Applications of Pointers (1A)

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

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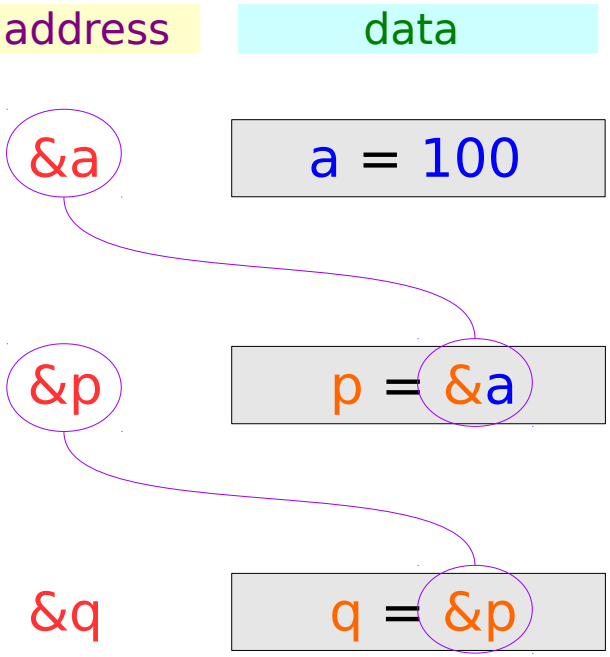
4/4/18

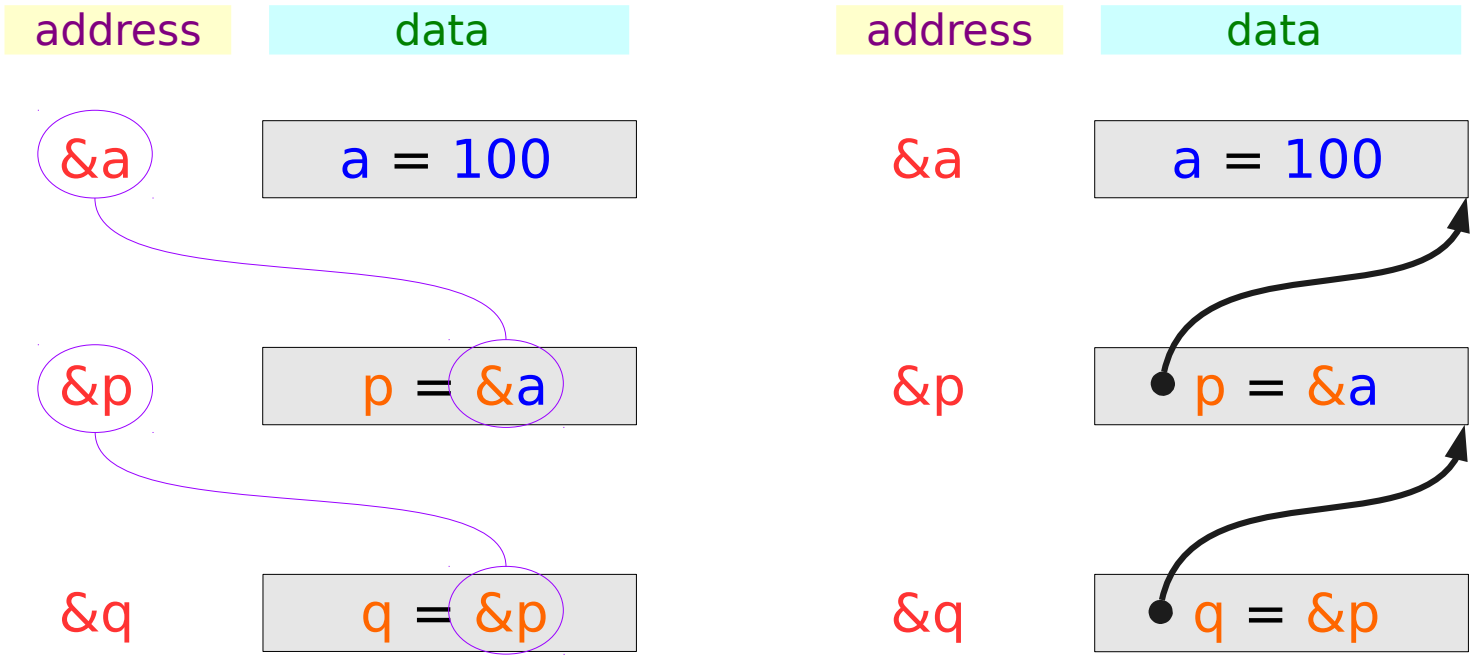
Variables and their addresses

Initialization of Variables

```
int    a = 100;

int  * p = &a;

int **q = &p;
```

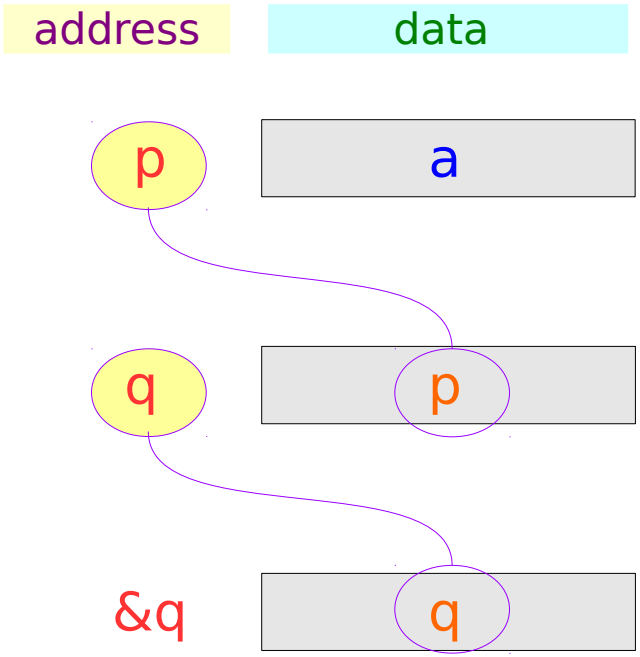


Traditional arrow notations



Pointed addresses : p, q

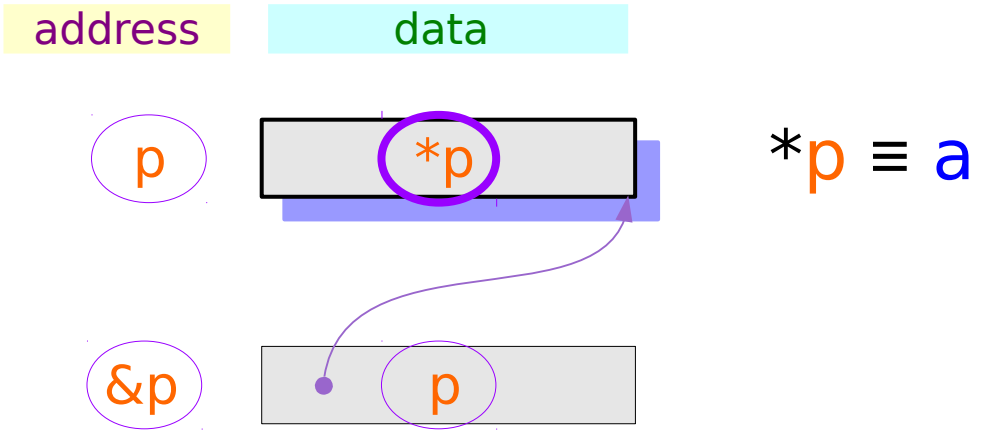
```
int    a;

int  * p = &a;

int **q = &p;
```



p = &a
q = &p

Dereferenced Variables : *p

```
int    a;

int  * p = &a;

int **q = &p;
```



Dereferenced Variables : *p

```
int    a;

int  * p = &a;

int **q = &p;
```

Address assignment

Variable aliasing

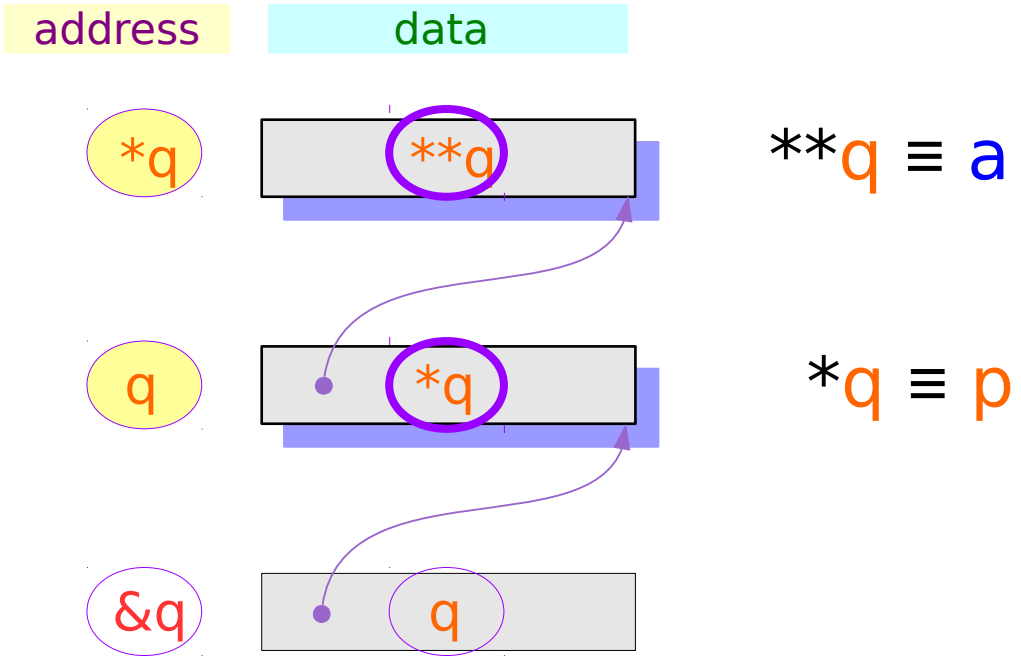
p = &a ➡ *p ≡ a

p	≡	&a
*(p)	≡	*(&a)
* p	≡	a

Relations after address assignment

Dereferenced Variables : *q, **q

```
int    a;

int  * p = &a;

int **q = &p;
```



**q ≡ a

*q ≡ p

Dereferenced Variables : *q, **q

```
int    a;

int  * p = &a;

int **q = &p;
```

Address assignment | Variable aliasing

p = &a ➡ *p ≡ a

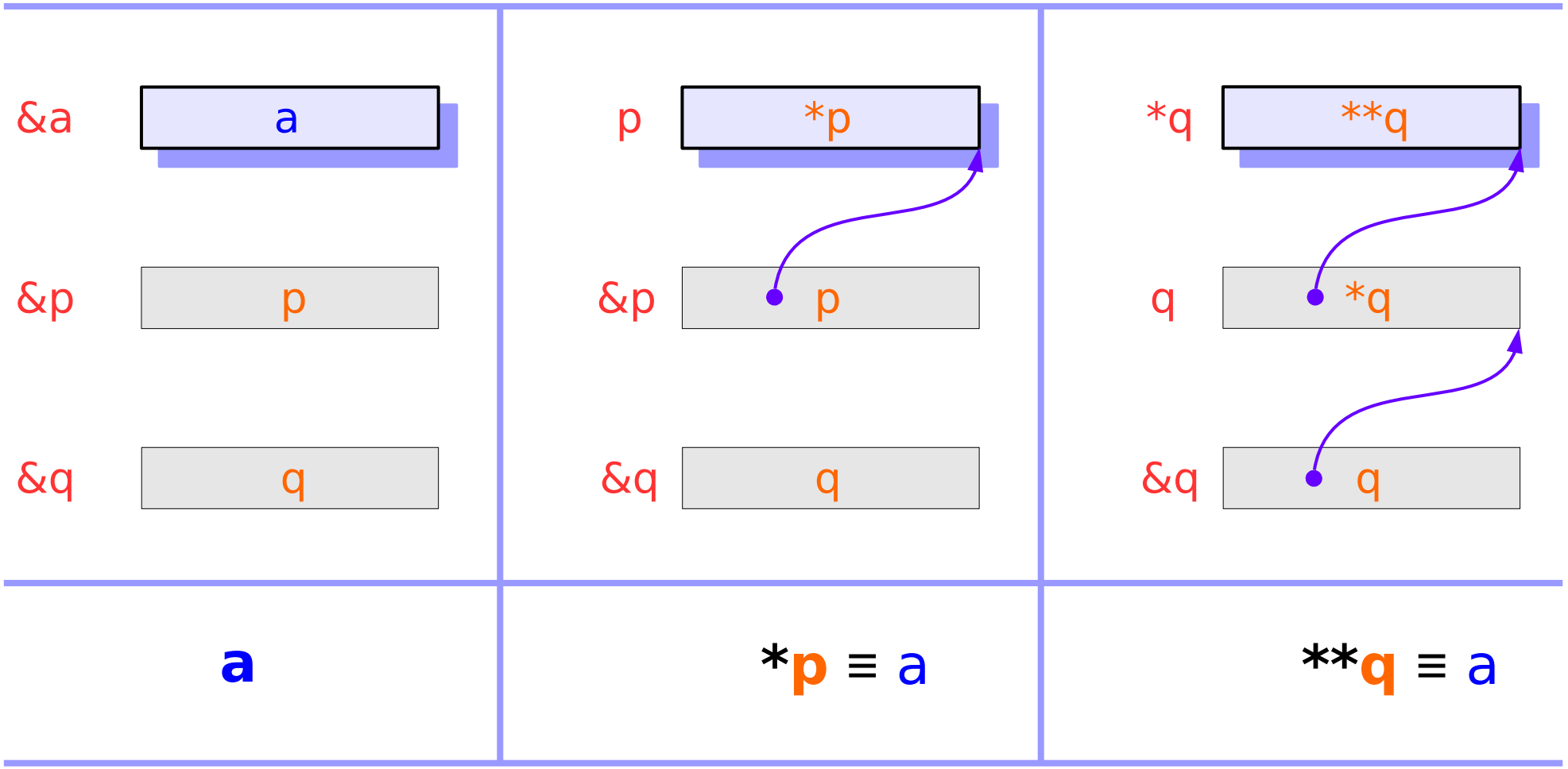
q = &p ➡ *q ≡ p

➡ **q ≡ a

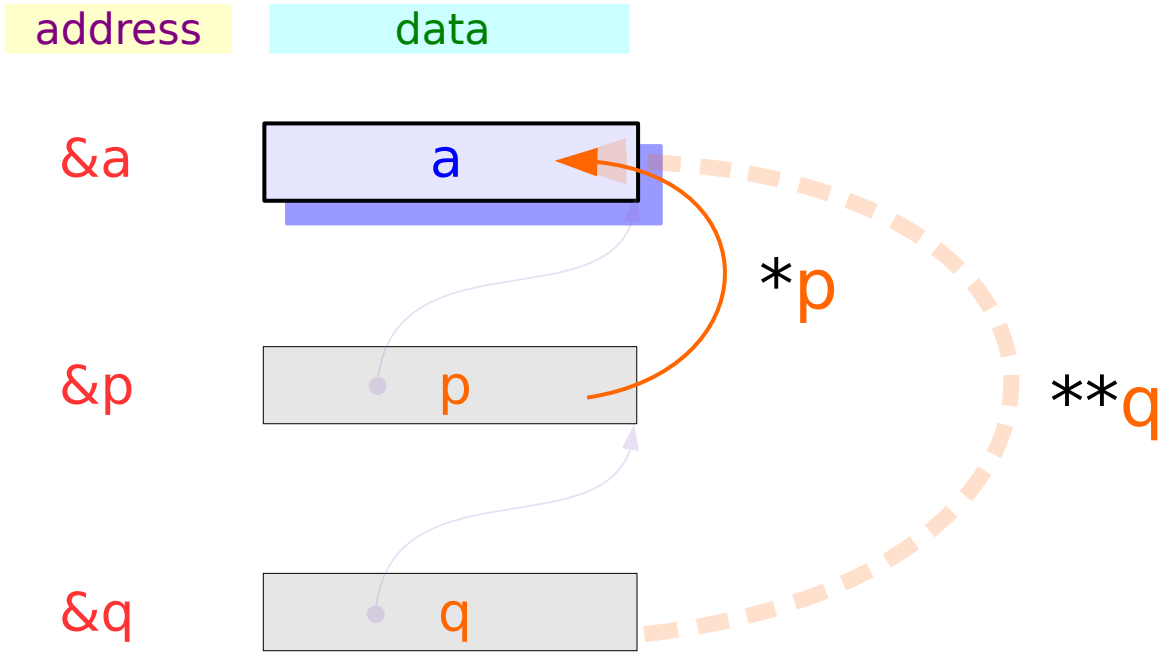
q	≡	&p
*(q)	≡	*(&p)
* q	≡	p
**q	≡	*p
**q	≡	a

