

122COM: Introduction to C++

David Croft

Coventry University

david.croft@coventry.ac.uk

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Highs and lows



- Programming languages split into levels.
- Low level languages are machine code, assembly language.
- High level languages are Python, C++, Java etc.

High level languages

`i += 1`



Assembly

`GOTO 0x42`

`INCF 0x68 0x01`

`SLEEP`



Machine code

01010011 01100101 01110010 01101001

01101111 01110101 01110011 01101100 01111001

00111111 01111001 00111111



Hardware



Languages

C++

Variables

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Recap

↑	High level	Python, Ruby Java C++ C Forth, Basic	3 rd generation
↓	Low level	Assembly Machine code Hardware	2 nd generation 1 st generation

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Recap

Machine code

- 1st generation.
- Really hard to understand.
- Really hard to write.
- The actual instructions to the hardware.

Assembly

- 2nd generation.
- Hard for humans to understand.
- Hard for humans to write.
- 1-to-1 correspondence with what is run.

High level

Python, C, C++, Java, PHP, Perl etc.

- 3rd generation.
- Favour programmer, not machine.
- Easy for humans to understand...compared to the alternatives.
- Easy for humans to write...compared to the alternatives.
- Portable.
 - Different machine == different compiler.
 - Same C/Python/C++/Java code.

So far you have used Python.
Now going to learn C++.

- Created somewhere in 1979-1983.
- Based on C (created 1972).
 - Going to be learning C++11 (approved 2011).
- C++14 has been approved (2014).
 - No support yet.
- 99.9% backwards compatible.
 - All the way to C.
- Supports the same paradigms as Python.
 - Object oriented, functional, declarative etc.

- All students are expected to learn some C++.
- In future weeks we will be looking at generic programming concepts.
 - Sorting.
 - Searching.
 - Data structures.
- Those weeks will be taught in Python and C++.
 - Everyone else will have some mandatory C++ tasks.
 - BIT students can choose Python or C++ most tasks.
 - Will be specified at the time.
- BIT will not be examined on C++ code.
 - May be examined on language differences.
 - High/low languages.
 - Compiling.
 - Static/dynamic typing.
 - Stack/heap memory.

Most significant difference...

- C++ is statically typed.
 - Python is dynamically typed.
- In Python variables keep track of values AND type.

```
var = 42           # type(var) = <type 'int'>
var = 'foo'        # <type 'str'>
var = 0.123        # <type 'float'>
```

- In C++ variables have one type forever.
 - Have to specify type when creating.

```
int    var1 = 42;
string var2 = "foo";
float  var3 = 0.123;
```

In C++ have to specify a variable's type.

- So what types are available?
- Thousands (at least).
 - You can create your own.
- Few standard ones.
- Most basic data types are called primitive types.

- Knowing what the different variables are.
- Knowing all the primitives and the variations.
- Knowing ranges/sizes.

Type	Bytes	Values
bool	1	true/false
char	1	'a', 'Z', '6', '+'
int	4	-2147483647 → 2147483647
unsigned int	4	0 → 4294967295
float	4	1.234, -0.0001
double	8	1.23456789, -0.000000001
void		

Sizes are correct for a 32bit machine.

Moving from Python to C++.

- Not as bad/scary as it seems.
- Same basic structure.
- Slightly different syntax.

Python.

```
print('Hello World!')
```

```
import sys
```

```
def main():  
    print('Hello World!')
```

```
if __name__ == '__main__':  
    sys.exit(main())
```

C++.

```
#include <iostream>  
using namespace std;  
  
int main()  
{  
    cout << "Hello World!" << endl;  
  
    return 0;  
}
```

- All programs in C++ **MUST** have exactly one `main()` function.
- C++ uses `{` and `}` instead of indentation.
 - You should still have indentation in C++ but is aesthetic only.
- Semi-colons at the end of lines.

Same rules as Python.

- Slightly different syntax.
- and is now &&.
- or is now ||.
- == is still ==.

```
a = 1
b = 2

if a == b and b > 0:
    print('Hello World')
```

```
int a = 1;
int b = 2;

if( a == b && b > 0 )
{
    cout << "Hello World!" << endl;
}
```

Similar to Python lists.

- Can't be resized.

```
sequence = [1, 2, 42, 69, 8]
sum = 0

for i in range(len(sequence)):
    sum += sequence[i]
```

```
int sequence[5] = {1, 2, 42, 69, 8};
int sum = 0;

for( int i=0; i<5; i+=1 )
{
    sum += sequence[i];
}
```


Three ways to create a C array.

1 Just supply size

```
int    arrayOfInt [3];  
char   arrayOfChars [5];  
float  arrayOfFloats [2];
```

2 Supply size and initialisation list

```
int    arrayOfInt [3]    = { 42, 69, 12 };  
char   arrayOfChars [5] = { 'A', 'z', '9' };  
float  arrayOfFloats [2] = { 1.23, 0.001, 8.1 };
```

3 Just initialisation list (will figure out the size)

```
int    arrayOfInt []    = { 42, 69, 12 };  
char   arrayOfChars [] = { 'A', 'z', '9' };  
float  arrayOfFloats [] = { 1.23, 0.001, 8.1 };
```

So far looked at the old style arrays.

