Array Pointers (1A)

Young Won Lim
6/20/22

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

Young Won Lim
6/20/22

Assumption

assume that

value(c) returns the hexadecimal number
that is obtained by printf("%p", c),
when the variable c contains
an address as its value

```
#include <stdio.h>
int main(void) {
  int c[3] ;
  printf ("c= %p \n", &c);
}
```

```
c= 0x7fffd923487c
```

type(c) can be determined
by the warning messsage of printf("%d", c),
when the variable c contains
an address as its value

```
#include <stdio.h>
int main(void) {
  int c[3] ;
  printf ("c= %d \n", &c);
}
```

```
t.c: In function 'main':
t.c:5:16: warning: format '%d' expects argument of type 'int',
but argument 2 has type 'int (*)[3]' [-Wformat=]
   printf ("c= %d \n", &c);
```

Array Pointers

Pointer to Arrays

1. pointer to 1-d arrays

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

2. pointer to 2-d arrays

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

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]
```

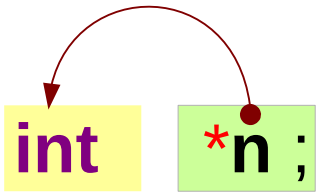
an array pointer

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

a function pointer

Pointer to an array – variable declarations

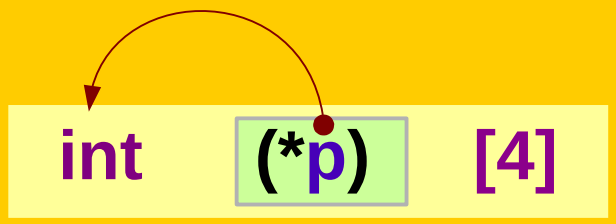
n points to a number (int)



an integer pointer

Array Pointer Approach
(pointer to arrays)

p points to an array (int [4])



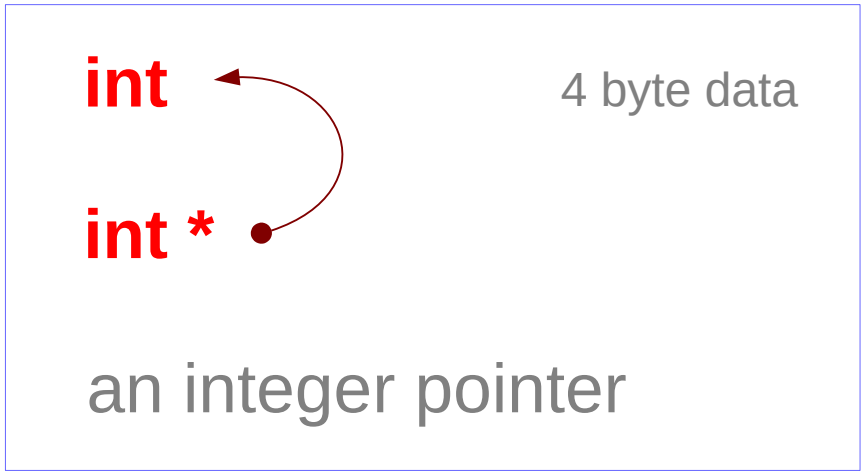
an array pointer

fp points to a function (int (int, int))

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

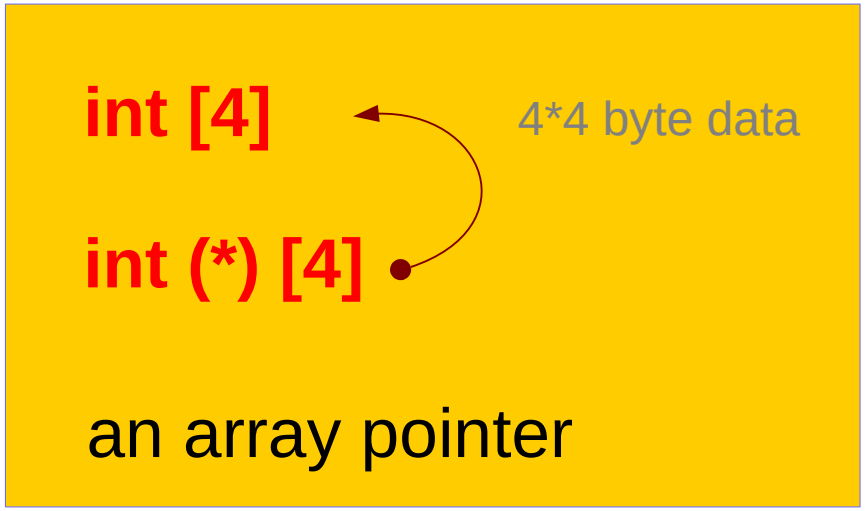
a function pointer

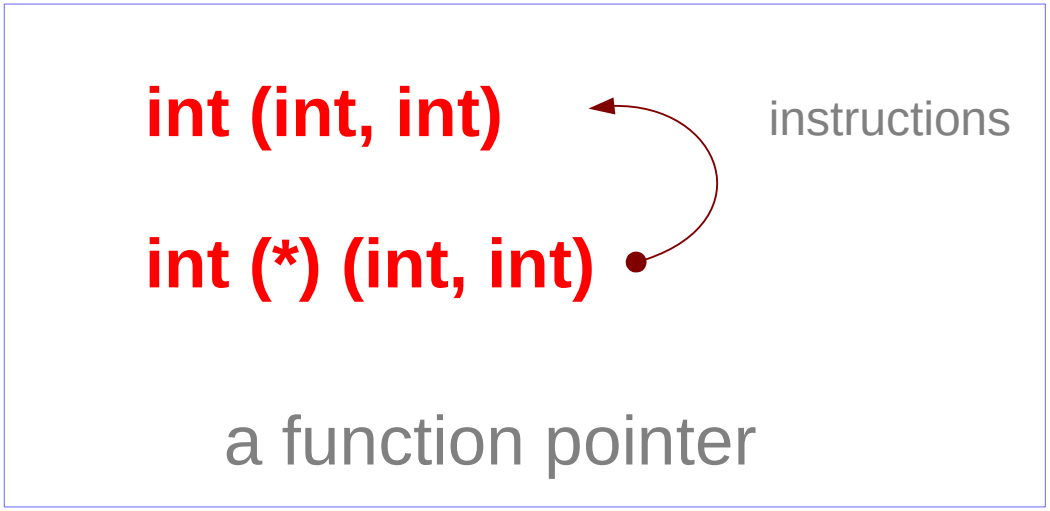
Pointer to an array – a type view



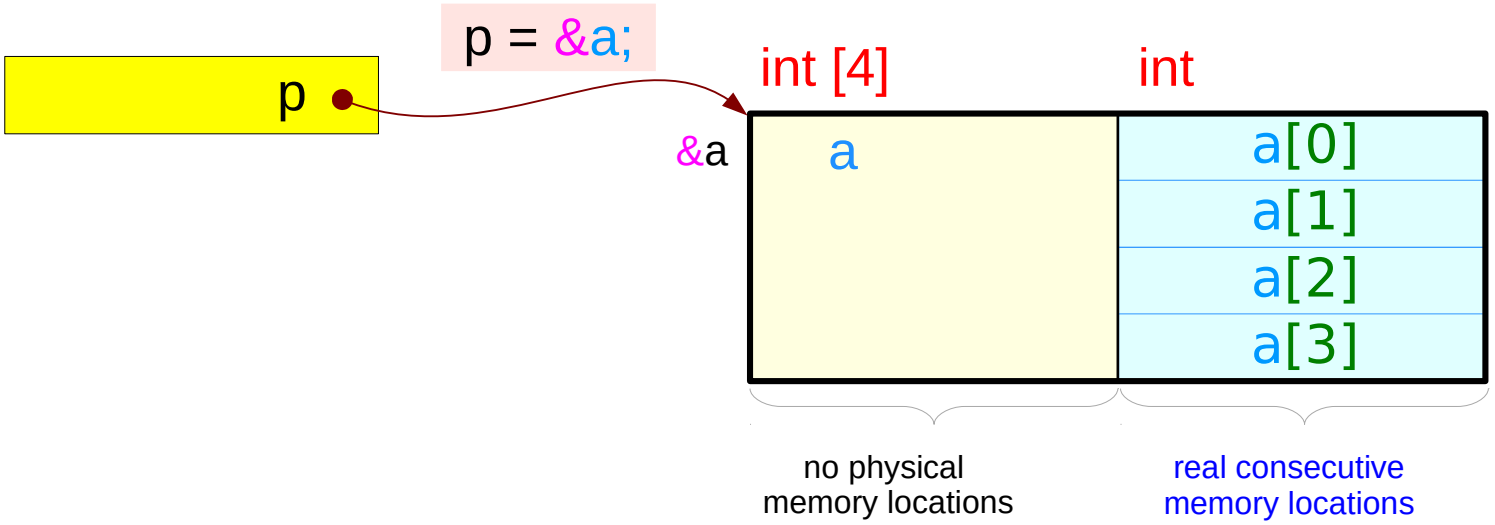
array pointer:
a pointer to an array

pointer array:
an array of pointers





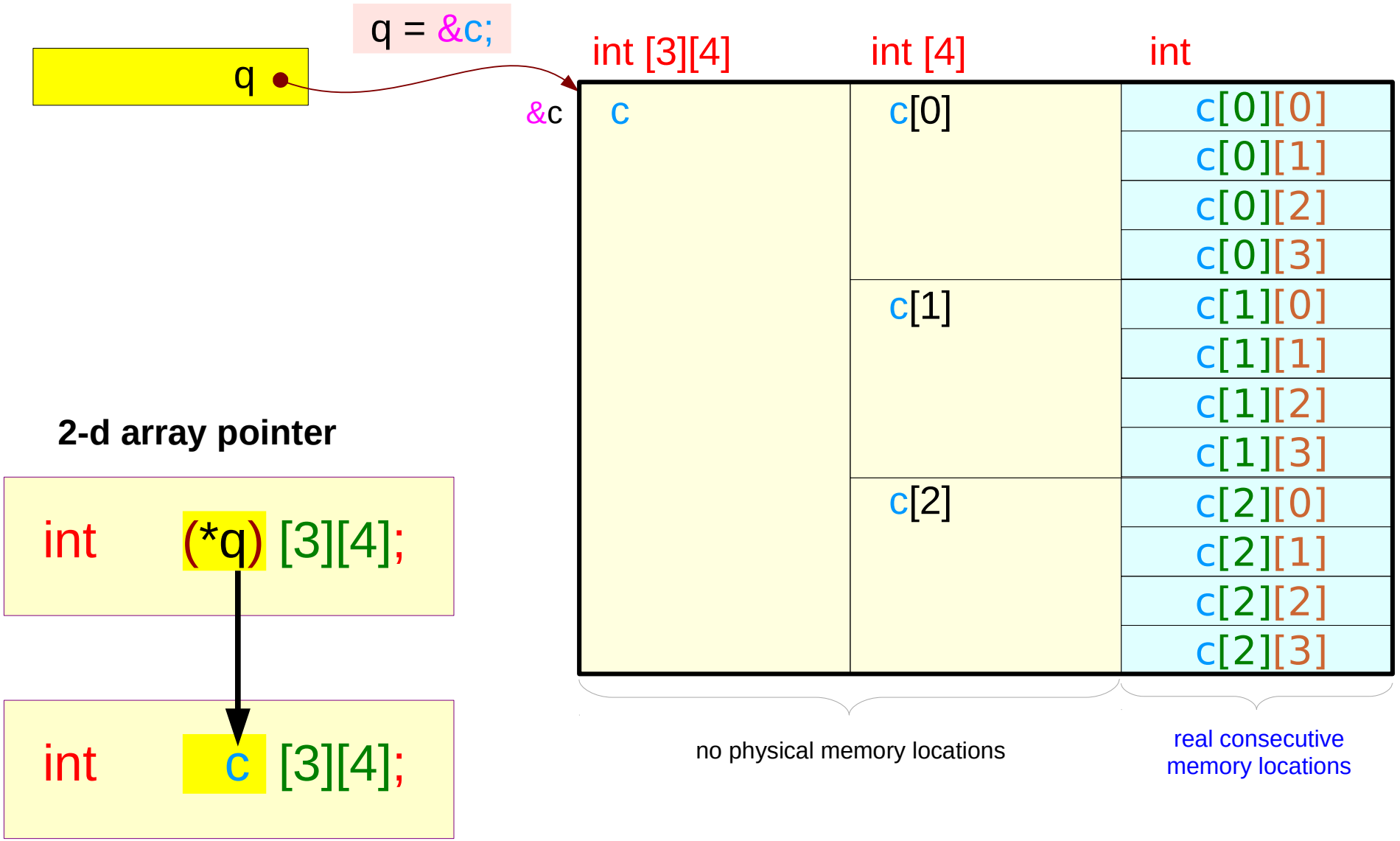
Pointer **q** to a **1-d** array **a**



1-d array pointer

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

int       a  [4];
```

