<L; ++i)
      c[i] = &b[i*M];
```

```
int *     b[L*M];
int       a[L*M*N];

for (j=0; j<L*M; ++j)
      b[j] = &a[j*N];
```

```
c[i][j][k]
= *(*(*(c+i)+j)+k)
= *(*(c[i]+j)+k)            ←   c[i] =&b[i*M]
= *(*(&b[i*M]+j)+k)         →   *(*(b+i*M+j)+k)
= *(b[i*M+j]+k)             ←   b[m] = &a[m*N]
= *(&a[(i*M+j)*N]+k)        →   *(a+(i*M+j)*N+k)
= a[(i*M+j)*N+k]
```

i*M*N, j*N, k – index offset values

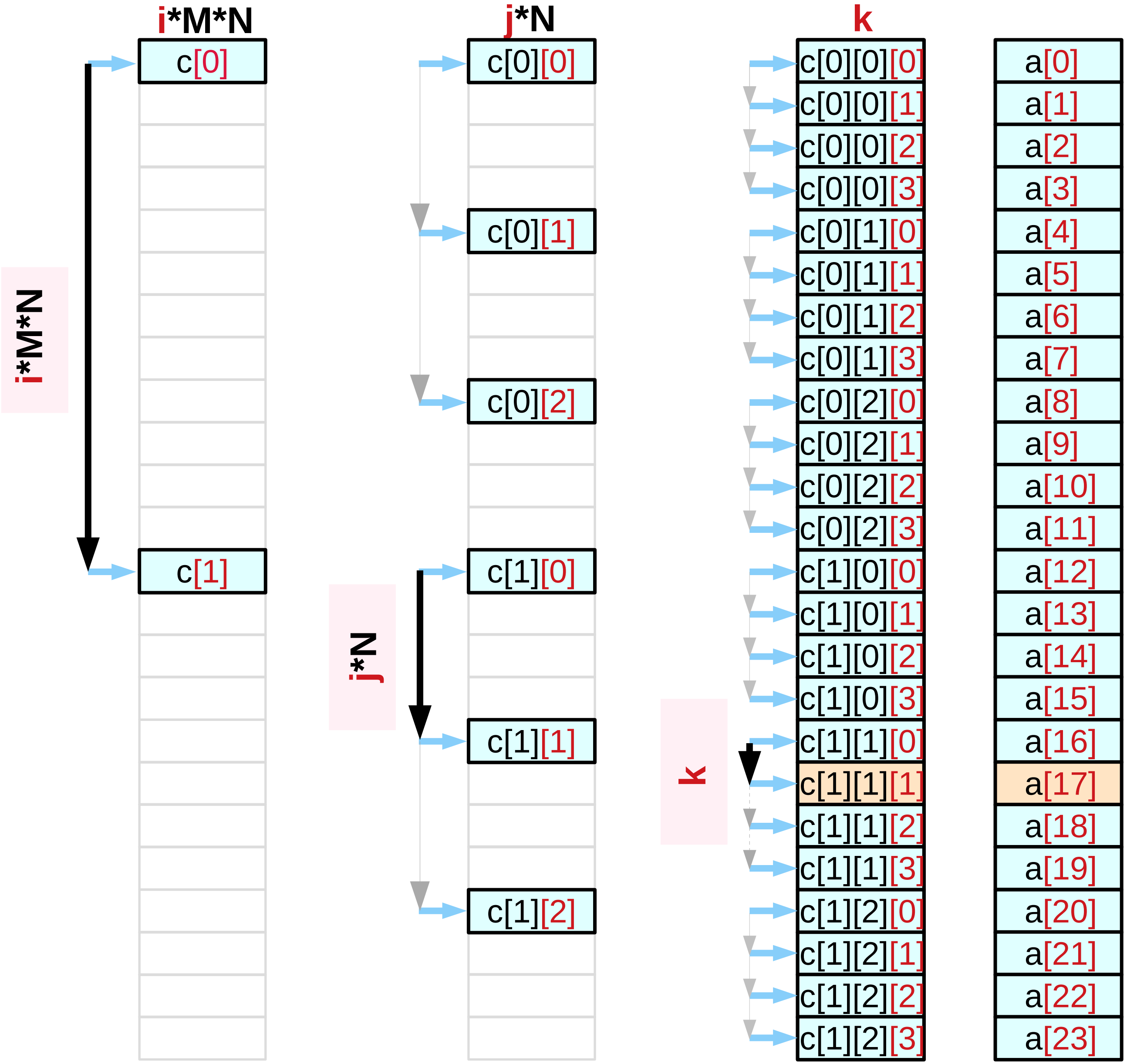
```
int     a [L*M*N];
int*    b [L*M];
int**   c [L];
```

```
int     c [L][M][N];
```

c [1][1][1]

i=1	j=1	k=1

a [(1*3 + 1)*4 + 1]



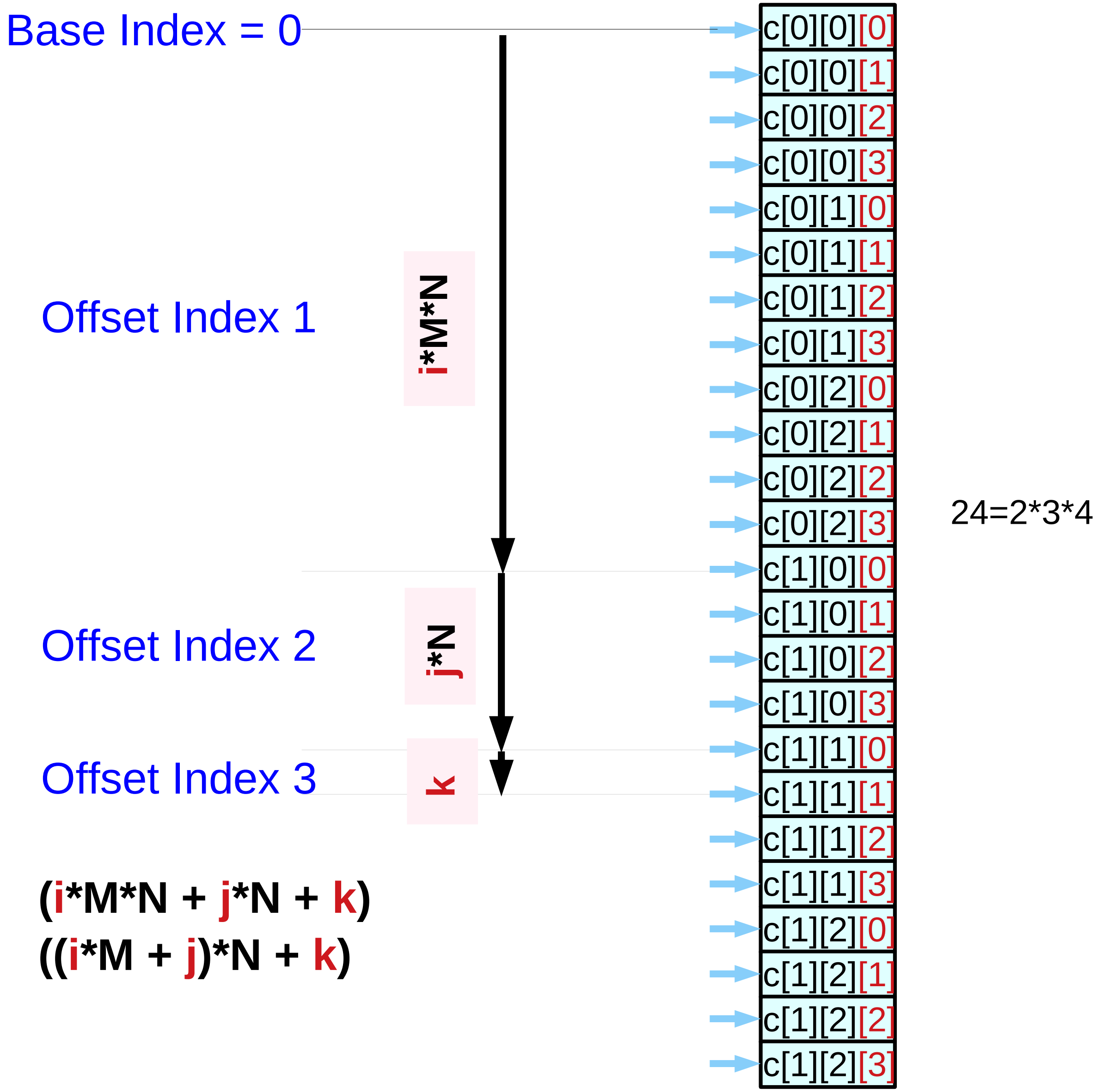
i*M*N	j*N	k	
c[0]	c[0][0]	c[0][0][0]	a[0]
		c[0][0][1]	a[1]
		c[0][0][2]	a[2]
		c[0][0][3]	a[3]
	c[0][1]	c[0][1][0]	a[4]
		c[0][1][1]	a[5]
		c[0][1][2]	a[6]
		c[0][1][3]	a[7]
	c[0][2]	c[0][2][0]	a[8]
		c[0][2][1]	a[9]
		c[0][2][2]	a[10]
		c[0][2][3]	a[11]
c[1]	c[1][0]	c[1][0][0]	a[12]
		c[1][0][1]	a[13]
		c[1][0][2]	a[14]
		c[1][0][3]	a[15]
	c[1][1]	c[1][1][0]	a[16]
		c[1][1][1]	a[17]
		c[1][1][2]	a[18]
		c[1][1][3]	a[19]
	c[1][2]	c[1][2][0]	a[20]
		c[1][2][1]	a[21]
		c[1][2][2]	a[22]
		c[1][2][3]	a[23]

Accessing **a** by base and offset indices

```
int     a [L*M*N];
int*    b [L*M];
int**   c [L];
```

```
int     c [L][M][N];
```

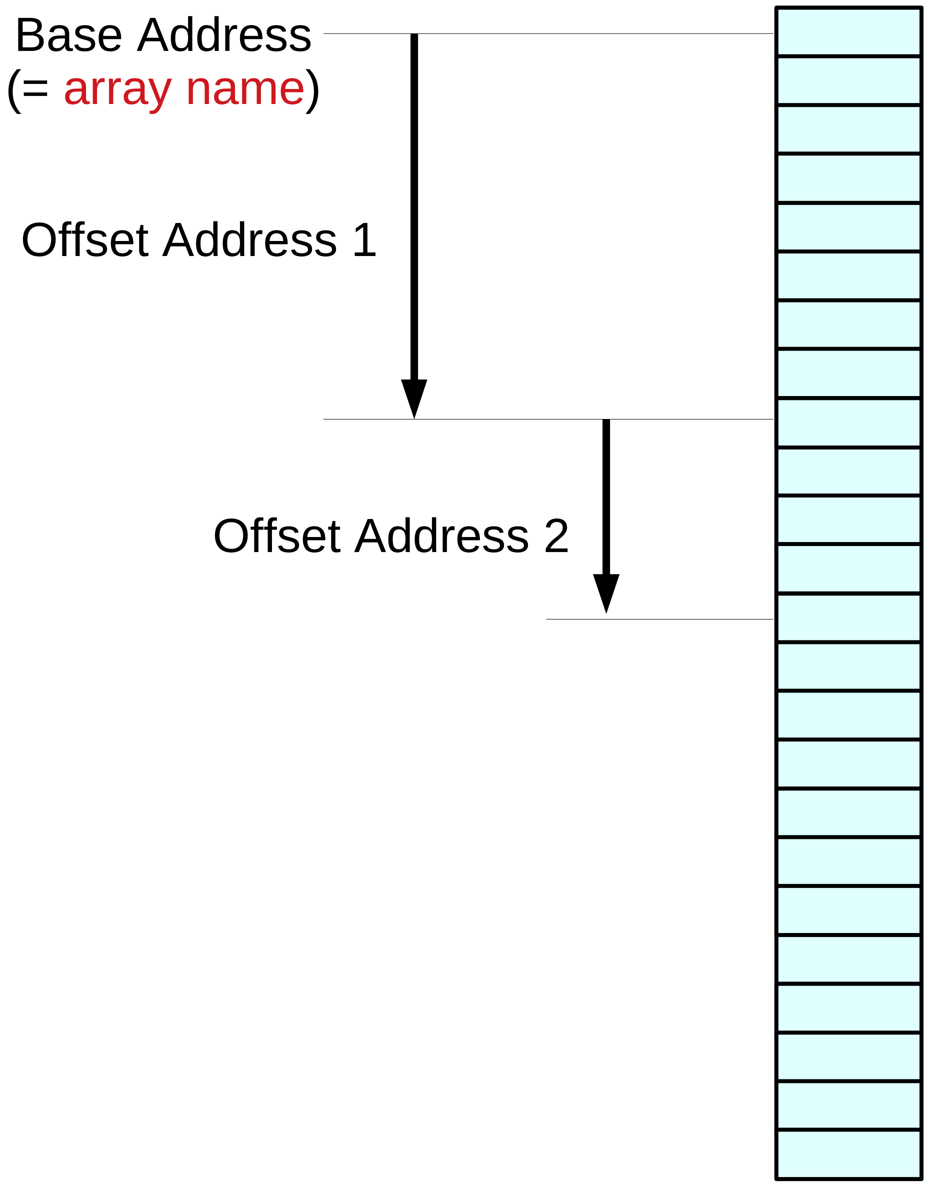
L	M	N
i [0..L-1]	j [0..M-1]	k [0..N-1]
i*M*N	j*N	k

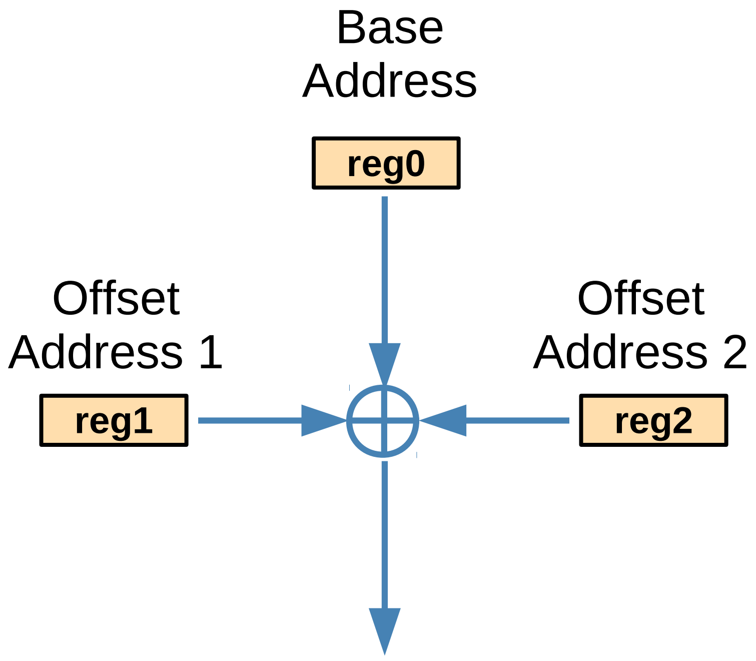


c[0][0][0]
c[0][0][1]
c[0][0][2]
c[0][0][3]
c[0][1][0]
c[0][1][1]
c[0][1][2]
c[0][1][3]
c[0][2][0]
c[0][2][1]
c[0][2][2]
c[0][2][3]
c[1][0][0]
c[1][0][1]
c[1][0][2]
c[1][0][3]
c[1][1][0]
c[1][1][1]
c[1][1][2]
c[1][1][3]
c[1][2][0]
c[1][2][1]
c[1][2][2]
c[1][2][3]

(i*M*N + j*N + k)
((i*M + j)*N + k)

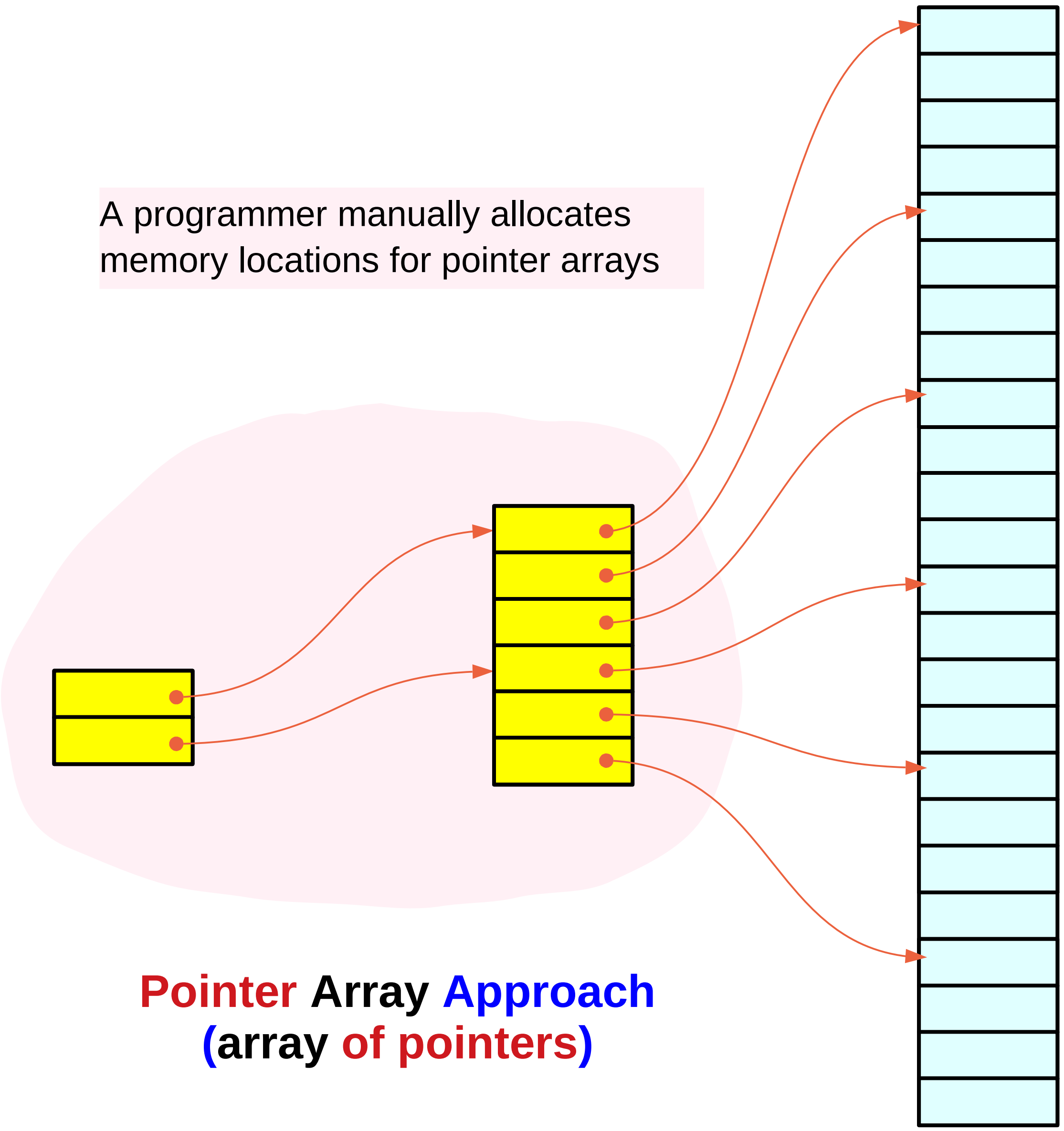
Base and Offset Addressing



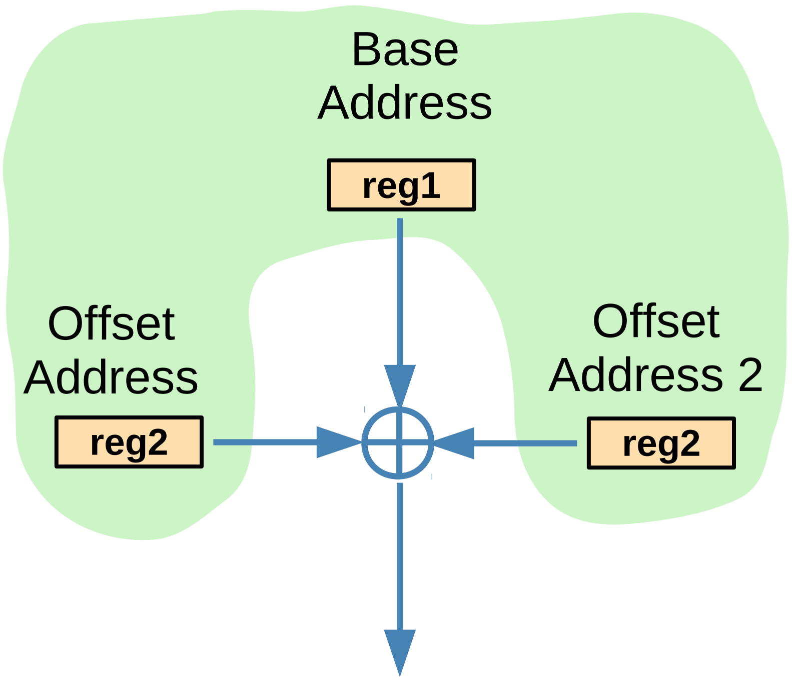


compiler
assembly instruction
Registers in the CPU

Pointer Array vs. Array Pointer



A programmer manually allocates memory locations for pointer arrays



register based address **computations** eliminate the pointer arrays – by a compiler

Pointer Array Approach (array of pointers)

Array Pointer Approach (pointer to arrays)

Pointer to an array – variable declarations

```
int   m ;
int  *n ;
```

an integer pointer

Array Pointer Approach
(pointer to arrays)

