Introduction to Programming

Lecture 5 — Computers' memory

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Université de Saint-Étienne | Year 2026/2027

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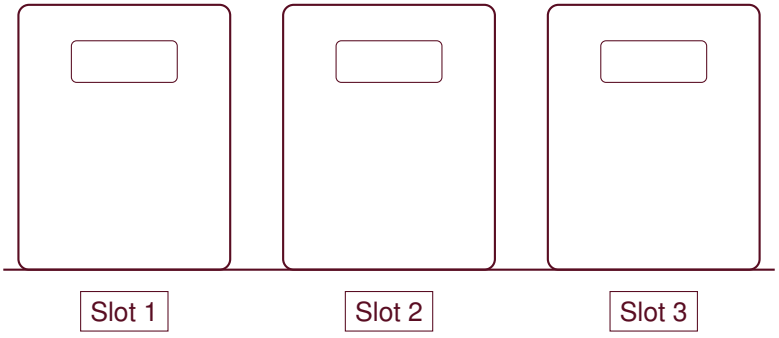
Université Jean Monnet Saint-Étienne

-1 Recap’ time

00 Assignment review

01 Memory spots, addresses and pointers

Boxes in your memory



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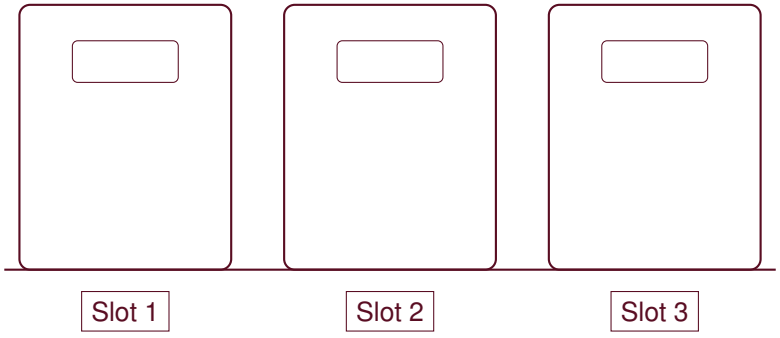


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int a = 6;
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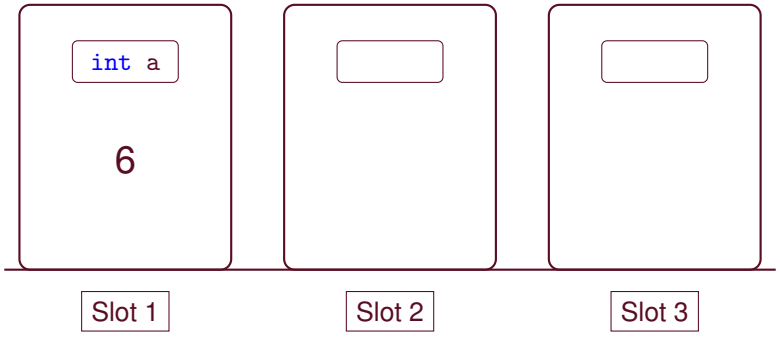
Boxes in your memory

