Applications of Array Pointers (1A)

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

Multi-dimensional Array Pointers

1-d & 2-d array pointers to 1-d & 2-d arrays

equivalence relations

1-d array pointer p

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

Let **p** points to a **1-d** array **a**

*p ≡ a equivalence

p = &a; assignment

2-d array pointer q

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

Let **q** points to a **2-d** array **c**

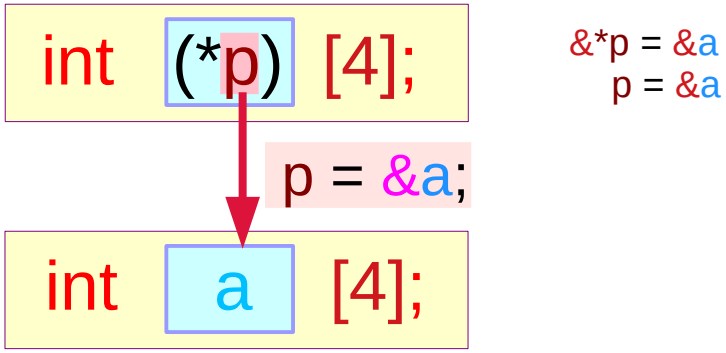
*q ≡ c equivalence

q = &c; assignment

1-d & 2-d array pointers to 1-d & 2-d arrays

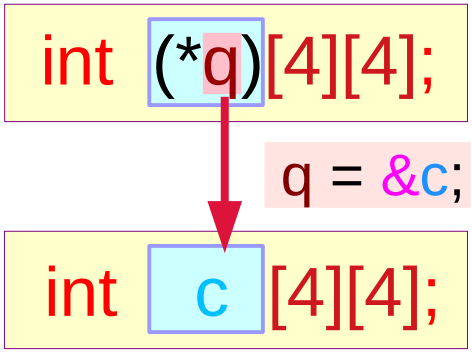
pointer relations

1-d array pointer p



&*p = &a
p = &a

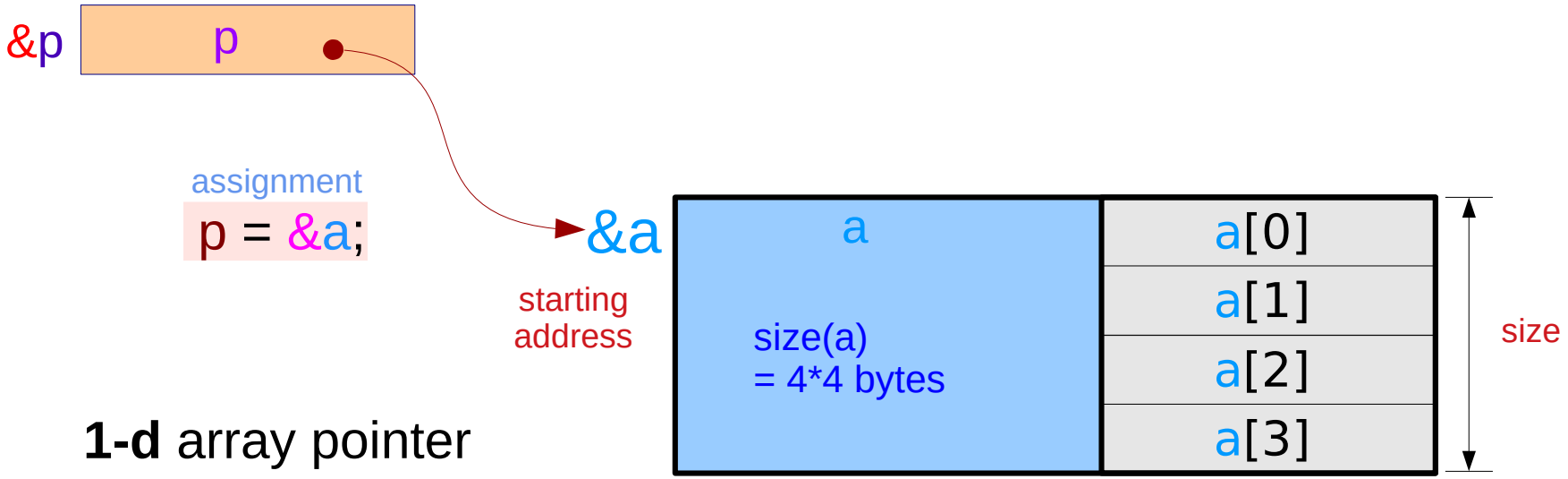
2-d array pointer q



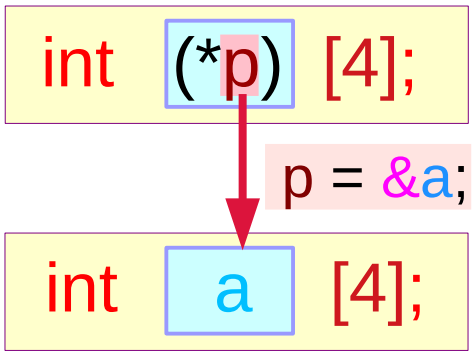
&*q = &c
q = &c

1-d array pointer to a 1-d array

1-d array pointer



1-d array pointer



sizeof(p) = 4/8 bytes
sizeof(*p) = sizeof(a)

2-d array pointer to a 2-d array

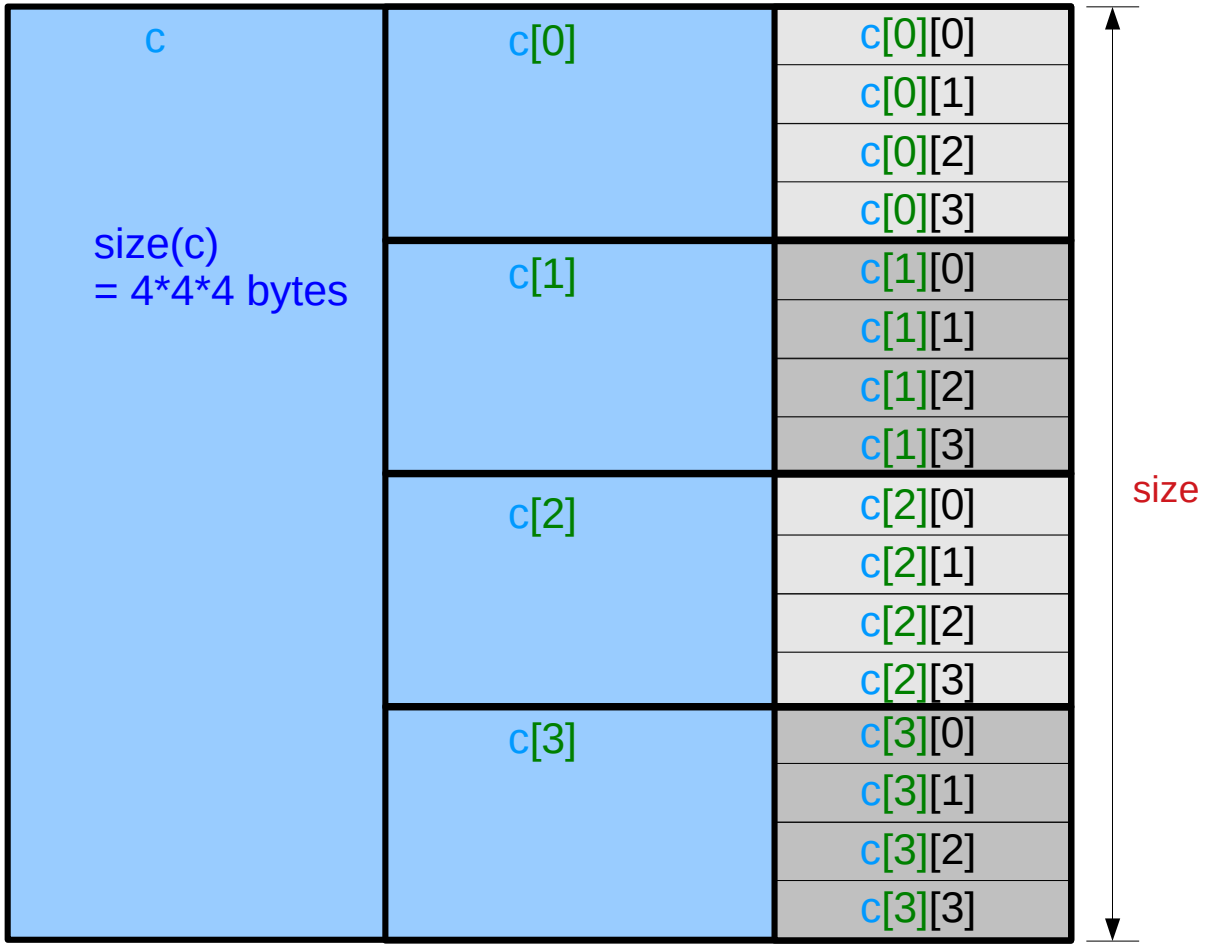
2-d array pointer

assignment

q = &c;

&c

starting address



2-d array pointer

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

q = &c;

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

sizeof(q) = 4/8 bytes

sizeof(*q) = sizeof(c)

1-d & 2-d array pointers to a 2-d array

equivalence relations

1-d array pointer

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

2-d array pointer

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

Let **p** points to the **1-d** subarray **c[0]**

*p ≡ c[0] equivalence

p = c; assignment

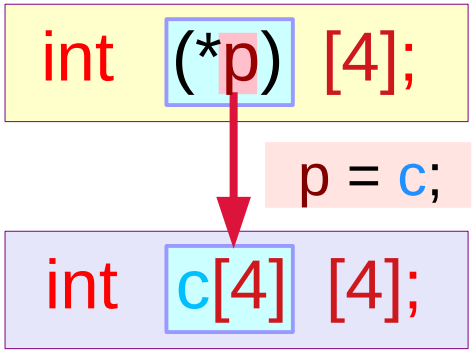
Let **q** points to the **2-d** array **c**

*q ≡ c equivalence

q = &c; assignment

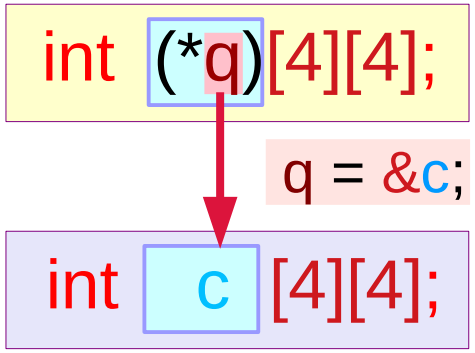
1-d & 2-d array pointers to a 2-d array

1-d array pointer



&*p = &c[0]
p = &(*c)

2-d array pointer



&*q = &c
q = &c

Extended references of **1-d** & **2-d** array pointers

1-d array pointer

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

(*p)[j] ≡ c[0][j] minimal reference

p[i][j] ≡ c[i][j] extended reference

2-d array pointer

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

(*q)[i][j] ≡ c[i][j] minimal reference

q[0][i][j] ≡ c[i][j] extended reference

Accessing a **2-d** array using a **2-d** & **1-d** array pointers

1-d array pointer

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

2-d array pointer

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

`(*p)[j]` **1-d** array access
minimal

`p [i][j]` **2-d** array access
extended

`(*q) [i][j]` **2-d** array access
minimal

`q[0] [i][j]` **3-d** array access
extended

Minimal reference using a **1-d** array pointer

1-d array pointer

&p p

assignment

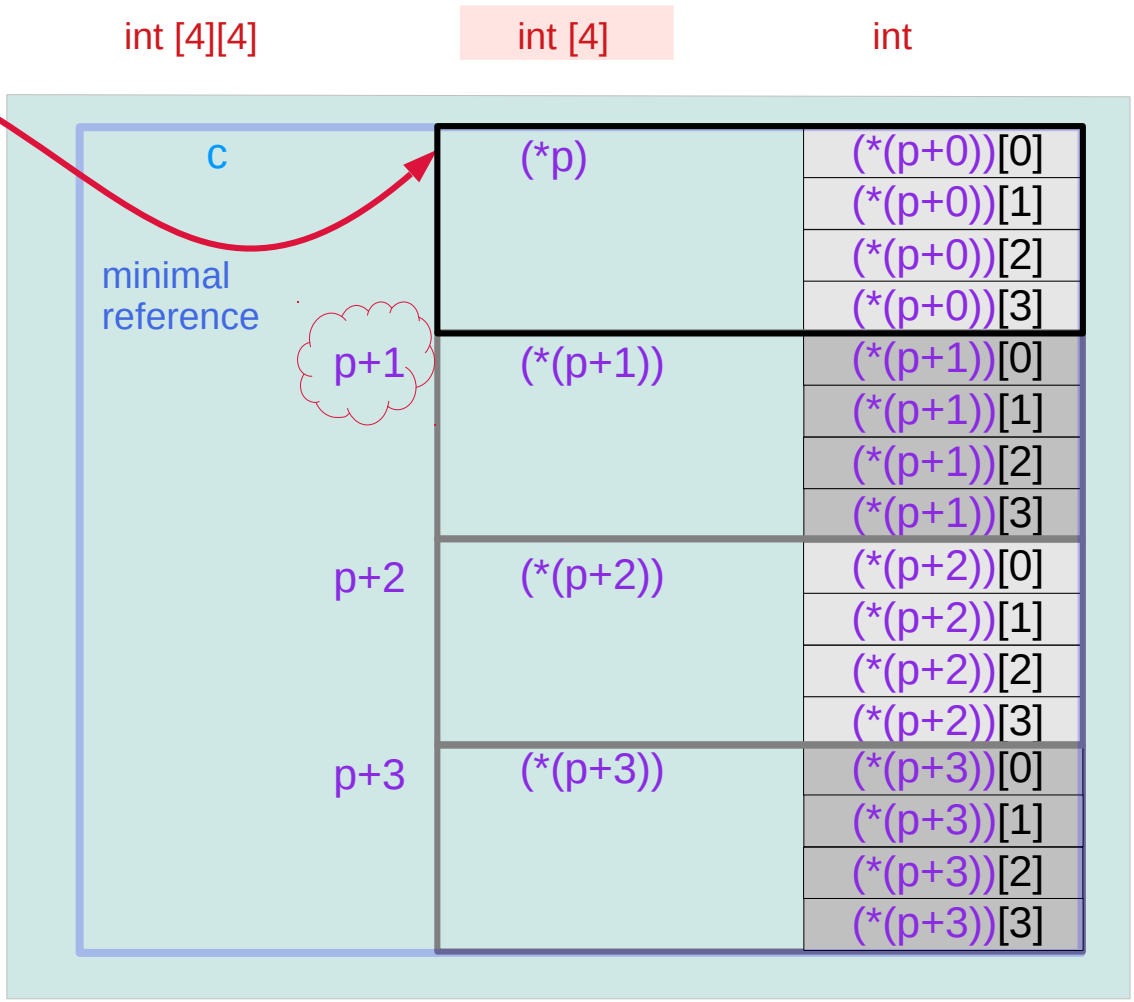
p = c;

int (*p) [4];

p = c;

int c[4] [4];

sizeof(p) = 4/8 bytes
sizeof(*p) = sizeof(c[0])



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

1-d array pointer

&p p

assignment

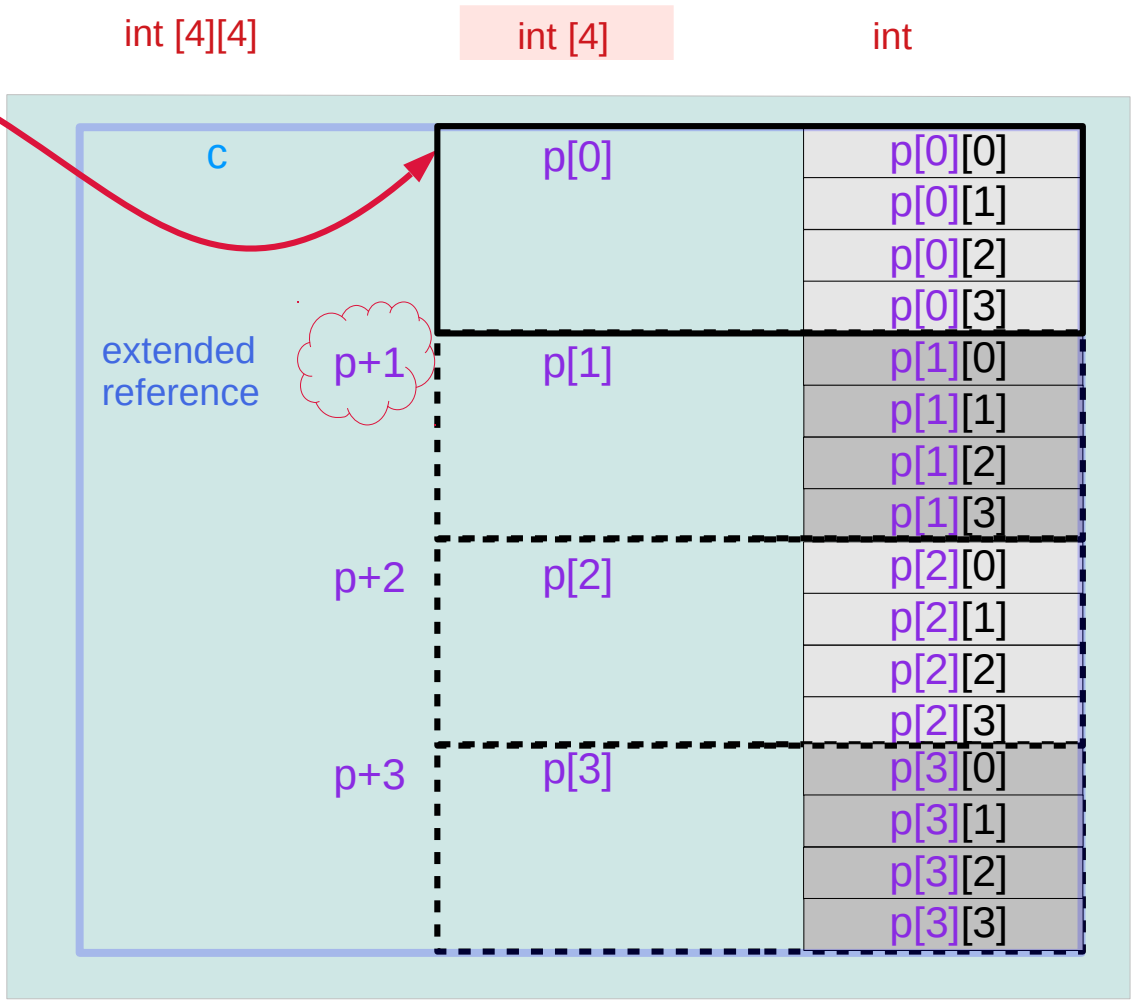
p = c;

int (*p) [4];