```
int   a     [4]
int  (*p)   [4]
```

an array pointer

```
int  func     (int  a,  int  b) ;
int  (* fp)   (int  a,  int  b) ;
```

a function pointer

Pointer to an array – a type view

int 4 byte data

int *

an integer pointer

array pointer:
a pointer to an array

pointer array:
an array of pointers

int [4] 4*4 byte data

int (*) [4]

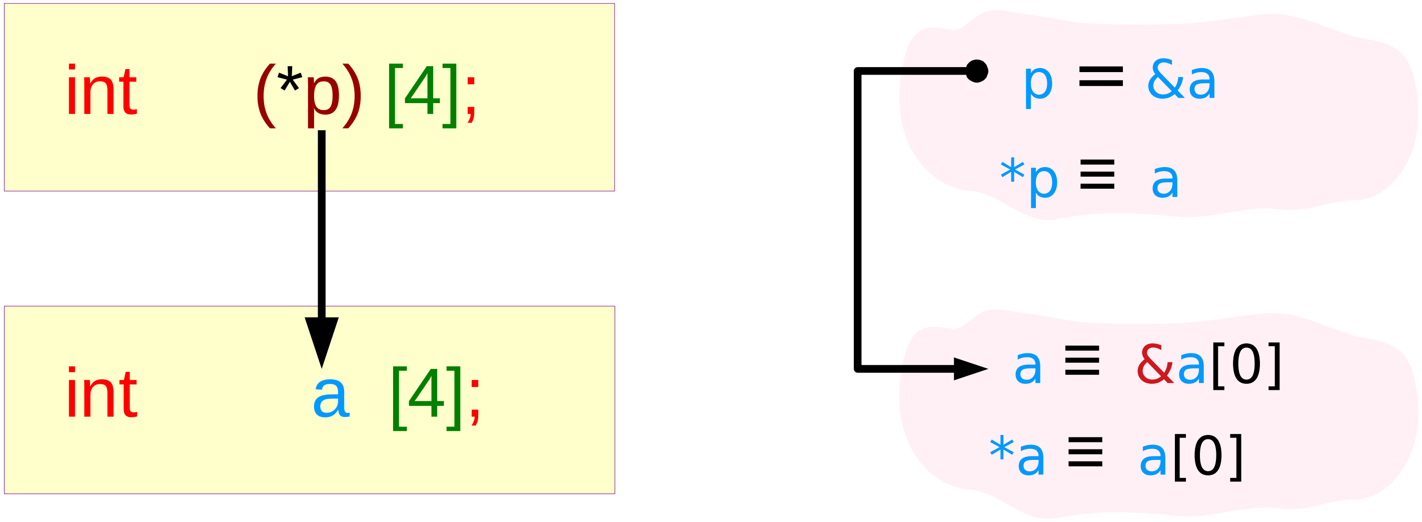
an array pointer

int (int, int) instructions

int (*) (int, int)

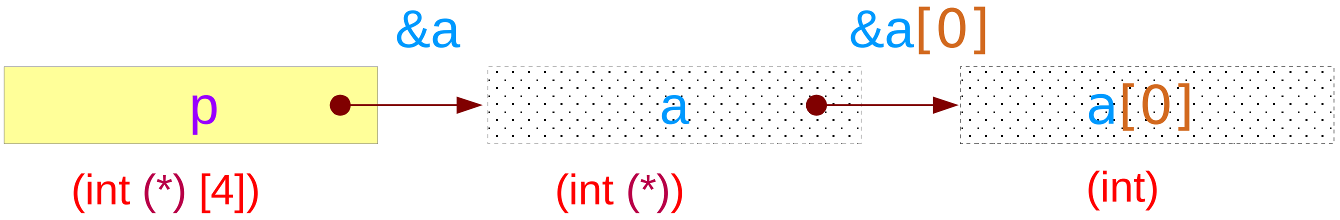
a function pointer

Pointer to a **1-d** array – a chain of pointers view (1)

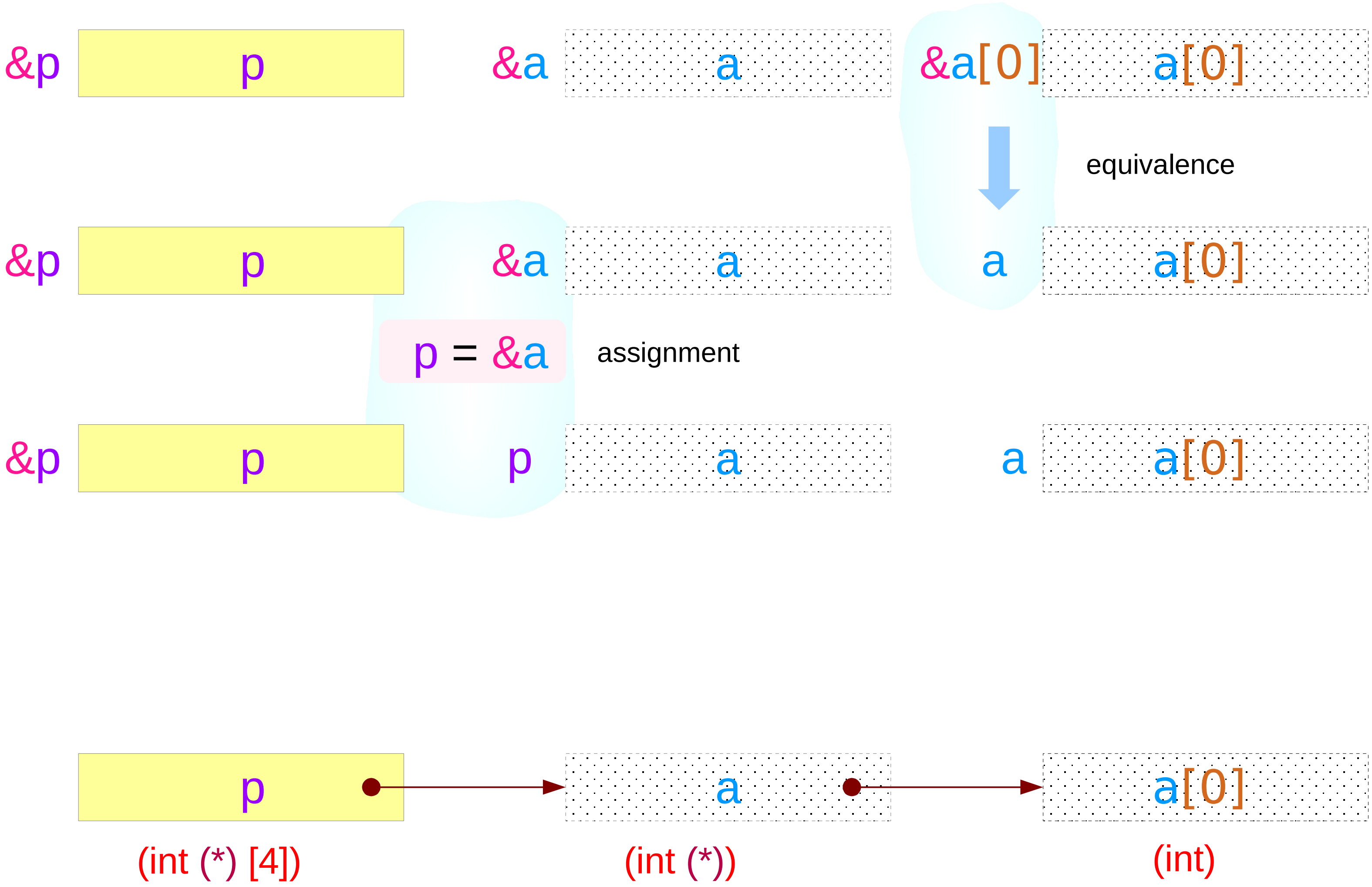


&a and &a[0] print
the same address
but have different types

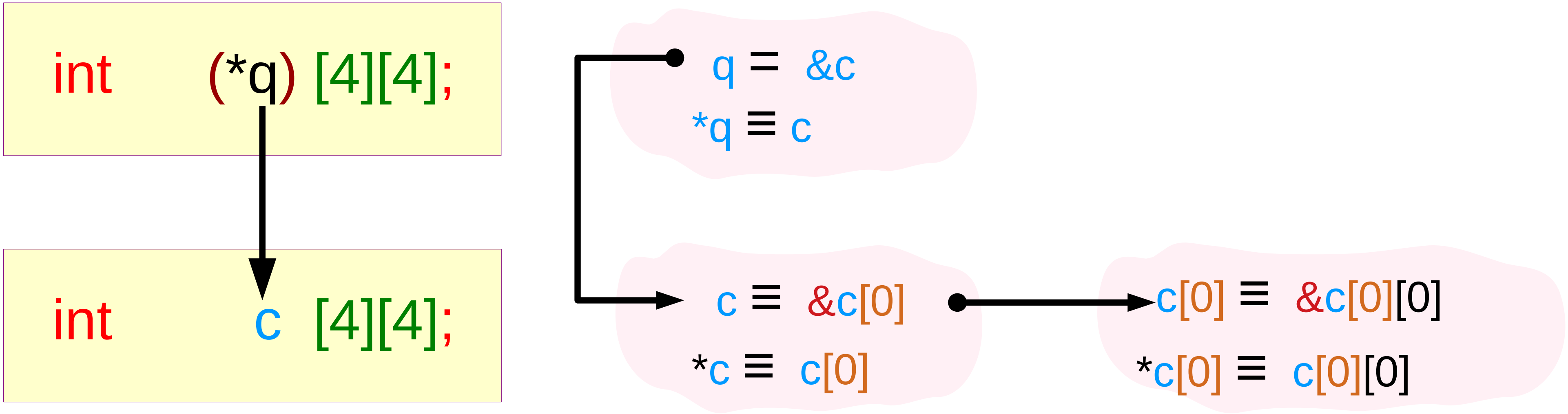
&a ≠ a



Pointer to a **1-d** array – a chain of pointers view (2)



Pointer to a **2-d** array – a chain of pointers view (1)



```
int     (*q) [4][4];
int       c  [4][4];
```

q = &c

*q ≡ c

c ≡ &c[0]

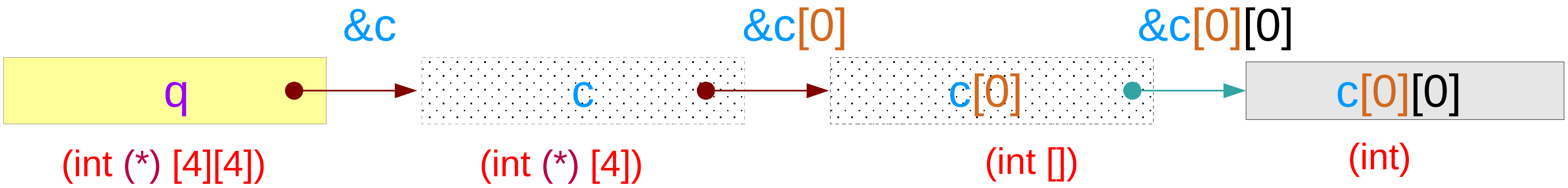
*c ≡ c[0]

c[0] ≡ &c[0][0]

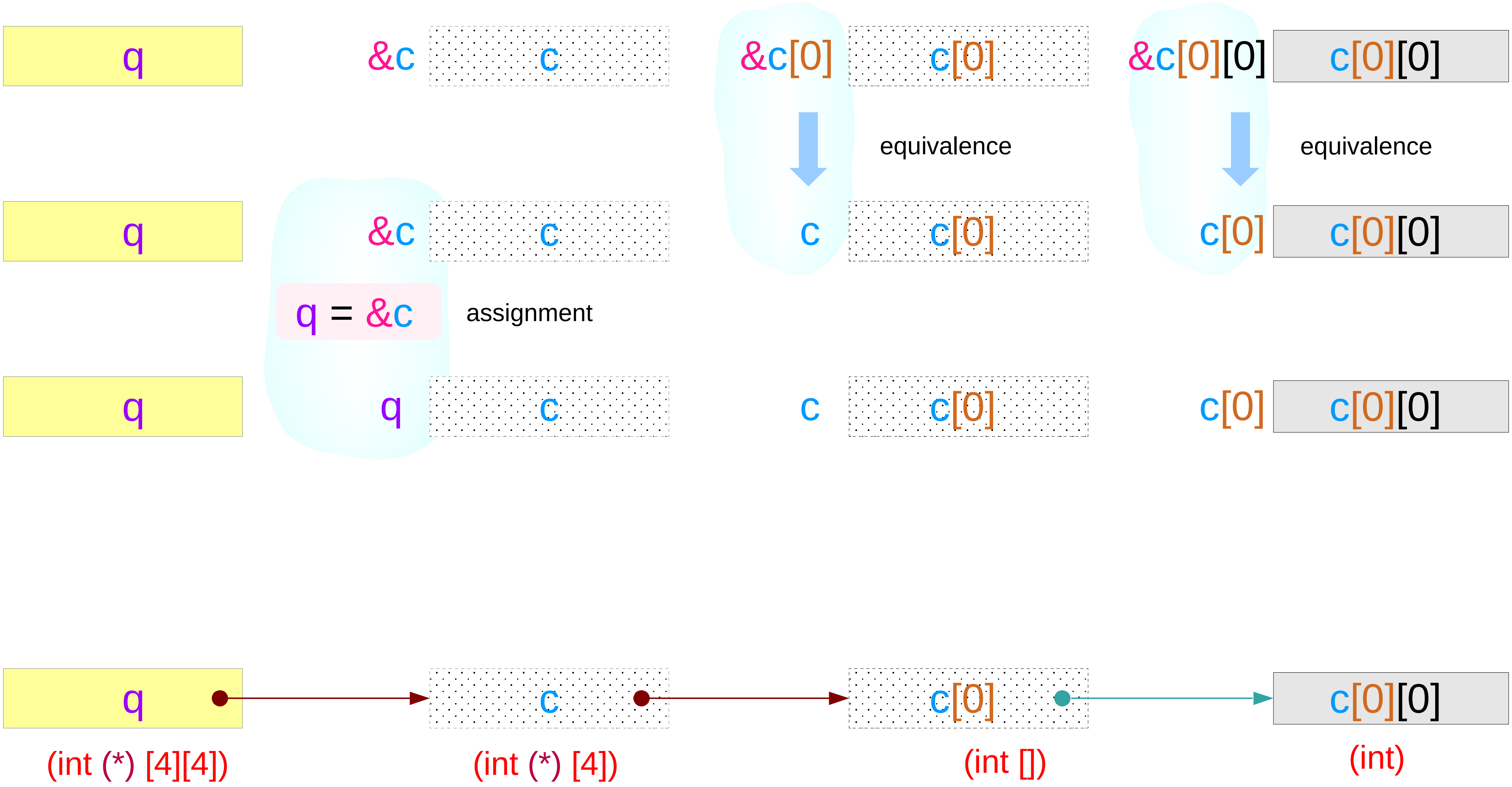
*c[0] ≡ c[0][0]

&c ≠ c

c, &c[0], &c[0][0] print
the same address
but have different types



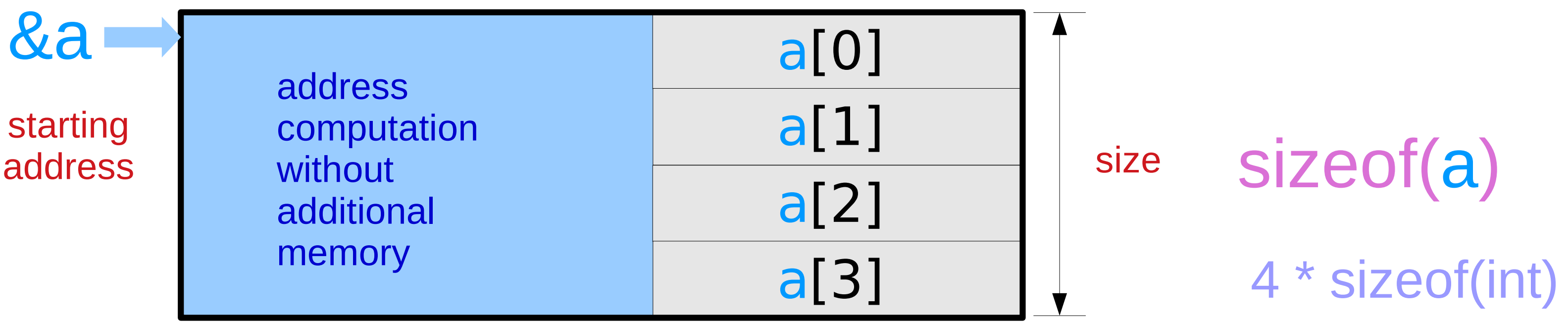
Pointer to a **2-d** array – a chain of pointers view (2)



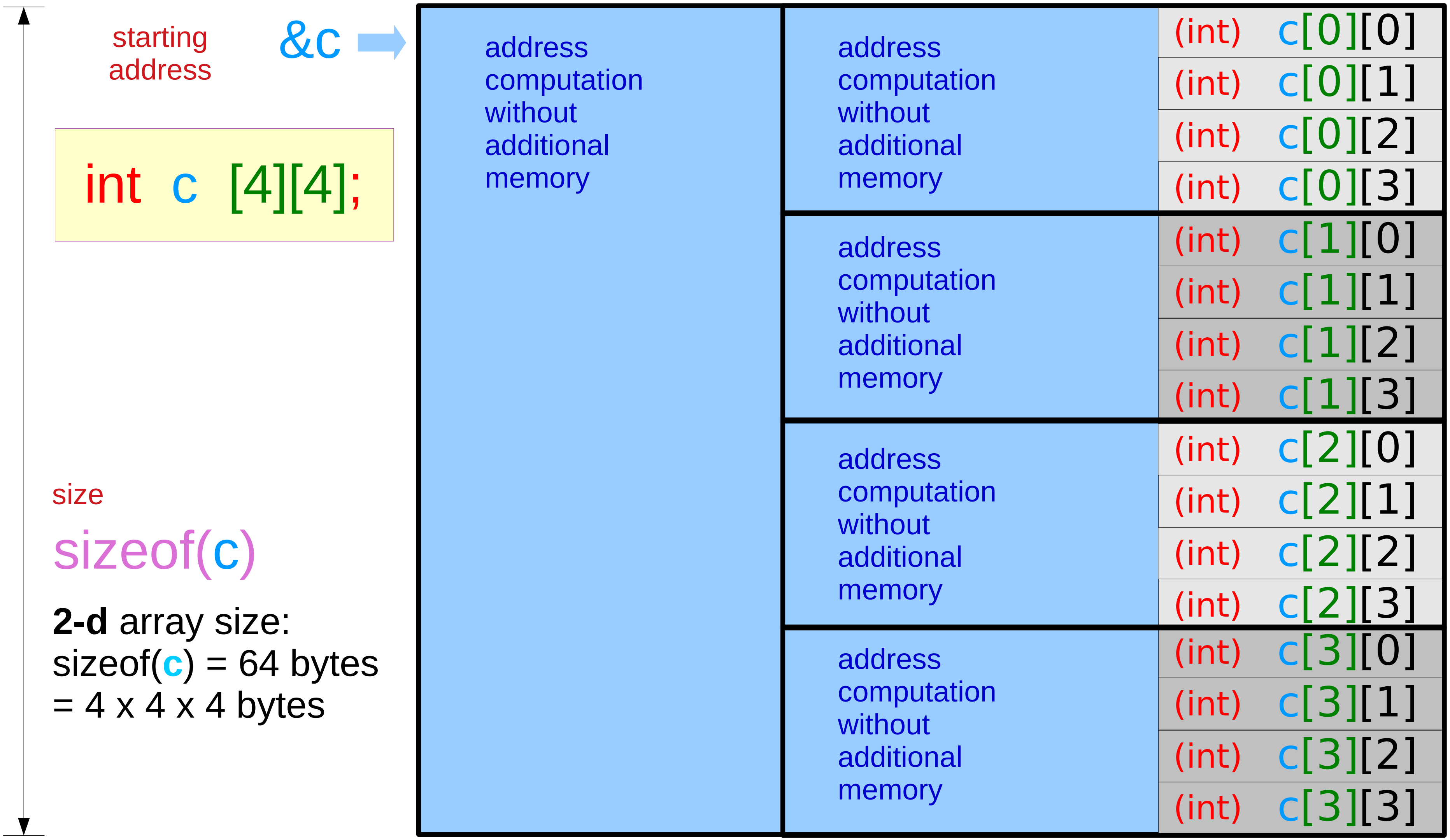
1-d array – an aggregated type view

An aggregated type
- starting address (&a)
- size of all the array elements (16 bytes)

```
int  a  [4];
```



2-d array – an aggregated type view



starting address

&c

```
int c [4][4];
```

size

sizeof(c)

2-d array size:
sizeof(c) = 64 bytes
= 4 x 4 x 4 bytes

address computation without additional memory

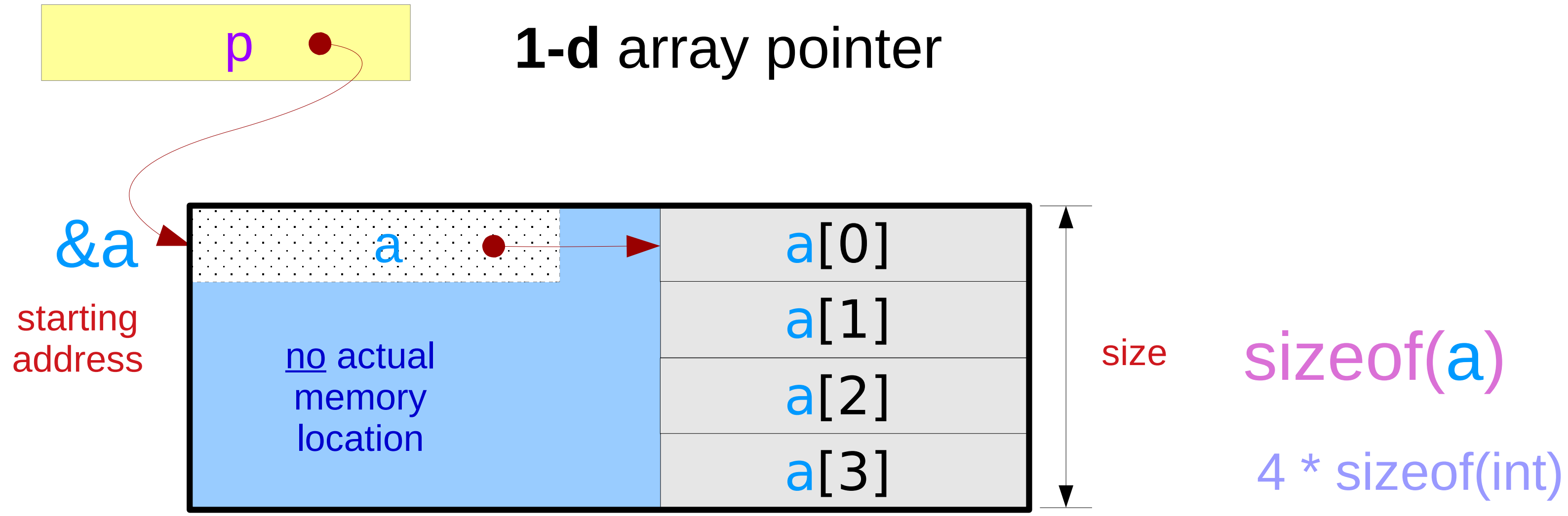
address computation without additional memory	(int) c[0][0] (int) c[0][1] (int) c[0][2] (int) c[0][3]
address computation without additional memory	(int) c[1][0] (int) c[1][1] (int) c[1][2] (int) c[1][3]
address computation without additional memory	(int) c[2][0] (int) c[2][1] (int) c[2][2] (int) c[2][3]
address computation without additional memory	(int) c[3][0] (int) c[3][1] (int) c[3][2] (int) c[3][3]

Pointer to a **1-d** array – an aggregated type view

