Object Oriented Programming - Lecture 1

Diana Borza - diana.borza@ubbcluj.ro

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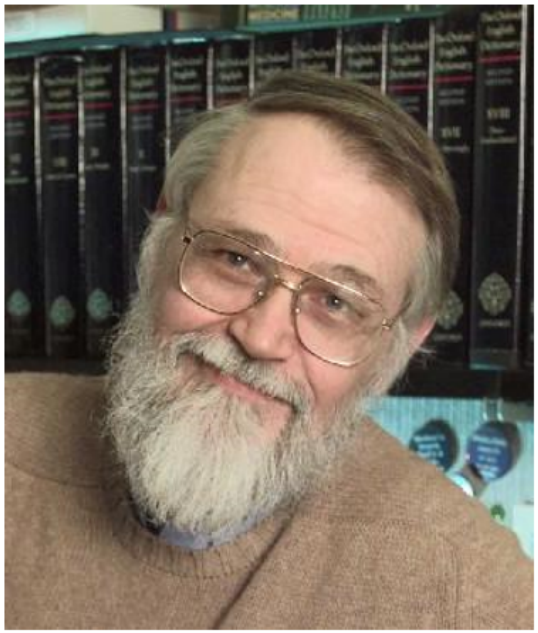
- C/C++ language
- Compilation process. Debugging
- Data types
- C/C++ lexical elements
- Statements
- Pointers
- Summary

C/C++ programming language

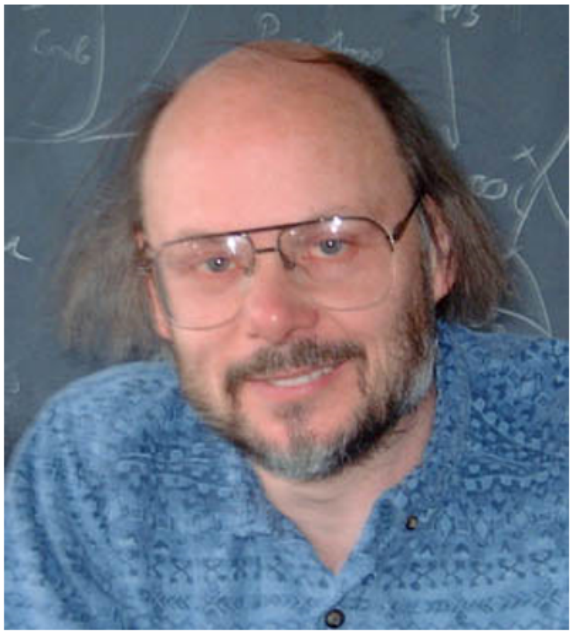
Hall of fame

"No beard, no belly, no guru "

Dennis Ritchie



Brian Kernighan



Bjarne Stroustrup

C/C++ language

Why use C/C++?

- **widely used**, both in industry and in education
- **hybrid, multi-paradigm language**: implements all the concepts required for object oriented programming
- **high-level programming** language; compiled language
- many programming languages are based on C/C++ (Java, C#). Knowing C++ makes learning other programming languages.
- C ranked second in the TOBIE index as of January 2022, and C++ is ranked fourth `https://www.tiobe.com/tiobe-index/`