Relations after address assignment

Two more ways to access **a** : ***p**, ****q**



Two more ways to access a : *p, **q



1) Read / Write a
2) Read / Write *p
3) Read / Write **q

Variables

```
int    a;
```

a can hold an *integer*

address	data
&a	a

```
a = 100;
```

a holds 100

address	data
&a	a ⬅ 100

Pointer Variables

```
int *     p;
```

p can hold an ***address***

```
int   *   p;
```

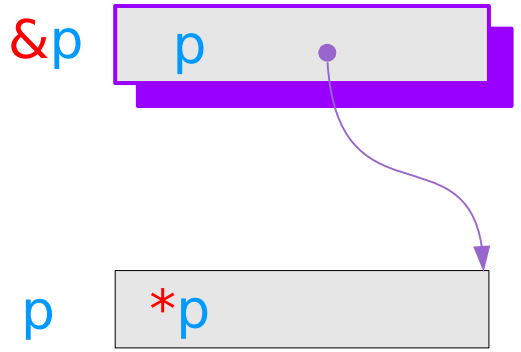
pointer to int

p holds an ***address***
of a int type data

```
int   *   p;
```

int

***p** holds
a int type ***data***



Pointer to Pointer Variable

```
int **    q;
```

q holds an *address*

```
int **   q;
```

pointer to
pointer to int

q holds an ***address*** of
a pointer to int type data

```
int *   *q;
```

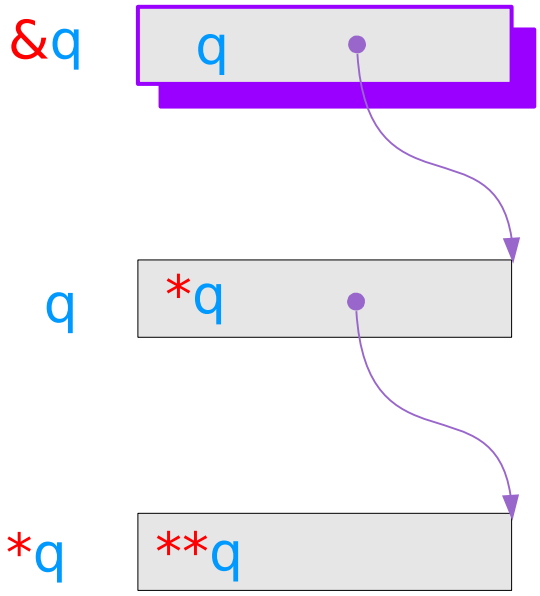
pointer to int

q** holds an ***address of
a int type data

```
int    **q;
```

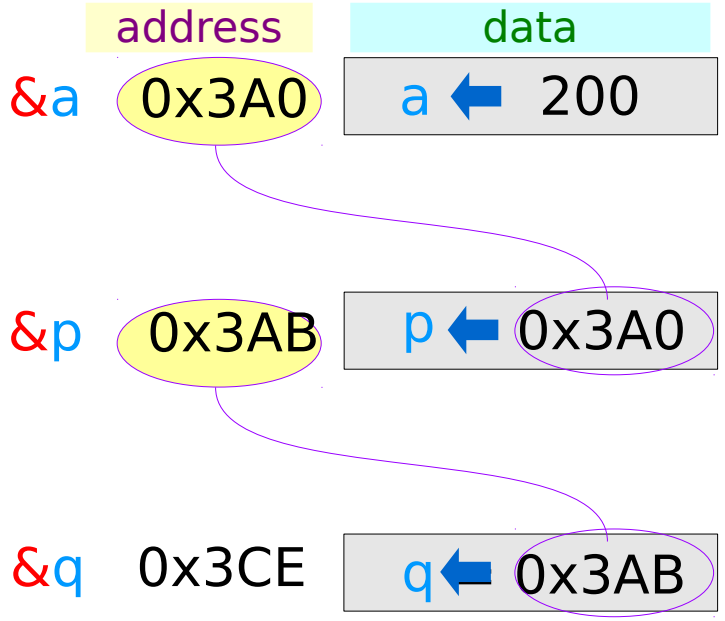
int

****q** holds a int type data



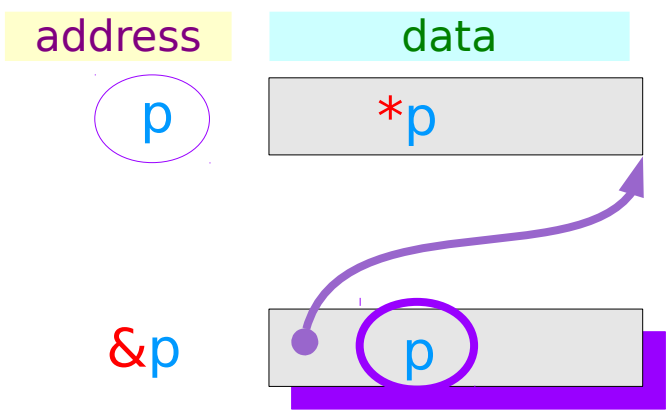
Pointer Variables Examples

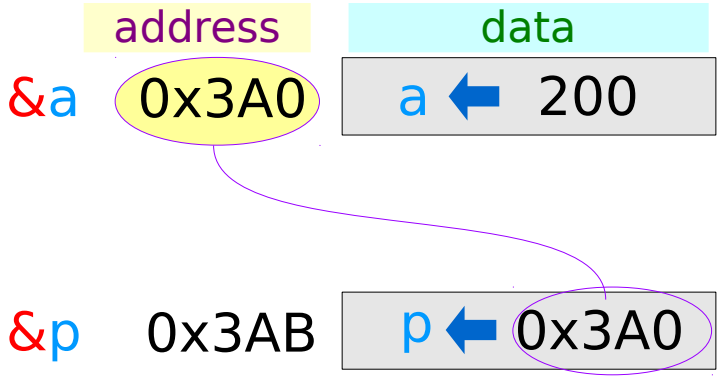
```
int      a = 200;
int *    p = & a;
int **   q = & p;
```



&q ➡ 0x3CE
q ➡ 0x3AB
*q ➡ 0x3A0
**q ➡ 200

Pointer Variable **p** with an arrow notation





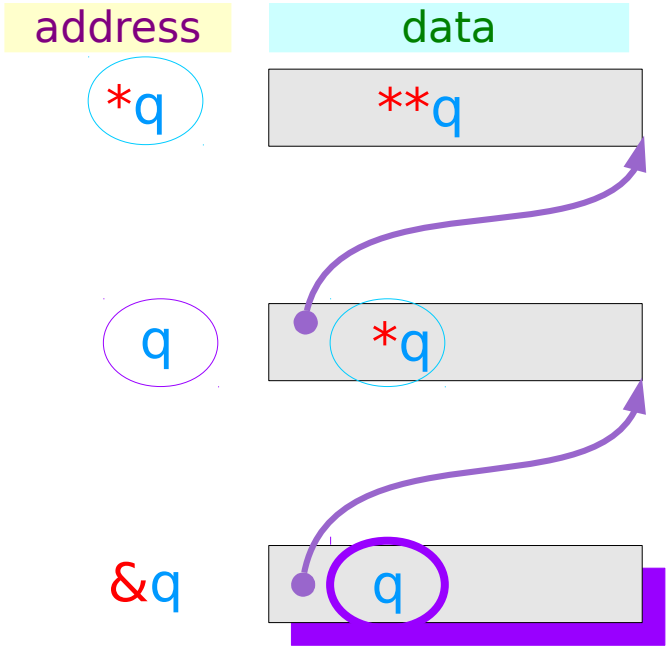
using an arrow notation

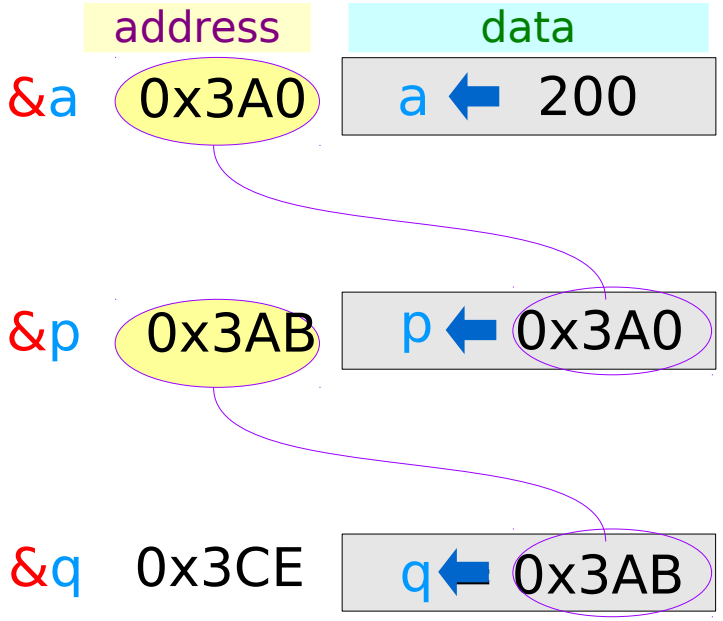
&p ➡ 0x3AB

p ➡ 0x3A0

*p ➡ 200

Pointer Variable **q** with an arrow notation

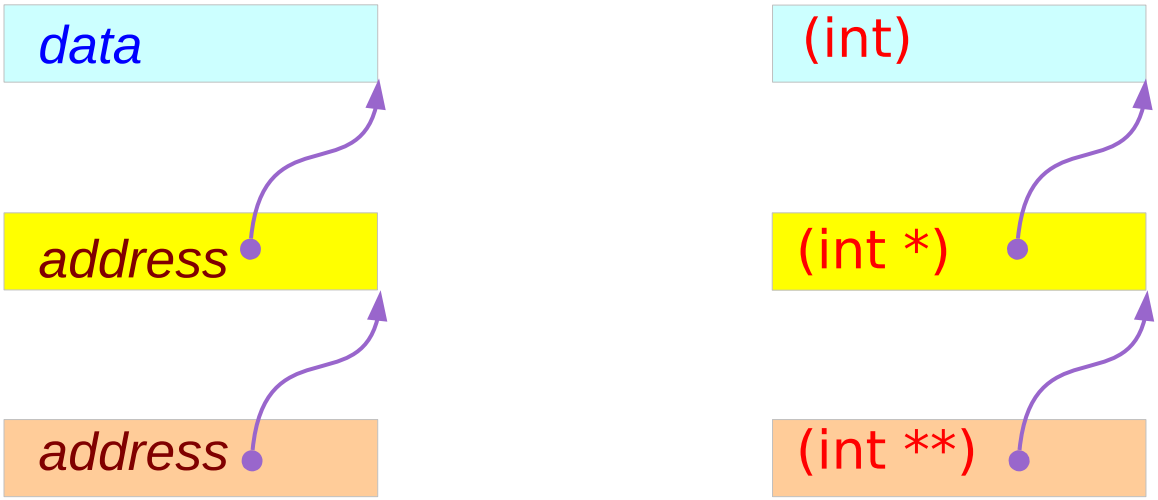




using an arrow notation

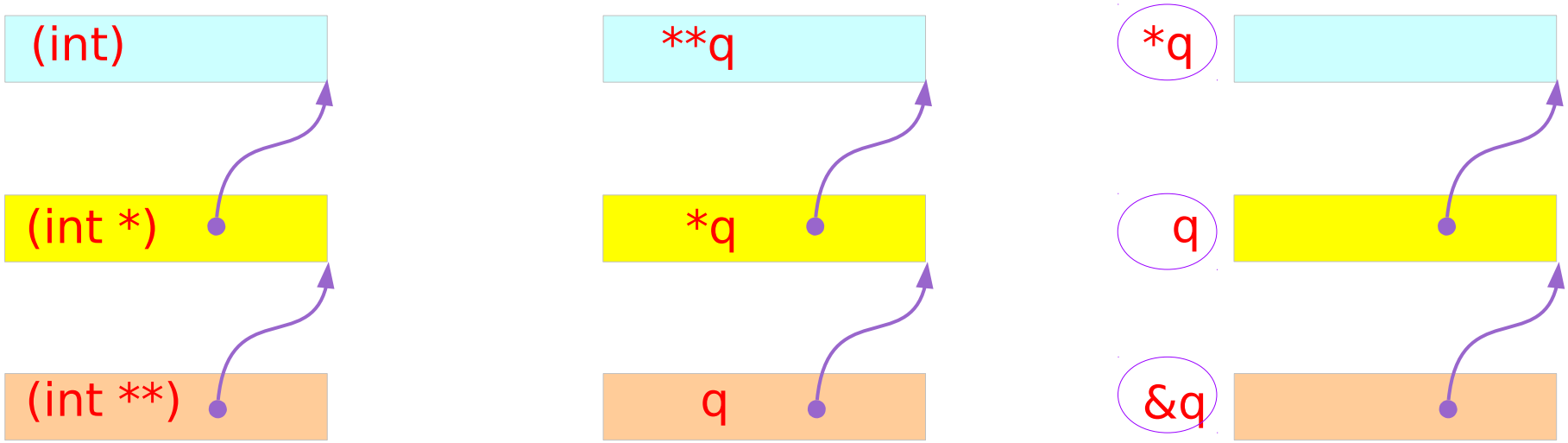
&q ➡ 0x3CE
q ➡ 0x3AB
*q ➡ 0x3A0
**q ➡ 200

