Applications of Pointers (1A)

Please send corrections (or suggestions) to youngwlim@hotmail.com.

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Array of Pointers

Array of Pointers

```
int     a [4];

int *   b [4];
```

No. of elements = 4

int a [4]

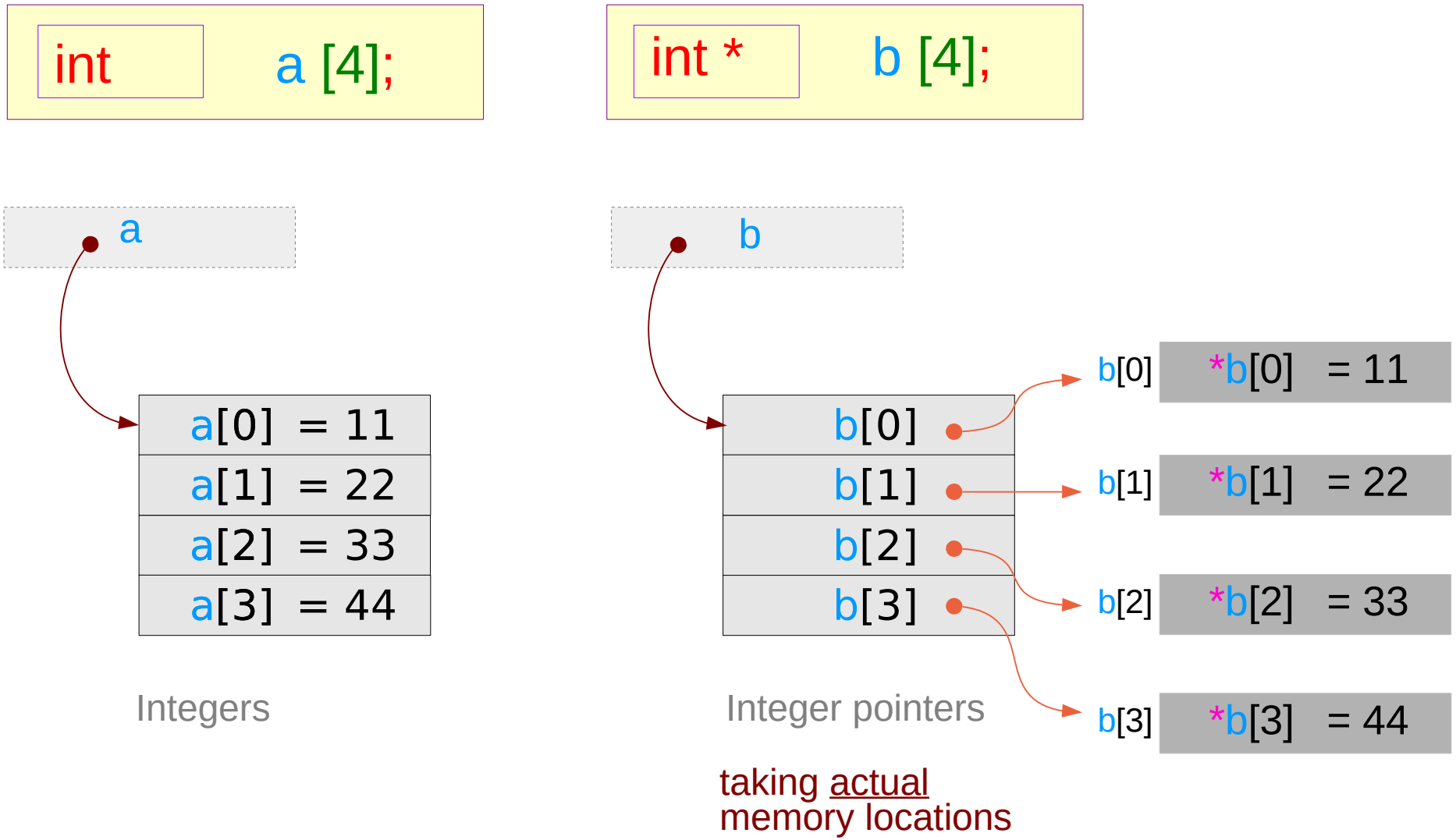
Type of each element

No. of elements = 4

int * b [4]

Type of each element

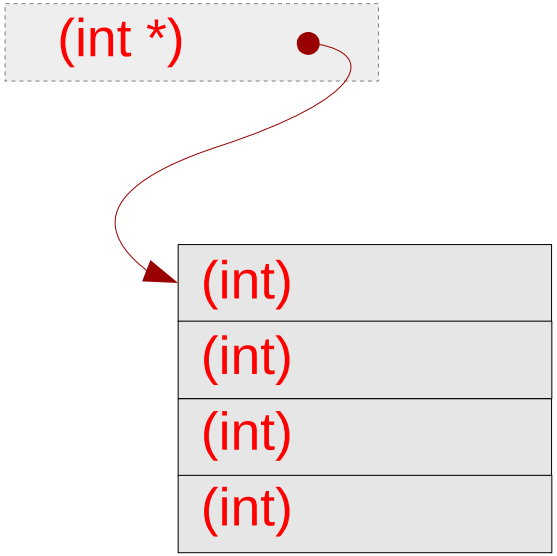
Array of Pointers – a variable view



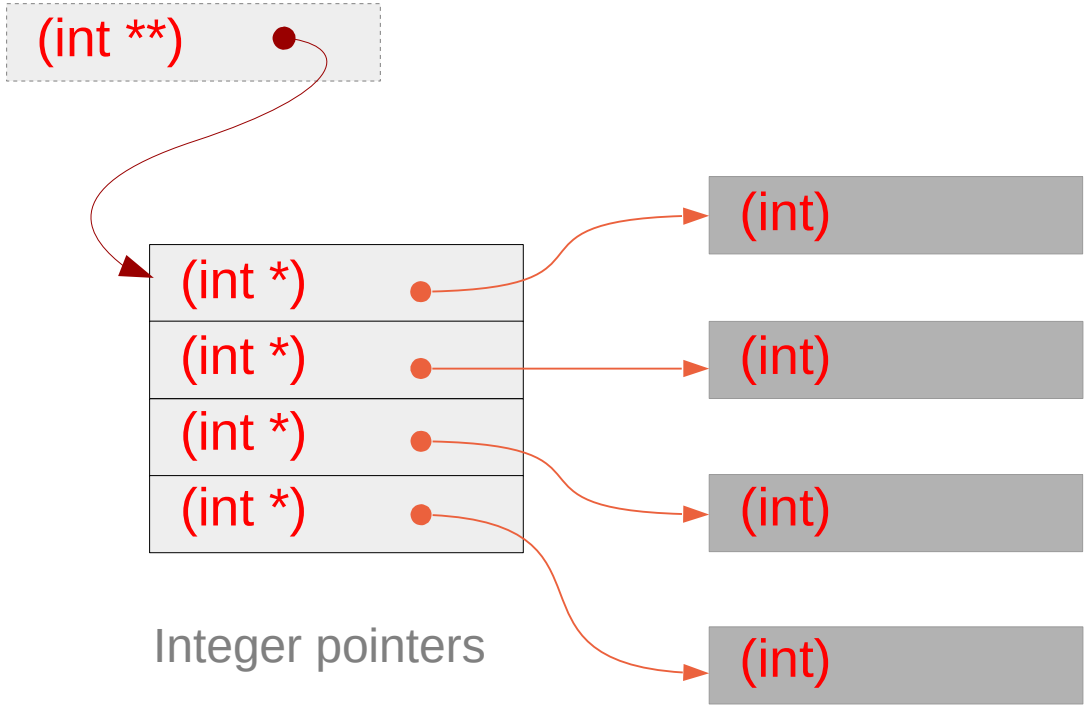
Array of Pointers – a type view

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

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



Integers



Integer pointers

taking actual
memory locations

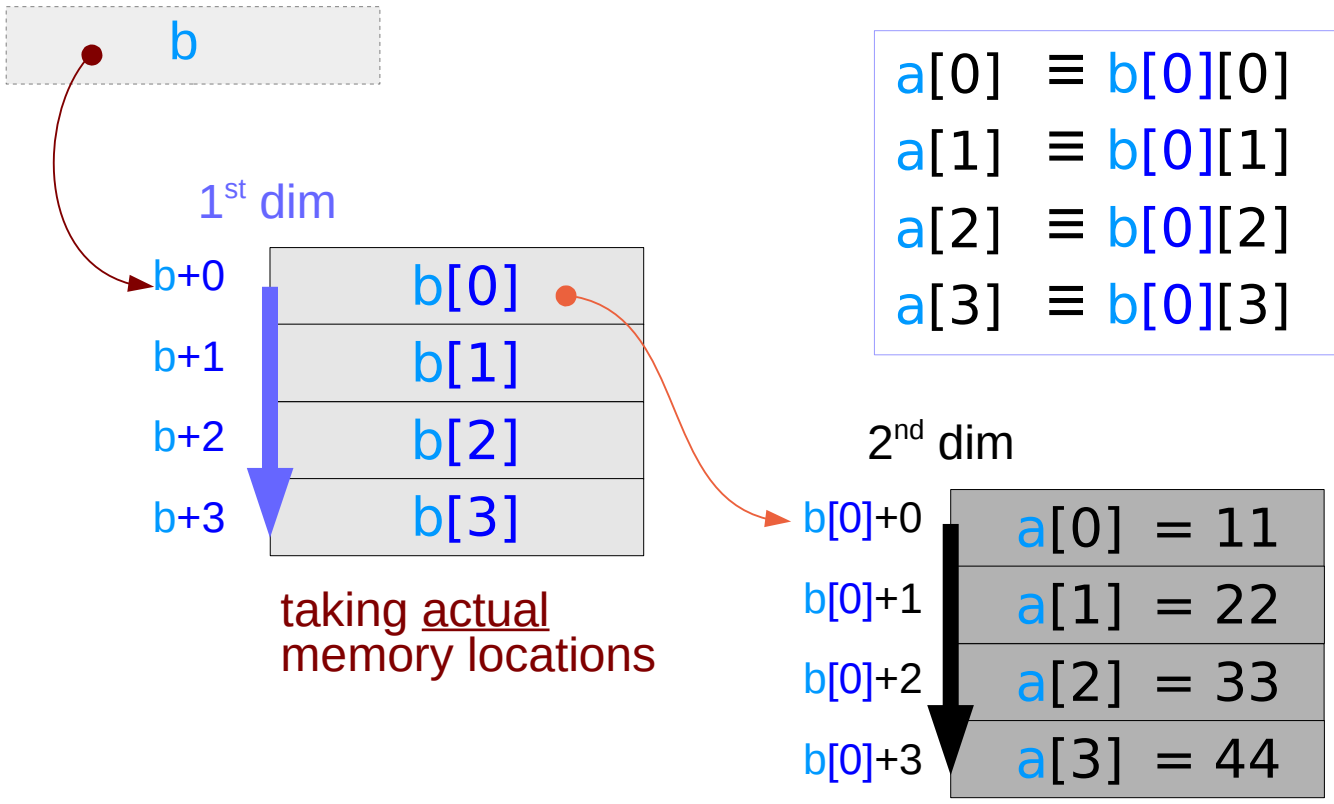
Array of Pointers – extending a dimension

```
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)
```