- Carried forward from C.
- Still used today.
- C++03 introduced an alternative.
 - STL arrays.

```
#include <array>
using namespace std;

int main()
{
    int oldArray[5] = {1,2,3,4,5};
    array<int,5> newArray = {1,2,3,4,5};

    cout << oldArray[0] << " " << newArray[0] << endl;

    return 0;
}
```

There's two of them?



Two types of arrays.

- Old style arrays are still very common.
 - Legacy.
 - Want you to start off using the new ones.
- What was wrong with the old ones?
- New arrays are safer.
 - Avoid overflows.
- Easier to use.
 - Sorting, searching, reversing, iterating etc.
- Are backwards compatible with old code.

Problem, C++ arrays have a set size.

- Saw we had to provide a size when declaring arrays.

C++ does have 'arrays' that can be resized.

- Called vectors.
- Uses arrays inside.

```
#include <array>
#include <vector>
#include <iostream>
using namespace std;

int main()
{
    array<int,5> myArray = {1,2,3,4,5};
    vector<int> myVector = {1,2,3,4};

    myVector.push_back(5);

    cout << myArray[0] << endl;
    cout << myVector[0] << endl;
}
```

C++ vectors are the closest thing to Python lists.

- If you are moving to C++ from Python easier to use vectors?
- `append()` → `push_back()` and `emplace_back()`
- `pop()` → `pop_back()`
- slicing → `resize()`

Same rules as Python.

- Slightly different syntax.
- Brackets ().
- Braces {}.
- Semicolons ;.

```
counter = 0
while counter < 10:
    print('Hello World!')
    counter += 1
```

```
int counter = 0;
while( counter < 10 )
{
    cout << "Hello World!" << endl;
    counter += 1;
}
```

C++ has two kinds of for loops.

- One type similar to Python for loops.
 - Actually a range-based loop.
 - Will be covered later.
- One type similar to a while loop.

The original C++ for loop.

- Seems very different to the python loop.
- Lots of commonalities.
- Also to while loops.

```
for counter in range(10):  
    print('Hello World!')
```

```
for counter in range(0,10,1):  
    print('Hello World!')
```

```
for( int counter=0; counter<10; counter+=1 )  
{  
    cout << "Hello World!" << endl;  
}
```

```
int counter = 0;  
while( counter < 10 )  
{  
    cout << "Hello World!" << endl;  
    counter += 1;  
}
```


The new C++11 ranged for loop, for iterating over a sequence.

- Less powerful than the old style.
- Easier.
- while > for > ranged for

Ranged for loops

1

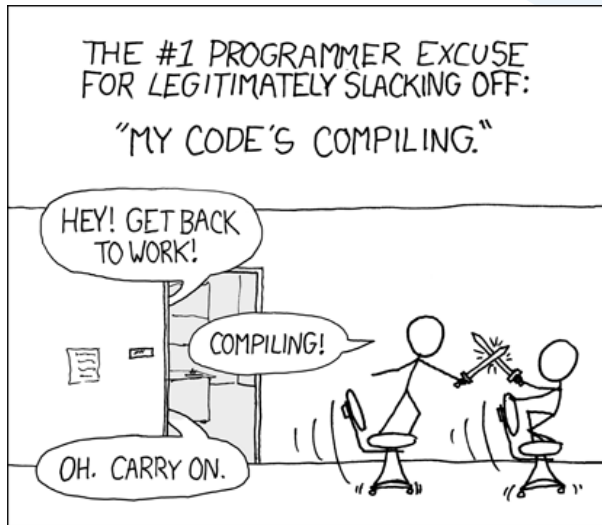
```
sequence = [1,2,3,4,5]
for i in sequence:
    print( i )
```

```
int main()
{
    array<int,5> sequence =
        { 1, 2, 3, 4, 5 };
    for( int i : sequence )
    {
        cout << i << endl;
    }

    return 0;
}
```

C++ code has to be compiled before it is run.

- So does Python it just happens automatically.
- Compiler converts C++ code into machine code.
- Many IDEs handle compiling for you.
 - Visual Studio, Eclipse etc.



GNU C Compiler (created 1987).

- Linux, Mac and Windows.

How to compile using g++.

- Demo
- `g++ -std=c++11 hello.cpp -o hello`
 - `g++` - the compiler program.
 - `-std=c++11` - we want to use the C++11 standard of C++.
 - `hello.cpp` - the file we want to compile.
 - `-o hello` - the name of the executable to create.

What if your code is wrong?

- Same as Python.
 - Syntax errors.
 - Runtime errors.
 - Logic errors.
- Spot the errors.

```
int main()
{
    cout << "Hi" << endl;

    for( int i=0; i>10; j+=1 )
    {
        cut << "Hello World!" << endl
    }

    return 0;
}
```

C++

David Croft

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Recap

- C++ is a high level language.
 - 3rd generation.
- Compiled.
- Statically typed.
- Arrays cannot be resized.
 - Use new STL arrays.

The End