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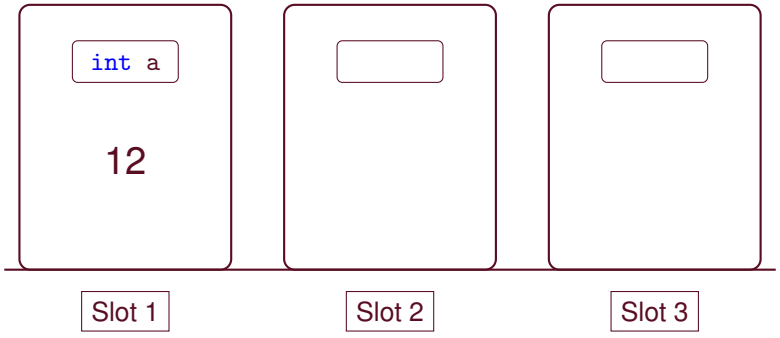
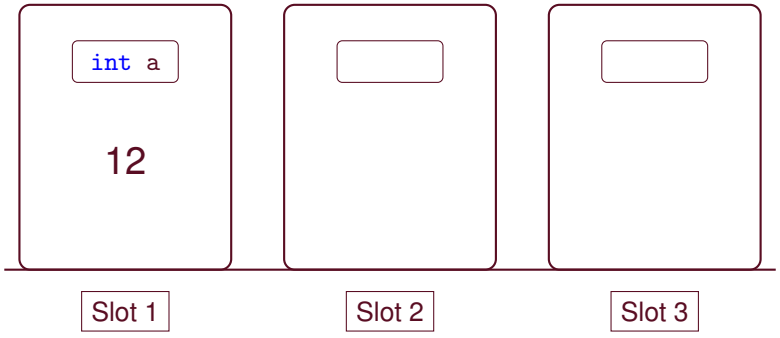



```
int a = 6;
a = 12;
```

Boxes in your memory

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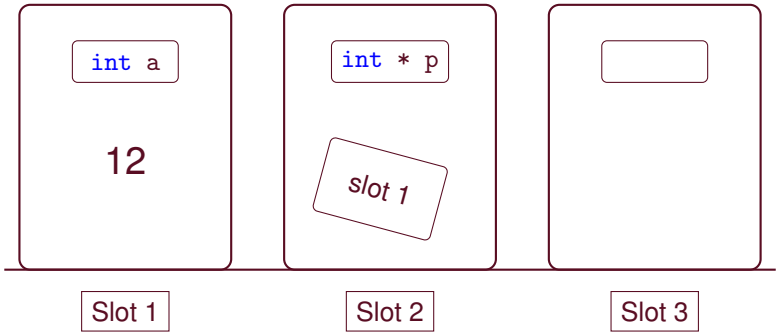


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To declare a pointer, you write the type of the variable you'll store the address of, and add a $*$.

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```
int a = 12;
int * p = &a; // p contains the address of a
// we say that p points to a
```

Reaching the value pointed by a pointer

You can **dereference** a pointer to read the value contained in the variable it is pointing at.

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int a = 12;
int * p = &a; // p contains the address of a
std::cout << "a = "  << *p;
```

Pointers initialization

When initializing a pointer, if you don’t assign it a value yourself, it will contain a random memory address. This means the pointer points at a memory spot on your computer that may contain anything. It could contain sensitive data.

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You set a pointer to point to 0 with either one of the following:

```
int * p = 0;
int * p = NULL;
int * p = nullptr;
```

Copying a pointer 1/2

```
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int b = a;
a = 4;
// b still contains 12 because a and b are different boxes
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int * p1 = &a;
int * p2 = p1;
*p1 = b;
std::cout << *p2 << std::endl;
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Practise time!

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In the same way, a variable uses up program storage / memory. A variable also has a size, that depends on its *type*. This means the boxes on the shelf have *different sizes*.
You can get the size of a variable, that is the memory it uses in a program, with `sizeof`. It will give you the size in bytes.

Incrementing a pointer 1/2

A pointer points to a spot in the program's memory. To increment a pointer is to make it point to the next spot in the program's memory.

