Advanced Programming Concepts with C++ CSI2372 – Fall 2019

Jochen Lang &
Mohamed Taleb
EECS

uOttawa

L'Université canadienne
Canada's university

C++

- **Object-oriented programming language**
  - Data abstraction (class concepts)
  - Operator overloading
- **C/C++ (and Objective C) together are (still) the de-facto standard (except for web centric applications)**
- **Combines a high-level language with low-level features**
  - C++ is a *superset* of C
  - C is a functional programming language
- **Goals:**
  - Augment C with the notion of classes and inheritance
  - Keep the same performance as C
  - Keep same applicability as C

Brief History of C/C++

1967-1980	Development of Unix by Ken Thompson, Denis Ritchie and others at Bell Labs
1969-1973	C by Denis Ritchie, Bell Labs Based on B written by Ken Thompson, most of Unix written in C
1984	C++ by Bjarne Stroustroup, Bell Labs Object oriented programming constructs were added to C
1998	C++ Standard ISO/IEC 14882 and revised in 2003 as ISO/IEC 14882:2003
2011	C++ Standard C++11 “C++0x”, ISO/IEC 14882:2011
2014	C++ Standard ISO/IEC 14882:2014
2017	C++ Standard ISO/IEC 14882:2017
2020	Next scheduled release

Bjarne Strousroup

C++

- C++ has been derived from the well-known programming language C.

- The name C++ is related to the expression C++, which we can write in a C program to increment a variable C.

- C++ is a much younger language than C, its use is already widespread, and its popularity will no doubt increase considerably as a result of the excellent quality of popular compilers such as Turbo C++ from Borland.

- One of the attractive aspects of C++ is that it offers good facilities from Object-Oriented Programming (OOP), but, as a hybrid language, it also permits the traditional programming style, so that programmers can shift to OOP id and when they feel the need to do so.

C++

- In this regard, C++ differs from some ‘purely’ OO languages, such as: Smalltalk, Eiffel and Java.

- Viewed from the angle of many C programmers, C++ is simply ‘a better C’.

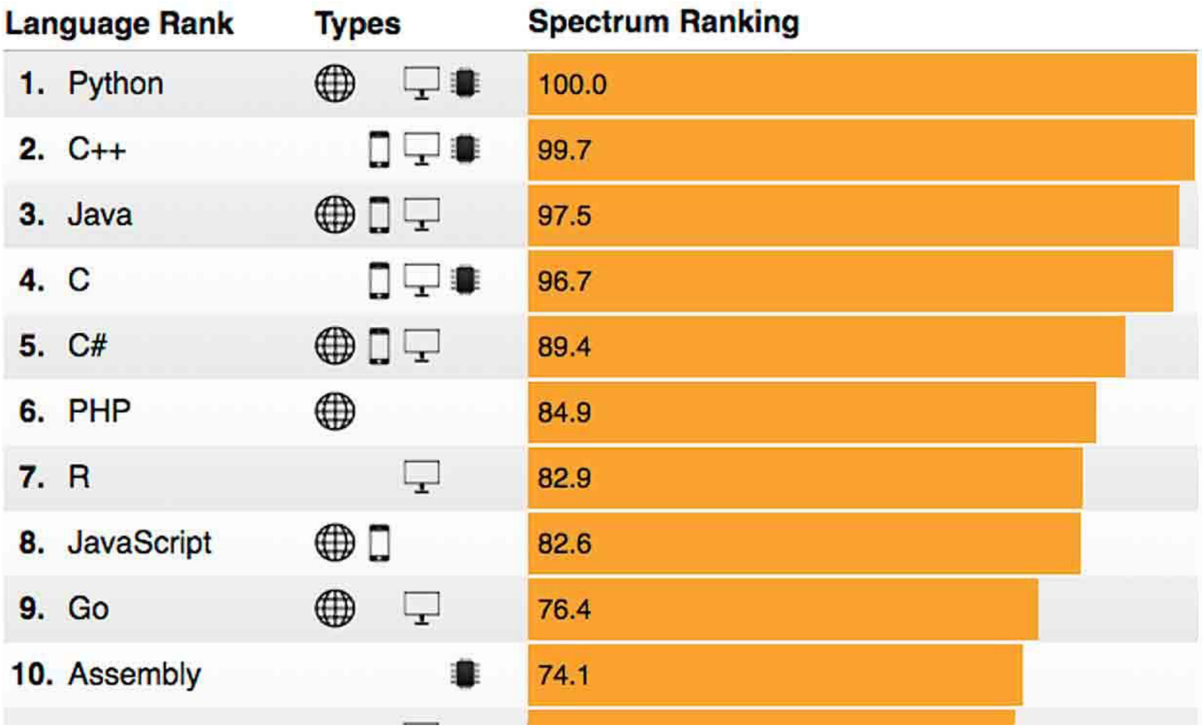
- Besides the important: *class concept*, essential to OOP, there are many other points in C++ that are not available to C programmers. To mention just a few, related to functions: *function overloading*, *inline functions*, *default arguments*, *type-safe linkage*, and the very simple requirement that functions be declared before they are used.

