CS319: Scientific Computing

Functions: overloading and pass-by-reference

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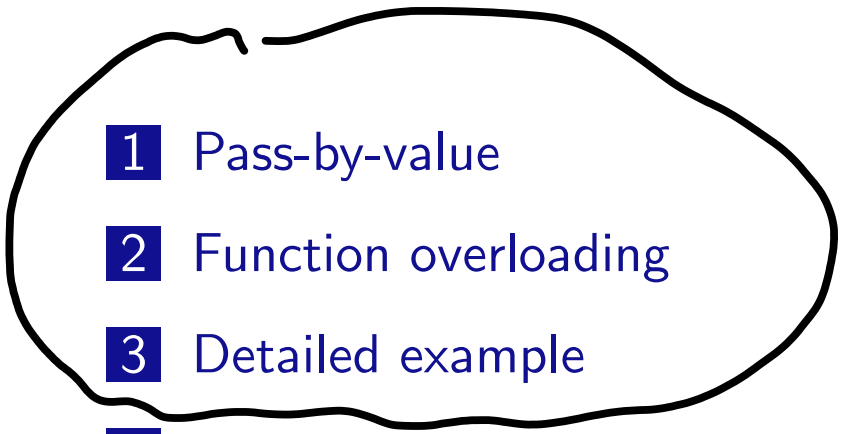
Slides and examples: https://www.niallmadden.ie/2324-CS319

Outline



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3. Detailed example
4. Arrays and memory allocation
   - Arrays
   - Pointers
5. Dynamic Memory Allocation
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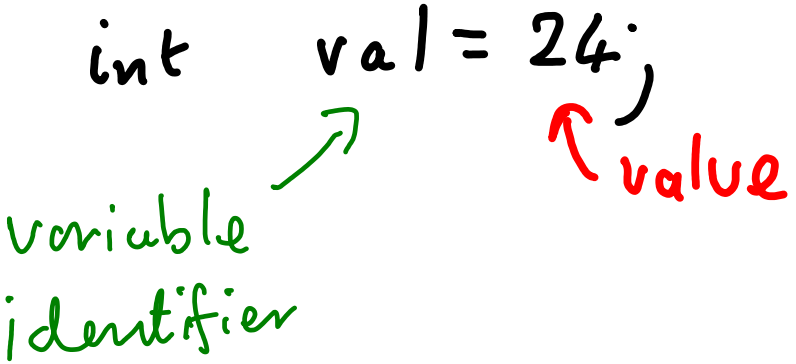
Pass-by-value

In C++ we need to distinguish between

- the value stored in the variable.
- a variable's identifier (might not be unique)
- a variable's (unique) memory address

In C++, if (say) `v` is a variable, then `&v` is the memory address of that variable.

We'll return to this at a later point, but for now we'll check the output of some lines of code that output a memory address.



Pass-by-value

00MemoryAddresses.cpp

```
    int i=12;
10  std::cout << "main: Value stored in i: " << i << '\n';
    std::cout << "main: address of i: " << &i << '\n';
12  Address(i);
    std::cout << "main: Value stored in i: " << i << '\n';
```

Typical output might be something like:

value stored in i

```
main: The value stored in i  is 12
main: The address of i is 0x7ffcd1338314
```

↑ value of &i, ie memory address of i

Address is stored in hexadecimal ("hex"), i.e, base 16.

Pass-by-value

A while back we learned that, when we pass a variable as an argument to a function, a new **copy** of the variable is made.

This is called **pass-by-value**.

Even if the variable has the same name in both `main()` and the function called, and the same value, they are different: the variables are **local** to the function (or block) in which they are defined.

We'll test this by writing a function that

- Takes a `int` as input;
- Displays its value and its memory address;
- Changes the value;
- Displays the new value and its memory address.

Pass-by-value

00MemoryAddresses.cpp

```
18 void Address(int i)
   {
20   std::cout << "Address: Value stored in i: " << i << '\n';
     std::cout << "Address: address of i: " << &i << '\n';
22   i+=10; // Change value of i
     std::cout << "Address: New val stored in i: " << i << '\n
24   std::cout << "Address: address of i: " << &i << '\n';
   }
```

Typical output:

Line	
20	Address: Value stored in i: 12
21	Address: address of i: 0x7ffc471e18ac
23	Address: New val stored in i: 22
24	Address: address of i: 0x7ffc471e18ac

memory address does not change.