The type view point of pointers



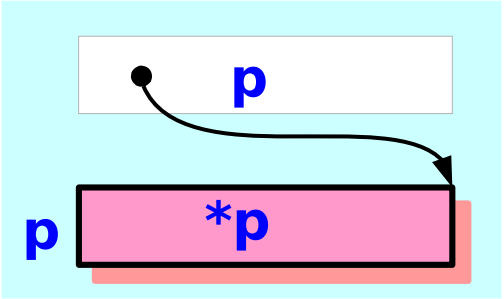
Types

The different view points of pointers

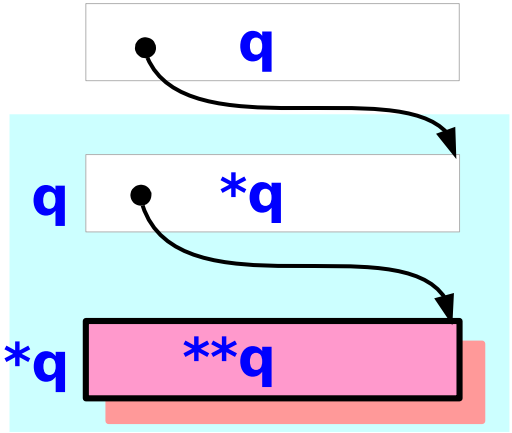


Single and Double Pointer Examples (1)

```
int   a ;
int  *p ;
int  **q ;
```

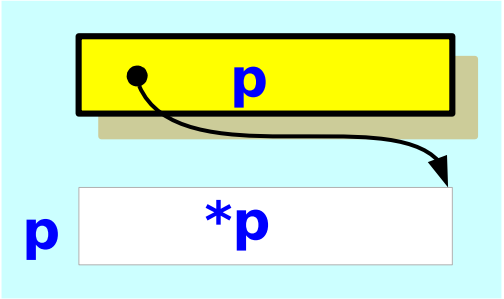


a, ***p**, and ****q**:
int variables

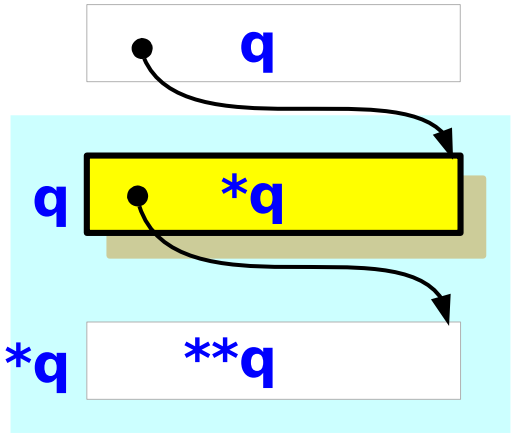


Single and Double Pointer Examples (2)

```
int      a ;
int *    p ;
int *   *q ;
```

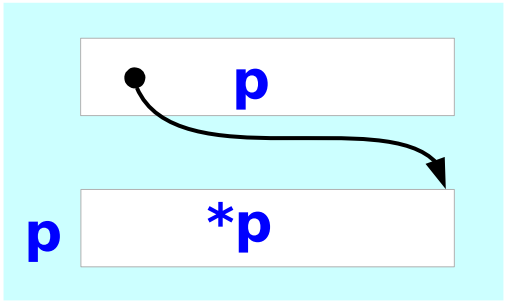


p and ***q** :
int pointer variables
(singlepointers)

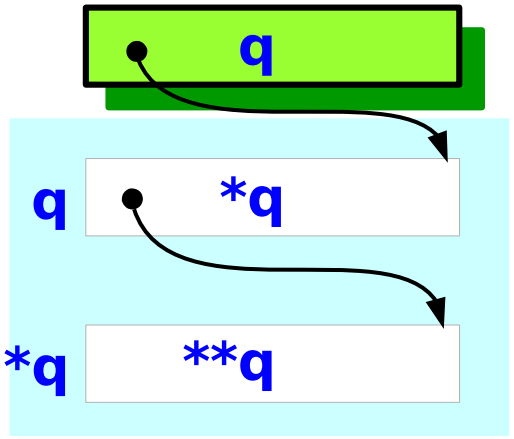


Single and Double Pointer Examples (3)

```
int      a ;
int *    p ;
int **   q ;
```

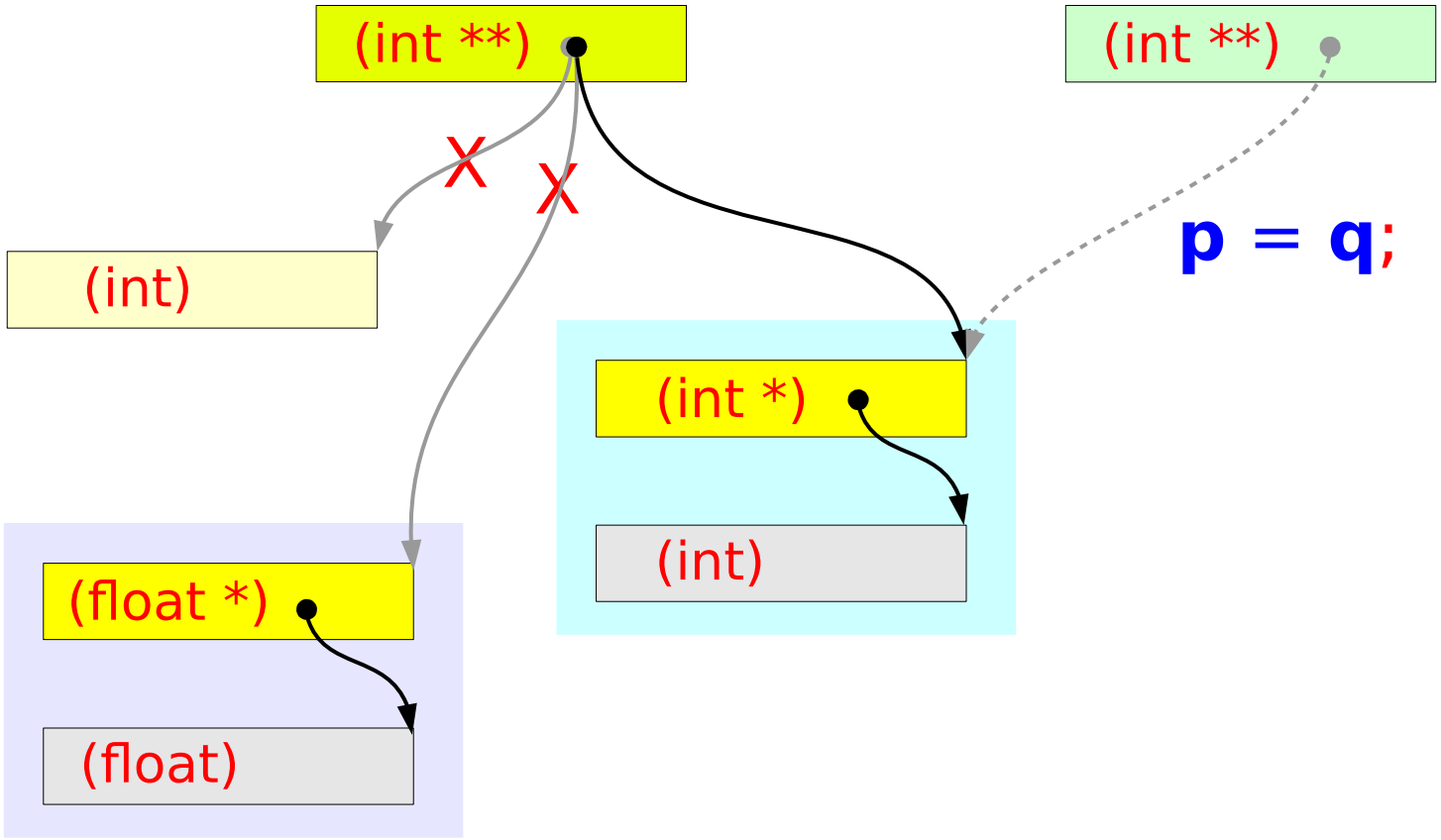


q :
double int pointer variables



Values of double pointer variables

```
int  ** p, **q ;
```



Pointed Addresses and Data

int a ; &a a =100

The variable a holds an integer data

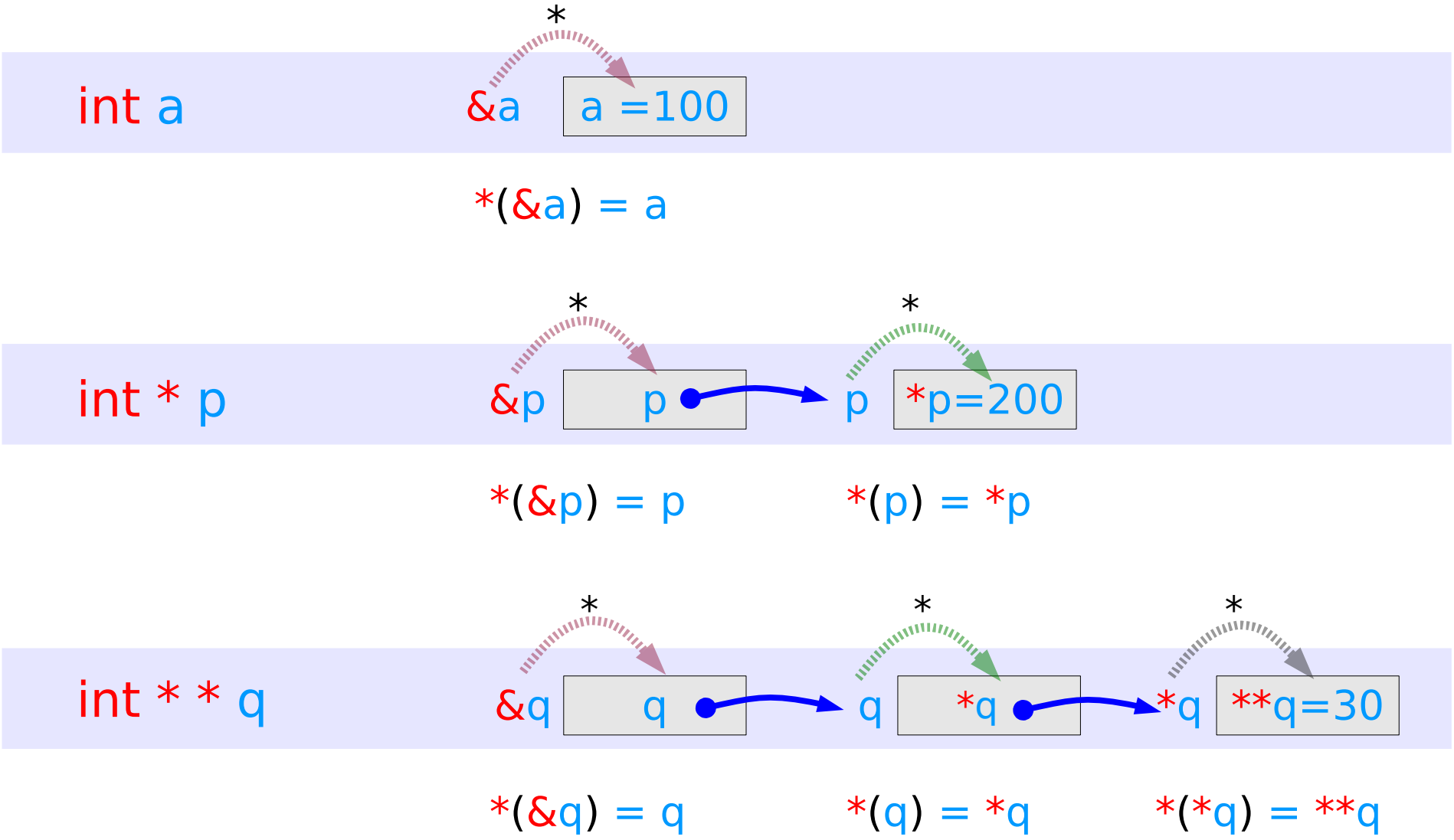
int * p ; &p p → 200

The **pointer** variable p holds an address,
at this address, an integer data is stored

int * * q ; &q q → *q → 30

The **pointer** variable q holds an address,
at the address q, another address *q is stored,
at the address *q, an integer data **q is stored

Dereferencing Operations



Direct Access to an integer **a**

```
int a ;
```

&a | a =100

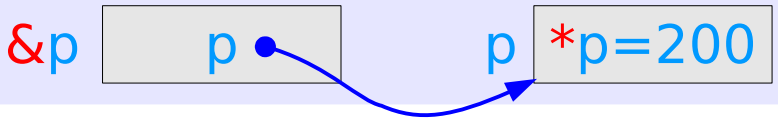
address	value	
&a	a	integer

Direct Access

1 memory access

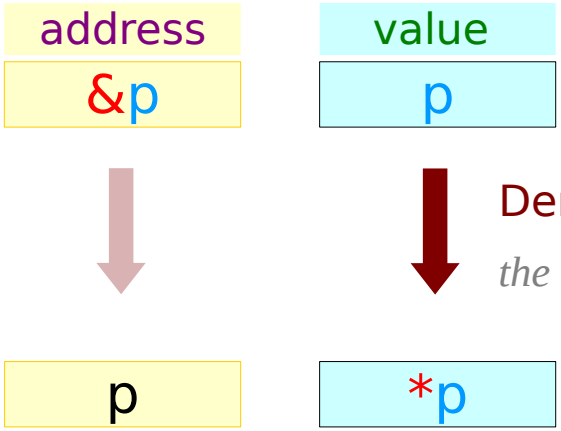
Indirect Access *p to an integer a

```
int * p ;
```