- In C, the old practice of using undeclared functions is still allowed in order to keep many existing C programs valid; in C++ it is not.

C++

- **Strengths**
  - Low-level systems programming
  - High-level systems programming
  - Generic programming
  - Embedded code
  - High performance programming
  - Numeric/scientific computation
  - Games programming
  - General application programming
- **Weaknesses**
  - Legacy of C
  - Insecurities
  - Complexity
  - No standard GUI library

Popularity of Programming Languages

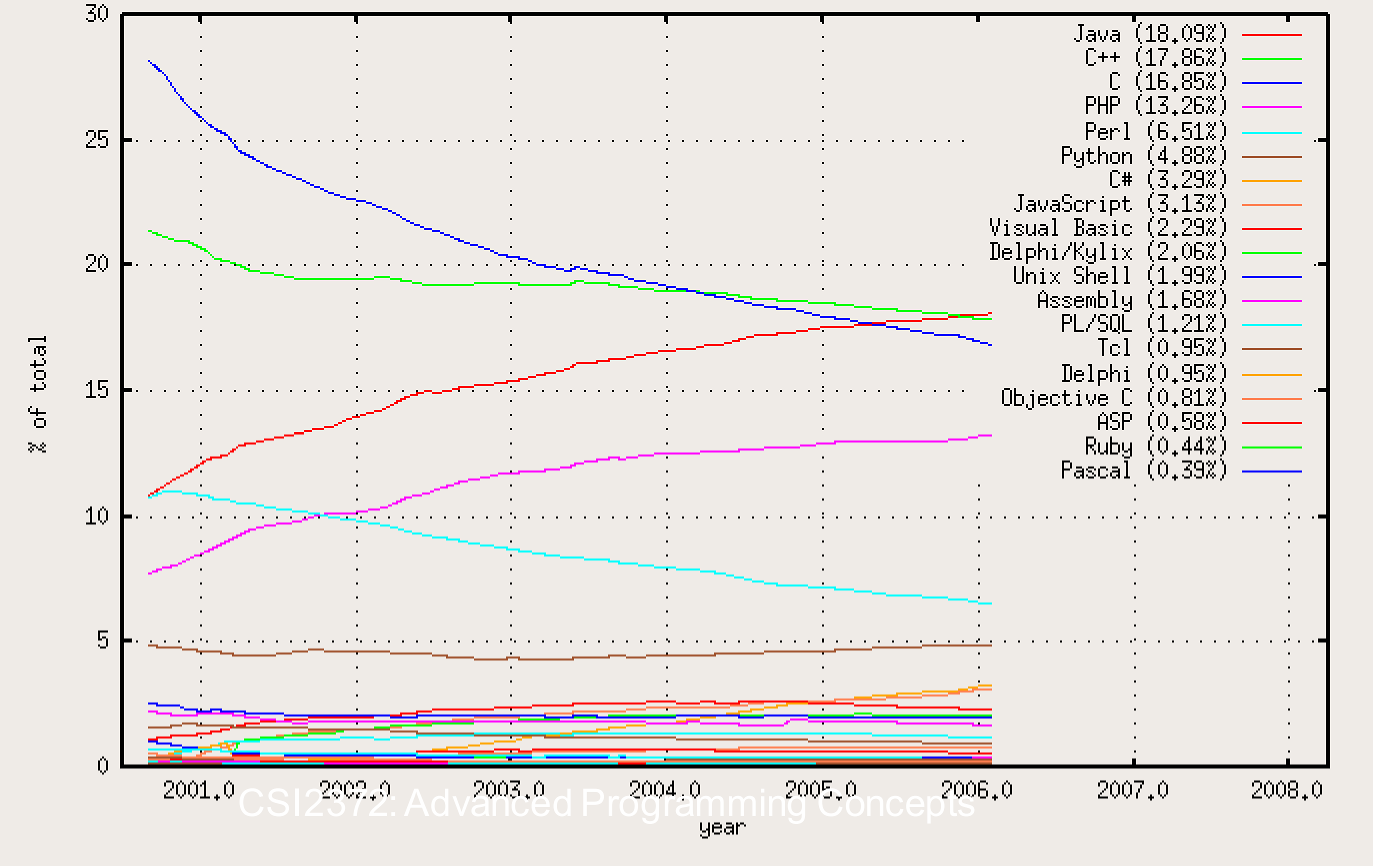


Language Rank	Types	Spectrum Ranking
1. Python	🌐 🖥 ■	100.0
2. C++	📱 🖥 ■	99.7
3. Java	🌐 📱 🖥	97.5
4. C	📱 🖥 ■	96.7
5. C#	🌐 📱 🖥	89.4
6. PHP	🌐	84.9
7. R	🖥	82.9
8. JavaScript	🌐 📱	82.6
9. Go	🌐 🖥	76.4
10. Assembly	■	74.1

“The 2018 Top Programming Languages” IEEE Spectrum ranking [accessed Sep. 1, 2018]. Based on web searches, specific web pages, IEEE digital library etc.

