

Pointers (1A)

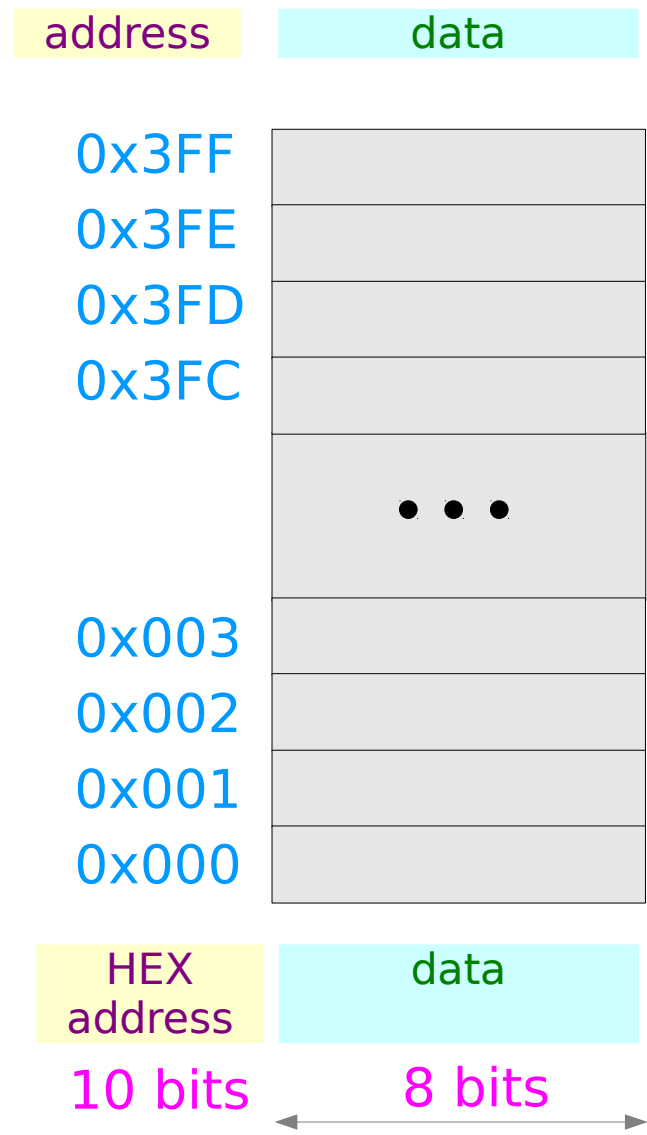
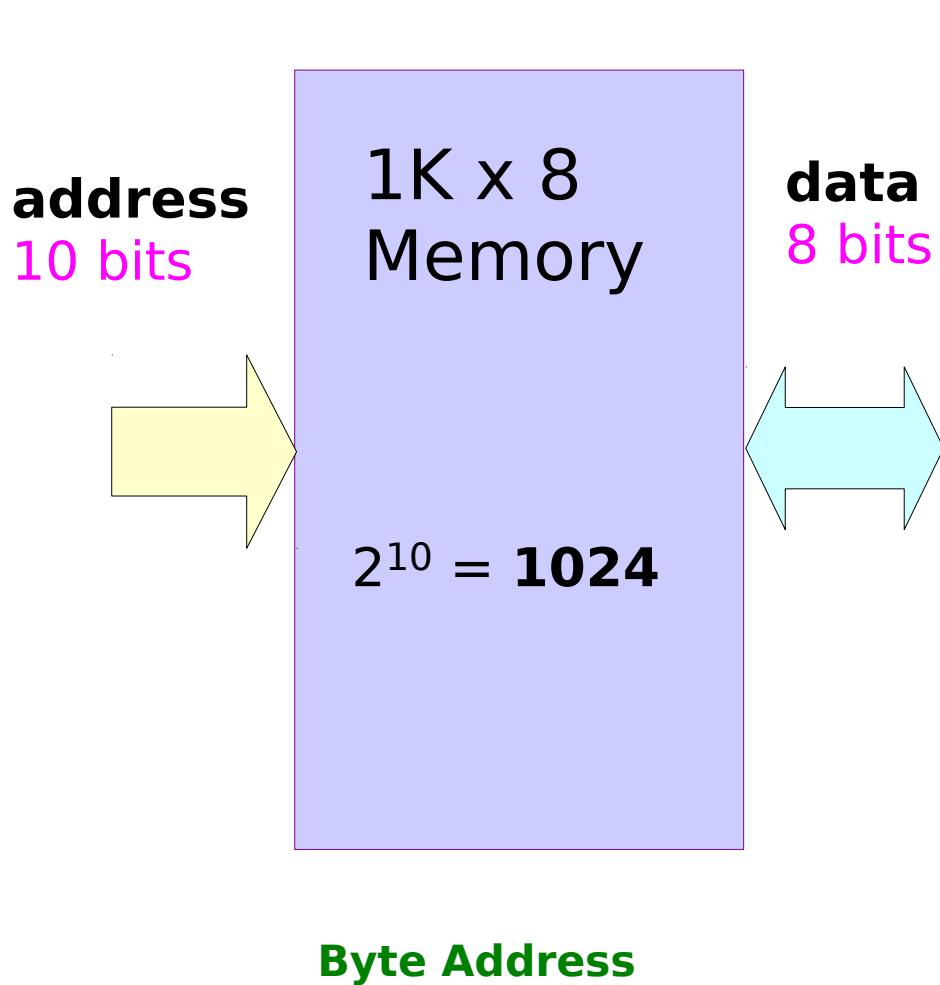
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Byte Address and Data in a Memory



Variables

```
int a;
```

a can hold an *integer* value

address

data

&a

a

```
a = 100;
```

a holds the *integer* 100

address

data

&a

a ← 100

Pointer Variables

```
int * p;
```

`p` holds an address

`p` can hold the address of an `int` data

`*p` can hold an integer value

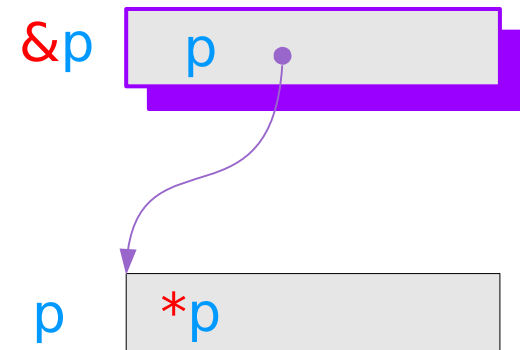
type **variable**

```
int * p;
```

pointer to int

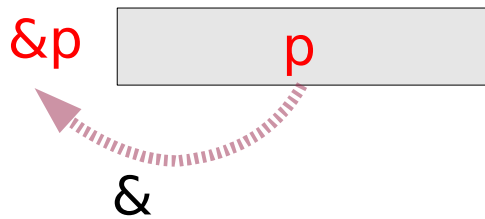
```
int * p;
```

int

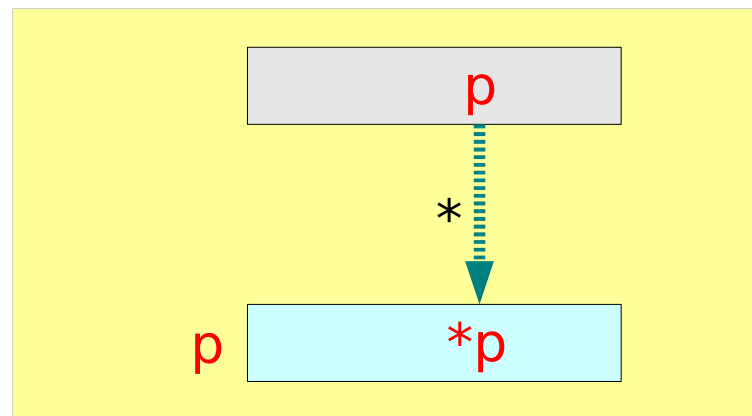
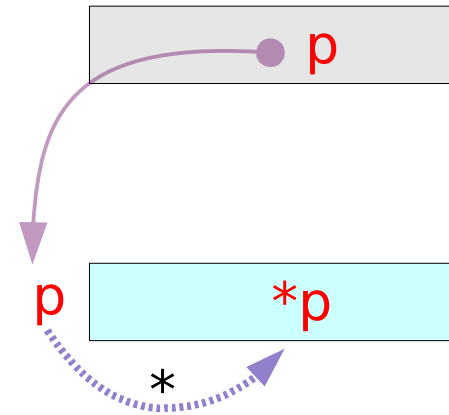


Dereferencing

*The address of a variable :
Address of operator &*



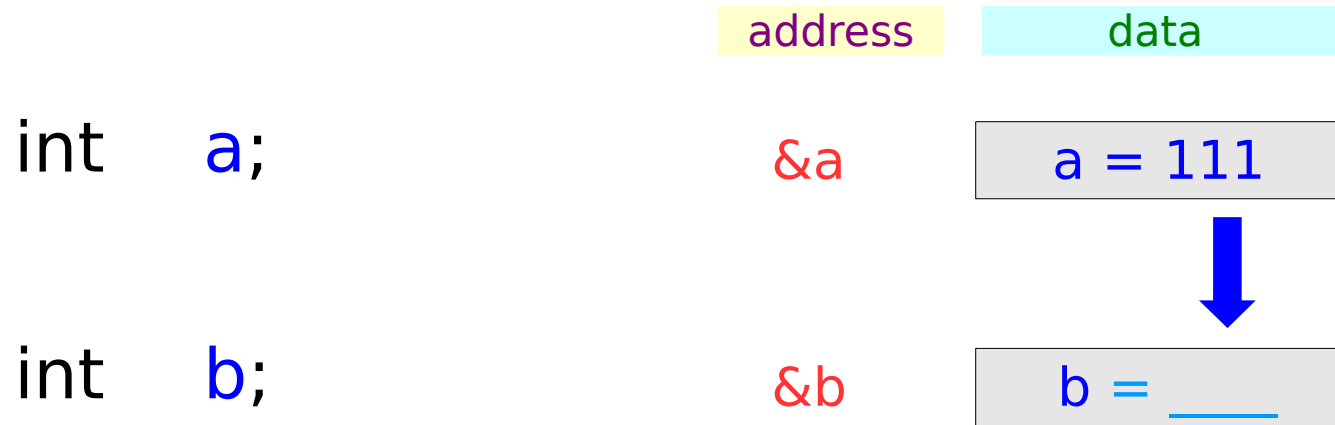
*The content of a pointed location :
Dereferencing operator **