Pointer **q** to a **2-d** array **c**

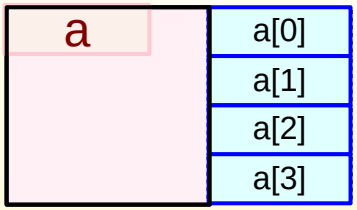


2-d array pointer

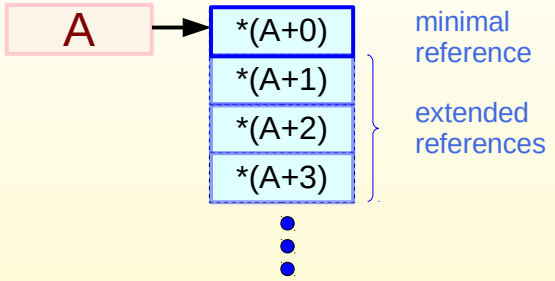
```
int (*q) [3][4];

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

Array **a** vs array pointer **A**

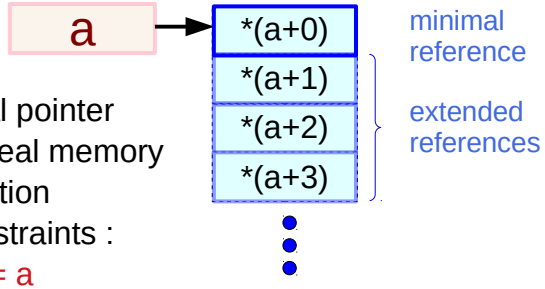
int a[4] ; **1-d** array a



int (*A) ; **0-d** array pointer A

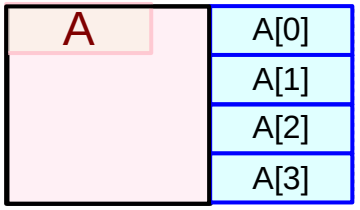


int (*) a as a **0-d** array pointer



virtual pointer
- no real memory location
- constraints :
  &a = a

int [N] A as a **1-d** array



N is not fixed to 4

sizeof(A) is not the size of the array but the size of a pointer variable

Array **a** and array pointers **A**

`int a[4] ;` **1-d** array a

- sizeof(a) = an array size
  = 4 * 4 bytes
- # of 0-d arrays = fixed
  = 4

`int (*A) ;` **0-d** array pointer A

- sizeof(A) = a pointer size
  = 4 / 8 bytes
- # of 0-d arrays = not fixed
  = at least 1

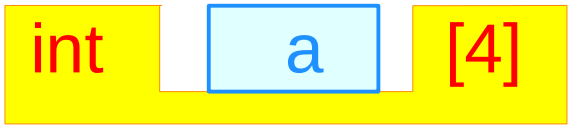
`int (*)` a as a **0-d** array pointer

a is not a real pointer
- sizeof(a) = an array size
- a = &a

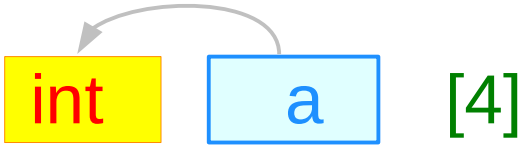
`int [N]` A as a **1-d** array

A is not a real array
- sizeof(A) = a pointer size
- A ≠ &A

Array and pointer types in a **1-d** array

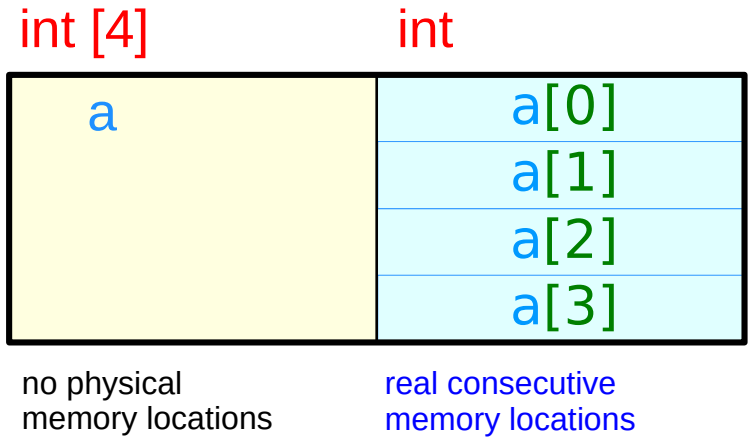


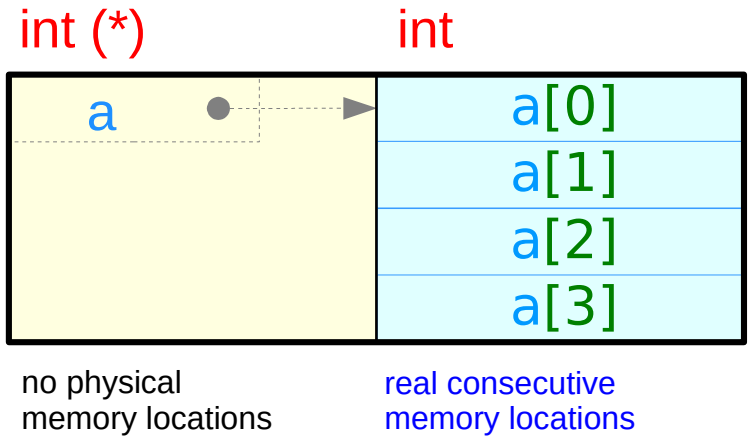
a **1-d array**
type : int [4]
size : 4 * 4



a **0-d array pointer** (virtual)
type : int (*)
size : 4 * 4

a points to the 1st **int** element
there are 4 **int** elements





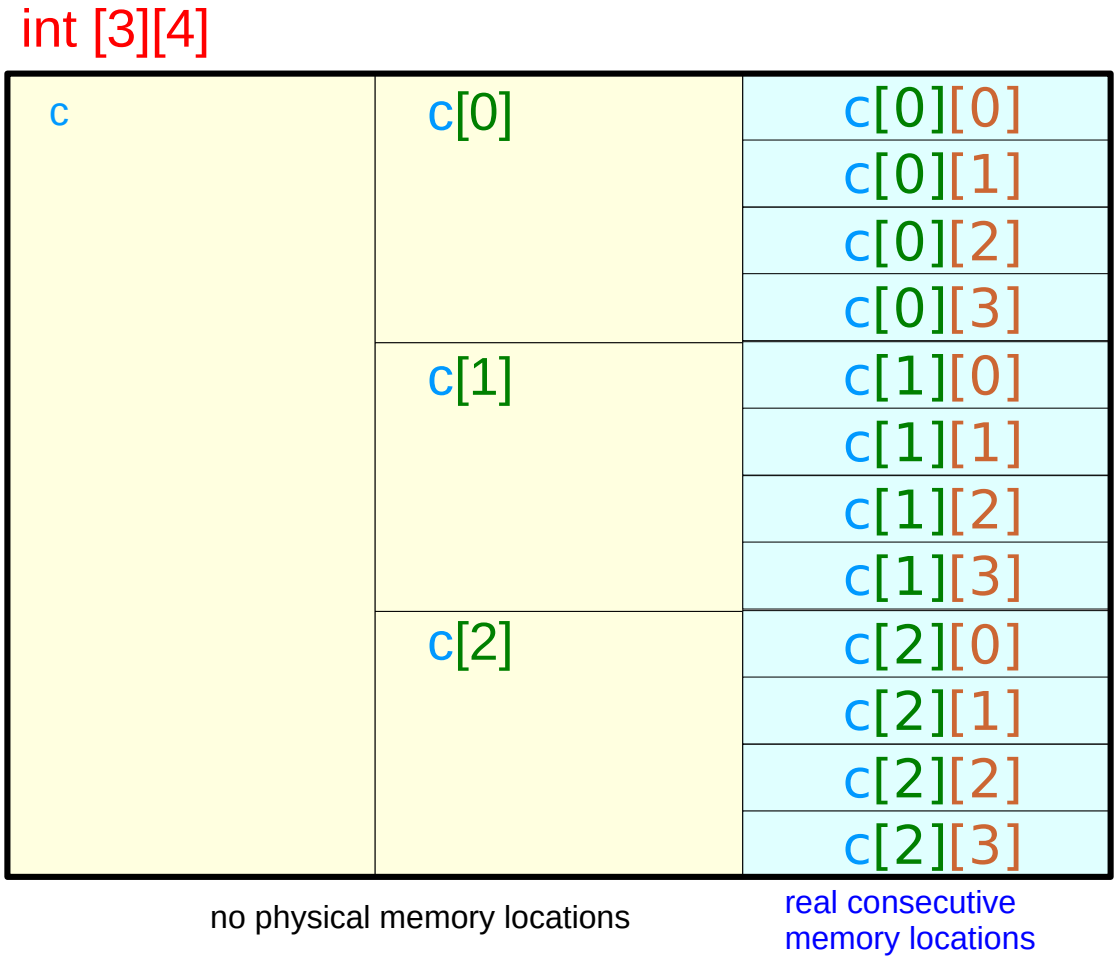
2-d array type

int c [3] [4]

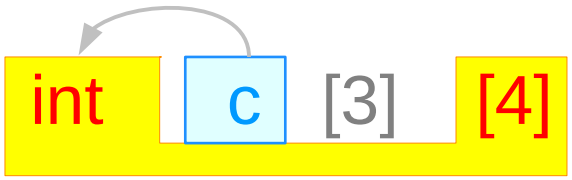
C 2-d array

type : int [3][4]

size : 3 * 4 * 4



1-d array pointer type

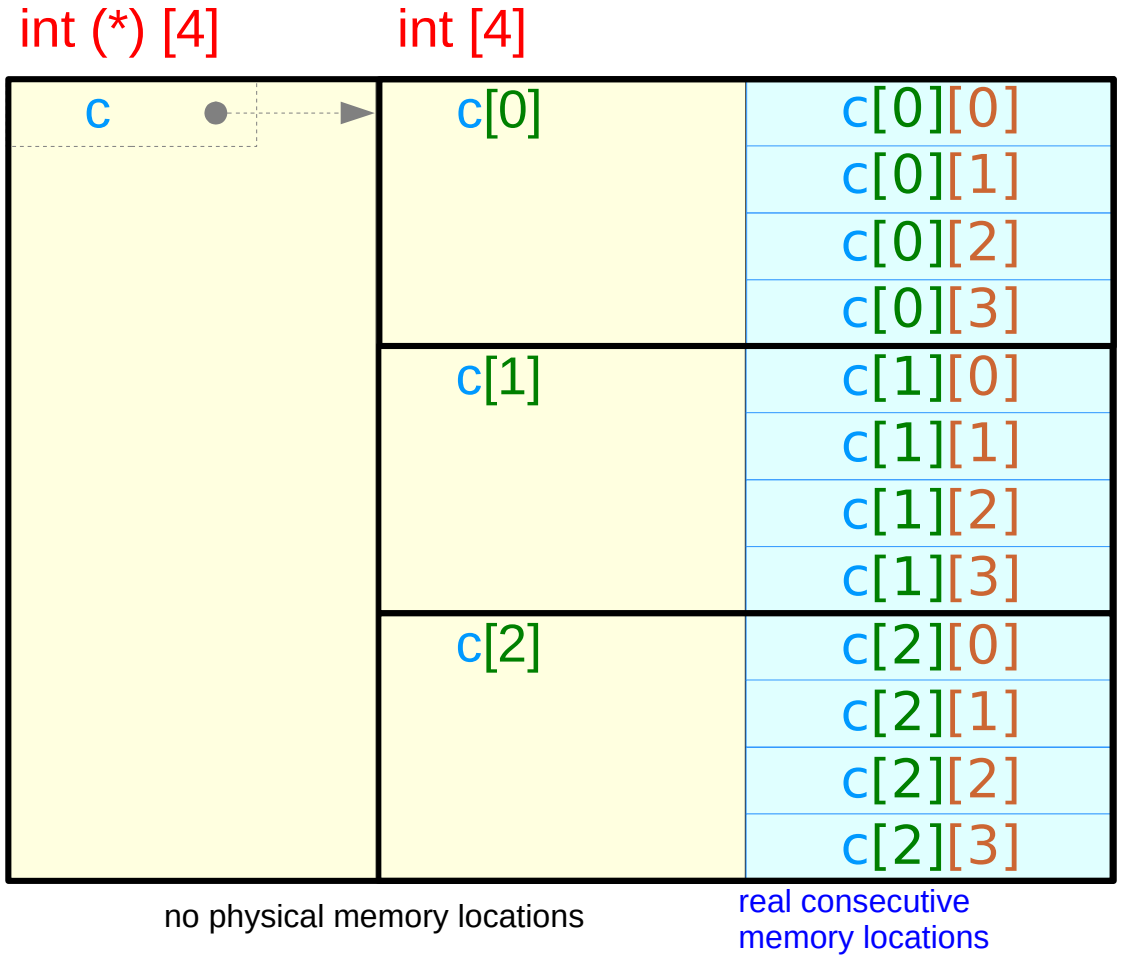


C **1-d array pointer** (virtual)

type : int (*) [4]