```
int     (*p) [4];
```

An aggregated type
- starting address (&a)
- size of all the array elements (16 bytes)

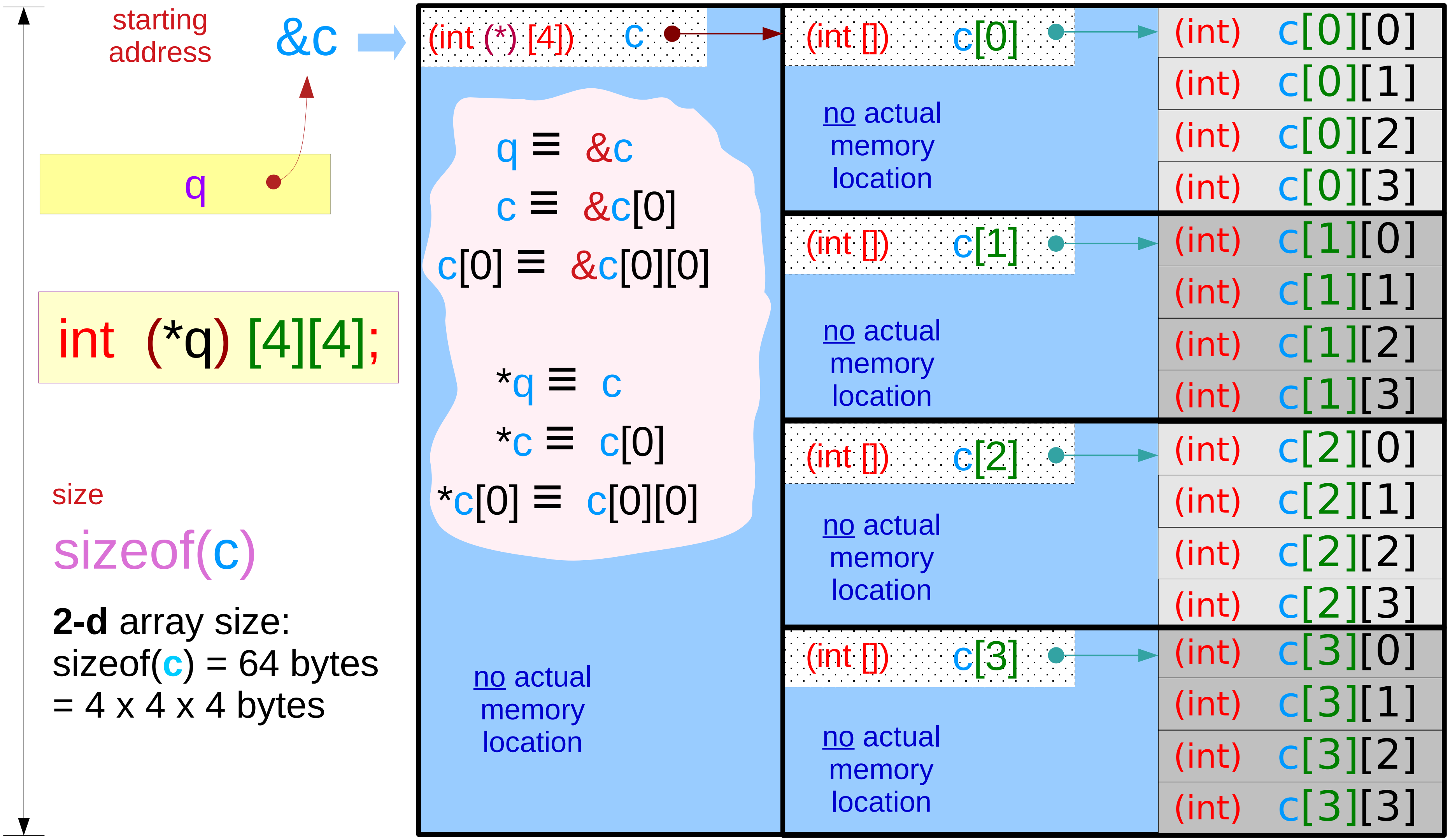
1-d array pointer



p ≡ &a   *p ≡ a

a ≡ &a[0]   *a ≡ a[0]

Pointer to a **2-d** array – an aggregated type view



starting address

&c

q

int (*q) [4][4];

size

sizeof(c)

2-d array size:
sizeof(c) = 64 bytes
= 4 x 4 x 4 bytes

(int (*) [4]) c

q ≡ &c
c ≡ &c[0]
c[0] ≡ &c[0][0]

*q ≡ c
*c ≡ c[0]
*c[0] ≡ c[0][0]

no actual memory location

(int []) c[0]

no actual memory location

(int []) c[1]

no actual memory location

(int []) c[2]

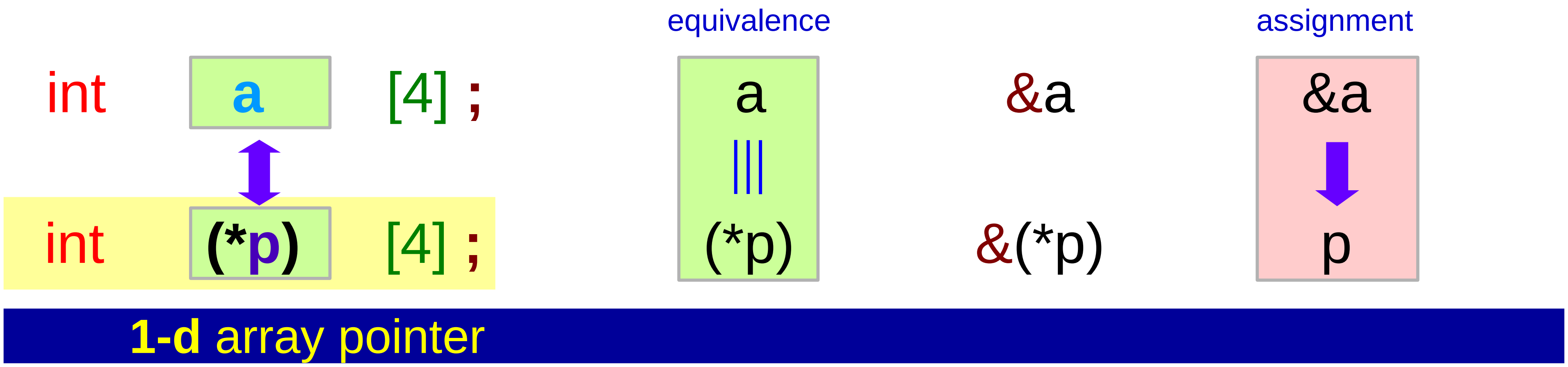
no actual memory location

(int []) c[3]

no actual memory location

(int)	c[0][0]
(int)	c[0][1]
(int)	c[0][2]
(int)	c[0][3]
(int)	c[1][0]
(int)	c[1][1]
(int)	c[1][2]
(int)	c[1][3]
(int)	c[2][0]
(int)	c[2][1]
(int)	c[2][2]
(int)	c[2][3]
(int)	c[3][0]
(int)	c[3][1]
(int)	c[3][2]
(int)	c[3][3]

Pointer to an array : assignment and equivalence



equivalence

assignment

int a [4] ;

int (*p) [4] ;

a ||| (*p)

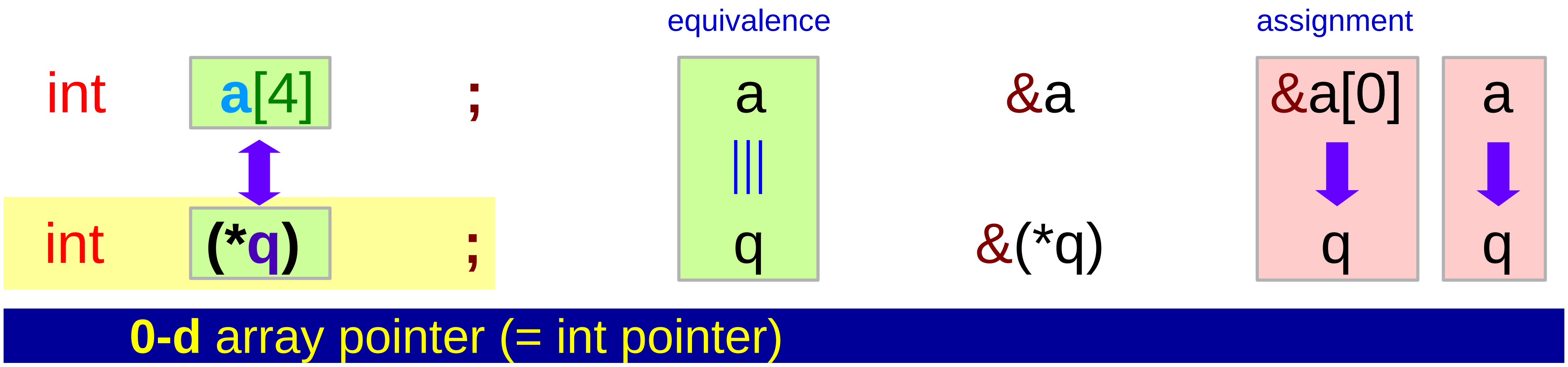
&a

&(*p)

&a

p

1-d array pointer



equivalence

assignment

int a[4] ;

int (*q) ;

a ||| q

&a

&(*q)

&a[0]

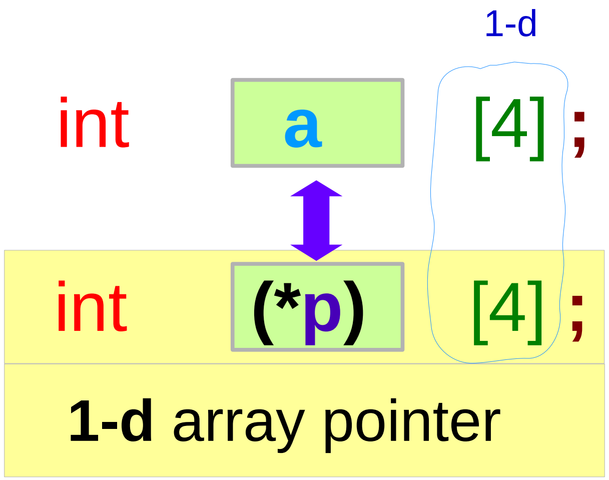
q

a

q

0-d array pointer (= int pointer)

Pointer to an array : size of array



1-d

int a [4] ;

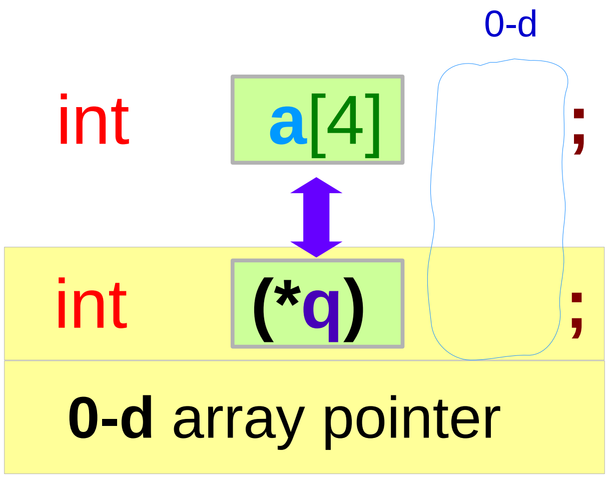
int (*p) [4] ;

1-d array pointer

p = &a;

sizeof(p) = 8 bytes : the size of a pointer

sizeof(*p) = 4*4 bytes : the size of the 1-d array



0-d

int a[4] ;

int (*q) ;

0-d array pointer

q = a;

sizeof(q) = 8 bytes : the size of a pointer

sizeof(*q) = 4 bytes : the size of the 0-d array (int)

Pointer to an array – a variable view (1)

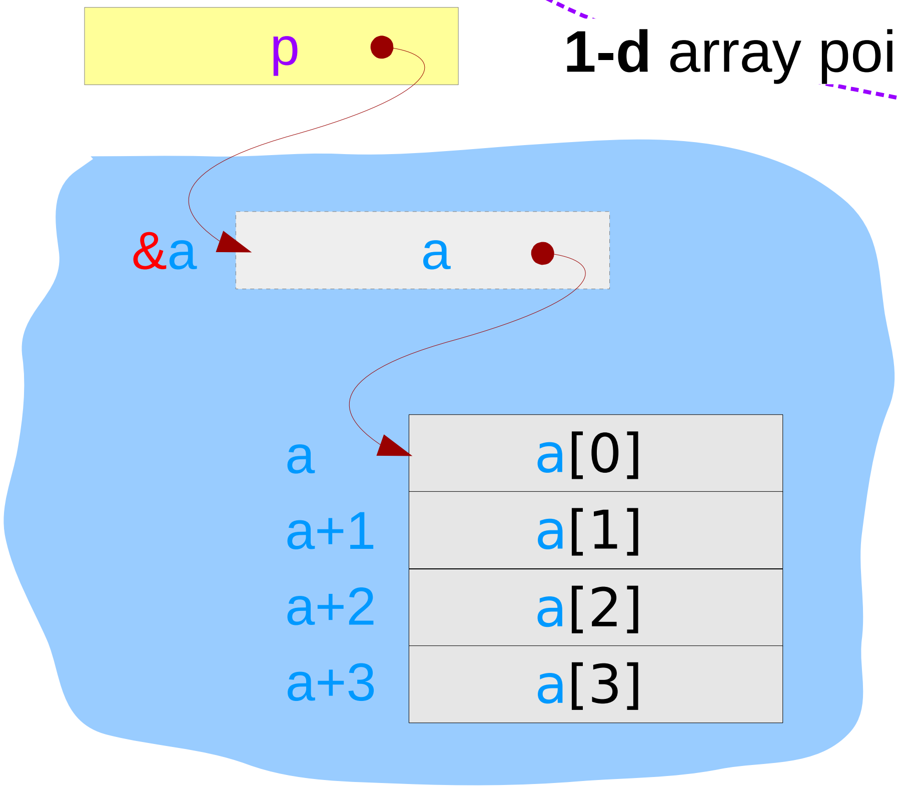
```
int     (*p) [4];
```

assignment

p = &a

equivalence

***p ≡ a**



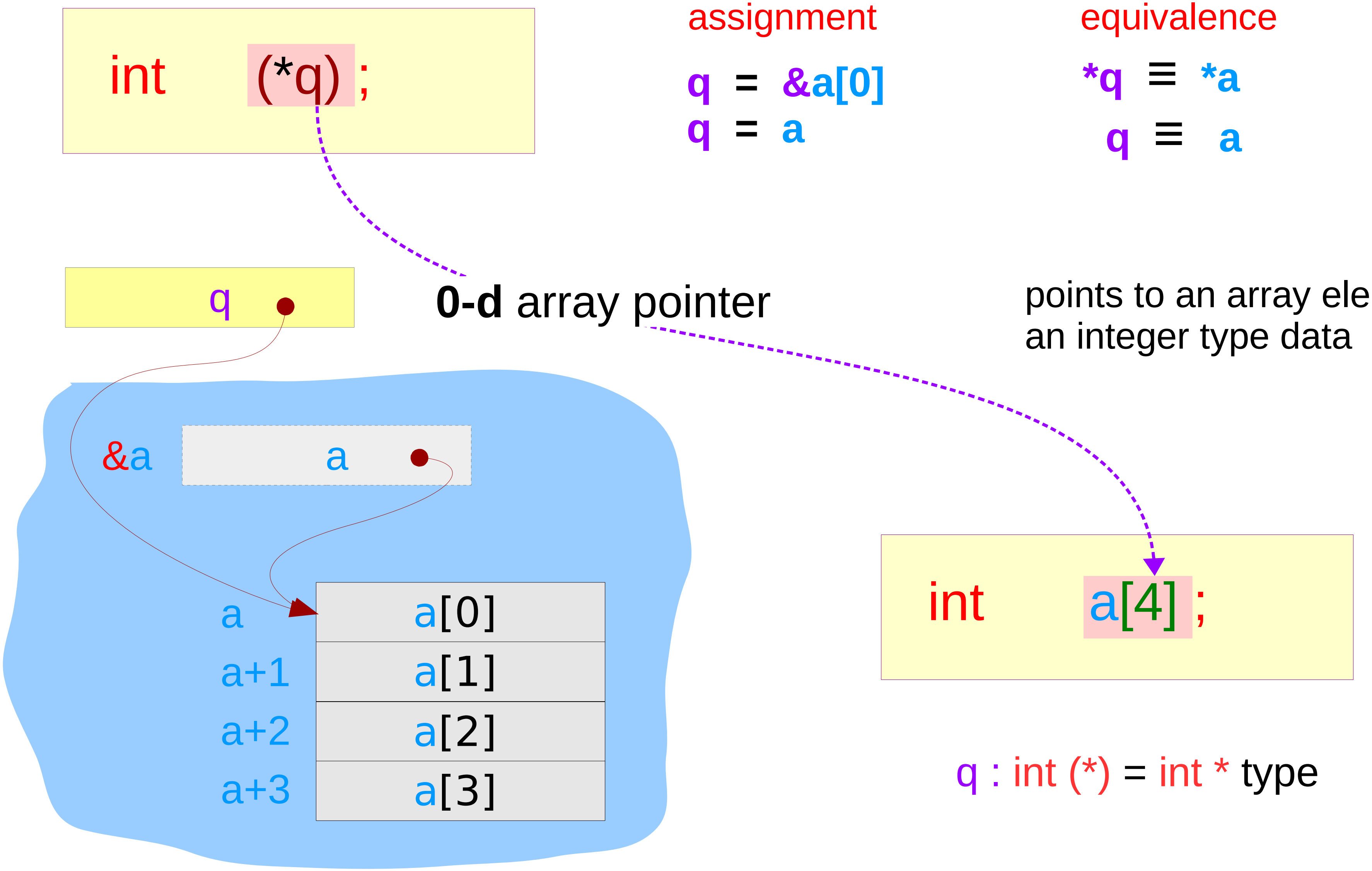
1-d array pointer

points to a **1-d** array –
a aggregated type data