Variables and their addresses

	address	data
<code>int a;</code>	<code>&a</code>	<code>a</code>
<code>int *p;</code>	<code>&p</code>	<code>p</code>

Assignment of a value

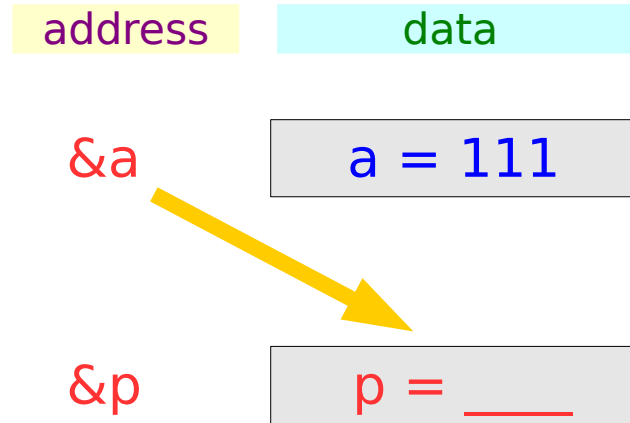


b = a;

Assignment of an address

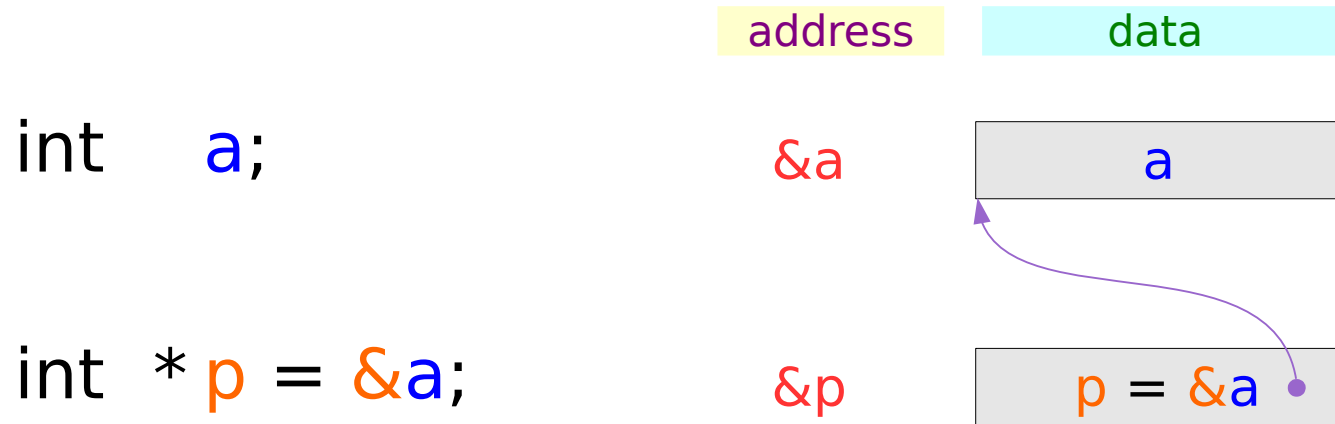
```
int a;
```

```
int *p;
```



```
p = &a;
```

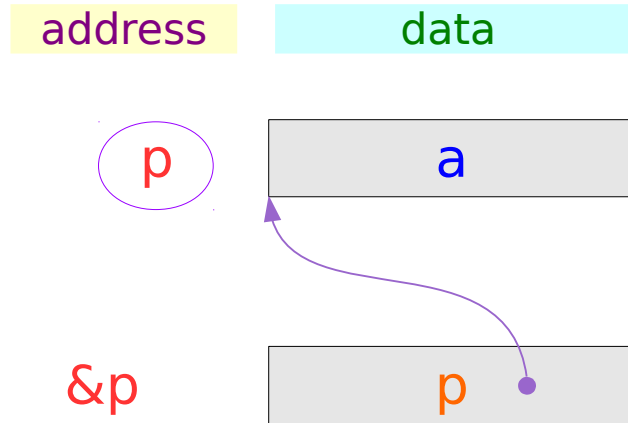
Variables with initializations



Pointed addresses : p

```
int a;
```

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

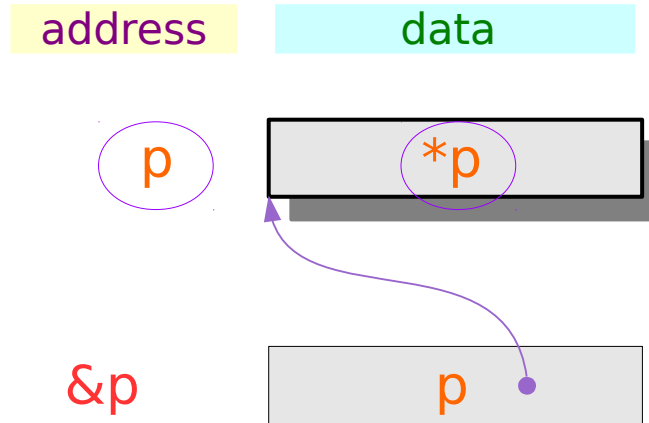


$p \equiv \&a$

Dereferenced Variable : *p

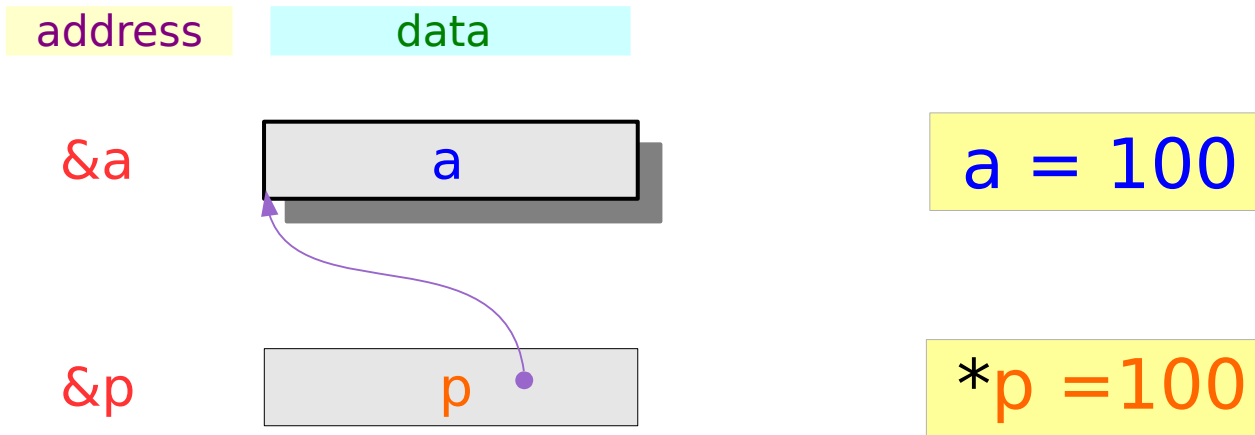
```
int a;
```

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



$p \equiv \&a$
 $*p \equiv a$

Two way to access: `a` and `*p`



- 1) Read/Write `a`
- 2) Read/Write `*p`

-
1. Pass by Reference
 2. Arrays

Pass by Reference

Variable Scopes

```
int func1 (int a, int b)  
{  
    int i, int j;  
    ...  
    ...  
    ...  
    ...  
}
```

i and **j**'s
variable scope



cannot access
each other

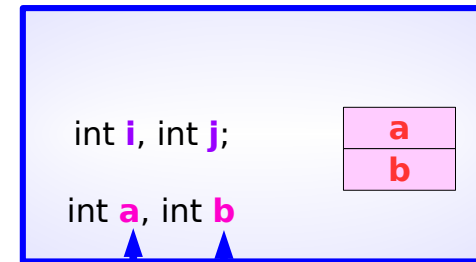
```
int main ()  
{  
    int x, int y;  
    ...  
    ...  
    func1 ( 10, 20 );  
    ...  
    ...  
}
```

x and **y**'s
variable scope

Only **top** stack frame is active
and its variable can be accessed

Communications are performed
only through the **parameter** variables

func1's
Stack
Frame



(10, 20)

main's
Stack
Frame

int **x**, int **y**;



Pass by Reference

```
int func1 (int* a, int* b)  
{  
  int i, int j;  
  ...  
  ...  
  ...  
  ...  
}
```

x and **y** are made known to **func1**
func1 can read / write **x** and **y**
through their addresses

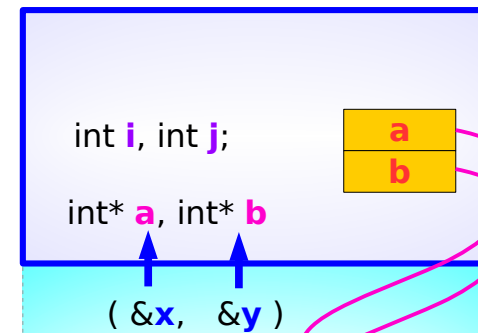
a=&**x**
b=&**y**

x and **y**'s
variable scope

```
int main ()  
{  
  int x, int y;  
  ...  
  ...  
  func1 ( &x, &y );  
  ...  
  ...  
}
```

***a**
***b**

func1's
Stack
Frame

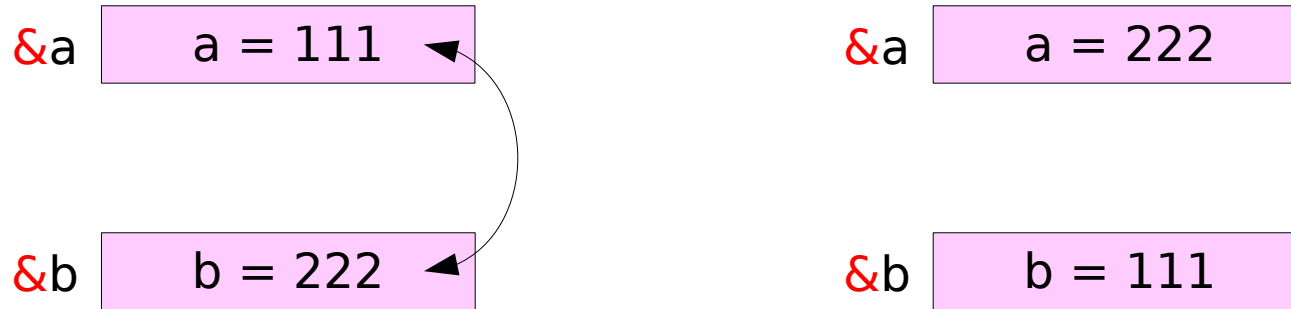


main's
Stack
Frame

int **x**, int **y**;