size : 3 * 4 * 4

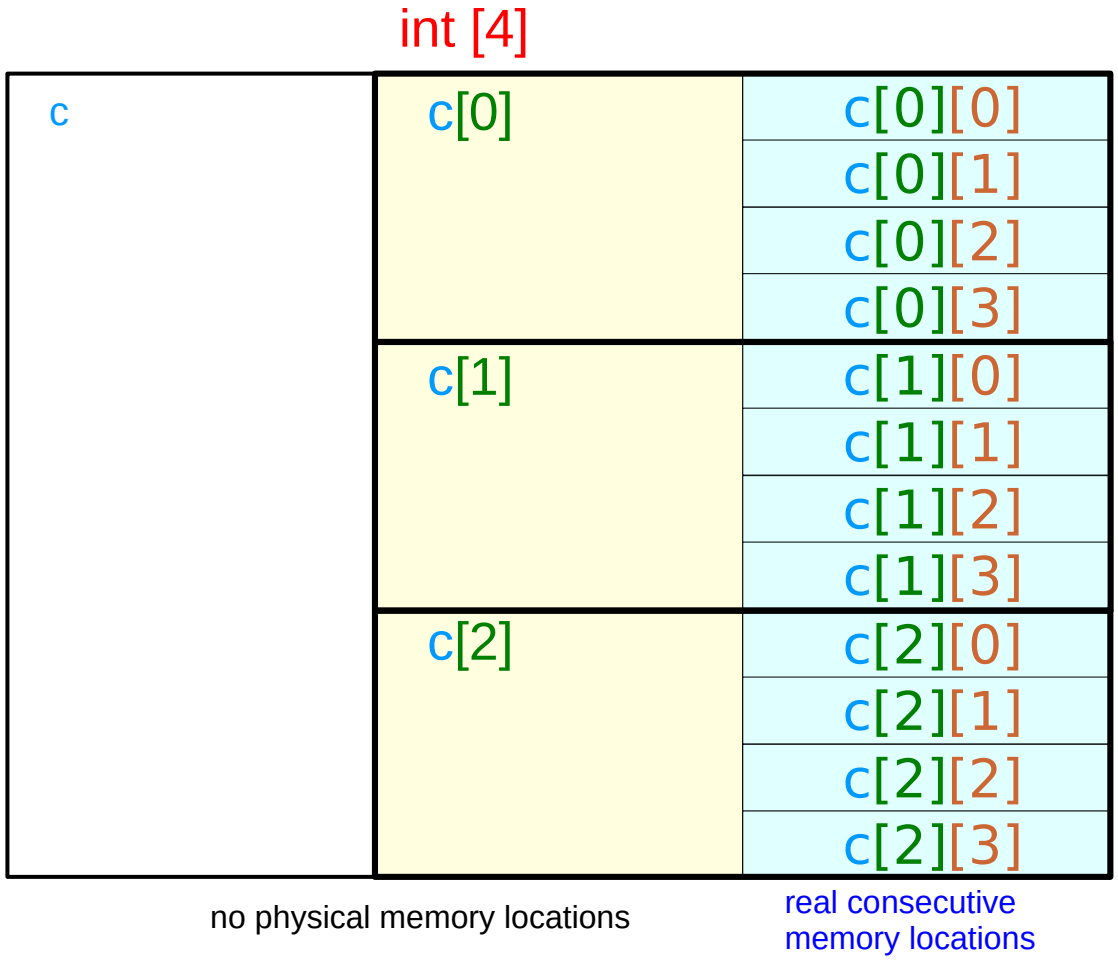
c points to the 1st **int [4]** element
There are 3 **int [4]** elements



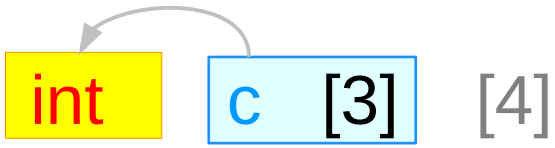
1-d array type

int c [3] [4]

c[i] **1-d array**
type : int [4]
size : 4 * 4



0-d array pointer type

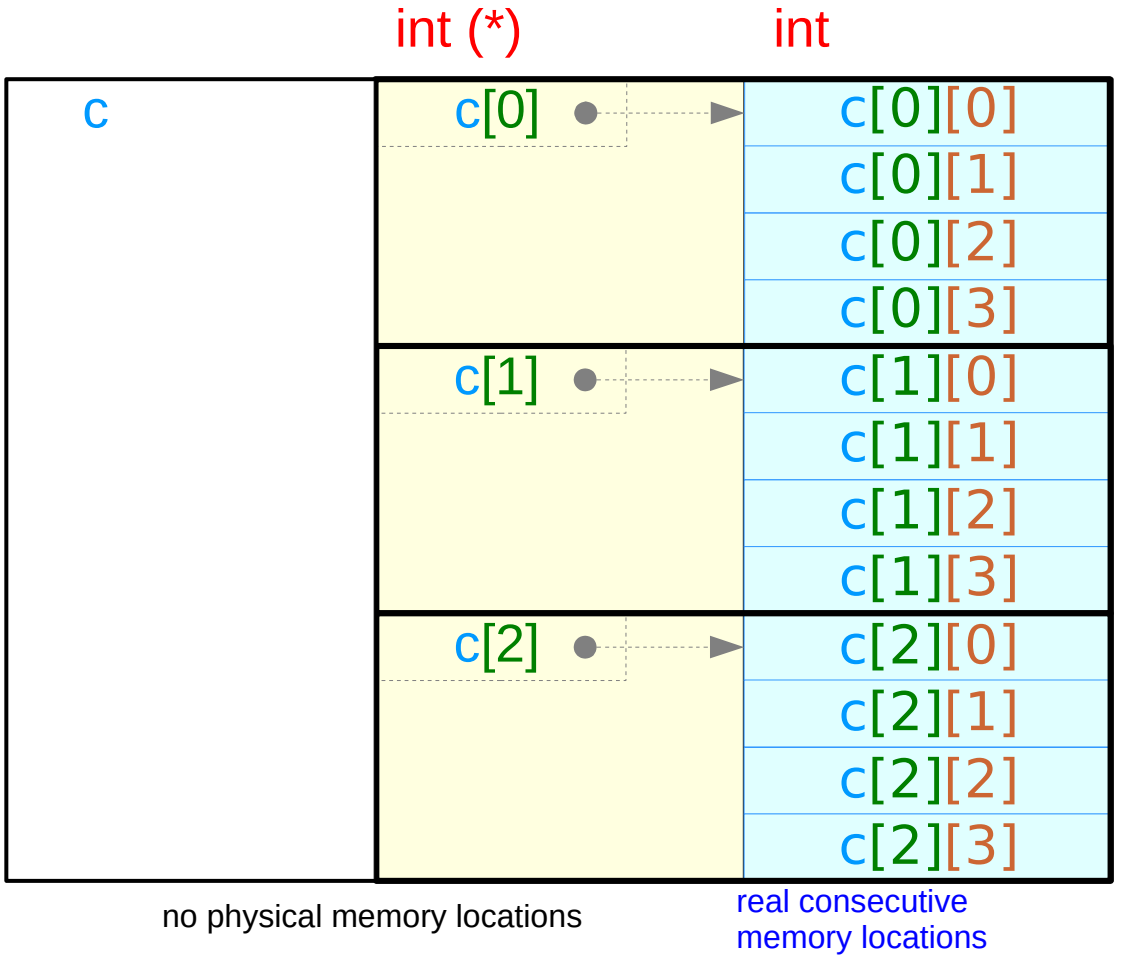


c[i] **0-d array pointer** (virtual)

type : int (*)

size : 4 * 4

c[i] points to the 1st **int** element
There are 4 **int** elements

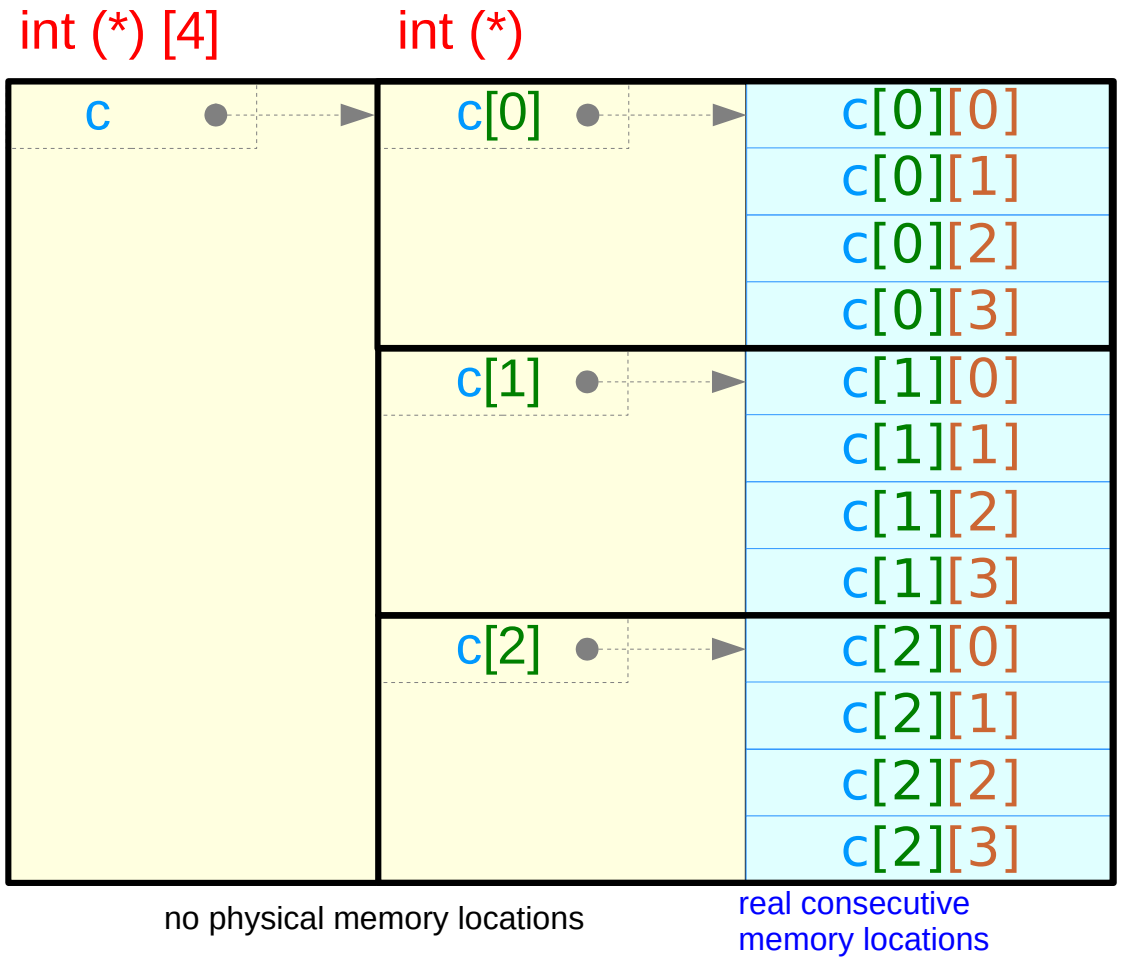


Values of virtual array pointer in a **2-d** array

c = c[0] = &c[0][0]

c[1] = &c[1][0]

c[2] = &c[2][0]



Types in a **2-d** array

int c [3] [4]

c **2-d array**
type : int [3][4]
size : 3 * 4 * 4
value : &c[0][0]

relaxing the 1st dimension

int c [3] [4]

c **1-d array pointer** (virtual)
type : int (*) [4]
size : 3 * 4 * 4
value : &c[0][0]

int c [3] [4]

c[i] **1-d array**
type : int [4]
size : 4 * 4
value : &c[i][0]

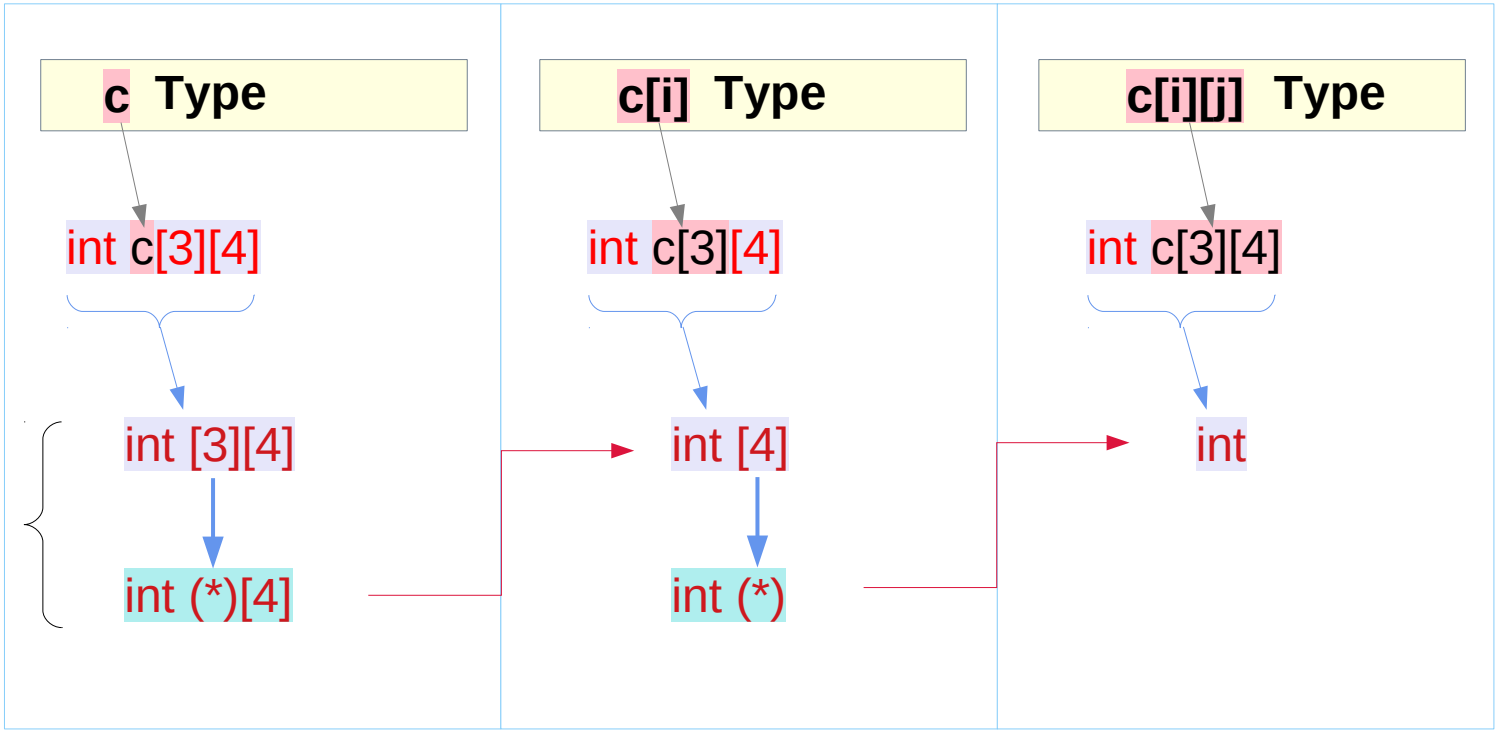
relaxing the 1st dimension

int c [3] [4]

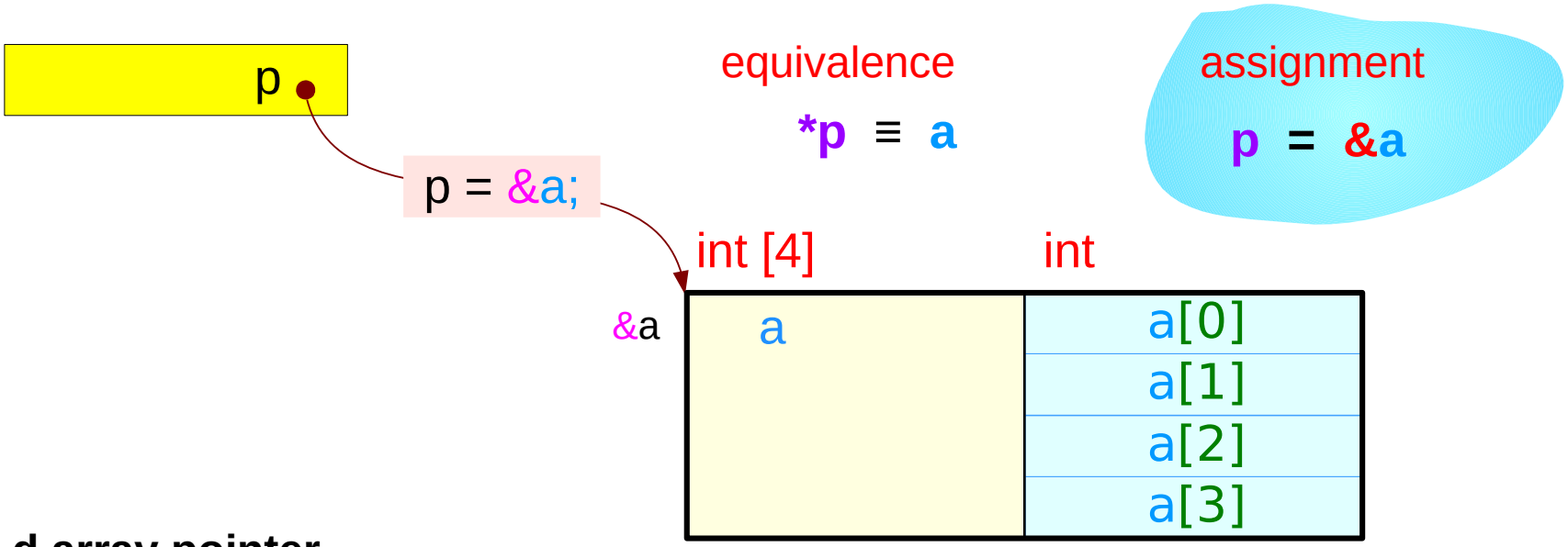
c[i] **0-d array pointer** (virtual)
type : int (*)
size : 4 * 4
value : &c[i][0]

Subarray types in a **2-d** array

int c[3][4]; **2-d** array c



Pointer **p** to a **1-d** array **a**



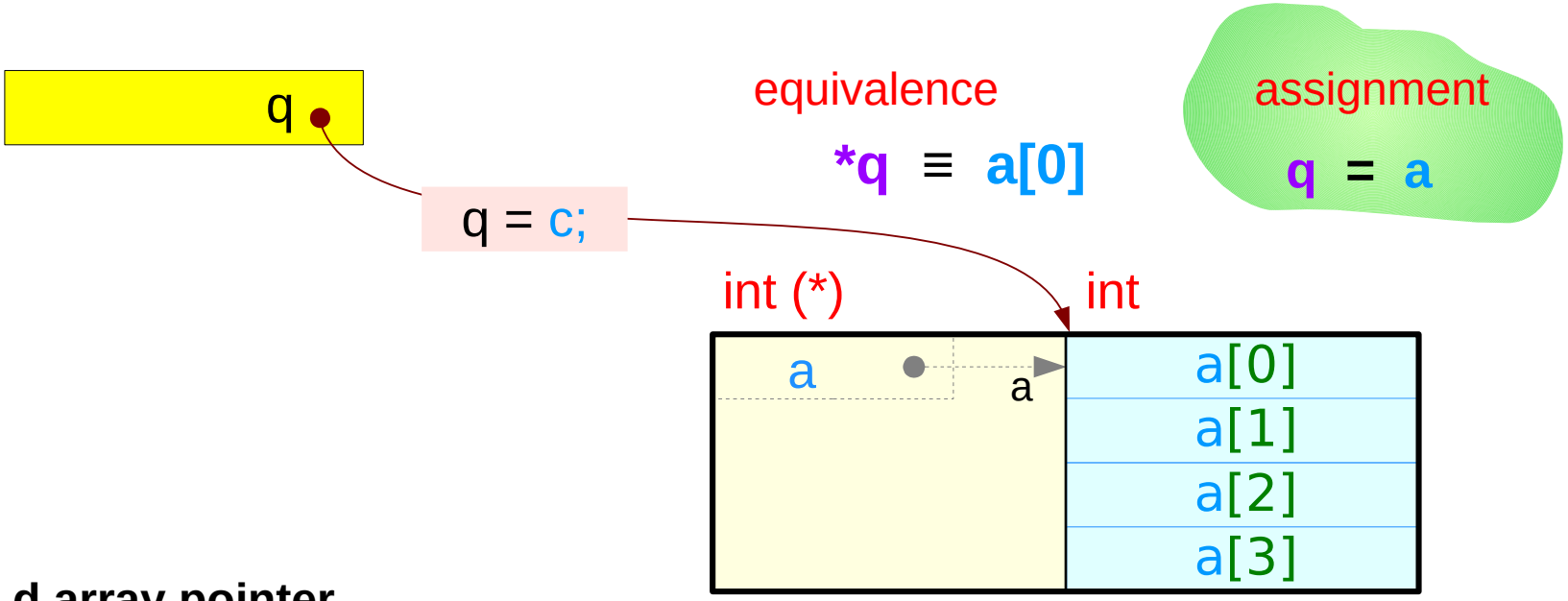
1-d array pointer

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

1-d array

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

Pointer **q** to a **0-d** array **a[0]**



0-d array pointer

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

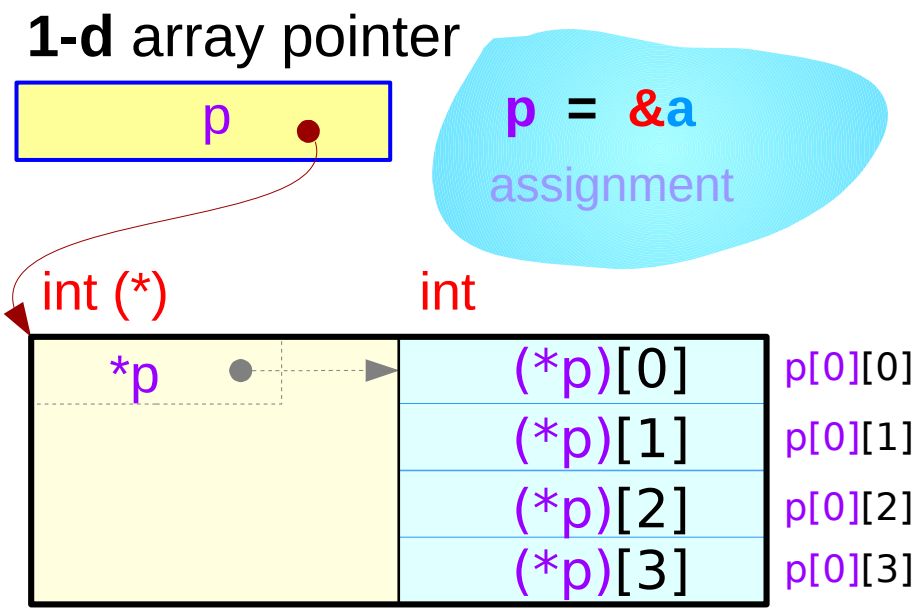
1-d array

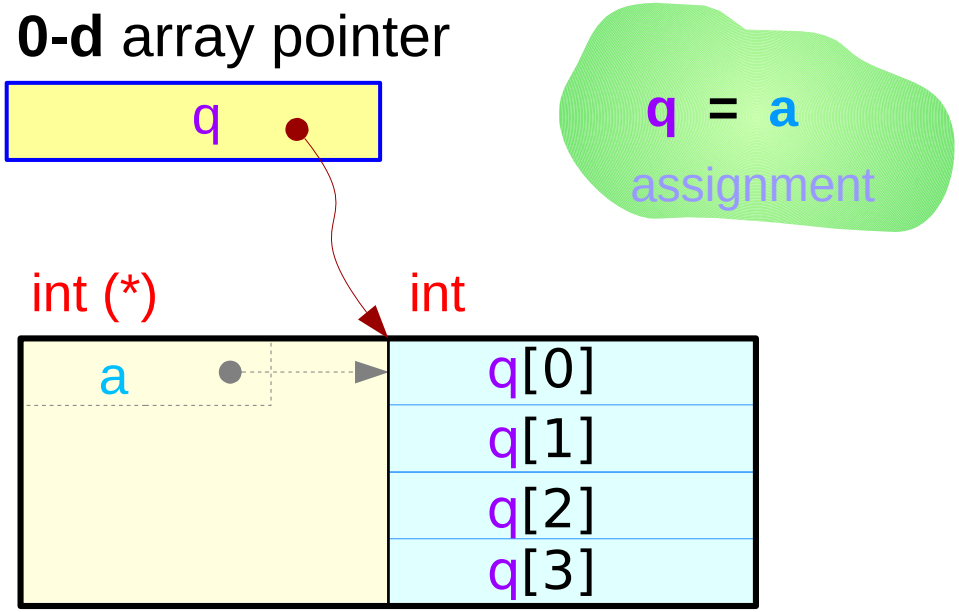
```
int     a[4]  ;
```

1-d array access using p and q

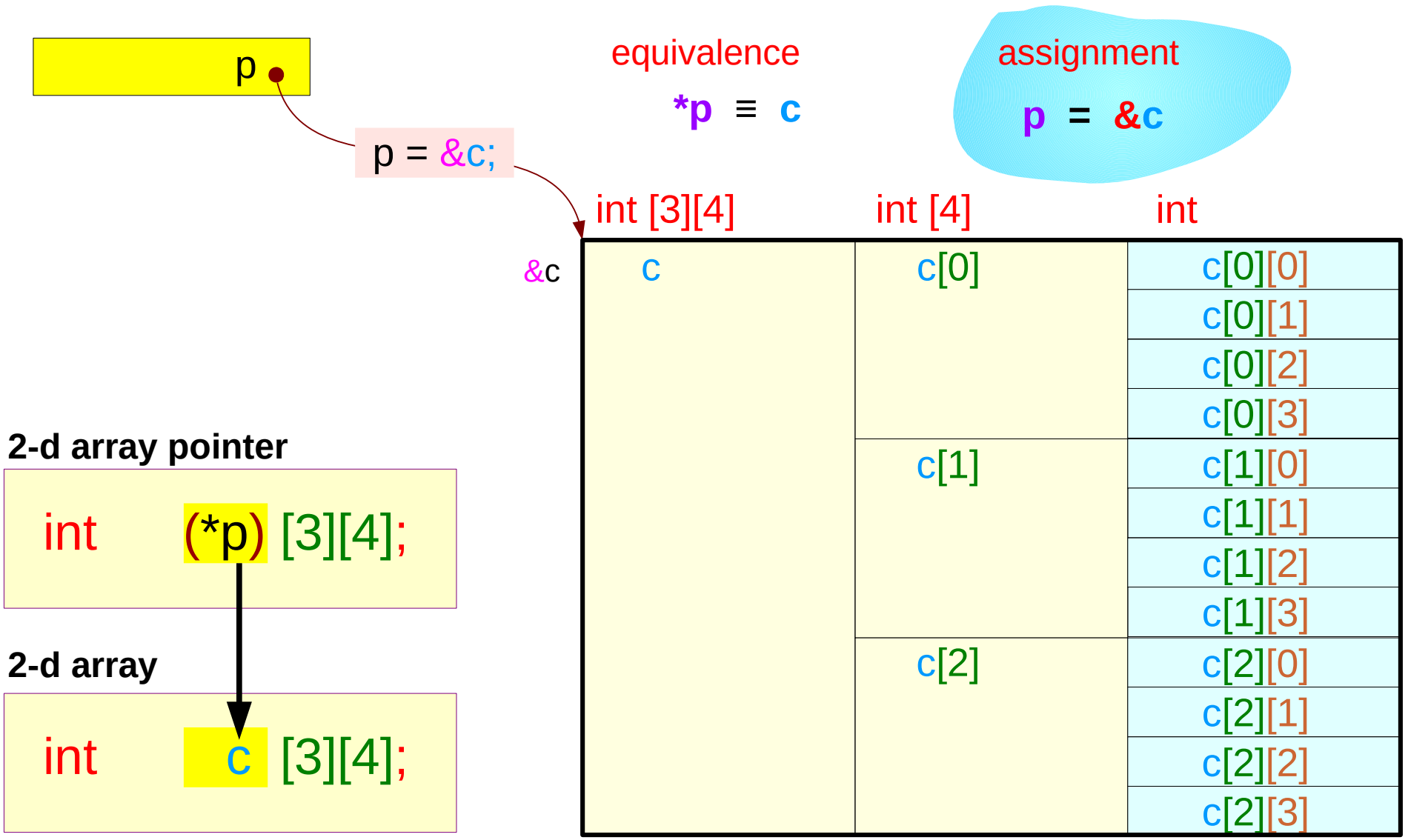
```
int  (*p) [4]   = &a;
```