```
int     a [4];
```

p : int (*) [4] type

Pointer to an array – a variable view (2)



int (*q) ;

assignment

q = &a[0]
q = a

equivalence

*q ≡ *a
q ≡ a

0-d array pointer

points to an array element –
an integer type data

int a[4] ;

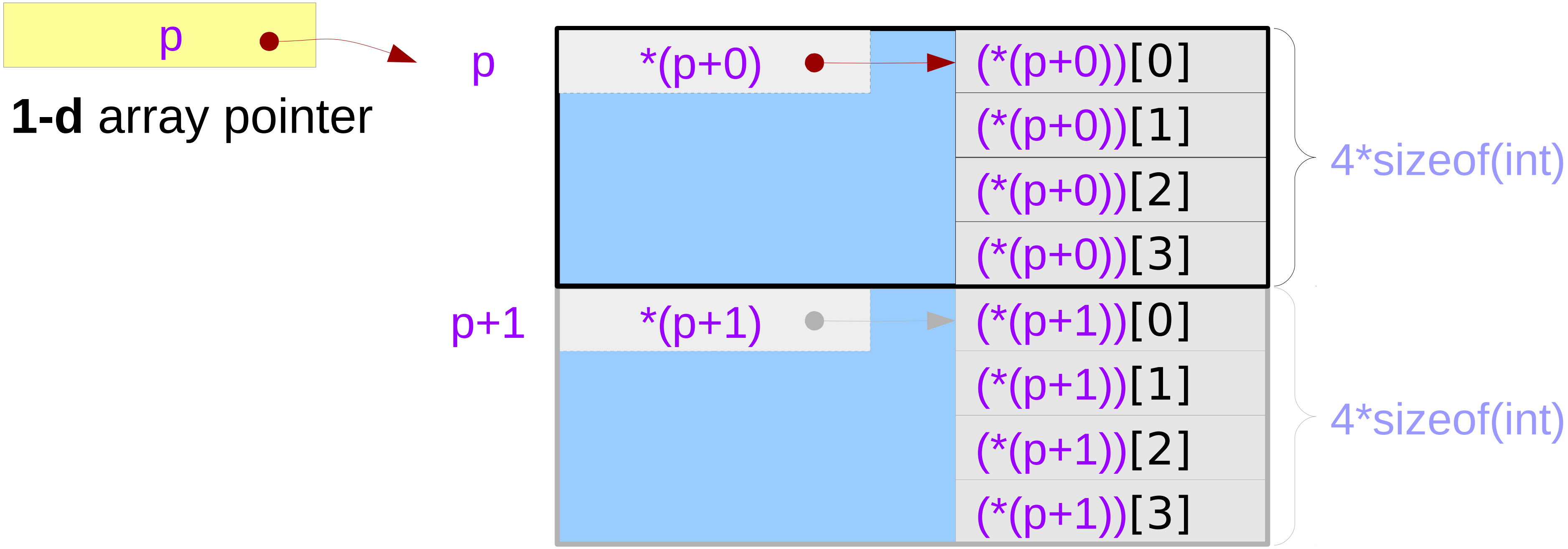
q : int (*) = int * type

Incrementing an array pointer

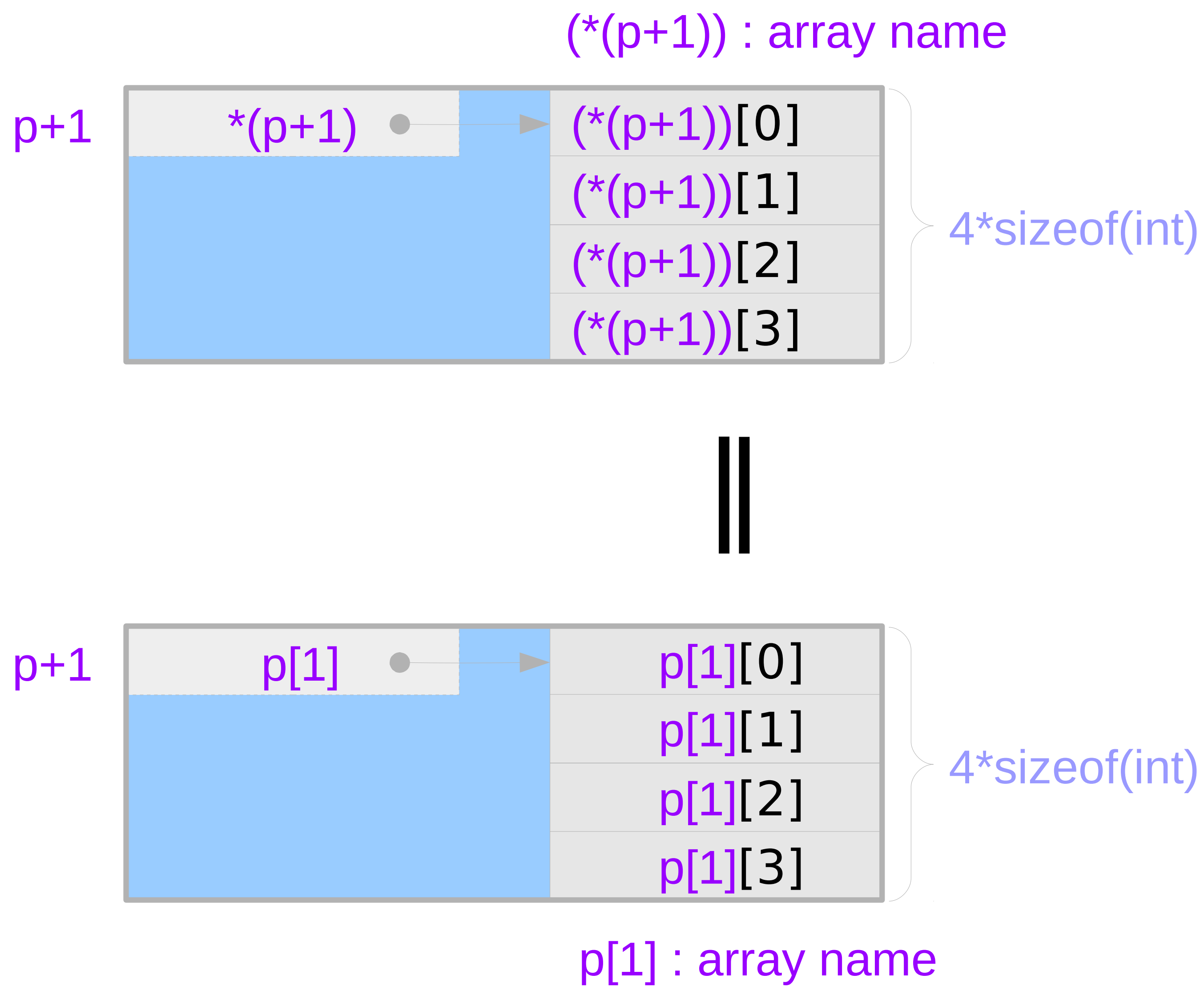
```
int      (*p) [4];
```

address p+1 – **address** p
= (long) (p+1) - (long) (p)   = 4 * sizeof(int)

Aggregated Type Size



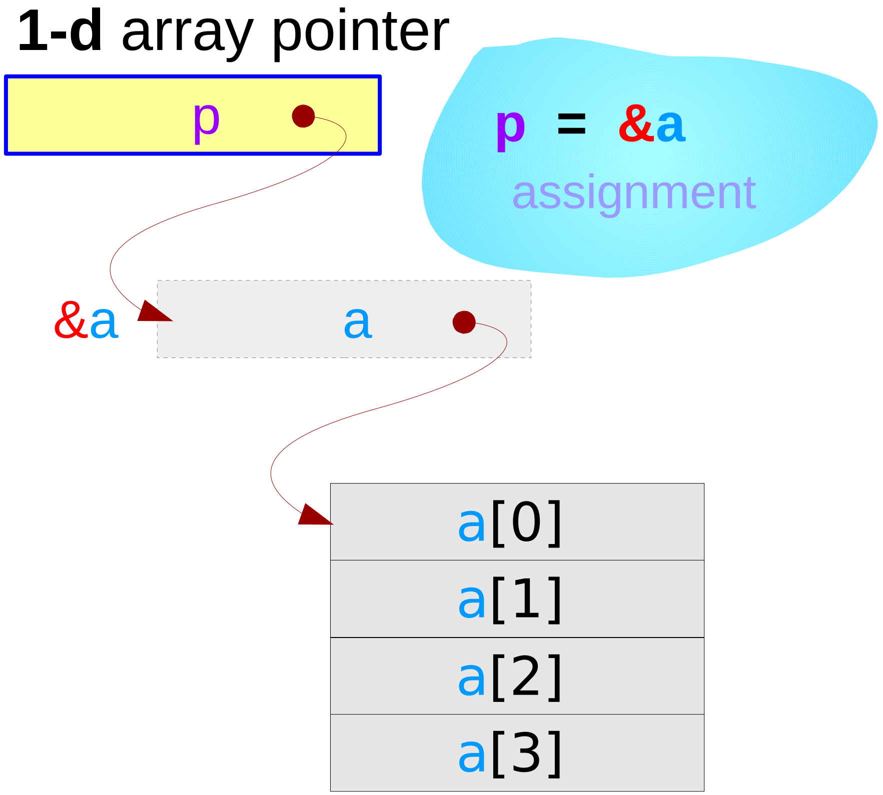
Incrementing an array pointer – extending a dimension

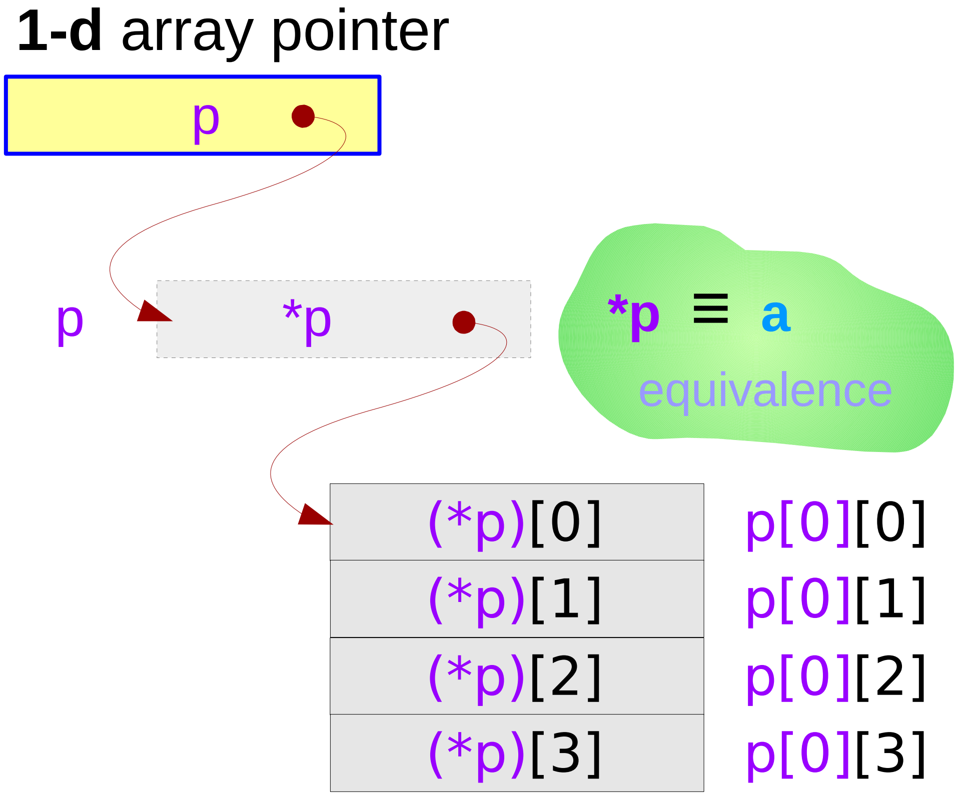


A **1-d** array pointer and a **1-d** array

```
int         a [4];
```

```
int  (*p) [4]  = &a;
```

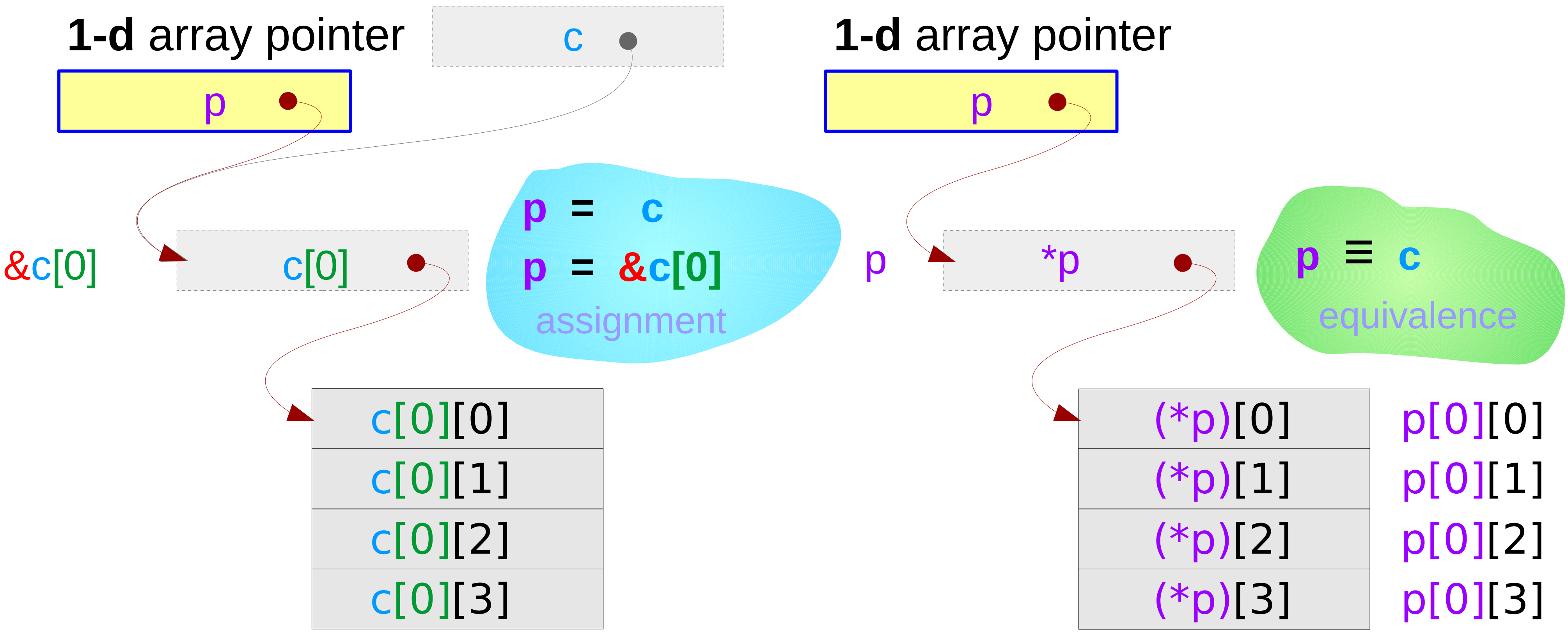




A **1-d** array pointer and a **2-d** array

```
int        c [4][4];
```

```
int  (*p) [4]  = &c[0];
```



1-d array pointer

p

c

&c[0]

c[0]

p = c

p = &c[0]

assignment

c[0][0]

c[0][1]

c[0][2]

c[0][3]

1-d array pointer

p

p

*p

p ≡ c

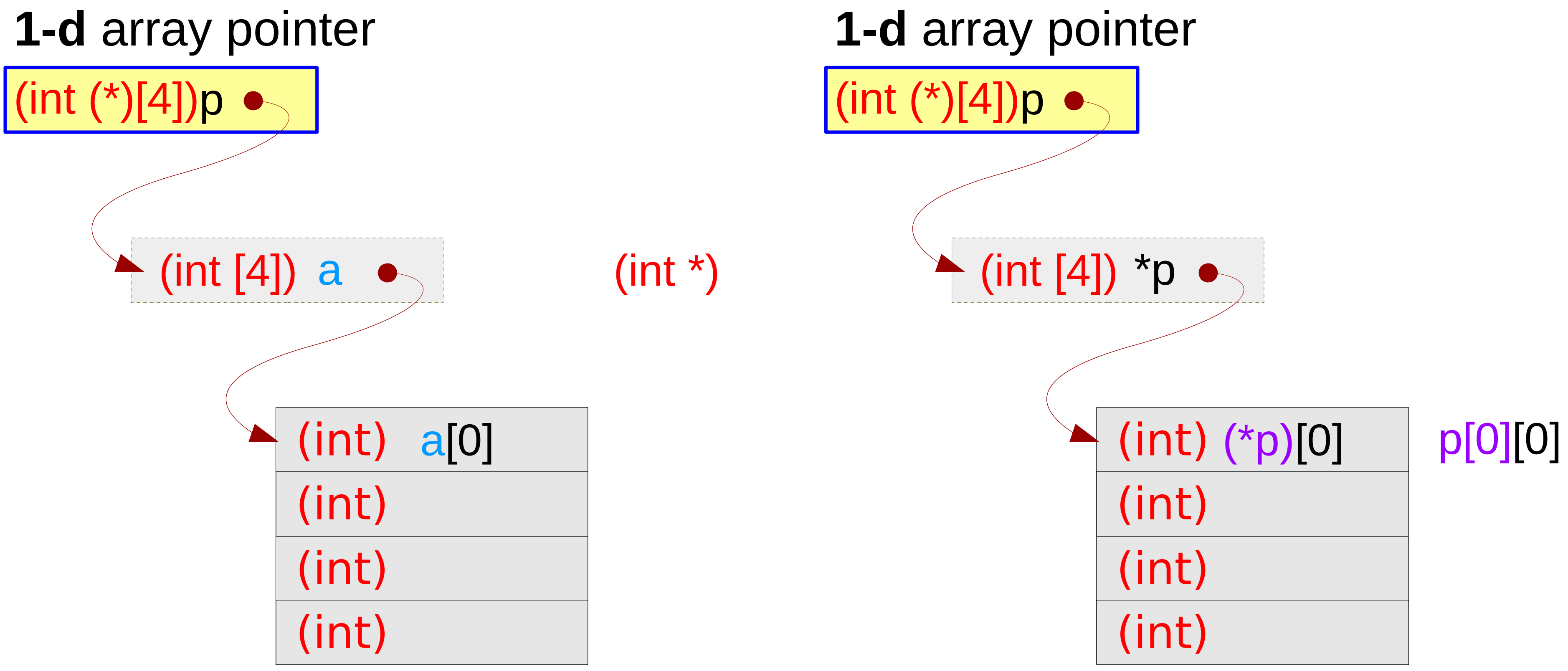
equivalence

(*p)[0]	p[0][0]
(*p)[1]	p[0][1]
(*p)[2]	p[0][2]
(*p)[3]	p[0][3]

A **1-d** array pointer and a **1-d** array – a type view

```
int          a [4];
```

```
int  (*p) [4]  = &a;
```



1-d array pointer

(int (*)[4])p

(int [4]) a

(int *)

(int) a[0]
(int)
(int)
(int)

1-d array pointer

(int (*)[4])p

(int [4]) *p

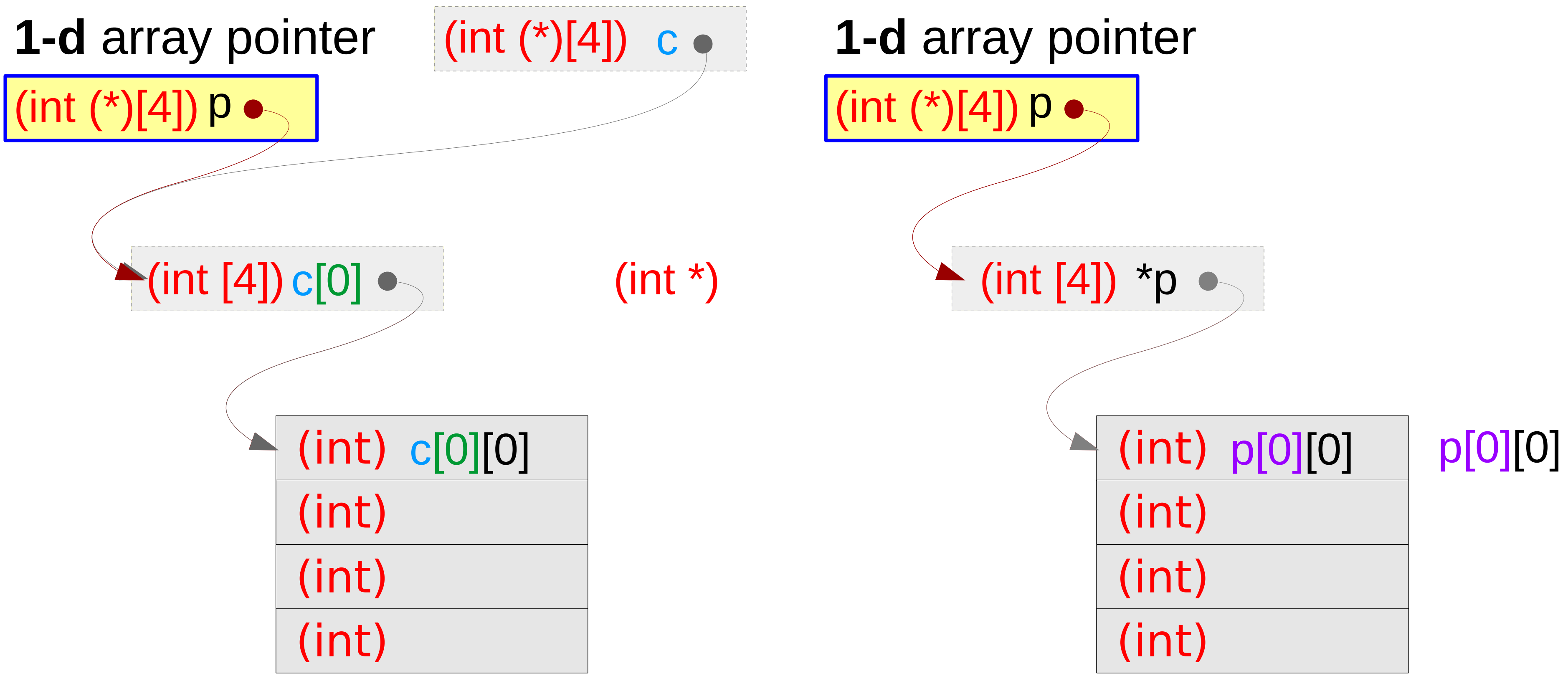
(int) (*p)[0]
(int)
(int)
(int)

p[0][0]

A **1-d** array pointer and a **2-d** array – a type view

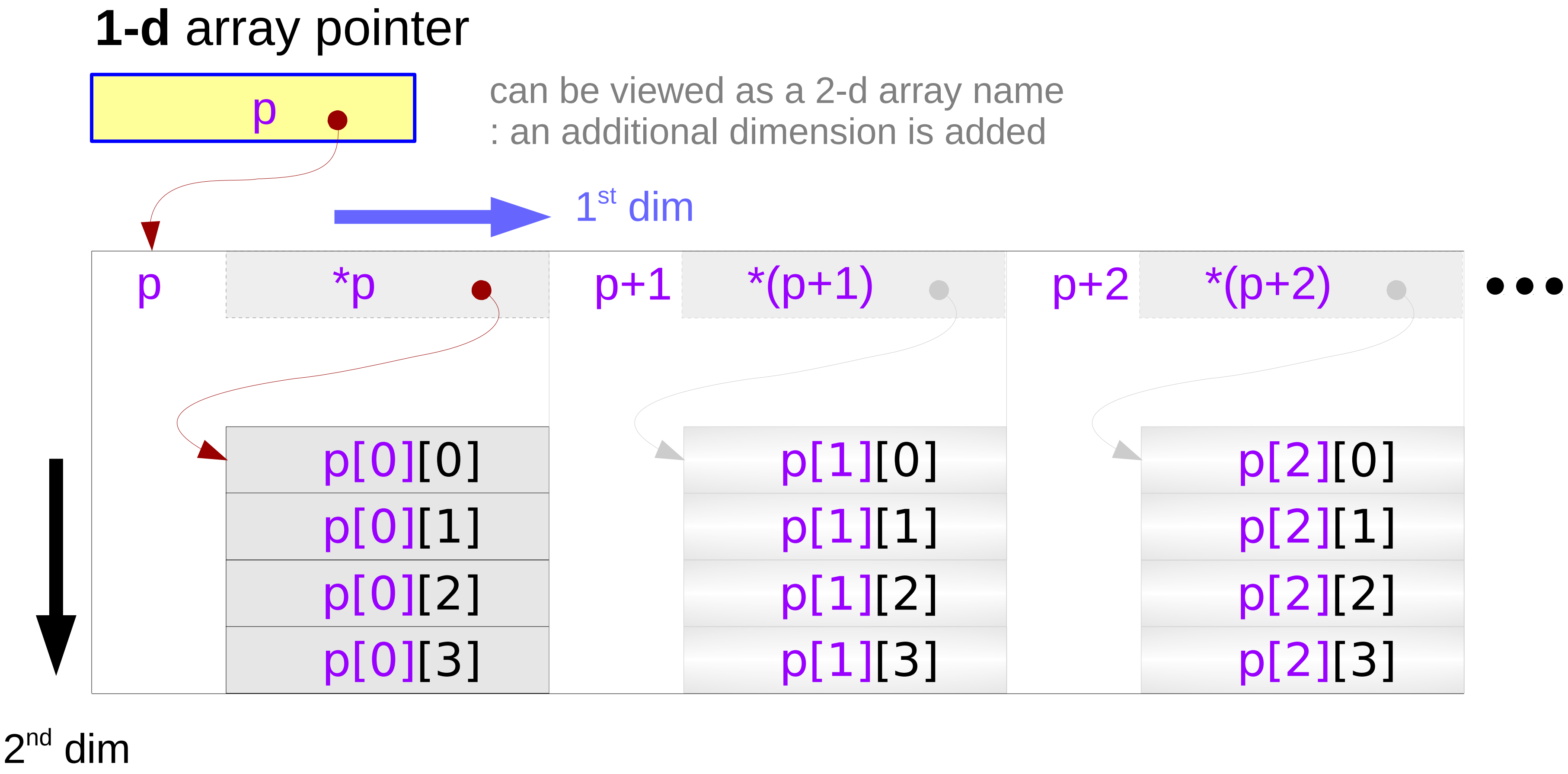
```
int         c [4][4];
```