Pointer to Arrays

Pointer to an array – variable declarations

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

an integer pointer

```
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]

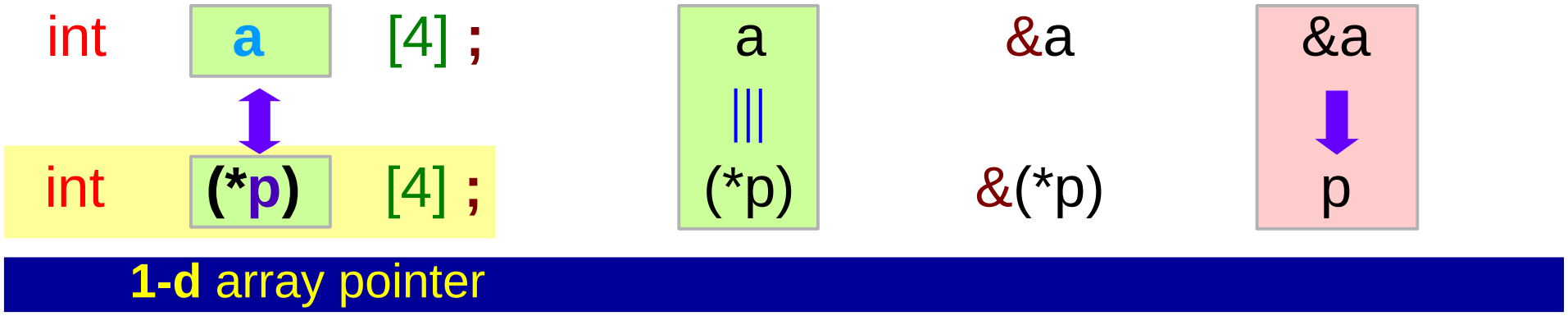
an array pointer

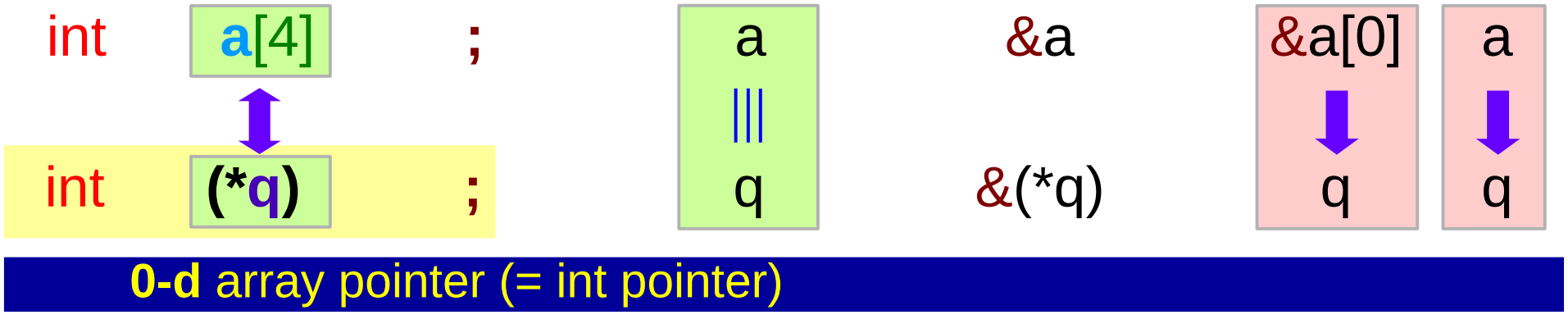
int (int, int) instructions

int (*) (int, int)

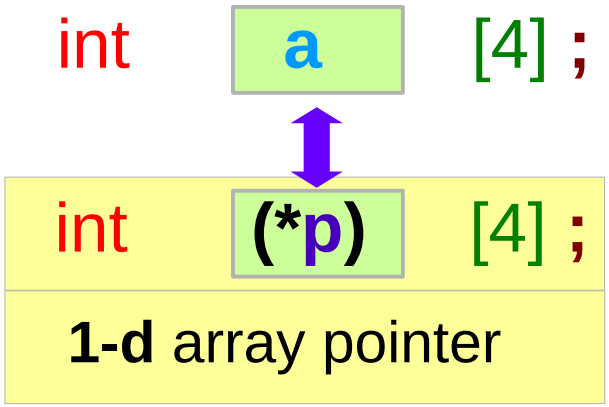
a function pointer

Pointer to an array : assignment and equivalence



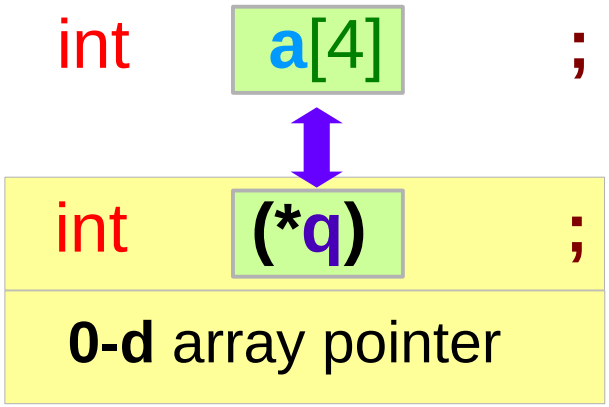


Pointer to an array : size of array



p = &a;

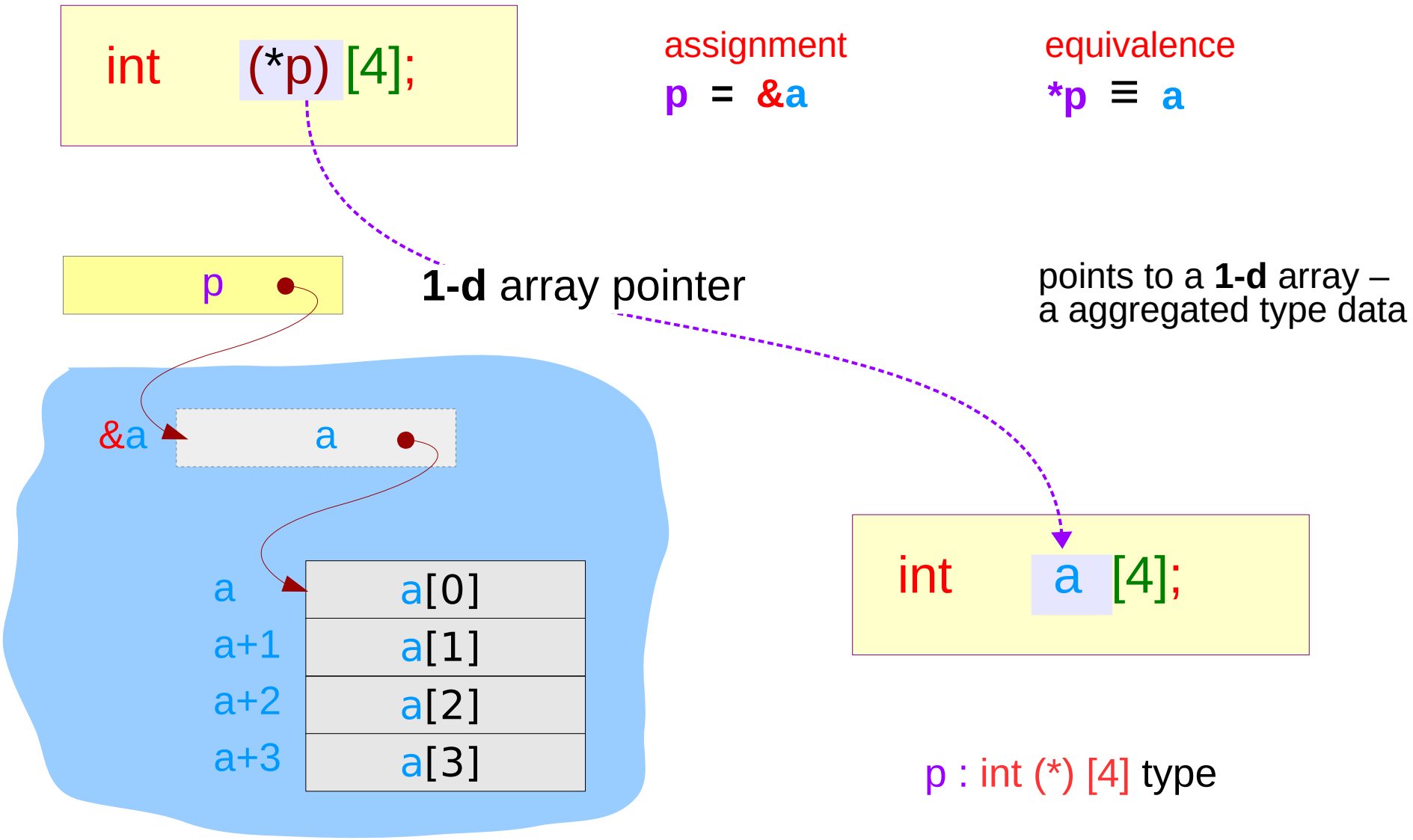
sizeof(p)= 8 bytes : the size of a pointer
sizeof(*p)= 4*4 bytes : the whole size of the pointed 1-d array



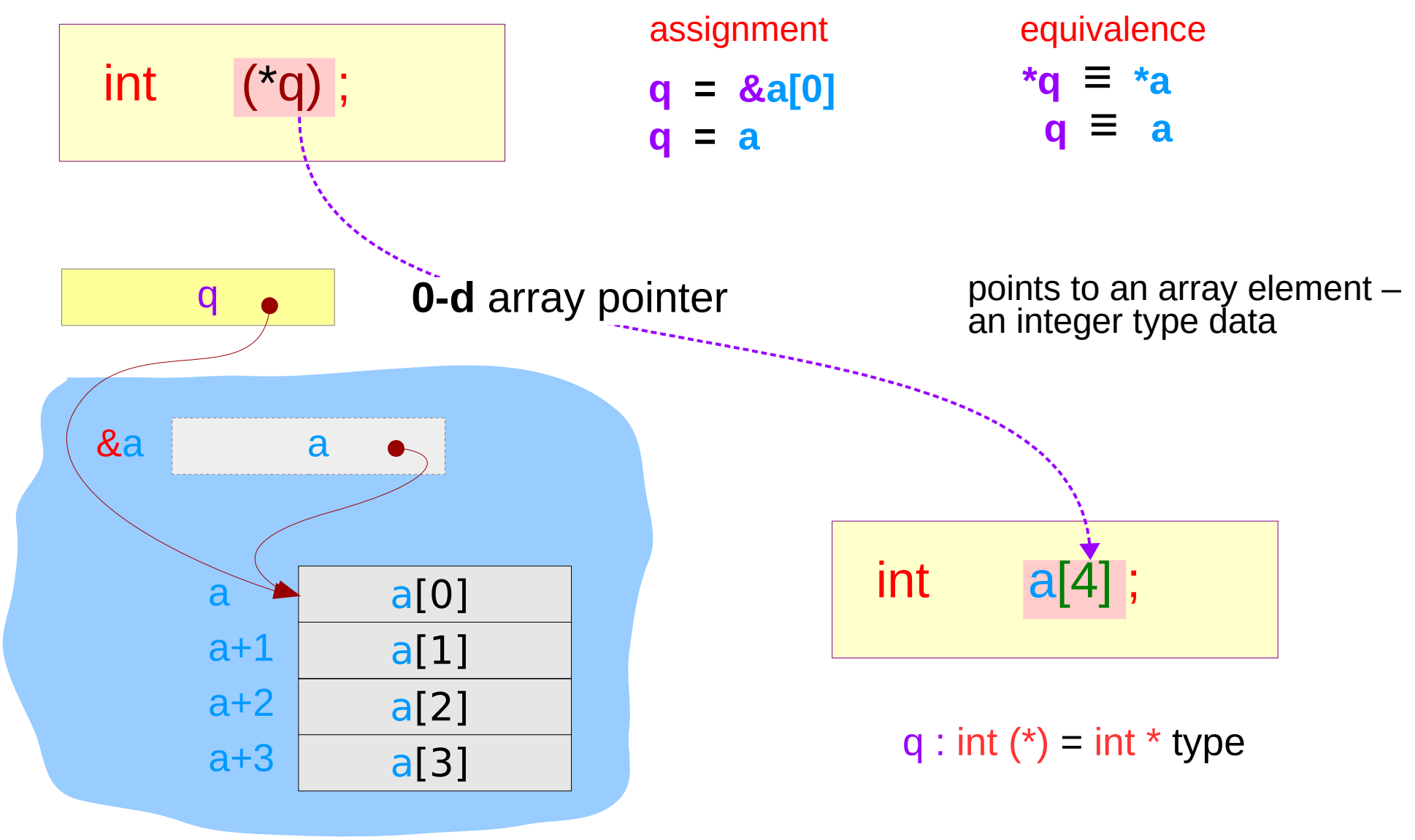
q = a;

sizeof(q)= 8 bytes : the size of a pointer
sizeof(*q)= 4 bytes : the whole size of the pointed 0-d array

Pointer to an array – a variable view (1)



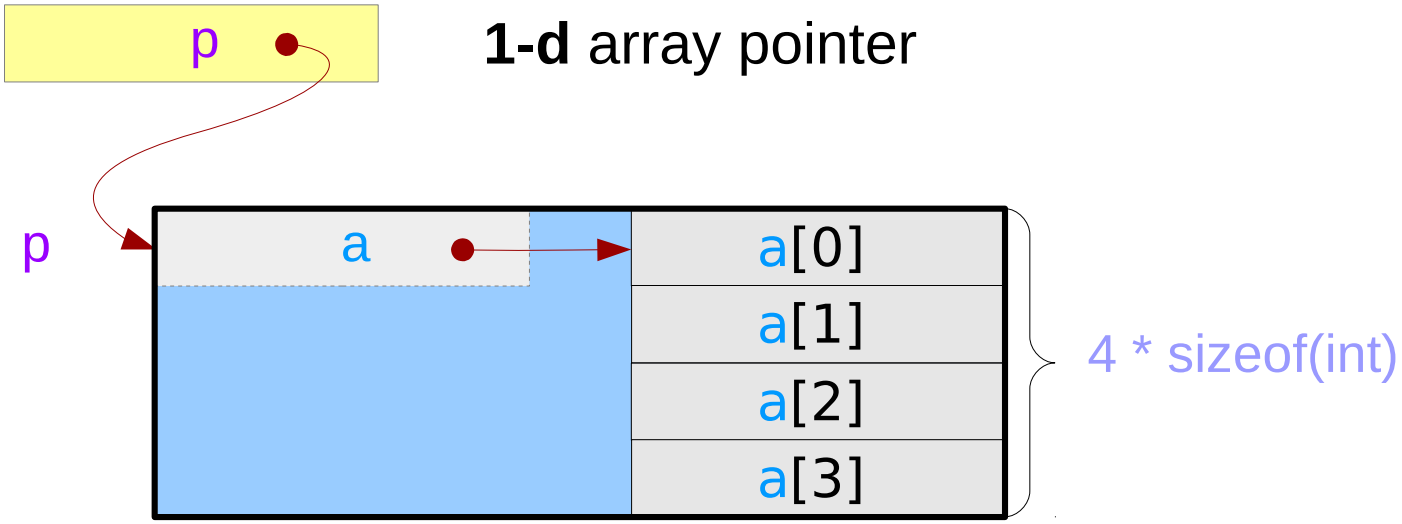
Pointer to an array – a variable view (2)



Pointer to an array – an aggregated type view

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

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



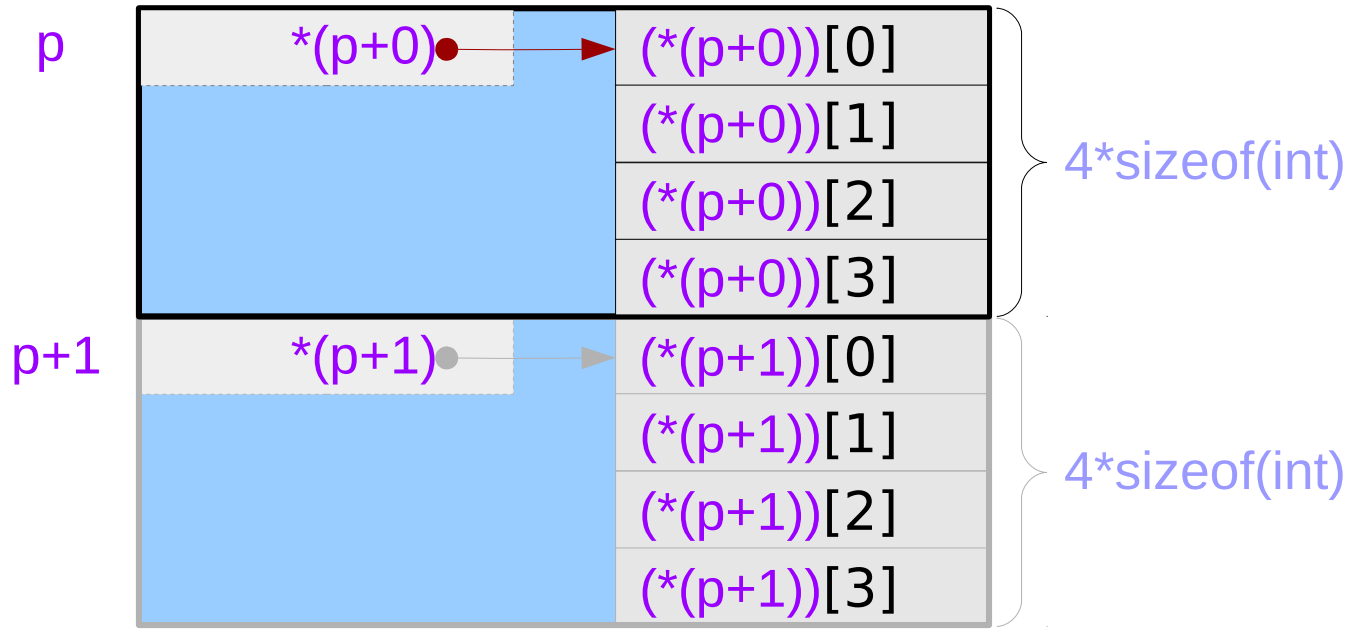