```
int  (*q)   = a;
```

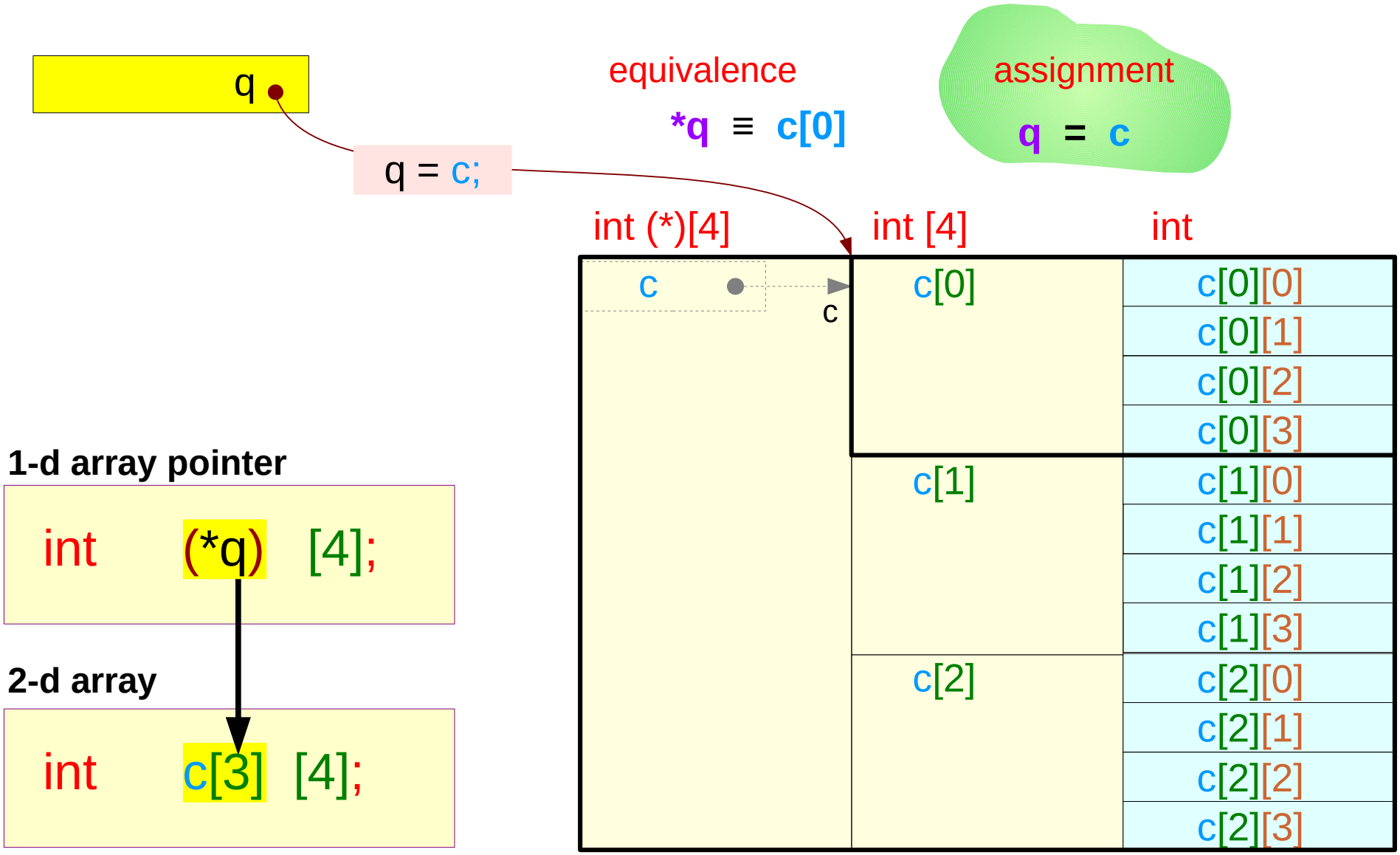




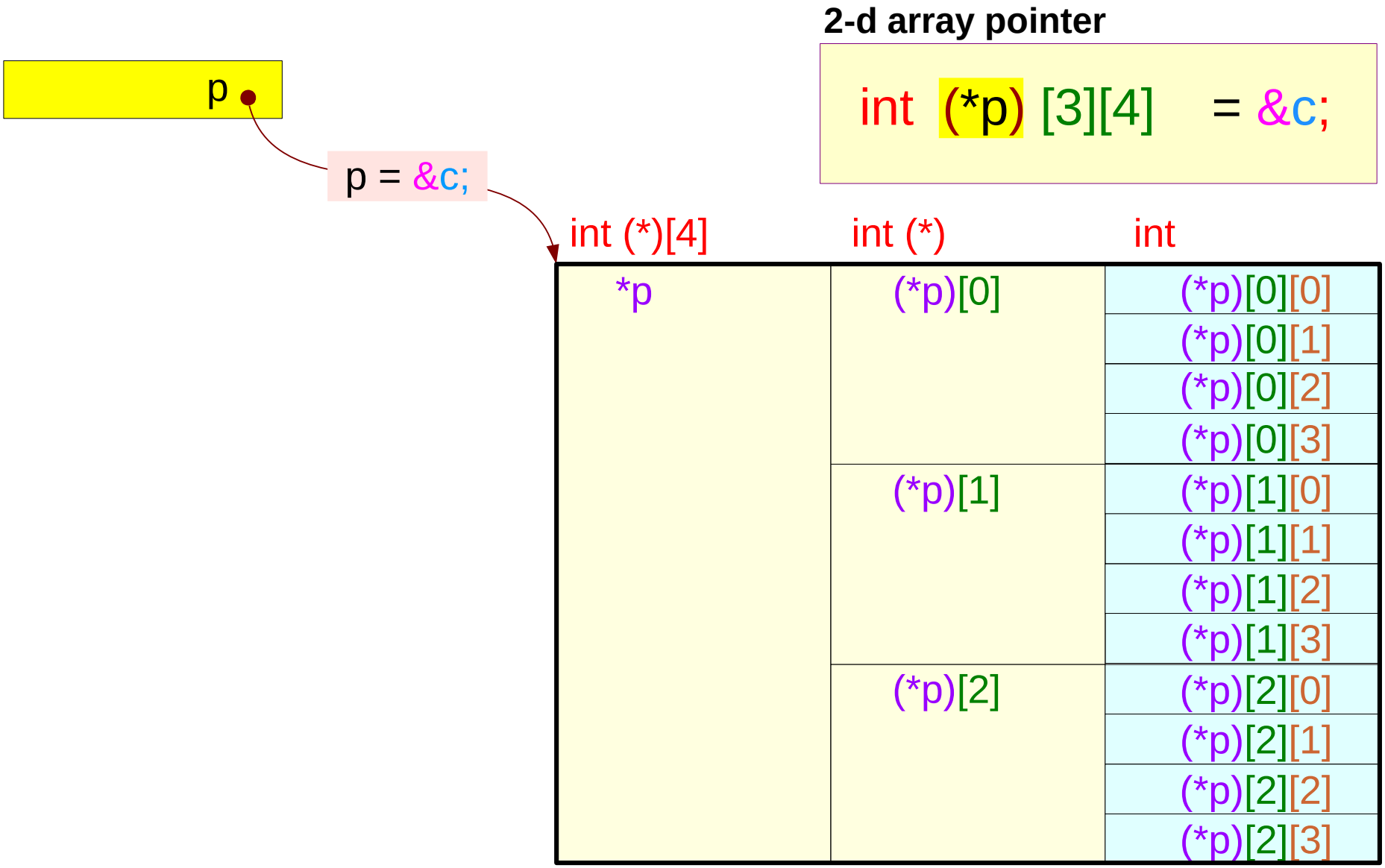
Pointer **p** to a **2-d** array **c**



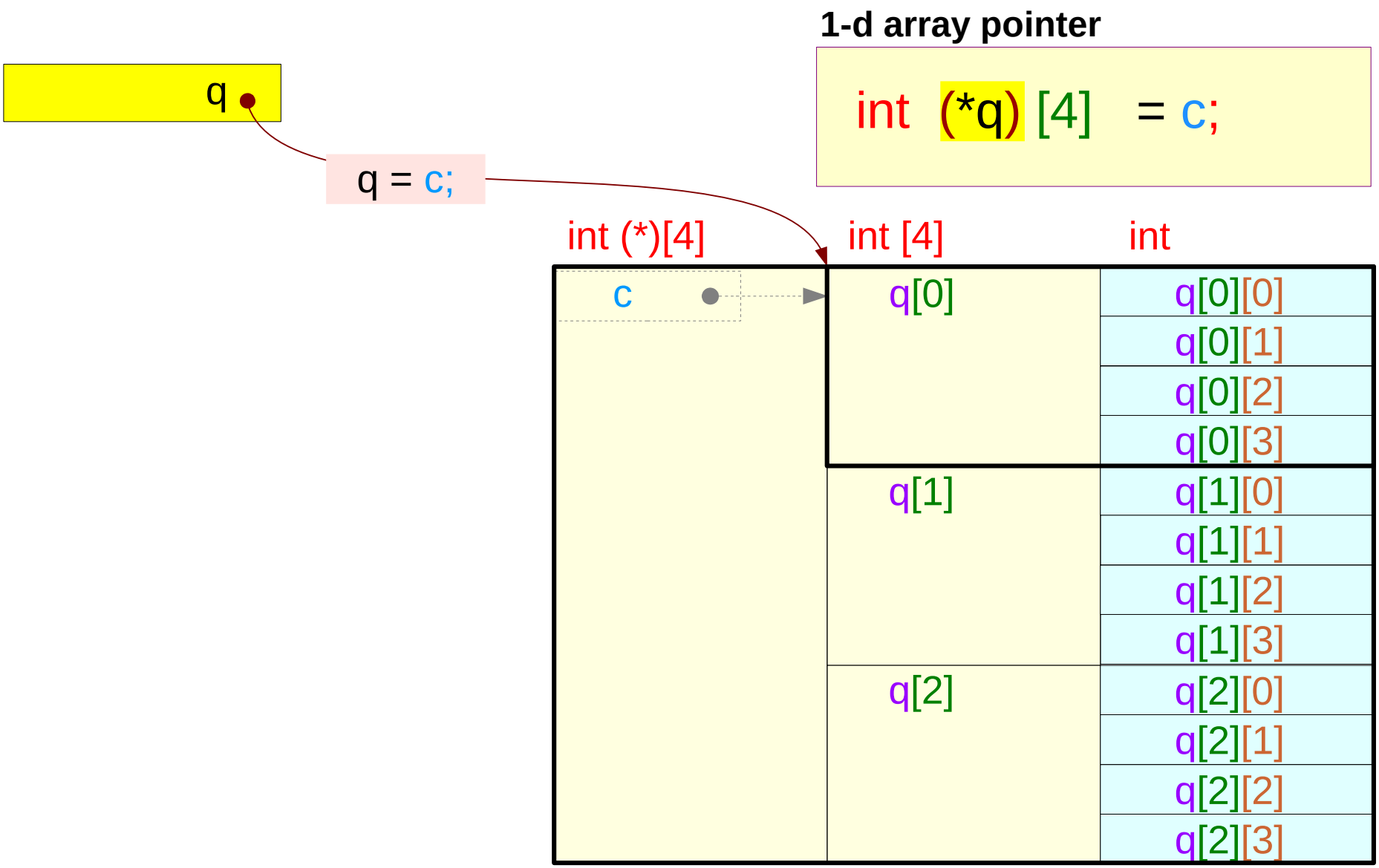
Pointer **q** to a **1-d** array **c[0]**



2-d array access using p

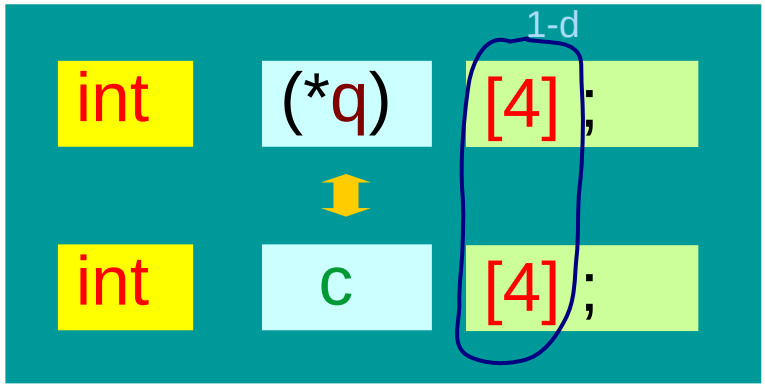


2-d array access using q



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

1-d array pointer



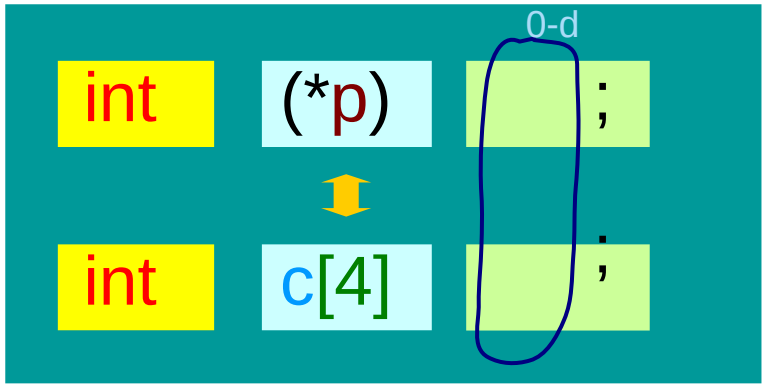
int (*) [4]

equivalence *q ≡ c;

assignment q = &c;

(*q)[**i**] ≡ q[0][**i**] ≡ c[**i**]

0-d array pointer : int pointer



int (*)

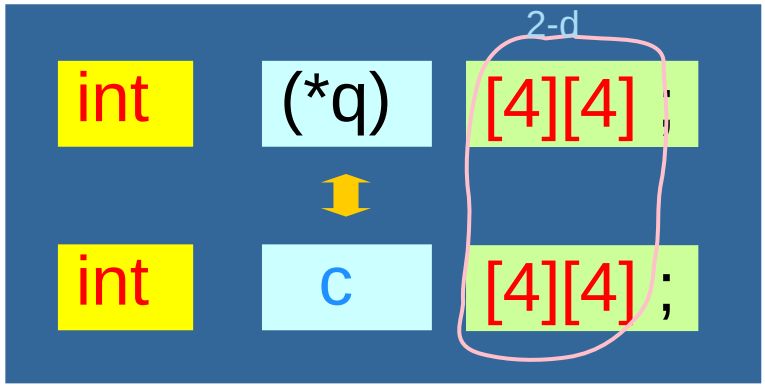
equivalence *p ≡ *c;

assignment p = c;

p[**i**] ≡ c[**i**]

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

2-d array pointer



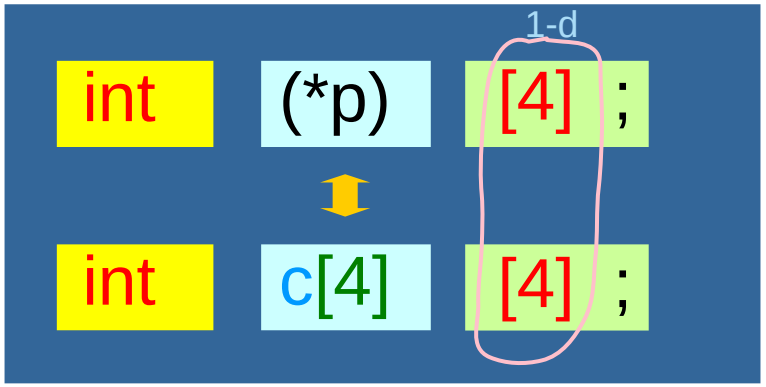
int (*) [4][4]

equivalence *q ≡ c;

assignment q = &c;

(*q)[i][j] ≡ q[0][i][j] ≡ c[i][j]

1-d array pointer



int (*) [4]

equivalence *p ≡ *c;

assignment p = c;

p[i] ≡ c[i]

Array pointers to a **2-d** array

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

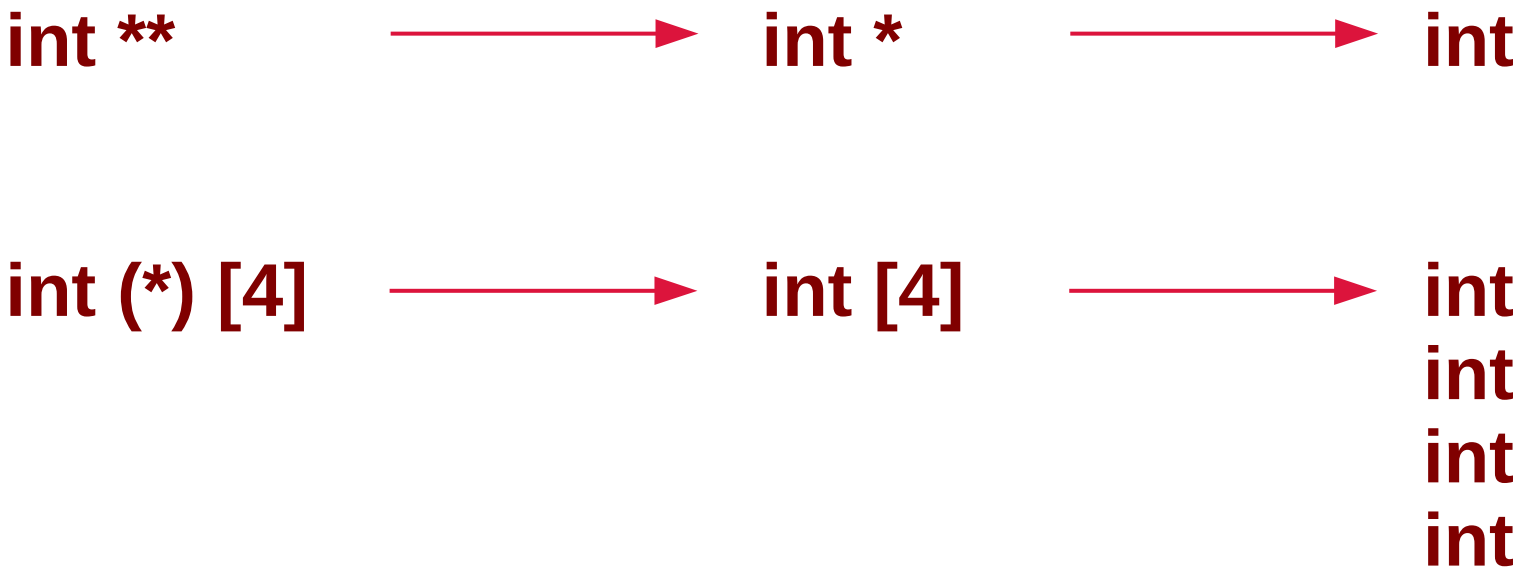
2-d array c

2-d array pointer q

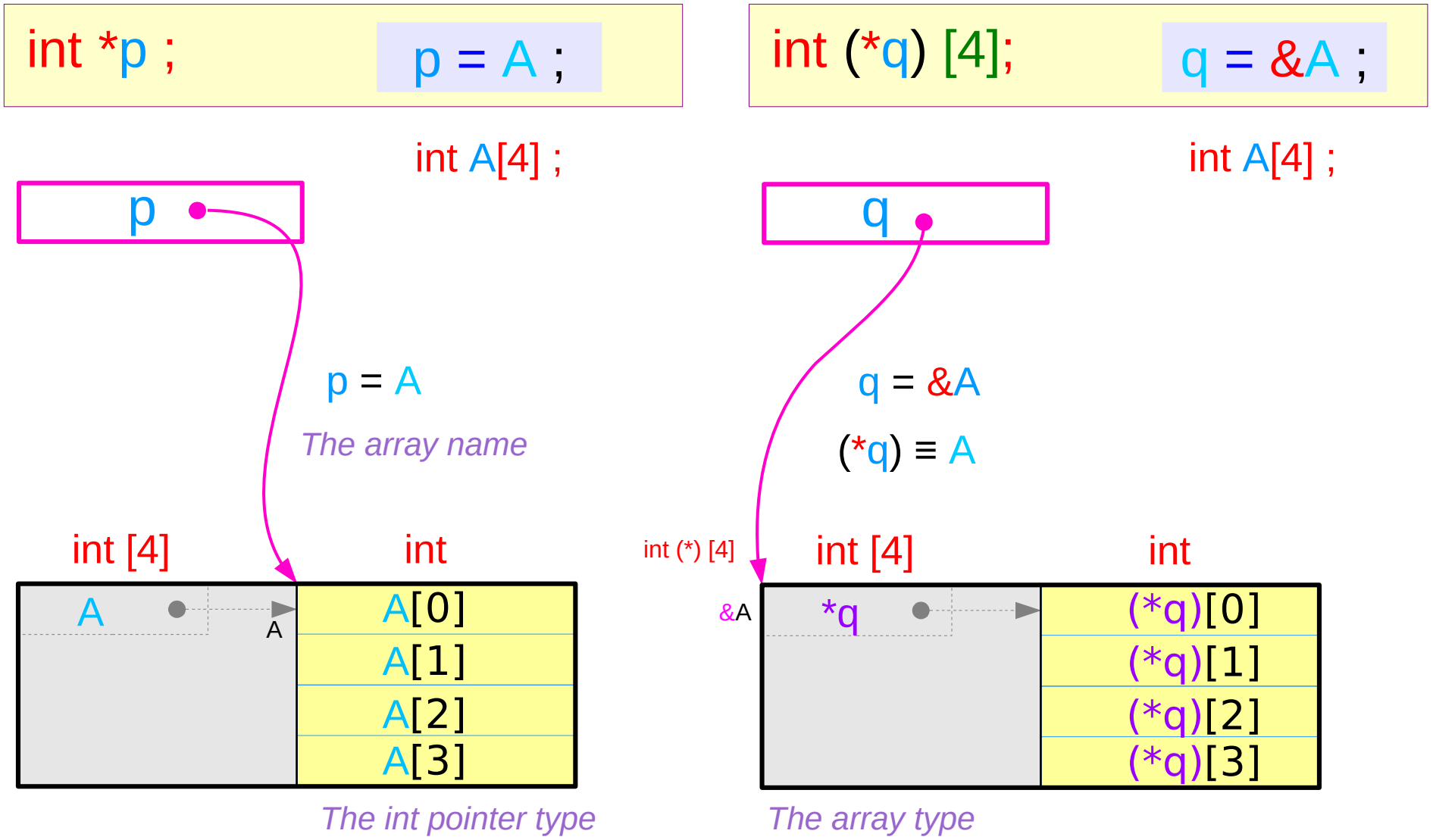
1-d array pointer p

c[i][j] ➡ (*q)[i][j]

c[i][j] ➡ p[i][j]


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

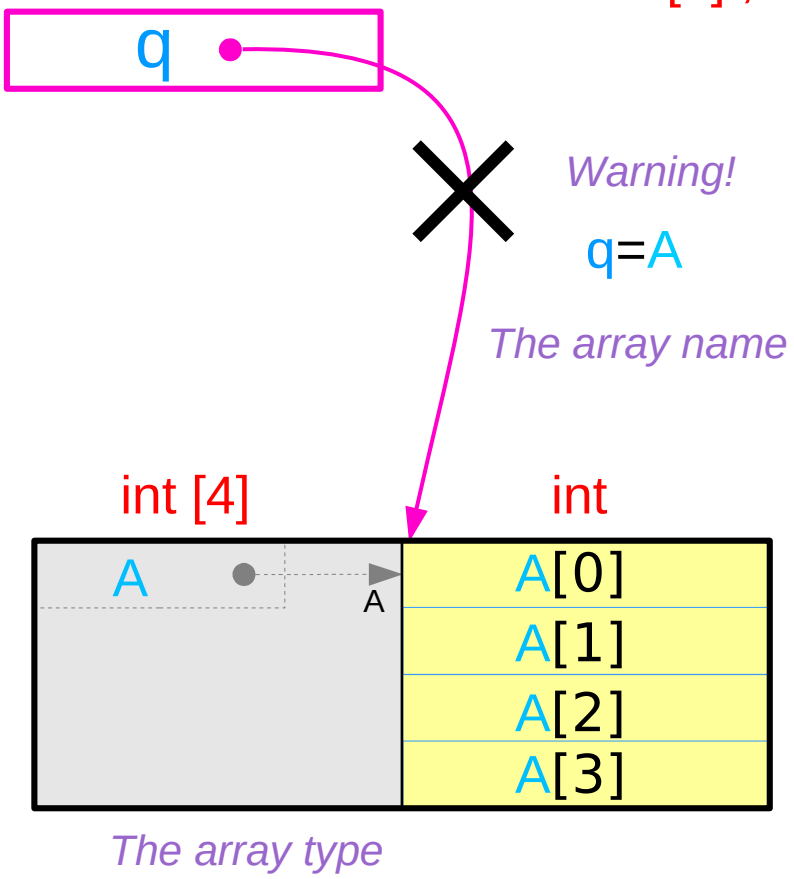
Integer pointer **p** vs. array pointer **q**



Must point to an array type (array name)

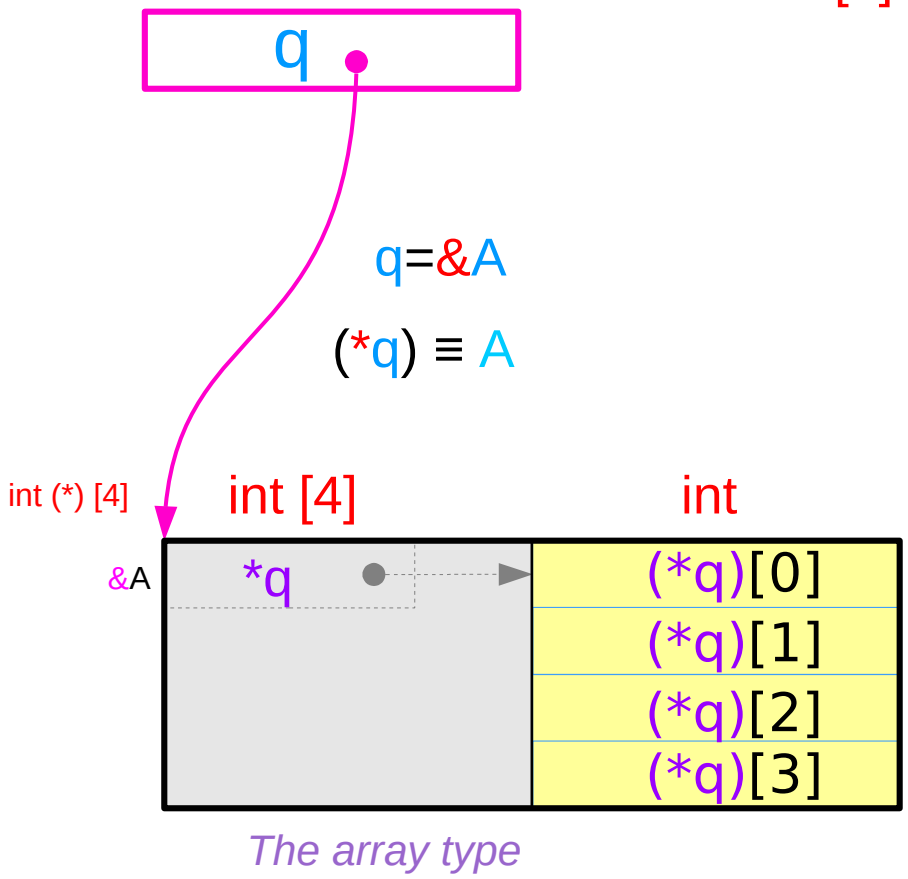
```
int (*q) [4];
q = A ;
```

int A[4] ;

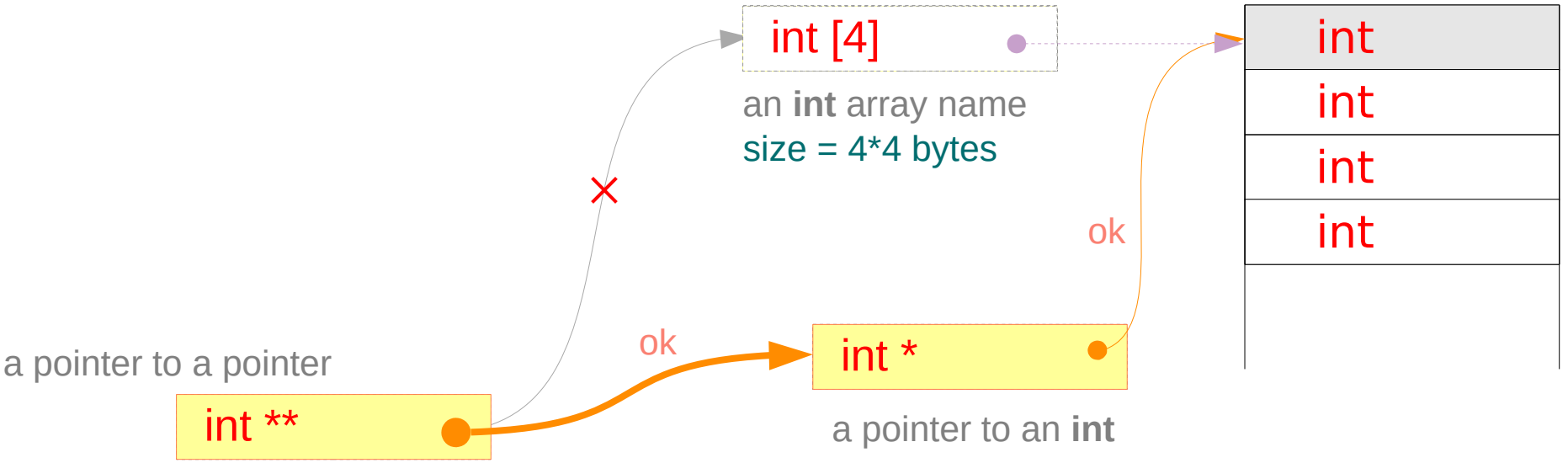