```
int  (*p) [4]  = &c[0];
```

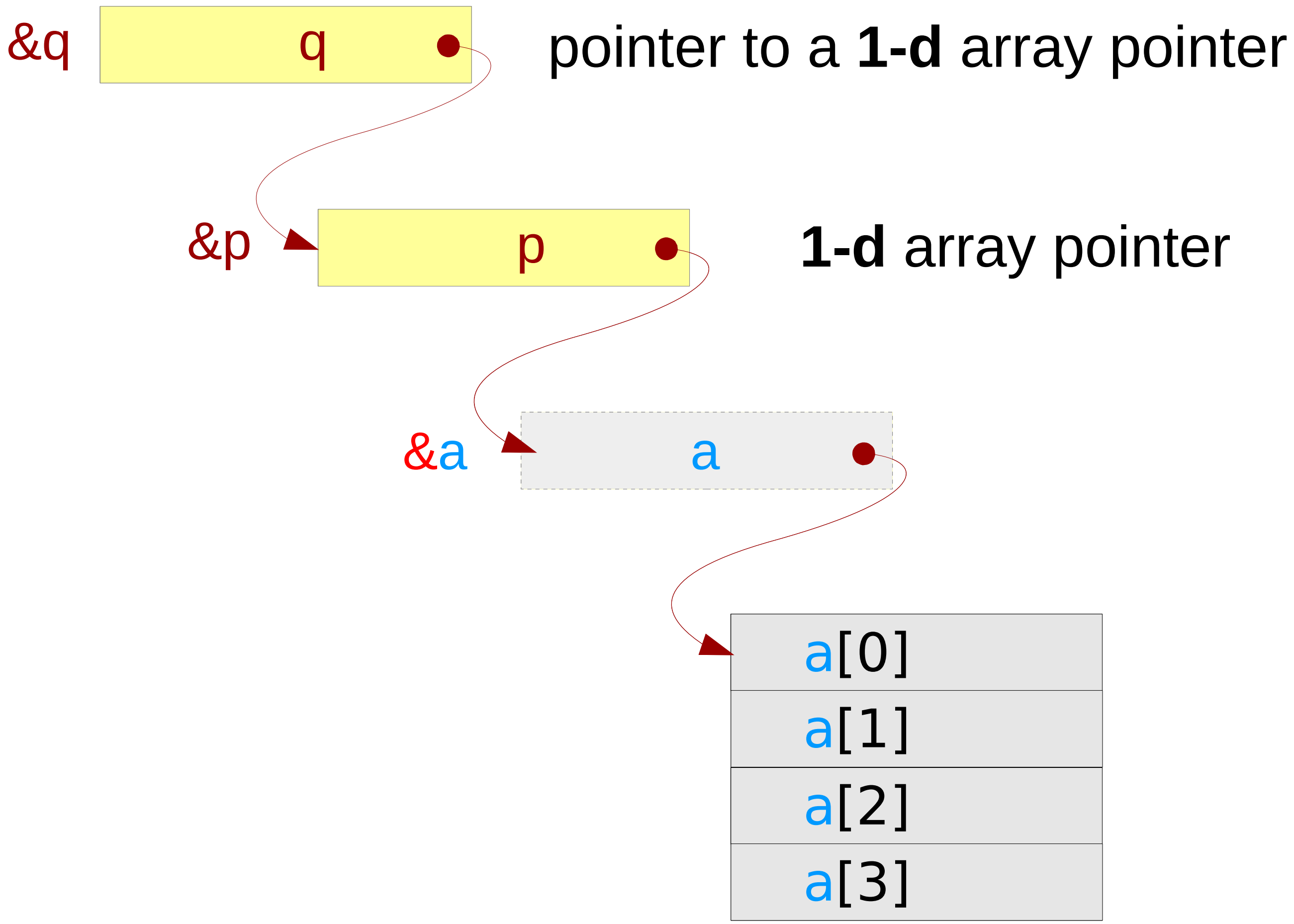


A **1-d** array pointer – extending a dimension

```
int  (*p) [4]  ;
```



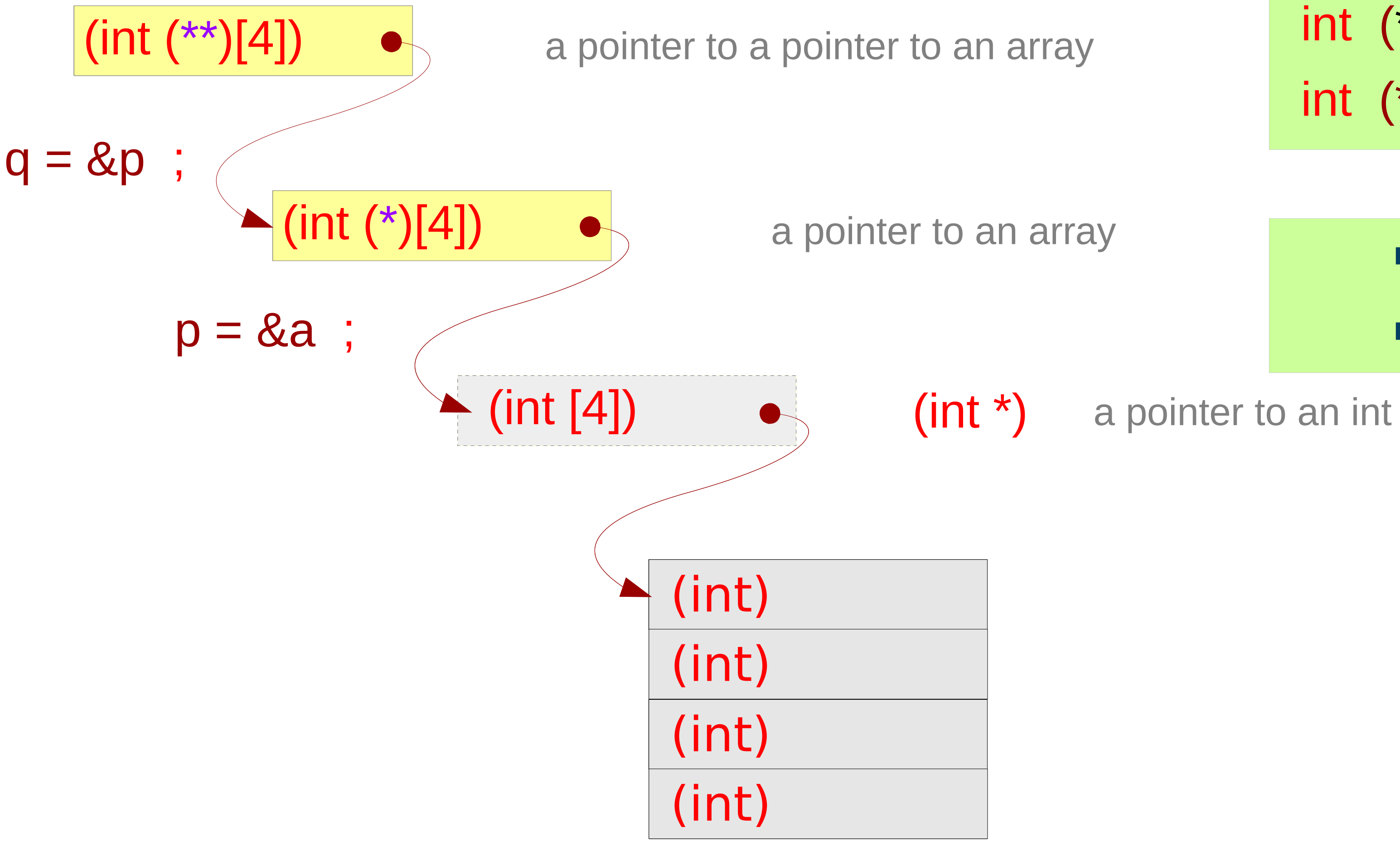
Double pointer to a **1-d** array – a variable view



```
int  a[4]  ;
int  (*p) [4] = &a ;
int  (**q) [4] = &p ;
```

```
➡    p = &a ;
➡    q = &p ;
```

Double pointer to a **1-d** array – a type view



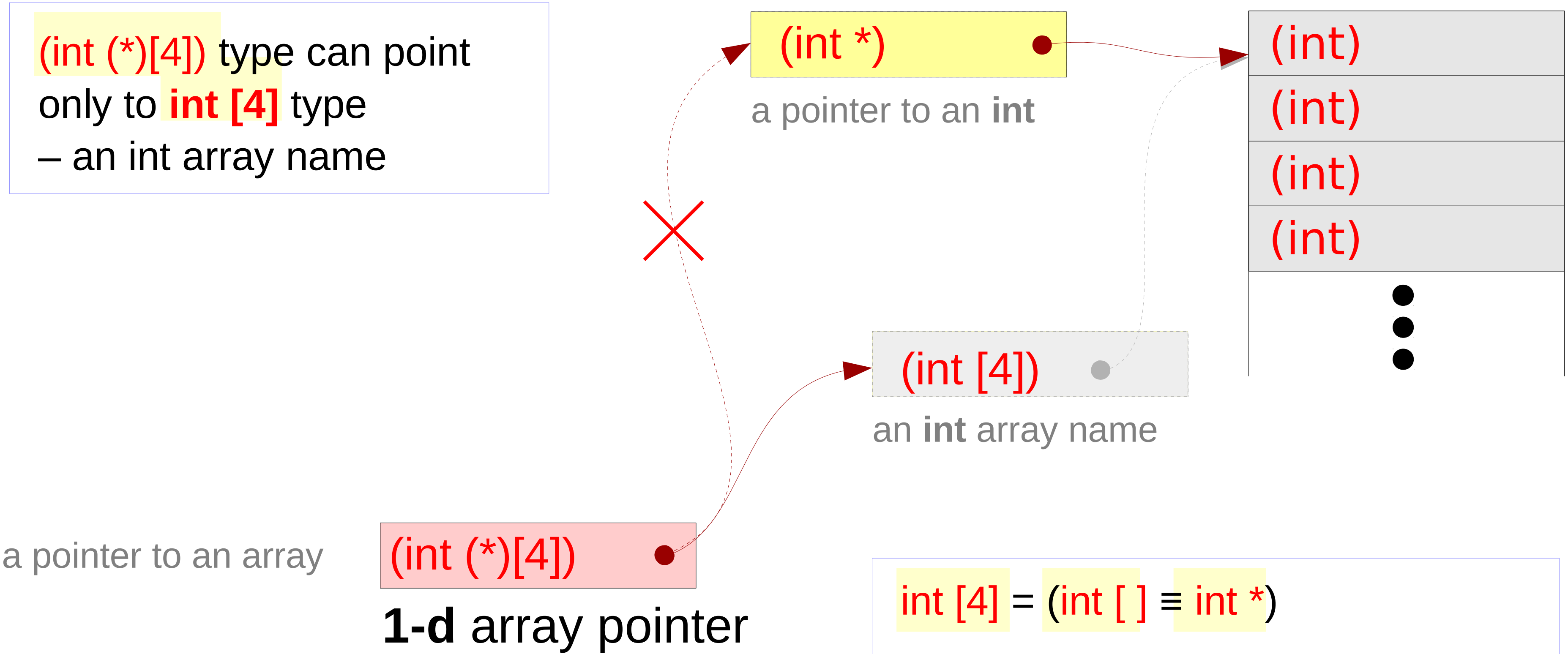
```
int  a[4]  ;
int  (*p) [4] = &a ;
int  (**q) [4] = &p ;
```