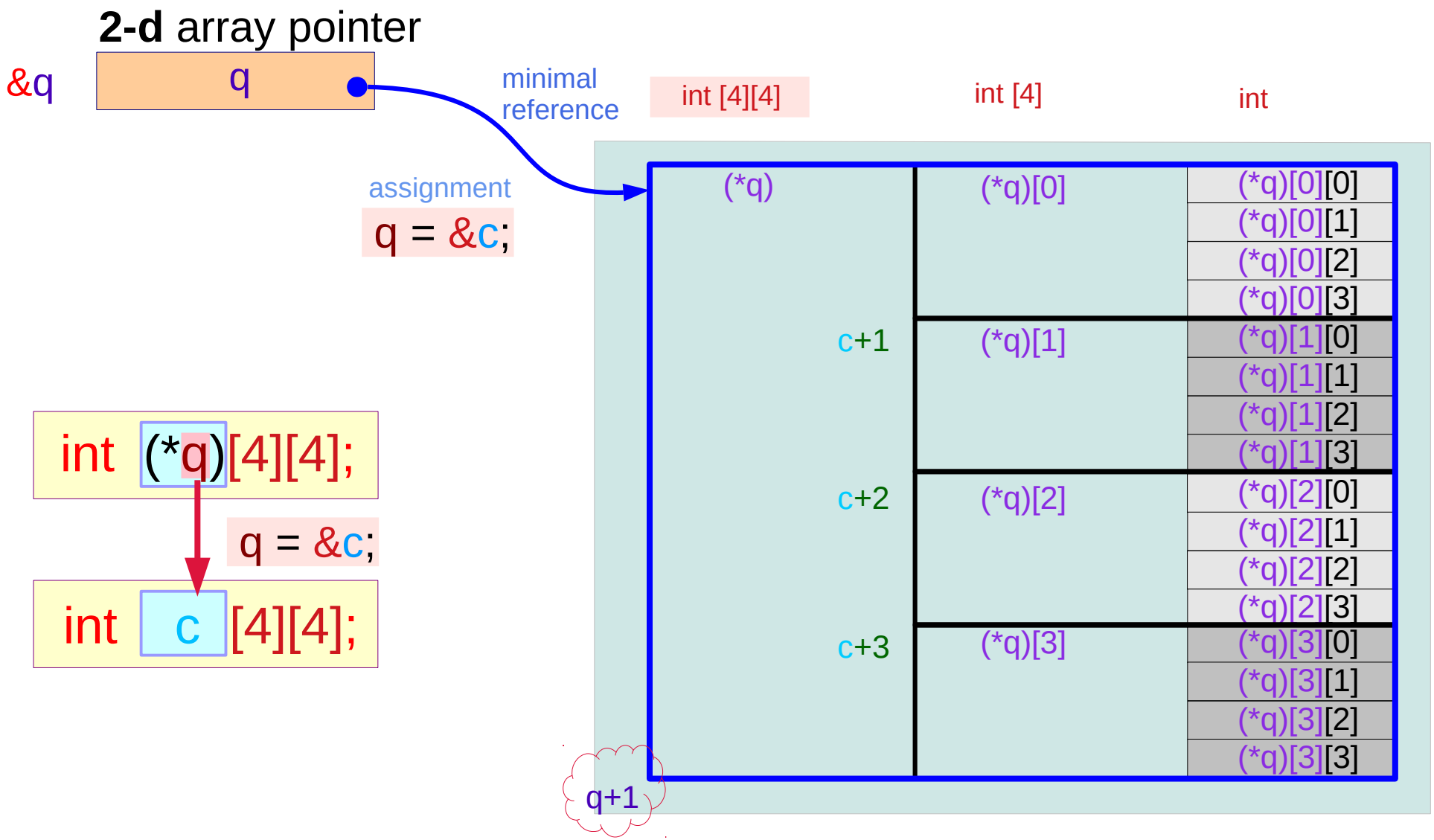
p = c;

int c[4] [4];

sizeof(p) = 4/8 bytes
sizeof(*p) = sizeof(c[0])



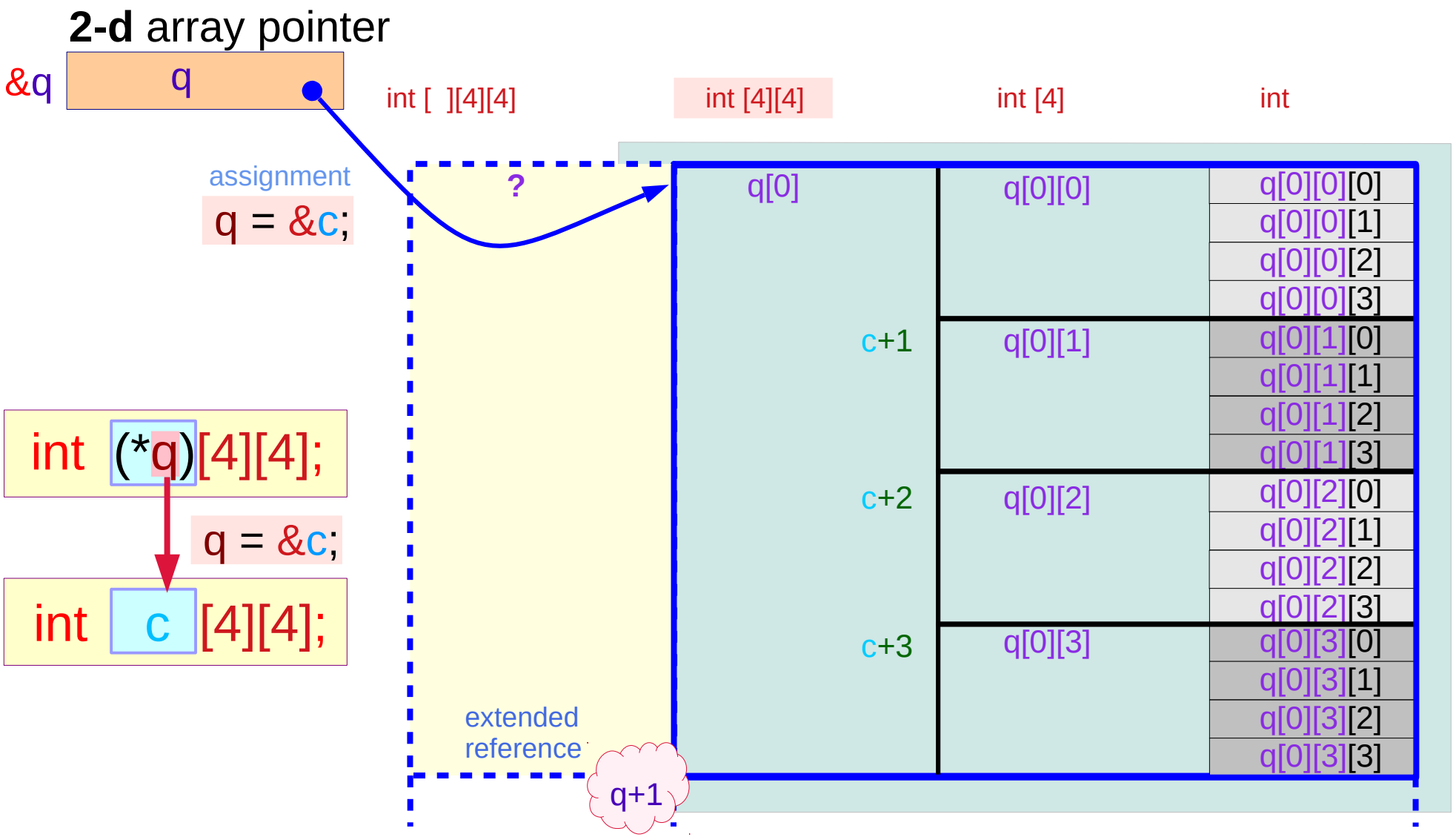
Minimal reference using a **2-d** array pointer



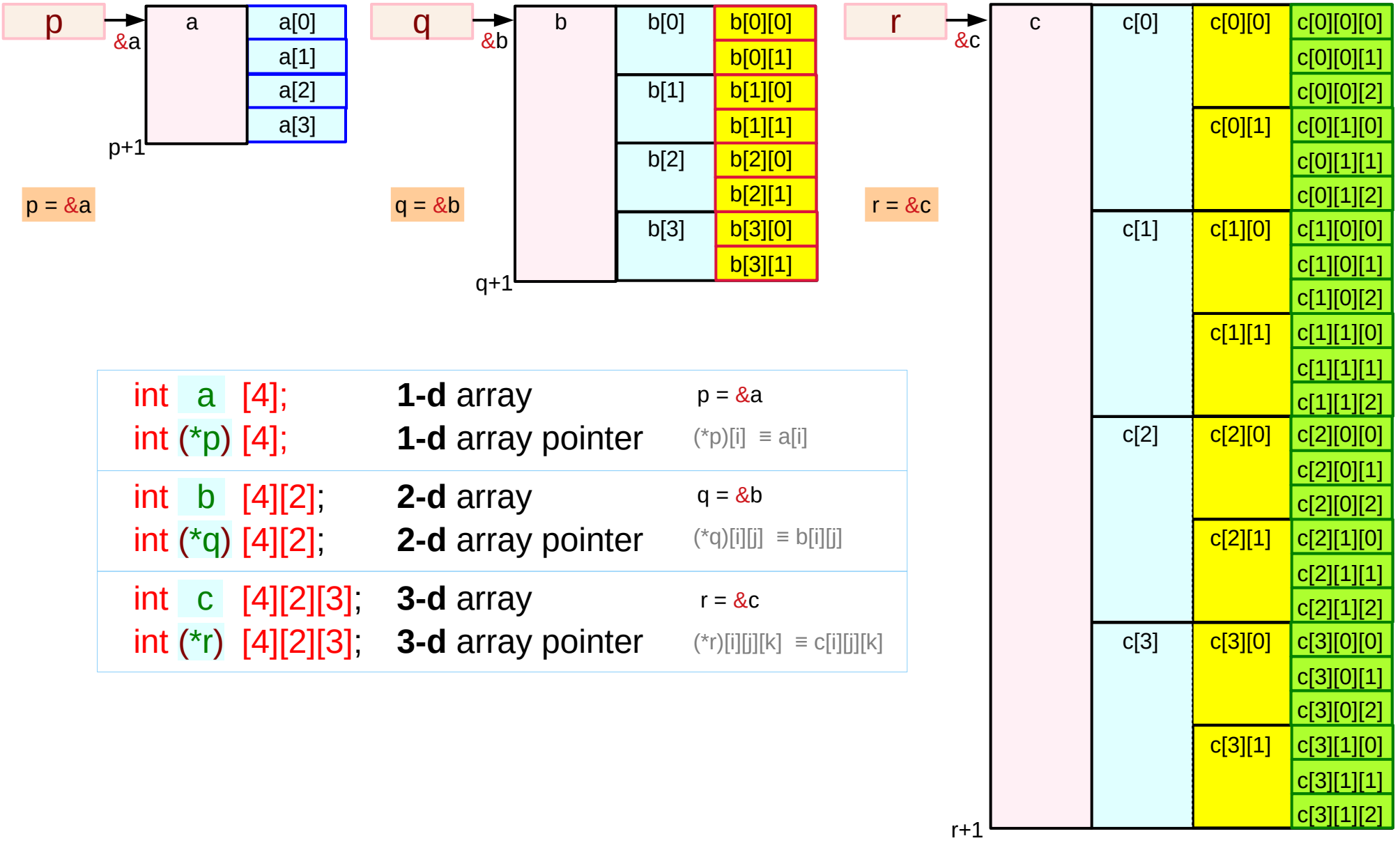
Extended **3-d** access using a **2-d** array pointer

★ as a **2-d** subarray in a **3-d** array

*q ≡ q[0]

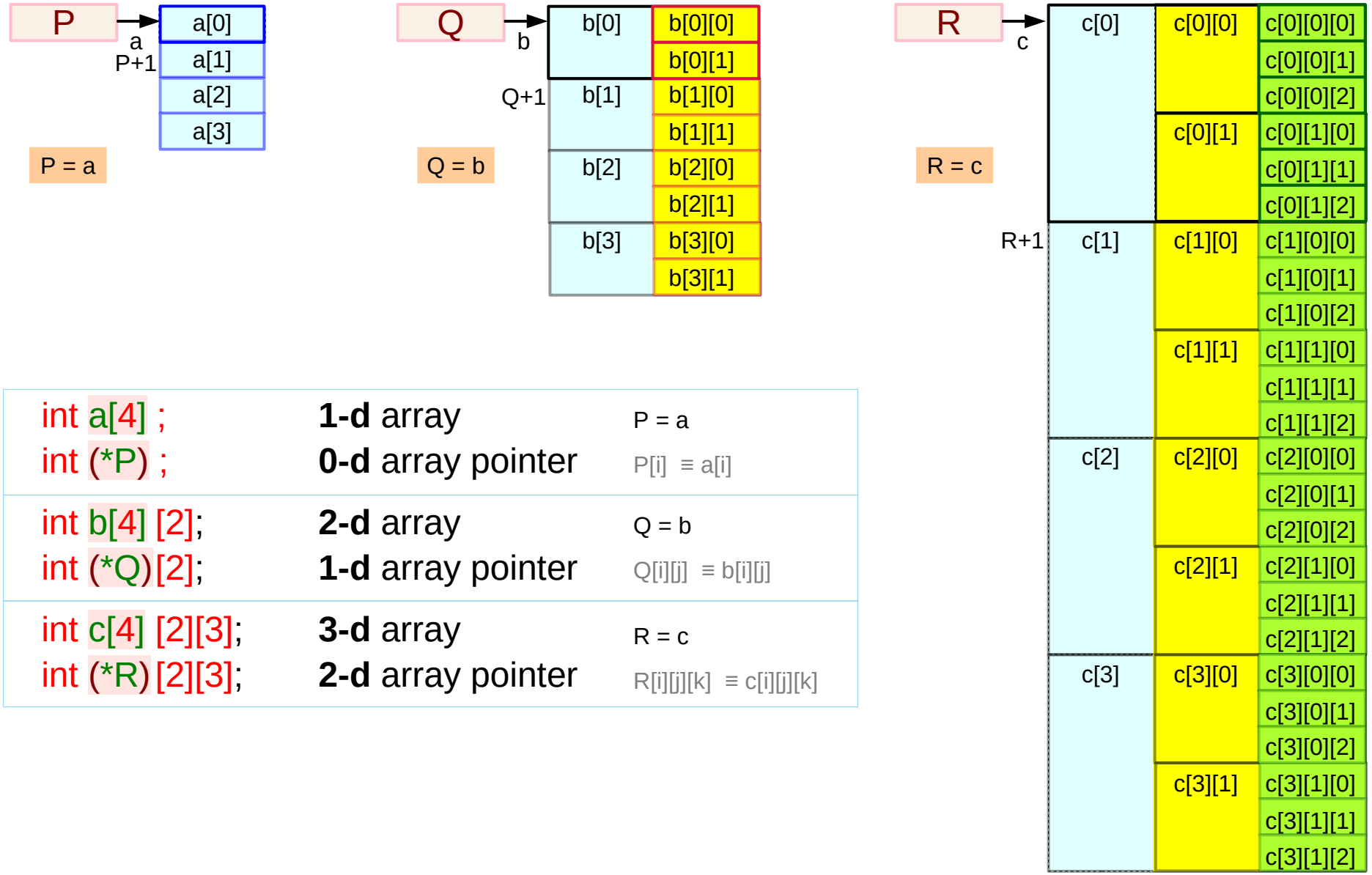


Array pointers p, q, r for **minimal** references



int a [4];	**1-d** array	p = &a
int (*p) [4];	**1-d** array pointer	(*p)[i] ≡ a[i]
int b [4][2];	**2-d** array	q = &b
int (*q) [4][2];	**2-d** array pointer	(*q)[i][j] ≡ b[i][j]
int c [4][2][3];	**3-d** array	r = &c
int (*r) [4][2][3];	**3-d** array pointer	(*r)[i][j][k] ≡ c[i][j][k]

Array pointers P, Q, R for **extended** references



int a[4] ;	**1-d** array	P = a
int (*P) ;	**0-d** array pointer	P[i] ≡ a[i]
int b[4] [2];	**2-d** array	Q = b
int (*Q)[2];	**1-d** array pointer	Q[i][j] ≡ b[i][j]
int c[4] [2][3];	**3-d** array	R = c
int (*R)[2][3];	**2-d** array pointer	R[i][j][k] ≡ c[i][j][k]

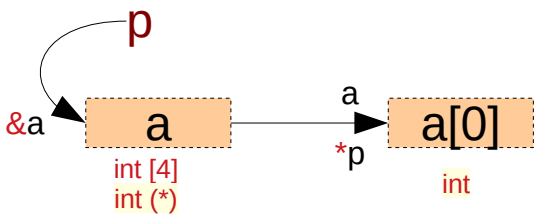
n-d array pointer to a *n*-d array – **minimal** references

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

a[i] ≡ (*p)[i]

1-d array a

1-d array pointer p (p = &a)

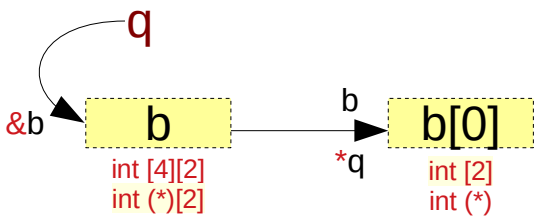



```
int  b [4][2];
int (*q) [4][2];
```

b[i][j] ≡ (*q)[i][j]

2-d array b

2-d array pointer q (q = &b)

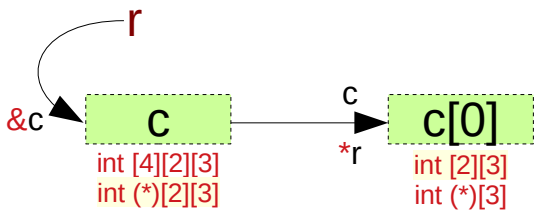



```
int  c [4][2][3];
int (*r) [4][2][3];
```

c[i][j][k] ≡ (*r)[i][j][k]

3-d array c

3-d array pointer r (r = &c)

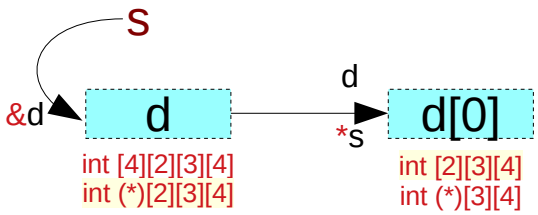



```
int  d [4][2][3][4];
int (*s) [4][2][3][4];
```

d[i][j][k][l] ≡ (*s)[i][j][k][l]

4-d array d

4-d array pointer s (s = &d)



(*n*-1)-d array pointer to a *n*-d array – **extended** references

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

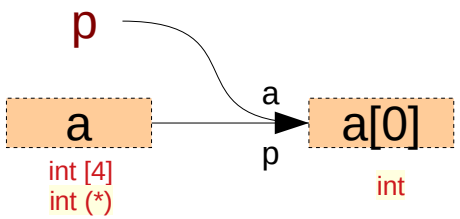
a[i] ≡ p[i]

1-d array a

0-d array pointer p

p = &a[0];

(p = a)




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

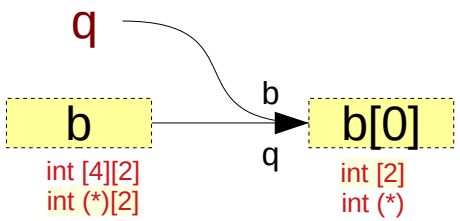
b[i][j] ≡ q[i][j]

2-d array b

1-d array pointer q

q = &b[0];

(q = b)




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

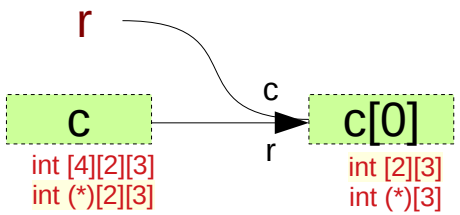
c[i][j][k] ≡ r[i][j][k]

3-d array c

2-d array pointer r

r = &c[0];

(r = c)




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

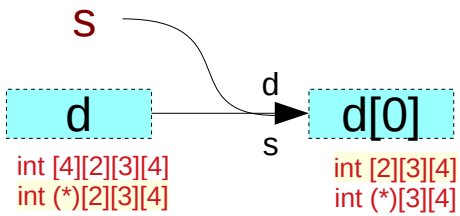
d[i][j][k][l] ≡ s[i][j][k][l]

4-d array d

3-d array pointer s

s = &d[0];

(s = d)