```
int (*q) [4];
q = &A ;
```

int A[4] ;



Double integer pointer type – **int ****

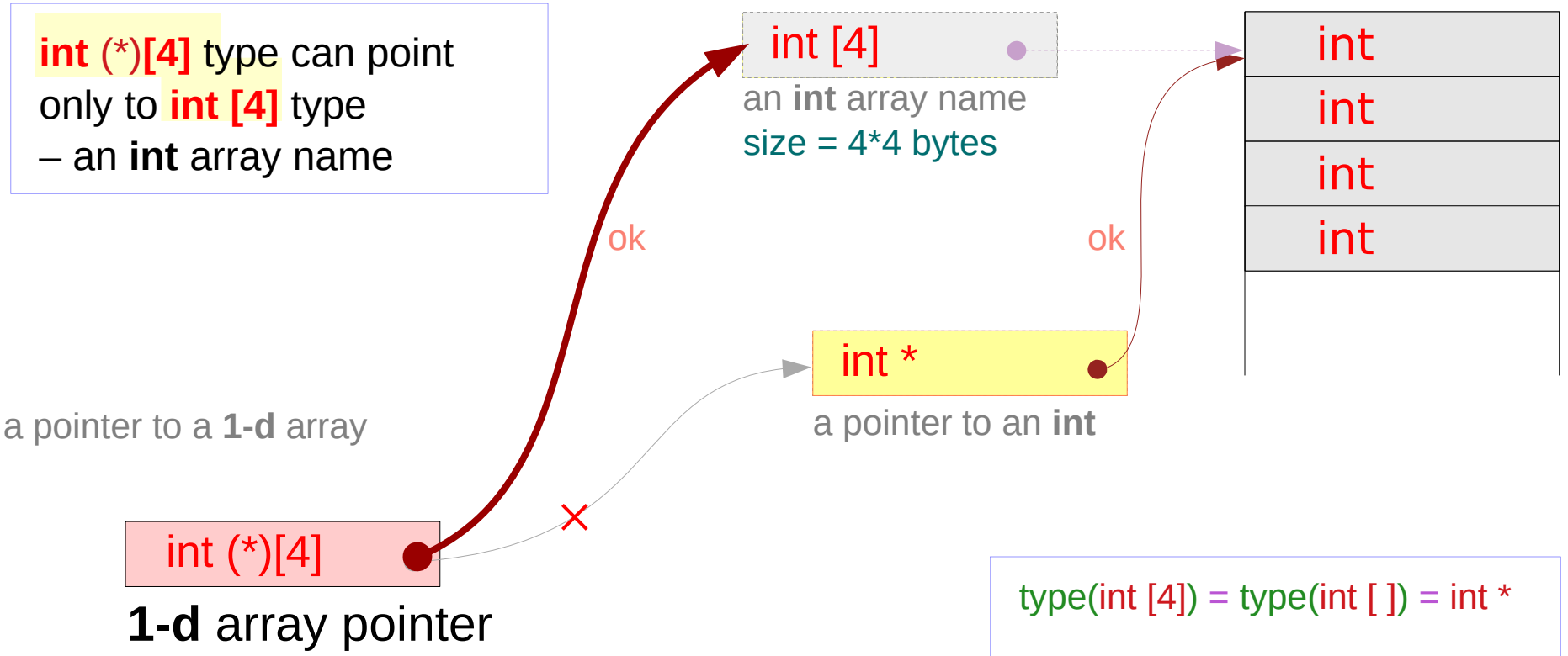


int ** type can point only to **int *** type – an **int** array name (X)

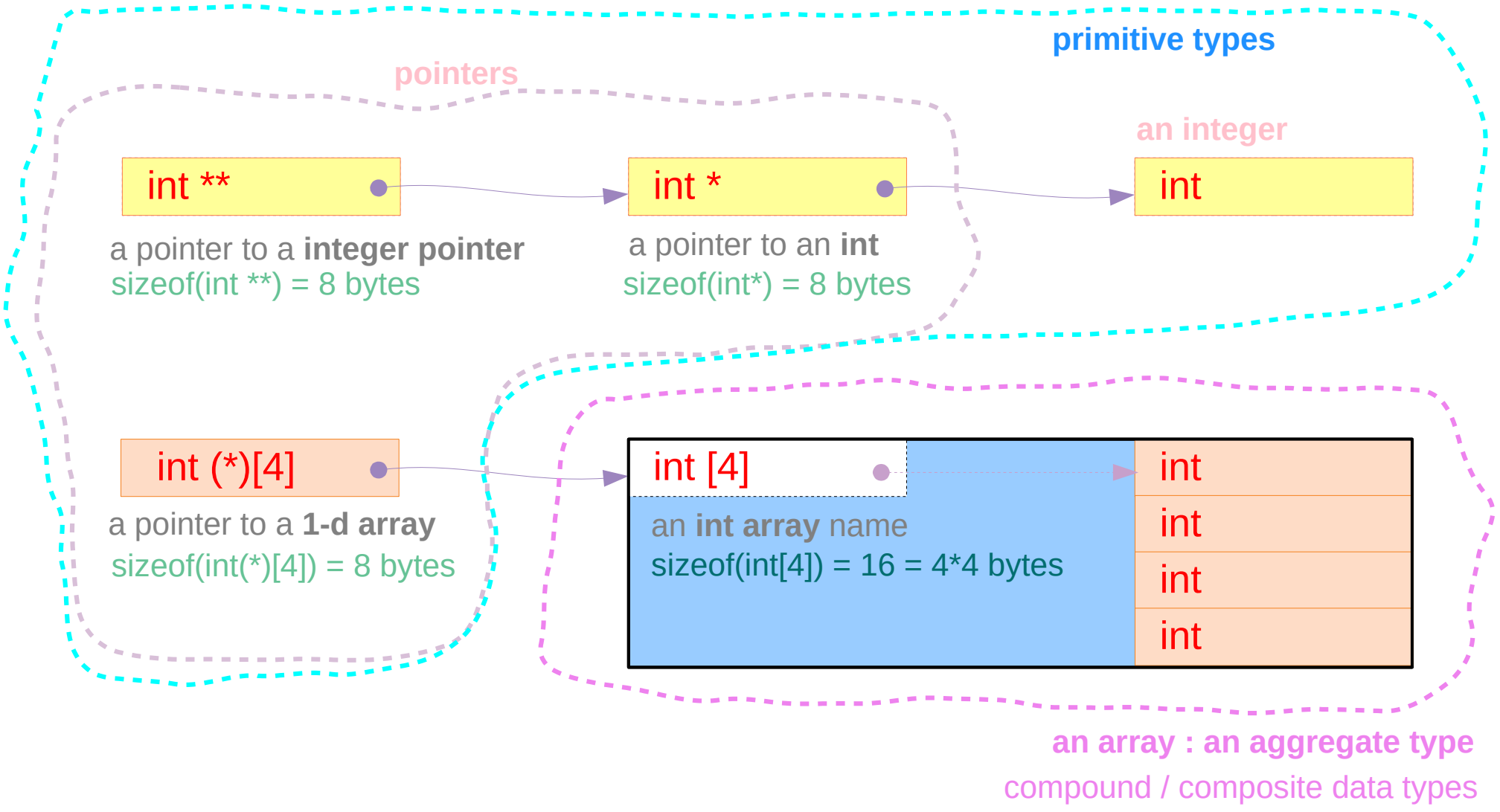
type(int [4]) = type(int [ ]) = int *

each of these types points to an **int** type data

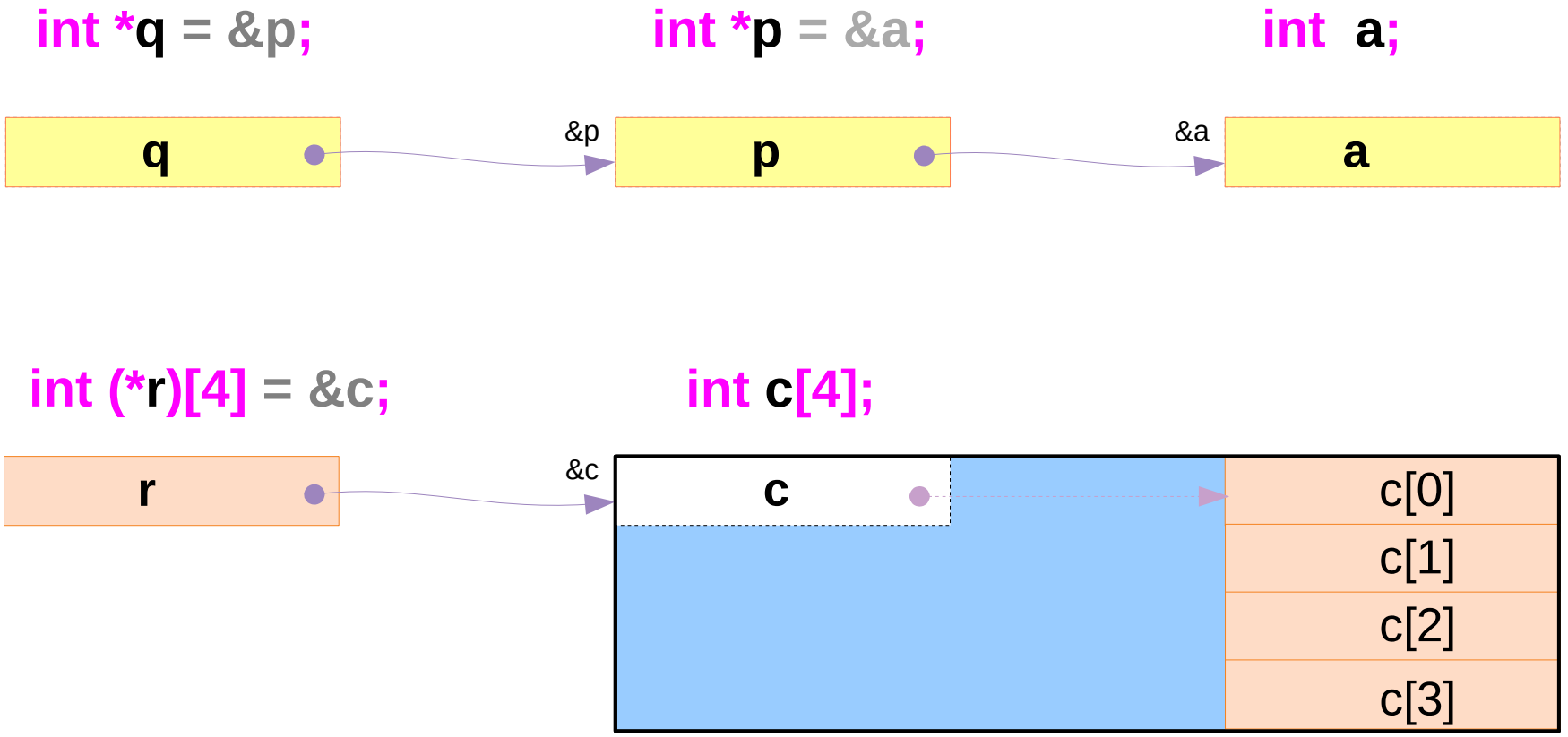
Integer array pointer type – **int (*)[4]**



Types of integer pointers



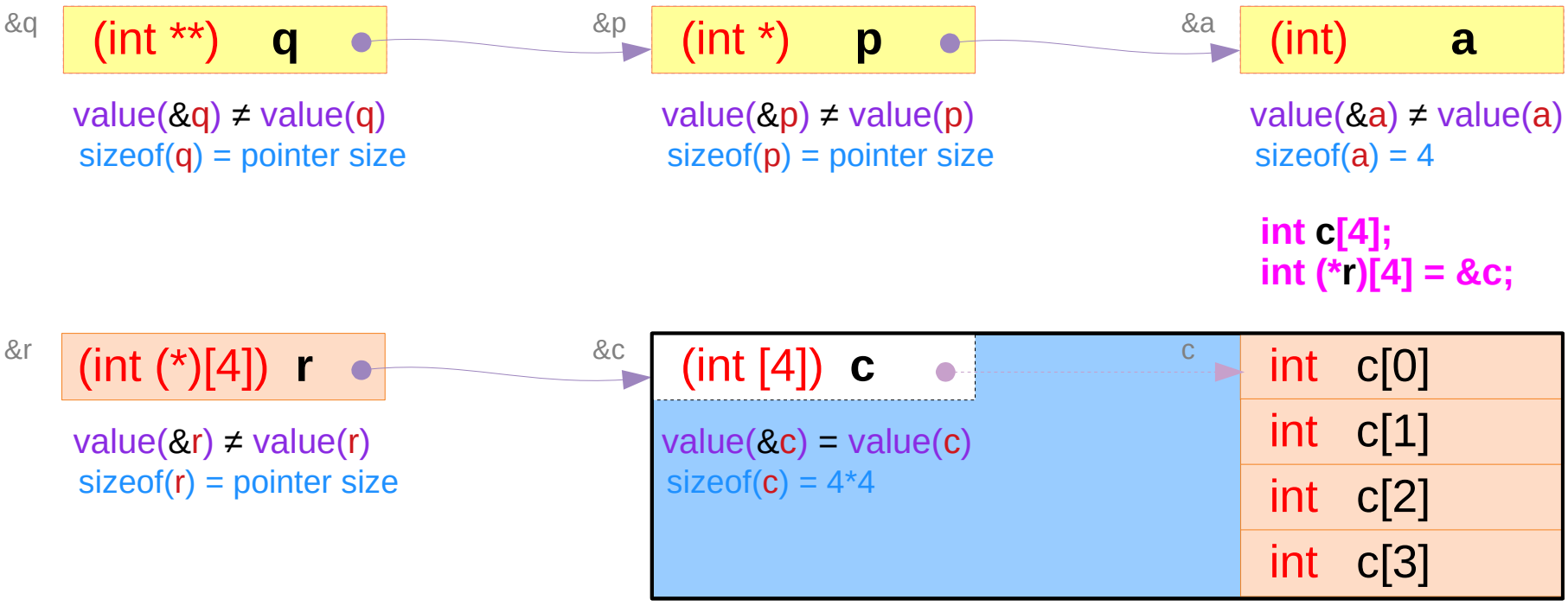
Variable declaration of integer pointers



Types and sizes of integer pointers

type(int [4]) = type(int [ ]) = (int *)

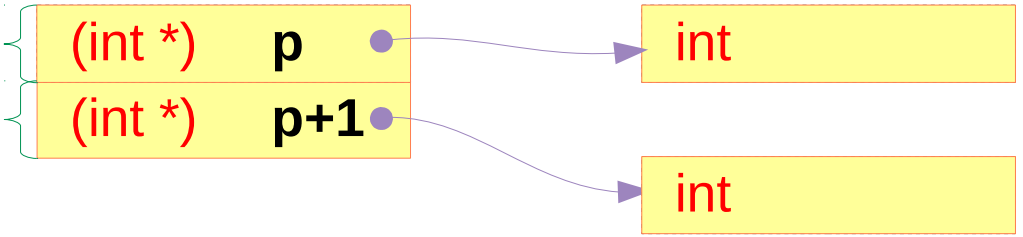
```
int  a;
int *p = &a;
int *q = &p;
```



Sizes of integer pointers

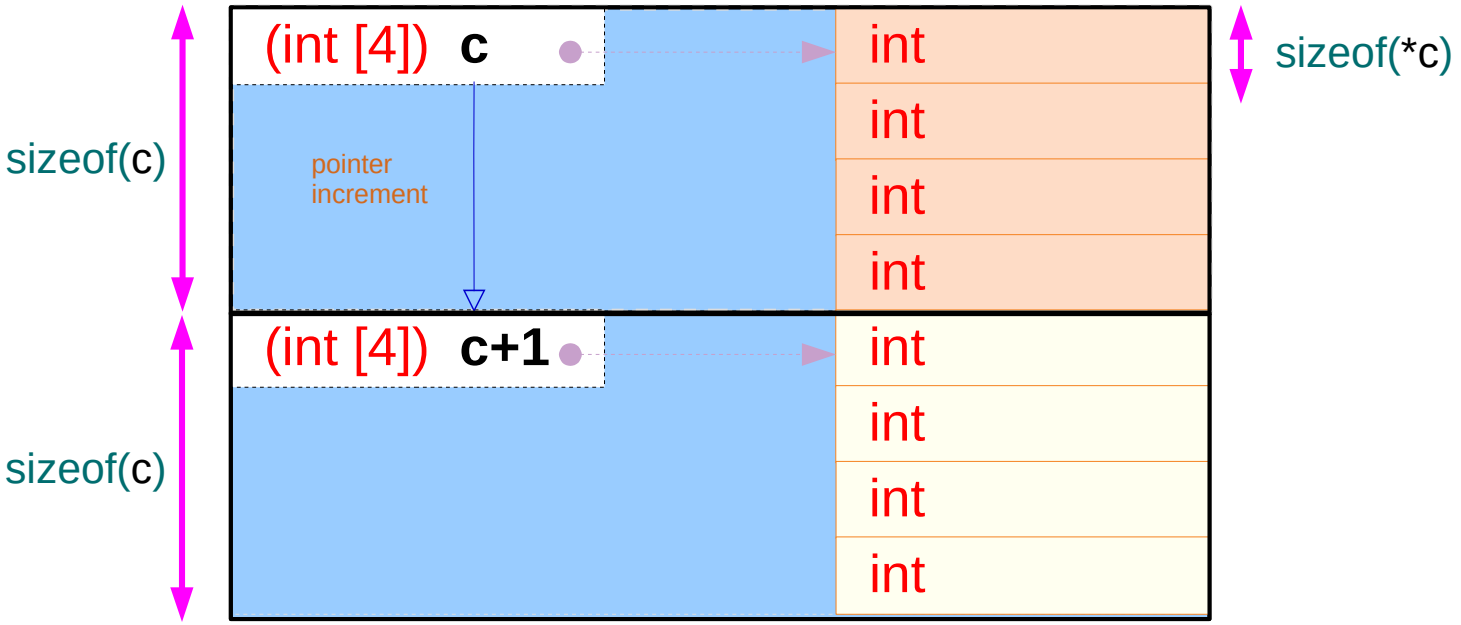
a pointer to an **int**

sizeof(p) = pointer size
= 8 bytes on 64-bit machine
= 4 bytes on 32-bit machine



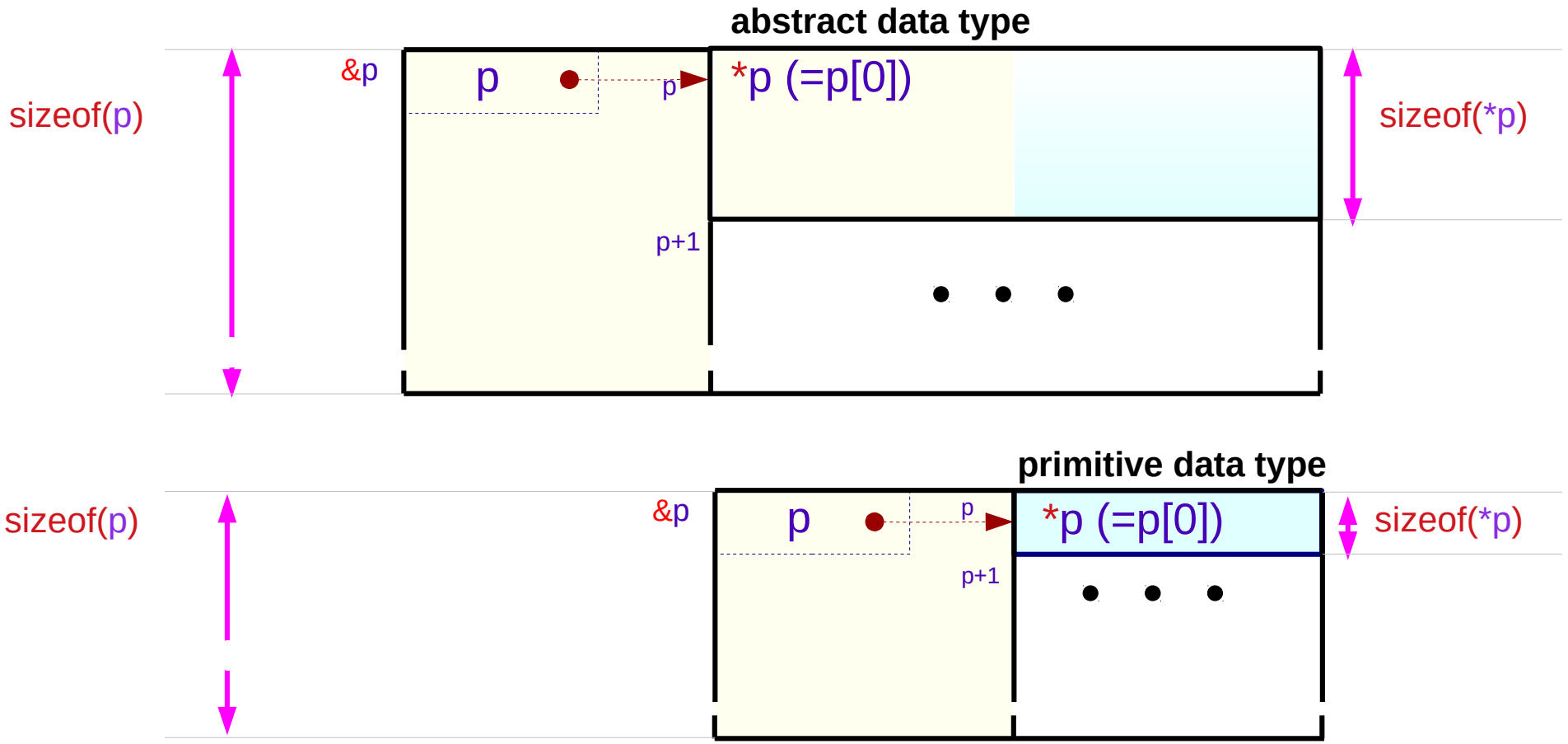
an **int array** name

an array :
an aggregate type
sizeof(c)
= sizeof(*c) * 4
= sizeof(int) * 4
= 4*4 = 16 bytes



type(int [4]) = type(int [ ]) = (int *)