***a**
***b**

Swapping integers



```
int a, b;
```

```
swap( &a, &b );
```

```
swap( int *, int * );
```

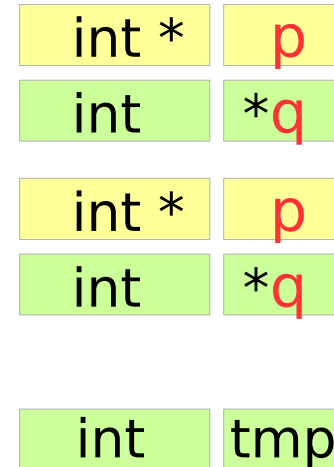
function call

function prototype

Pass by integer reference

```
void swap(int *p, int *q) {  
    int tmp;  
  
    tmp = *p;  
    *p = *q;  
    *q = tmp;  
}
```

```
int a, b;  
...  
swap( &a, &b );
```



Integer and Integer Pointer Types

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

integer pointer declarations



a way of thinking

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



```
m  
n  
*m  
*n
```

integer pointer variables

treated as integer variables

variables

```
int *
```

```
int
```

types

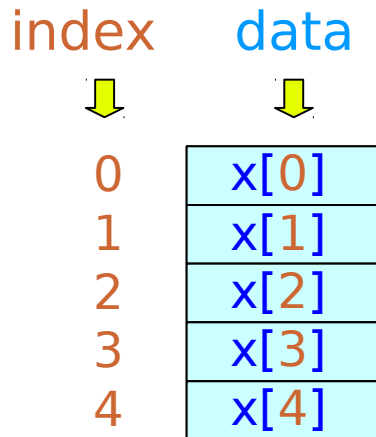
Arrays

Accessing array elements - using an address

```
int    x[5];
```

x holds the *starting address* of **5** consecutive **int** variables

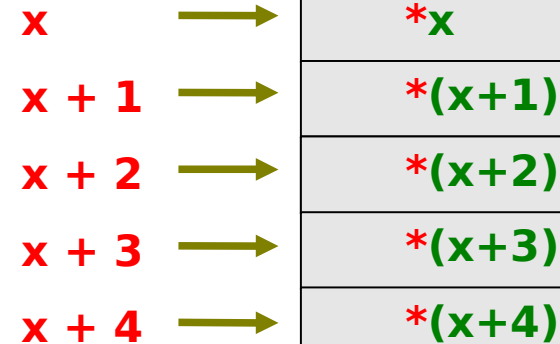
5 int variables



cannot change
address x
(constant)

address

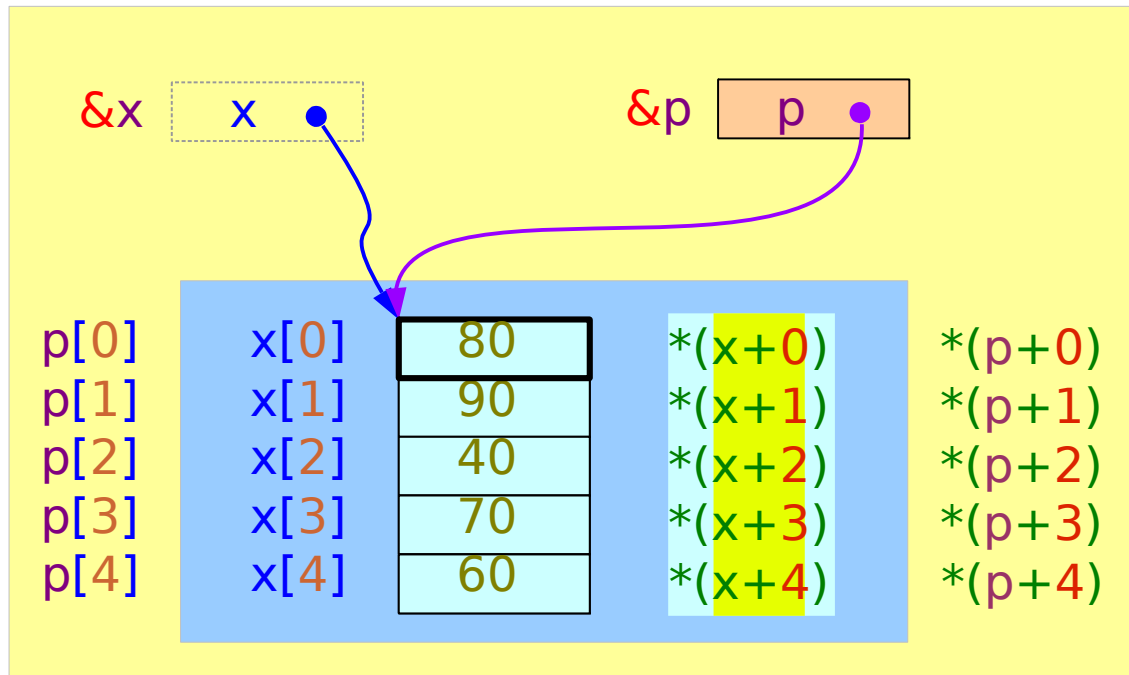
data



Accessing an Array with a Pointer Variable

```
int x [5] = { 1, 2, 3, 4, 5 };
```

```
int *p = x;
```



`x` is a constant symbol
cannot be changed

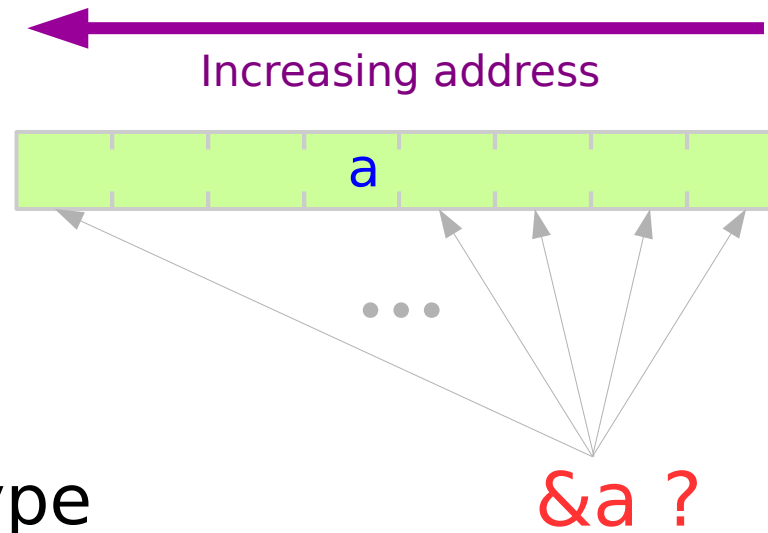
`p` is a variable
can point to other addresses

Byte Address
Little Endian
Big Endian

Byte Addresses

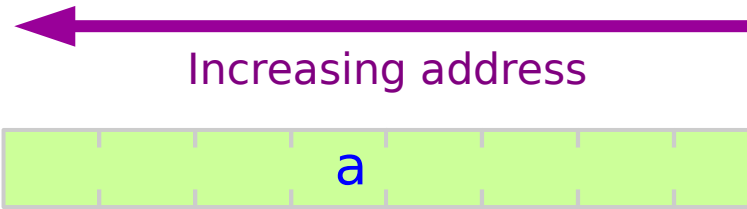
long a;

8-byte size data type



Little / Big Endian Ordering of Bytes

long a;



MSByte Little Endian LSByte



$a_7 a_6 a_5 a_4 a_3 a_2 a_1 a_0$

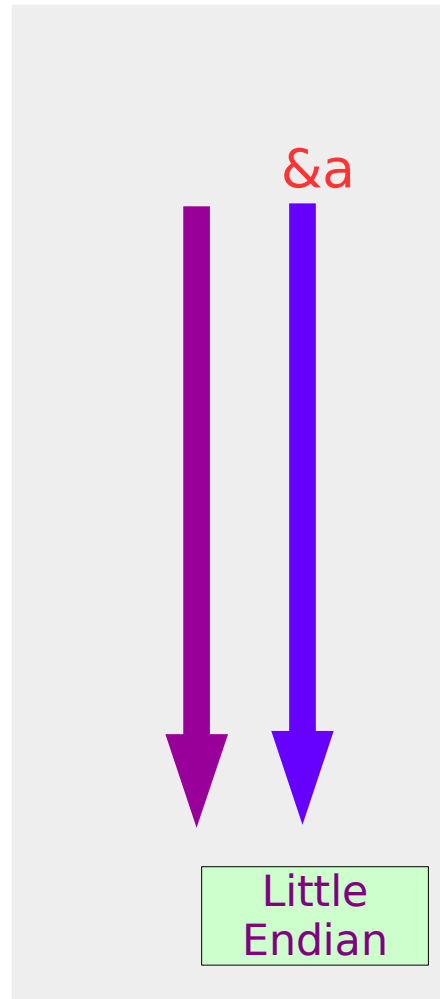
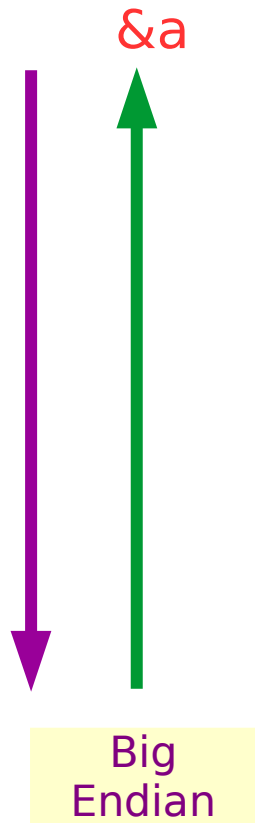
LSByte Big Endian MSByte