Relationship between array and array pointer types

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

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

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

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

int b[4][2] ; declare a **2-d** array b

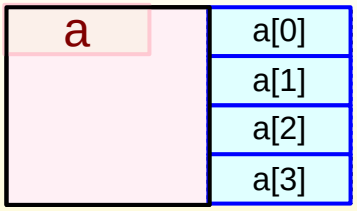
int (*) [2] b as a **1-d** array pointer

int (*B)[2] ; declare a **1-d** array pointer B

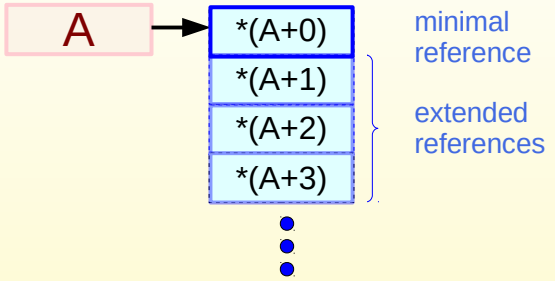
int [N][2] B as a **2-d** array

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

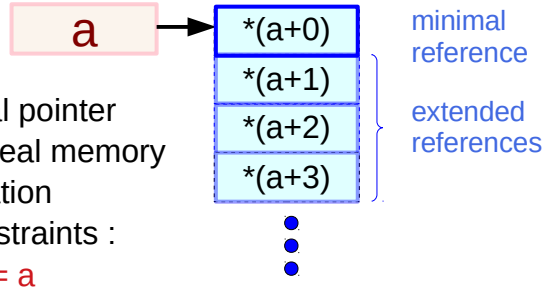
int a[4] ; **1-d** array a



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

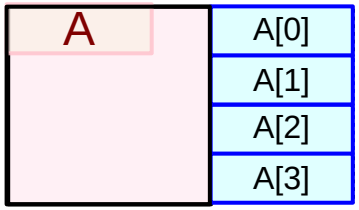


int (*) a as a **0-d** array pointer



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

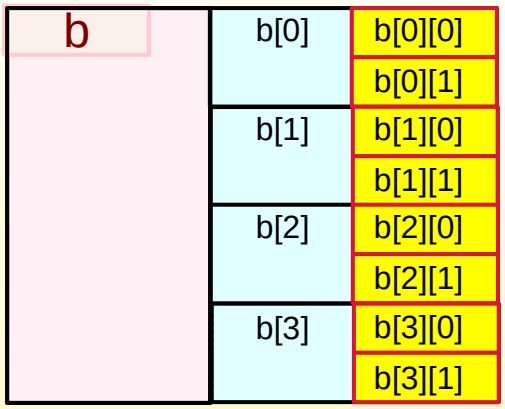
a is not a real pointer
- sizeof(a) = an array size
- a = &a

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

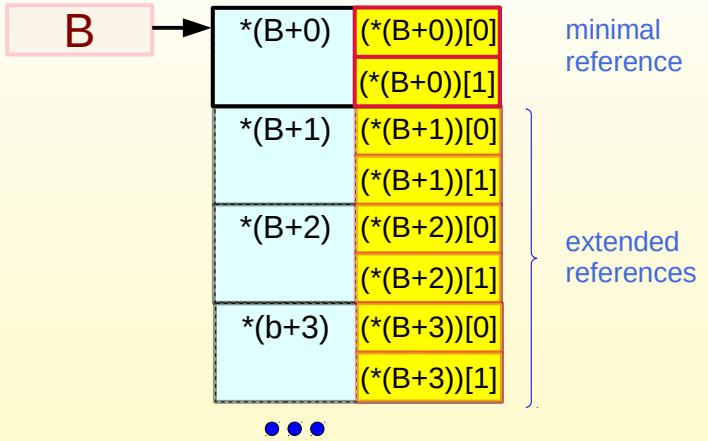
A is not a real array
- sizeof(A) = a pointer size
- A ≠ &A

Array **b** and array pointers **B**

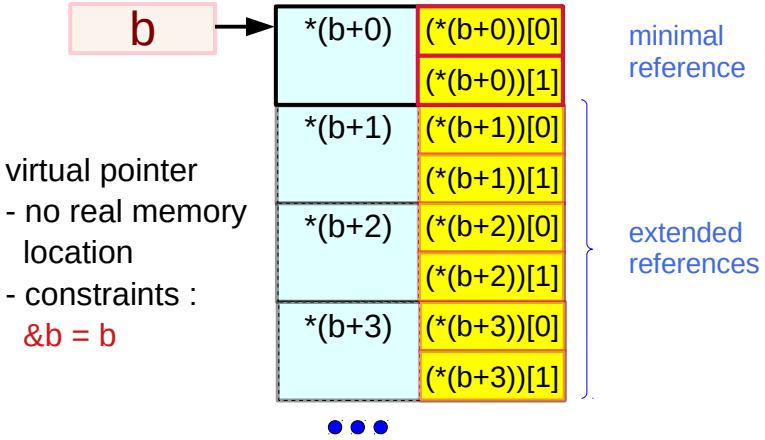
int b[4][2] ; **2-d** array b



int (*B) [2] ; **1-d** array pointer B

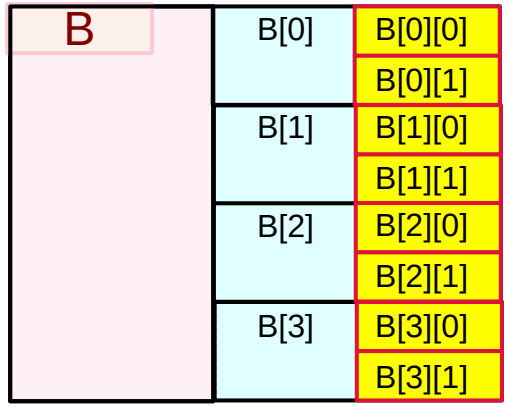


int (*) [2] b as a **1-d** array pointer



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

int [N][2] B as a **2-d** array



N is not fixed to 4

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

Array **b** and array pointers **B**

`int b[4][2] ;` **2-d** array b

- sizeof(b) = an array size
  = 4 * 2 * 4 bytes
- # of 1-d arrays = fixed
  = 4

`int (*) [2]` b as a **1-d** array pointer

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

`int (*B) [2] ;` **1-d** array pointer B

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

`int [N][2]` B as a **2-d** array

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

Dual type - relaxing the 1st dimension of an array

int a[4] ; *array declaration*

int [4]	**1-d** array
∩	more constrained type Like a **subtype**
int (*)	**0-d** array pointer
	more general type Like a **supertype**

int (*A) ; *pointer declaration*

int (*)	**0-d** array pointer
∪	more general type Like a **supertype**
int [N]	**1-d** array
	more constrained type Like a **subtype**

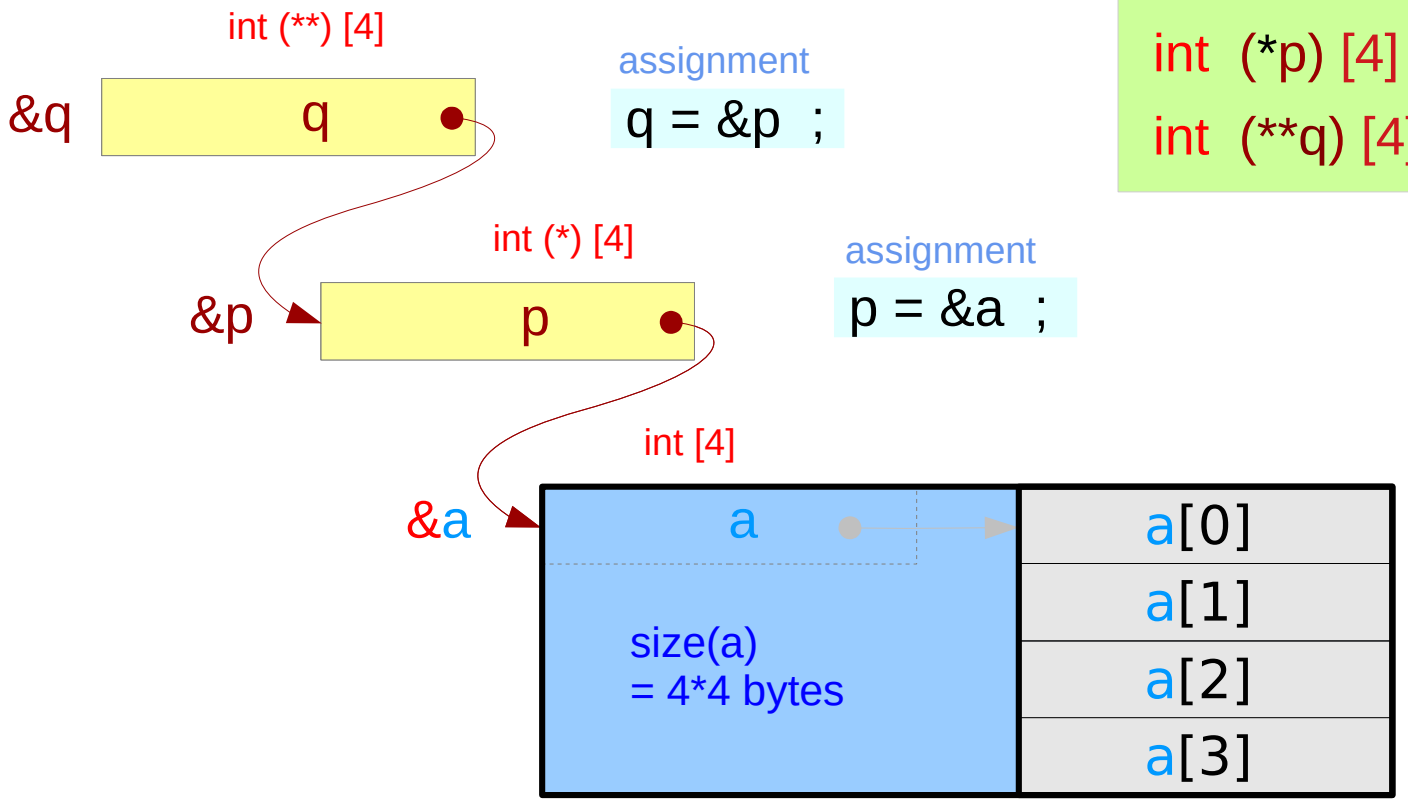
int b[4][2] ; *array declaration*

int [4][2]	**2-d** array
∩	more constrained type Like a **subtype**
int (*)[2]	**1-d** array pointer
	more general type Like a **supertype**

int (*B) [2] ; *pointer declaration*

int (*)[2]	**1-d** array pointer
∪	more general type Like a **supertype**
int [N][2]	**2-d** array
	more constrained type Like a **subtype**

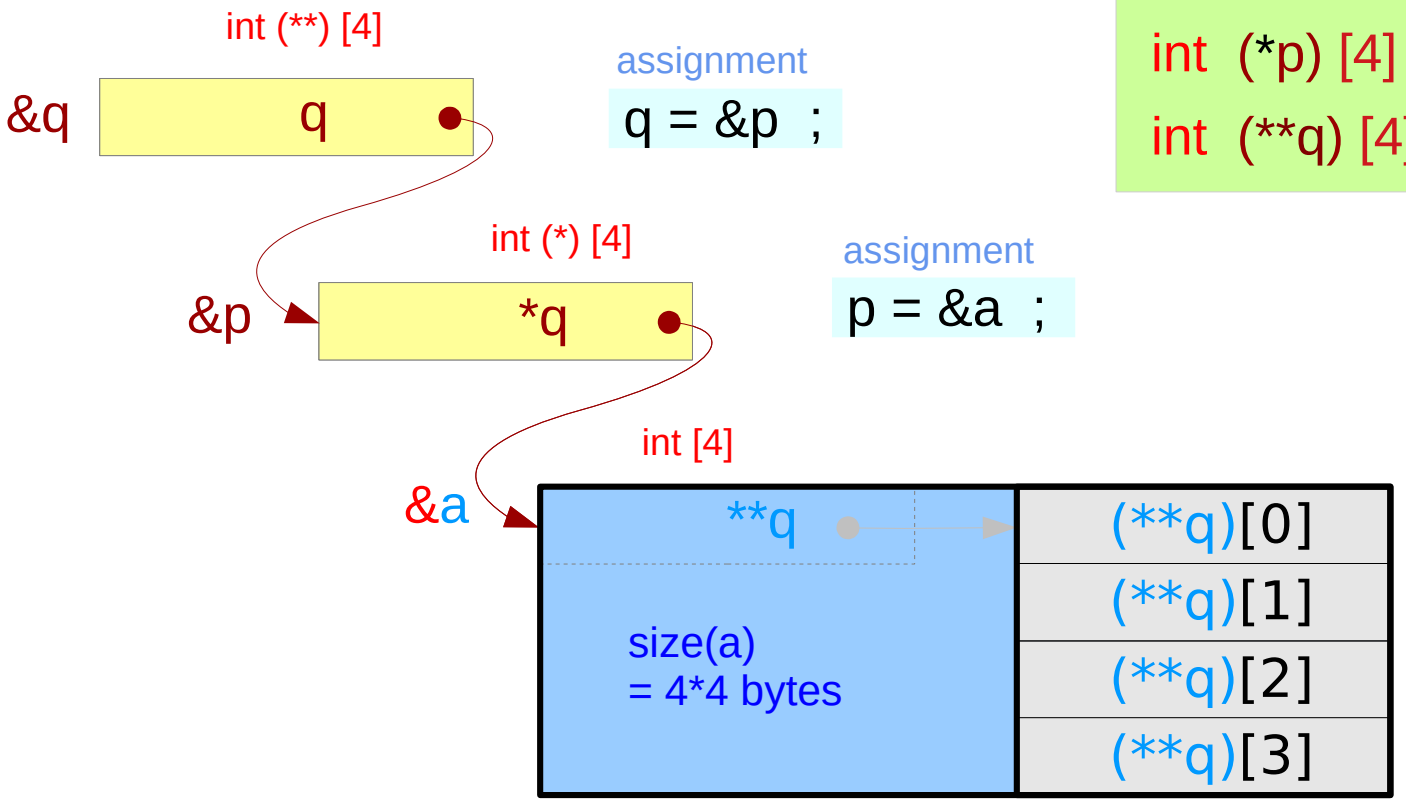
Double pointer to a **1-d** array – a variable view (p, q)




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

```
p = &a ;
q = &p ;
```

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

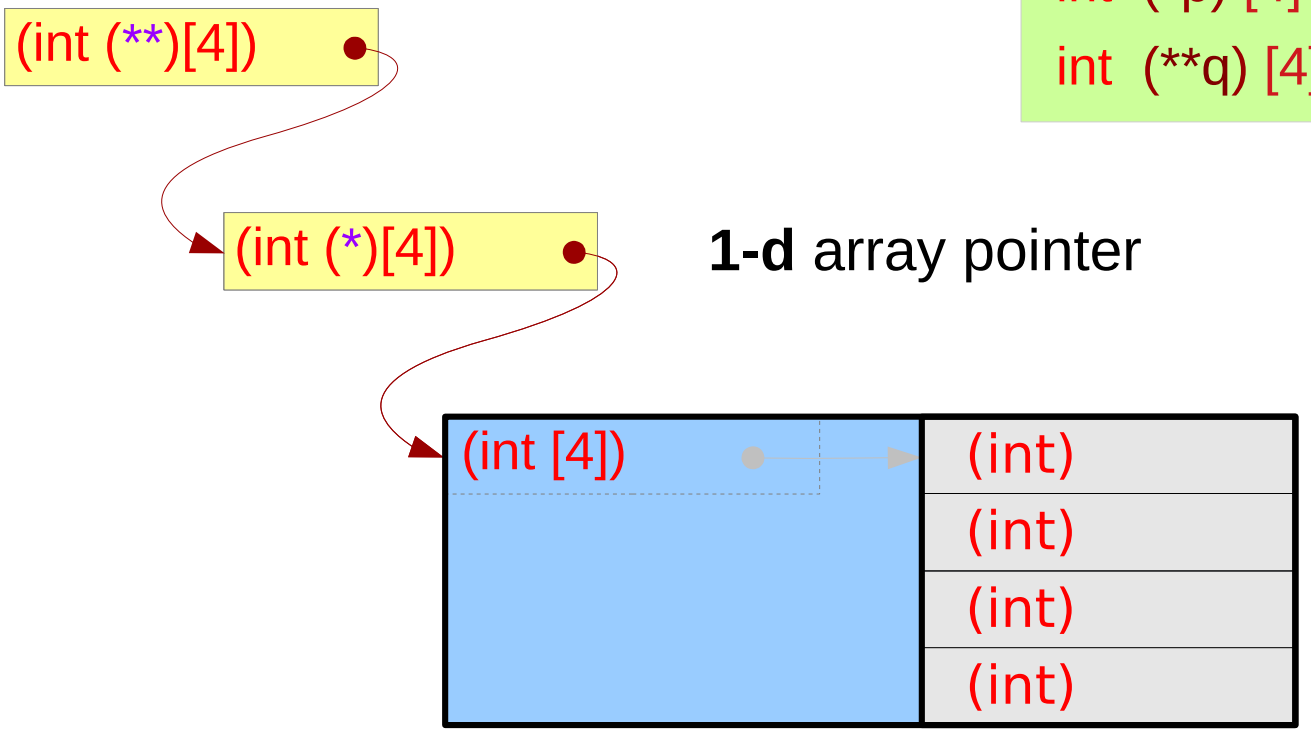



```
int  a [4]  ;
int  (*p) [4] = &a ;
int  (**q) [4] = &p ;
```

```
p = &a ;
q = &p ;
```

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

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



1-d array pointer

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

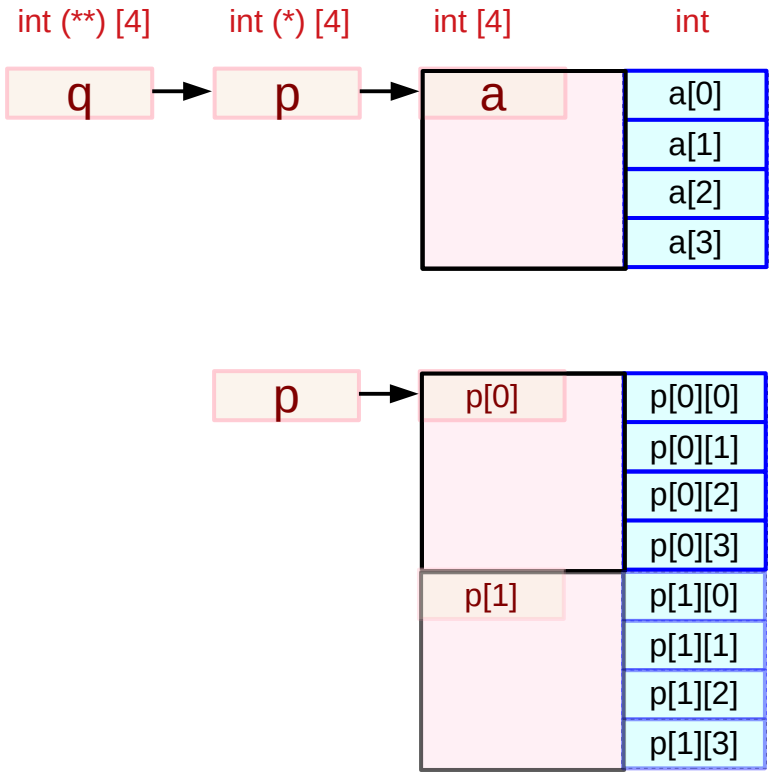
p = &a ;

q = &p ;