Indirect Access

2 memory accesses



Dereference Operator *

the content of the pointed location

Double Indirect Access **q to an integer a

```
int * * q ;
```

Double Indirect Access

3 memory accesses

address	value
&q	q
q	*q
*q	**q

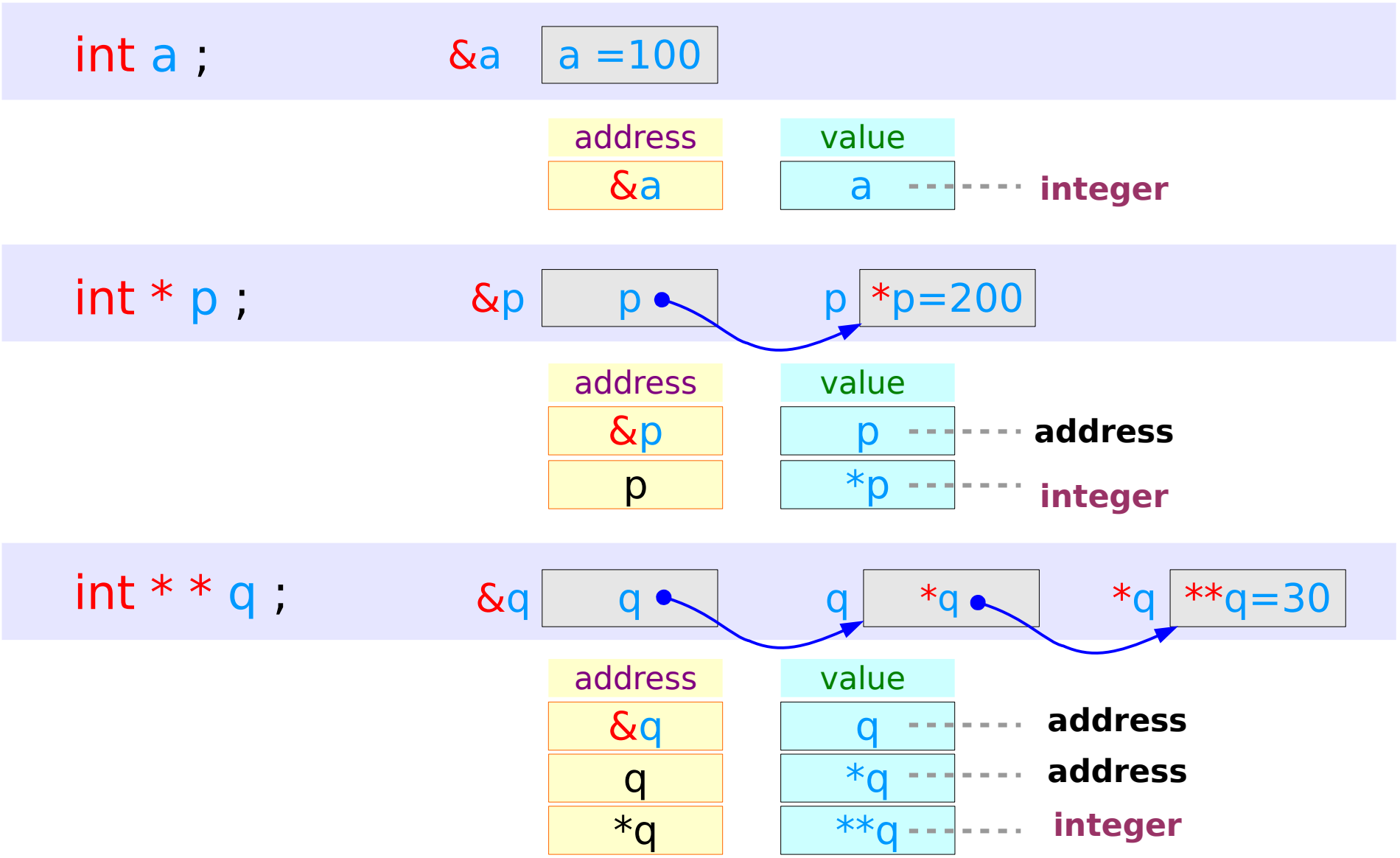
Dereference Operator *

the content of the pointed location

Dereference Operator *

the content of the pointed location

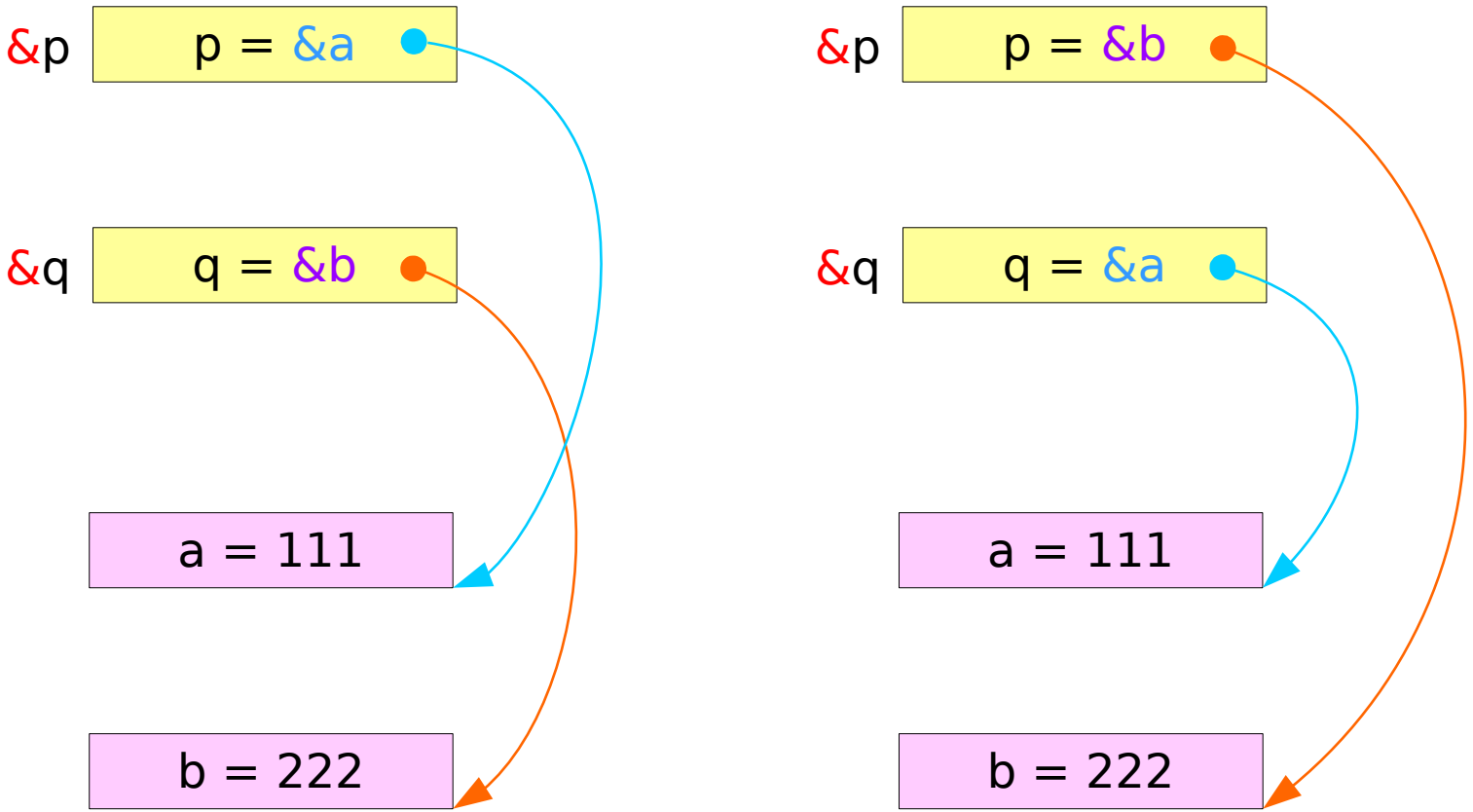
Values of Variables



Swapping pointers

- pass by reference
- double pointers

Swapping integer pointers



Swapping integer pointers


```
int *p, *q;

swap_pointers( &p, &q );          function call

swap_pointers( int **, int ** );  function prototype
```

Pass by integer pointer reference

```
void swap_pointers (int **m, int **n)
{
    int* tmp;

    tmp = *m;
    *m = *n;
    *n = tmp;
}
```

int **	m
int *	*m

int **	n
int *	*n

int *	tmp

```
int   a,  b;
int *p, *q;          p=&a, q=&b;
     ...
swap_pointers( &p, &q );
```

Array of Pointers

Array of Pointers

```
int     a [4];

int *   b [4];
```

No. of elements = 4

int a [4]

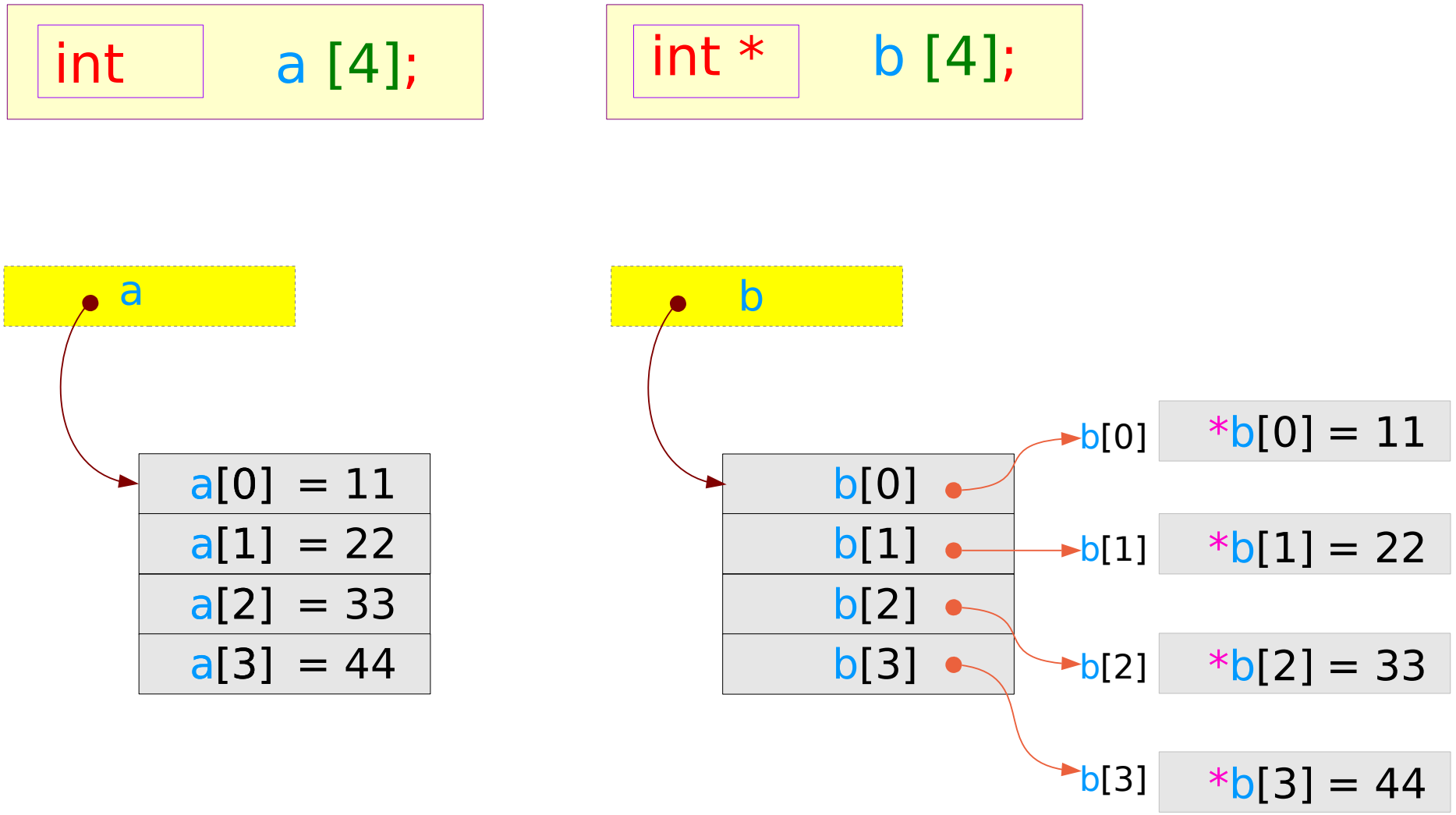
Type of each element

No. of elements = 4

int * b [4]

Type of each element

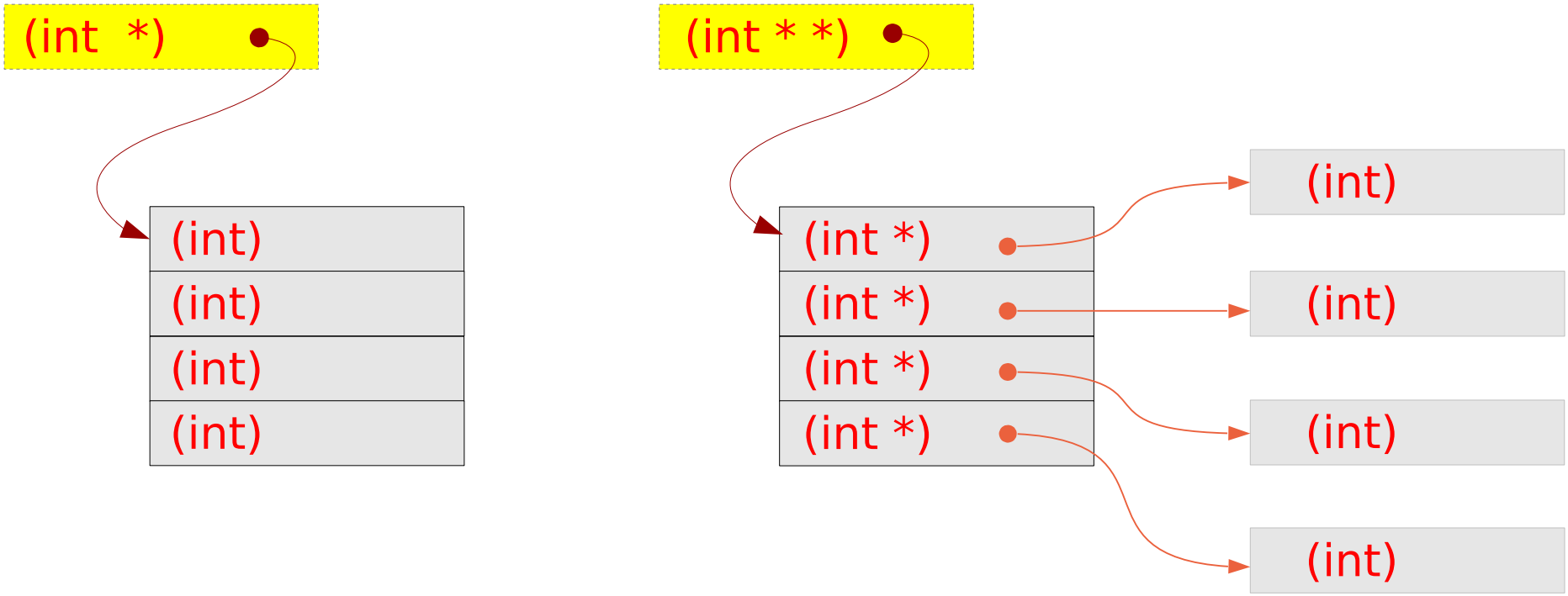
Array of Pointers – variable view



Array of Pointers – type view

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

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



Pointer to Arrays

Pointer to array – variable declarations

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

an integer pointer

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

an integer array pointer

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

a function pointer

Pointer to array – type

int

int *

an integer pointer

int []

int (*) [4]

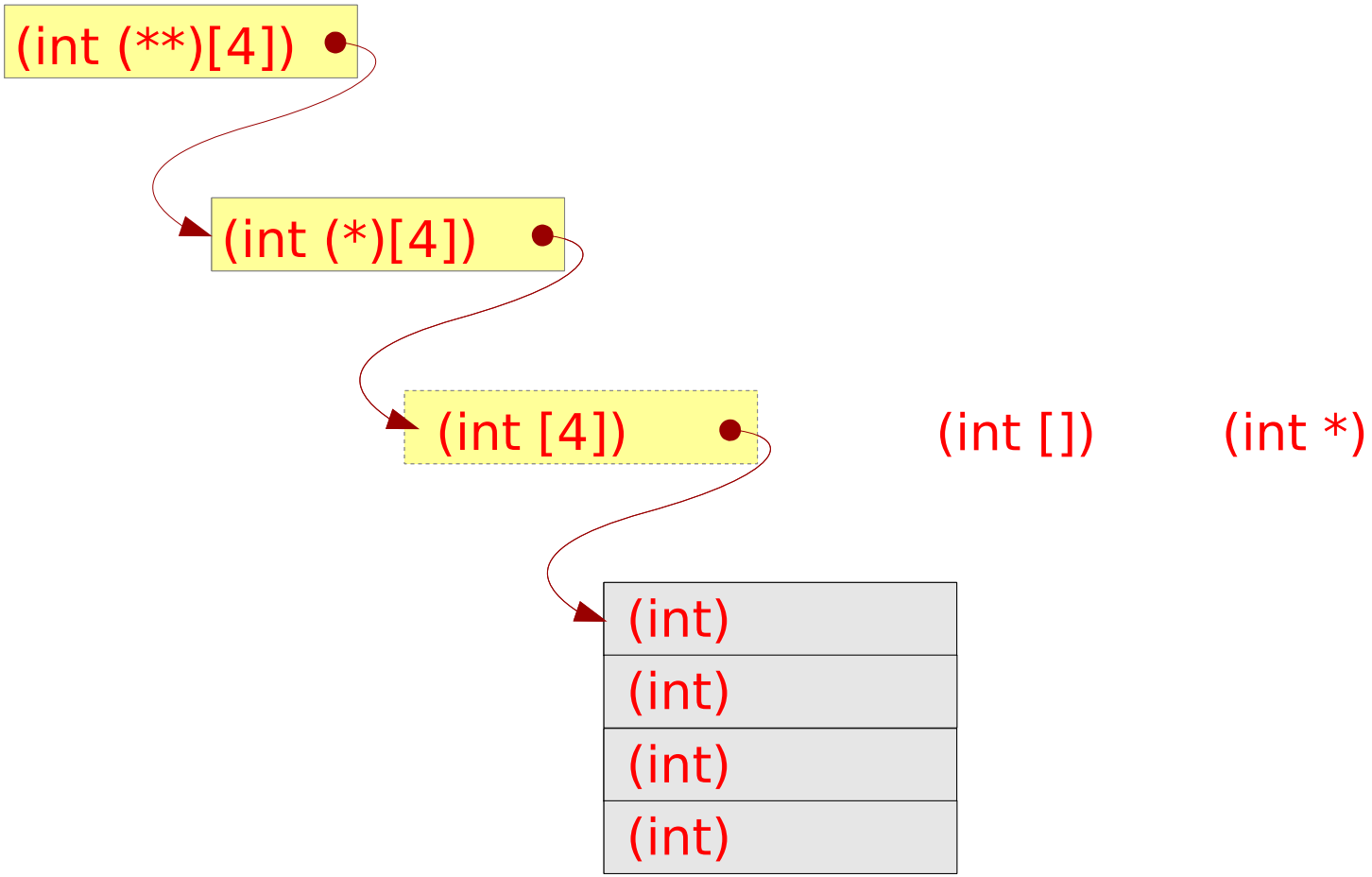
an integer array pointer

int (int, int)