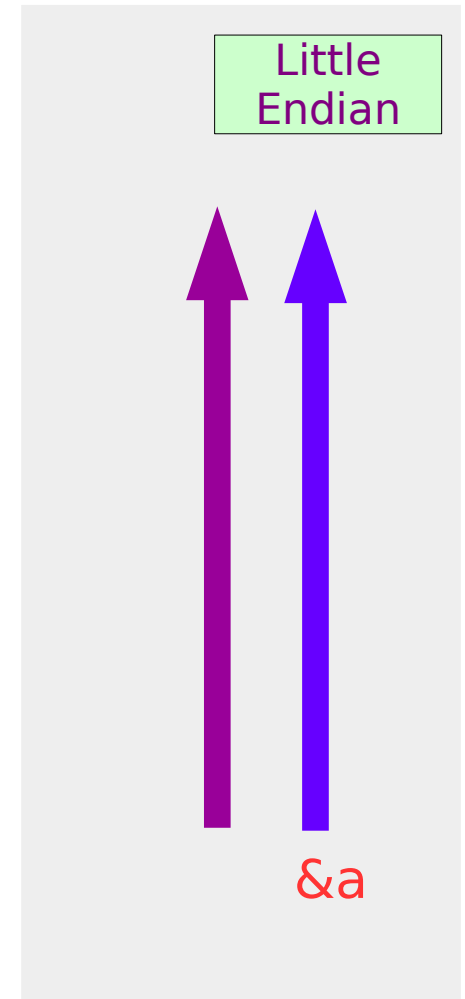
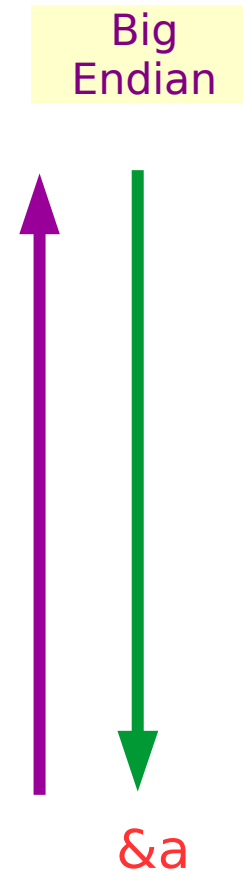
$a_0 a_1 a_2 a_3 a_4 a_5 a_6 a_7$

Increasing address, Increasing byte weight

downward, increasing address



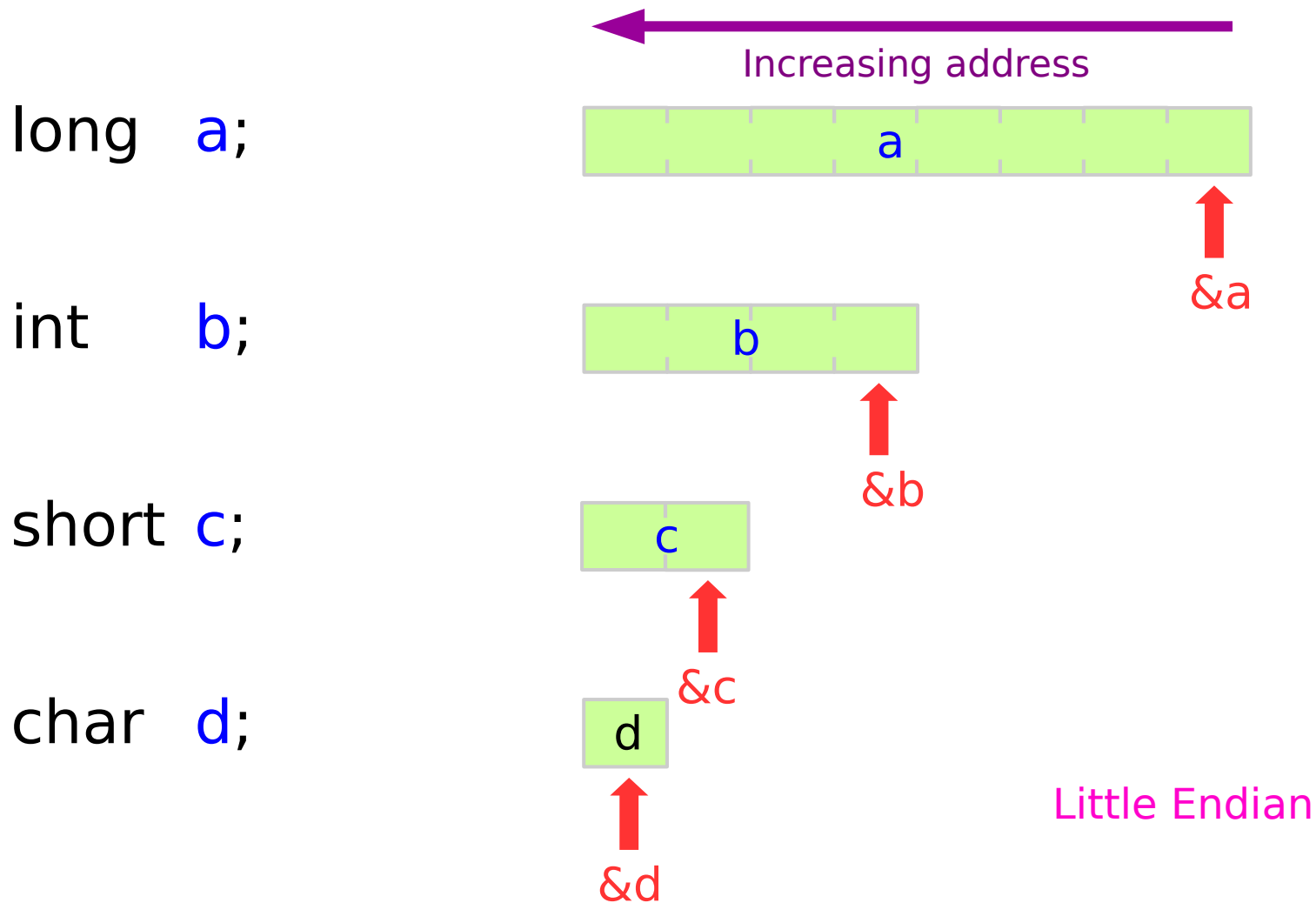
upward, increasing address



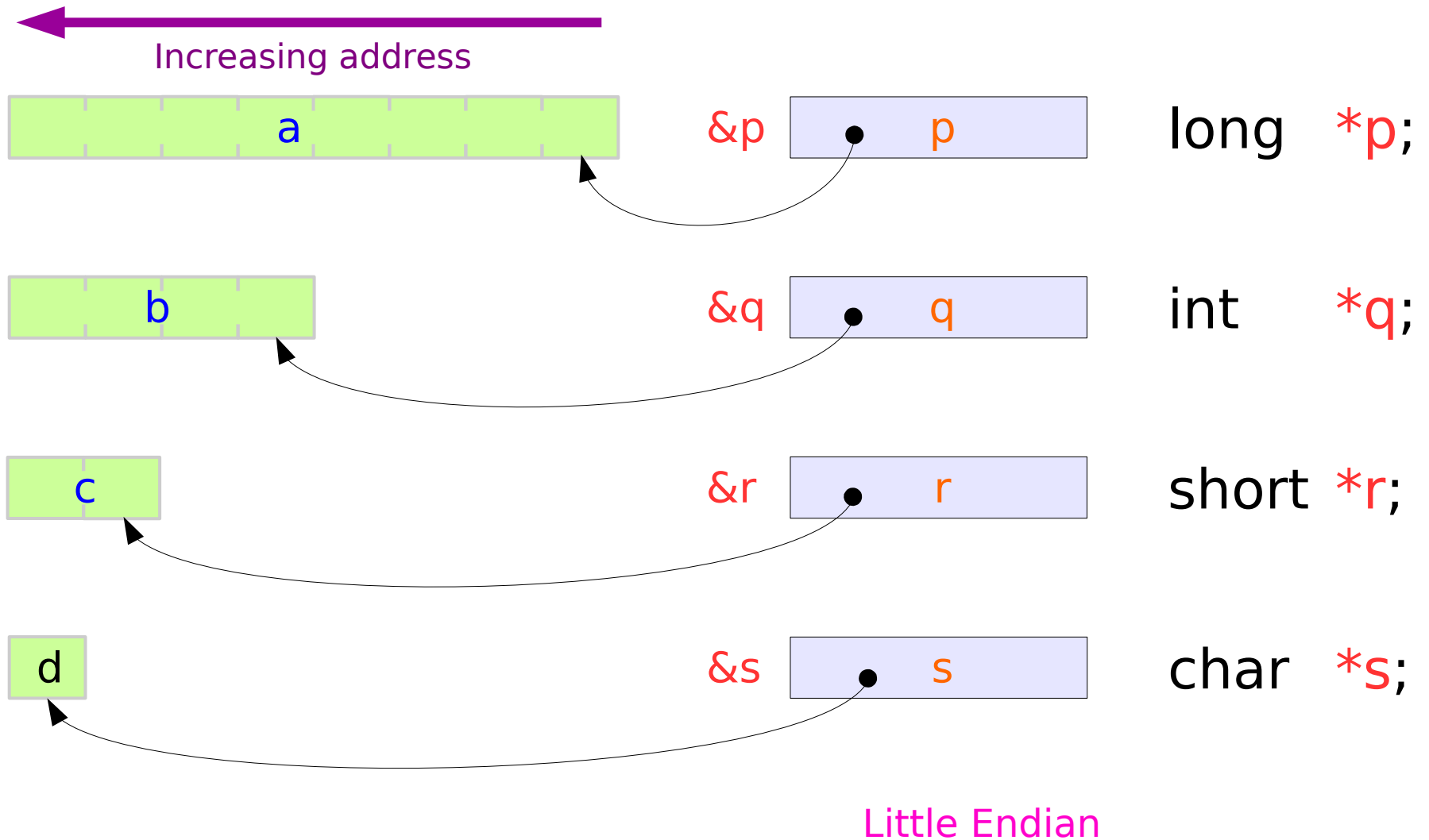
<https://stackoverflow.com/questions/15620673/which-bit-is-the-address-of-an-integer>