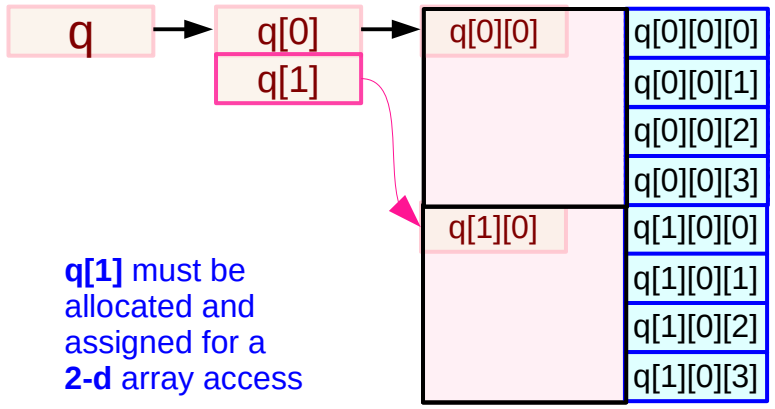
Double array pointer

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

1-d array a




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

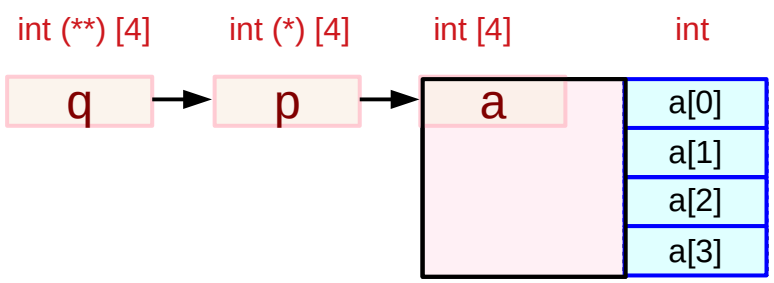


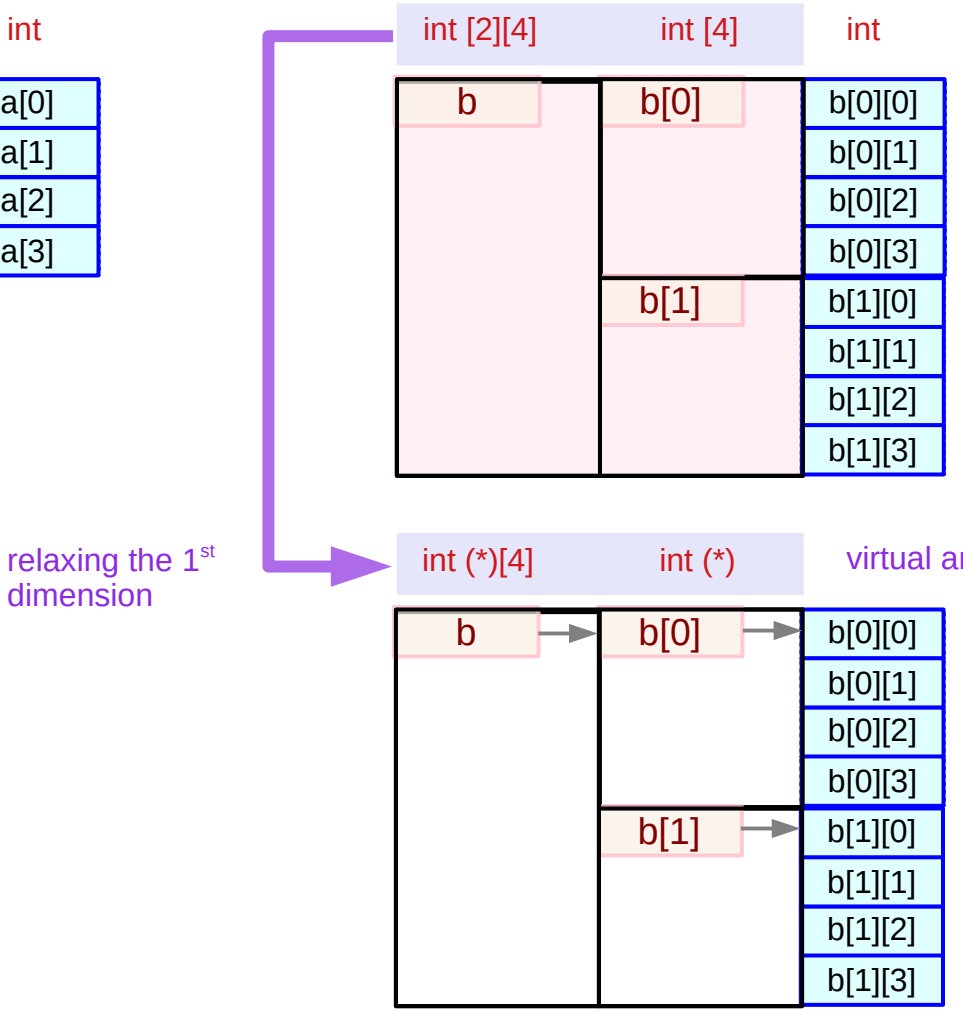
q[1] must be allocated and assigned for a **2-d** array access

Array pointer and subarray types

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

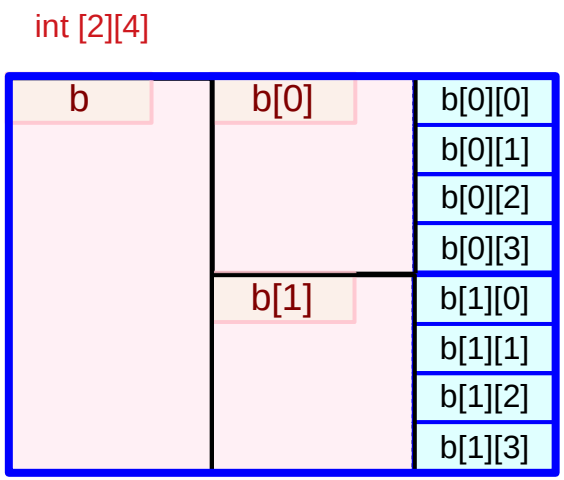
int b[2][4]; **2-d** array b

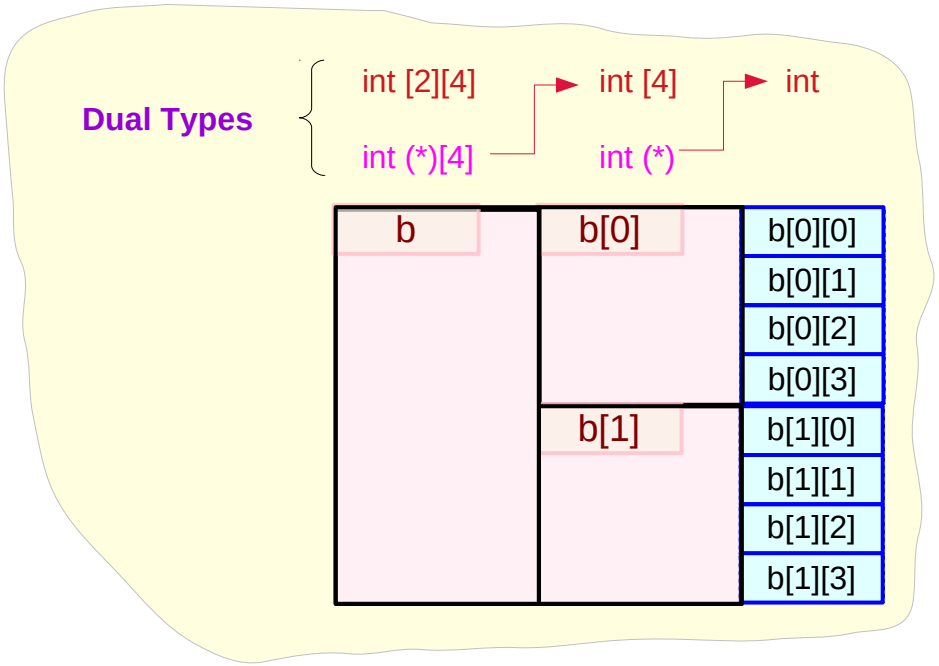


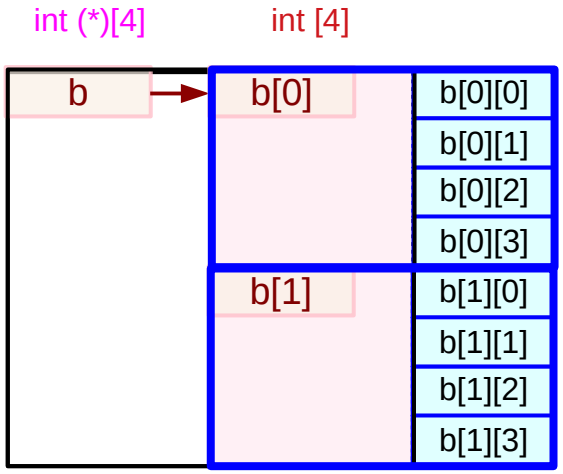


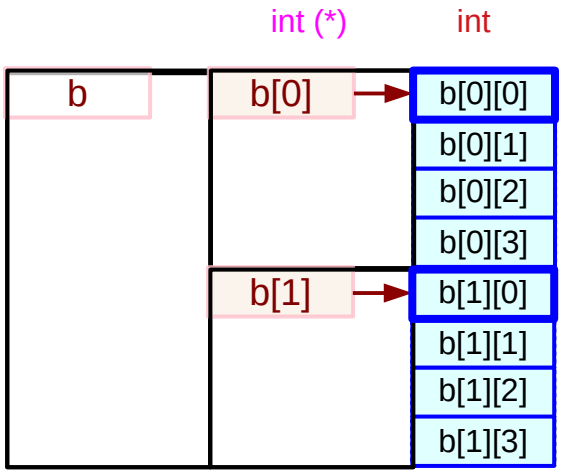
Dual types in a **2-d** array

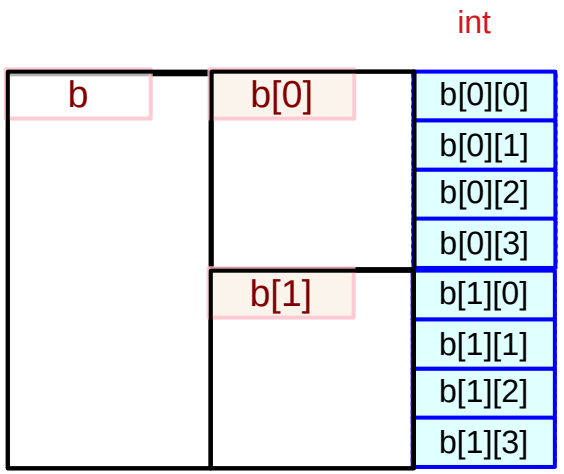
`int b[2][4];` **2-d** array b





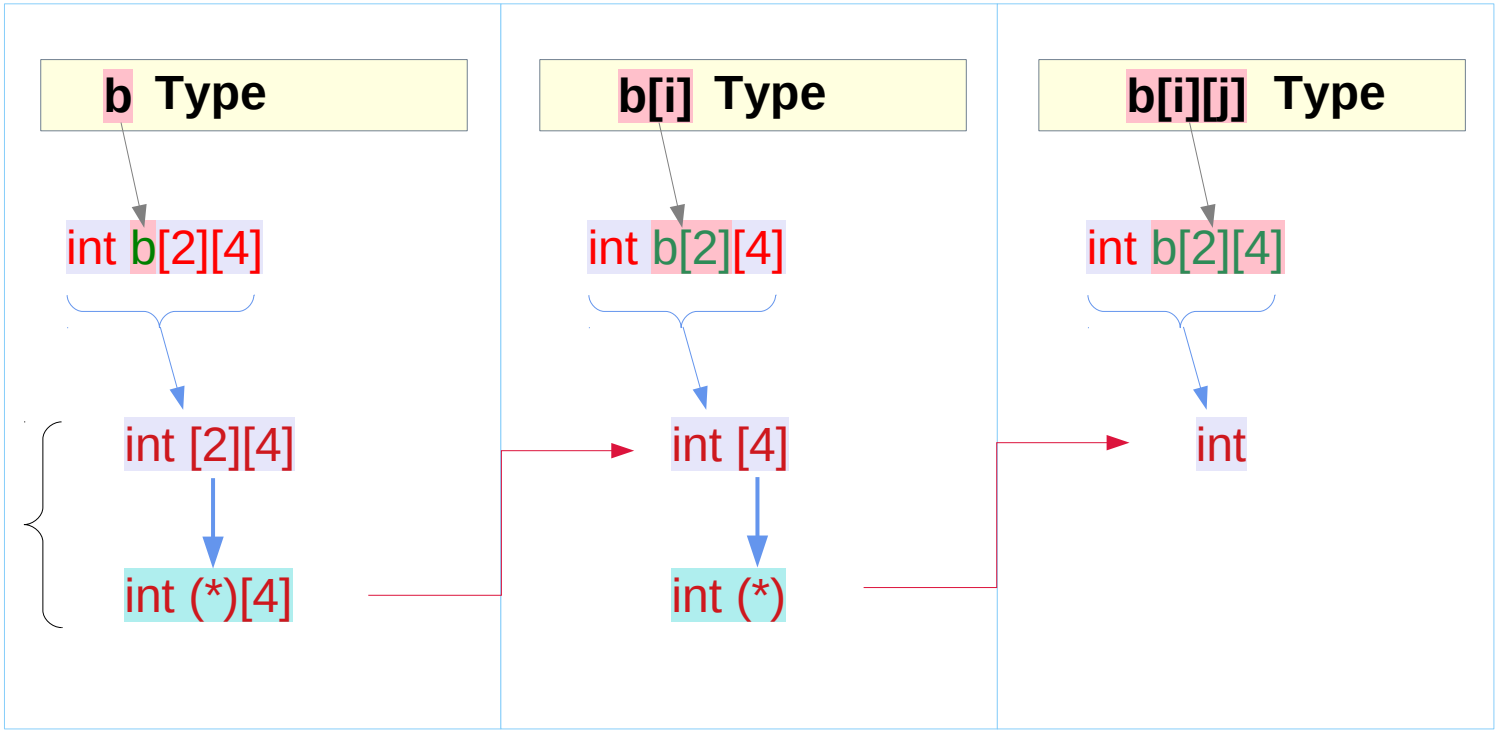






Subarray types in a **2-d** array

int b[2][4]; **2-d** array b



Subarray type examples

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

			virtual	
a	int [4]	**1-d** array type	int (*)	**0-d** array pointer type
a[i]	int	**0-d** array type		

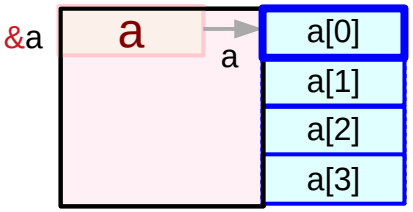
`int b[2][4];` **2-d** array b

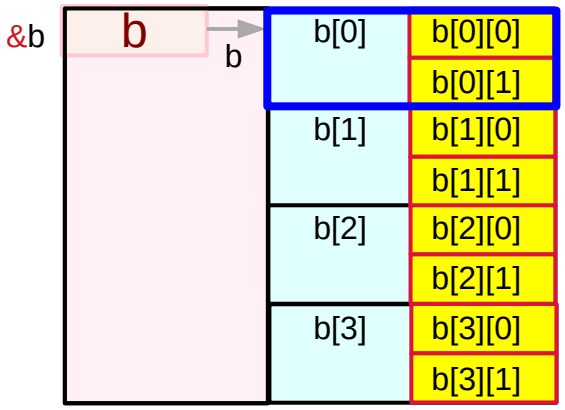
			virtual	
b	int [2][4]	**2-d** array type	int (*)[4]	**1-d** array pointer type
b[i]	int [4]	**1-d** array type	int (*)	**0-d** array pointer type
b[i][j]	int	**0-d** array type		

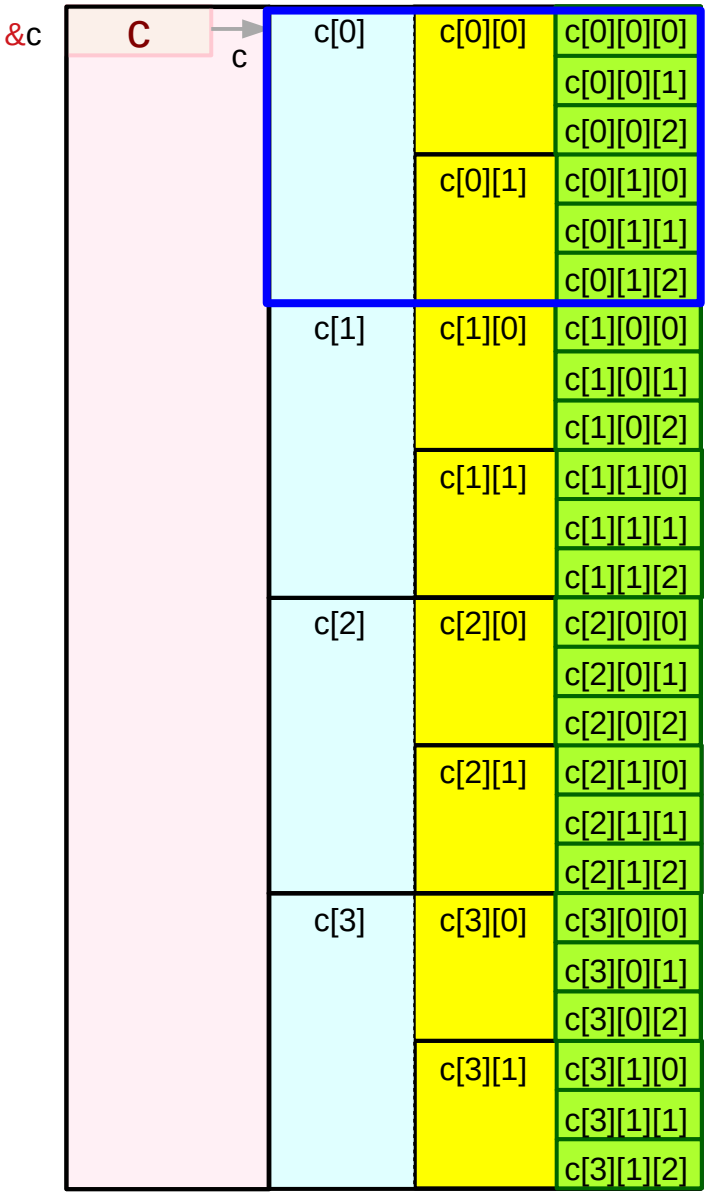
`int c[4][2][3];` **3-d** array c

			virtual	
c	int [4][2][3]	**3-d** array type	int (*)[2][3]	**2-d** array pointer type
c[i]	int [4][2]	**2-d** array type	int (*)[2]	**1-d** array pointer type
c[i][j]	int [4]	**1-d** array type	int (*)	**0-d** array pointer type
c[i][j][k]	int	**0-d** array type		

Types of **a**, **b**, **c** arrays



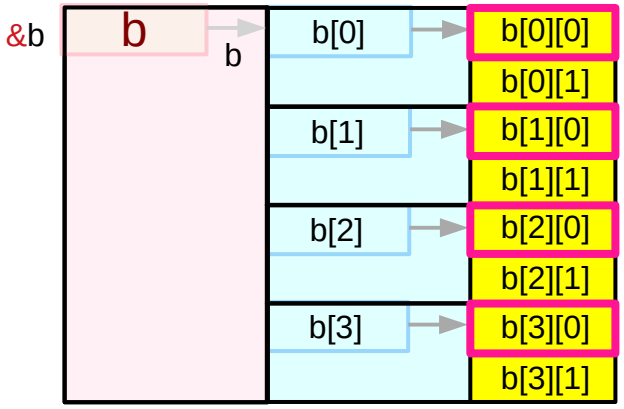


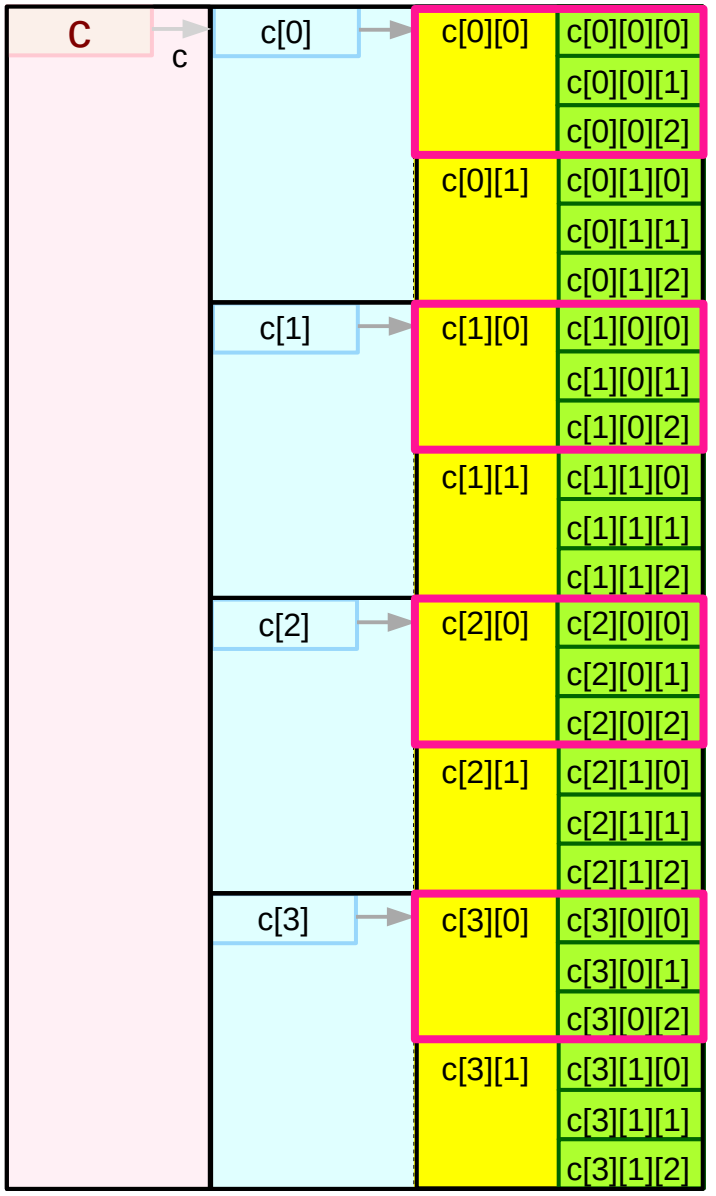


dual types

int [4]	**1-d** array **a**
int (*)	**0-d** array pointer **a** (virtual)
int [4][2];	**2-d** array **b**
int (*)[2];	**1-d** array pointer **b** (virtual)
int [4][2][3];	**3-d** array **c**
int (*)[2][3];	**2-d** array pointer **c** (virtual)