Use of Programming Languages at the Beginning of the Century

- **François Labelle, Programming Language Usage Graph**
  - https://wismuth.com/lang/languages.html
  - – Statistics based on open source projects at SourceForge



Is C++ in decline?

- **Bjarne Stroustrup:**
  - *“No, I don't think so. C++ use appears to be declining in some areas and to be on an upswing in others. If I had to guess, I'd suspect a net decrease sometime during 2002-2004 and a net increase in 2005-2007 and again in 2010-2011, but I doubt anyone really knows. Most of the popular measures basically measures noise and ought to report their findings in decibel rather than "popularity." A professional survey in 2015 estimated the number of C++ programmers to be 4.4 million*.”
  - See the Tiobe index at https://www.tiobe.com/tiobe-index/ – a very popular measure
  - *"There are more useful systems developed in languages deemed awful than in languages praised for being beautiful--many more“*

Bjarne Stroustrup's FAQ: Did you really say that?. Retrieved on 2017-09-03.

Benefits of Learning C++

- Low-level control over many features including memory management, and, the breadth of C++
  - Improves understanding of software design
  - Helps to make informed choices about design
  - Bjarne Stroustrup: *"To use C++ well, you have to understand design and programming technique"* Bjarne Stroustrup's FAQ: Did you really say that?. Retrieved on 2017-09-03.
- Wide use and popularity of C/C++
  - Increases employment prospects
  - Helps to communicate with expert developers
  - Helps to evaluate and adapt projects by others

A First Look at C/C++

- **Java syntax is based on C**
- **Execution of C/C++ starts with main**
- **System functions are not grouped in a class**
- **C++ has the concept of a namespace**

Namespaces allow to group entities like classes, objects and functions under a name. This way the global scope can be divided in "sub-scopes", each one with its own name.

- **Example**
  - Hello World in Java and C

- Namespaces defined:
    * Collection of name definitions
- For now: interested in namespace "std"
    * Has all standard library definitions we need
- **Examples:**

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

    * Includes entire standard library of name definitions

```
- #include <iostream>
using std::cin;
using std::cout;
```

    * Can specify just the objects we want

- Used to resolve name clashes
- Programs use many classes, functions
    * Commonly have same names
    * Namespaces deal with this
    * Can be "on" or "off"
        ** If names might conflict à turn off

Example #1 : namespace

```
// namespaces
#include <iostream>
using namespace std;

namespace NS1
{
     int x = 5;
}

namespace NS2
{
    double x = 3.1416;
}

int main () {
  cout << NS1::x << endl;
  cout << NS2::x << endl;
  return 0;
}
```

```
5
3.1416
```

Example #2 : namespace

```
// namespaces
#include <iostream>
using namespace std;

namespace NS1
{
    int x = 5;
    int y = 10;
}

namespace NS2
{
   double x = 3.1416;
   double y = 2.7183;
}

int main () {
 using NS1::x;
 using NS2::y;
 cout << x << endl;
 cout << y << endl;
 cout << NS1::y << endl;
 cout << NS2::x << endl;
 return 0;
}
```

```
5
2.7183
10
3.1416
```

Example #3 : namespace

```
// Using
#include  <iostream>
using namespace std;

namespace NS1
{
    int  x = 5;
    int  y = 10;
}

namespace NS2
{
   double  x = 3.1416;
   double  y = 2.7183;
}

int main () {
 using namespace NS1::x;
 cout << x << endl;
 cout << y << endl;
 cout << NS2::x << endl;
 cout << NS2::y << endl;
 return  0;
}
```

```
5
10
3.1416
2.7183
```

Example #4 : namespace

```
// Using namespace
#include  <iostream>
using namespace std;

namespace NS1
{
    int  x = 5;
}

namespace NS2
{
   double  x = 3.1416;
}

int main () {
  {
     using namespace NS1;
     cout << x << endl;
   }
   {
      using namespace NS2;
      cout << x << endl;
   }
  return  0;
}
```

```
5
3.1416
```

Hello World

```java
/* Hello World in Java */
public class HelloWorld {

  static public void main( String args[] ) {
    System.out.println( "Hello World!");
    return;
  }
}
```

```cpp
#include <iostream>

/* Hello World in C++ */
int main() {
  std::cout << "Hello World!" << std::endl;
  return 0;
}
```

Standard Input and Output

- **Output stream cout**
  - Object-oriented printing to console
  - Built-in types can be printed using the left-shift operator
  - Similar than System.out.print in Java but more flexible (stream modifiers; more later)

```
std::cout << myVar;
```

- **Input stream cin**
  - Object-oriented input from console
  - Built-in types can be converted and assigned with the right-shift operator

```
std::cin >> myVar;
```

Using Definitions of the Standard Namespace

- **iostream library necessary for console input and output.**
- **Declarations are in the namespace std (standard).**
  - Using a single declaration:
    - just once

      ```
      std::cout
      ```

    - in the whole scope

      ```
      using std::cout;
      ```

  - Using all the declaration within a namespace in a scope (avoid!)