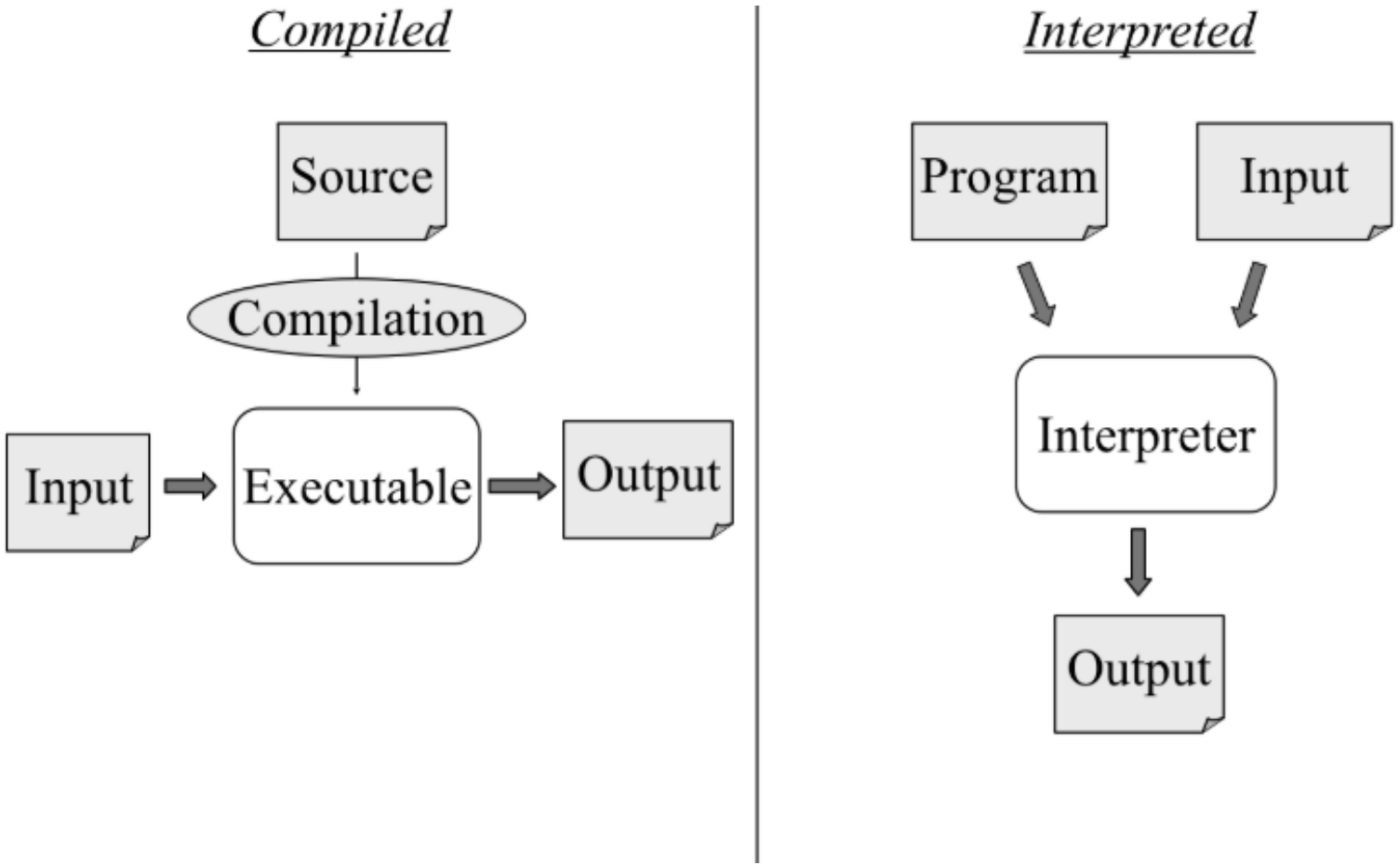
Why use C/C++?

- **rich library support** - many functionalities are already available, which helps in quickly writing code.
- **Speed**: C++ is the preferred choice when latency is a critical metric.
- C++ is an evolving, **highly standardized language**

Usage of the C/C++ programming language

- **Operating Systems** - C/C++ is the backbone of all the well-known operating systems
- **Libraries** - high-level libraries use C++ as the core programming language; e.g. *tensorflow* machine learning library
- **Graphics and Web Browsers** - require fast rendering and C++ helps in reducing the latency
- **Embedded Systems** - medical machines, smartwatches, etc. use C++ as it is closer to the hardware level as compared to other high-level programming languages.
- **Banking Applications**: process millions of transactions on a daily basis and require high concurrency and low latency support.