Types of **b[i]**, **c[i]** subarrays





dual types

int [2]	**1-d** array **b[i]**
int (*)	**0-d** array pointer **b[i]** (virtual)
int [2][3];	**2-d** array **c[i]**
int (*)[3];	**1-d** array pointer **c[i]** (virtual)

Types of **c[i][j]** subarrays

dual types

int [3]	**1-d** array **c[i][j]**
int (*)	**0-d** array pointer **c[i][j]** (virtual)

Types of a **4-d** array and its subarrays

int **d**[4][2][3][4];

		types	
d	consider d[4][2][3][4]	➡ int [4][2][3][4]	⇨ **4-d** array
	relax the 1st dimension	➡ int (*)[2][3][4]	⇨ **3-d** array pointer (virtual)
d[i]	consider d[i][2][3][4]	➡ int [2][3][4]	⇨ **3-d** array
	relax the 1st dimension	➡ int (*)[3][4]	⇨ **2-d** array pointer (virtual)
d[i][j]	consider d[i][j][3][4]	➡ int [3][4]	⇨ **2-d** array
	relax the 1st dimension	➡ int (*)[4]	⇨ **1-d** array pointer (virtual)
d[i][j][k]	consider d[i][j][k][4]	➡ int [4]	⇨ **1-d** array
	relax the 1st dimension	➡ int (*)	⇨ **0-d** array pointer (virtual)

i,j,k are specific index values i=[0..3], j=[0..1], k=[0..2]

Initializing *n*-d array pointers with *n*-d subarrays

int d[4][2][3][4];

d	**4-d** array	d[4][2][3][4]	p = &d (*p=d)
p	**4-d** array pointer	(*p)[4][2][3][4]	int (*p)[4][2][3][4] = &d;
			(*p)[i][j][k][l] ≡ d[i][j][k][l]
d[i]	**3-d** array	d[i][2][3][4]	q = &d[i] (*q=d[i])
q	**3-d** array pointer	(*q)[2][3][4]	int (*q)[3][4] = &d[i];
			(*q)[j][k][l] ≡ d[i][j][k][l] given i
d[i][j]	**2-d** array	d[i][j][3][4]	r = &d[i][j] (*r=d[i][j])
	2-d array pointer	(*r)[3][4]	int (*r)[4] = &d[i][j];
r			(*r)[k][l] ≡ d[i][j][k][l] given i, j
d[i][j][k]	**1-d** array	d[i][j][k][4]	s = &d[i][j][k] (*s=d[i][j][k])
	1-d array pointer	(*s)[4]	int (*s) = &d[i][j][k];
s			(*s)[l] ≡ d[i][j][k][l] given i, j, k

Initializing (*n*-1)-**d** array pointers with *n*-**d** subarrays

int **d**[4][2][3][4];

d	**4-d** array	d[4][2][3][4]	p = d
p	**3-d** array pointer	(*p)[2][3][4]	int (*p)[2][3][4] = d;
			p[i][j][k][l] ≡ d[i][j][k][l]
d[i]	**3-d** array	d[i][2][3][4]	q = d[i]
q	**2-d** array pointer	(*q)[3][4]	int (*q)[3][4] = d[i];
			q[j][k][l] ≡ d[i][j][k][l] given i
d[i][j]	**2-d** array	d[i][j][3][4]	r = d[i][j]
r	**1-d** array pointer	(*r)[4]	int (*r)[4] = d[i][j];
			r[k][l] ≡ d[i][j][k][l] given i, j
d[i][j][k]	**1-d** array	d[i][j][k][4]	s = d[i][j][k]
s	**0-d** array pointer	(*s)	int (*s) = d[i][j][k];
			s[l] ≡ d[i][j][k][l] given i, j, k

Passing a *n*-d array pointer

1-d array

int **a** [4] ;

a :: int [4]

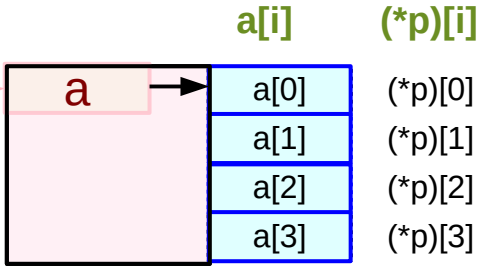
call &a :: int (*) [4]

funa(&**a**, …);

prototype

void **funa**(int (***p**)[4], …);

1-d array pointer p :: int (*) [4]



p

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

1-d array

int **a** [4] ;

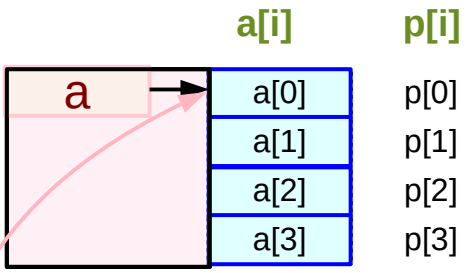
call a :: int [4]

funa(**a**, …);

prototype

void **funa**(int (***p**), …) {

0-d array pointer p :: int (*)



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

}

Passing *n*-d array pointers

1-d array	call	prototype 1-d array pointer
int **a** [4] ;	**funa**(&**a**, …);	void **funa**(int (***p**)[4], …);
a[i]		(*p)[i]

2-d array	call	prototype 2-d array pointer
int **b** [4][2];	**funb**(&**b**, …);	void **funb**(int (***q**)[4][2], …);
b[i][j]		(*q)[i][j]

3-d array	call	prototype 3-d array pointer
int **c** [4][2][3];	**func**(&**c**, …);	void **func**(int (***r**)[4][2][3], …);
c[i][j][k]		(*r)[i][j][k]

4-d array	call	prototype 4-d array pointer
int **d** [4][2][3][4];	**fund**(&**d**, …);	void **fund**(int (***s**)[4][2][3][4], …);
d[i][j][k][l]		(*s)[i][j][k][l]

Passing (*n*-1)-**d** array pointers

	call	prototype
1-d array		**0-d array pointer**
int **a**[4] ;	**funa**(**a**, …);	void **funa**(int (***p**), …);
a[i]		p[i]
2-d array		**1-d array pointer**
int **b**[4] [2];	**funb**(**b**, …);	void **funb**(int (***q**)[2], …);
b[i][j]		q[i][j]
3-d array		**2-d array pointer**
int **c**[4] [2][3];	**func**(**c**, …);	void **func**(int (***r**)[2][3], …);
c[i][j][k]		r[i][j][k]
4-d array		**3-d array pointer**
int **d**[4] [2][3][4];	**fund**(**d**, …);	void **fund**(int (***s**)[2][3][4], …);
d[i][j][k][l]		s[i][j][k][l]

Receiving (*n*-1)-**d** array pointers

1-d array

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

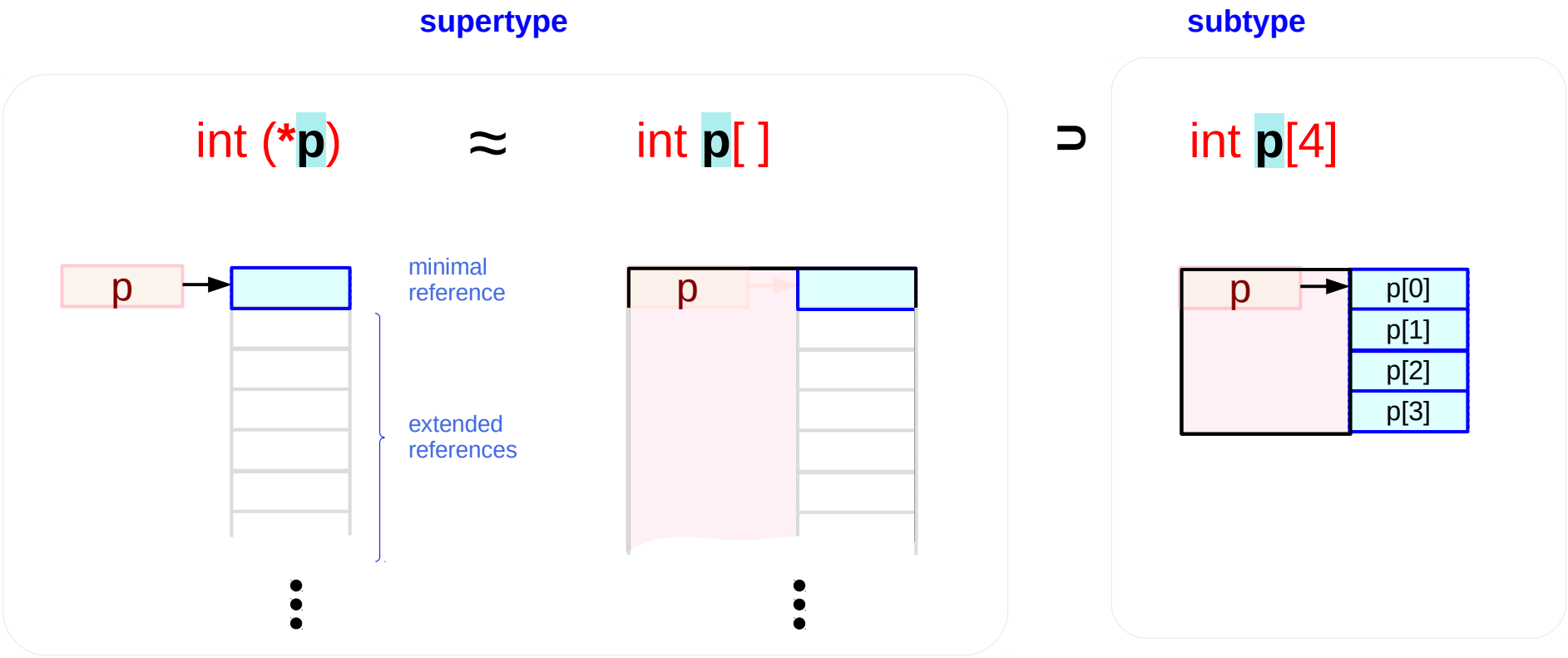
call a :: int [4]

```
funa(a, …);
```


prototype

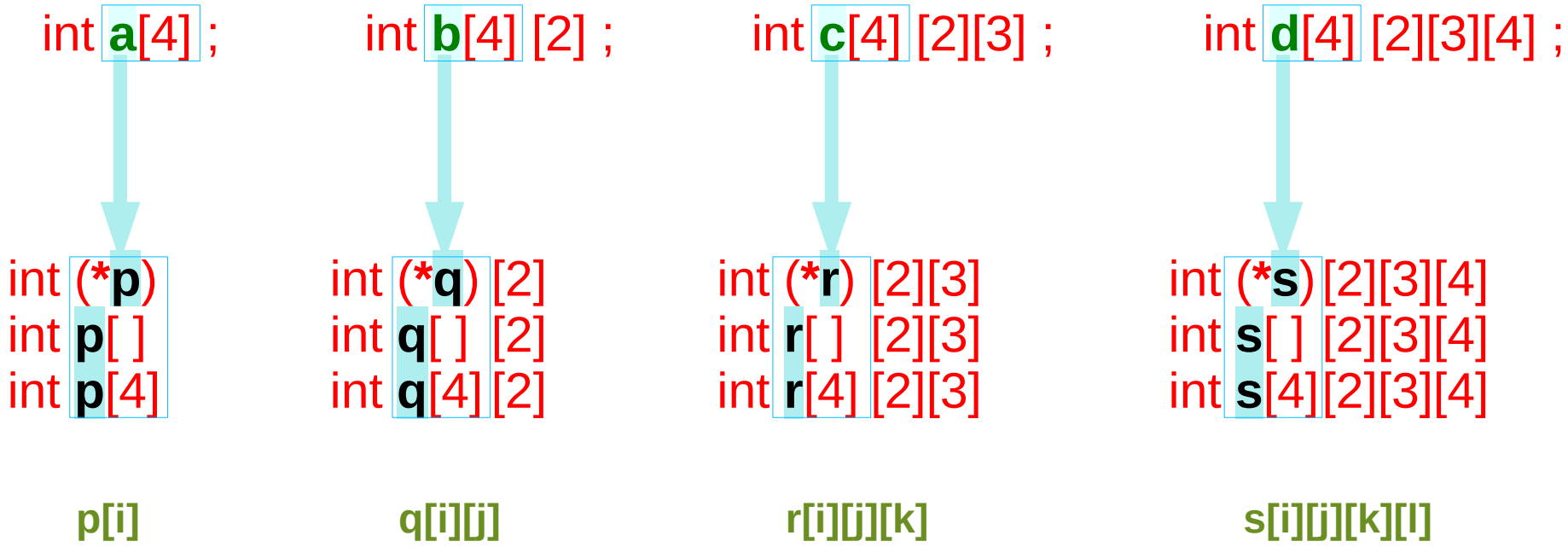
`void funa(int (*p), …) {`	**0-d array pointer**	p :: int (*)	**a[i]**
`void funa(int p[ ], …) {`	**1-d array, relaxed**	p :: int [ ]	**a[i]**
`void funa(int p[4], …) {`	**1-d array**	p :: int [4]	**a[i]**

int (*) and int [ ] types



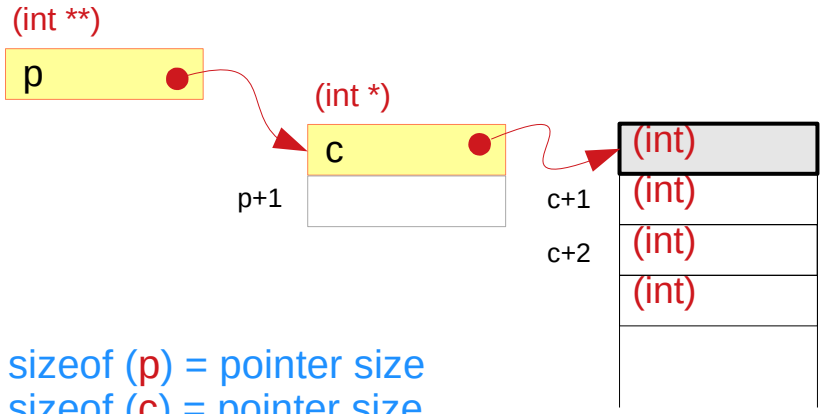
int p[ ] unsized array expression is only allowed
- in a function definition
- in an initialization

The 1st dimensions



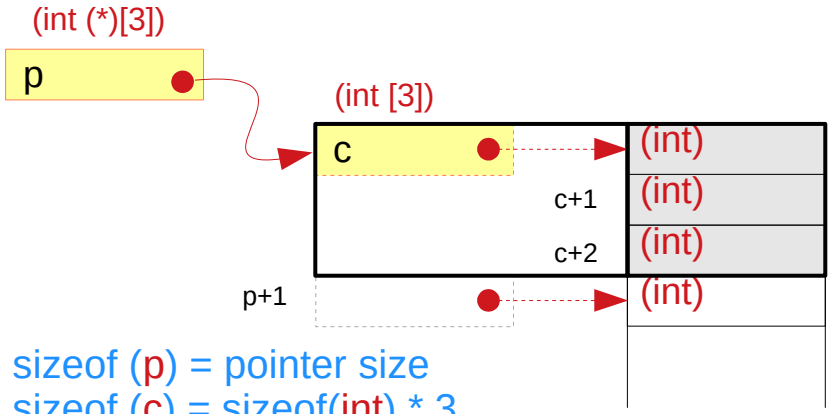
Integer pointer and array types – int **, int (*)[3], int[2][3]

int **p; int *c; v(&c) ≠ v(c)



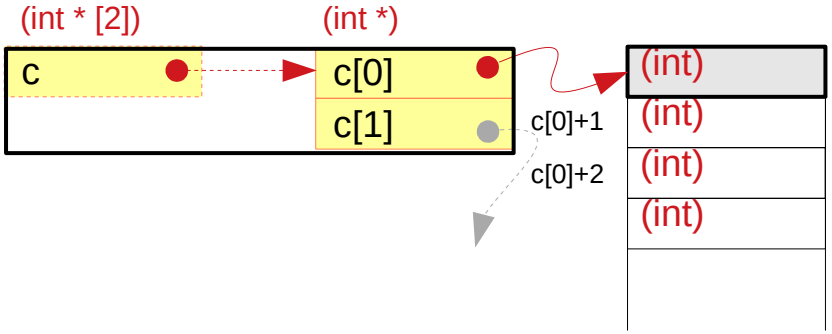
sizeof (p) = pointer size
sizeof (c) = pointer size

int (*p)[3]; int c[3]; v(&c) = v(c)



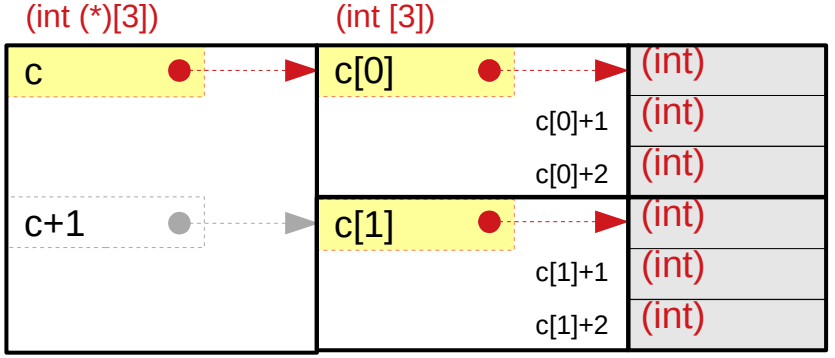
sizeof (p) = pointer size
sizeof (c) = sizeof(int) * 3

int* c[2]; v(&c[0]) ≠ v(c[0])



sizeof (c) = pointer size * 2
sizeof (c[0]) = pointer size

int c[2][3]; v(&c)=v(c) = v(&c[0])=v(c[0])



sizeof (c) = sizeof(int) * 2 * 3
sizeof (c[0]) = sizeof(int) * 3

Integer pointer types

```
#include <stdio.h>

void func(int d[ ])
{

}

int main(void) {
  int a[4];
  int *b;
  int **c;

  int (*p)[4];

  func(a);


}
```

```
sizeof(a)     = 16 = 4*4    // array size
sizeof(*a)    = 4           // int size

sizeof(b)     = 8           // pointer size
sizeof(*b)    = 4           // int size

sizeof(c)     = 8           // pointer size
sizeof(*c)    = 8           // pointer size
sizeof(**c)   = 4           // pointer size

sizeof(d)     = 8           // pointer size
sizeof(*d)    = 4           // int size

sizeof(p)     = 8           // pointer size
sizeof(*p)    = 16 = 4*4    // array size
```