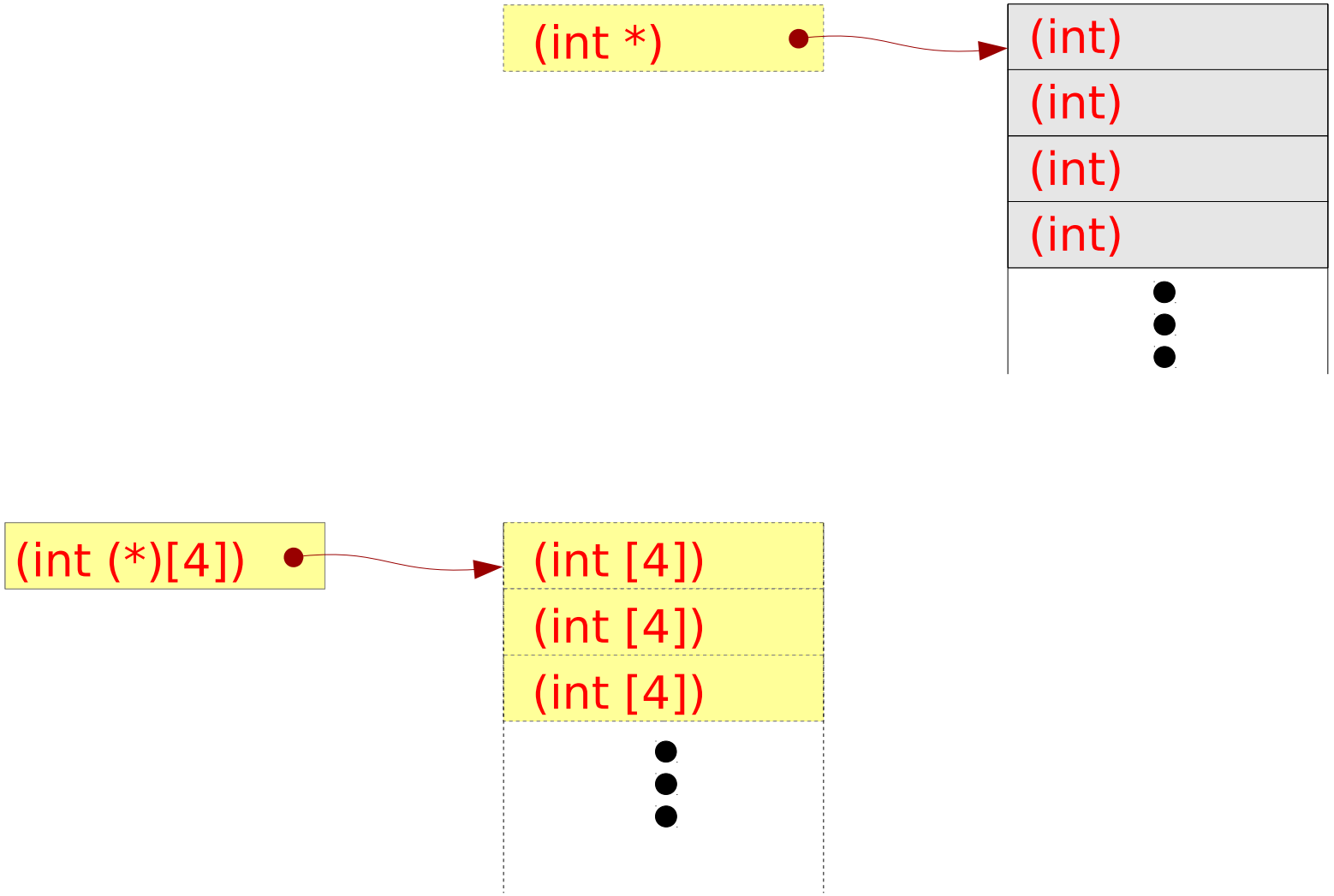
int (*) (int, int)

a function pointer

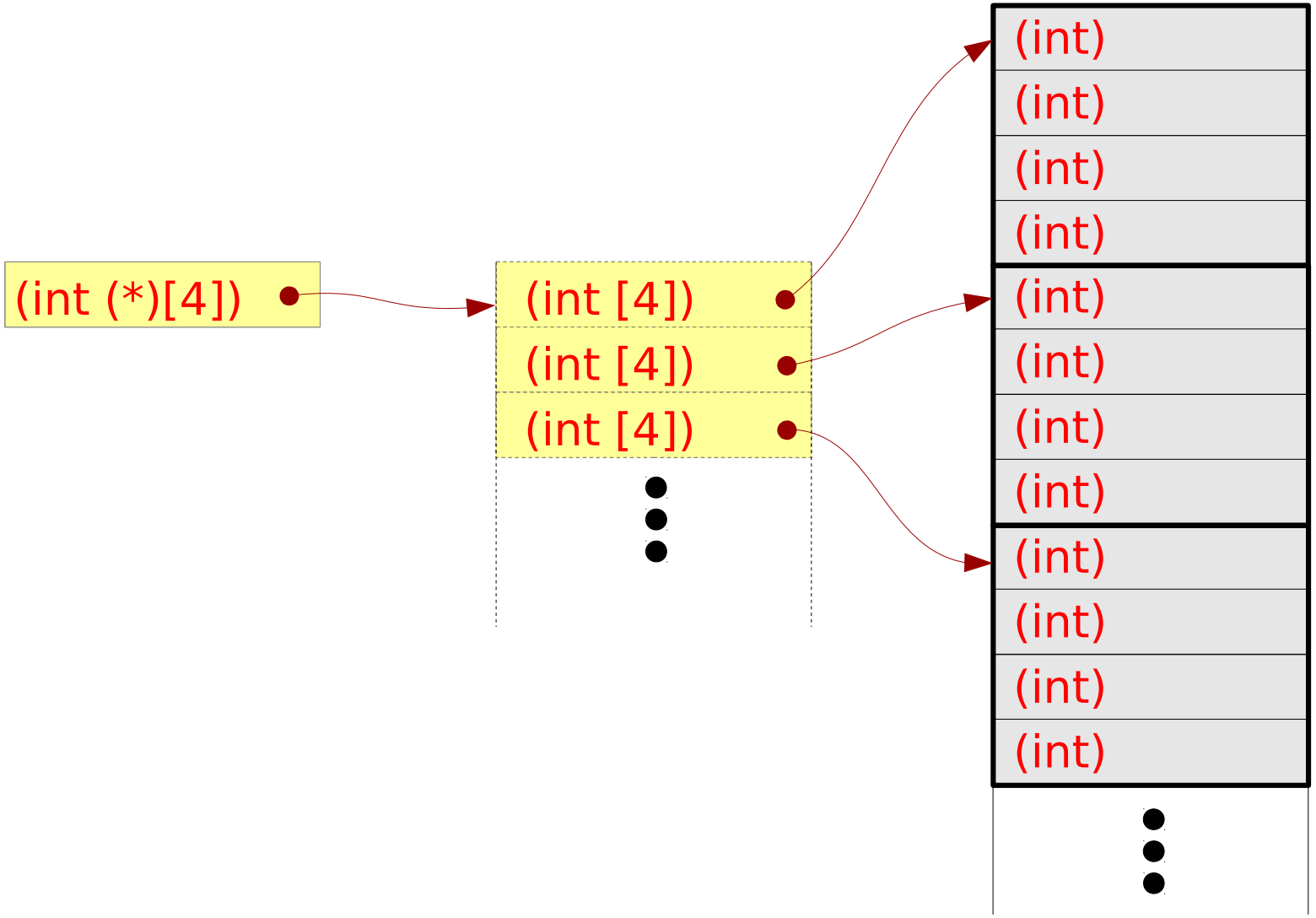
Pointer to array – type



Pointer to array – type



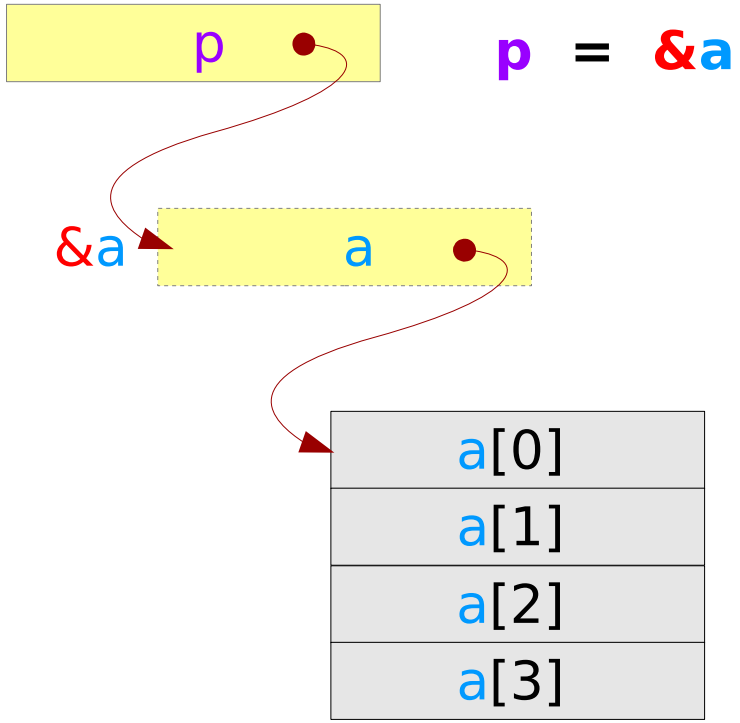
Pointer to array – type

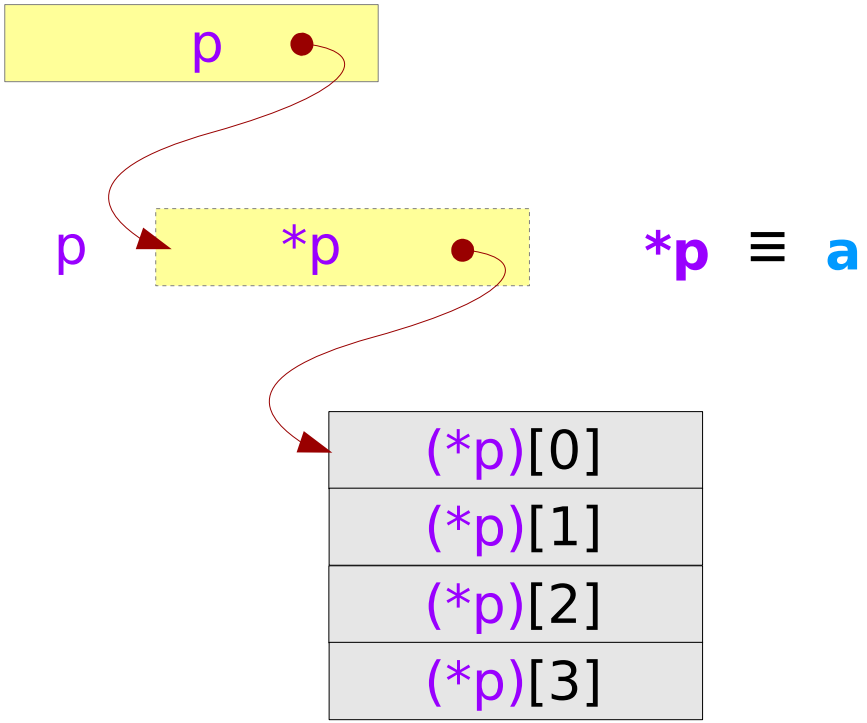


Pointer to array – a variable view

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

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

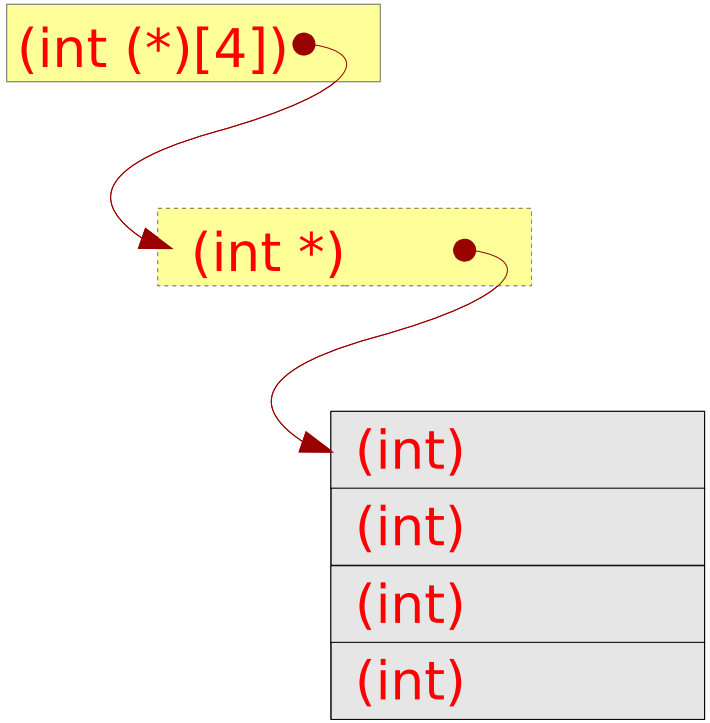


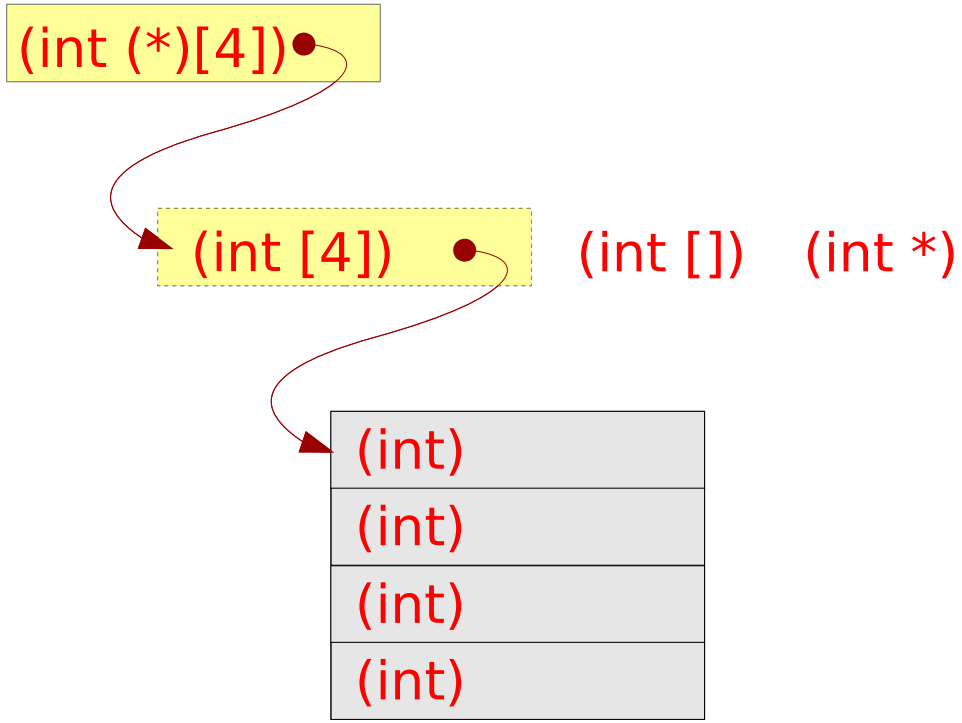


Pointer to array – a variable view

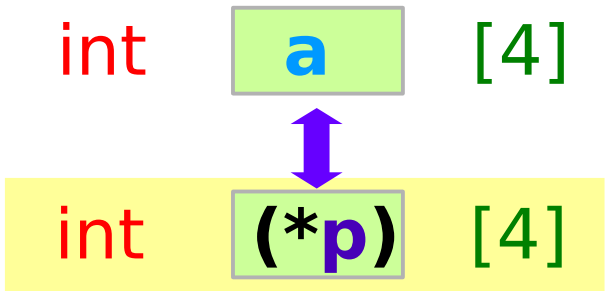
```
int       a [4];
```

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





Pointer to array (2)



a (*p)