```
➡    p = &a ;
➡    q = &p ;
```

Pointer to Multi-dimensional Arrays

Integer pointer type

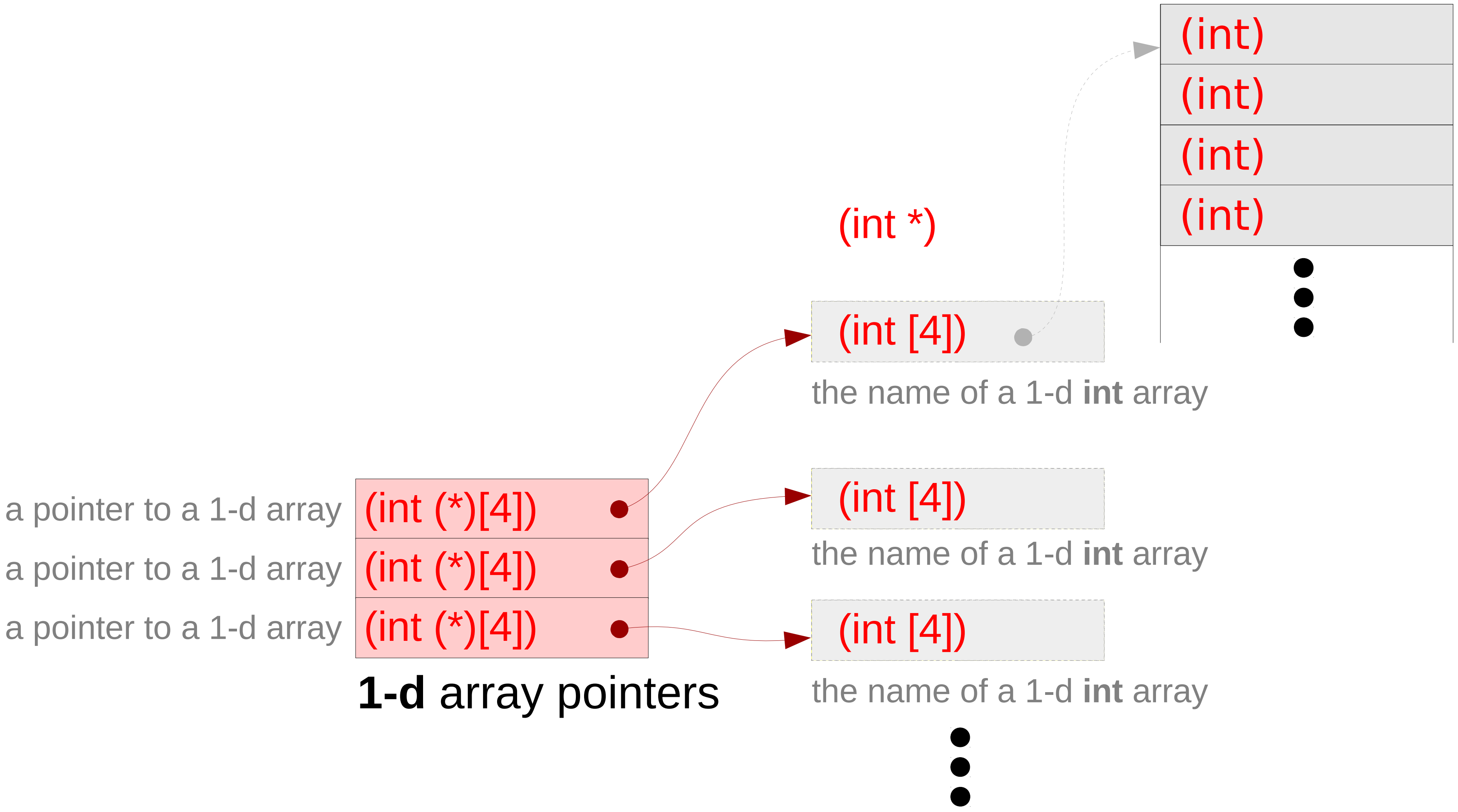
(int (*)[4]) type can point only to **int [4]** type – an int array name



int [4] = (int [ ] ≡ int *)

equivalent in the sense that each of these types points to an **int** type data

Series of array pointers – a type view



(int)

(int)

(int)

(int)

(int *)

(int [4])

the name of a 1-d **int** array

a pointer to a 1-d array (int (*)[4])

a pointer to a 1-d array (int (*)[4])

a pointer to a 1-d array (int (*)[4])

(int [4])

the name of a 1-d **int** array

(int [4])

1-d array pointers

the name of a 1-d **int** array

Series of array pointers – a variable view

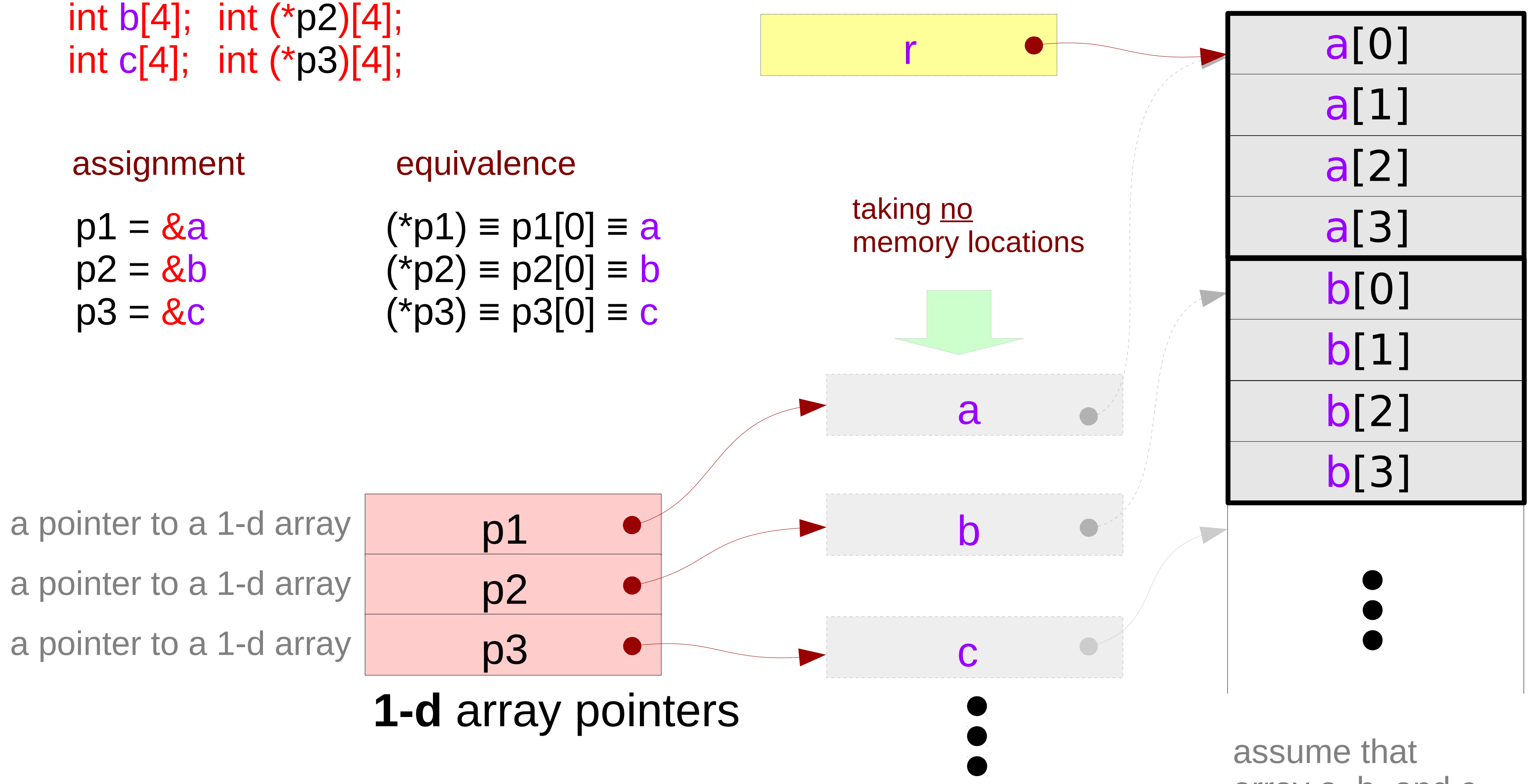
```
int a[4];  int (*p1)[4];   int  (*r);
int b[4];  int (*p2)[4];
int c[4];  int (*p3)[4];
```

assignment

p1 = &a
p2 = &b
p3 = &c

equivalence

(*p1) ≡ p1[0] ≡ a
(*p2) ≡ p2[0] ≡ b
(*p3) ≡ p3[0] ≡ c

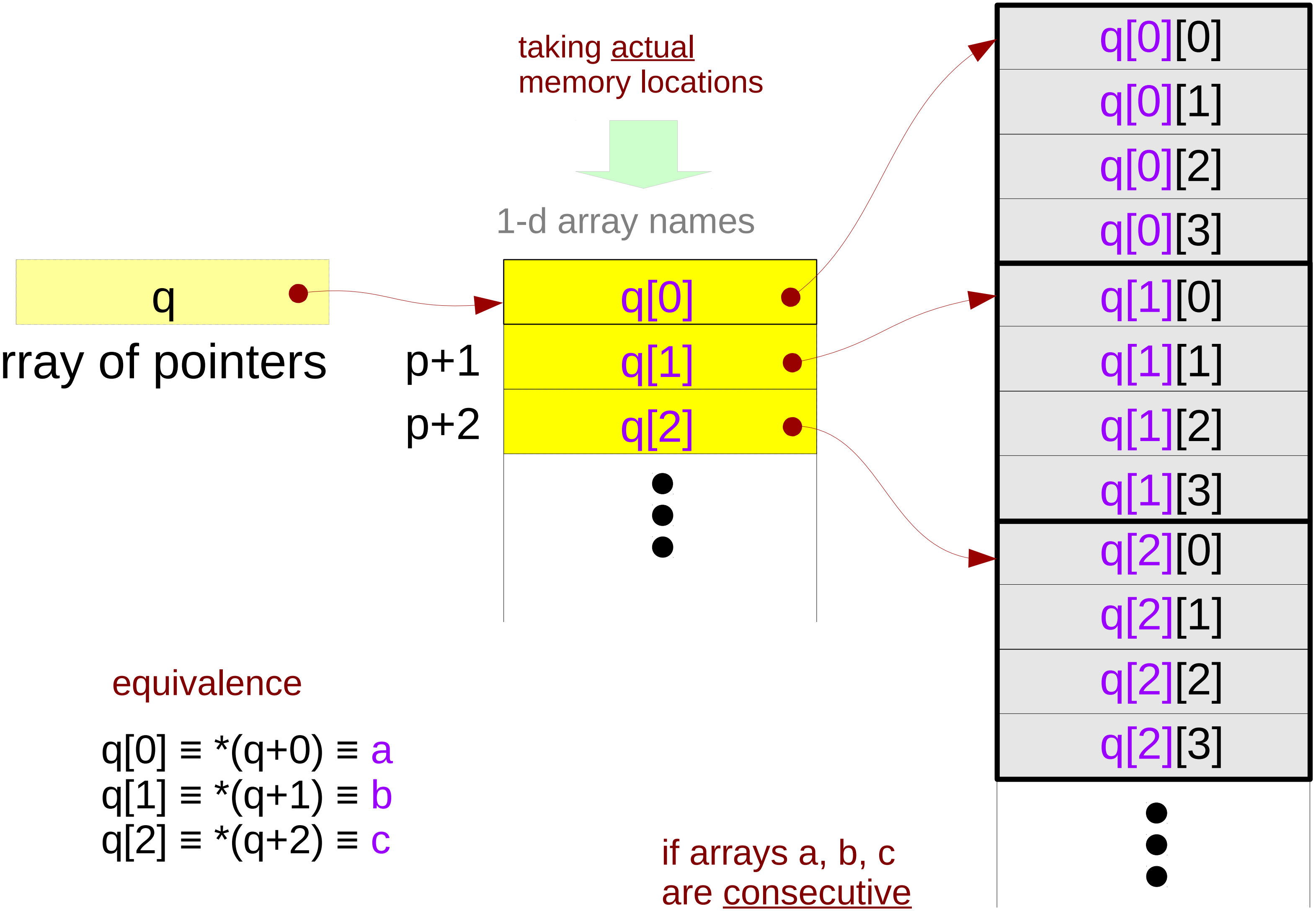


1-d array pointers

assume that array a, b, and c are contiguous in the memory

Pointer array – a variable view

int *q[3];



assignment

q[0] = a
q[1] = b
q[2] = c

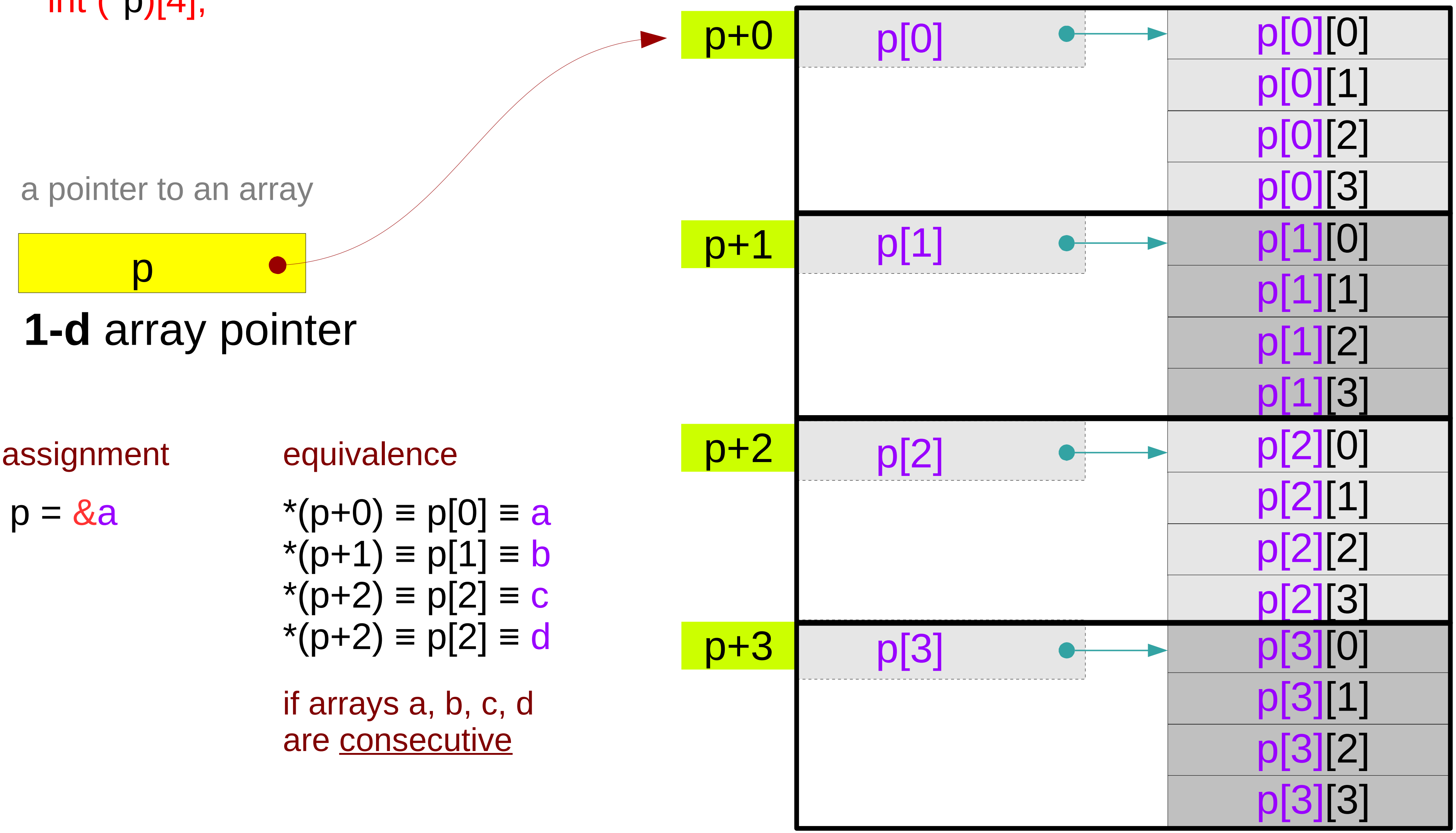
equivalence

q[0] ≡ *(q+0) ≡ a
q[1] ≡ *(q+1) ≡ b
q[2] ≡ *(q+2) ≡ c

if arrays a, b, c
are consecutive

Array pointer to consecutive **1-d** arrays

int (*p)[4];



1-d array pointer

assignment	equivalence
p = &a	*(p+0) ≡ p[0] ≡ a *(p+1) ≡ p[1] ≡ b *(p+2) ≡ p[2] ≡ c *(p+2) ≡ p[2] ≡ d

if arrays a, b, c, d
are consecutive

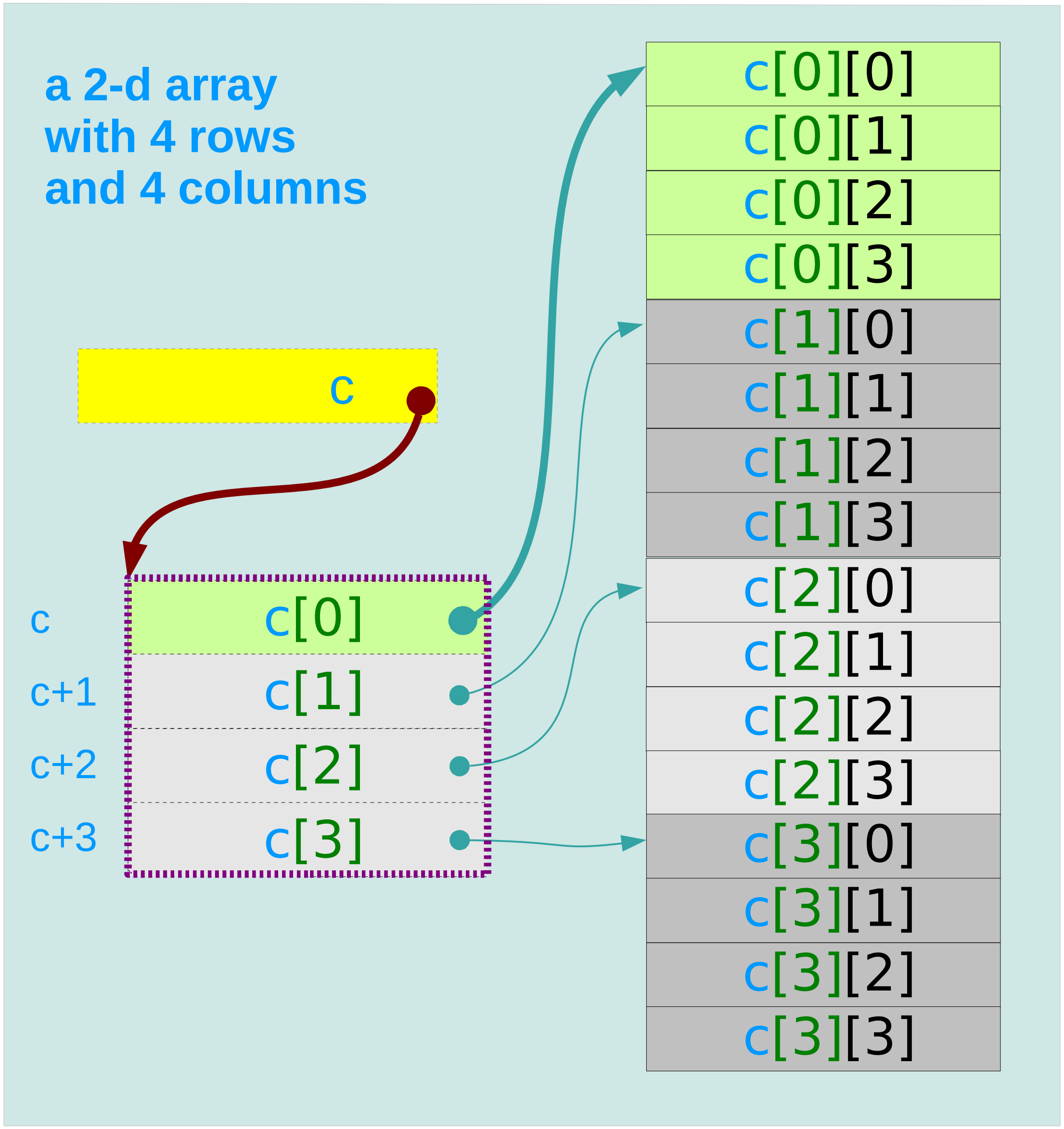
A **2-d** array and its sub-arrays – a variable view

the array name **c** of a **2-d** array as a **1-d** array pointer which points to its 1st **1-d** sub-array

c is the **1-d** array pointer
c[i]'s are the **1-d** sub-array name

c[0]	the 1st	1-d sub-array name
c[1]	the 2nd	1-d sub-array name
c[2]	the 3rd	1-d sub-array name
c[3]	the 4th	1-d sub-array name

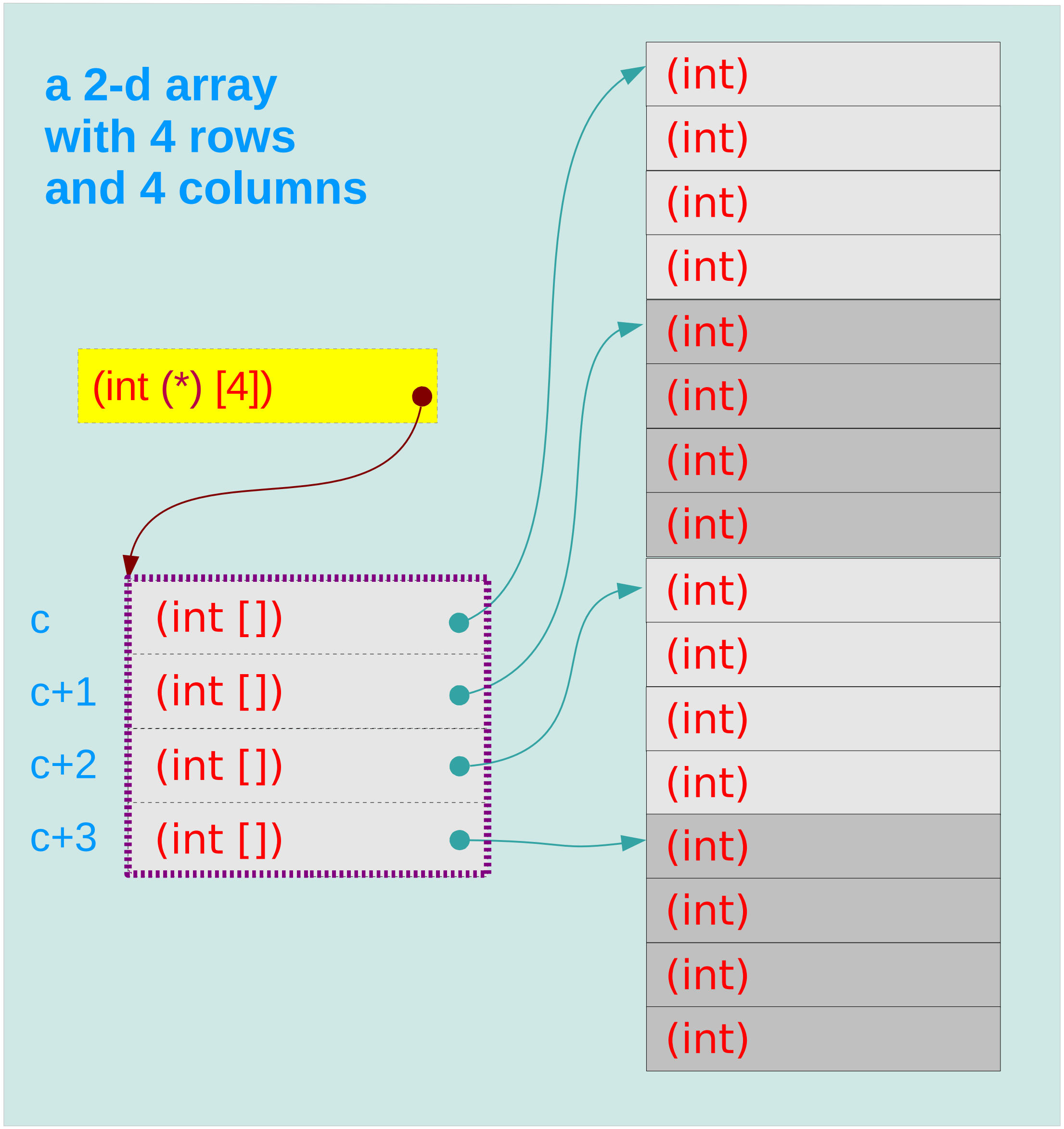
Compilers can make **c[i]**'s require no actual memory locations



A **2-d** array and its sub-arrays – a type view

1-d array pointer

1-d array name
1-d array name
1-d array name
1-d array name



1-d subarray aggregated data type

The 1st subarray c[0] (=array name)

sizeof(c[0]) = 16 bytes

The 2nd subarray c[1] (=array name)

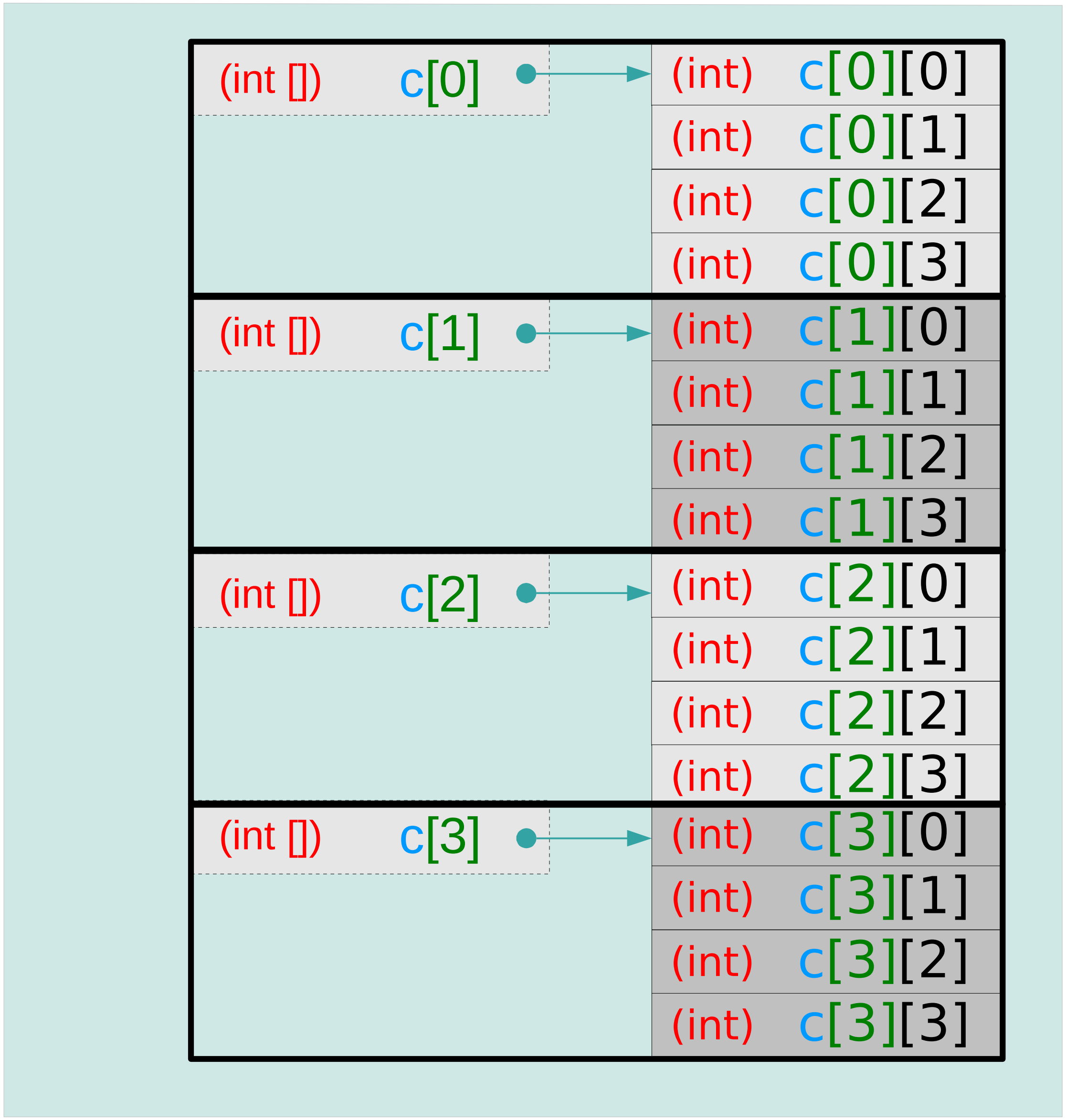
sizeof(c[1]) = 16 bytes

The 3rd subarray c[2] (=array name)

sizeof(c[2]) = 16 bytes

The 4th subarray c[3] (=array name)

sizeof(c[3]) = 16 bytes



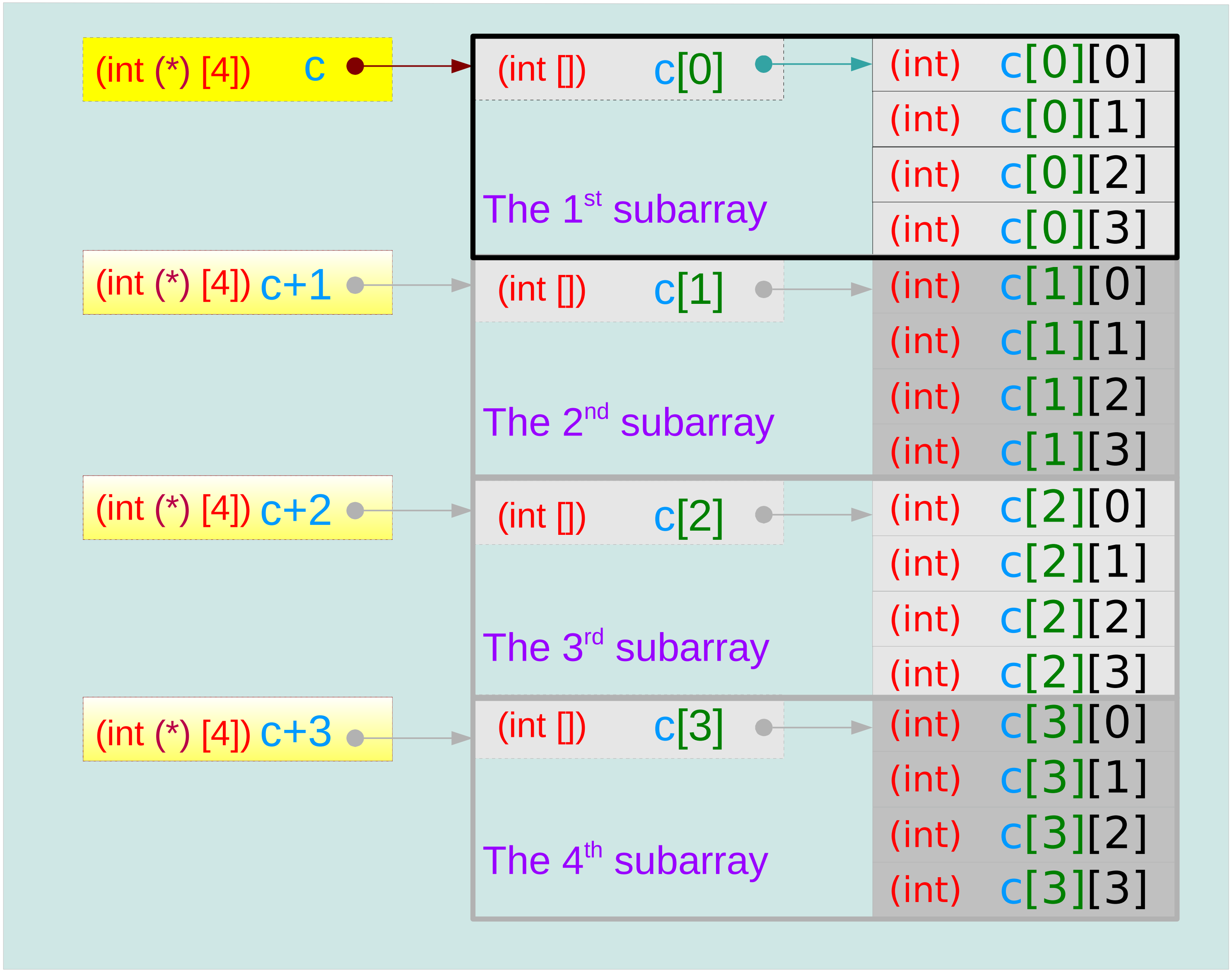
2-d array name as a pointer to a **1-d** subarray

1-d array pointer

1-d array pointer

1-d array pointer

1-d array pointer



(int (*) [4]) c

(int []) c[0]

(int) c[0][0]

(int) c[0][1]

(int) c[0][2]

(int) c[0][3]

The 1st subarray

(int (*) [4]) c+1

(int []) c[1]

(int) c[1][0]

(int) c[1][1]

(int) c[1][2]

(int) c[1][3]

The 2nd subarray

(int (*) [4]) c+2

(int []) c[2]

(int) c[2][0]

(int) c[2][1]

(int) c[2][2]

(int) c[2][3]

The 3rd subarray

(int (*) [4]) c+3

(int []) c[3]

(int) c[3][0]

(int) c[3][1]

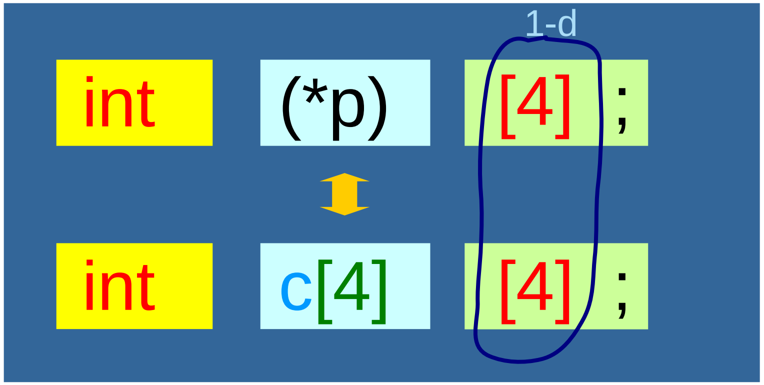
(int) c[3][2]

(int) c[3][3]

The 4th subarray

2-d array and **1-d** and **2-d** array pointers

1-d array pointer



1-d

int (*p) [4] ;

int c[4] [4] ;

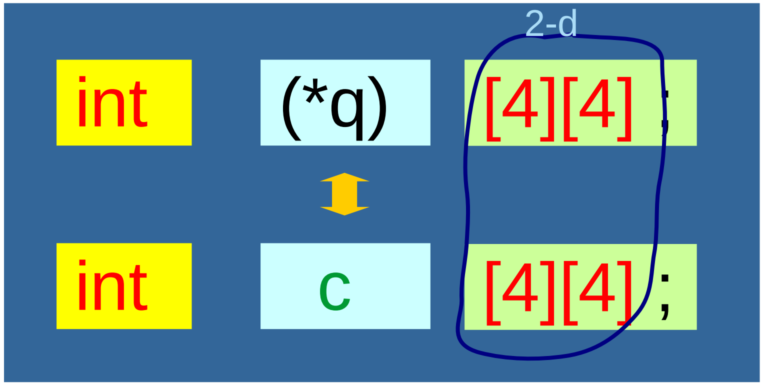
(int (*) [4])