Pointer Types

Integer Type Variables and Their Addresses

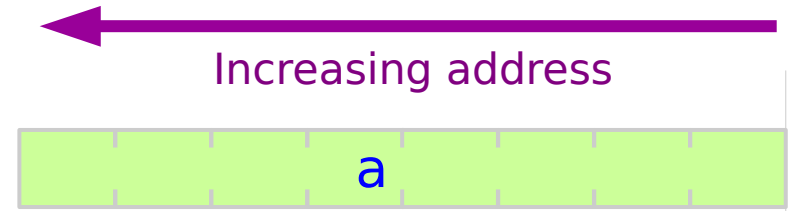


Points to the LSByte



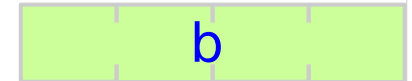
Aligning variables of different sizes

`long a;` `sizeof(long)` → 8 (bytes)



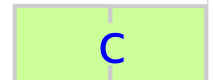
`&a` ↑

`int b;` `sizeof(int)` → 4 (bytes)



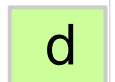
`&b` ↑

`short c;` `sizeof(short)` → 2 (bytes)



`&c` ↑

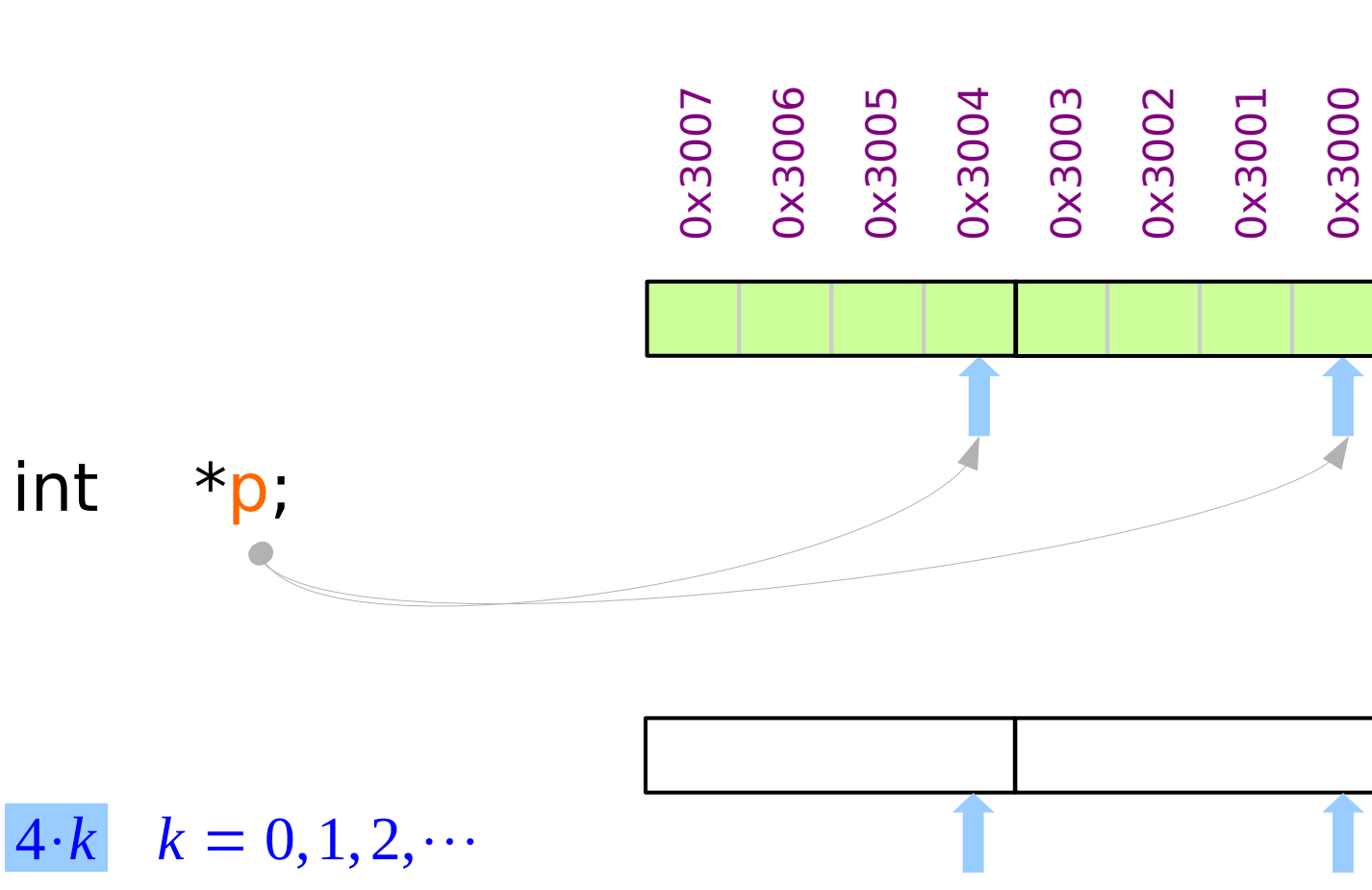
`char d;` `sizeof(char)` → 1 (bytes)