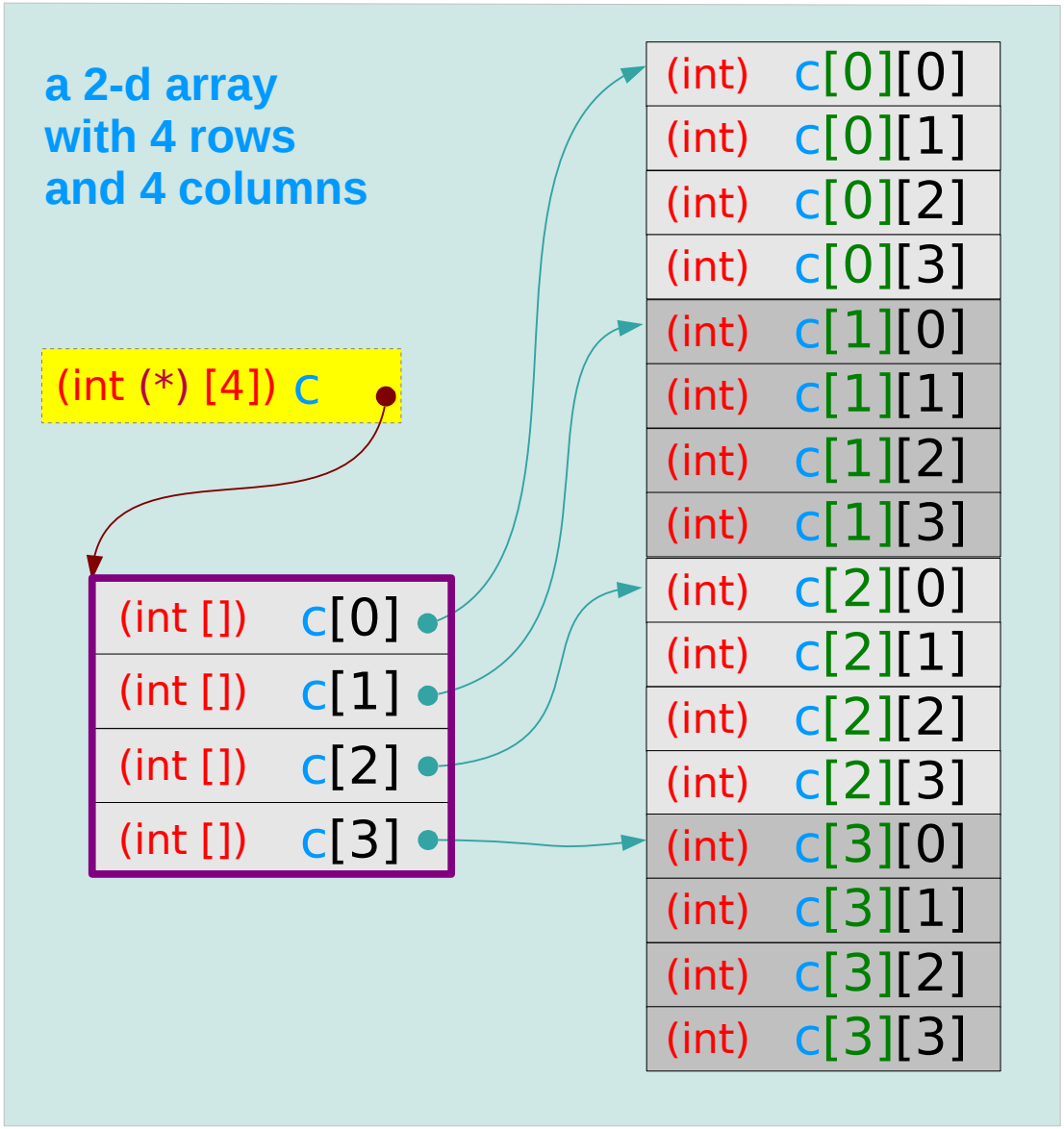
&a &(*p)

&a p

sizeof(p)= 4 bytes

sizeof(*p)= 16 bytes

Pointer to array (3)



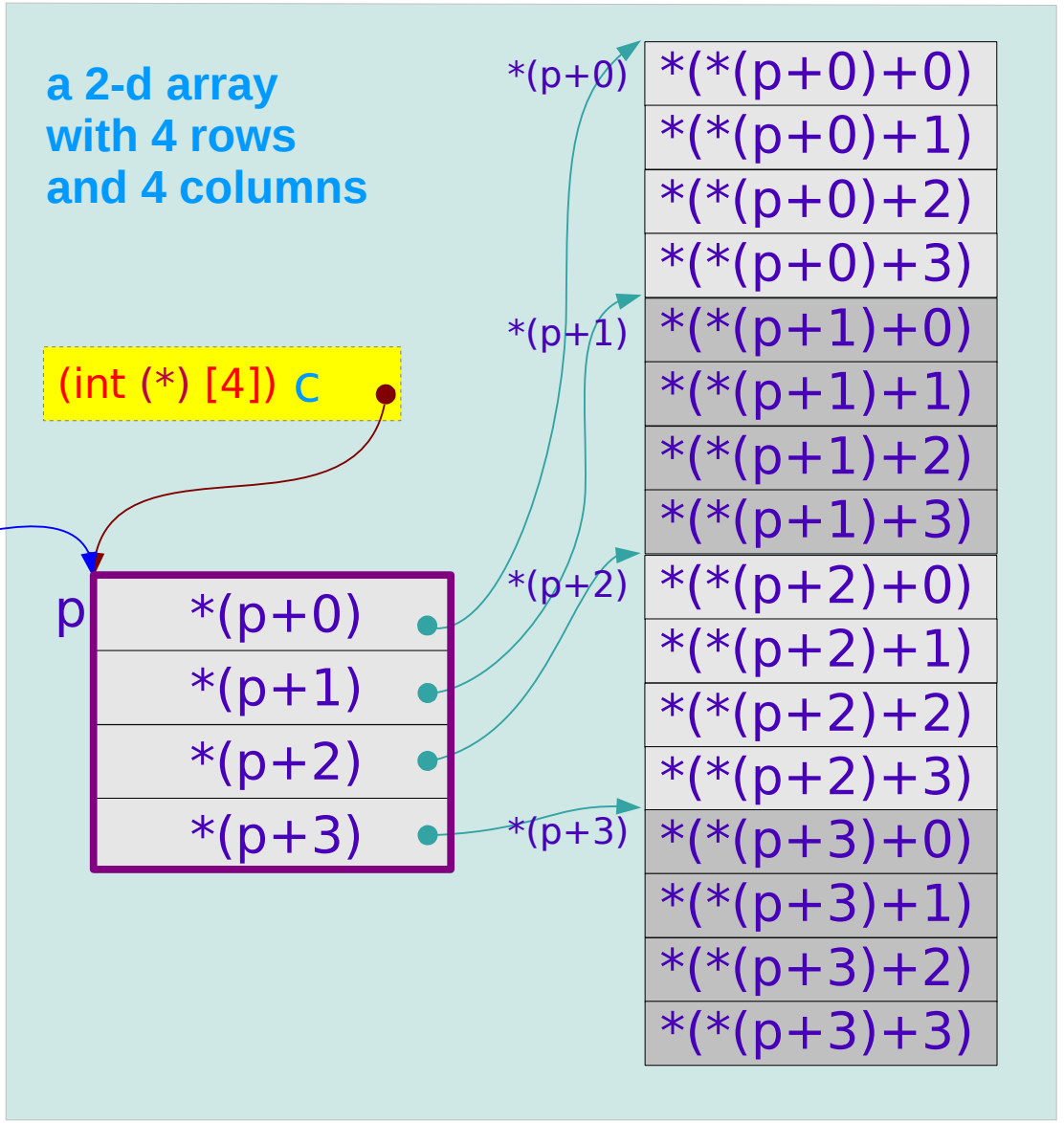
Pointer to array (3)

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

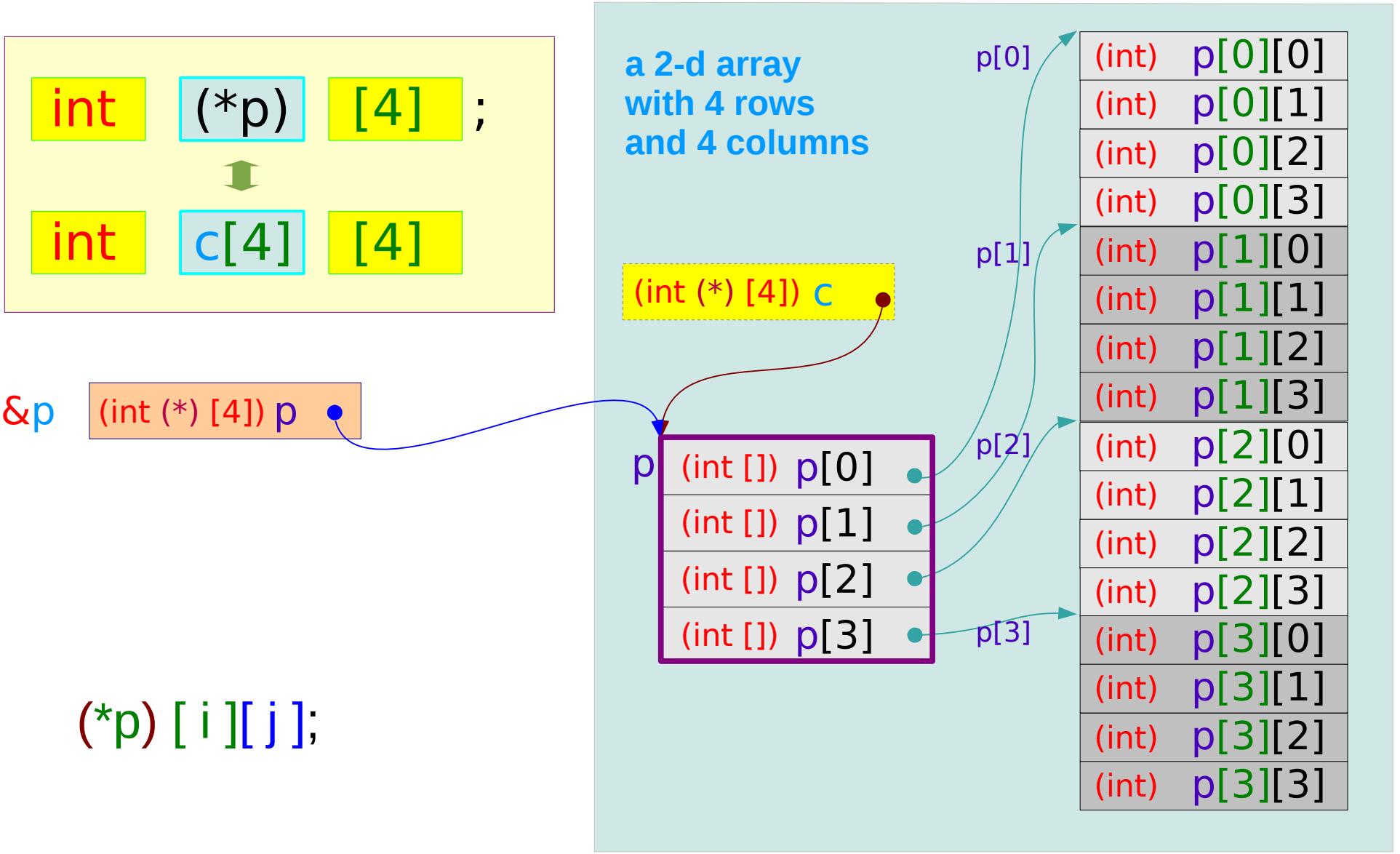
&p (int (*) [4]) p

p = c

(*p) [i][j];



Pointer to array (3)



(*p) [i][j];

Pointer to array (4)

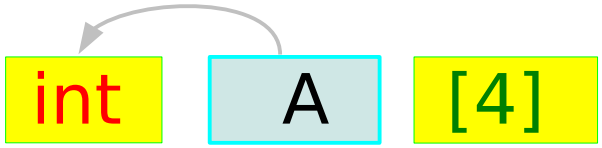
```
int c [4][4];
int (*p) [4];

p = c;

func(p, ... );
```

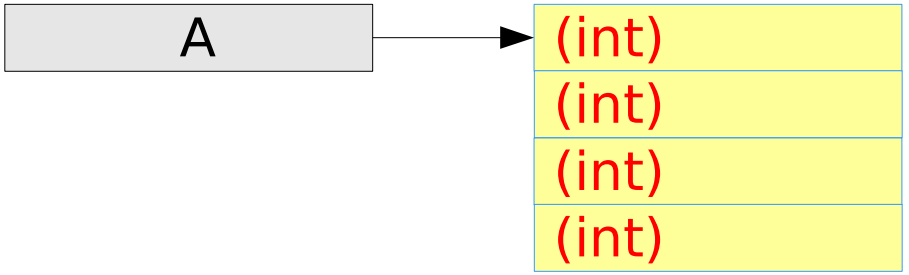
```
void func(int (*x)[4], ... )
{

    x[r][c] =

}
```

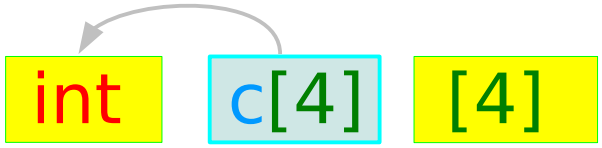
```
void func(int x[ ][4], ... )
{

    x[r][c] =

}
```