```
p = &c[0];
```

```
p = c;
```

p[0] ≡ c[0]
p[1] ≡ c[1]
p[2] ≡ c[2]
p[3] ≡ c[3]

2-d array pointer



2-d

int (*q) [4][4] ;

int c [4][4];

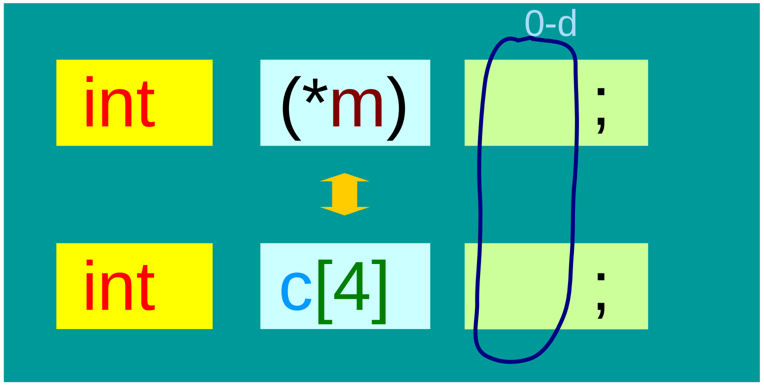
(int(*)[4][4])

```
q = &c;
```

(*q)[0] ≡ q[0][0] ≡ c[0]
(*q)[1] ≡ q[0][0] ≡ c[1]
(*q)[2] ≡ q[0][0] ≡ c[2]
(*q)[3] ≡ q[0][0] ≡ c[3]

1-d array and **0-d** and **1-d** array pointers

0-d array pointer : int pointer



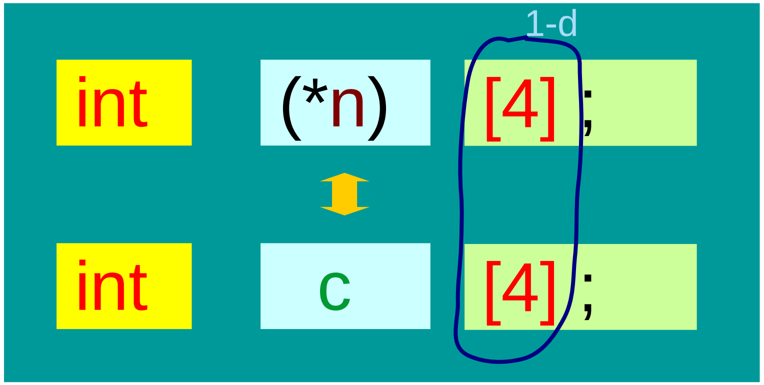
(int (*))

```
m = &c[0];
```

```
m = c;
```

m[0] ≡ c[0]
m[1] ≡ c[1]
m[2] ≡ c[2]
m[3] ≡ c[3]

1-d array pointer

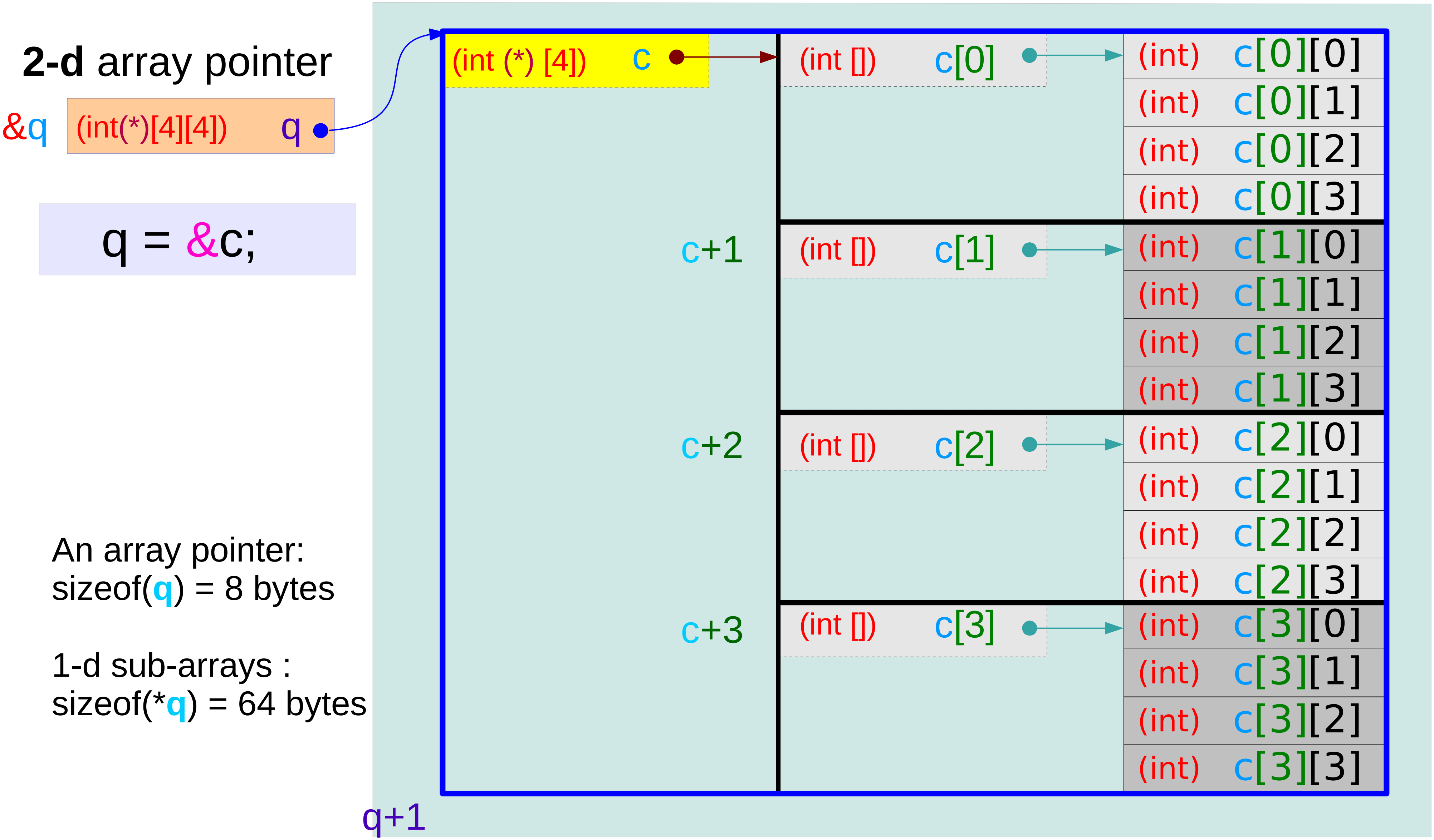


(int(*)[4])

```
n = &c;
```

(*n)[0] ≡ n[0][0] ≡ c[0]
(*n)[1] ≡ n[0][0] ≡ c[1]
(*n)[2] ≡ n[0][0] ≡ c[2]
(*n)[3] ≡ n[0][0] ≡ c[3]

2-d array pointer to a 2-d array



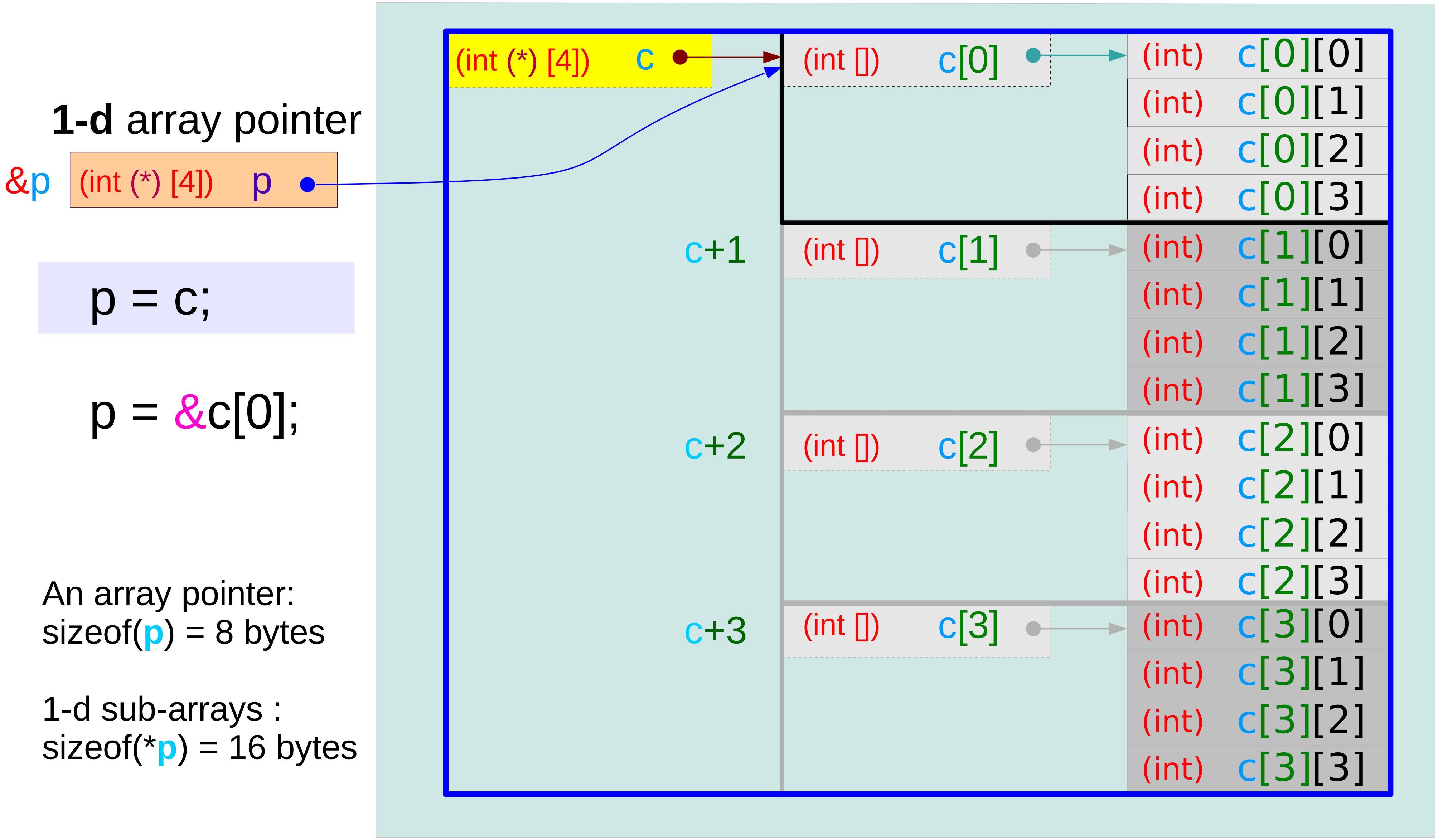
```
q = &c;
```

An array pointer:
sizeof(q) = 8 bytes

1-d sub-arrays :
sizeof(*q) = 64 bytes

1-d array pointer to a **2-d** array

1-d array pointer



```
p = c;
```

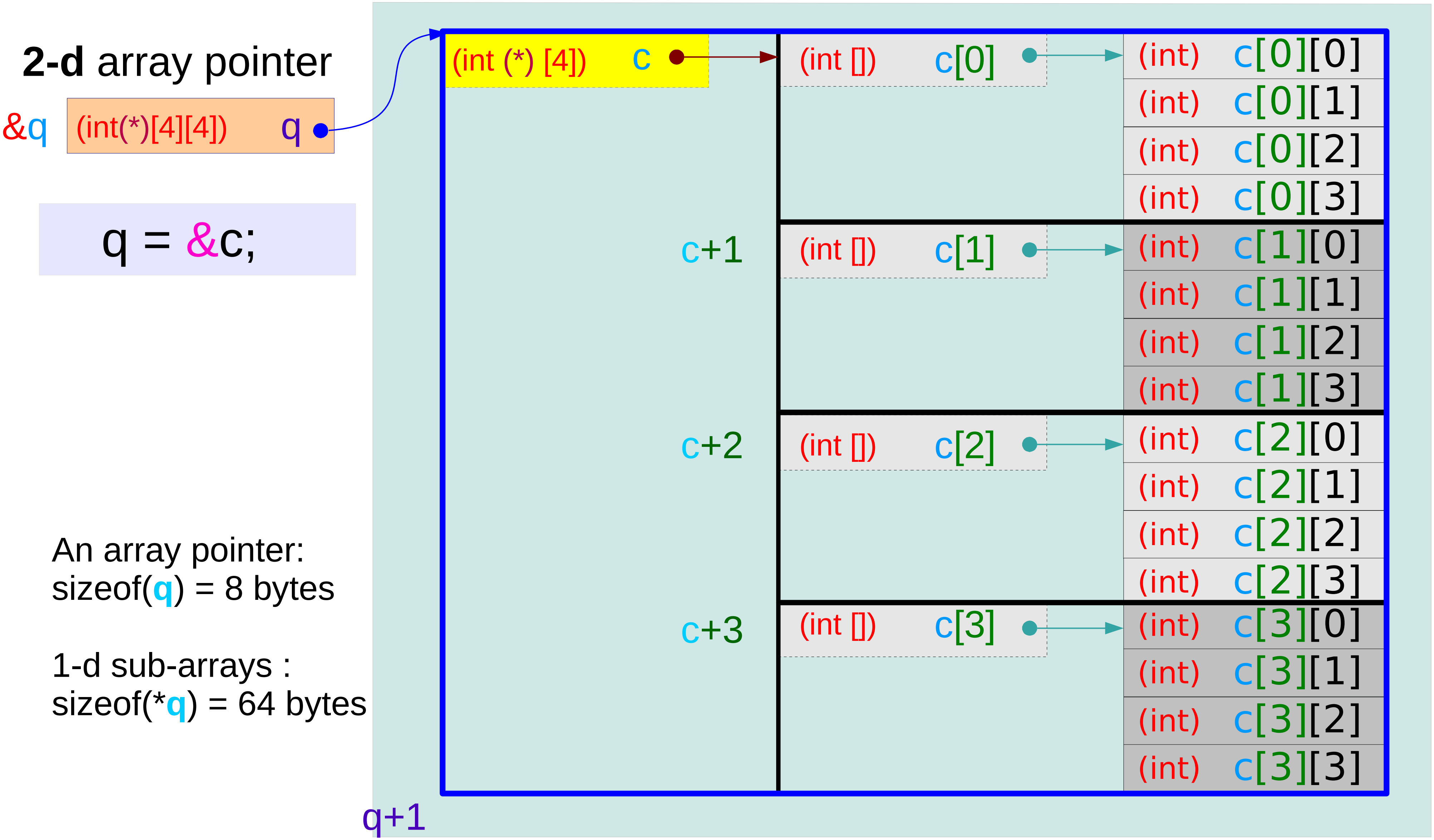
```
p = &c[0];
```

An array pointer:
sizeof(p) = 8 bytes

1-d sub-arrays :
sizeof(*p) = 16 bytes

2-d array pointer to a 2-d array

2-d array pointer



```
q = &c;
```

An array pointer:
sizeof(q) = 8 bytes

1-d sub-arrays :
sizeof(*q) = 64 bytes

Using a **1-d** array pointer to a **2-d** array

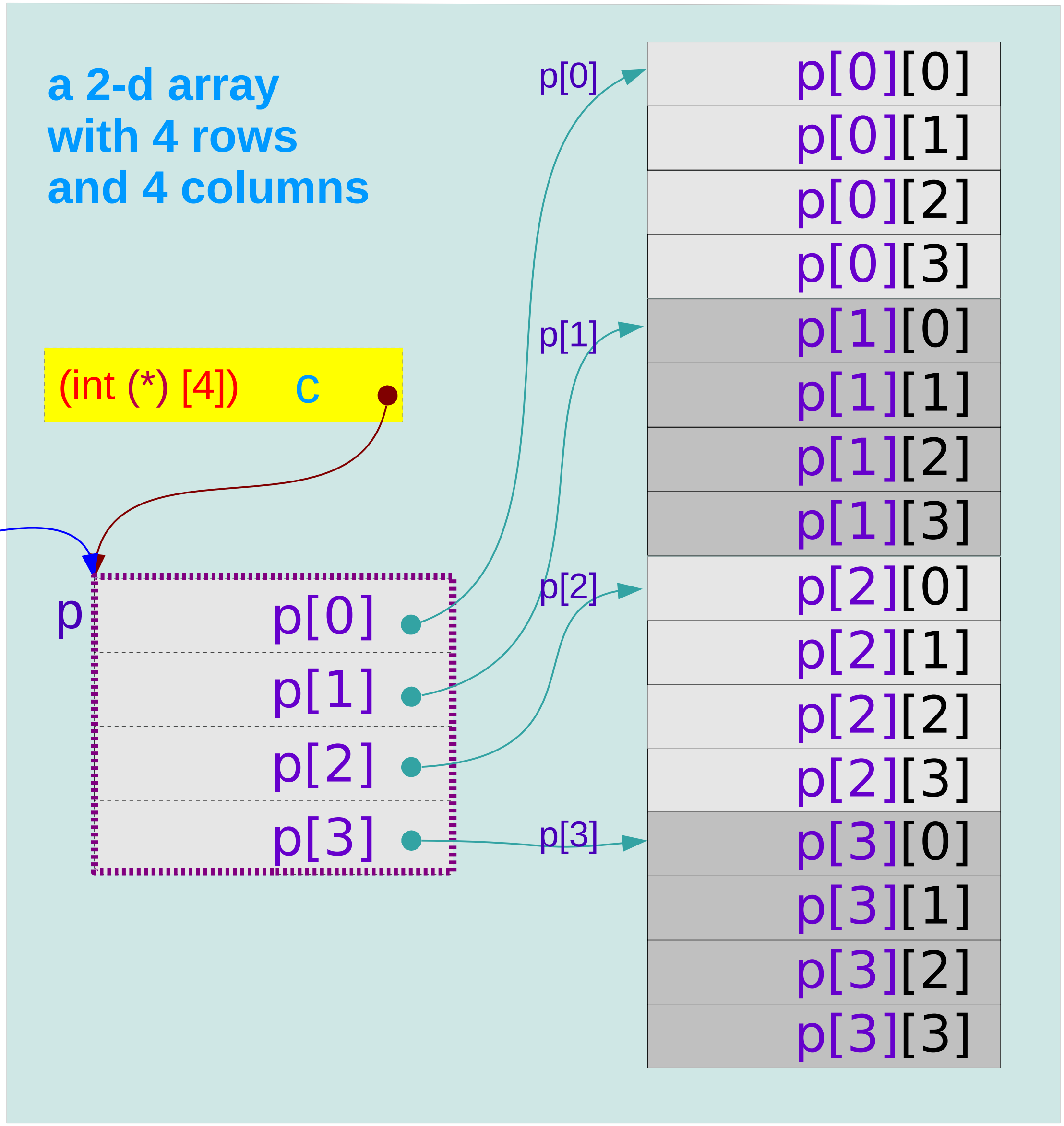
```
int   (*p)   [4] ;
        ↕
int   c[4]   [4]
```

1-d array pointer

&p (int (*) [4]) p