Aggregate Data Types
Abstract Data Types
Virtual Array Pointers

Aggregate data type

an aggregate type

consists of **N** elements

each element
- starting address
- size

int [4][4]

dual type

a virtual pointer

the address and value of
a virtual pointer
are the *same*

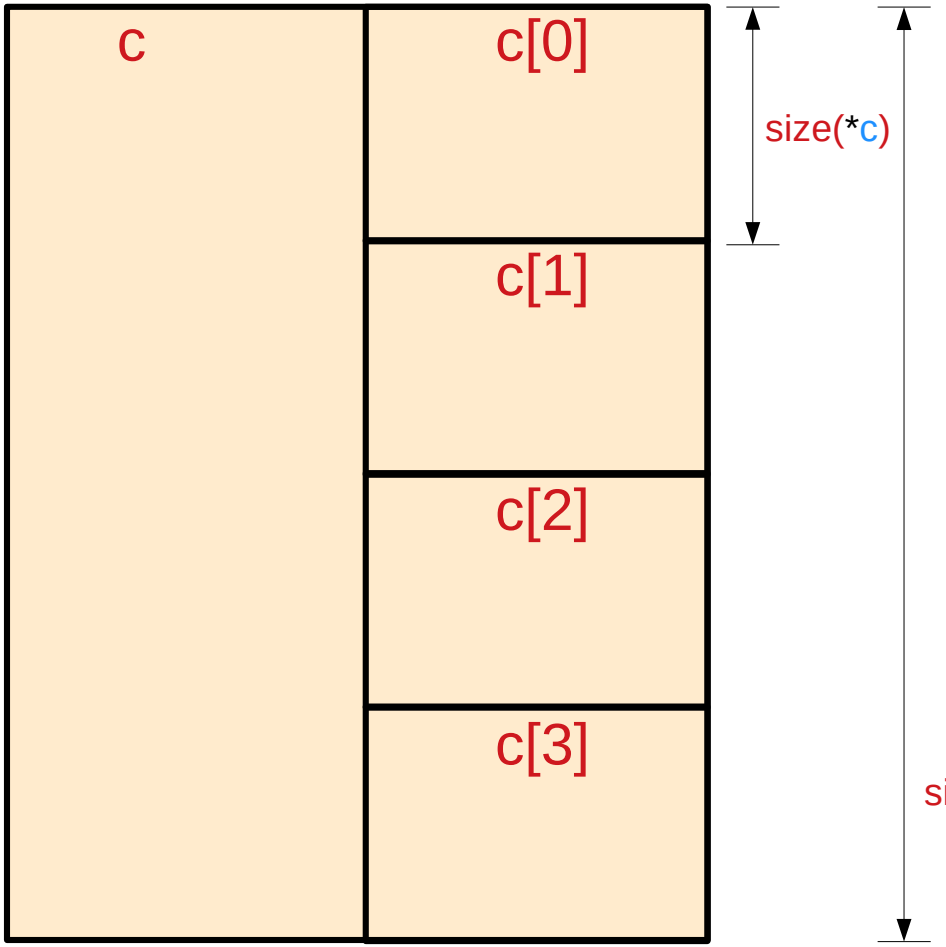
int (*)[4]

an abstract type

is considered as one unit

- starting address
- size

Aggregate data **c**

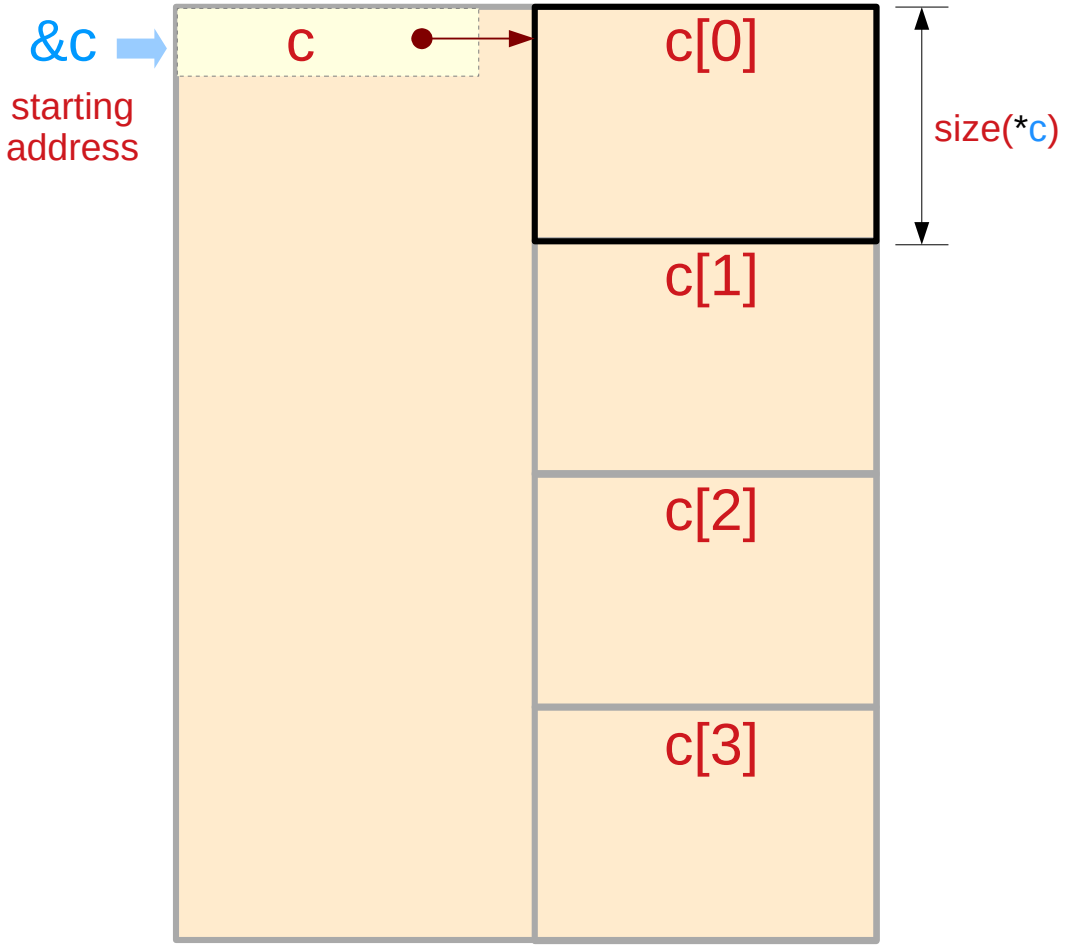


an aggregate type data c

- 1st element c[0]
- 2nd element c[1]
- 3rd element c[2]
- 4th element c[3]

Virtual pointer **c**

&c = c = &c[0]



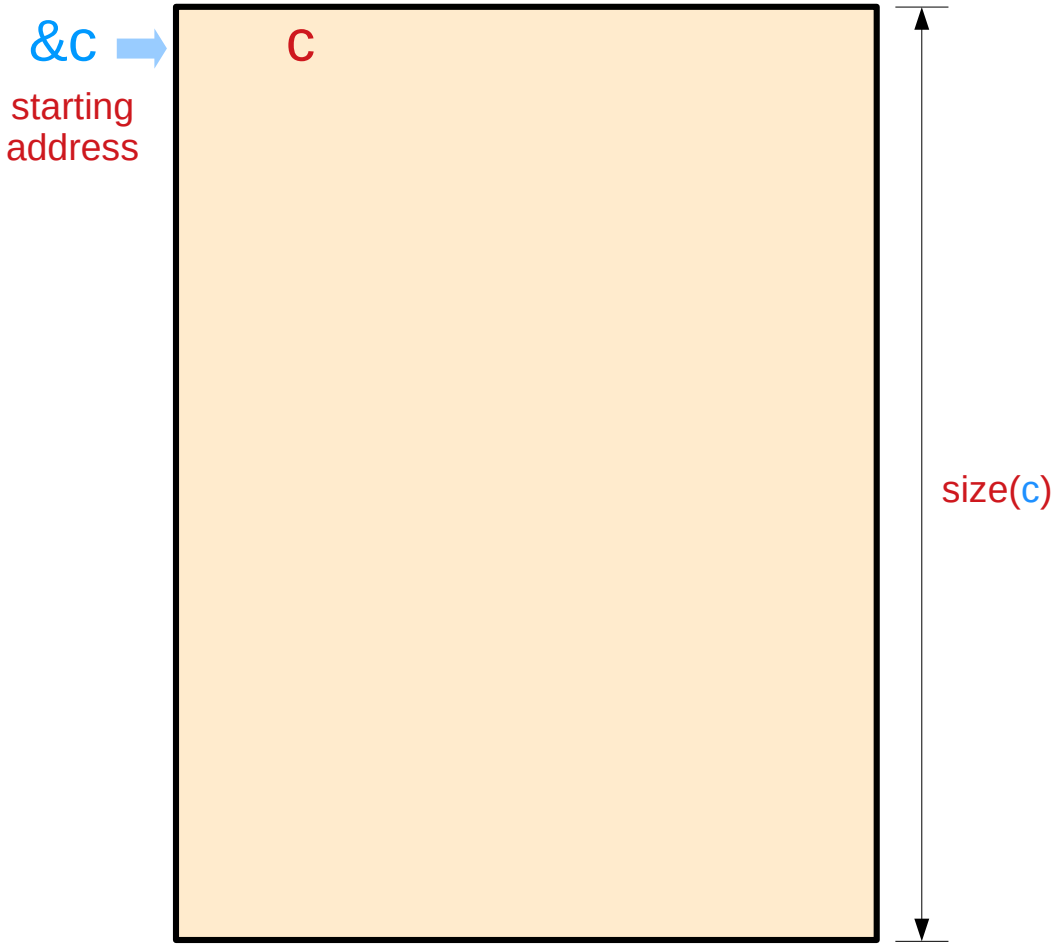
a virtual pointer c
- pointer address &c
- pointer value c = &c[0]

with the constraint
c = &c

an abstract data c[0]
- start address &c[0]
- size sizeof(c[0])

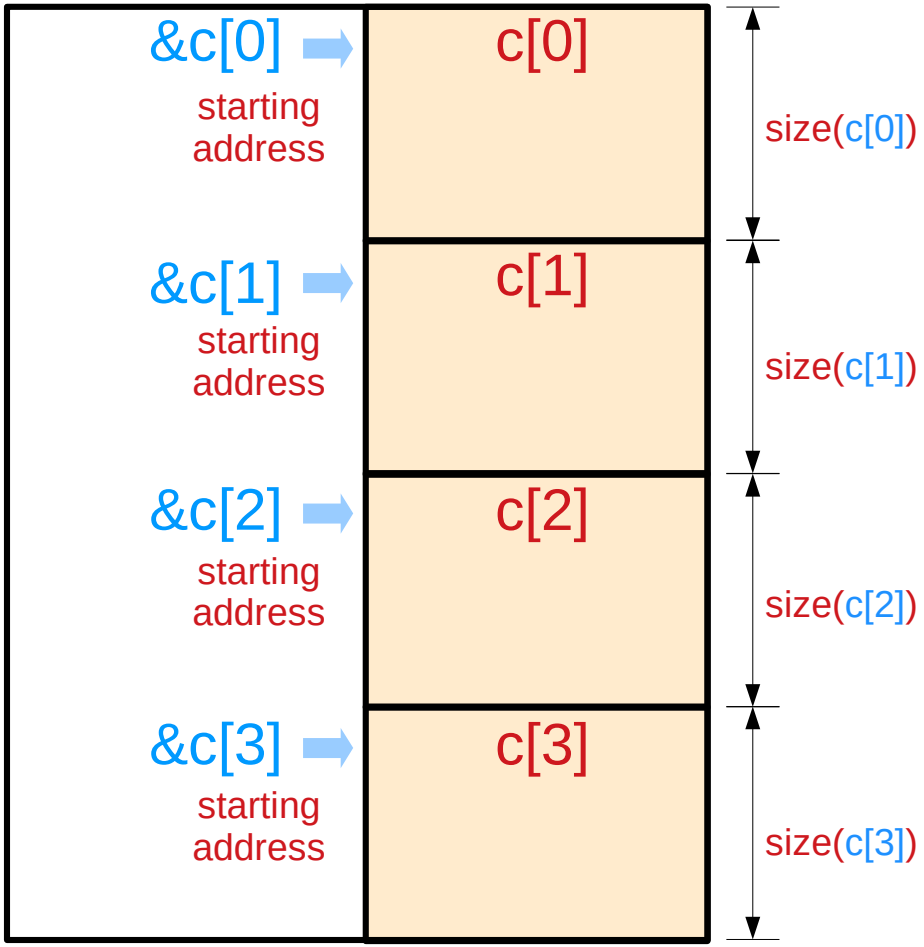
relationship between c and c[i]
virtual pointer c
points to abstract data c[i]

Abstract data **c**



an abstract data c
- start address &c
- size sizeof(c)

Abstract data **c[i]**

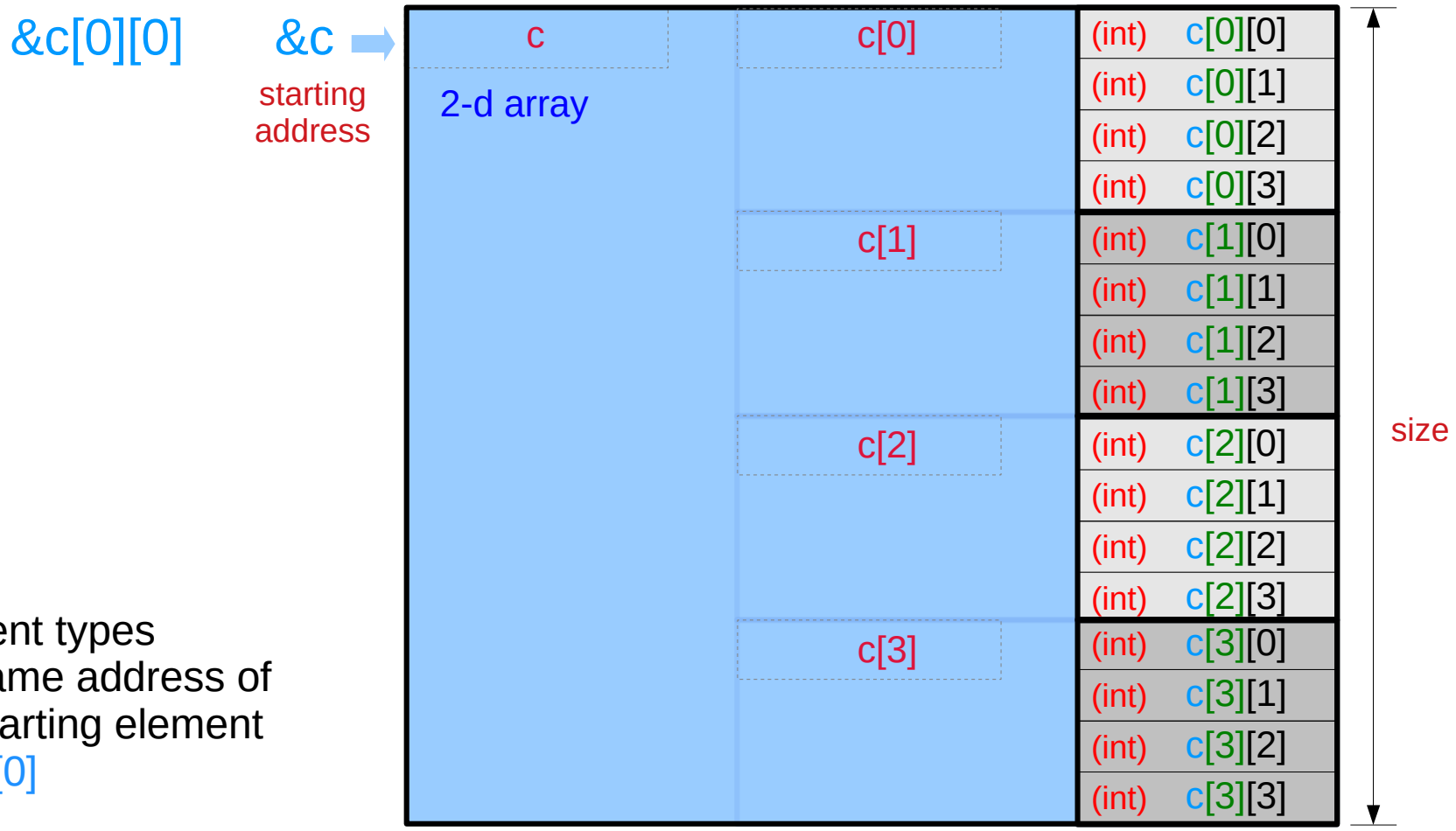


- an abstract data c[0]
  - start address &c[0]
  - size sizeof(c[0])
- an abstract data c[1]
  - start address &c[1]
  - size sizeof(c[1])
- an abstract data c[2]
  - start address &c[2]
  - size sizeof(c[2])
- an abstract data c[3]
  - start address &c[3]
  - size sizeof(c[3])

Abstract data **c**

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

An aggregate data c
- starting address &c
- size sizeof(c)

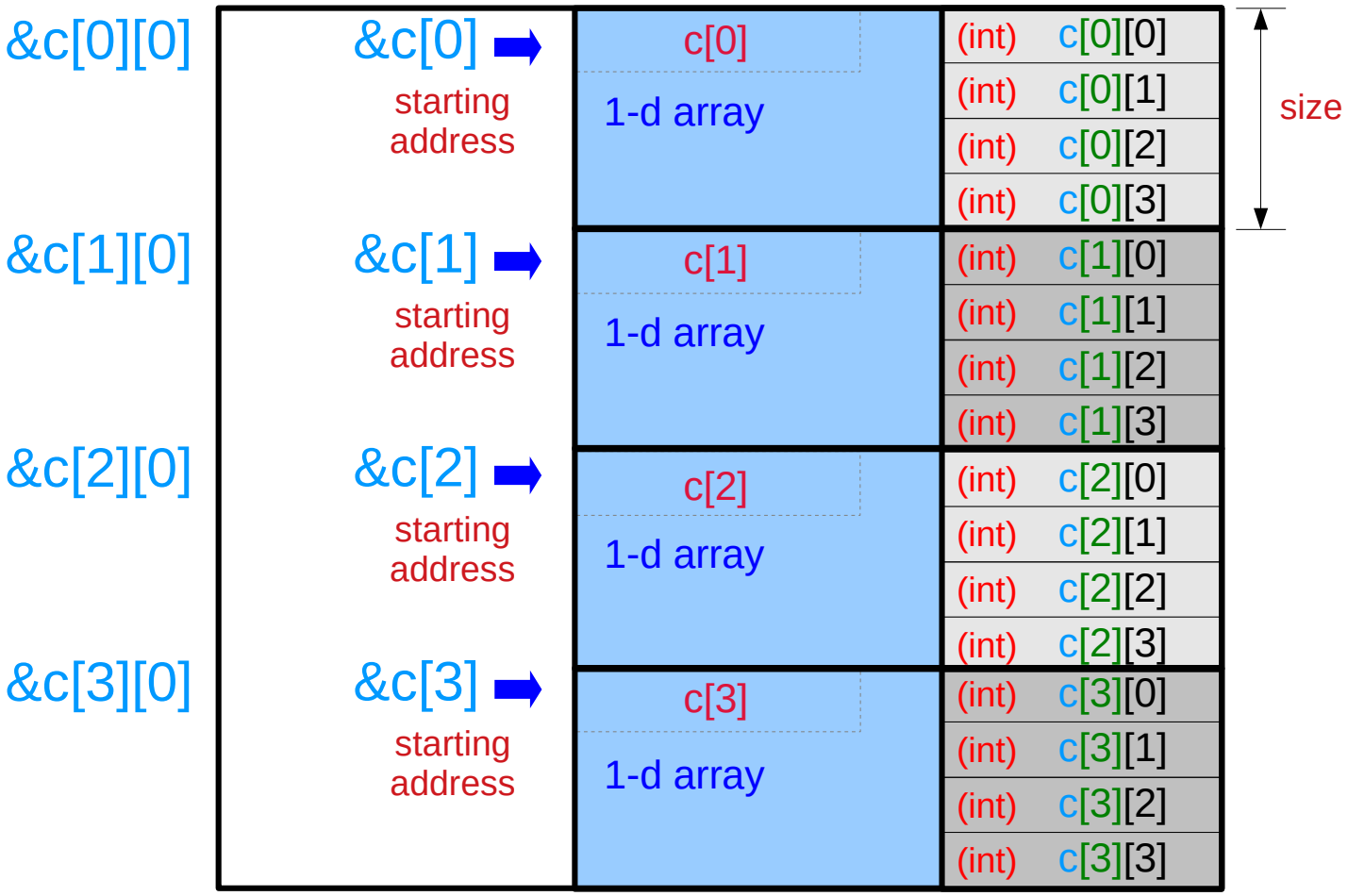


c and c[0]
- different types
- the same address of the starting element &c[0][0]