Incrementing an array pointer

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

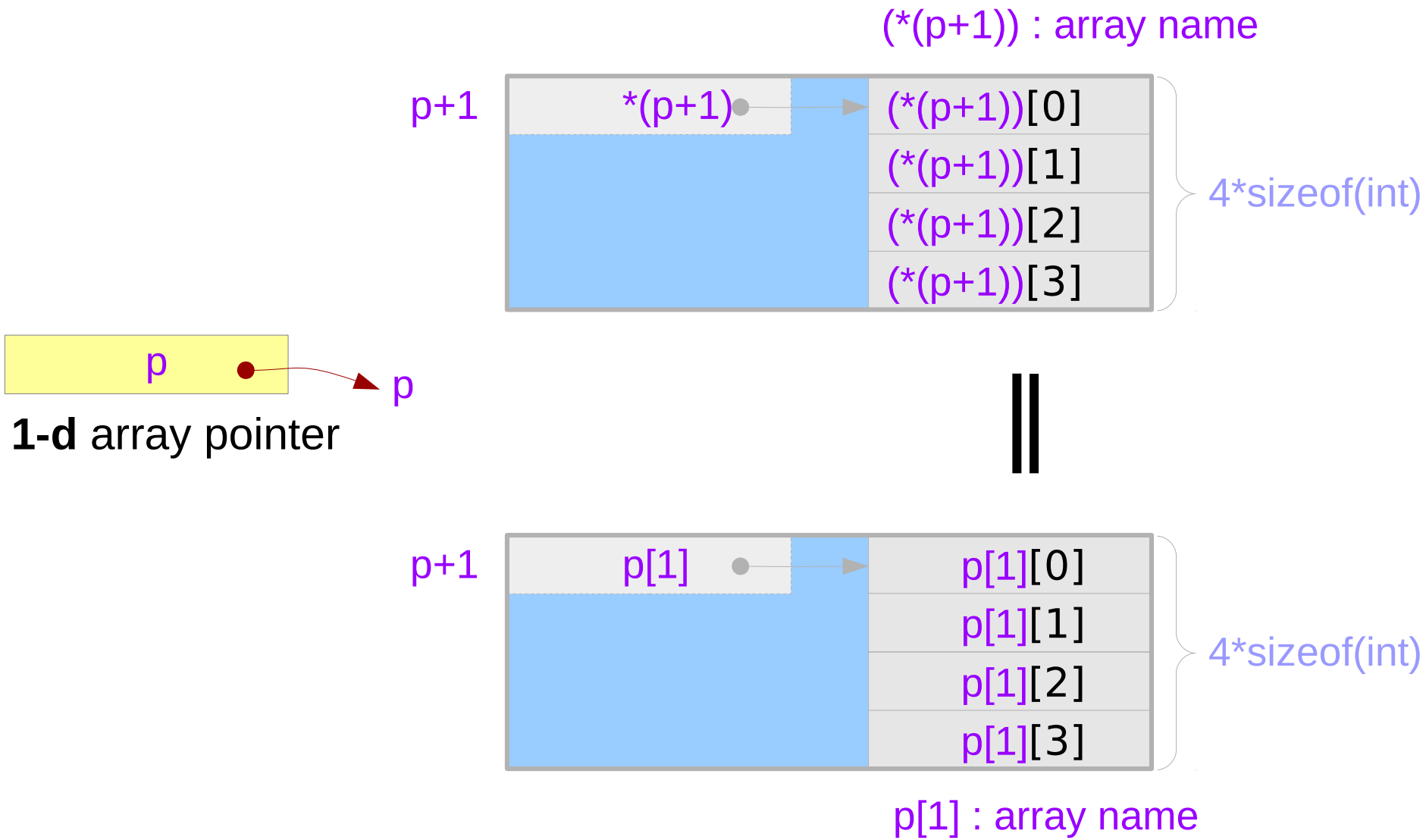
Aggregated Type Size

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

1-d array pointer



Incrementing an array pointer – extending a dimension

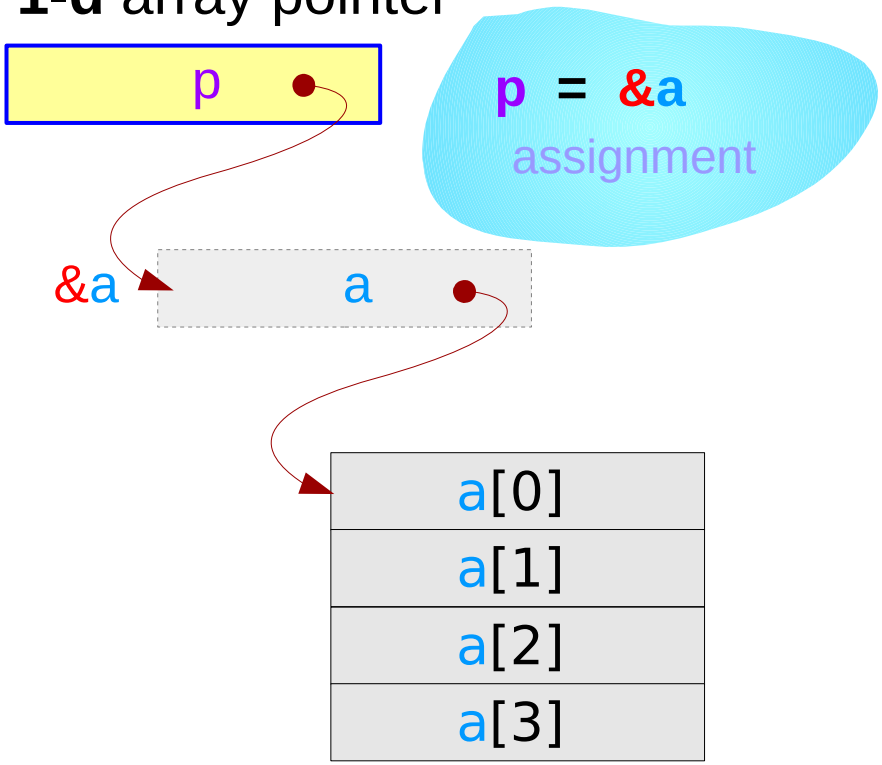


A **1-d** array pointer and a **1-d** array

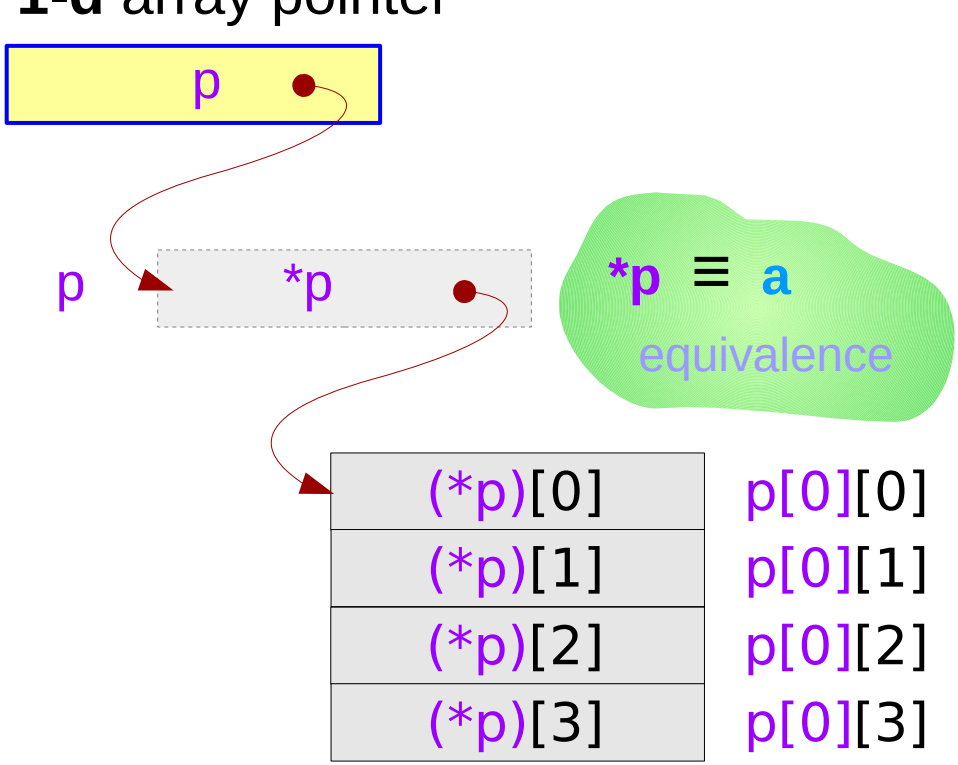
```
int         a [4];
```

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

1-d array pointer



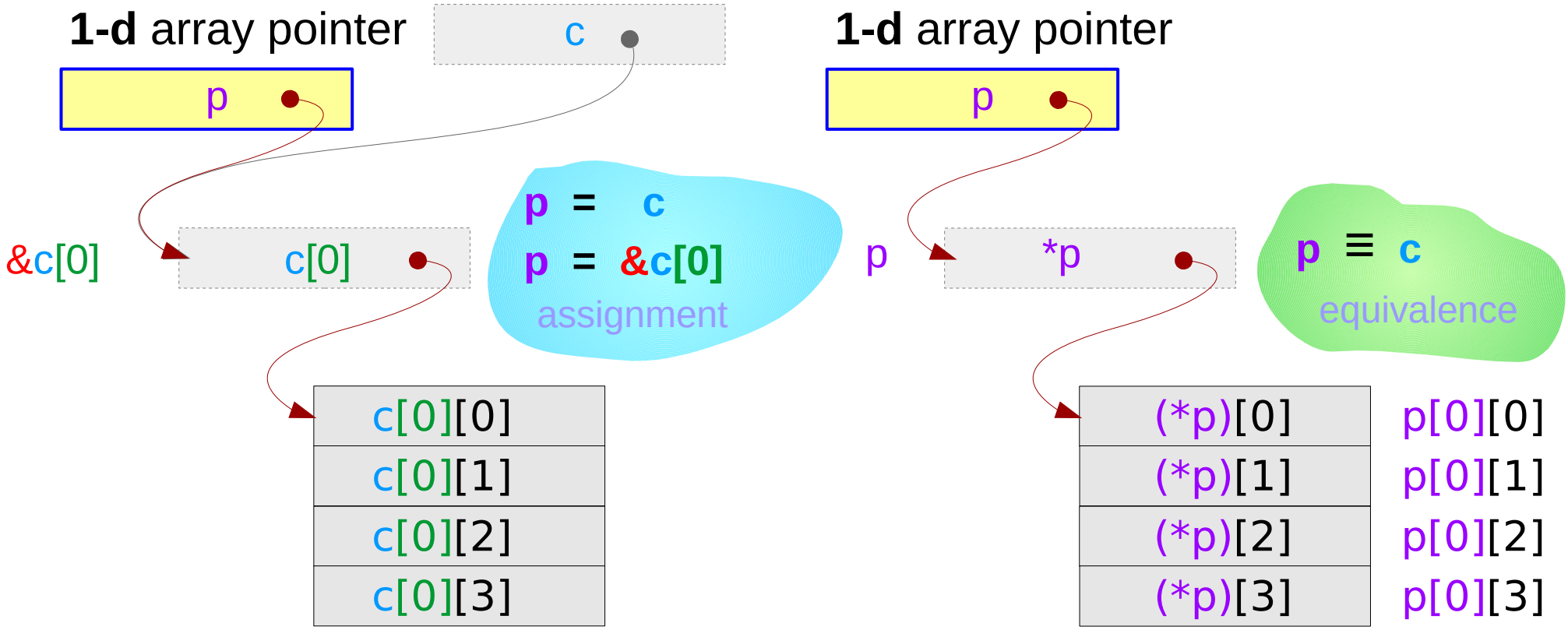
1-d array pointer



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

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

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

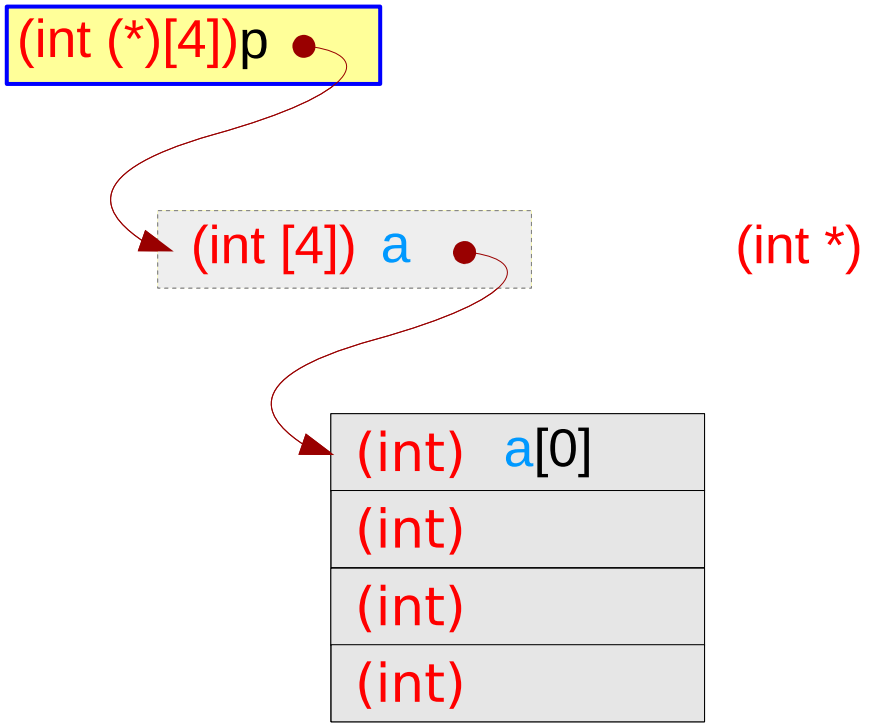


A **1-d** array pointer and a **1-d** array – a type view

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

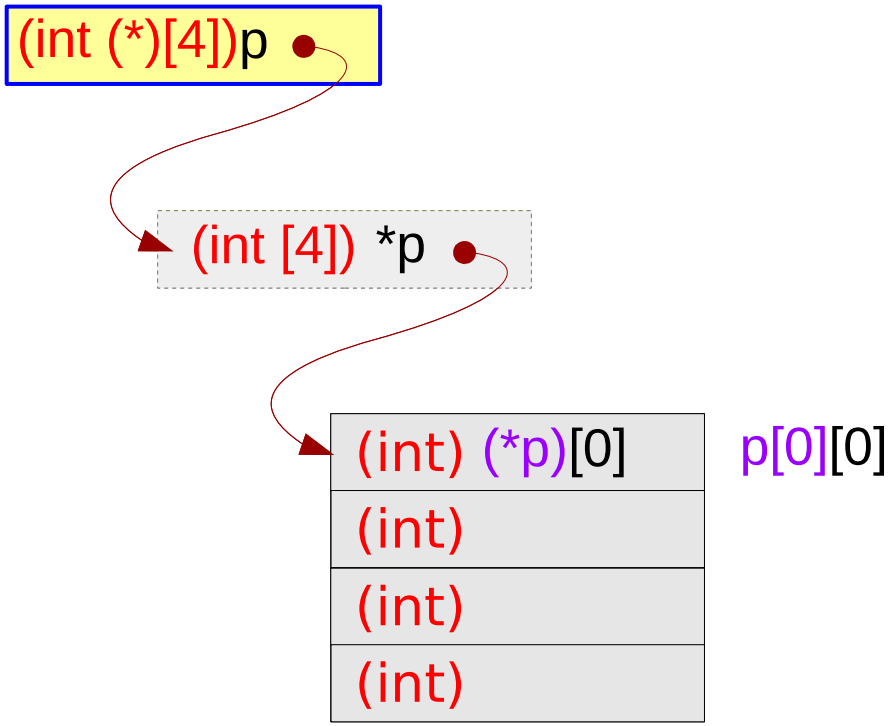
```
int  (*p) [4]  = &a;
```

1-d array pointer



(int *)

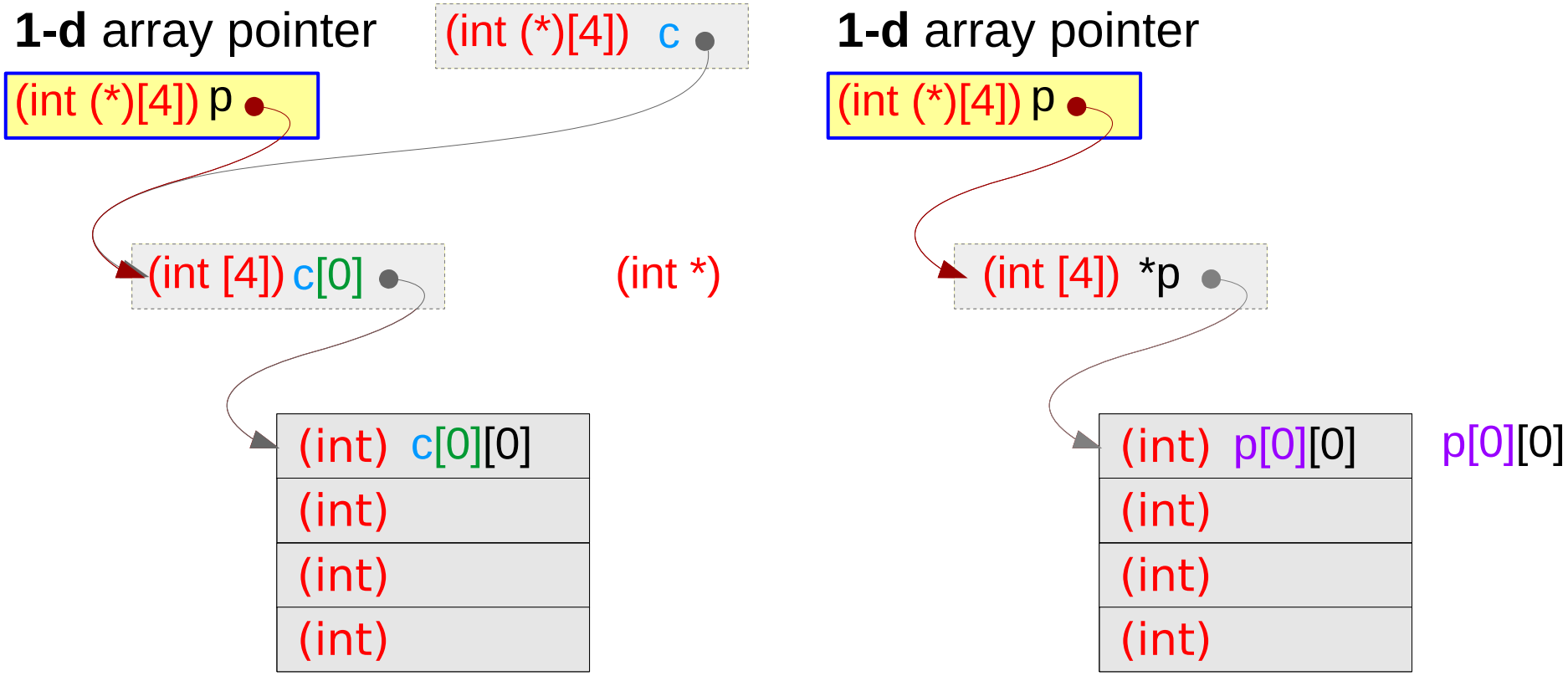
1-d array pointer



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

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

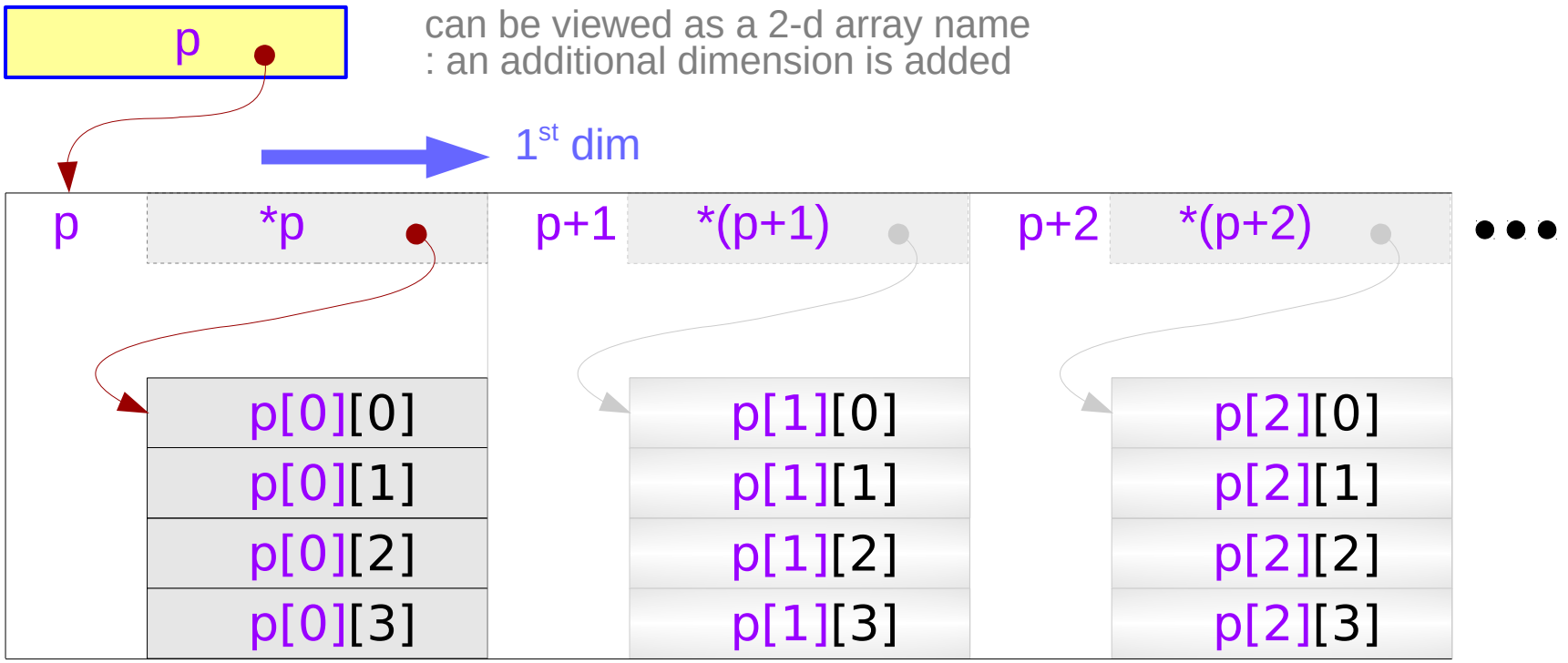