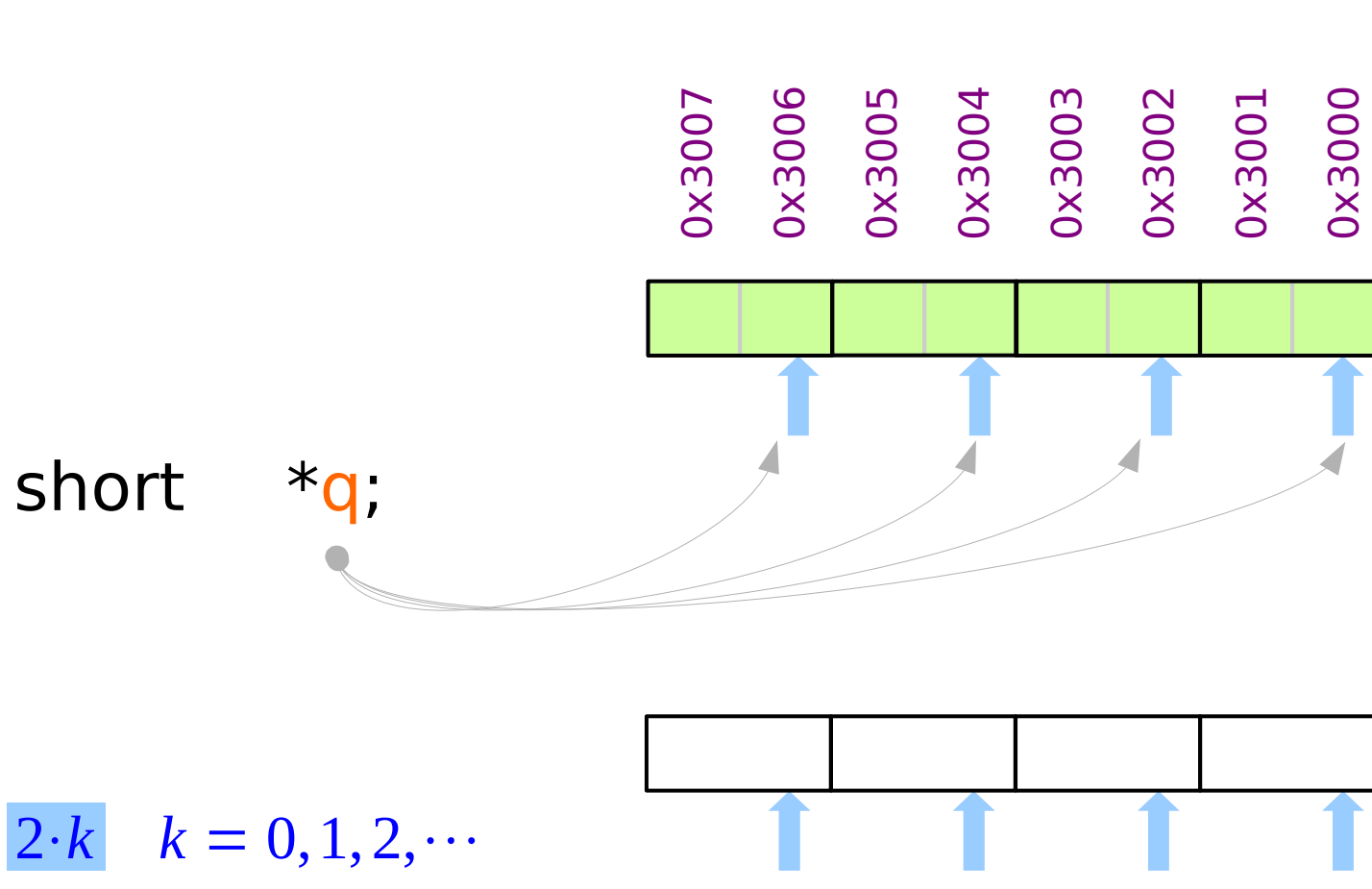
`&d` ↑

Memory Alignment
in the Little Endian

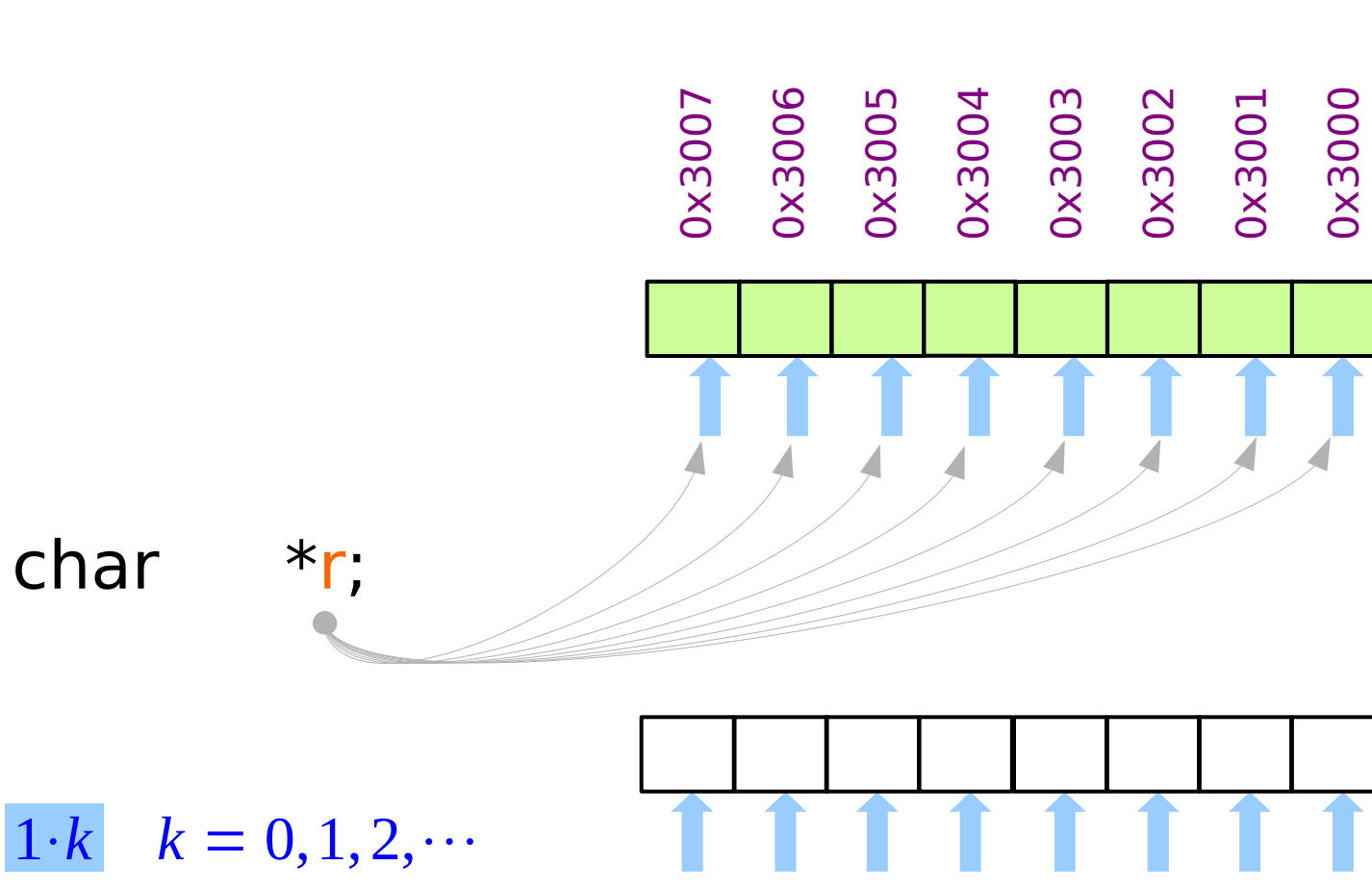
Possible addresses for **int** values



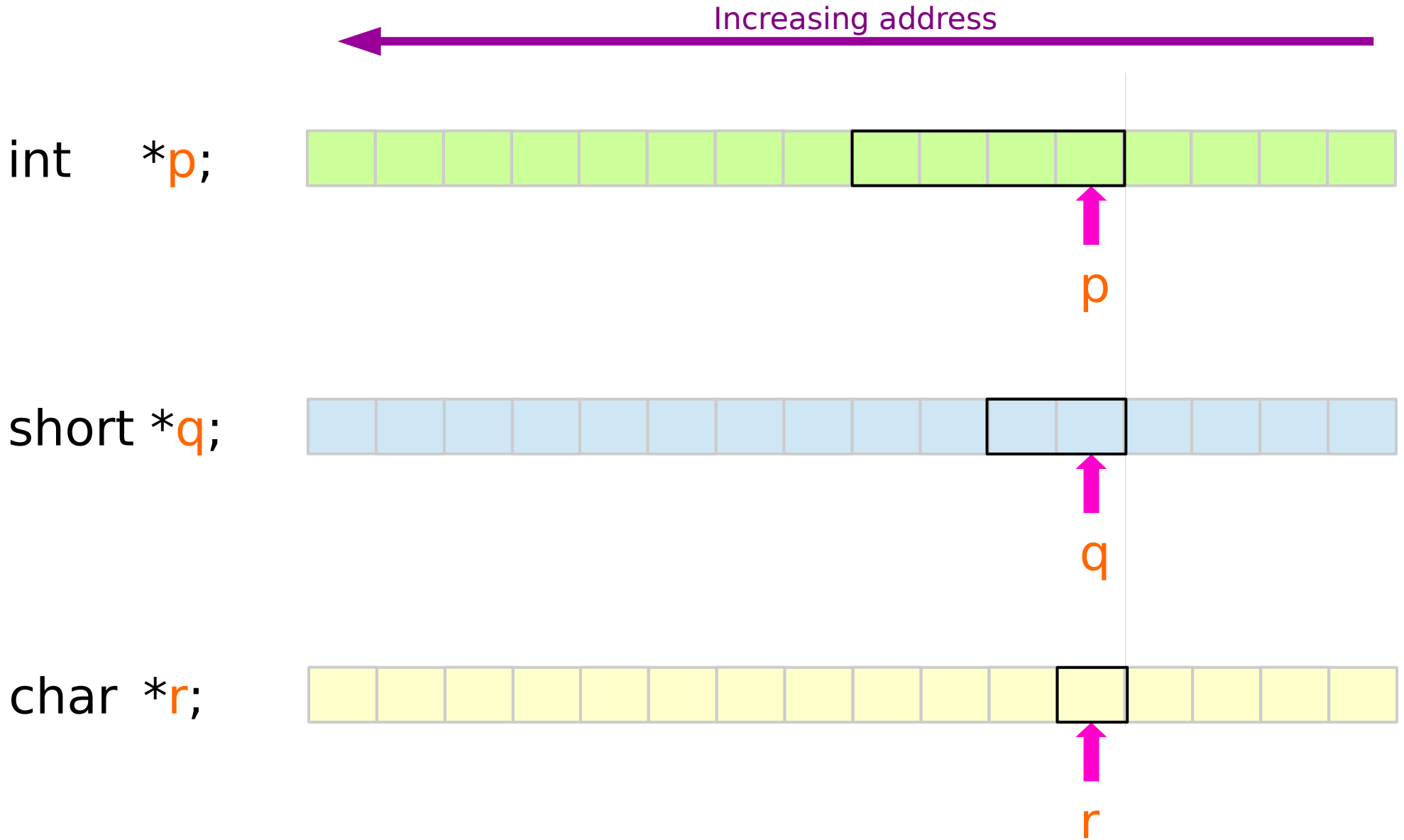
Possible addresses for **short** values



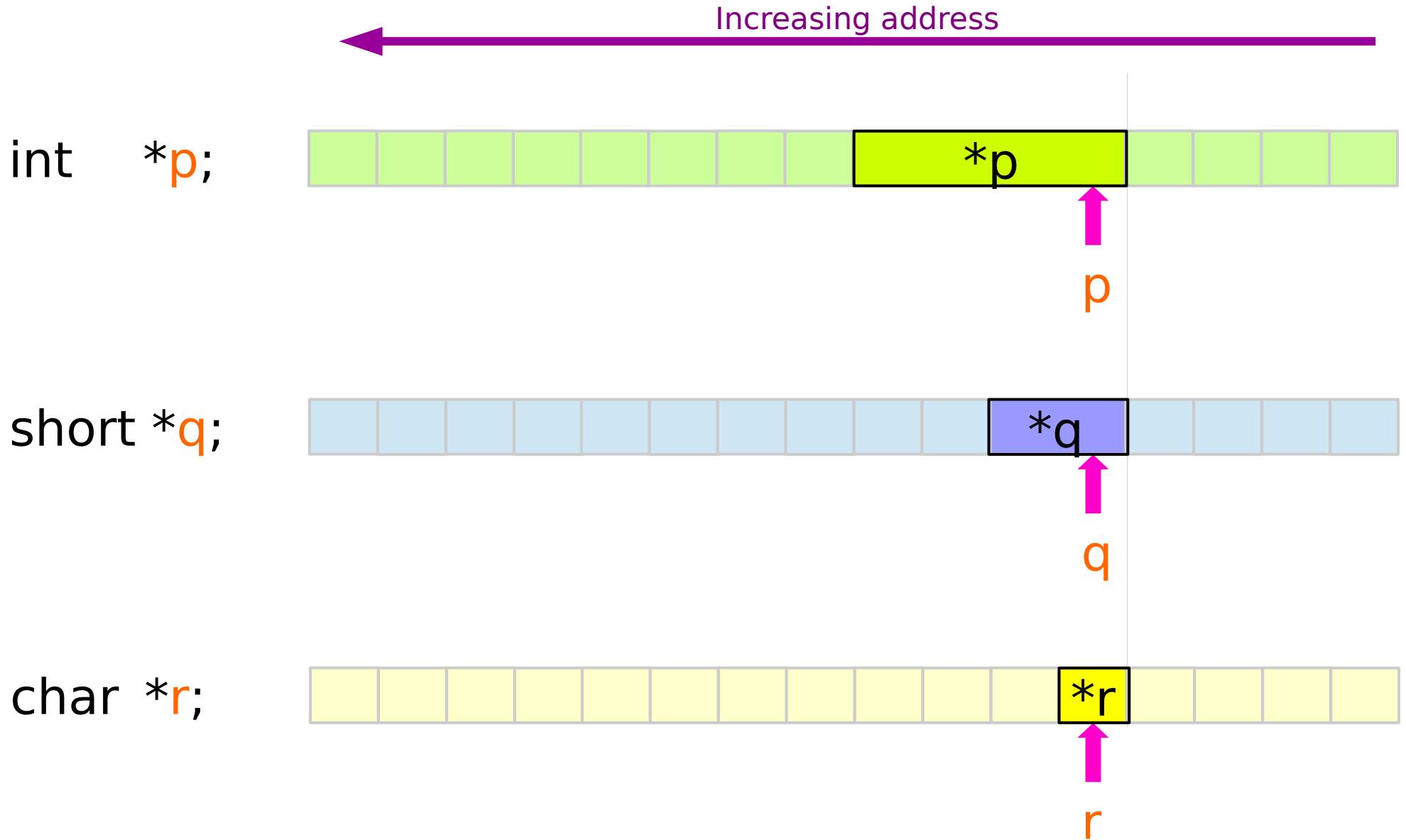
Possible addresses for **char** values



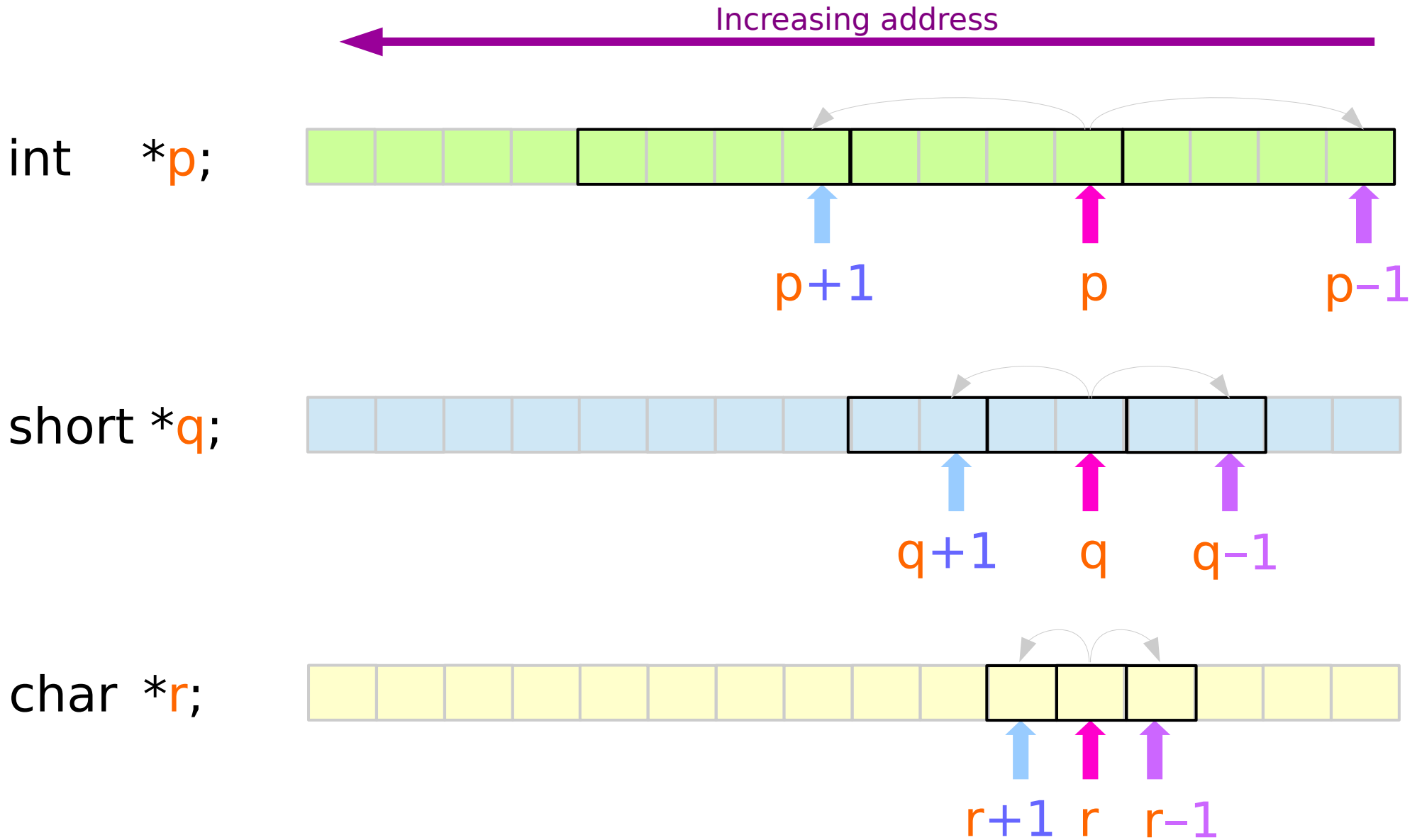
Data size at the pointed addresses



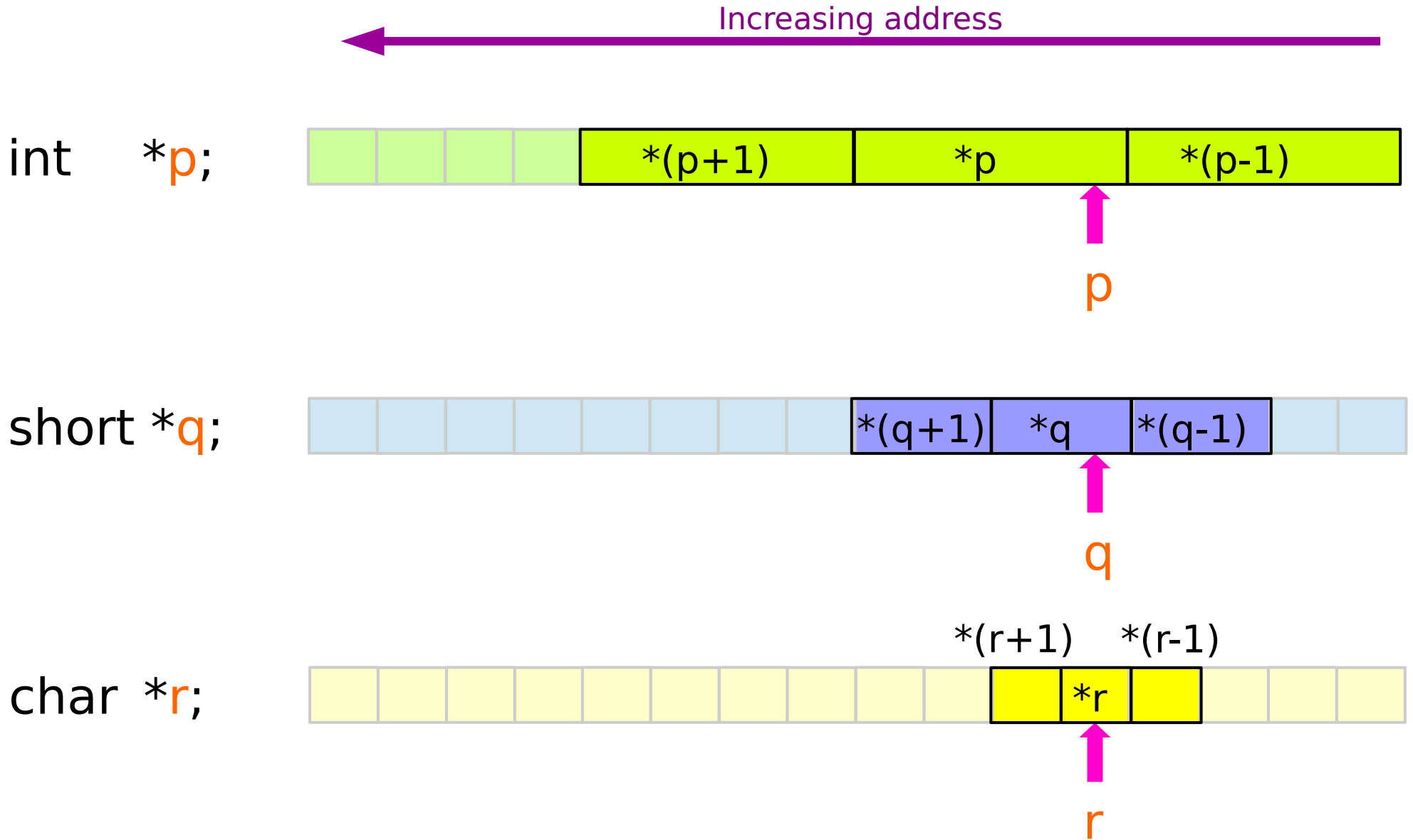
Associated data at the pointed addresses



