EDAF30 – Programming in C++

1. Introduction

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Outline

1. About the course
2. Presentation of C++
   - History
   - Introduction
   - Statements and operators
   - Functions
3. Data types and variables

EDAF30: Programmering i C++, 7.5 hp
Syfte och mål

Kursens syfte är att ge kunskaper i objektorienterad programmering i C++.

Kunskap och förståelse:

- känna till och kunna beskriva skillnaderna mellan C++ och Java
- vara förtrogen med språket C++ och standardbiblioteket STL
- kunna förklara grundläggande begrepp inom objektorienterad C++-programmering
- förstå och kunna förklara de olika typerna av funktionsanrop
- kunna tolka, analysera och förklara befintlig C++-kod.

Färdighet och förmåga:

- kunna utveckla ett fungerande C++-program från en given specifikation
- kunna felsöka metodiskt i C++-kod.

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Important differences to Java

New or extended concepts in C++
(compared to Java / introductory courses):

- Pointers and memory management
- Functions: call-by-value and call-by-reference
- Polymorphism: both static and dynamic
  (compare *templates* to *generics*)
- Operator overloading

And also

- The tool chain

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Examination details

The compulsory course items are

- laborations
- project
- written examination

The final grade is based on the result of the written examination.

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Administration

- Course plan
- Registration
- Sign up for labs
  - On the web - link from the course web page
  - Work in pairs
  - Sign up for a group – same time all weeks
- Resources
  - Course web page
    - News
    - Assignments
    - Lecture slides
  - Canvas
    - Lectures: short videos to watch as preparation for lectures
    - Labs: reflection question quizzes
  - Slack

History
C++ is a descendent of Simula and C.

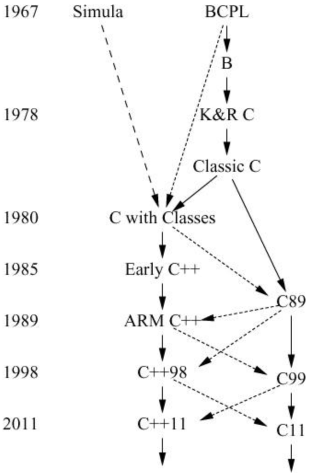
1967: Simula (Dahl & Nygaard)
1972: C (Dennis Ritchie)
1978: K&R C (Kernighan & Ritchie)
1980: C with Classes (Bjarne Stroustrup)
1985: C++ (Bjarne Stroustrup)

- ISO standard 1998

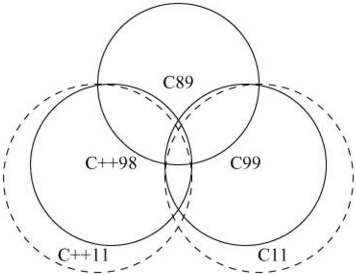
Other relatives:

1995: Java (James Gosling et al.)
2000: C# (Anders Hejlsberg)

- virtual machine
- automatic memory management
- *safe* languages



C++ is not a pure extension of C



- both ISO C and ISO C++ are descendants of K&R C, and are “siblings”
- some details are incompatible between ISO C och C++
- Areas are not to scale

In general: Don’t write C++ as if it were C

What is C++?

The ISO standard for C++ defines two things

- *Core language features*, e.g.,
  - data types (e.g., **`char`**, **`int`**)
  - control flow mechanisms (e.g., **`if`** and **`while`** statements).
  - rules for declarations
  - templates
  - exceptions
- *Standard-library components*, e.g.,
  - Data structures (e.g., `string`, `vector`, and `map`)
  - Operations for in- and output (e.g., << and `getline()`)
  - Algorithms (e.g., `find()` and `sort()`)

The standard library is written in C++

- Example of what is possible

A minimal program in C++

empty.cc

```
int main( ) { }
```

- has no parameters
- does nothing
- the return value of `main()` is interpreted by the system as an error code
  - non-zero means error
  - no explicit return value is interpreted as zero (NB! only in `main()`)
  - rarely used in Windows
  - often used on Linux/Mac

The first C++ program
Hello, World!

hello.cc

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

hello.cc

```
#include <iostream>
using std::cout;
using std::endl;

int main( )
{
   cout << "Hello, World!" << endl;
   return 0;
}
```

Statements

Mostly the same syntax as in Java:

- **`if`**, **`switch`**
- **`for`**, **`while`**, **`do while`**
- **`break`**, **`continue`**

but **`goto`** *is spelled differently:*

- No **`break`** to a label
- **`goto`** (used in C, rarely used in C++)

Operators

Operators and expressions quite similar to Java

The same as in Java

E.g., `+ - * / % ++ -- += -= *= && || & |` etc., and `[] . ?:`

The trinary operator `?:`(like in Java)

```
z = (x>y) ?  x : y;
```

```
if (x>y)
  z=x;
else
  z=y;
```

Many more, including

Pointer operators: `* & ->`

Input and output: `<< >>` (*overloaded shift operators*)

`sizeof`, **`decltype`** (*compile-time*)

Functions
Declaration and definition

The main way of getting sonething done in C++:

- call a *function*
    - Declare before use
      A function must have been *declared* before it can be called
    - A function declaration specifices
        - name
        - return type
        - types of the parameters
    - Example: function declarations

      ```
      int random();
      void exit(int);
      double square(double);
      int pow(int x, int exponent);
      ```

        - The compiler ignores parameter names
        - Give names if it increases readability
- A function *definition* contains the implementation
    - Must not occur more than once (*One Definition Rule*)

Difference from Java
Function and variable declarations

- In Java functions and variables can only be declared inside a class.
- In C++, functions and variables can exist independently of classes.
    - free functions do not belong to a class
    - member functions in a class

    - global variables
    - member variables

Function declaration
Example

- Declaration and definition

Example: Mean value – variant 1

```
double mean(double x1, double x2) // Declaration and definition
{
   return (x1+x2)/2;
}

int main()
{
   double a=2.3;
   double b=3.9;
   cout << mean(a, b) << endl;
}
```

Function definition
With previous declaration

- *Forward declaration*
- Fuction definition after `main()`

Example: mean – variant 2

```cpp
double mean(double, double);        // declaration (prototype)

int main()
{
   double a=2.3;
   double b=3.9;
   cout << mean(a, b) << endl;      // use
}

double mean(double x1, double x2)   //definition
{
   return (x1+x2)/2;
}
```

Function declaration and definition in separate files

Header file with declaration (mean.h)

```
double mean(double, double);          // declaration (prototype)
```

Main source file

```
#include ”mean.h”
int main()
{
   double a=2.3;
   double b=3.9;
   cout << mean(a, b) << endl;        // use
}
```

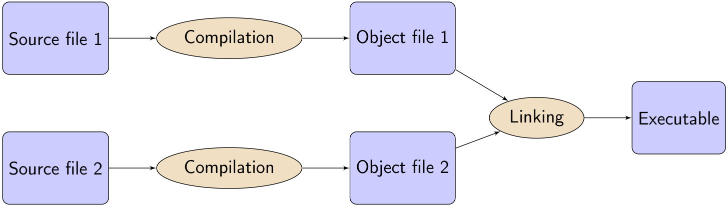
Library source file (mean.cc)

```
double mean(double x1, double x2)    //definition
{
   return (x1+x2)/2;
}
```

What is a program?

C++ is a compiled language

- Source code
- Object file(s)
- Executable file



Data types and variables

- Every name and every expression has a type
- some concepts:
  - a *declaration* introduces a *name* (and gives it a *type*)
  - a *type* defines the set of possible values and operations (for an *object*)
  - an *object* is a place in memory that holds a *value*
  - a *value* is a sequence of bits interpreted according to a *type*.
  - a *variable* is a named *object*

An object has

- a *value* and
- a *representation*

Unnamed objects

Unnamed objects include

- temporary values
- objects on the heap (allocated with **`new`**)

Data types
Primitive types

- Integral types: **`char`**, **`short`**, **`int`**, **`long`**, **`long long`**
  - **`signed`** (as in Java)
  - **`unsigned`** (*modulo* 2^N “non-negative” numbers, not in Java)
- Floting point types: **`float`**, **`double`**, **`long double`**
- **`bool`** (`boolean` in Java)
  - integer values are implicitly converted to **`bool`**
  - zero is **`false`**, non-zero is **`true`**
- The type **`char`** is “the natural size to hold a character” on a given machine (often 8 bits). Its size (in C/C++) is called “a byte” regardless of the number of bits.
- **`sizeof`**`(`**`char`**`)` $\equiv 1$ (1 byte)
- The sizes of all other data types are multiples of **`sizeof`**`(`**`char`**`)`.
  - sizes are *implementation defined*
  - **`sizeof`**`(`**`int`**`)` is commonly 4.

Variables

Declaration and initialization

Declaration without initialization (avoid)

```
int x;        // x has an undefined value (if local)
              // (as local variables in Java)
```

Declaration and initialization

```
int x{7};     // C++ style (recommended if unsure)
int y = {7};  // C++ with extra =
int z = 7;    // C style

vector<int> v{1,2,3,4,5};
```

C style: Beware of implicit type conversion

```
int x = 7.8;  // x == 7. No warning
int y {7.8};  // Gives a warning (or error with -pedantic-errors)
```

The usual arithmetic conversions

The compiler tries really hard to compile your program.

Example

Do not mix signed and unsigned values!

Suggested reading

References to sections in Lippman

Functions	6.1 (p 201–207)
Types, variables	2.1,2.2,2.5.2 (p 31–37, 41–47, 69)
Type aliases	2.5.1
Arithmetic	4.1-4.5, 4.11
Constants	2.4 2.4.4 (p 59–60, 65–66)
Pointers and references	2.3 (p 50–59)

Next lecture
Function calls. Pointers. User-defined types

References to sections in Lippman

Literals	2.1.3
Pointers and references	2.3
std::string	3.2
std::vector	3.3
Arrays and pointers	3.5
Classes	2.6, 7.1.4, 7.1.5, 13.1.3
Scope and lifetimes	2.2.4, 6.1.1
I/O	1.2, 8.1–8.2, 17.5.2