```
int  (*p) [4]  = &c[0];
```



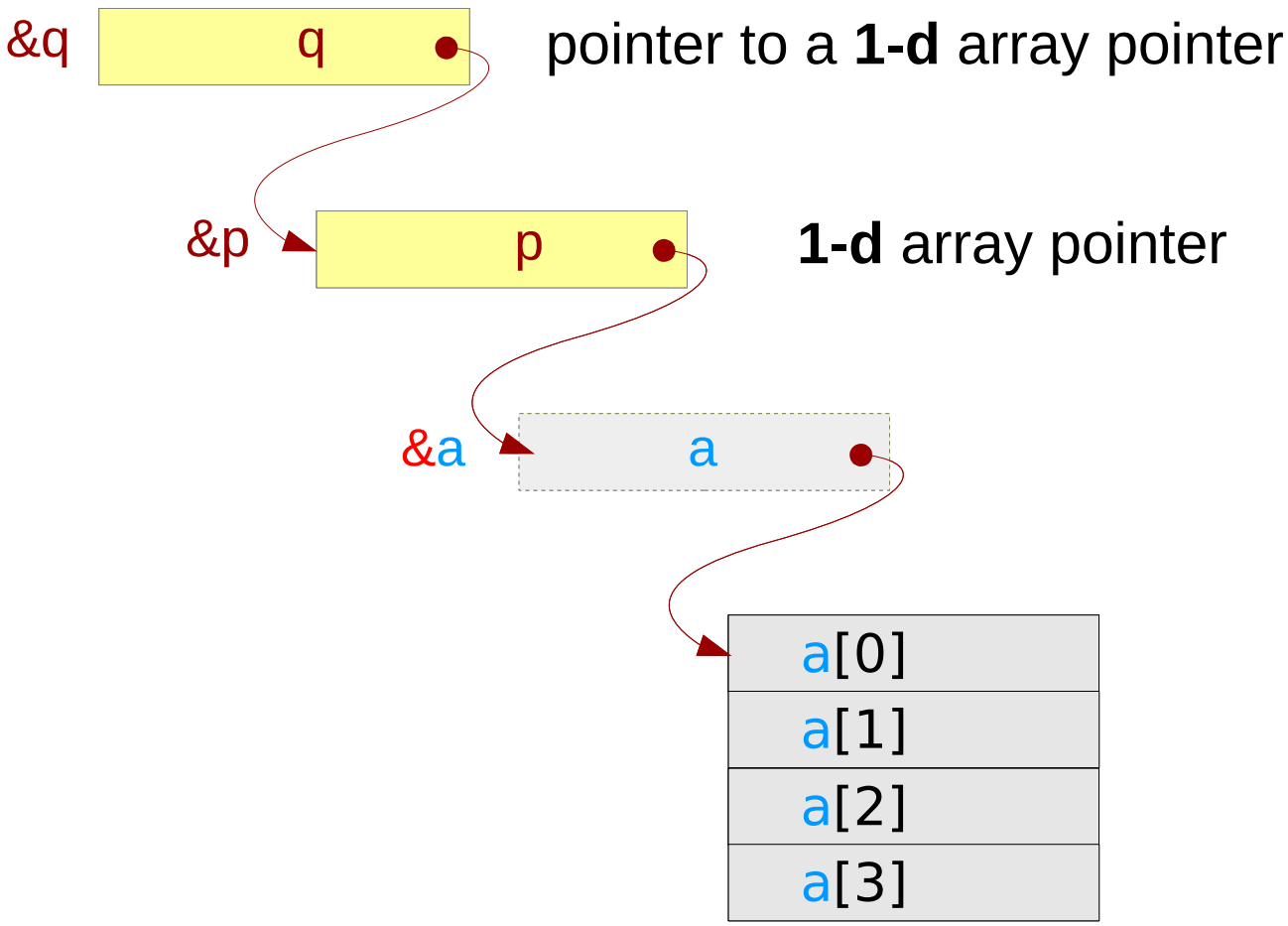
A **1-d** array pointer – extending a dimension

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

1-d array pointer



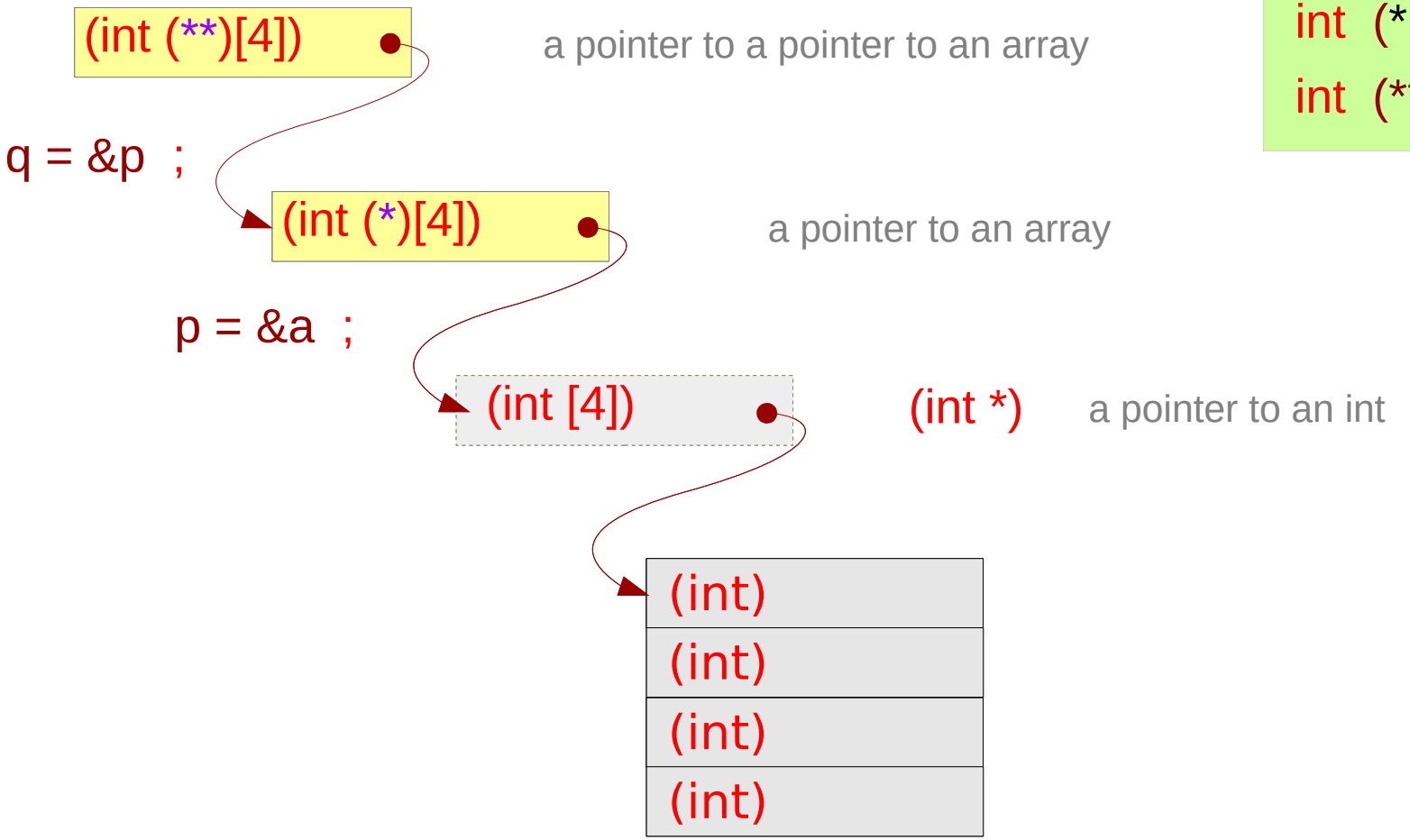
Double pointer to a **1-d** array – a variable view




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

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

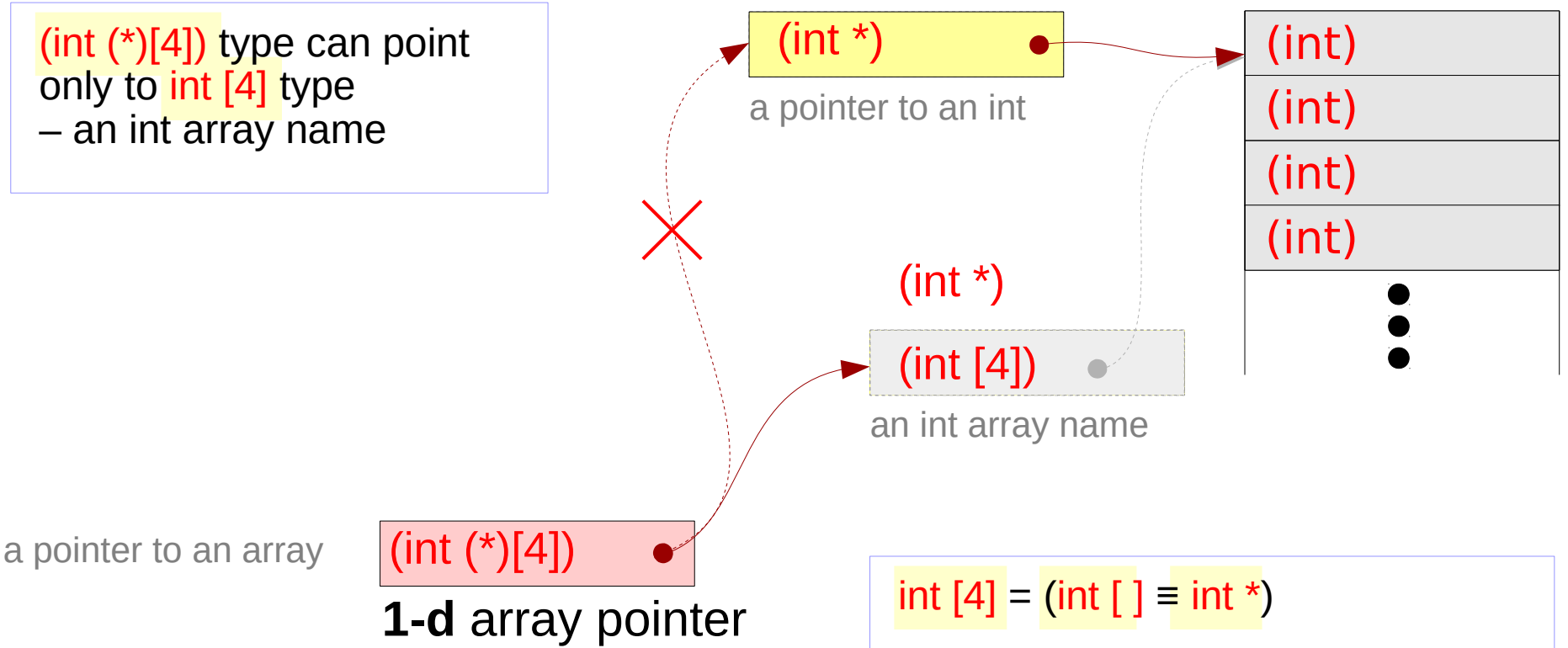
```
int  a[4]  ;
int  (*p) [4] = &a ;
int  (**q) [4] = &p ;
```



Pointer to Multi-dimensional Arrays

Integer pointer type

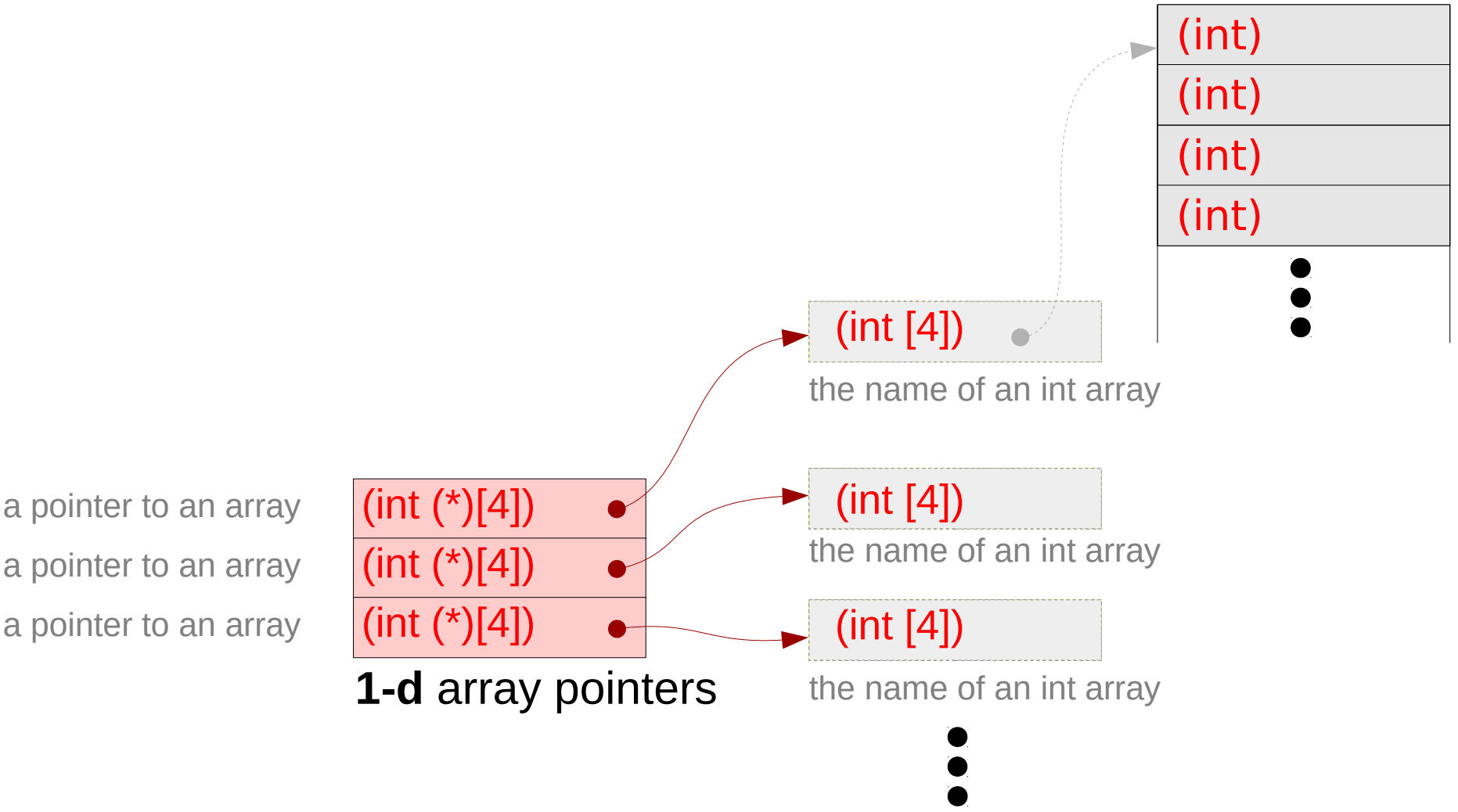
(int (*)[4]) type can point only to int [4] type
– an int array name



int [4] = (int [ ] ≡ int *)

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

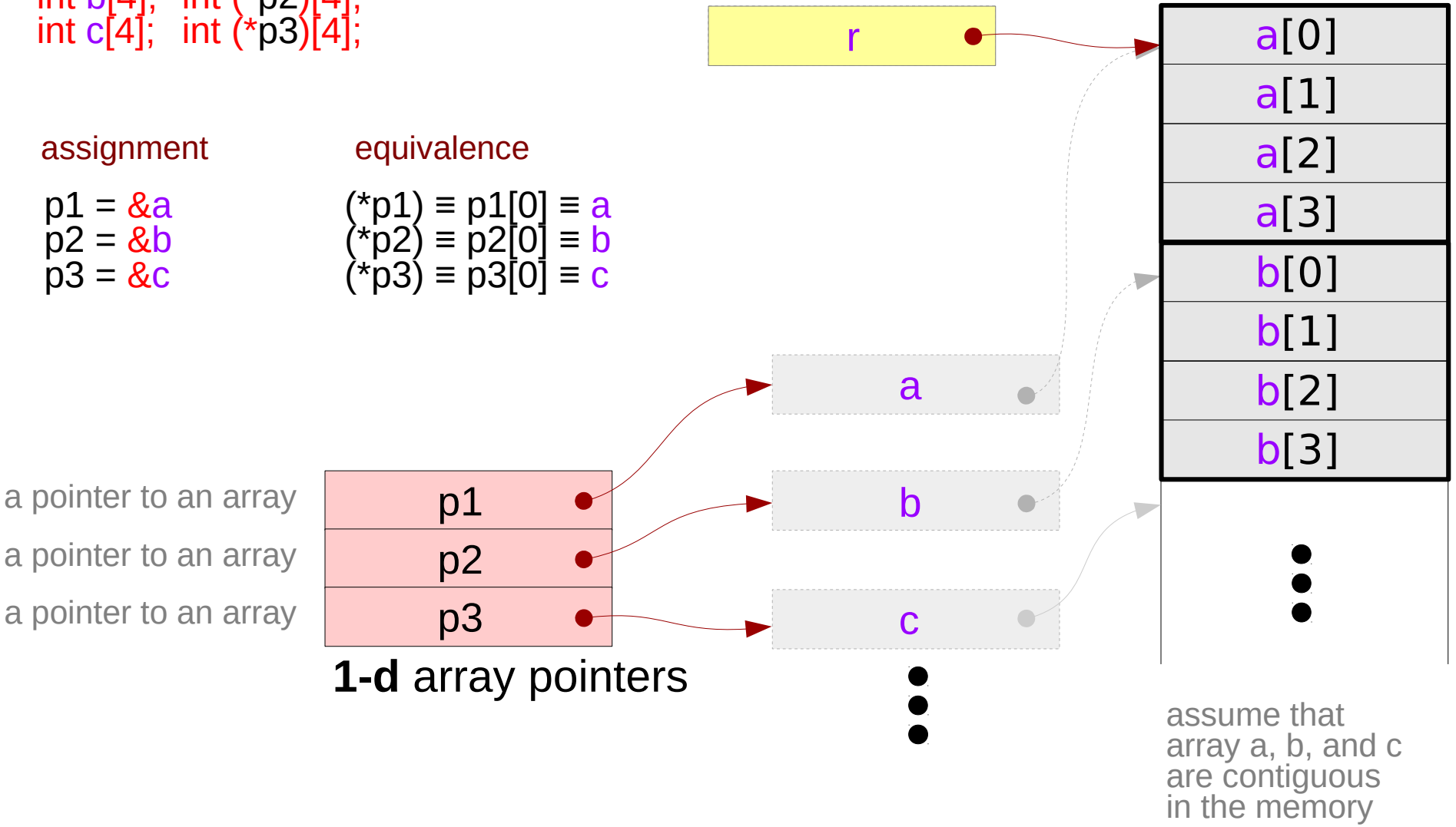
Series of array pointers – a type view



Series of array pointers – a variable view

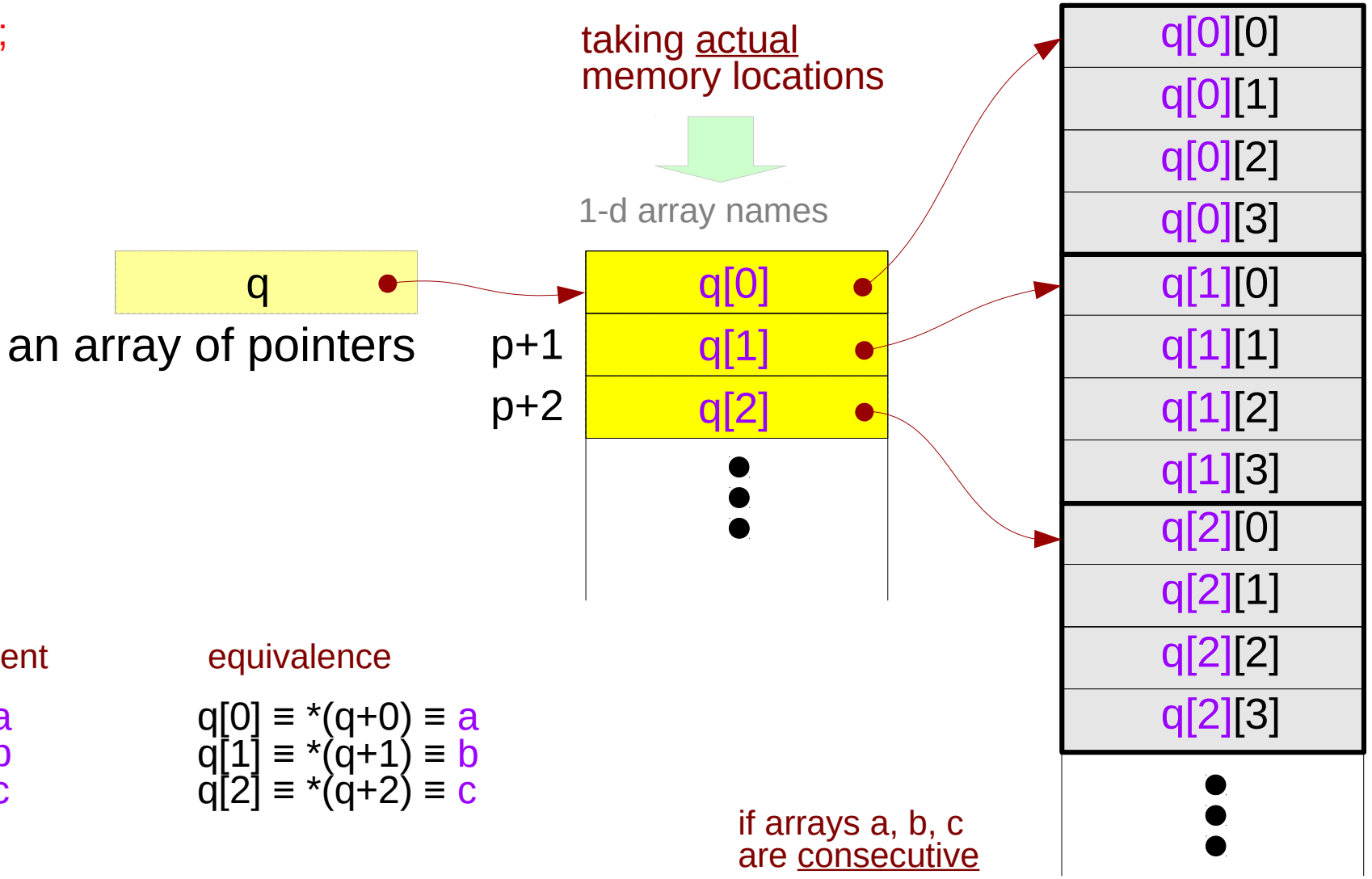
```
int a[4];  int (*p1)[4];   int  (*r);
int b[4];  int (*p2)[4];
int c[4];  int (*p3)[4];
```

assignment	equivalence
p1 = &a	(*p1) ≡ p1[0] ≡ a
p2 = &b	(*p2) ≡ p2[0] ≡ b
p3 = &c	(*p3) ≡ p3[0] ≡ c



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];
```