```
int a;
```

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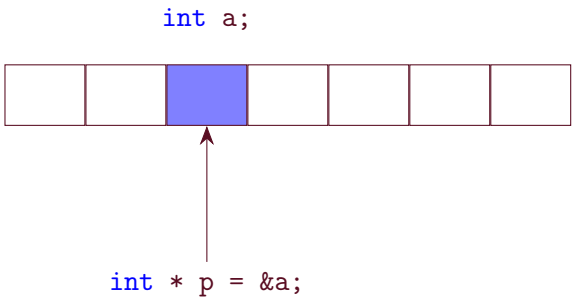

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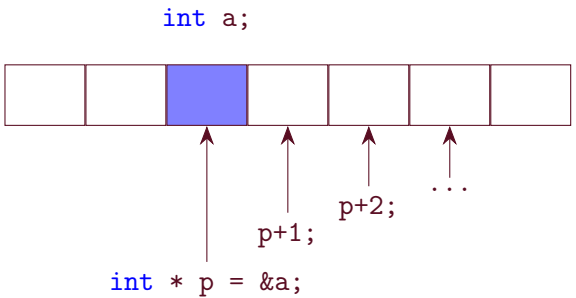

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Look at this.

Why would we want to increment a pointer?

Remember `argv`?

Pointers and arrays

If some elements are stored contiguously in memory, then a pair composed of a pointer and element count can represent an array.

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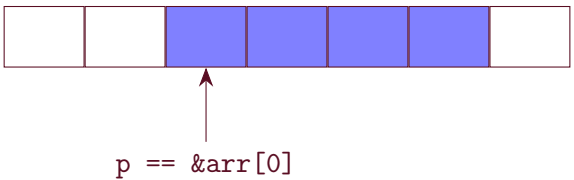
```
std::array<int, 4> arr {1,2,3,4};
int * p = arr.data();
size_t count = arr.size(); // == 4
```



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```
std::array<int, 4> arr
    {1,2,3,4};
int * p = arr.data();
for(int i = 0; i < arr.size();
     ++i){
    std::cout << arr[i]
        << std::endl;
}
```

```
std::array<int, 4> arr
    {1,2,3,4};
int * p = arr.data();
for(int i = 0; i < arr.size();
     ++i){
    std::cout << *(p+i)
        << std::endl;
}
```

C-style arrays

```
<type> arr [] = { ... };
```

C-style arrays are static arrays, very much like `std::array`. The difference is they don't have member functions like `size()`, so you have to keep track of their element count in a seperate variable.

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C-style arrays and pointers are most often interchangeable once instanciated.

```
void foo(int * ptr);
int arr [] = {1,2,3,4};
foo(arr); // OK
```

Pointer to const

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```
int a = 10;
const int * p = &a;
*p = 8; // illegal, p is pointer to const
```

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int a = 10, b = 78;
int * const p = &a;
p = &b; // illegal, p is a const pointer
```

References vs pointers 1/3

References are only an *alias* to a variable. It's like putting a second label on a same box.

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int a = 6;
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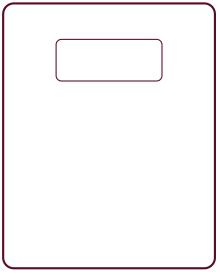

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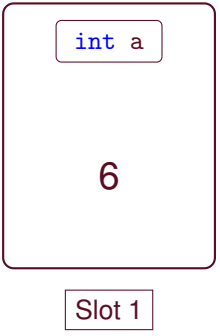

References vs pointers 1/3

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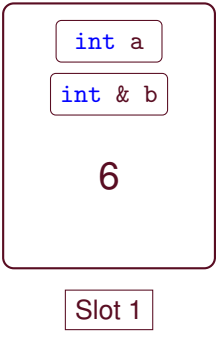
```
int a = 6;

int & b = a;
```



References vs pointers 2/3

References	Pointers
Have the same address as the variable they denote	Have their own address

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References	Pointers
Have the same address as the variable they denote	Have their own address
Cannot be empty, thus cannot exist beyond the scope of the variable they denote.	Will contain an address no matter what. If the object they point to is destroyed before them, the pointer becomes invalid but can still exist and be used.

References vs pointers 3/3

Because pointers can become invalid and references can't, the latter as safer to use than the former.

Rule of thumb: whenever possible, if you have the choice between the two, prefer references.