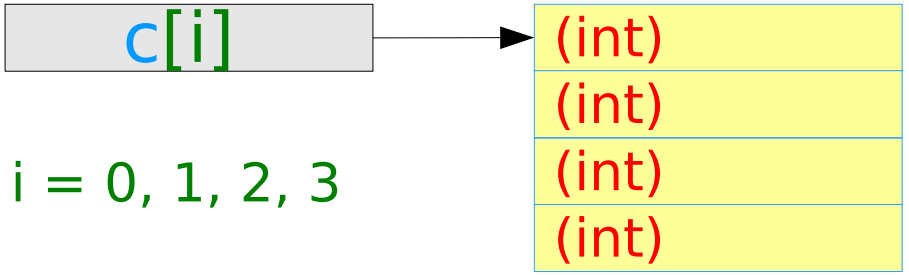
2-d Arrays

Addresses of 4 element integer arrays





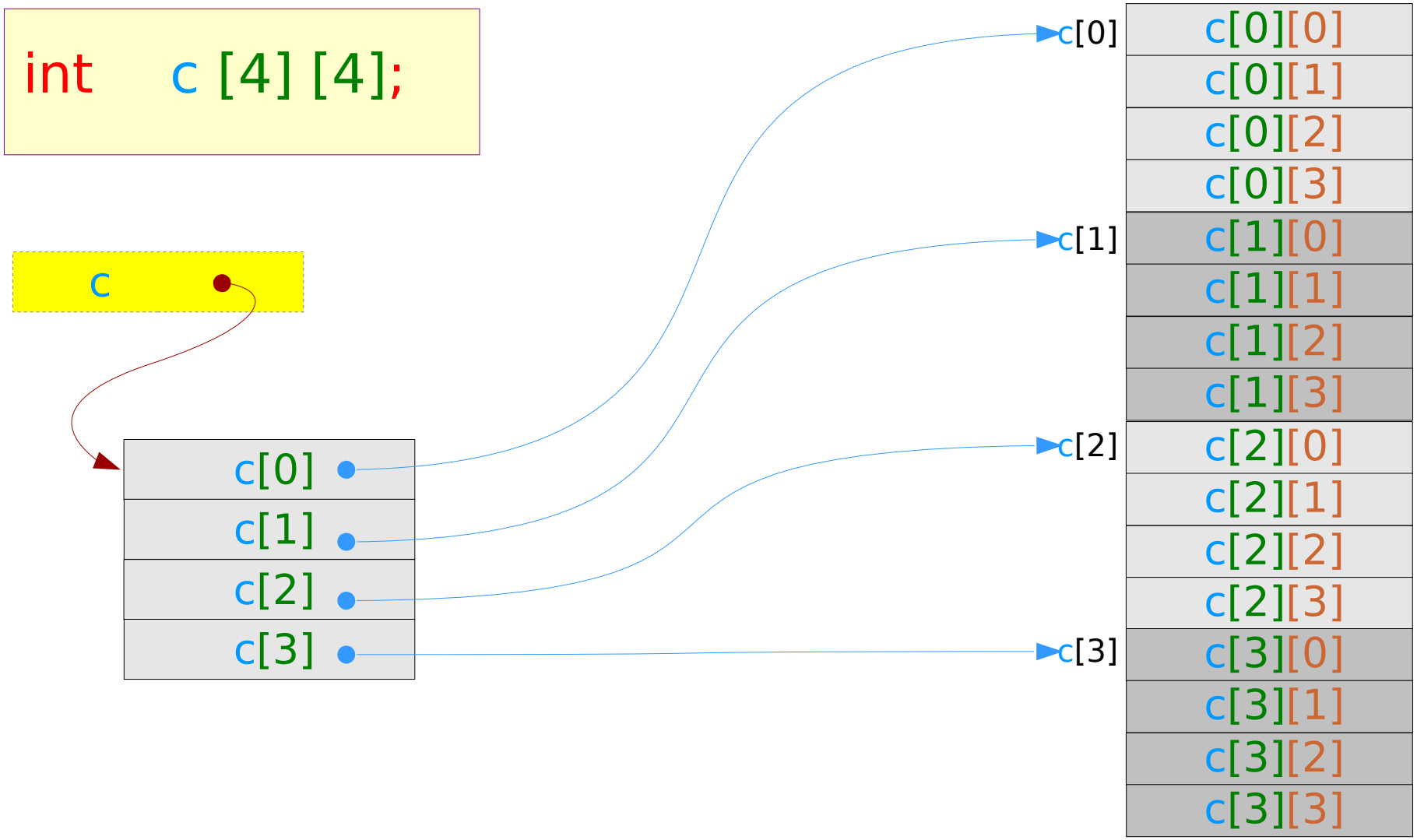




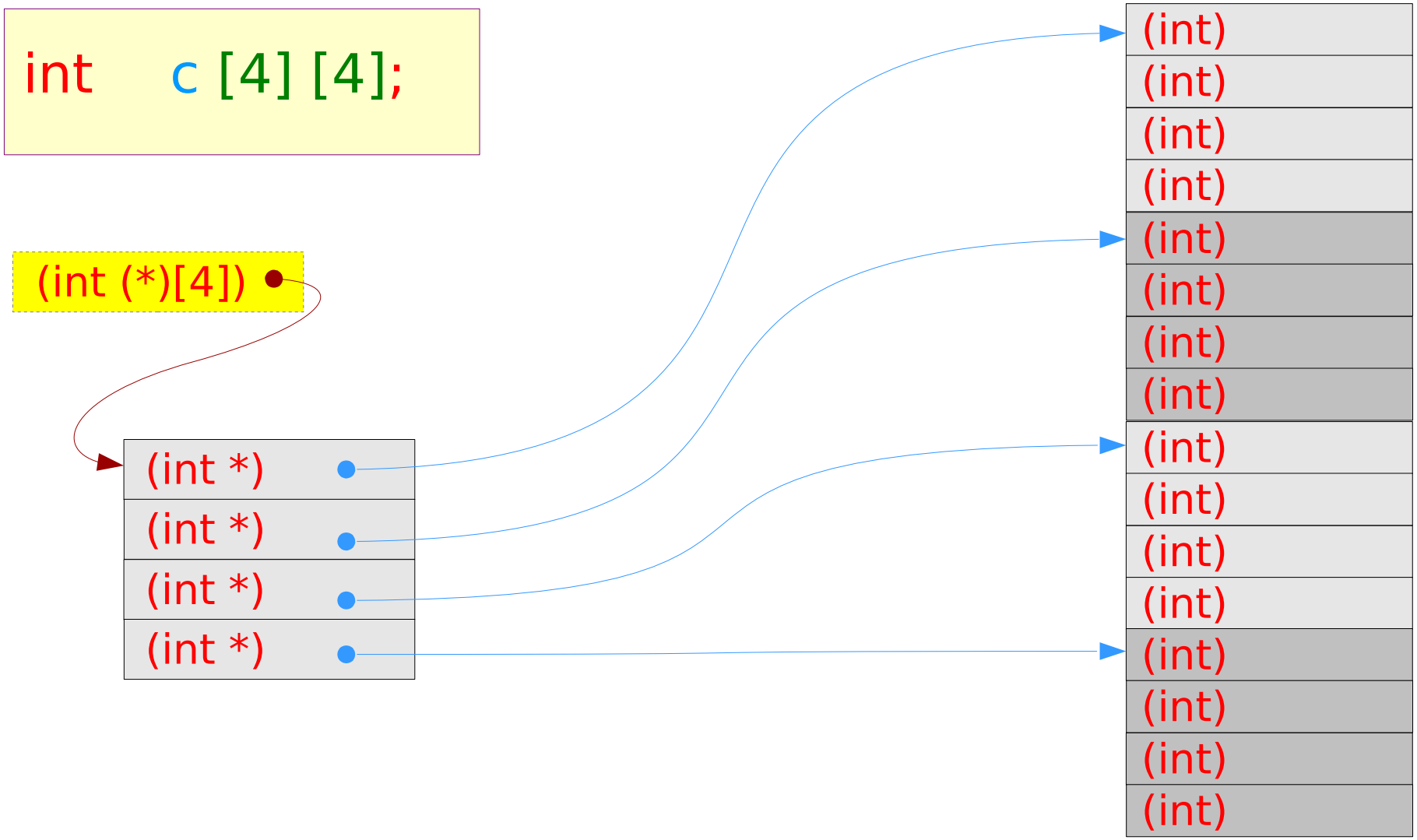
i = 0, 1, 2, 3

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

A 2-D Array – a variable view

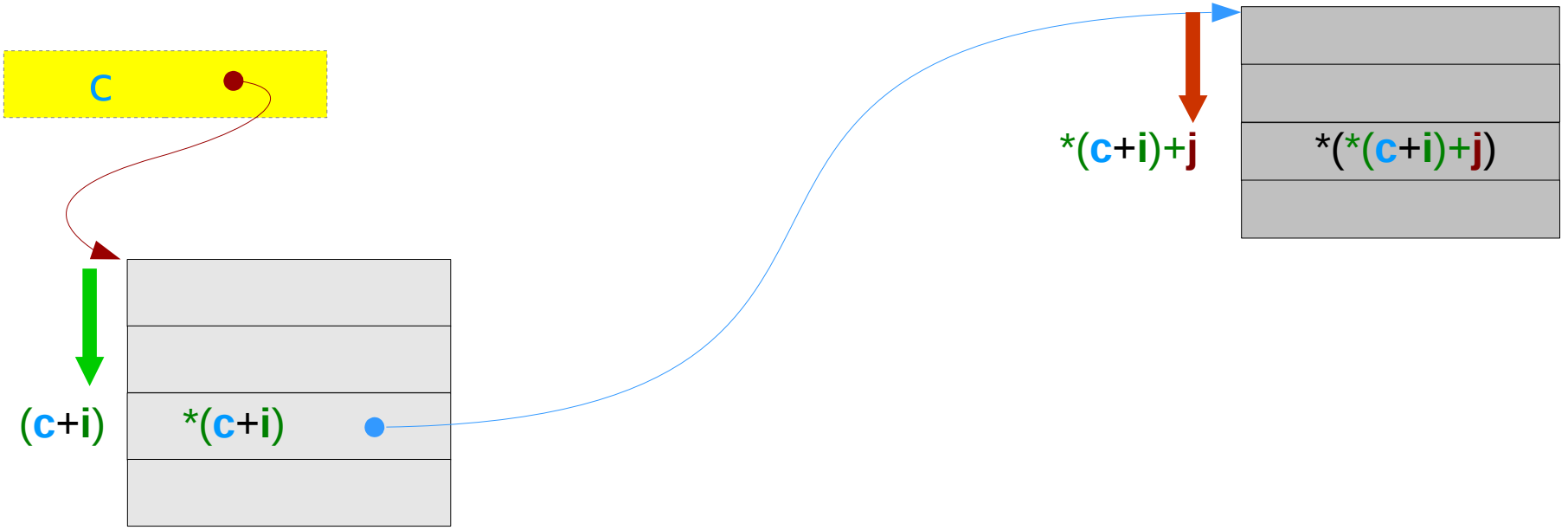


A 2-D Array – a type view



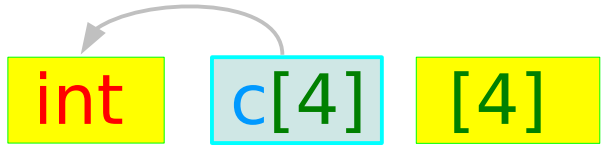
A 2-D Array – an index view

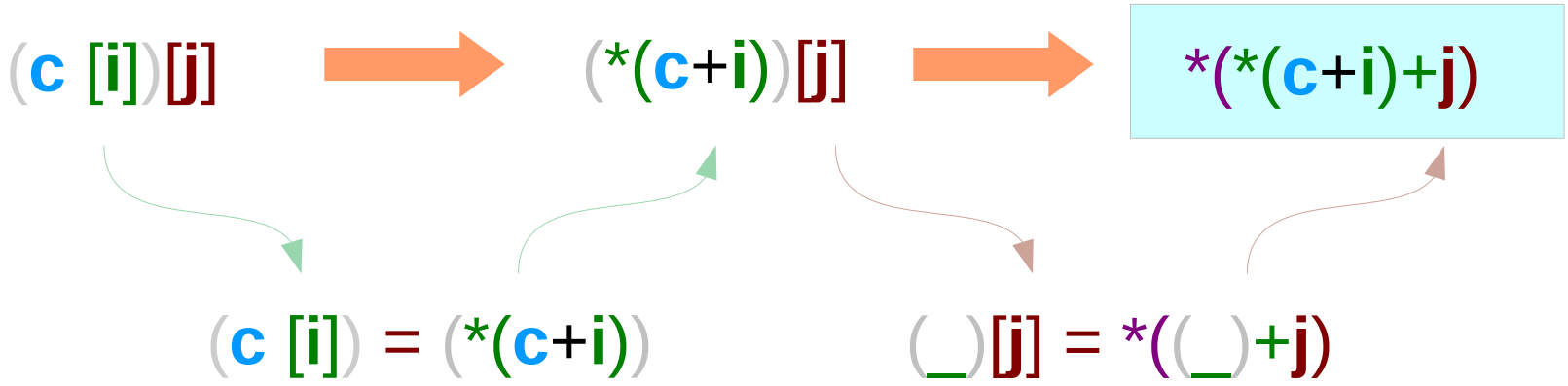
```
int    c [4] [4];
```



A 2-D Array via a double indirection

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





A 2-D Array via an array pointer

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

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

(c [i])[j] → (*(c+i))[j] → *(*(c+i)+j)

p = c

(p [i])[j] → (*(p+i))[j] → *(*(p+i)+j)