```
p = c;
```

p[0] ≡ c[0]
p[1] ≡ c[1]
p[2] ≡ c[2]
p[3] ≡ c[3]



Using a **2-d** array pointer to a **2-d** array

int (*q) [4][4] ;

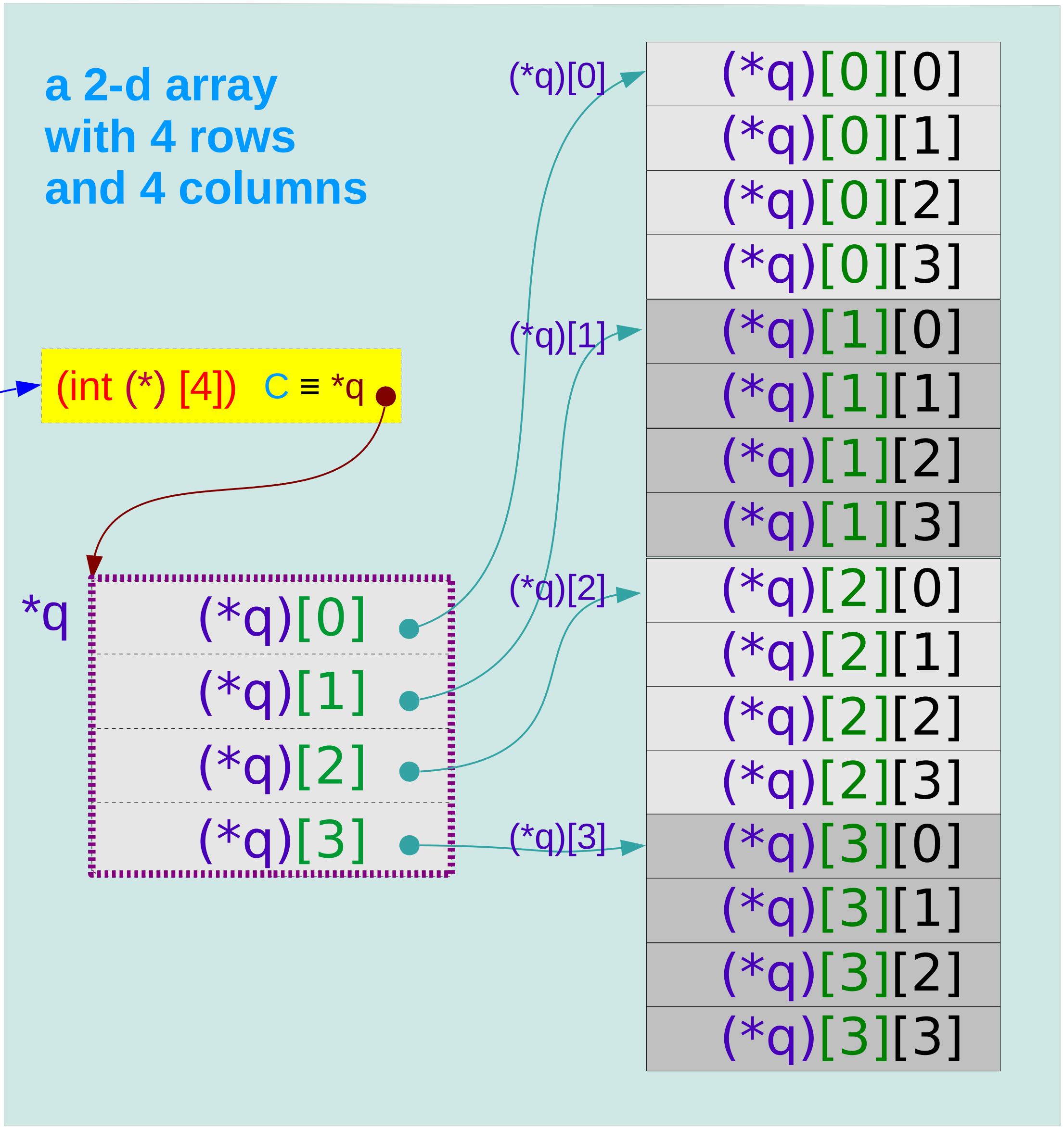
int c [4][4] ;

2-d array pointer

&p (int(*)[4][4]) q

q = &c;

(*q)[0] ≡ c[0]
(*q)[1] ≡ c[1]
(*q)[2] ≡ c[2]
(*q)[3] ≡ c[3]

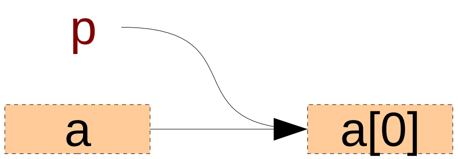


(***n-1***)**-d** array pointer to a ***n*-d** array

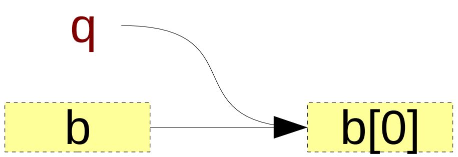
`int a[4] ;`	**1-d** array
`int (*p) ;`	**0-d** array pointer
`int b[4]  [2];`	**2-d** array
`int (*q)  [2];`	**1-d** array pointer
`int c[4]  [2][3];`	**3-d** array
`int (*r)  [2][3];`	**2-d** array pointer
`int d[4]  [2][3][4];`	**4-d** array
`int (*s)  [2][3][4];`	**3-d** array pointer

n-d array name : (*n-1*)-d array pointer

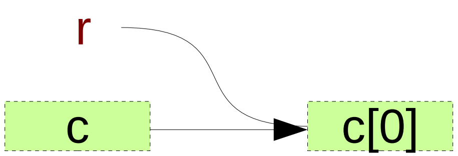
```
int a[4] ;              p = &a[0];
int (*p) ;              p = a;
```



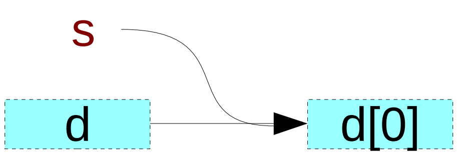
```
int b[4]  [2];          q = &b[0];
int (*q)  [2];          q = b;
```



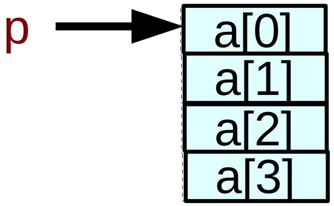
```
int c[4]  [2][3];       r = &c[0];
int (*r)  [2][3];       r = c;
```

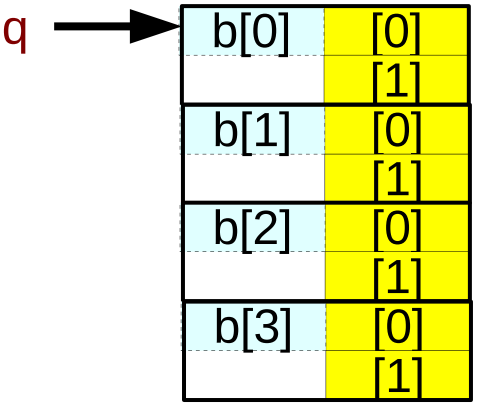


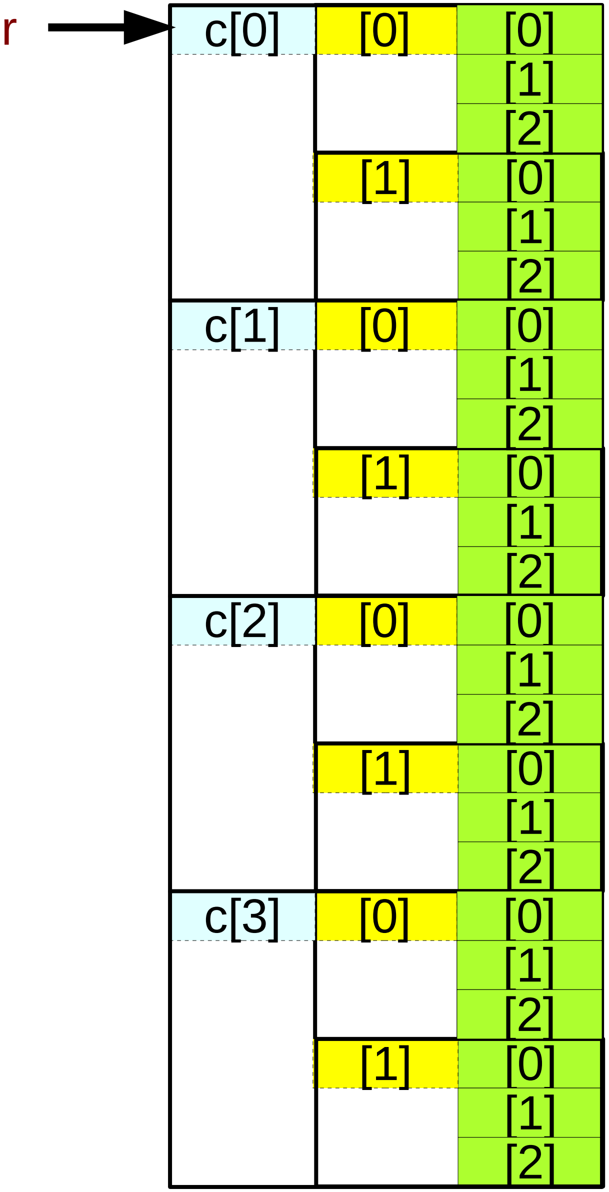
```
int d[4]  [2][3][4];    s = &d[0];
int (*s)  [2][3][4];    s = d;
```



multi-dimensional array pointers

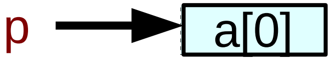


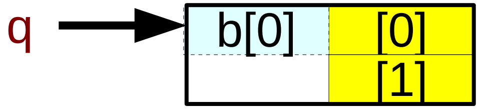




```
int a[4] ;                 int (*p) ;
int b[4]  [2];             int (*q)  [2];
int c[4]  [2][3];          int (*r)   [2][3];
int d[4]  [2][3][4];       int (*s)  [2][3][4];
```

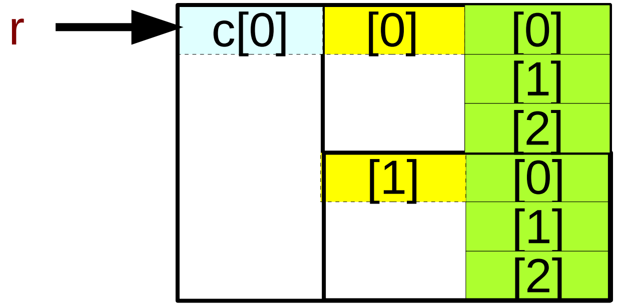
multi-dimensional array pointers





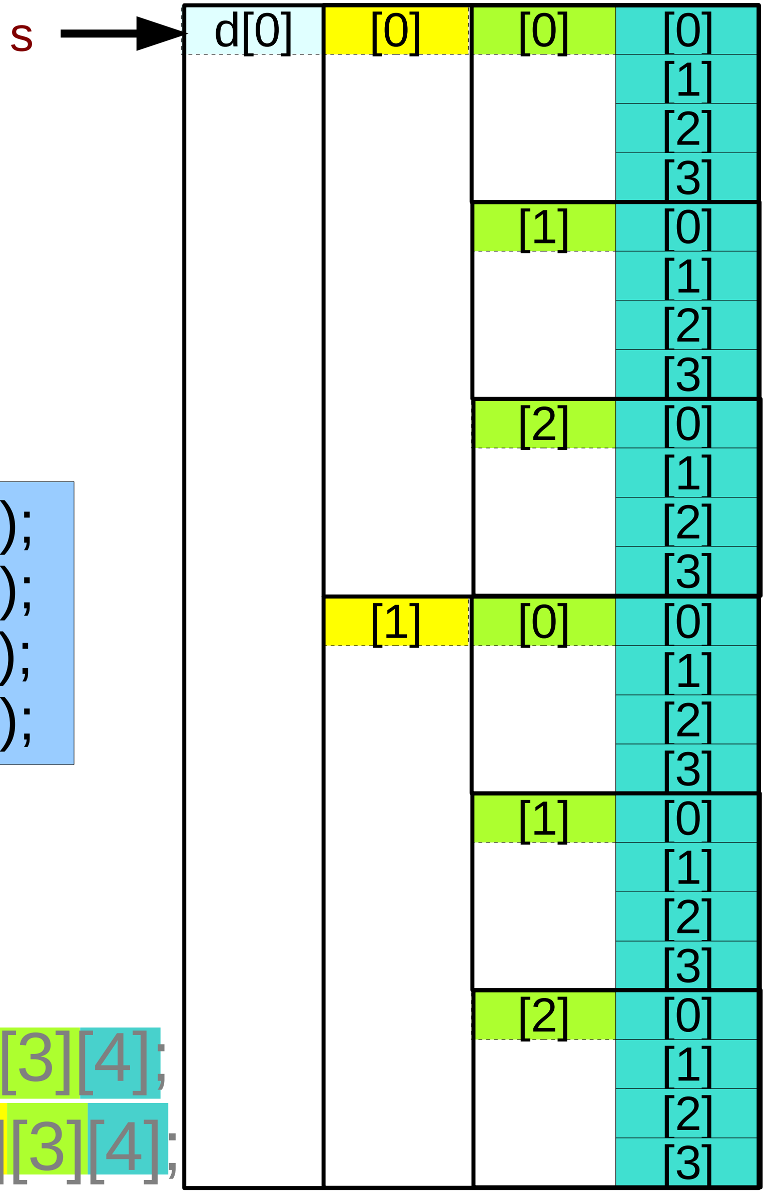
```
int a[4] ;
int (*p) ;
```

```
int b[4] [2];
int (*q) [2];
```



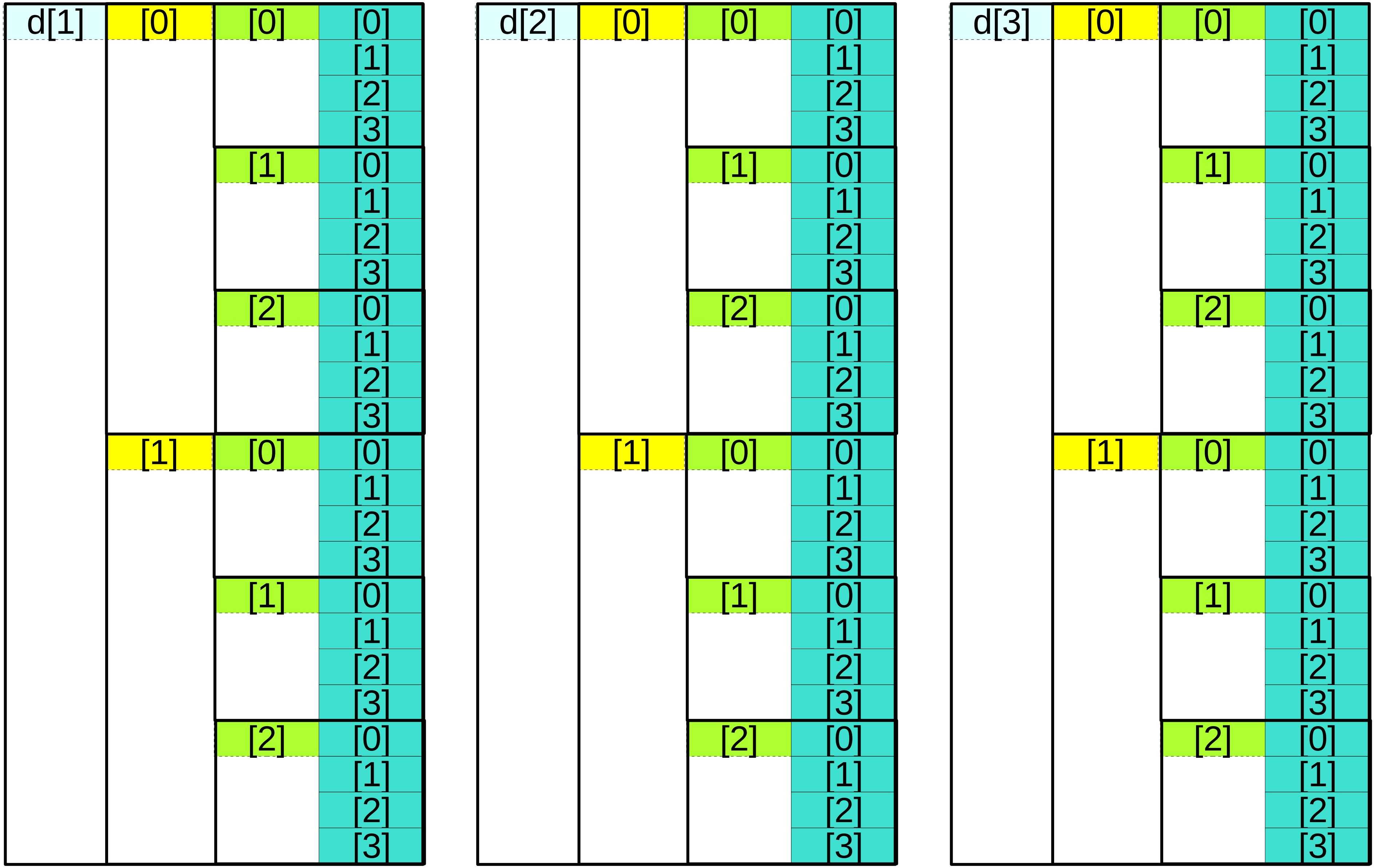
```
p = a;   (=&a[0]);
q = b;   (=&b[0]);
r  = c;  (=&c[0]);
s = d;   (=&d[0]);
```

```
int c[4] [2][3];
int (*r) [2][3];
```



```
int d[4] [2][3][4];
int (*s) [2][3][4];
```

multi-dimensional array pointers



d[1]	[0]	[0]	[0]
			[1]
			[2]
			[3]
		[1]	[0]
			[1]
			[2]
			[3]
		[2]	[0]
			[1]
			[2]
			[3]
	[1]	[0]	[0]
			[1]
			[2]
			[3]
		[1]	[0]
			[1]
			[2]
			[3]
		[2]	[0]
			[1]
			[2]
			[3]

d[2]	[0]	[0]	[0]
			[1]
			[2]
			[3]
		[1]	[0]
			[1]
			[2]
			[3]
		[2]	[0]
			[1]
			[2]
			[3]
	[1]	[0]	[0]
			[1]
			[2]
			[3]
		[1]	[0]
			[1]
			[2]
			[3]
		[2]	[0]
			[1]
			[2]
			[3]

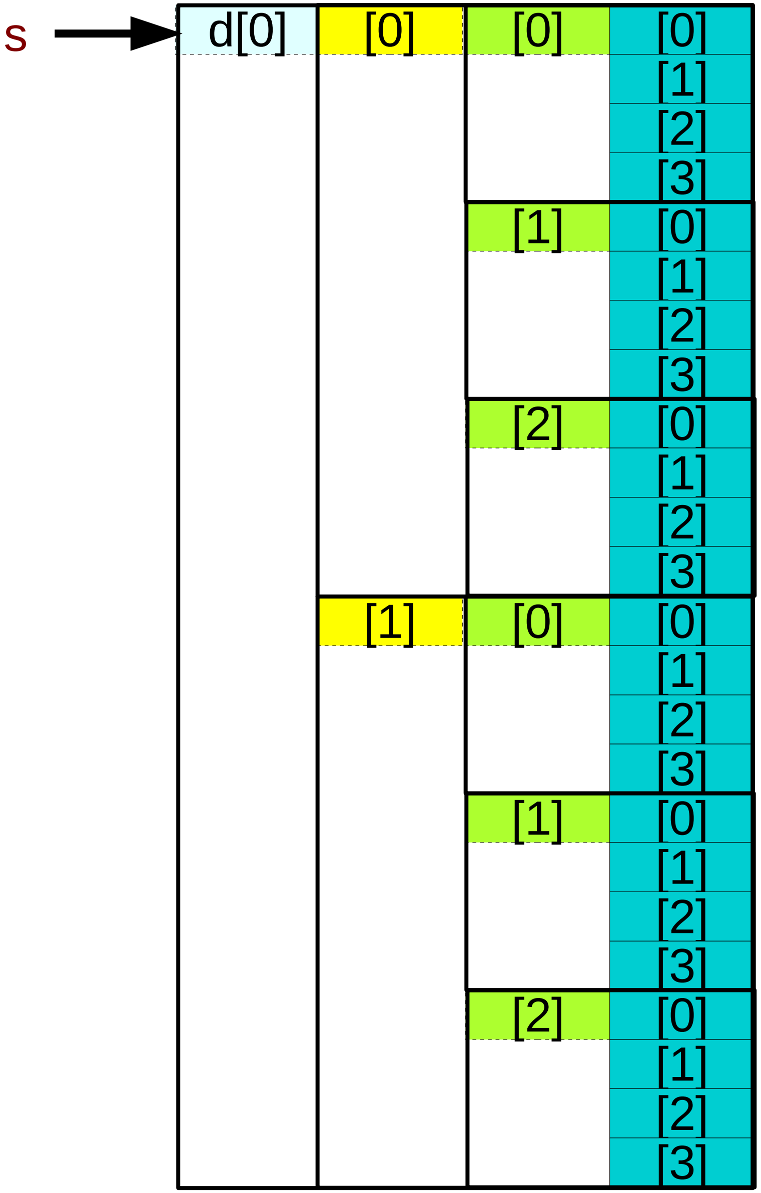
d[3]	[0]	[0]	[0]
			[1]
			[2]
			[3]
		[1]	[0]
			[1]
			[2]
			[3]
		[2]	[0]
			[1]
			[2]
			[3]
	[1]	[0]	[0]
			[1]
			[2]
			[3]
		[1]	[0]
			[1]
			[2]
			[3]
		[2]	[0]
			[1]
			[2]
			[3]

multi-dimensional array pointers

```
int d[4] [2][3][4];
int (*s)  [2][3][4];
```

d	4-d array name	d[4] [2][3][4]
	3-d array pointer	(*d) [2][3][4]
d[i]	3-d array name	d[i][2][3][4]
	2-d array pointer	(*d[i])[3][4]
d[i][j]	2-d array name	d[i][j][3][4]
	1-d array pointer	(*d[i][j])[4]
d[i][j][k]	1-d array name	d[i][j][k][4]
	0-d array pointer	(*d[i][j][k])

i =[0..3], j = [0..1], k= [0..2]



To pass multidimensional array names

```
int a[4] ;
int (*p) ;
```

call

```
funa(a, …);
```

prototype

```
void funa(int (*p), …);
```

```
int b[4]  [2];
int (*q)  [2];
```

call

```
funb(b, …);
```

prototype

```
void funb(int (*q)[2], …);
```

```
int c[4]  [2][3];
int (*r)  [2][3];
```

call

```
func(c, …);
```

prototype

```
void func(int (*r)[2][3], …);
```

```
int d[4]  [2][3][4];
int (*s)  [2][3][4];
```

call

```
fund(d, …);
```

prototype

```
void fund(int (*s)[2][3][4], …);
```

References

[1] Essential C, Nick Parlante

[2] Efficient C Programming, Mark A. Weiss

[3] C A Reference Manual, Samuel P. Harbison & Guy L. Steele Jr.

[4] C Language Express, I. K. Chun