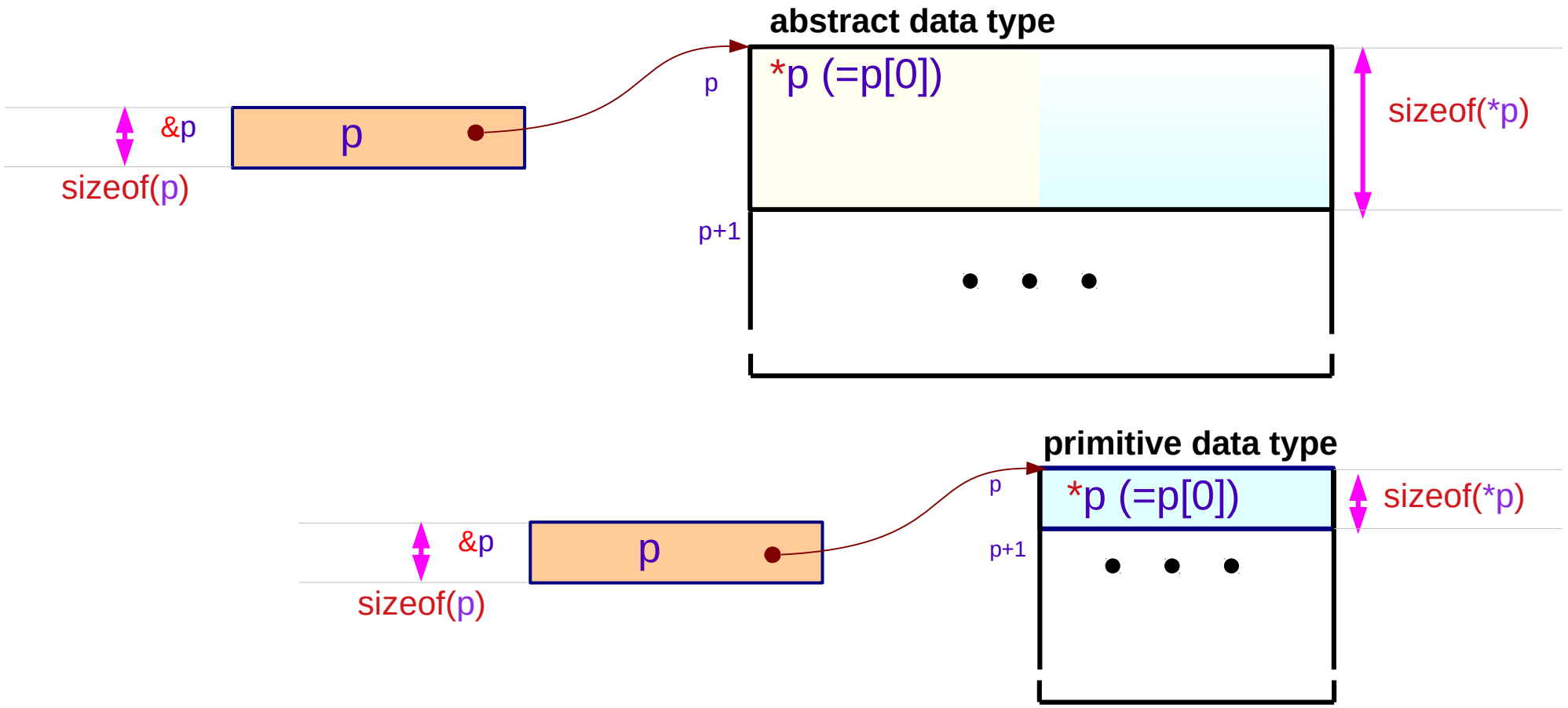
Virtual pointer p in an aggregated data



sizeof(p) = sizeof(*p) * N

value(p+1) = value(p) + sizeof(*p)

Real pointers



sizeof(p) = 4 / 8 bytes

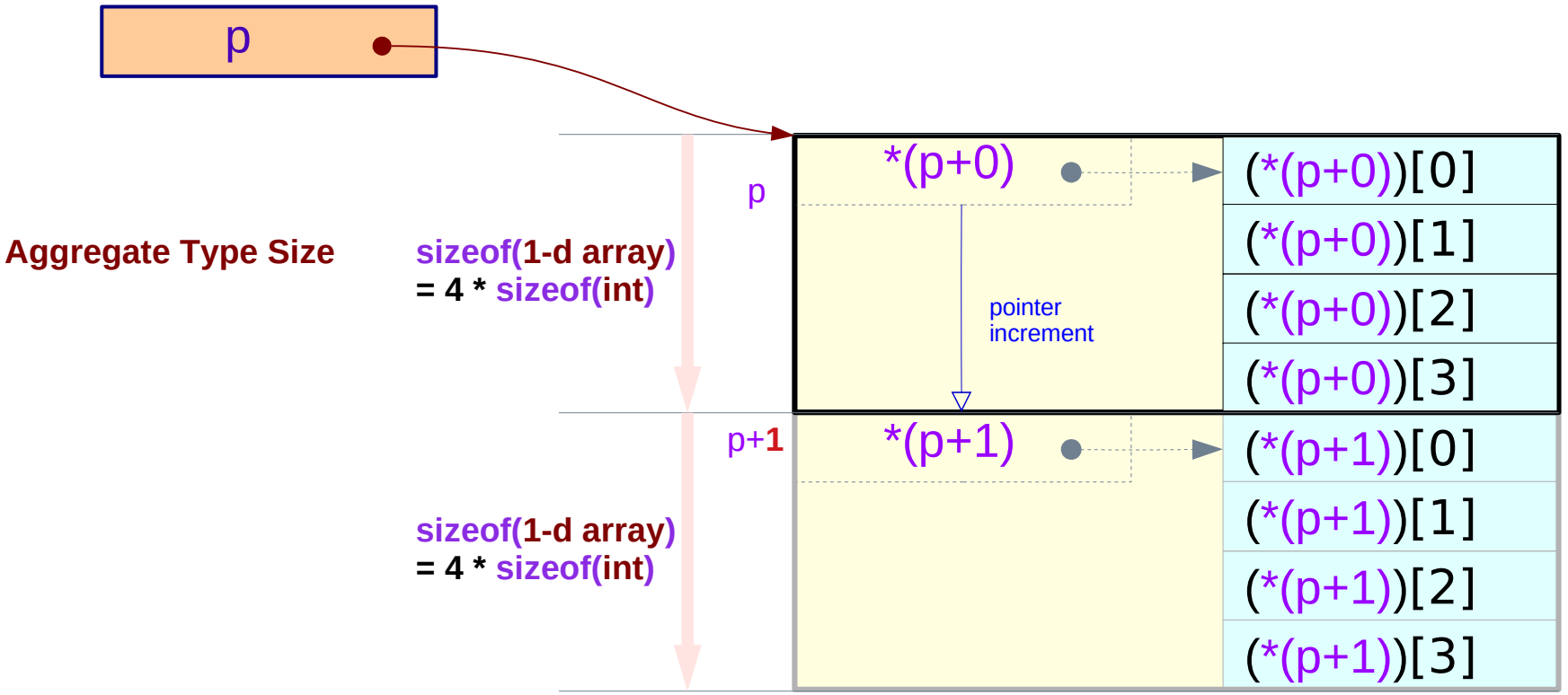
value(p+1) = value(p) + sizeof(*p)

Incrementing a **1-d** array pointer

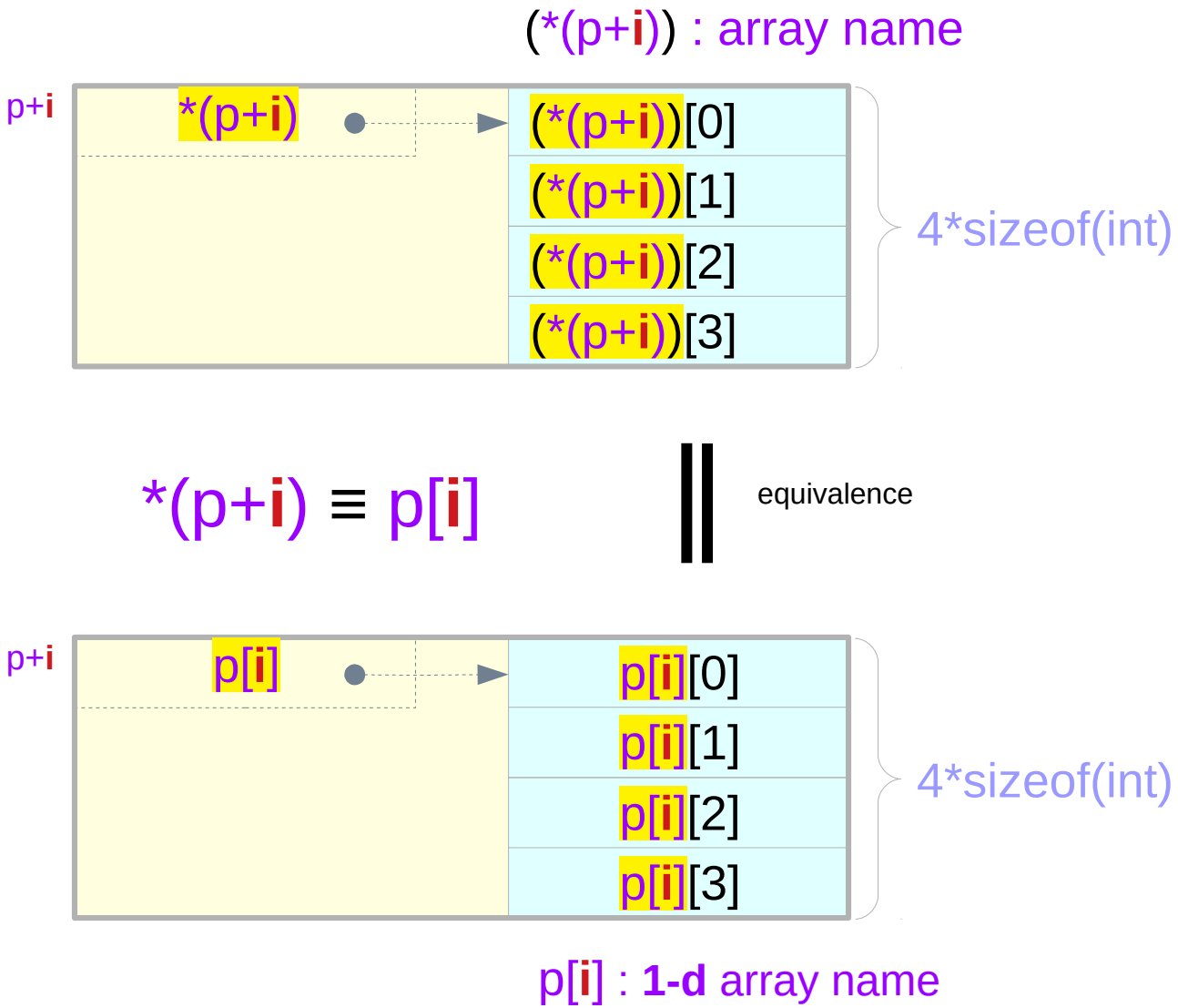
```
int     (*p) [4];
```

value(p+1) – **value**(p) = sizeof(*p)

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

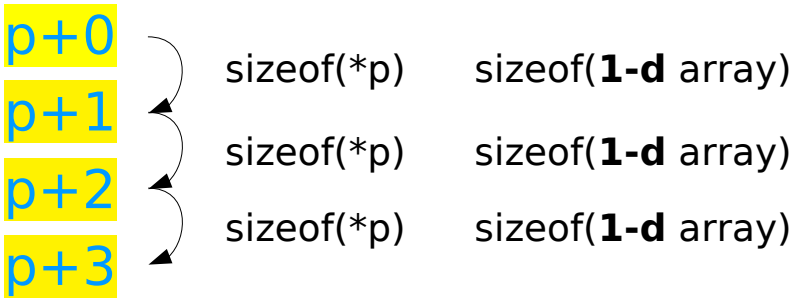


Equivalence : *(p+i) = p[i]



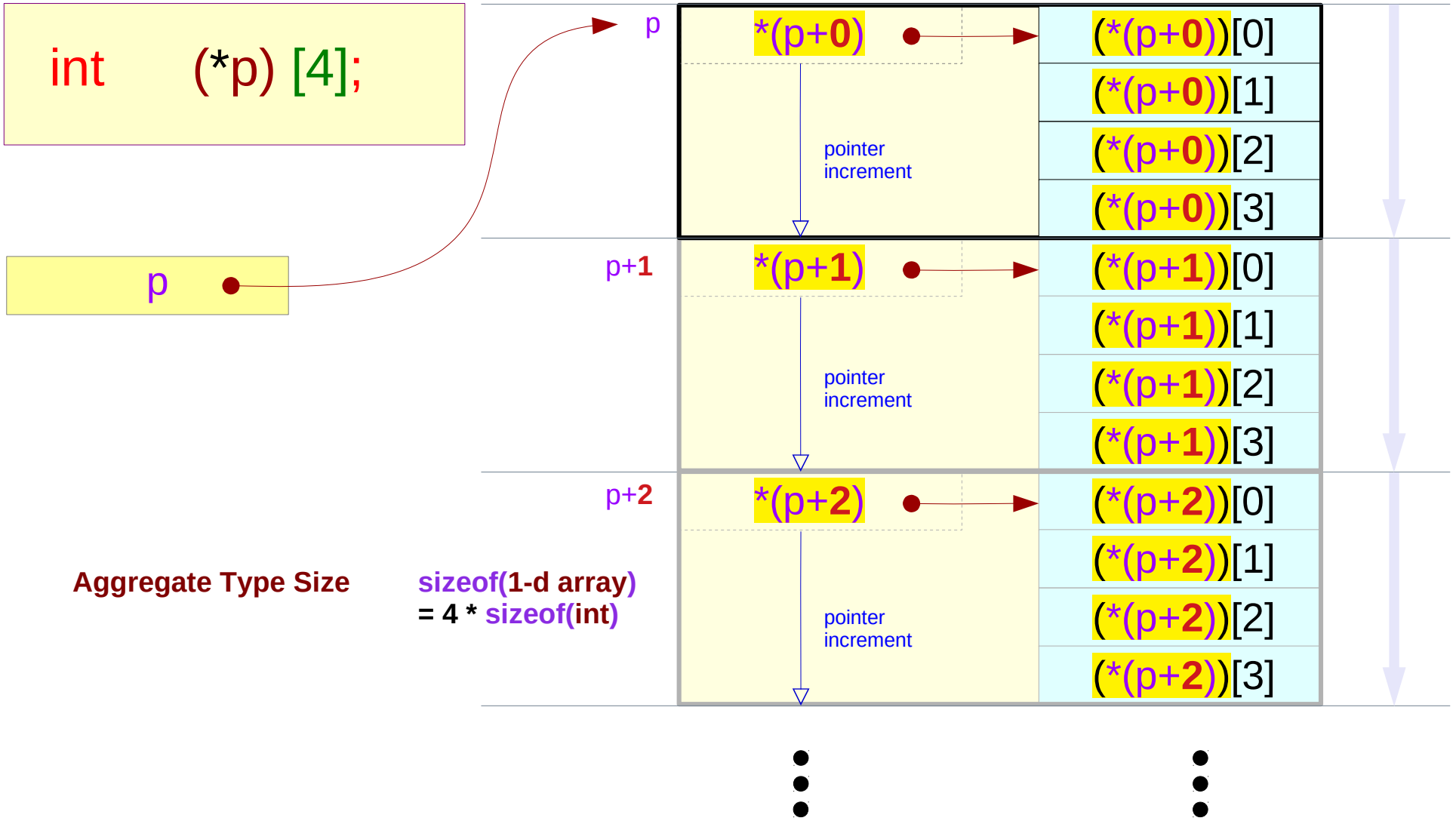
Incrementing a pointer to a **1-d** array

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

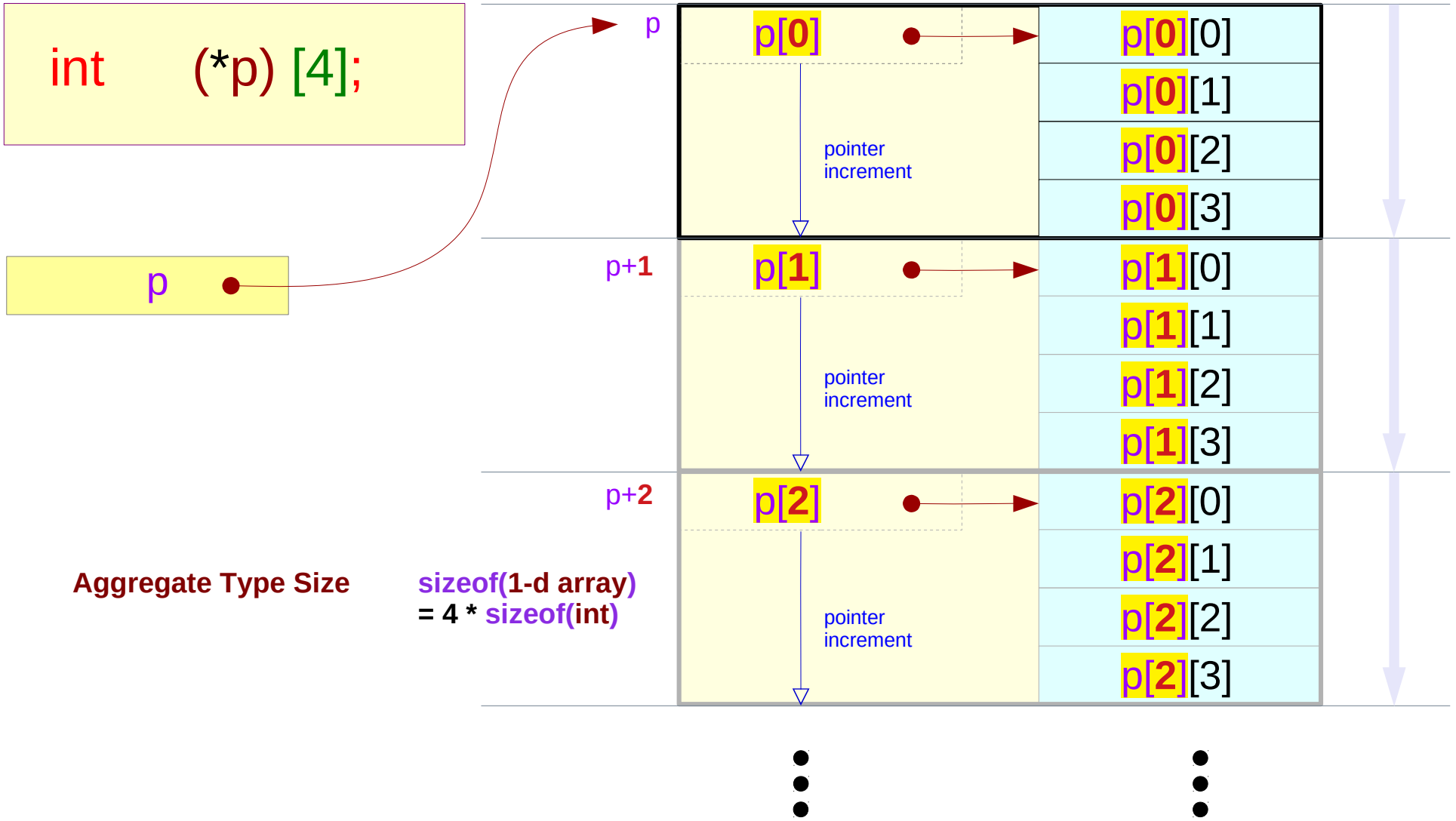


*(p+0)	⟺	p[0]	(*(p+0))[j]	⟺	p[0][j]
*(p+1)	⟺	p[1]	(*(p+1))[j]	⟺	p[1][j]
*(p+2)	⟺	p[2]	(*(p+2))[j]	⟺	p[2][j]
*(p+3)	⟺	p[3]	(*(p+3))[j]	⟺	p[3][j]

Accessing a **2-d** array using a **1-d** array pointer



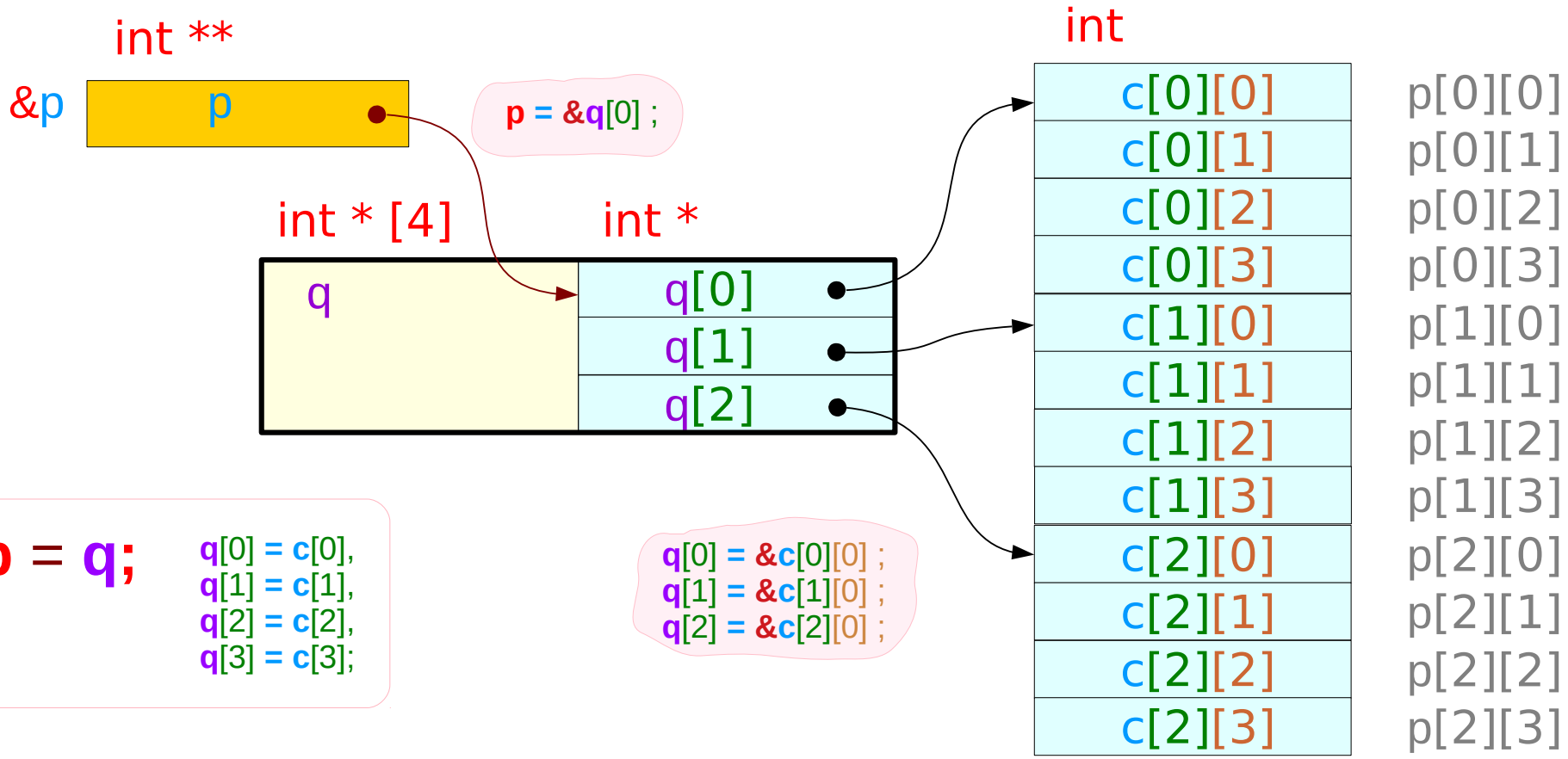
2-d array access using a 1-d array pointer



2-d array access using double pointers q

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