Incrementing / decrementing pointers



Dereferencing the inc/decremented pointers



Pointer Type Cast

Changing the associated data type of an address

long a; &a address of a long value

int * p; address of an int value

short * q; address of a short value

char * r; address of a char value



Pointer Type Casting

long a;

address of a long value



&a



int * p;

address of an int value



p = (int *) &a

short * q;

address of a short value



q = (short *) &a

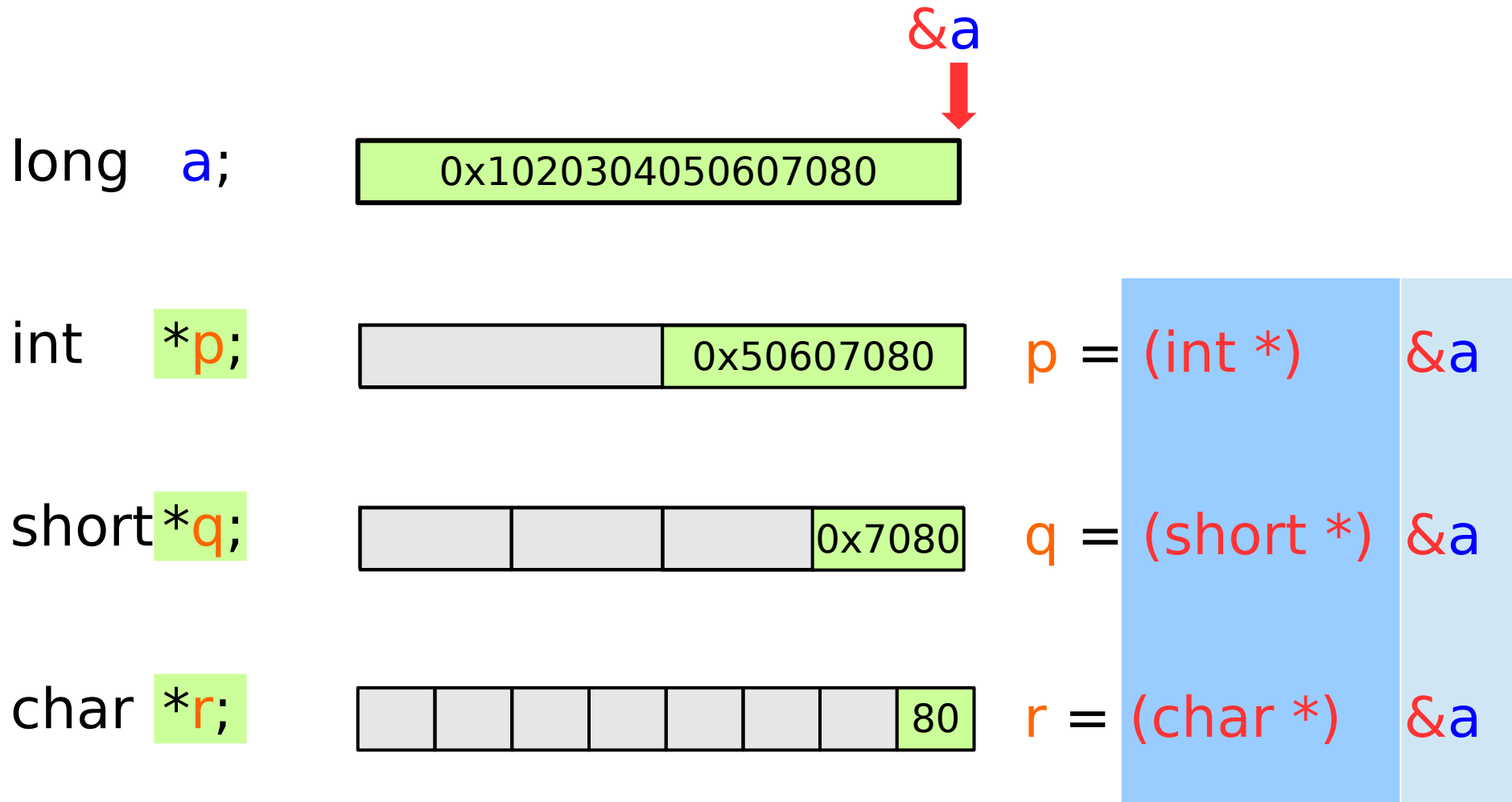
char * r;