Pass-by-value

Finally, let's call this function:

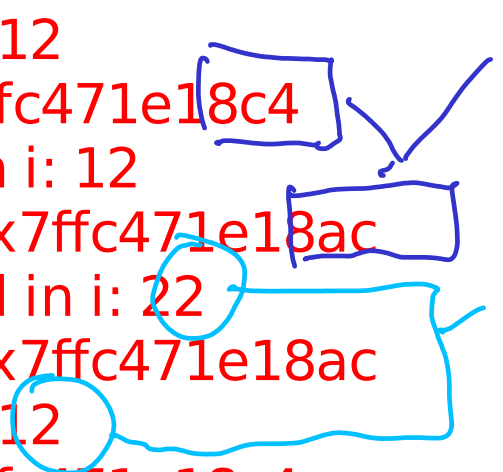
00MemoryAddresses.cpp

```
    int i=12;
10  std::cout << "main: Value stored in i: " << i << '\n';
    std::cout << "main: address of i: " << &i << '\n';
12  Address(i);
    std::cout << "main: Value stored in i: " << i << '\n';
14  std::cout << "main: address of i: " << &i << '\n';
```

10+11
main: Value stored in i: 12
main: address of i: 0x7ffc471e18c4

12
Address: Value stored in i: 12
Address: address of i: 0x7ffc471e18ac
Address: New val stored in i: 22
Address: address of i: 0x7ffc471e18ac

13+4
main: Value stored in i: 12
main: address of i: 0x7ffc471e18c4



different memory addresses.

Value of i changed in Address, but not main()

Pass-by-value

In many case, "pass-by-value" is a good idea: a function can change the value of a variable passed to it, without changing the data of the calling function.

But sometimes we **want** a function to be able to change the value of a variable in the calling function.

The classic example is function that

- takes two `int`eger inputs, `a` and `b`;
- after calling the function, the values of `a` and `b` are swapped.

Pass-by-value

01SwapByValue.cpp

```
#include <iostream>
void Swap(int a, int b);

int main(void )
{
  int a, b;

  std::cout << "Enter two integers: ";
  std::cin >> a >> b;

  std::cout << "Before Swap: a=" << a << ", b=" << b
            << std::endl;
  Swap(a,b);
  std::cout << "After Swap: a=" << a << ", b=" << b
            << std::endl;

  return(0);
}
```

← tries to swap values in a & b.

Pass-by-value

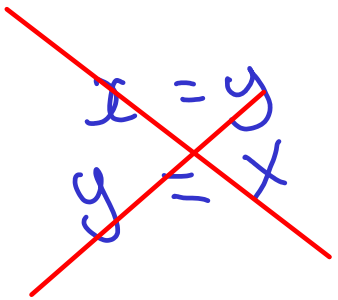
```
void Swap(int x, int y)
{
   int tmp;

   tmp=x;
   x=y;
   y=tmp;
}
```

x	y	tmp
5	10	5
10	10	5
10	5	5

This won't work.

We have passed only the *values stored in the variables a and b*. In the `swap` function these values are copied to local variables x and y. Although the local variables are swapped, they remained unchanged in the calling function.

What we really wanted to do here was to use **Pass-By-Reference** where we modify the contents of the memory space referred to by `a` and `b`. This is easily done...



Pass-by-value

...we just change the declaration and prototype from

```
void Swap(int x, int y)  // Pass by value
```

pass variables

to

```
void Swap(int &x, int &y)  // Pass by Reference
```

the pass-by-reference is used.

pass memory address

Pass-by-value

Exercise

Change the `Address()` function in `OOMemoryAddresses.cpp` so that the variable `i` is passed by reference.
How does the output change?

Function overloading

C++ has certain features of **polymorphism**: where a single identifier can refer to two (or more) different things. A classic example is when two different functions can have the same name, but different argument lists.

This is called **function overloading**.

There are lots of reasons to do this. For example, just now we wrote a function called `Swap()` that swapped the value of two `int` variables. But suppose we wanted to write a function that swapped two `float`s, or two `string`s. Would we have to give a different name to each function? No!

Function overloading

As a simple example, we'll write two functions with the same name: one that swaps the values of a pair of `int`s, and that other that swaps a pair of `float`s. (Really this should be done with `template`s...)