a pointer to an array

1-d array pointer

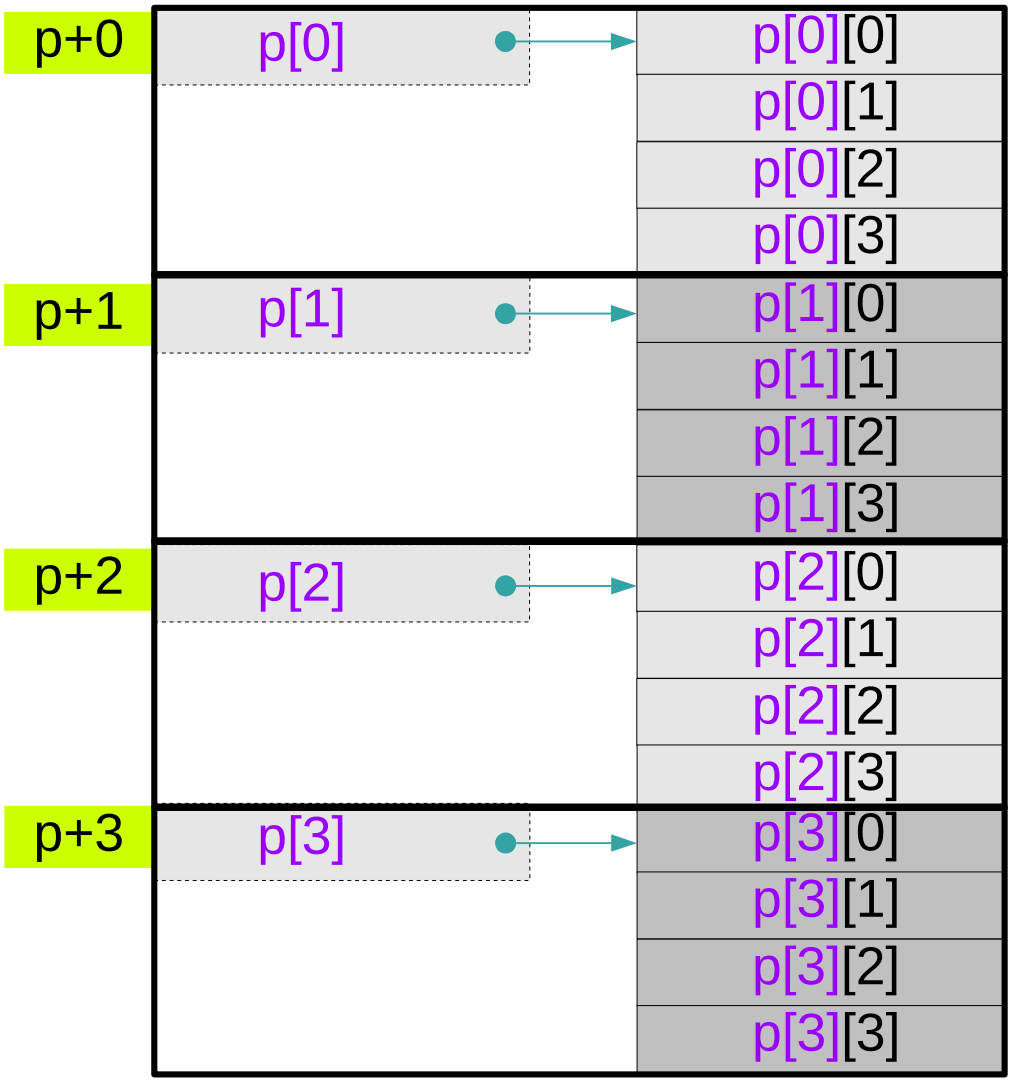
assignment

p = &a

equivalence

*(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



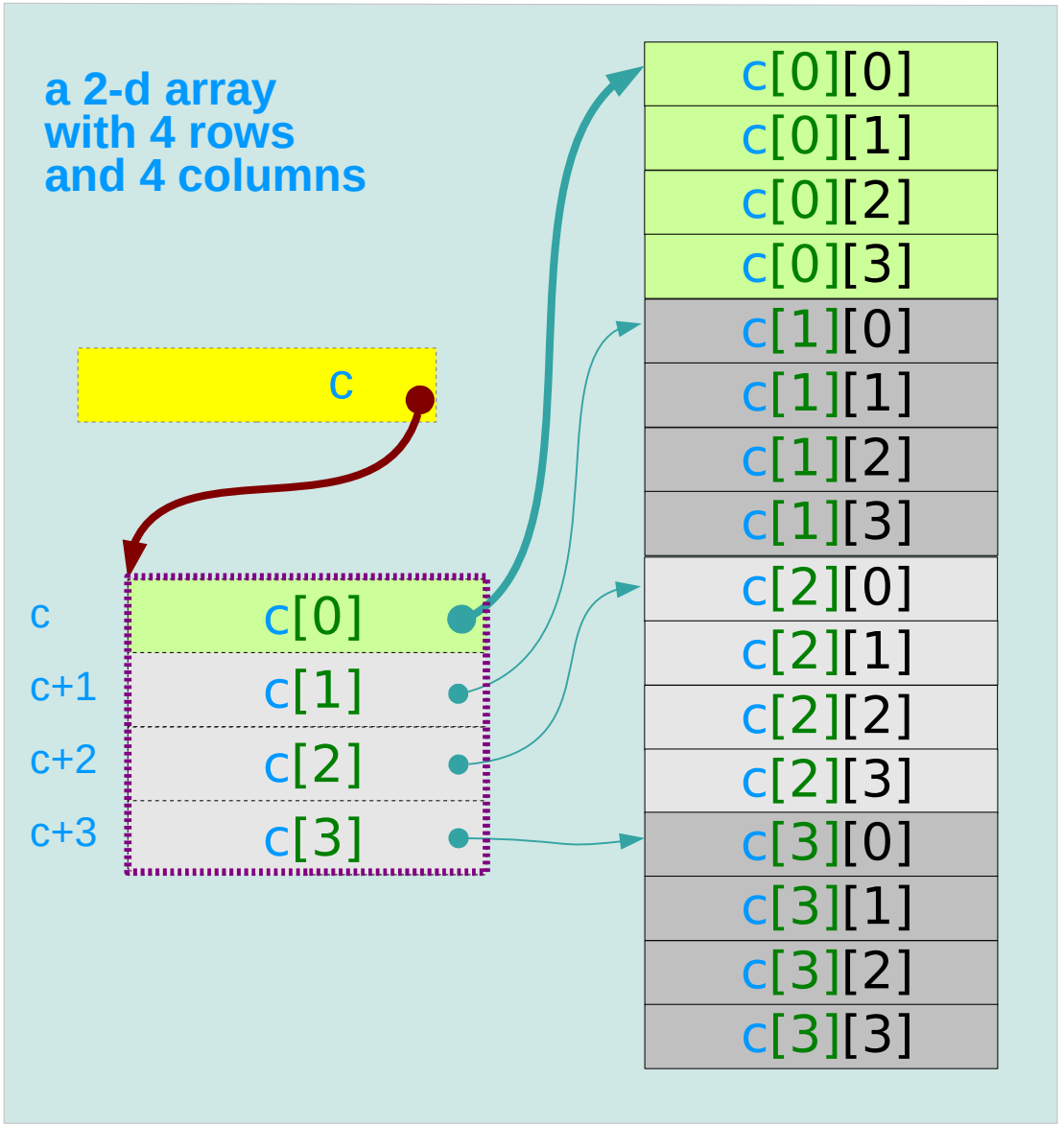
A **2-d** array and its sub-arrays – a variable view