Abstract data **c[i]**

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

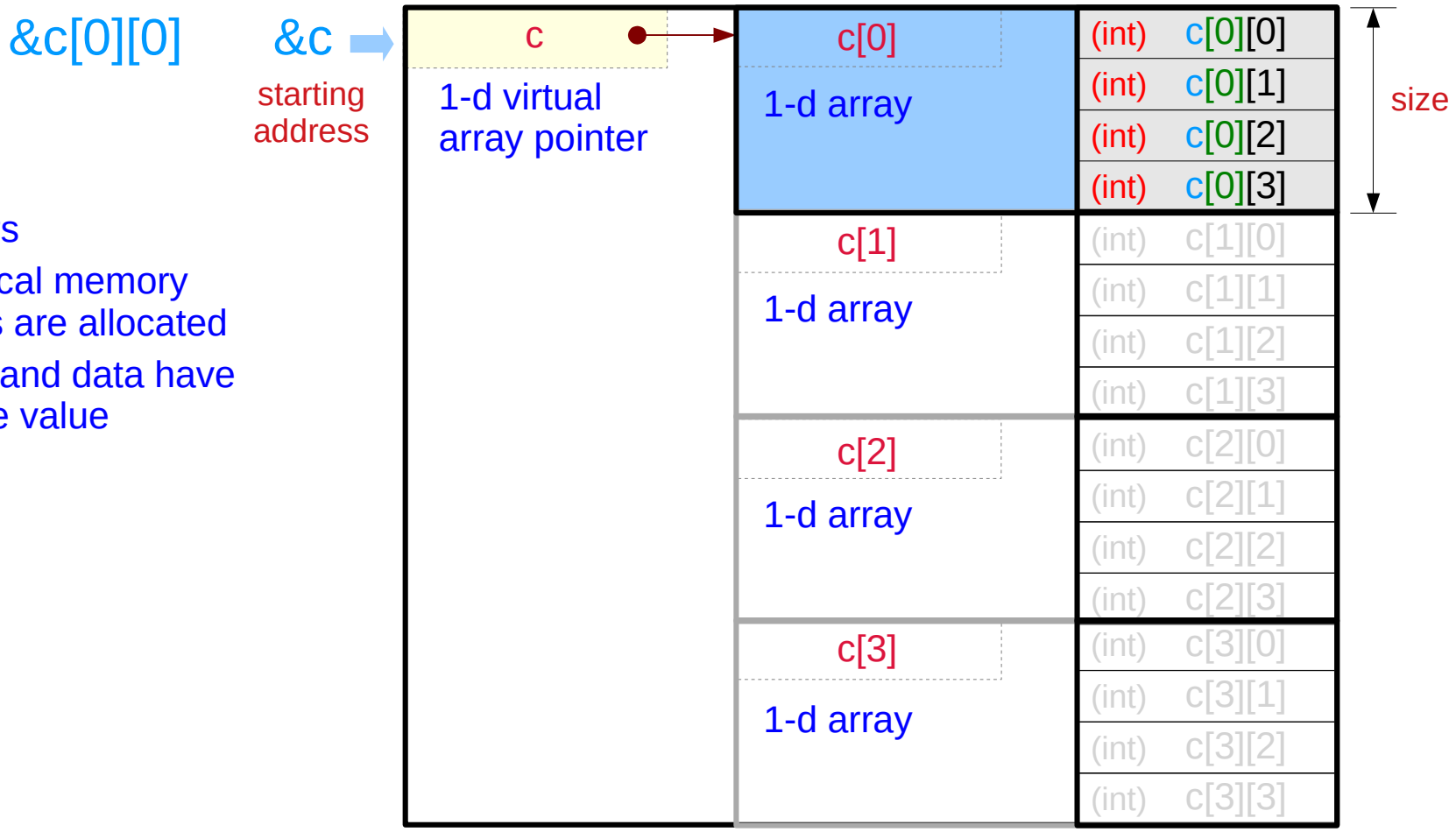
An aggregate data c[i]
- starting address &c[i]
- size sizeof(*c[i])



Virtual pointer **c**

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

A virtual pointer c
- pointer address &c
- pointer value &c[0] = c

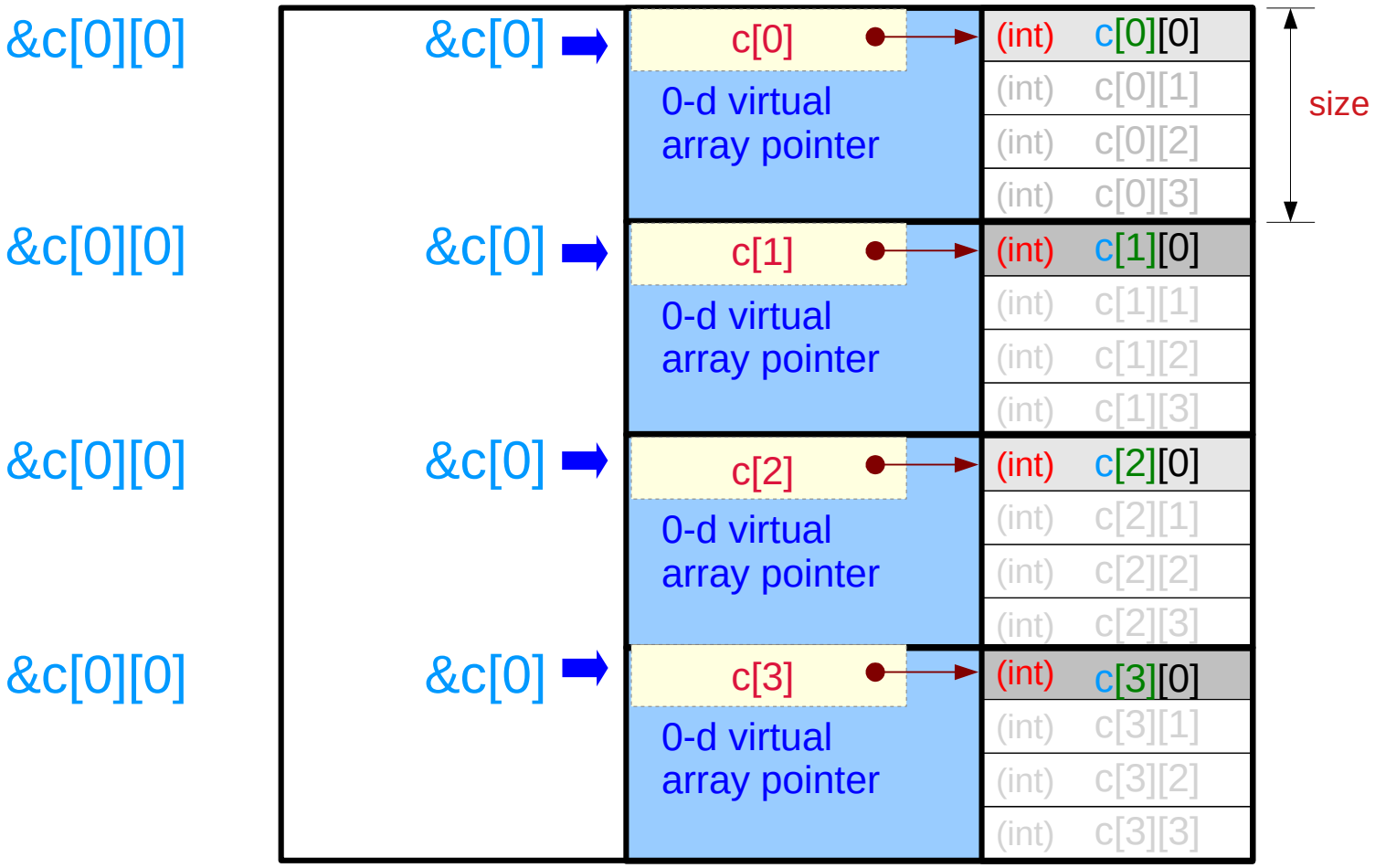


virtual pointers
- no physical memory locations are allocated
- address and data have the same value

Virtual pointer **c[i]**

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

A virtual pointer c[i]
- pointer address &c[i]
- pointer value &c[i][0]

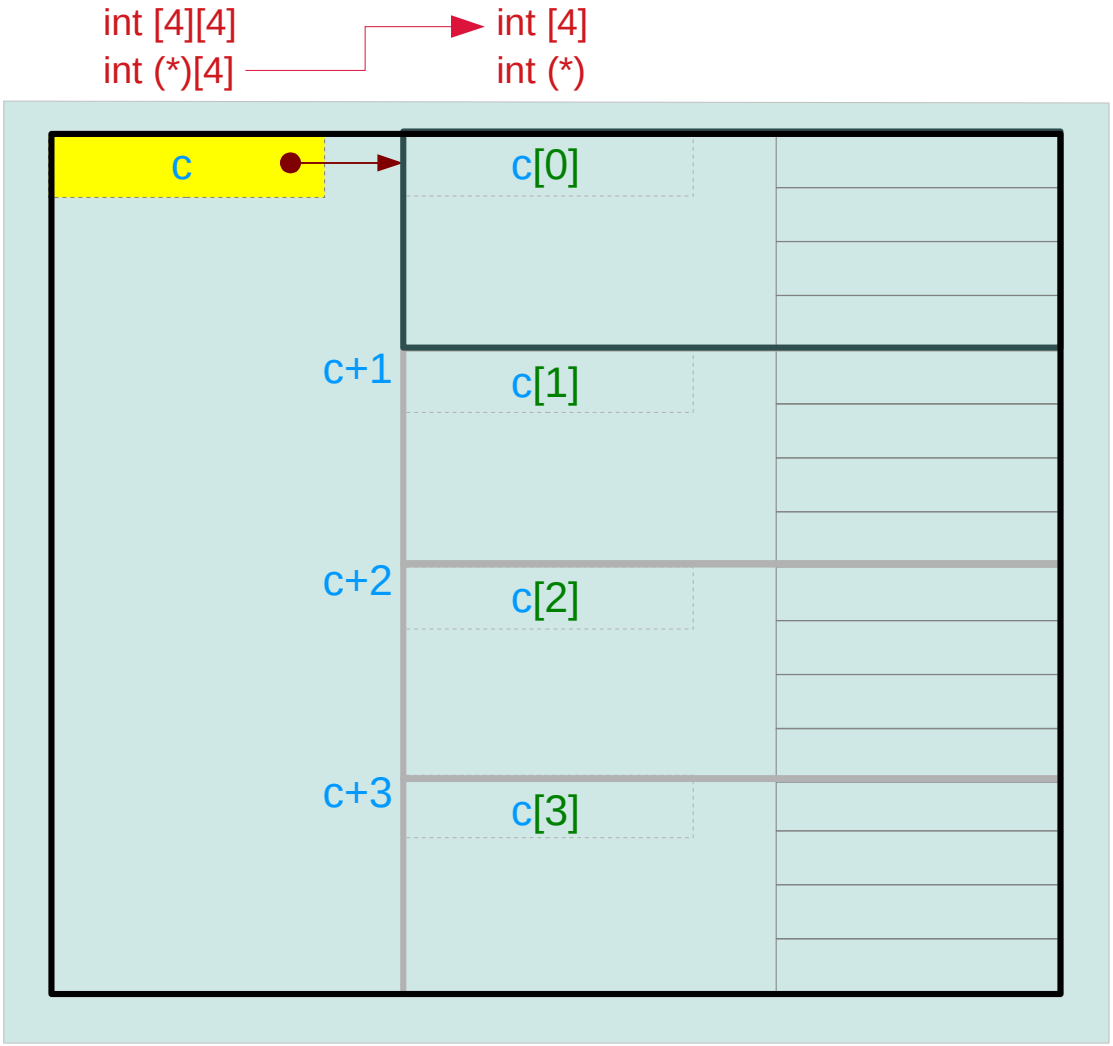


A **2-d** array **c**

int c[4][4];

c : dual type
- aggregate data int [4][4]
  a **2-d** array name
- virtual pointer int (*)[4]
  an **1-d** array pointer
  - value &c[0]
    starting address of
  - abstract data c[0]
    a **1-d** array int [4]

compilers do not allocate
a memory location for **c**



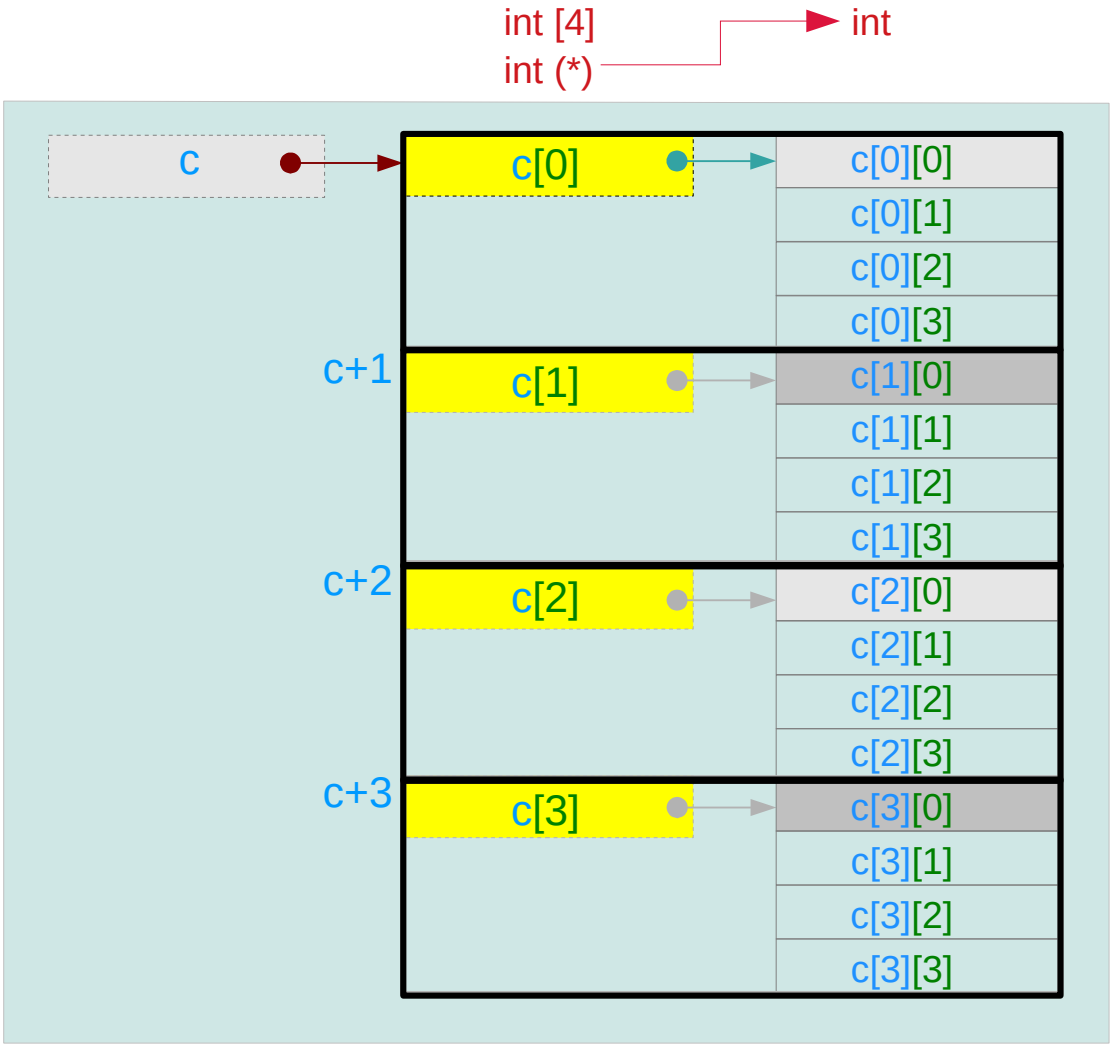
A **1-d** subarray **c[i]**

int c[4][4];

c[i] : dual type

- aggregate data int [4]
  a **1-d** array name
- virtual pointer int (*)
  a **0-d** array pointer
  - value &c[i][0]
    starting address
  - integer data c[i][0]
    a **0-d** array int

compilers do not allocate
memory locations for **c[i]**'s



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

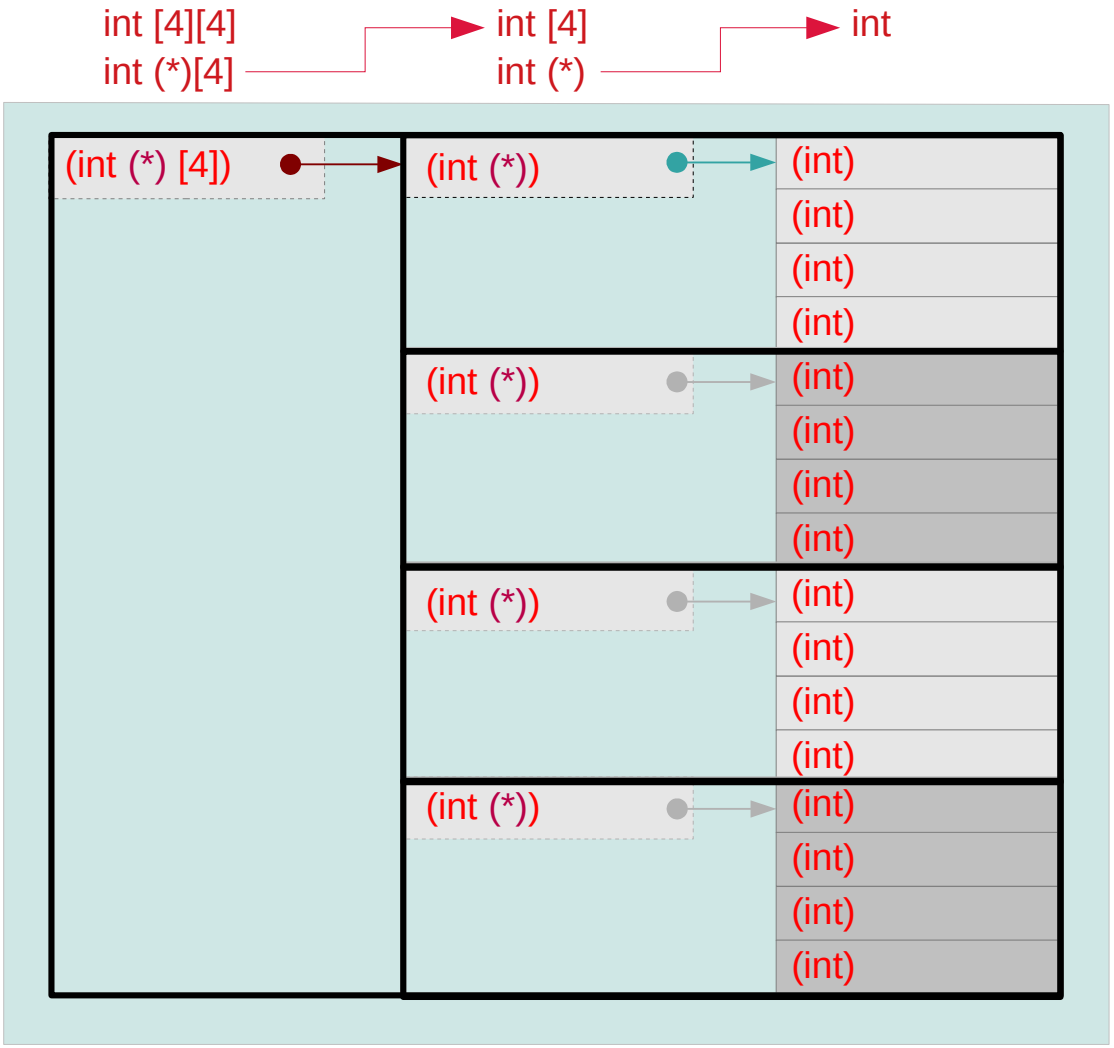
1-d array pointer c int (*) [4]