02Swaps.cpp

```
#include <iostream>

// We have two function prototypes!
void Swap(int &a, int &b);
void Swap(float &a, float &b);
```

Function overloading

02Swaps.cpp (continued)

```
int main(void) {
    int a, b;
    float c, d;

    std::cout << "Enter two integers: ";
    std::cin >> a >> b;
    std::cout << "Enter two floats: ";
    std::cin >> c >> d;

    std::cout << "a=" << a << ", b=" << b <<
      ", c=" << c << ", d=" << d << std::endl;
    std::cout << "Swapping ...." << std::endl;

    Swap(a,b);
    Swap(c,d);

    std::cout << "a=" << a << ", b=" << b <<
      ", c=" << c << ", d=" << d << std::endl;
    return(0);
```

Function overloading

02Swaps.cpp (continued)

```
void Swap(int &a, int &b)
{
  int tmp;

  tmp=a;
  a=b;
  b=tmp;
}

void Swap(float &a, float &b)
{
  float tmp;

  tmp=a;
  a=b;
  b=tmp;
}
```

Function overloading

What does the compiler take into account to distinguish between overloaded functions?

C++ takes the following into account: "function signature".

- **Type of arguments**. So, e.g., `void Sort(int, int)` is different from `void Sort(char, char)`.
- **The number of arguments**. So, e.g., `int Add(int a, int b)` is different from `int Add(int a, int b, int c)`.

But not

- **Return values**. For example, we cannot have two functions `int Convert(int)` and `float Convert(int)` since they have the same argument list.
- **user-defined types** (using `typedef`) that are in fact the same. See, for example, `03OverloadedConvert.cpp`.

Detailed example

In the following example, we combine two features of C++ functions:

- Pass-by-reference,
- Overloading,

We'll write two functions, both called `Sort`:

- `Sort(int &a, int &b)` – sort two integers in ascending order.
- `Sort(int list[], int n)` – sort the elements of a list of length n.

The program will make a list of length 8 of random numbers between 0 and 39, and then sort them using **bubble sort**.

Detailed example

04Sort.cpp (i)

```
#include <iostream>
#include <stdlib.h>

const int N=8;

void Sort(int &a, int &b);
void Sort(int list[], int length);
void PrintList(int x[], int n);
```

← ignore this

Detailed example

04Sort.cpp (ii)

```
14 int main(void )
   {
16    int i, x[N];

18    for (i=0; i<N; i++)
        x[i]=rand()%40;

      std::cout << "The list is:\t\t";
22    PrintList(x, N);
      std::cout << "Sorting..." << std::endl;

      Sort(x,N);

      std::cout << "The sorted list is:\t";
28    PrintList(x, N);
      return(0);
30 }
```

Returns a very large (pseudo) random int.

Detailed example

04Sort.cpp (iii)

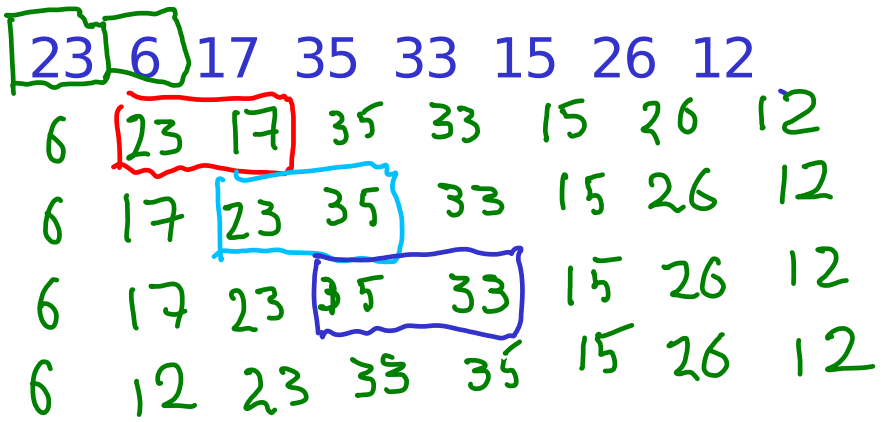
```
32 // Arguments: two integers
   // return value: void
34 // Does: Sorts a and b so that a¡=b.
   void Sort(int &a, int &b)
36 {
     if (a>b)
38   {
       int tmp;
40     tmp=a;  a=b;  b=tmp;
     }
42 }
```

if a > b swap their values.

Detailed example

04Sort.cpp (iii)

```
// Arguments: an integer array and its length
// return value: void
// Does: Sorts the 1st n elements of x
void Sort(int x[], int n)
{
  int i, k;
  for (i=n-1; i>1; i--)
    for (k=0; k<i; k++)
      Sort(x[k], x[k+1]);
}
```



Detailed example

```
62 void PrintList(int x[], int n)
   {
64   for (int i=0; i<n; i++)
       std::cout << x[i] << "  ";
66   std::cout << std::endl;
   }
```

Finished here 10am