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

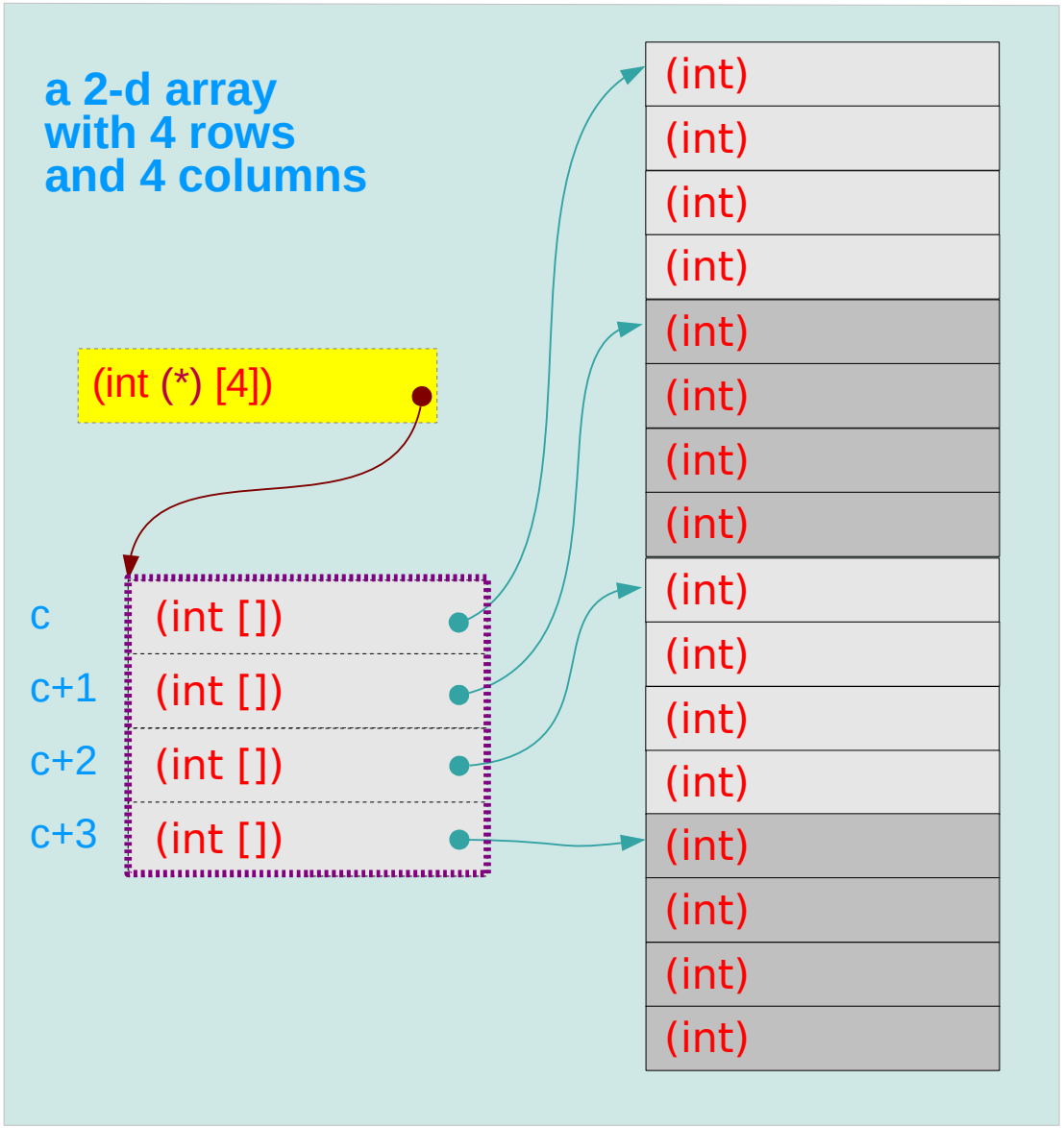
Compilers can make **c[i]**'s require no actual memory locations



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)

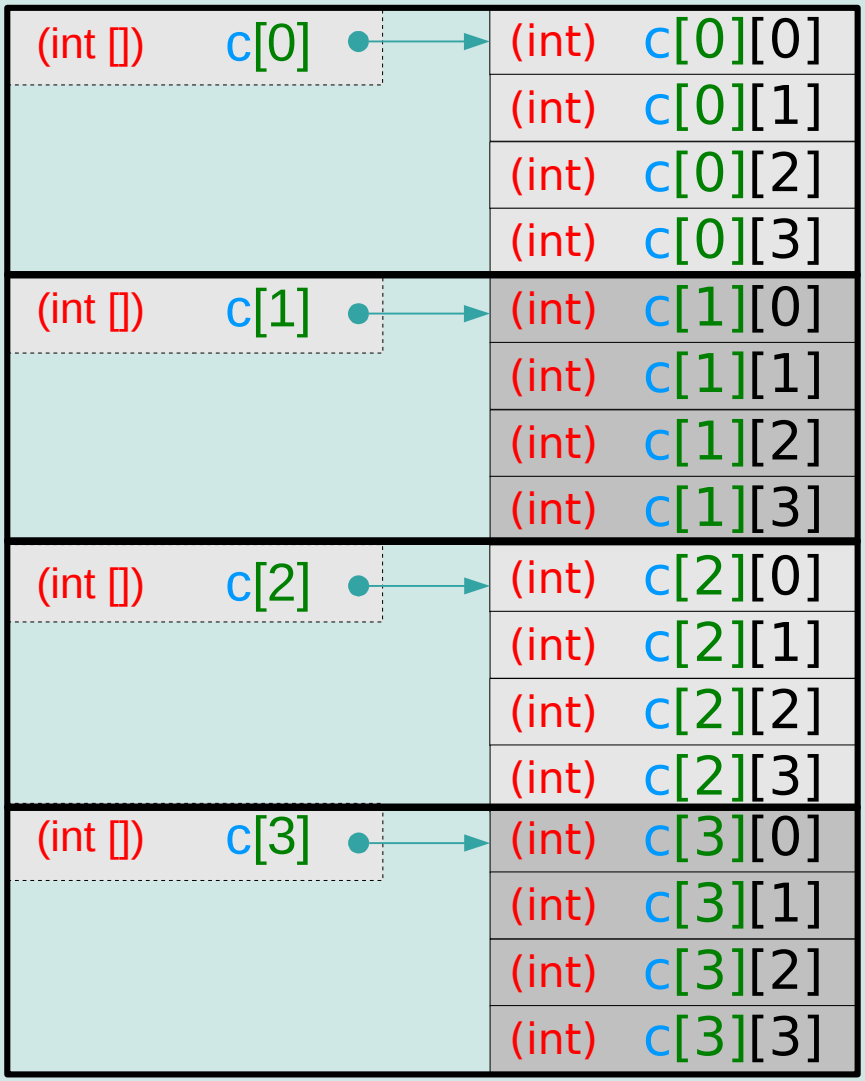
sizeof(**c[1]**) = 16 bytes

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

sizeof(**c[2]**) = 16 bytes

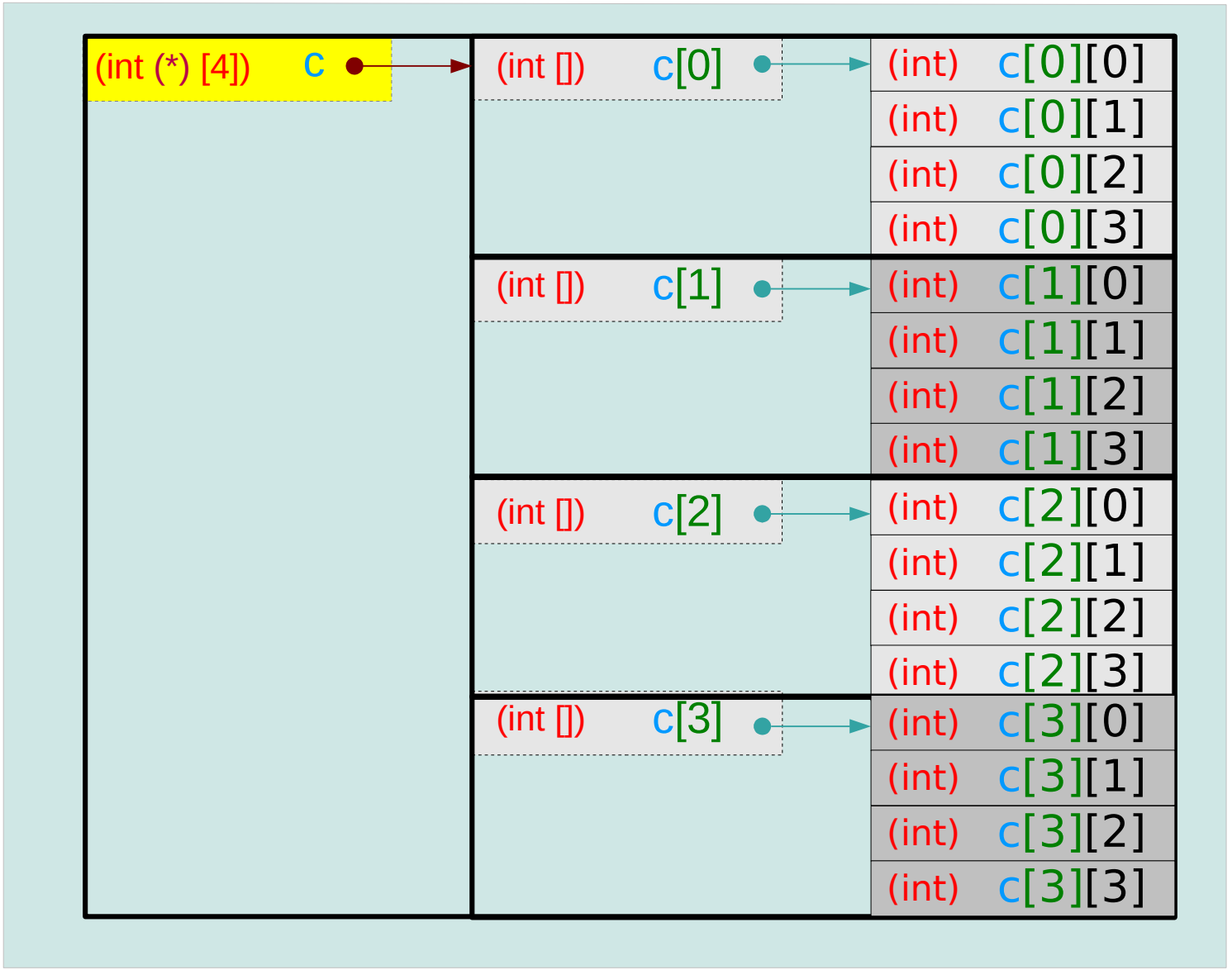
The 4th subarray c[3] (=array name)

sizeof(**c[3]**) = 16 bytes



2-d array name **: 1-d** array pointer

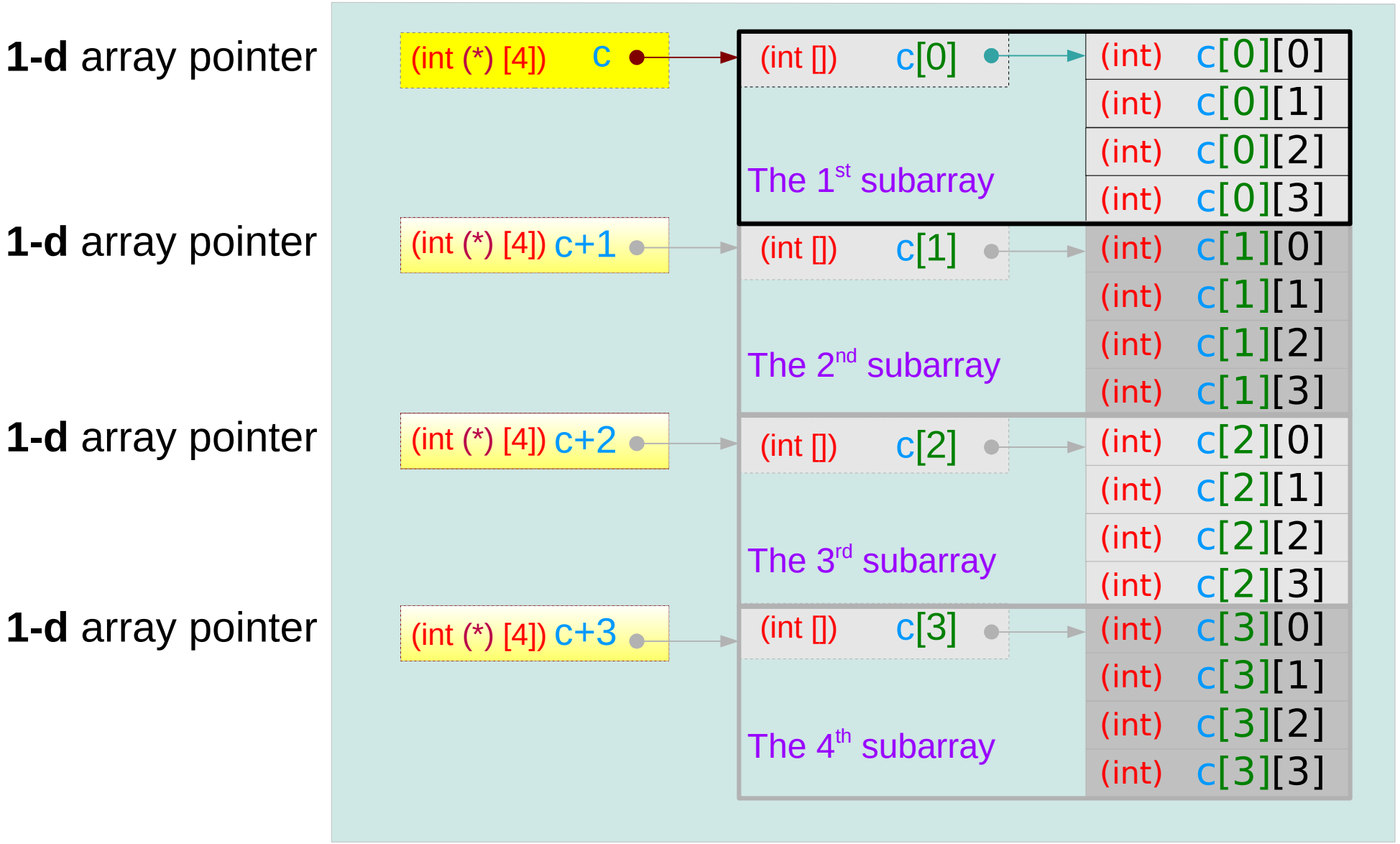
1-d array pointer



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

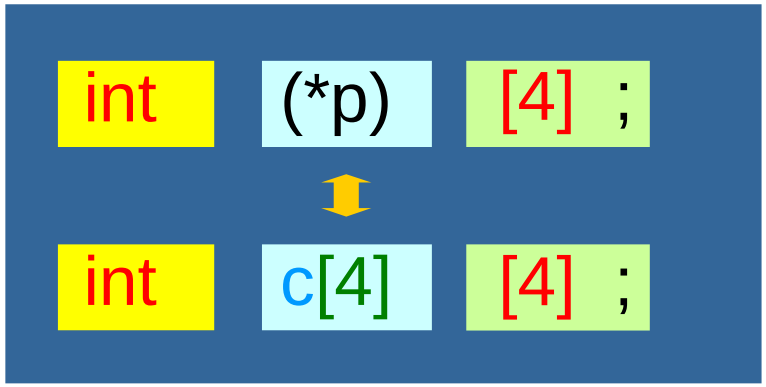
1-d sub-array size:
sizeof(***c**) = 16 bytes