```
int **p, *q[4];
```



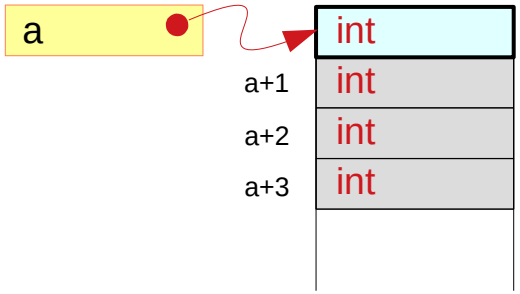
int *

int [N]

int [ ]

Integer pointer and array types – **int *, int [2], int [3]**

int *a;

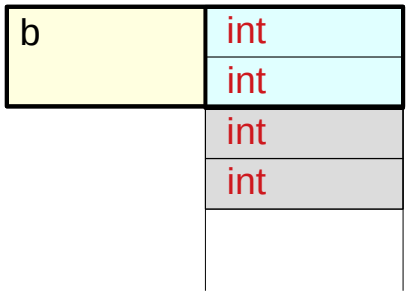


a[0] = *a
a[1] = *(a+1)
a[2] = *(a+2)
a[3] = *(a+3)

syntactically legitimate

programmers must
ensure their validity

int b[2]

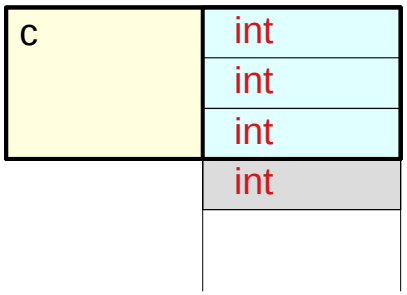


b[0] = *b
b[1] = *(b+1)
b[2] = *(b+2)
b[3] = *(b+3)

syntactically legitimate

programmers must
ensure their validity

int c[3];



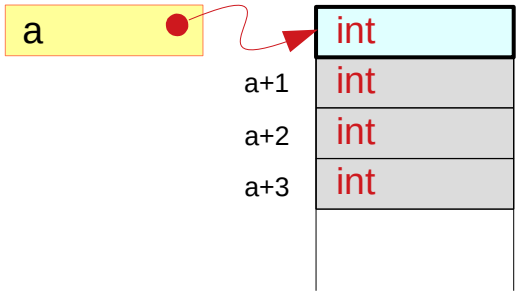
c[0] = *c
c[1] = *(c+1)
c[2] = *(c+2)
c[3] = *(c+3)

syntactically legitimate

programmers must
ensure their validity

Integer pointer and array types – **int *, int [2], int [3]**

int *a;

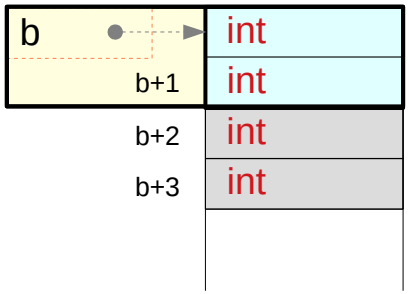


a[0] = *a
a[1] = *(a+1)
a[2] = *(a+2)
a[3] = *(a+3)

syntactically legitimate

programmers must ensure their validity

int b[2]

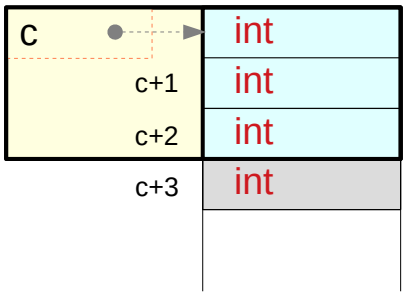


b[0] = *b
b[1] = *(b+1)
b[2] = *(b+2)
b[3] = *(b+3)

syntactically legitimate

programmers must ensure their validity

int c[3];



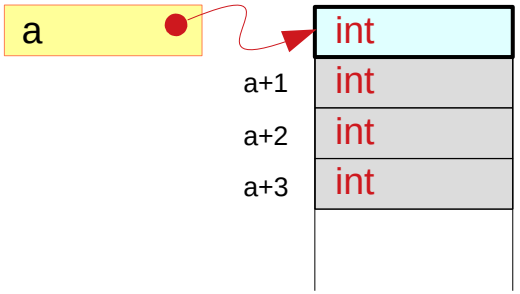
c[0] = *c
c[1] = *(c+1)
c[2] = *(c+2)
c[3] = *(c+3)

syntactically legitimate

programmers must ensure their validity

Integer pointer and array types – **int *, int [2], int [3]**

int *a;



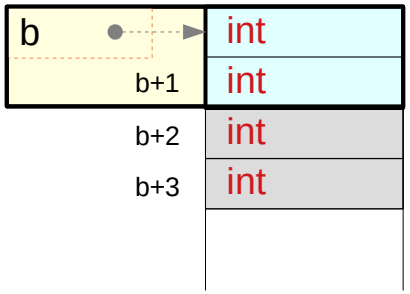
a[0] = *a

type(a) = int *
type(&a) = int **

value(&a) ≠ value(a)

sizeof(a)
= pointer size
= sizeof(int *)

int b[2]



b[0] = *b

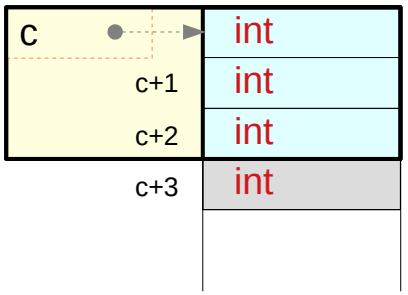
type(b) = int [2]
type(&b) = int (*) [2]

value(&b) = value(b)

sizeof(b)
= sizeof(*b) * 2
= sizeof(int) * 2

&b and b evaluate
the same address
but have different types
and also different sizes

int c[3];



c[0] = *c

type(c) = int [3]
type(&c) = int (*) [3]

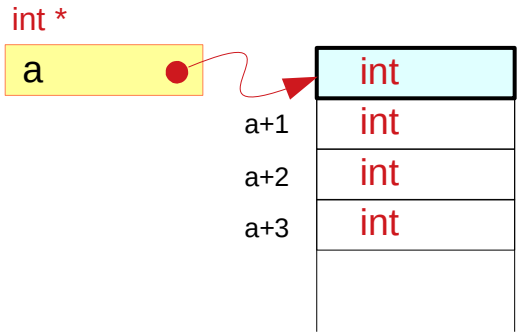
value(&c) = value(c)

sizeof (c)
= sizeof (*c) * 3
= sizeof(int) * 3

&c and c evaluate
the same address
but have different types
and also different sizes

Integer pointer and array types – **int *, int [3]**

int *a;



sizeof (a) = pointer size

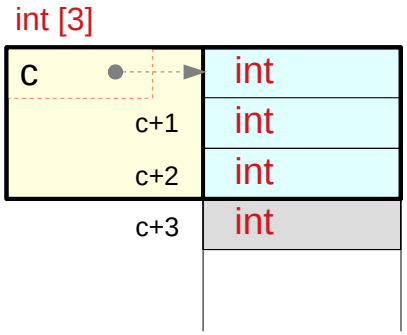
value(&a) ≠ value(a)

the address of pointer variable a is
not equal to the pointed address

real memory location for a

a :: int *
&a :: int **

int c[3];



sizeof (c) = sizeof(*c) * 3

value(&c) = value(c)

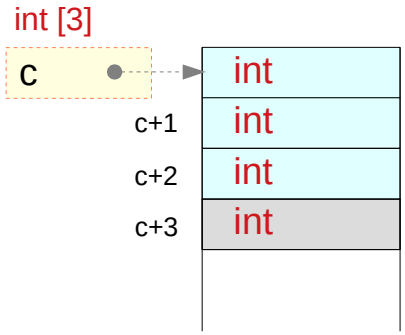
the starting address of array variable c
is equal to the address of the 1st element

no actual memory location for c

c :: int [3]
&c :: int (*) [3]

Integer pointer and array types – **int [3]**

int c[3];



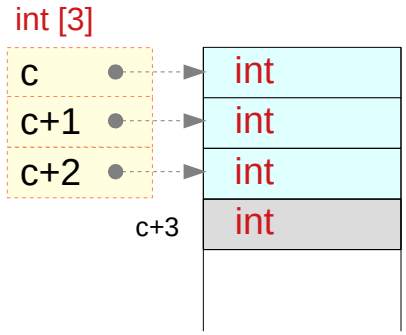
sizeof (c) = sizeof(int) * 3

value(&c) = value(c)

type(c) = int *

type(&c) = int (*) [3]

int c[3];



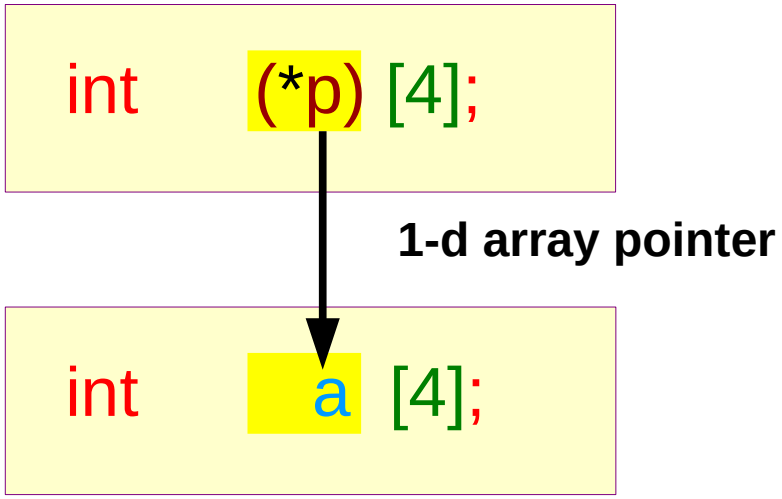
sizeof (c) = sizeof(*c) * 3 … *leading element*
sizeof (c+1) = pointer size
sizeof (c+2) = pointer size

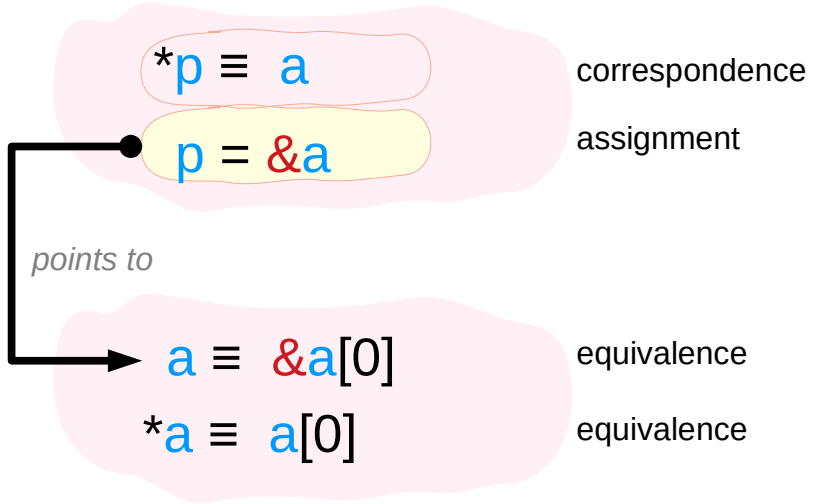
value(&c) = value(c) … *leading element*
value(c+1) = value(c) + sizeof(*c) *1
value(c+2) = value(c) + sizeof(*c) *2

type(c) = int *
type(c+1) = int *
type(c+2) = int *

type(&c) = int (*) [3]

Pointer to a **1-d** array – (1) type declarations





&a and a
print the same address
but have different types

value(&a) = value(a)
type(&a) ≠ type(a)

&a[0]
int (*)[4] ≠ int [4]

those values are evaluated as addresses

Pointer to a **1-d** array – (2) types and sizes

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

assignment: p = &a

equivalence: a ≡ &a[0]

int (*) [4]

sizeof(p) =
4 or 8 bytes

size of a pointer

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

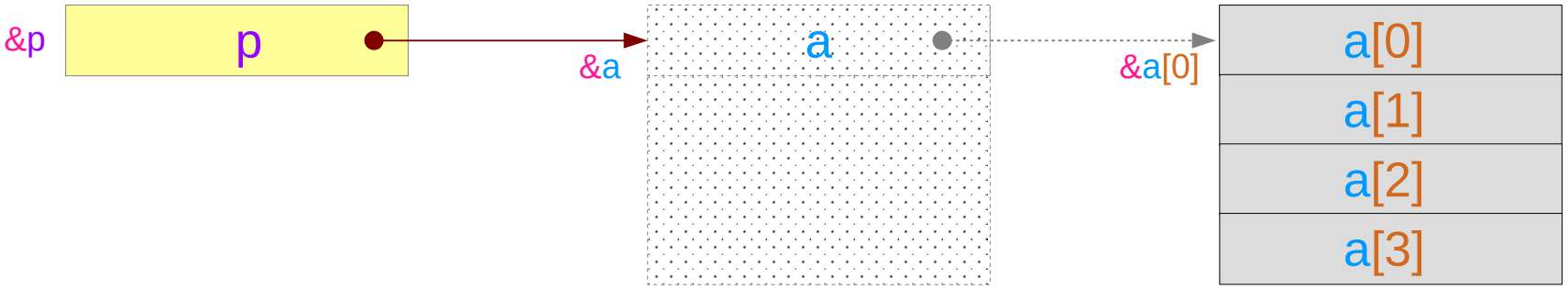
sizeof(a) =
4*4 bytes

not a real pointer a

int

sizeof(a[0]) =
4 bytes

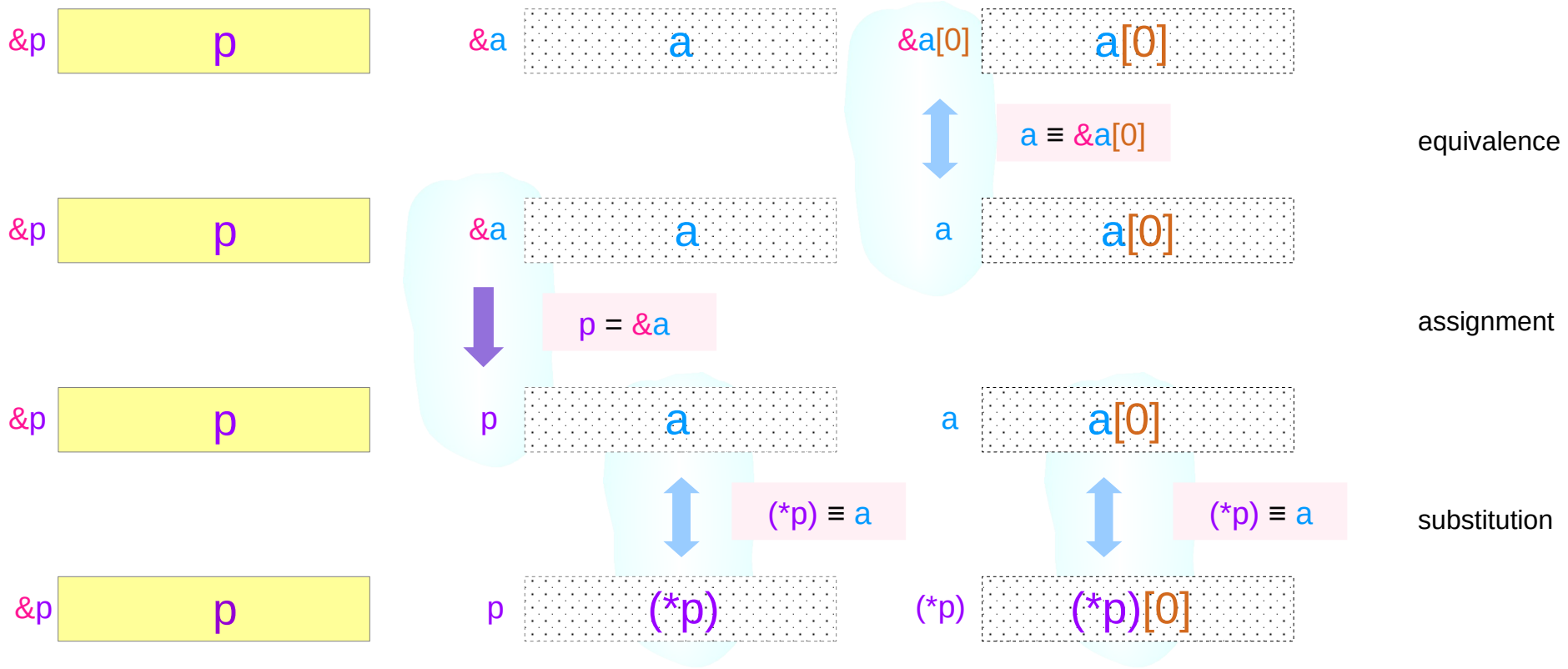
4



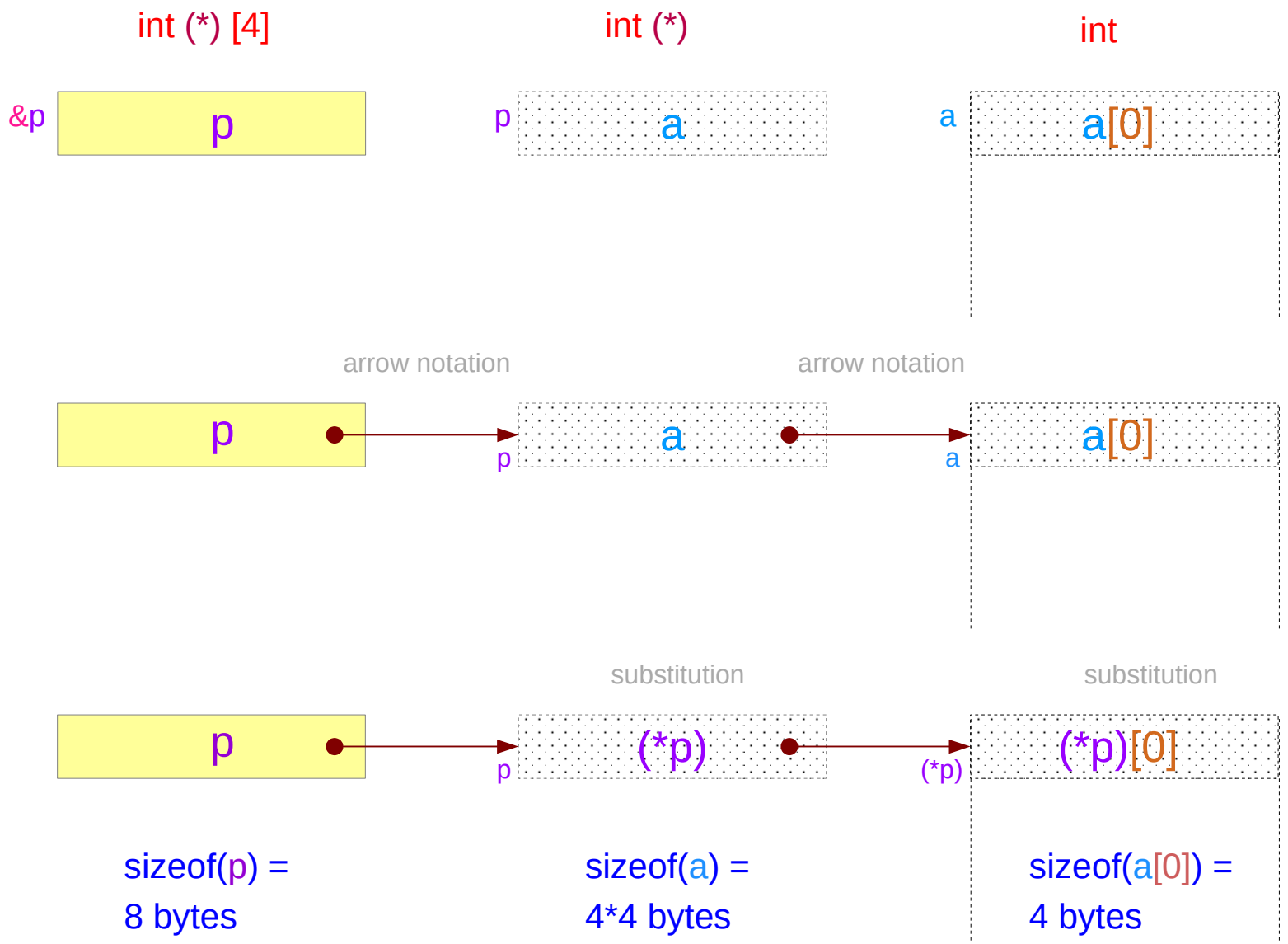
value(&a) = value(a) = value(&a[0])

not a real pointer a

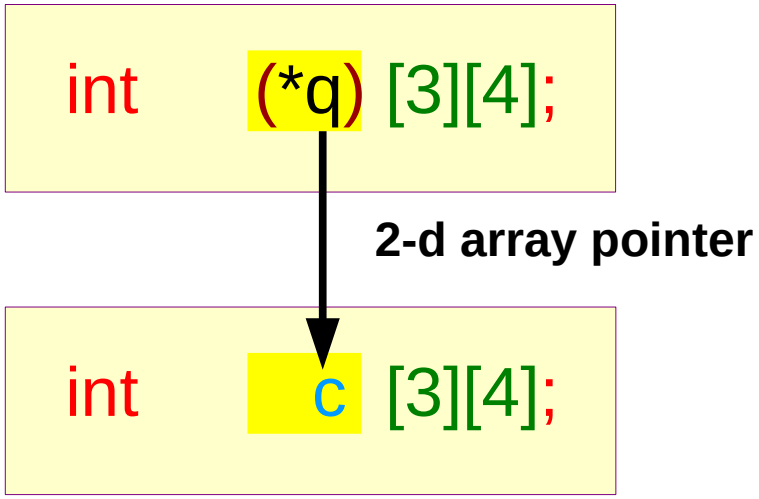
Pointer to a **1-d** array – (3) an assignment & equivalences

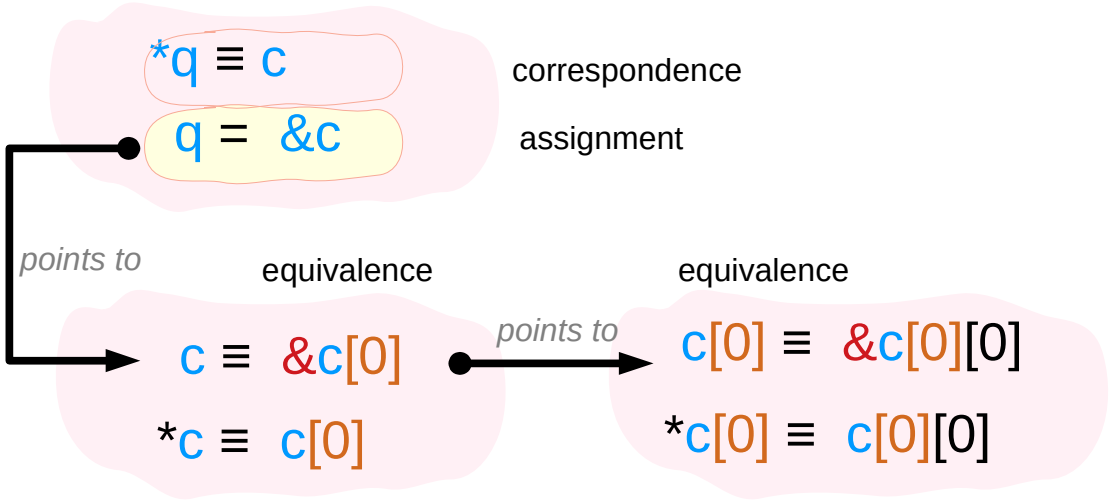


Pointer to a **1-d** array – (4) a chain of pointers view



Pointer to a **2-d** array – (1) type declarations





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

value(&c) = value(c) = value(c[0])
type(&c) ≠ type(c) ≠ type(c[0])

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

&c[0][0]

those values are evaluated as addresses

Pointer to a **2-d** array – (2) types and sizes