02 Algorithms on vectors and containers

Iterators

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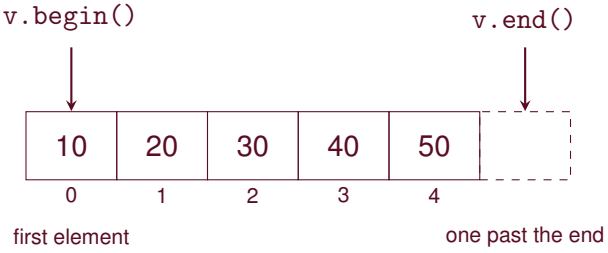
int * pointer = &vec[0];
auto iterator = vec.begin();

// prints first element of vec
std::cout << *ptr << std::endl;
std::cout << *iterator << std::endl;
 // prints second element
std::cout << *(ptr + 1) << std::endl;
std::cout << *(iterator + 1) << std::endl;
```

Begin and end



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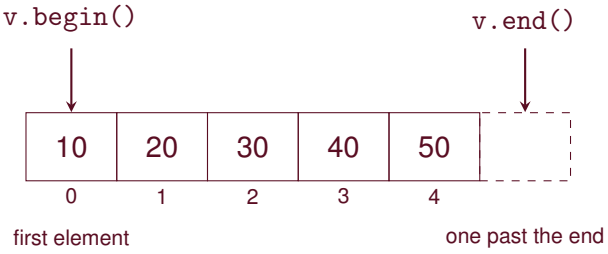

Traversing a `std::vector` using iterators:

```
for(auto iter = v.begin(); iter != v.end(); ++iter){
    // ...
}
```

STL's algorithms 1/2

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Some examples:

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// sorts in non-descending order
std::sort(v.begin(), v.end());
// copy elements from [v_src.begin(), v_src.end()-1] at the back of
    v_dst
std::copy(v_src.begin(), v_src.end(), std::back_inserter(v_dst));
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    v_dst
std::copy(v_src.begin(), v_src.end(), std::back_inserter(v_dst));

// search for the first occurence of 4 if any in v. If v contains a
    4, found will point at it; otherwise, found points at v.end().
auto found = std::find(v.begin(), v.end(), 4);
```

STL's algorithms 2/2

There are plenty of algorithms already implemented in the STL. If you need to do some basic operation on a container, always try to find if it hasn't been implemented in the STL. They are referenced here: `https://en.cppreference.com/cpp/header/algorithm`.

Practise time!

03 Accessing text files

Reading from text files: an example

Let’s have a look at an example.

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You can either read a file line by line with `std::getline`.
Or you can use the operator >> to read data into variables. You have to be careful about type (mis-)match.

Writing to text files: an example

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Writing to text files

`std::ofstream` is an **output file stream**. You can use it to **read** from a file.

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You can write anything to a file using << just like you'd write to the terminal output with `std::cout << ...`.

Practise time!

04 Reading and modifying audio files

What are sound files? Briefly

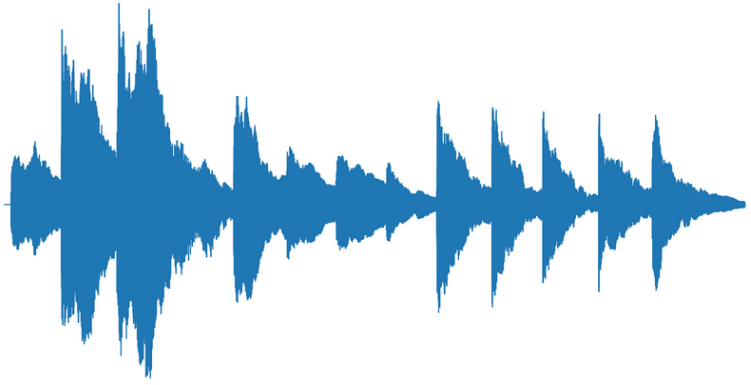

Figure: Audio waveform

Audio files and how to manipulate them

Sound can be represented as a collection of `float` values all in the range $[-1, 1]$.

Audio files and how to manipulate them

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We can use the libsnfile library to open, read from and write to audio files.

Practise time!

See you next time!