address of a char value

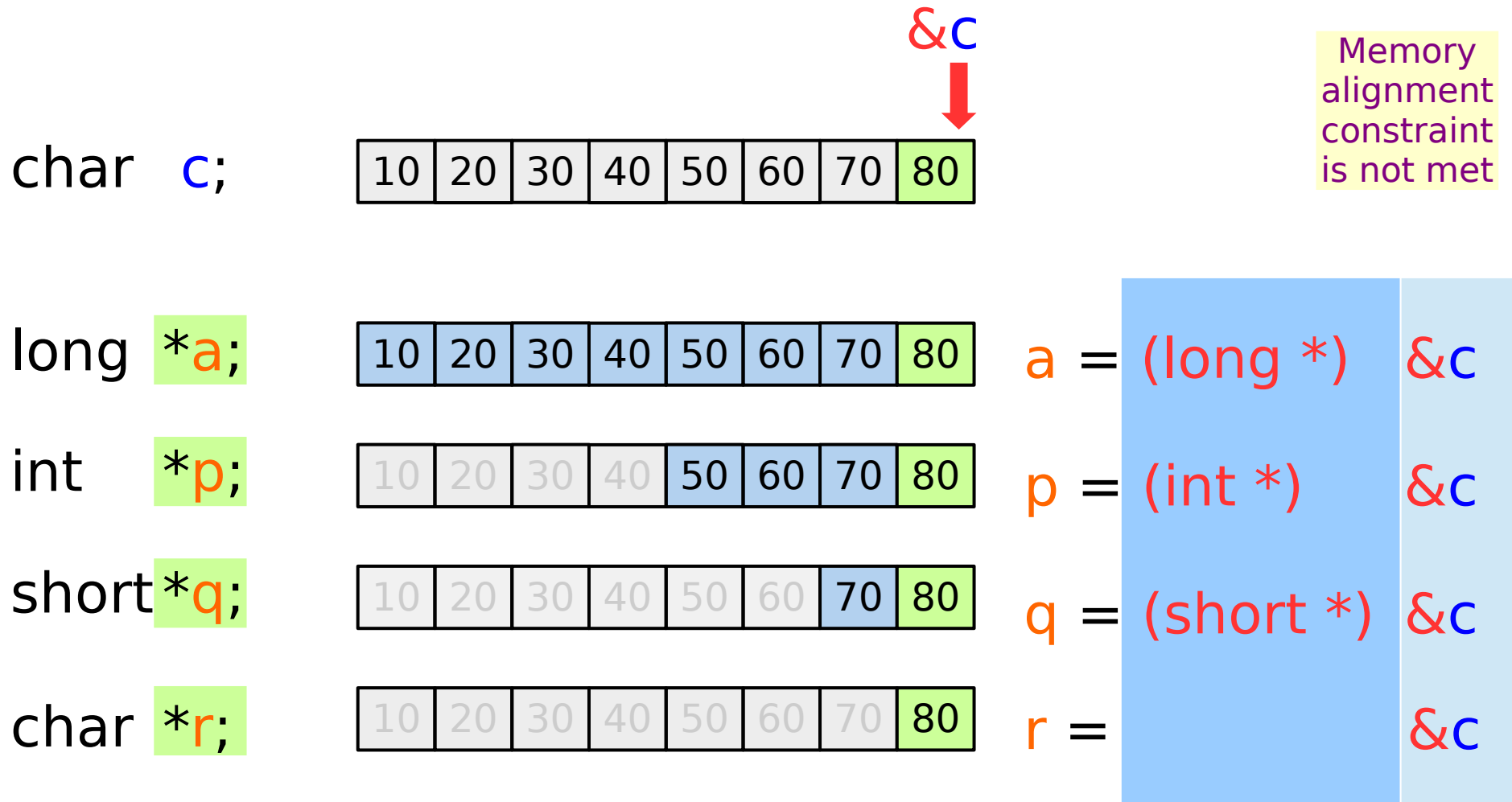


r = (char *) &a

Re-interpretation of memory data - case I



Re-interpretation of memory data - case II



Depending on `&c`, the memory alignment constraint can be broken

const pointers

const type, const pointer type (1)

```
const int * p;
```

read only integer value

```
int * const q ;
```

read only integer pointer

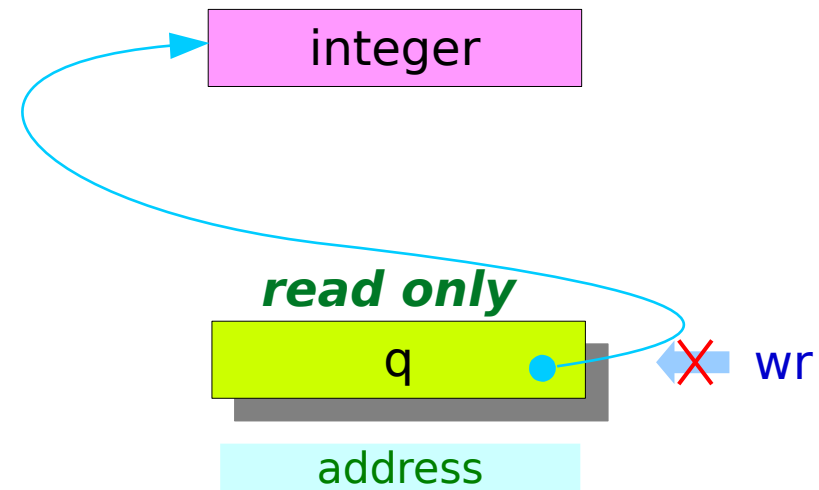
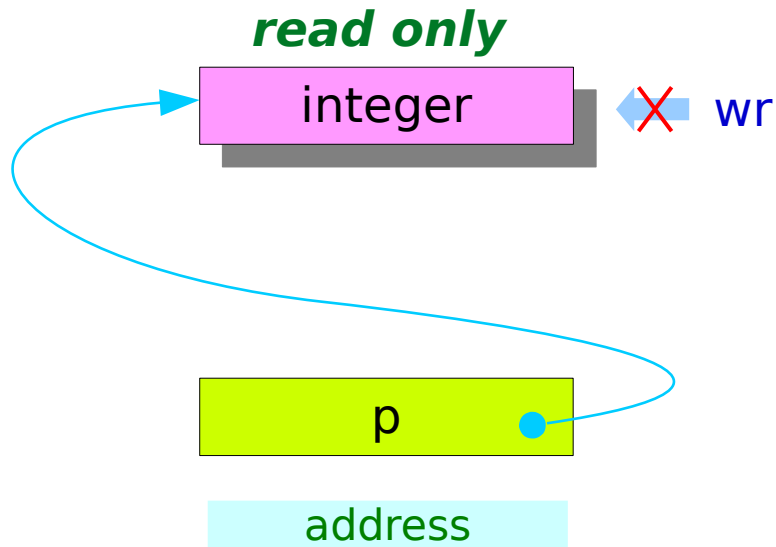
```
const int * const r ;
```

*read only integer value
read only integer pointer*

const type, const pointer type (2)

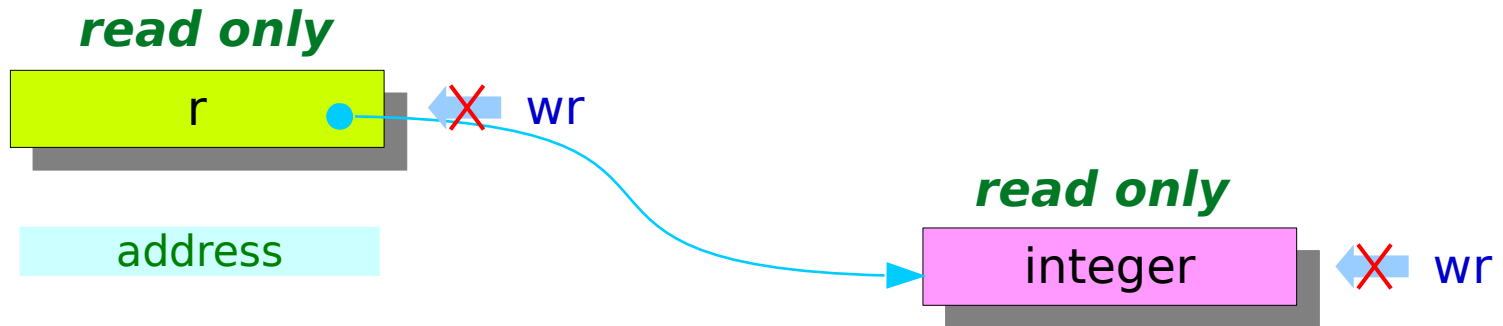
`const int * p;`

`int * const q;`



const type, const pointer type (3)

```
const int * const r ;
```



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