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



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

1-d array pointer

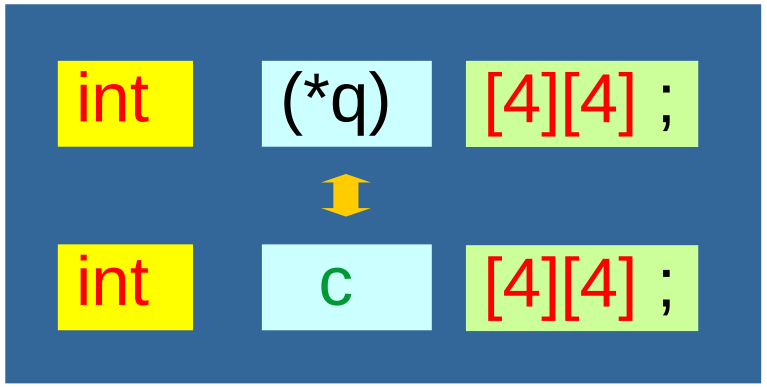


(int (*) [4])

```
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



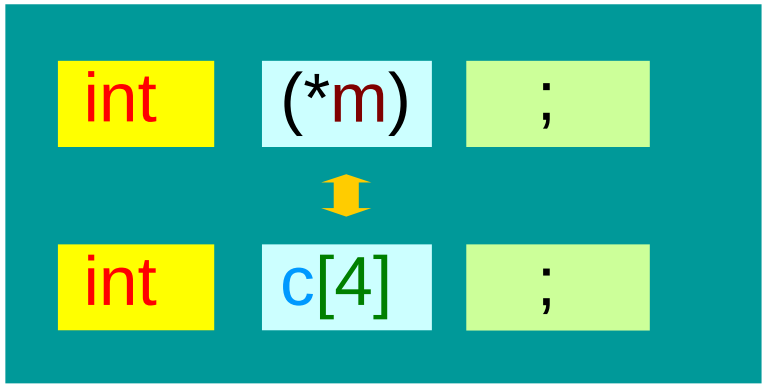
(int(*)[4][4])

```
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

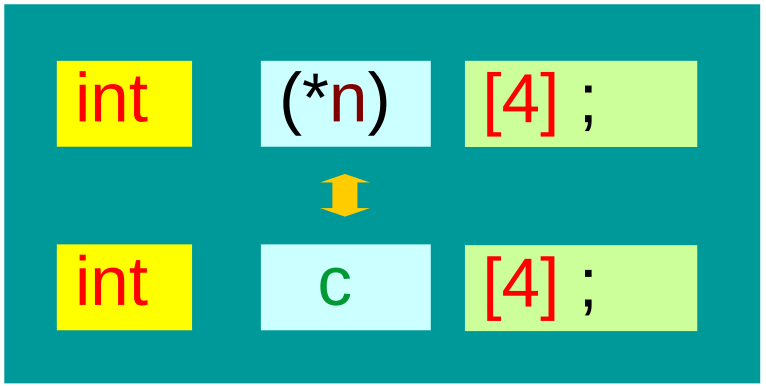


(int (*))

```
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]
```

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

1-d array pointer

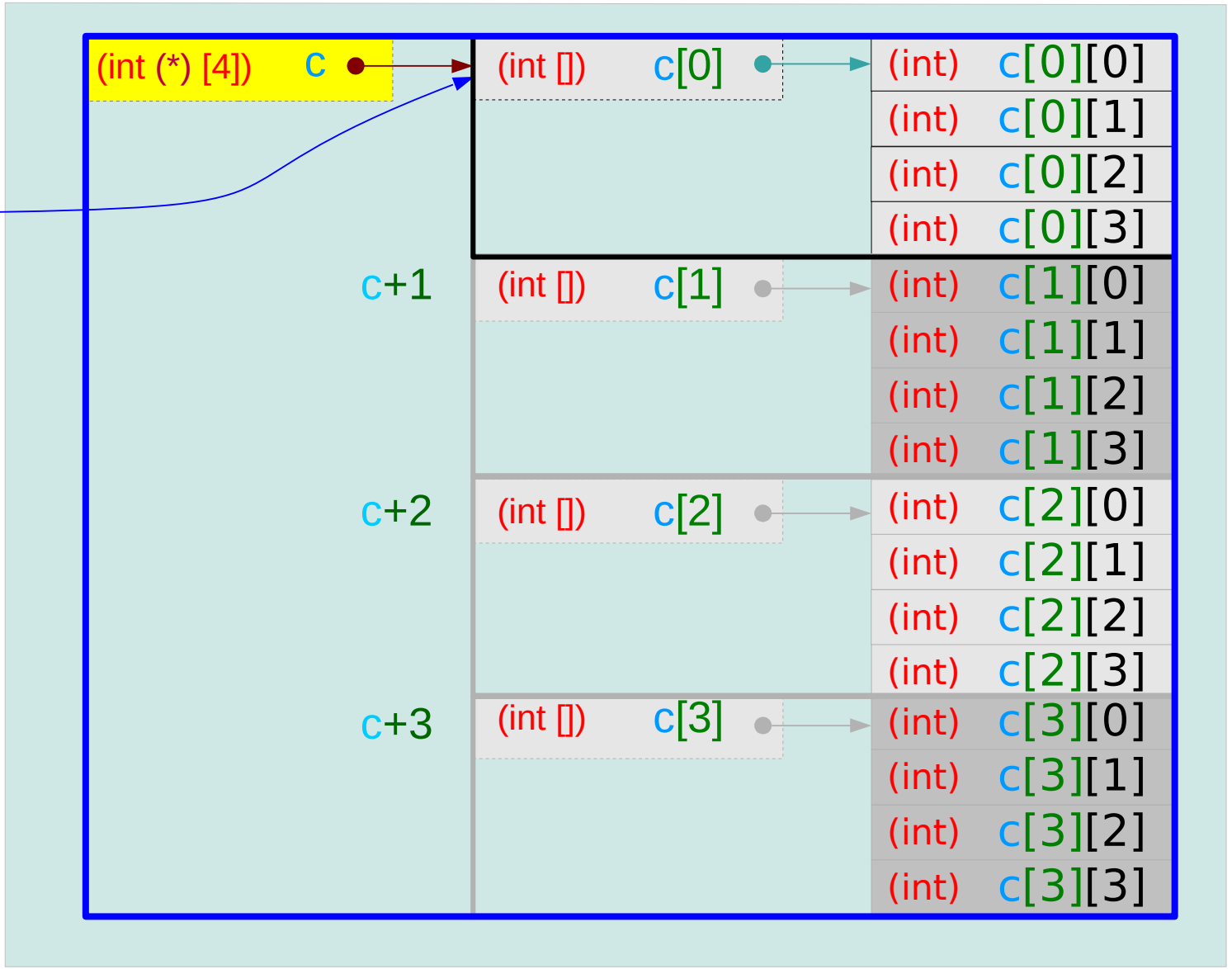
&p (int (*) [4]) p

p = c;

p = &c[0];

An array pointer:
sizeof(p) = 8 bytes

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

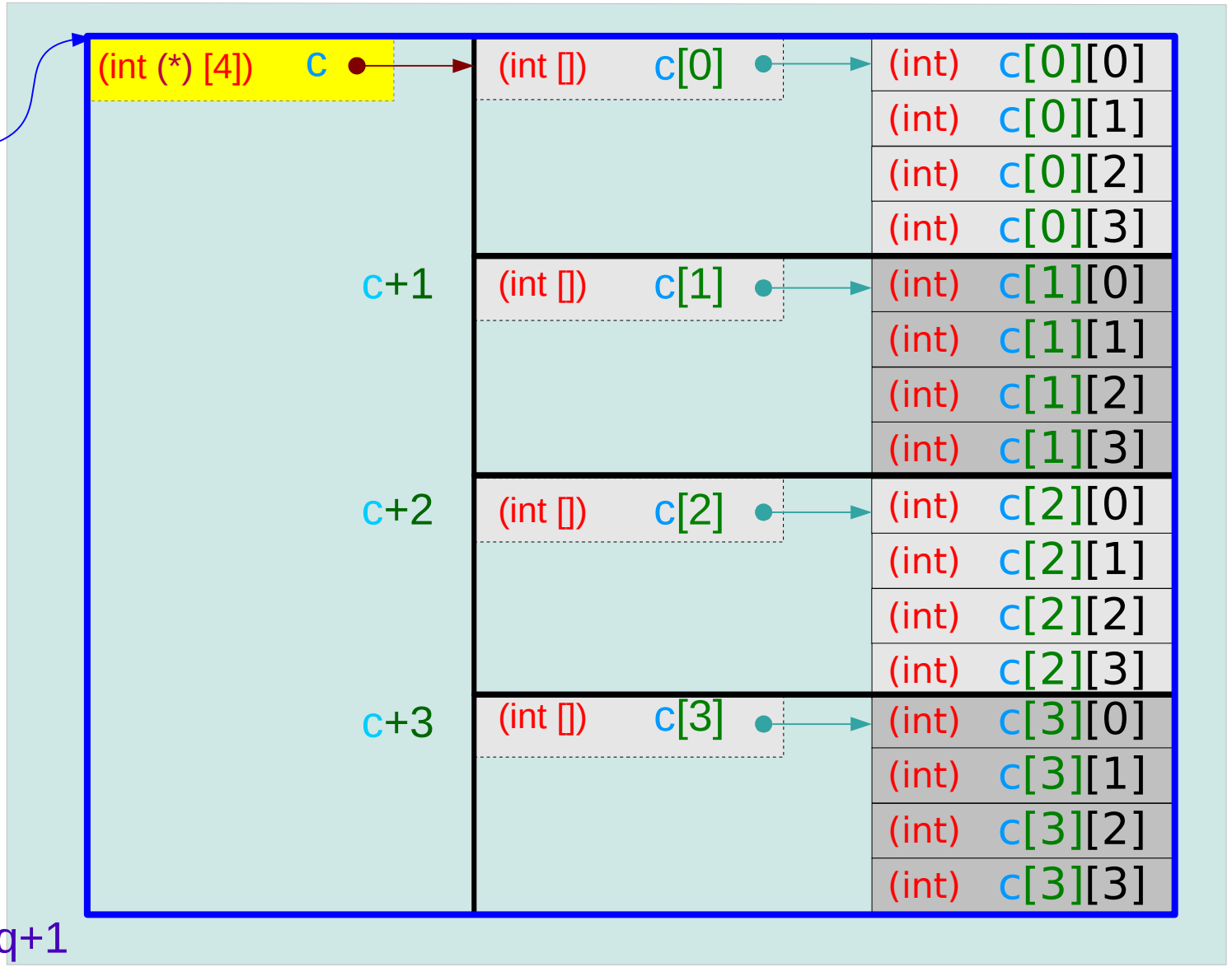


2-d array pointer to a **2-d** array

2-d array pointer

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

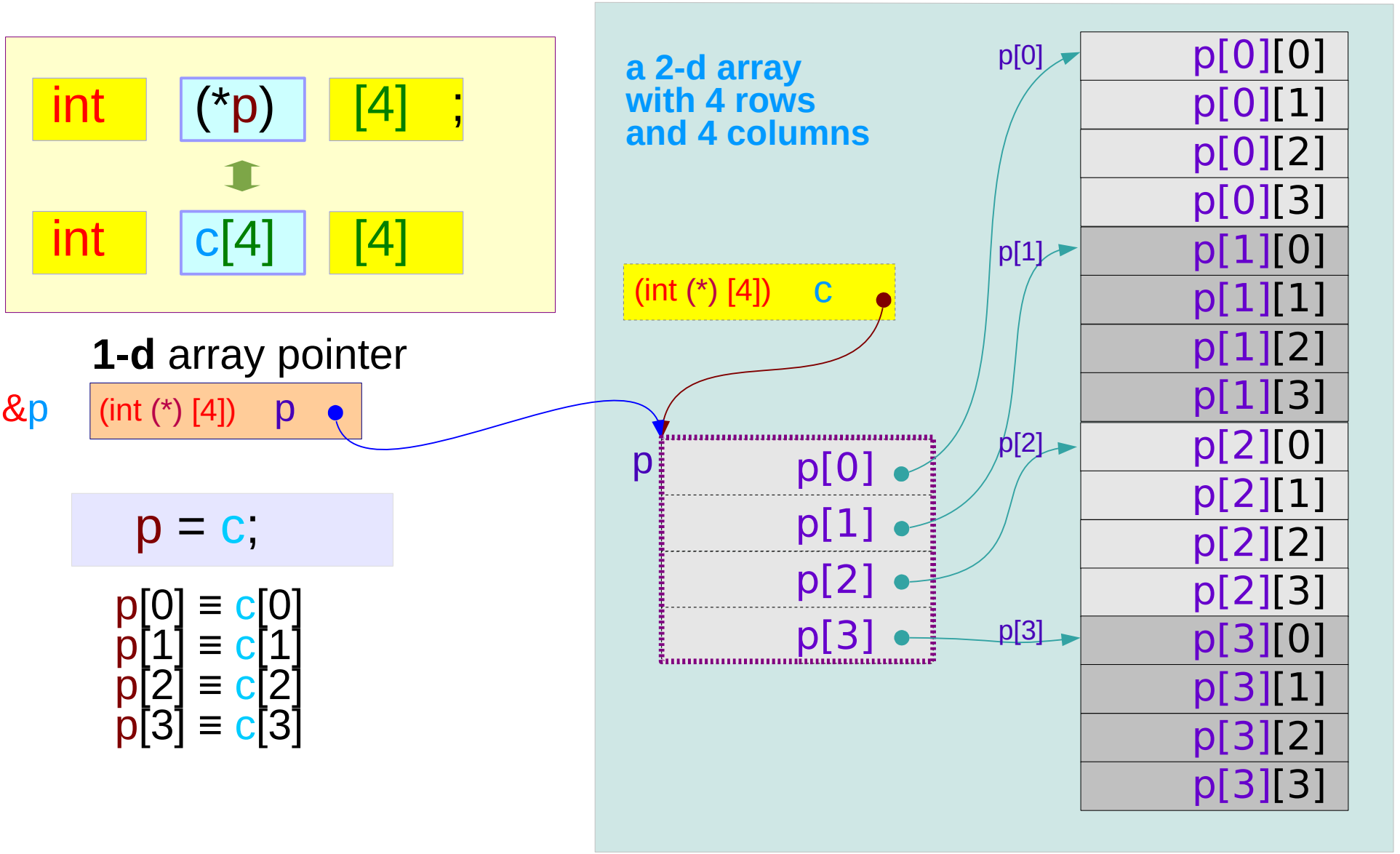
q = &c;