    ```
    using namespace std;
    ```

Main Function

- **C/C++ program entry point main which is of type**

```
int main( void );
int main( int argc, char *argv[] );
```

- **All source files in a project are allowed to define only one main function.**
  - Note: Visual Studio defines additionally program entry points (other “main” functions). Standard compliant C++ code will only use the above.

Java and C++

- **Java**
  - Compiled to byte code
  - Executed by virtual machine
    - Object-oriented
    - Platform-independent byte code
- **C++**
  - Preprocessor
  - Compiled to object code
  - Linked to binary executable
    - Object-oriented, generic and functional features
    - Object code and executable are platform-specific

C++ Fundamentals

- Fundamental and complex data types including classes and strings
- Operators for fundamental types
- Control and decision statements

Variable and Function Names

```
identifier :
   underscore
   letter
   identifier following-character


following-character :
   letter
   underscore
   digit

letter : one of

   A B ... Z a b ... z
digit : one of

   0 1 2 ...  9
underscore : _
```

Exactly like in Java

Case sensitive!

Examples:

```
i5
__do_not_use__
butUseThis
myFavoriteVariable
```

Declarations

- **Declarations introduce names into a program. Declarations may occur in different places in a program.**
- **What to declare?**
  - variables
  - functions
  - classes, structures and union components
  - types
  - type tags
  - enumeration constants
  - namespace
  - statement labels
  - preprocessor macros

Definition vs. Declaration

- **Java and C++ provide definitions in one file and use it in many files**
- **Java**
  - Name is imported into another file.
- **C++ (Each file is compiled separately – if not #include'd)**
  - Linker ensures that name (according to scoping rules) refers to the same entity everywhere.
    - Definition allocates a variable.
    - Declaration introduces only the name.

Fundamental Data Types

- **Three categories integral, floating and void.**
- **integral**
  - `bool, char, short, int, long, long long` (in C++11)
    - `intN_t` with N = 8,16,32 or 64 (only C99);
    - MSVC: `_intN` with N = 8,16,32 or 64
- **floating**
  - `float, double, long double`
- **void**

… close to Java

BUT size may vary with C++ compiler/OS

Standard defines minimum sizes

Type Modifiers and Size

- **Modifiers**
  - `unsigned, signed, short, long`
- **Sizes in MSVC++**
  - 1 byte
    `bool, char, unsigned char, signed char`
  - 2 bytes
    `short, unsigned short`
  - 4 bytes
    `int, unsigned int, long, unsigned long, float`
  - 8 bytes
    `double, long long`
  - 18 bytes
    `long double`

Derived Data Types

- **Directly derived data types**
  - *Arrays, functions, pointers, object references, constants*

To be defined later !

- **Composed derivative types**
  - classes, *structures, unions, scoped enumerations*

```
class myClass
{
…
};
```

Automatic Typing with `auto`

- **Most often initialization can be done better (less error prone) by using auto types.**

```
auto iVal=65;
auto oiVal=iVal;
auto fVal=3.0f;
auto ofVal=fVal;
```

- **Aside: Arithmetic literals**

```
1 is an int
1U is an unsigned int
1L is a long
1LL is a long long
1.0f is a float
1.0 is a double
'\1' is a char.
```

Compilers and IDEs

- Apple Xcode C++
- Bloodshed Dev-C++
- Code::Blocks
- Cygwin
- Eclipse for C++
- MINGW - "Minimalist GNU for Windows"
- GNU CC
- The LLVM Compiler Infrastructure
- Microsoft Visual C++ 2010
- Sun Studio NetBeans

Libraries

- General
  - Boost
  - MFC: Microsoft Foundation classes
  - STL: Standard Template Library
- GUI
  - MFC GUI
  - Qt
  - SFML
  - WxWidgets

Next week:

Java in C++

- **Basic Object-oriented C++**
  - Strongly-typed Enumerations
  - Operators, Ch. 4.1-4.9
  - Selection and Iteration Statements, Ch. 1.4, 5.3-5.5
  - Static casts, Ch. 4.11.3-5.12.6
  - Overview of std::string
  - Introduction to std::array and std::vector