A 2-D Array via a double pointer

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

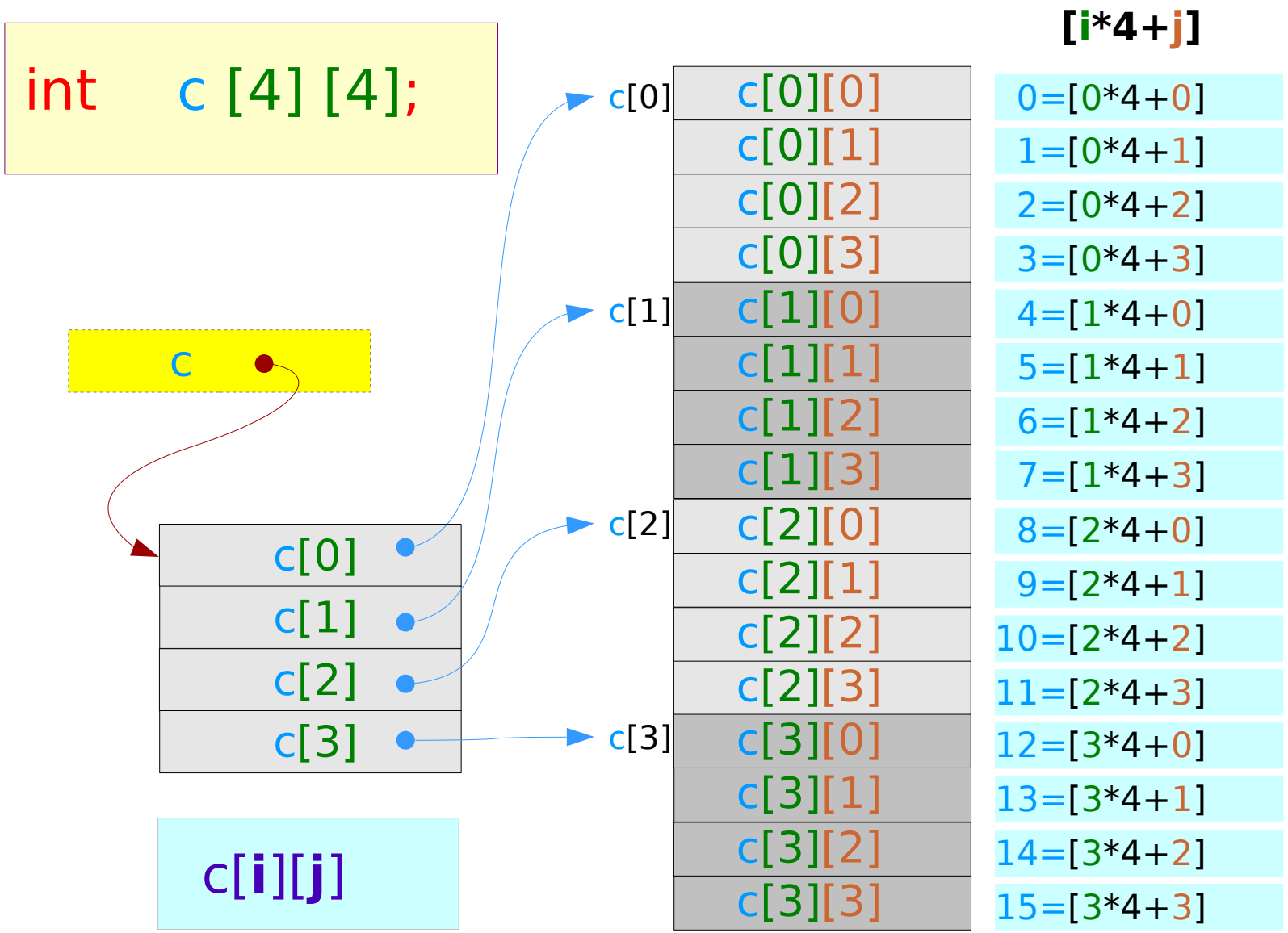
```
int    **p, *q[4];
```

(c [i])[j] → (*(c+i))[j] → *(*(c+i)+j)

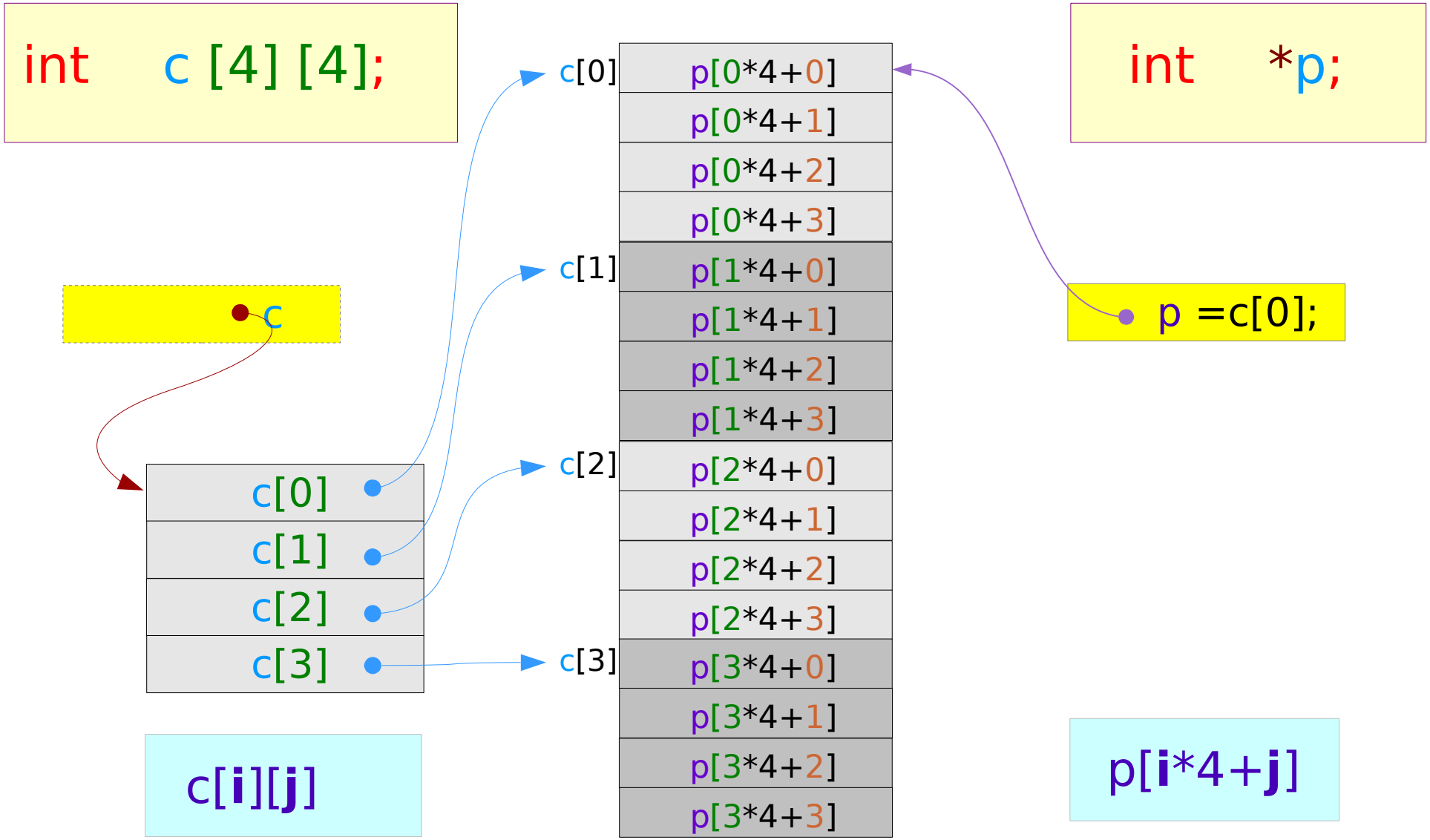
p = q; q[0]=c[0], q[1]=c[1], q[2]=c[2], q[3]=c[3];

(p [i])[j] → (*(p+i))[j] → *(*(p+i)+j)

2-D array as a 1-D array



Accessing a 2-D array via a single pointer



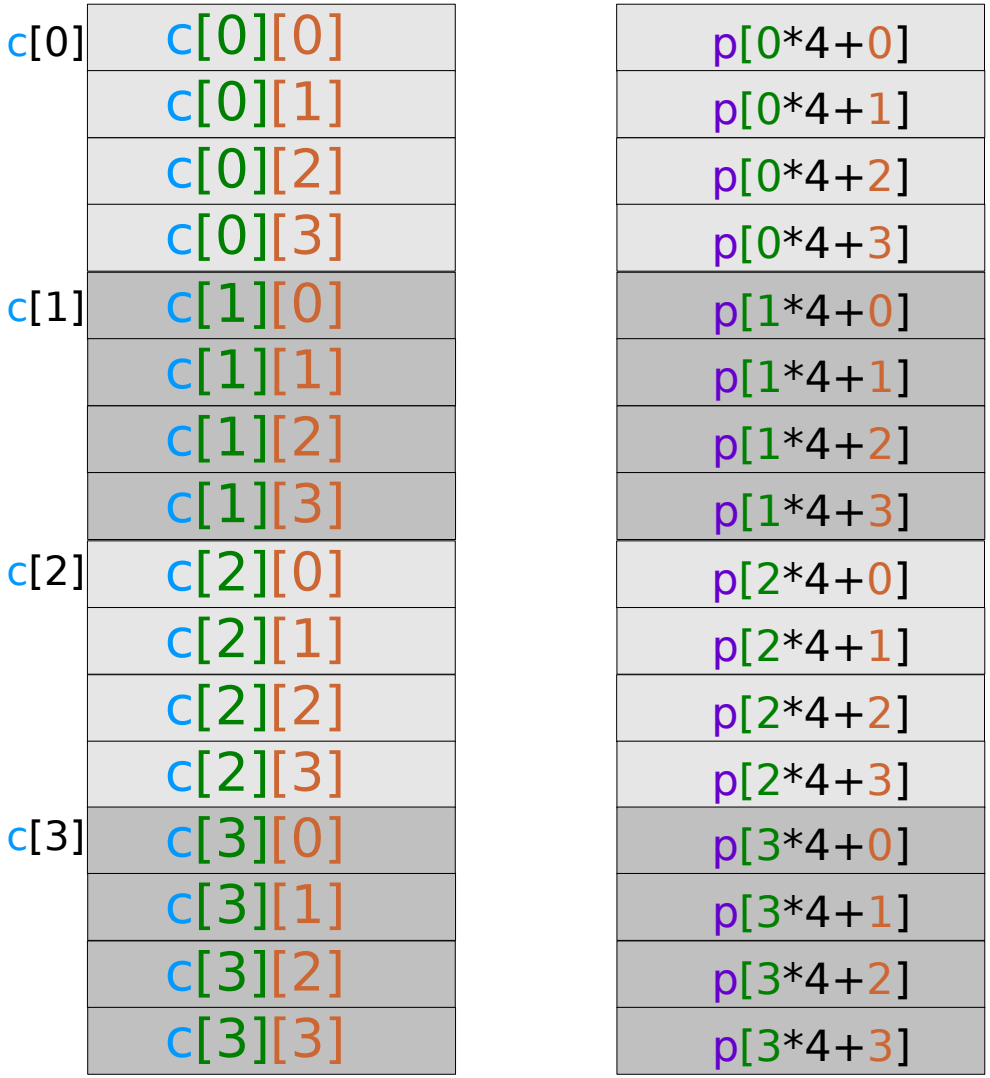
2-D array index vs 1-D array index

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

```
int    *p=c[0];
```

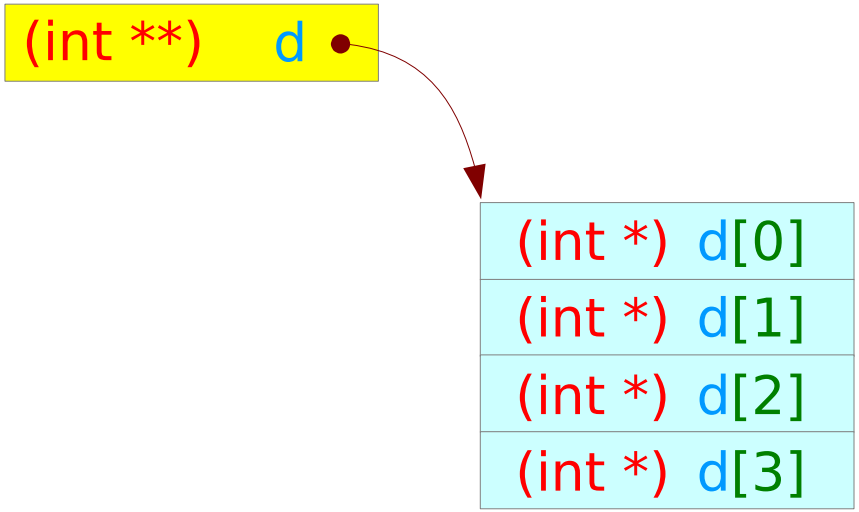
c[**i**][**j**]

p[**i***4+**j**]



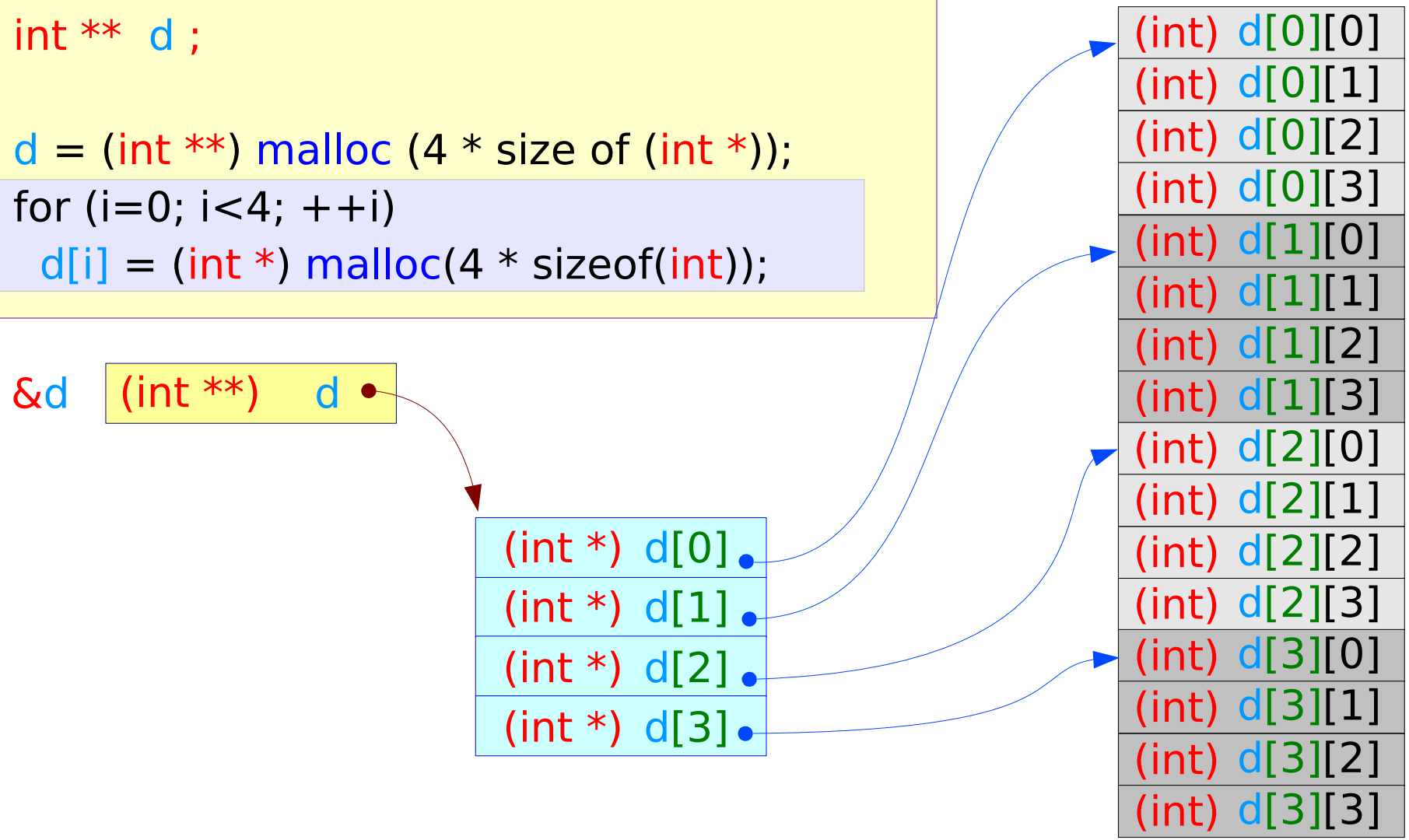
2-D Array Dynamic Memory Allocation (1)

```
int **  d ;

d = (int **) malloc (4 * size of (int *));
for (i=0; i<4; ++i)
  d[i] = (int *) malloc(4 * sizeof(int));
```



2-D Array Dynamic Memory Allocation (2)

```
int **  d ;

d = (int **) malloc (4 * size of (int *));
for (i=0; i<4; ++i)
  d[i] = (int *) malloc(4 * sizeof(int));
```



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