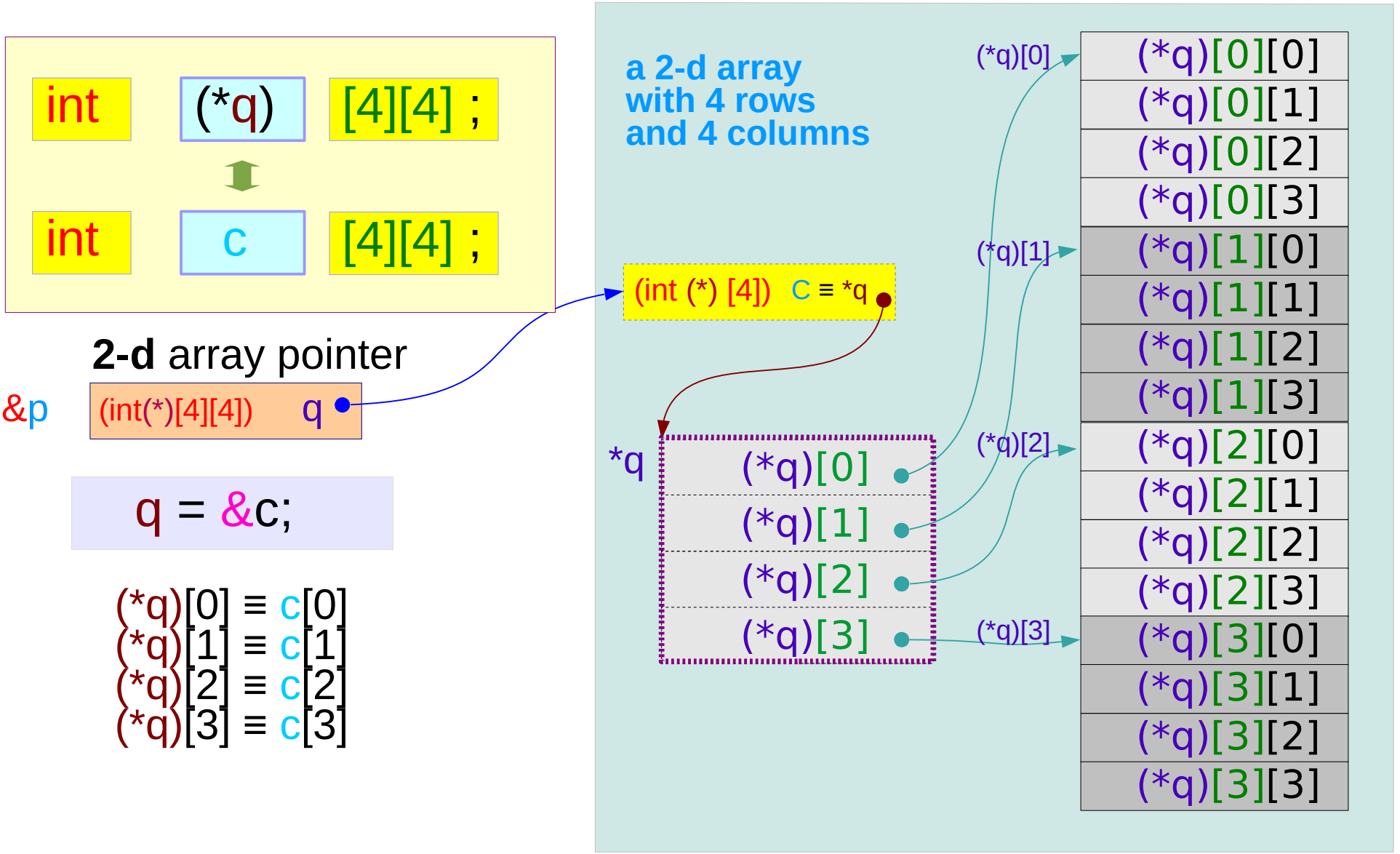
An array pointer:
sizeof(**q**) = 8 bytes

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

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



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



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

```
int a[4] ;
int (*p) ;
```
1-d array
0-d array pointer

```
int b[4]  [2];
int (*q)  [2];
```
2-d array
1-d array pointer

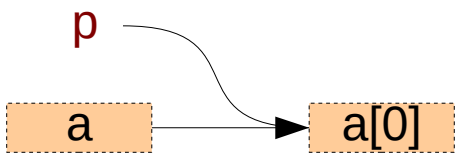
```
int c[4]  [2][3];
int (*r)  [2][3];
```
3-d array
2-d array pointer

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

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

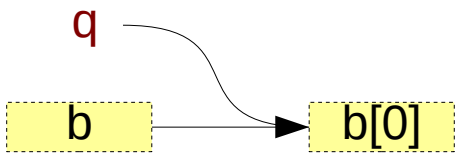
```
int a[4] ;
int (*p) ;
```

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



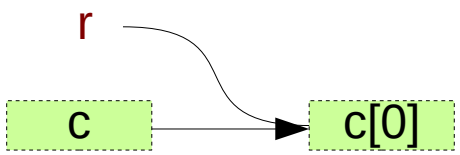

```
int b[4]  [2];
int (*q)  [2];
```

```
q = &b[0];
q = b;
```



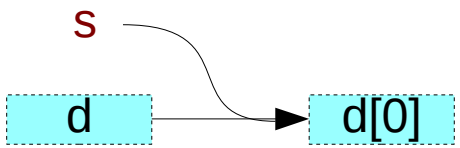

```
int c[4]  [2][3];
int (*r)  [2][3];
```

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

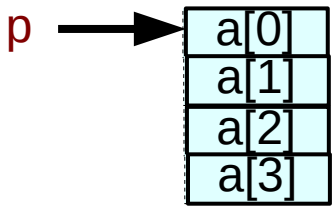


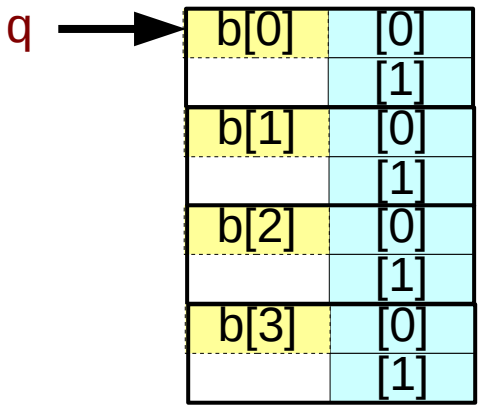

```
int d[4]  [2][3][4];
int (*s)  [2][3][4];
```

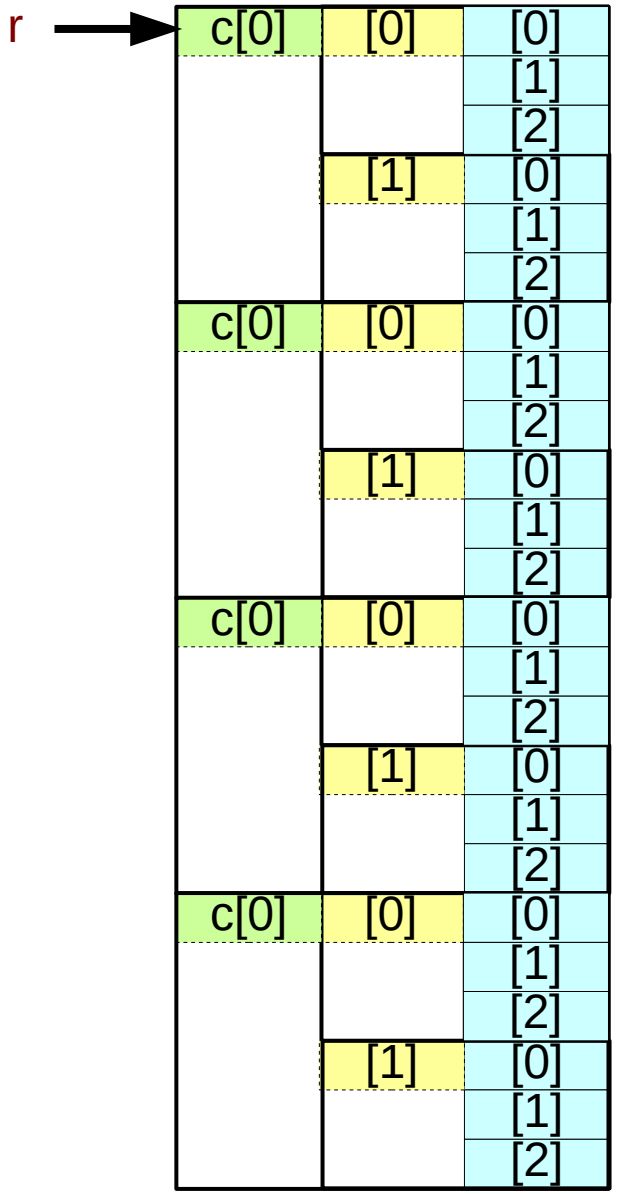
```
s = &d[0];
s = d;
```



multi-dimensional array pointers



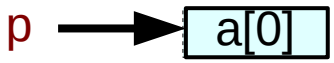


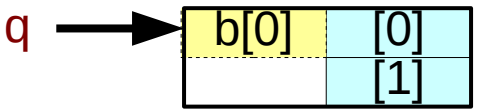


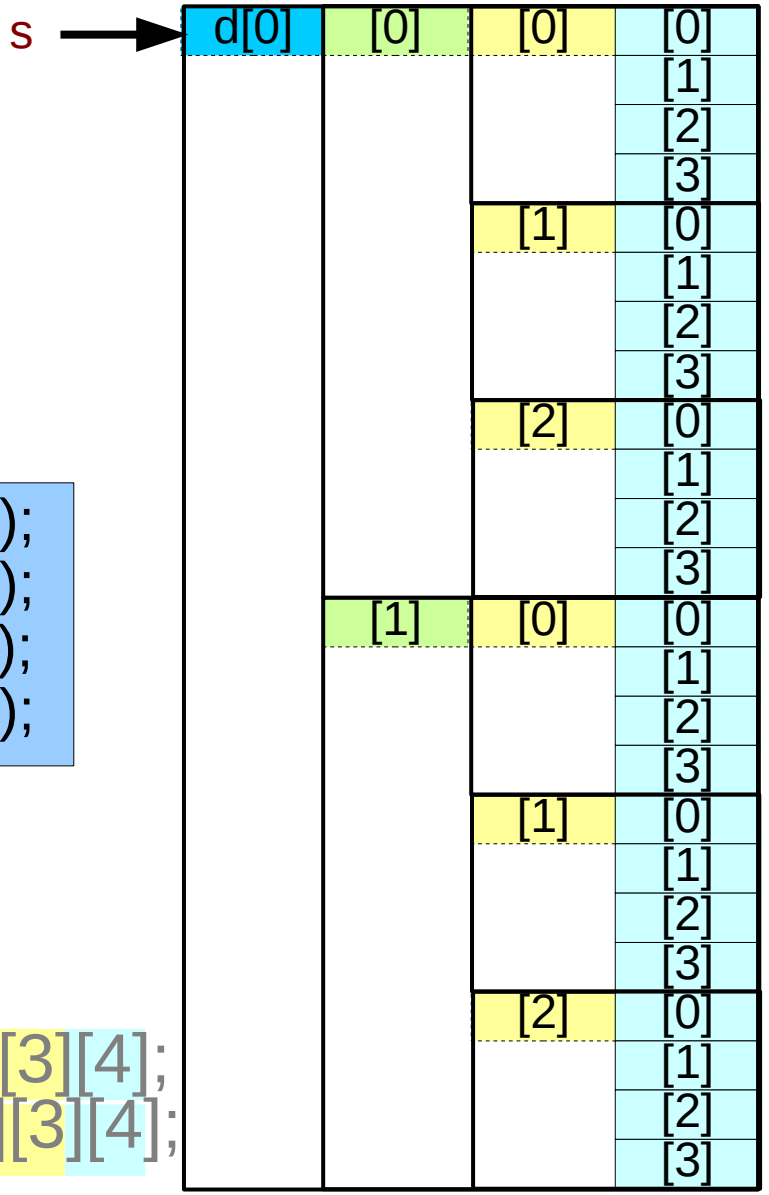

```
int a[4] ;
int b[4]  [2];
int c[4]  [2][3];
int d[4]  [2][3][4];
```

```
int (*p) ;
int (*q)  [2];
int (*r)  [2][3];
int (*s)  [2][3][4];
```

multi-dimensional array pointers

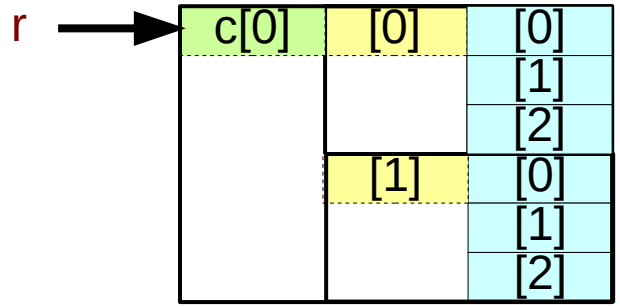







```
int a[4] ;
int (*p) ;
```

```
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];
```

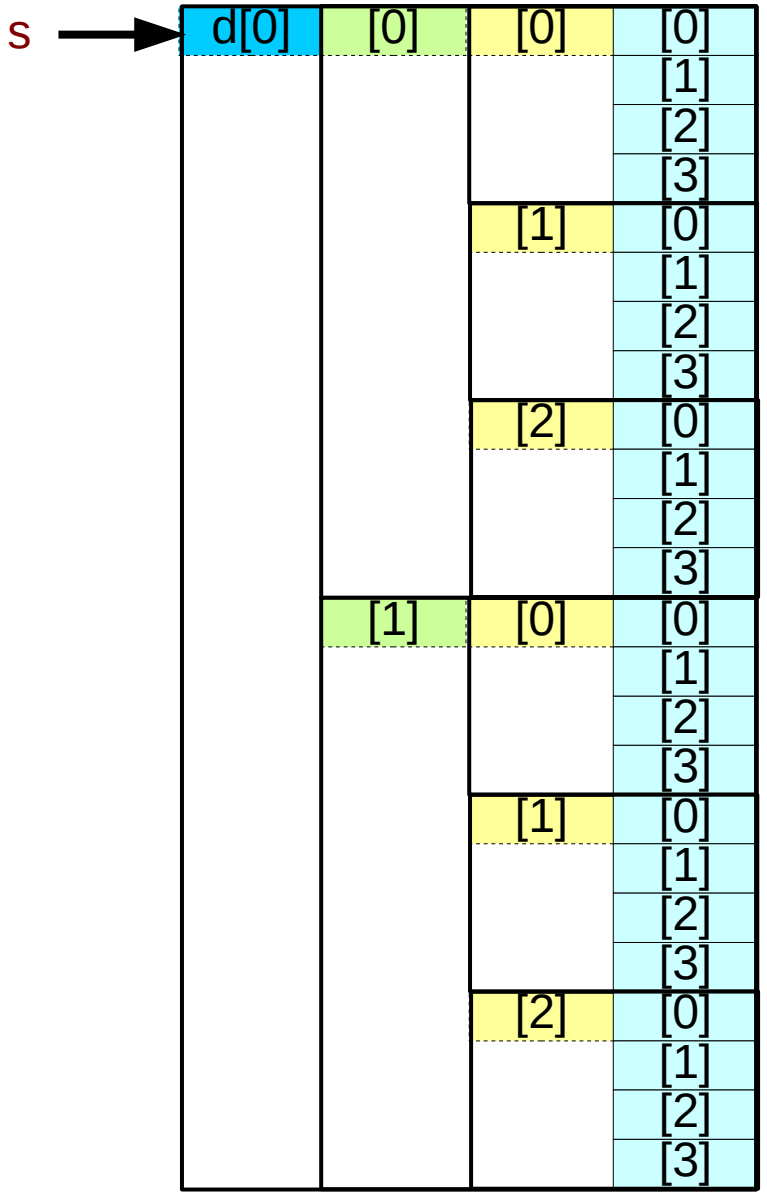
```
int d[4] [2][3][4];
int (*s)  [2][3][4];
```

multi-dimensional array pointers

```
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