```
int   c   [3][4];
int (*q) [3][4];
```

assignment: q = &c

equivalence: c ≡ &c[0]

equivalence: c[0] ≡ &c[0][0]

int (*) [3][4]

sizeof(q) =

8 bytes

size of a pointer

int [3][4] or int (*) [4]

sizeof(c) =

3*4*4 bytes

not a real pointer c

3

int [4] or int (*)

sizeof(c[0]) =

4*4 bytes

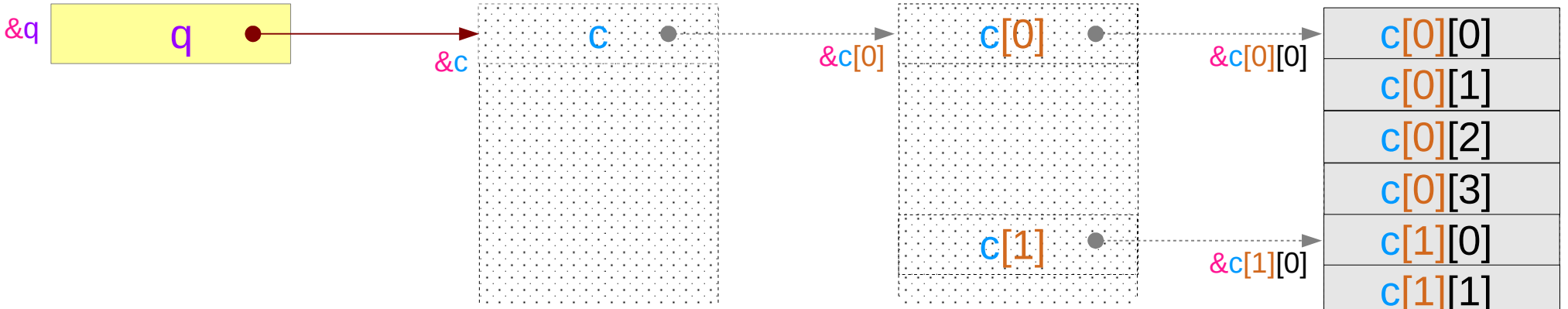
not a real pointer c[0]

4

int

sizeof(c[0][0]) =

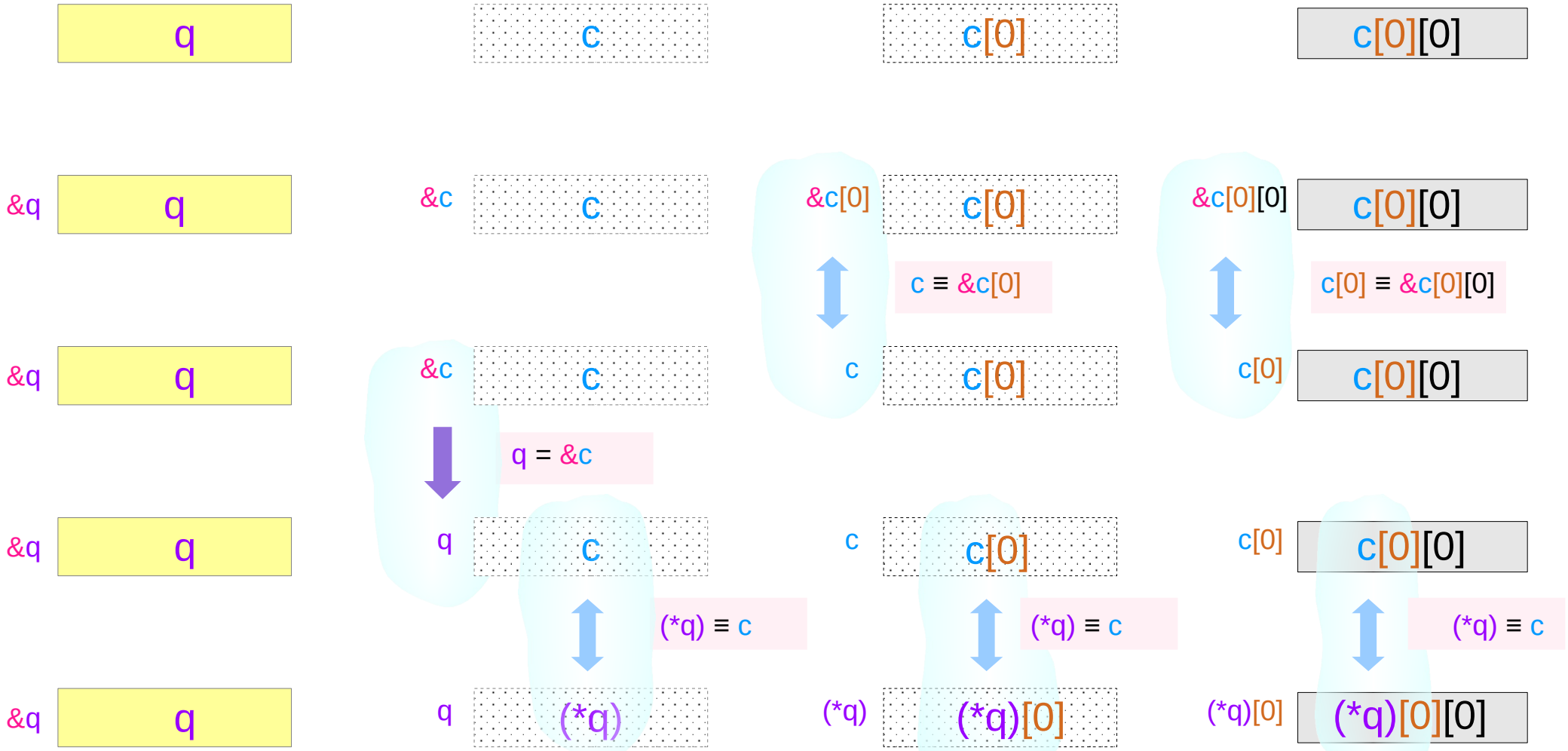
4 bytes



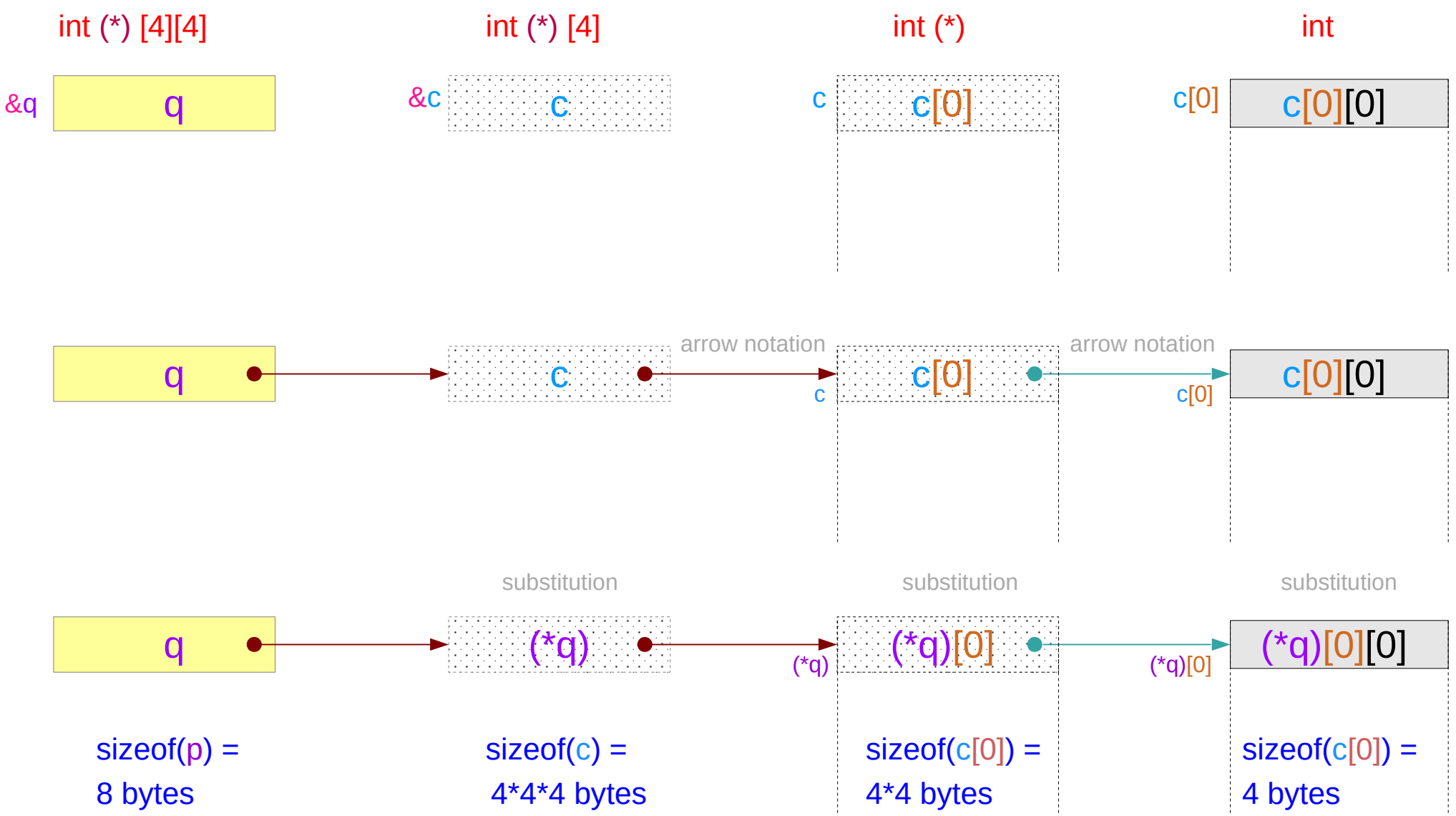
not a real pointer c, c[0]

value(&c) = value(c) = value(&c[0]) = value(c[0]) = value(&c[0][0])

Pointer to a **2-d** array – (3) an assignment & equivalences



Pointer to a **2-d** array – (4) a chain of pointers view



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