0-d array pointer c[0] int *

0-d array pointer c[1] int *

0-d array pointer c[2] int *

0-d array pointer c[3] int *



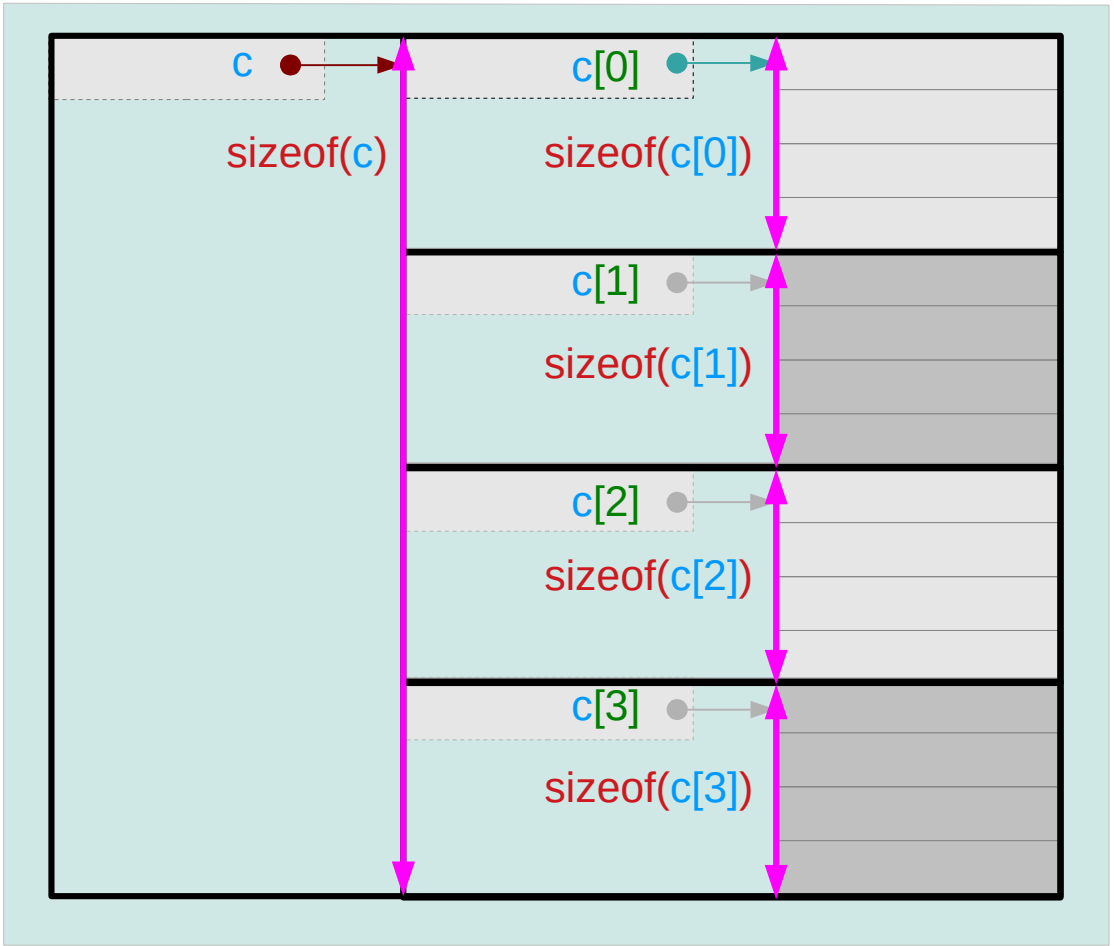
A **2-d** array and its sub-arrays – type sizes

sizeof(c) = 4*4*4 bytes

sizeof(c[i]) = 4*4 bytes

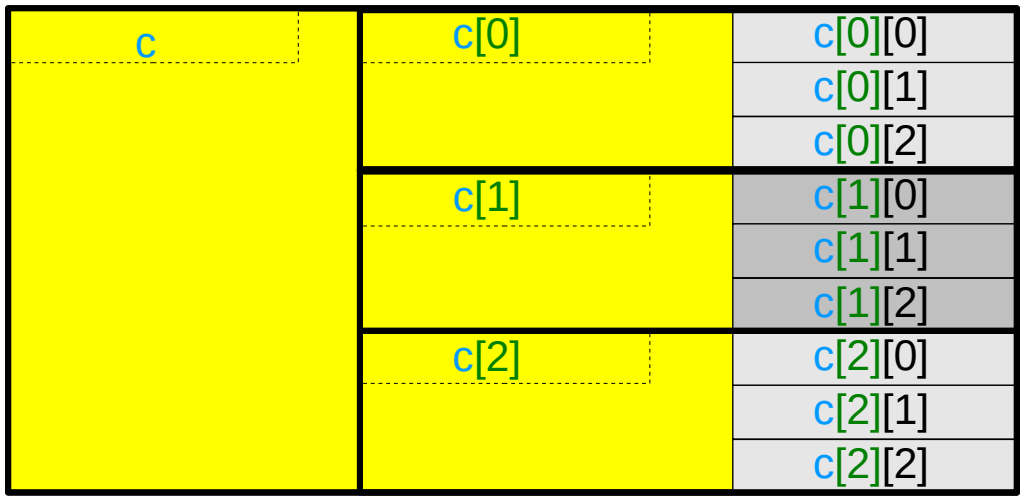
sizeof(c[i][j]) = 4 bytes

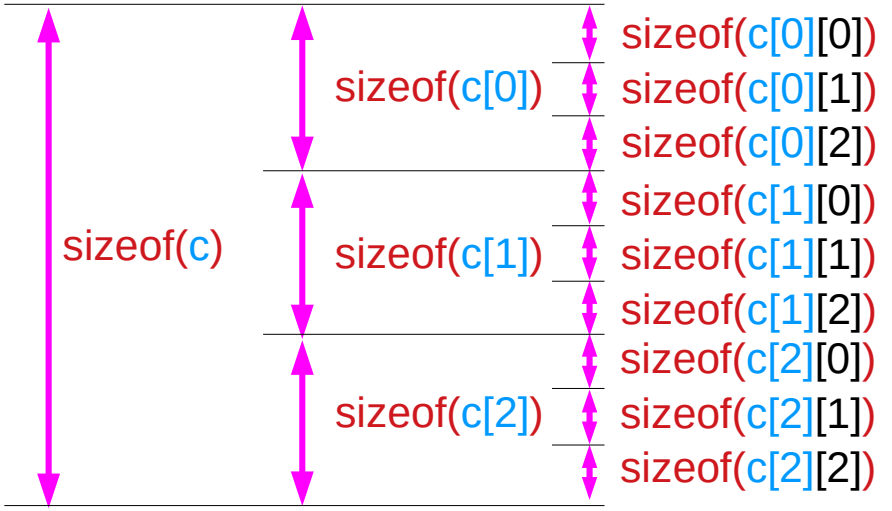
c	: the **2-d** array name
c[i]	: the **1-d** array name
c[i][j]	: the **0-d** array name (a scalar integer)



A **2-d** array and its **1-d** sub-arrays – a size view

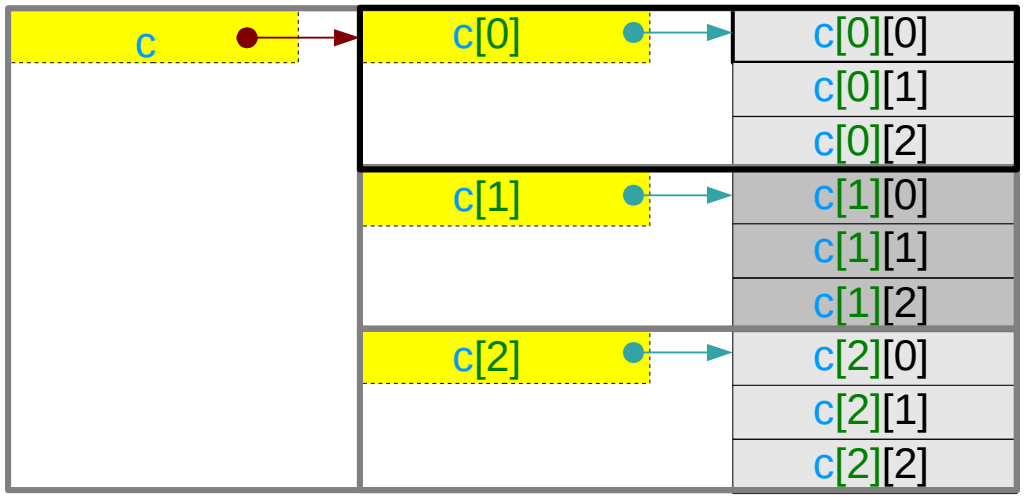

```
int c[3][3];
```





A **2-d** array and its **1-d** sub-arrays – a virtual pointer view

int c[3][3];

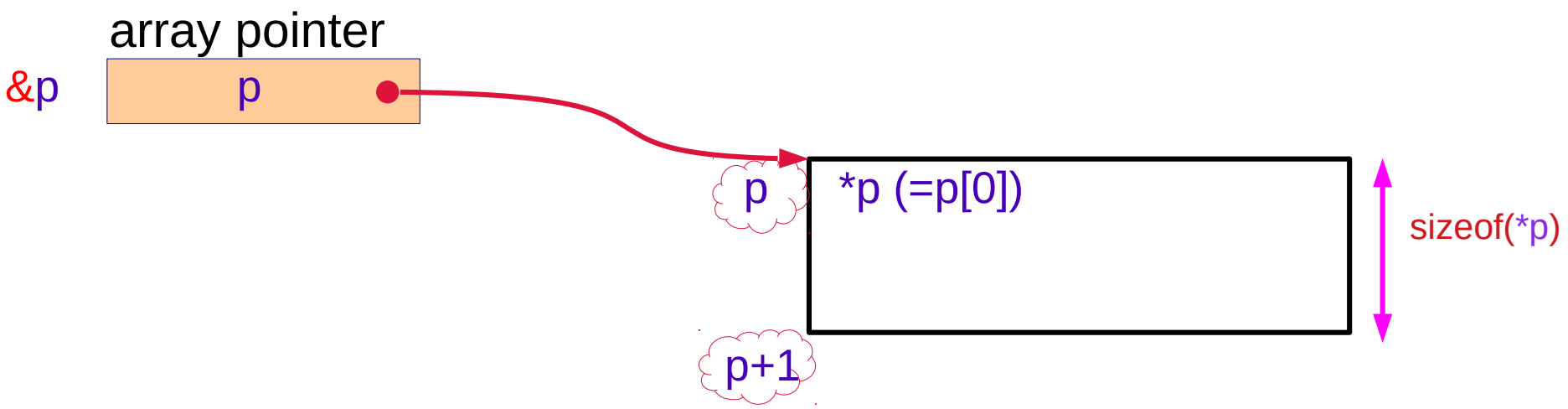


value(c) = value(c[0]) = value(&c[0][0])
value(c[1]) = value(&c[1][0])
value(c[2]) = value(&c[2][0])

value(&c) = value(&c[0]) = value(&c[0][0])
value(&c[1]) = value(&c[1][0])
value(&c[2]) = value(&c[2][0])

address(c) = address(c[0]) = address(c[0][0])
address(c[1]) = address(c[1][0])
address(c[2]) = address(c[2][0])

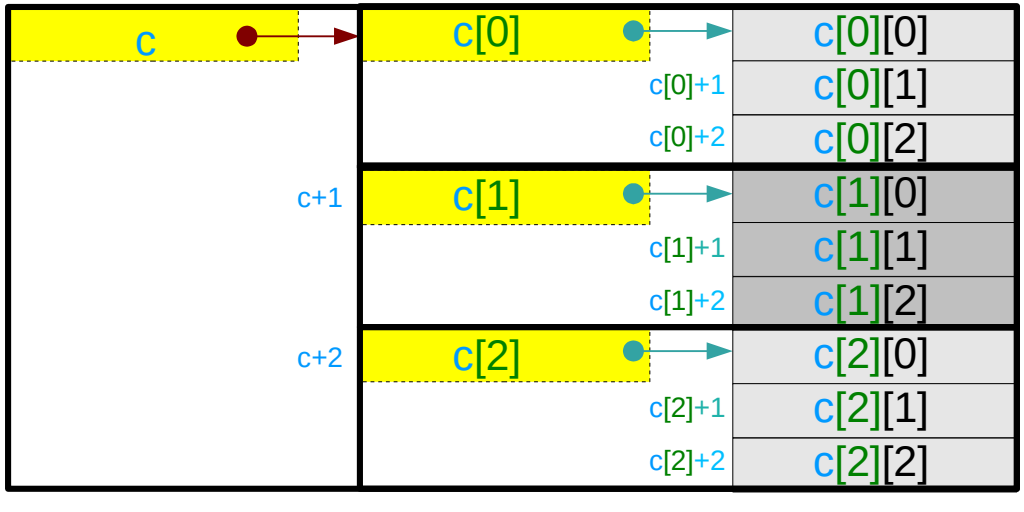
Array pointer **p** and **p+1** relationship

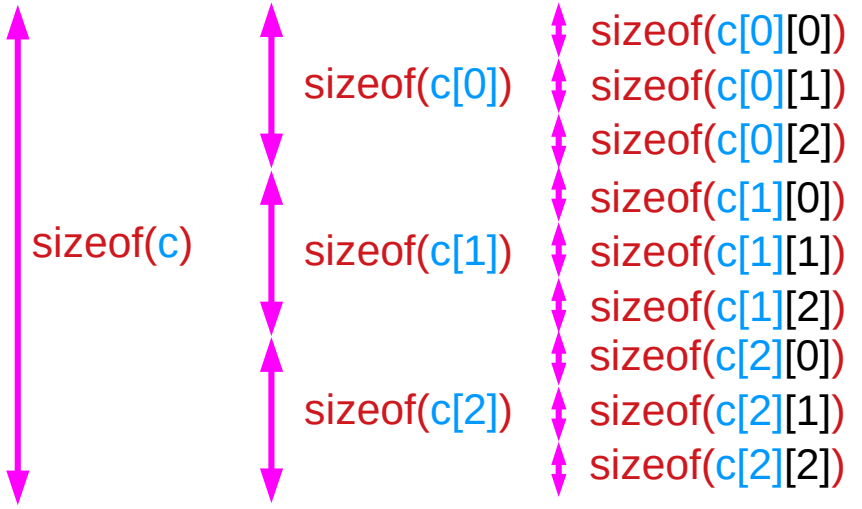


value(p+1) = value(p) + sizeof(*p)

Virtual array pointer **c** and **c+1** relationship

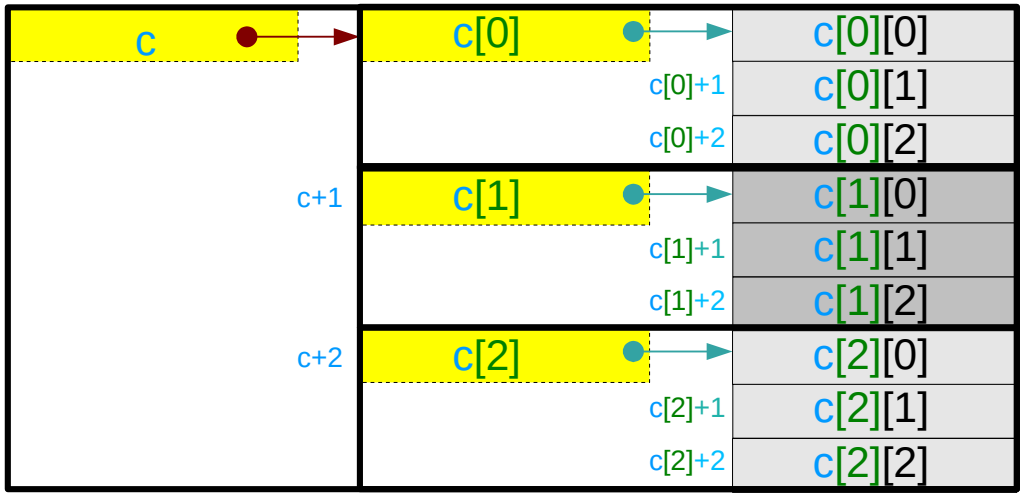

```
int c[3][3];
```





A **2-d** array and its **1-d** sub-arrays – value relation

int c[3][3];



value(c[0]) = value(c[0][0]) … *leading element*
value(c[0]+1) = value(c[0][0]) + sizeof(c[0][0]) * 1
value(c[0]+2) = value(c[0][0]) + sizeof(c[0][0]) * 2

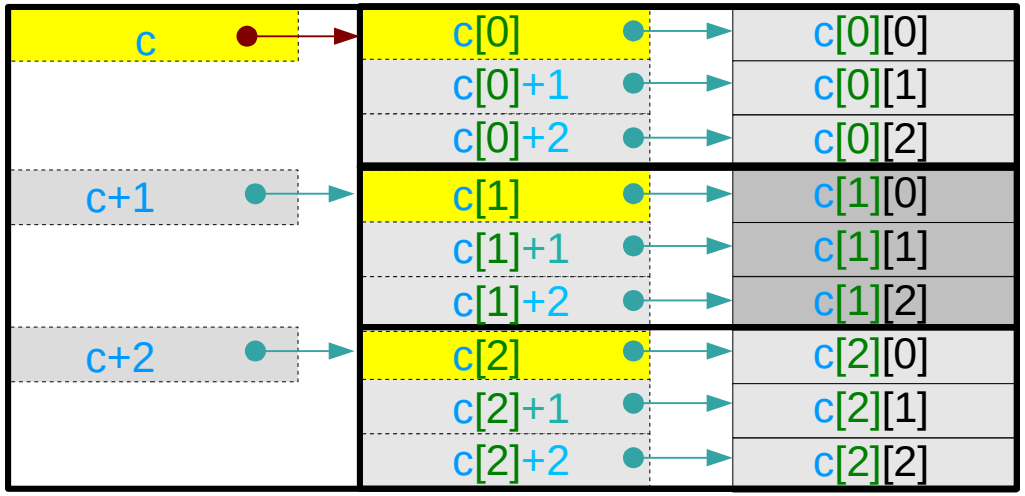
value(c[1]) = value(c[1][0]) … *leading element*
value(c[1]+1) = value(c[1][0]) + sizeof(c[1][0]) * 1
value(c[1]+2) = value(c[1][0]) + sizeof(c[1][0]) * 2

value(c[2]) = value(c[2][0]) … *leading element*
value(c[2]+1) = value(c[2][0]) + sizeof(c[2][0]) * 1
value(c[2]+2) = value(c[2][0]) + sizeof(c[2][0]) * 2

value(c) = value(c[0]) … *leading element*
value(c+1) = value(c[0]) + sizeof(c[0]) * 1
value(c+2) = value(c[0]) + sizeof(c[0]) * 2

A **2-d** array and its **1-d** sub-arrays – size relation

int c[3][3];



sizeof(c[0]) = sizeof(c[0][0]) * 3 … *leading element*
sizeof(c[0]+1) = pointer size (4/8 bytes)
sizeof(c[0]+2) = pointer size (4/8 bytes)

sizeof(c[1]) = sizeof(c[1][0]) * 3 … *leading element*
sizeof(c[1]+1) = pointer size (4/8 bytes)
sizeof(c[1]+2) = pointer size (4/8 bytes)

sizeof(c[2]) = sizeof(c[2][0]) * 3 … *leading element*
sizeof(c[2]+1) = pointer size (4/8 bytes)
sizeof(c[2]+2) = pointer size (4/8 bytes)

sizeof(c) = sizeof(c[0]) * 3 … *leading element*
sizeof(c+1) = pointer size (4/8 bytes)
sizeof(c+2) = pointer size (4/8 bytes)

C scalar data types

Arithmetic types and **pointer** types
- collectively called **scalar types**
- hold single data item
- size and format

Array and **structure** / **union** types
- collectively called **aggregate types**
- hold more than one data items

C scalar data types provide their size and format
The alignment of a scalar data types is equal to its size
Scalar alignment shows scalar alignments that apply to individual scalars and to scalars that are elements of an array or members of a structure or union.
Wide characters are supported (character constants prefixed with an L)
The size of each wide character is 4 bytes

https;//stackoverflow.com/questions/35722514

Data Types

- Void
- Scalar Types
  - Arithmetic Types
    - Integral Types
    - Floating Types
  - Pointer
  - Enum
- Aggregate Types
  - Array
  - Union
  - Union

https;//stackoverflow.com/questions/35722514

C abstract data types

Array as an **Abstract Data Type** and
as a **Data Structure**

Abstract Data Types, **ADT**s are
a way of classifying **data structures**
based on how they are used and
the behaviors they provide.

They do not specify
how the data structure must be implemented
but simply provide a minimal expected interface
and set of behviors.

Data structure is
a concrete implementation of a data type.

It's possible to analyze the time and memory
complexity of a Data Structure but not from a
data type.

The Data Structure can be implemented in
several ways and its implementation may vary
from language to language

Lucasmagnum.edium.com/sidenotes-array-sbstract-data-type-data-structure…

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