Compiled vs interpreted languages I



Compiled vs interpreted languages II

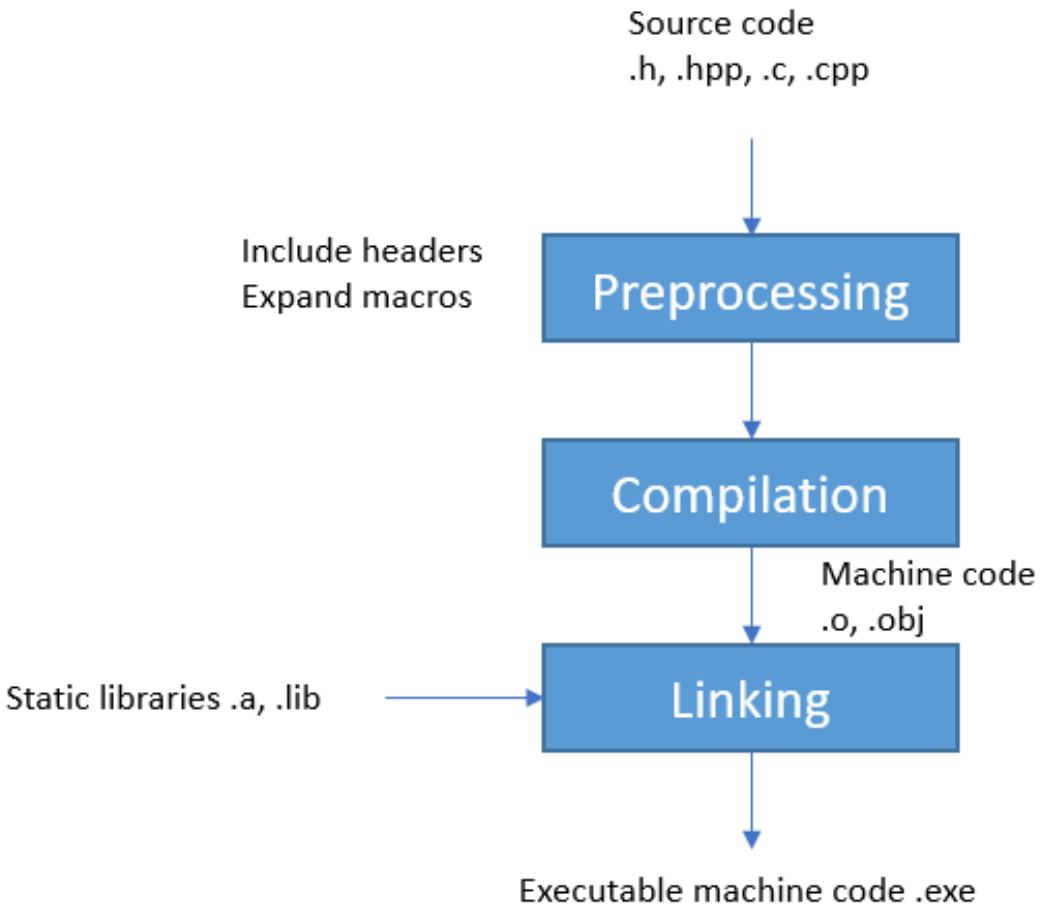
Compiled

- **input**: takes entire program as input
- **speed**: executes faster
- **workload** doesn't need to compile every time, just once
- generates intermediate object code
- **error checking** at compilation the entire program is checked
- **Examples**: C/C++, BASIC, C# (to bitcode)

Interpreted

- **input**: takes a single instruction as input
- **speed**: executes slower
- **workload** has to convert high level languages to low level machine code at execution
- does not generate any intermediate data
- **error checking** displays errors when each instruction is run
- **Examples**: python, Matlab, javascript, Ruby

Compiled languages



Compiling...


THE #1 PROGRAMMER EXCUSE FOR LEGITIMATELY SLACKING OFF:
"MY CODE'S COMPILING."
HEY! GET BACK TO WORK!
COMPILING!
OH. CARRY ON.

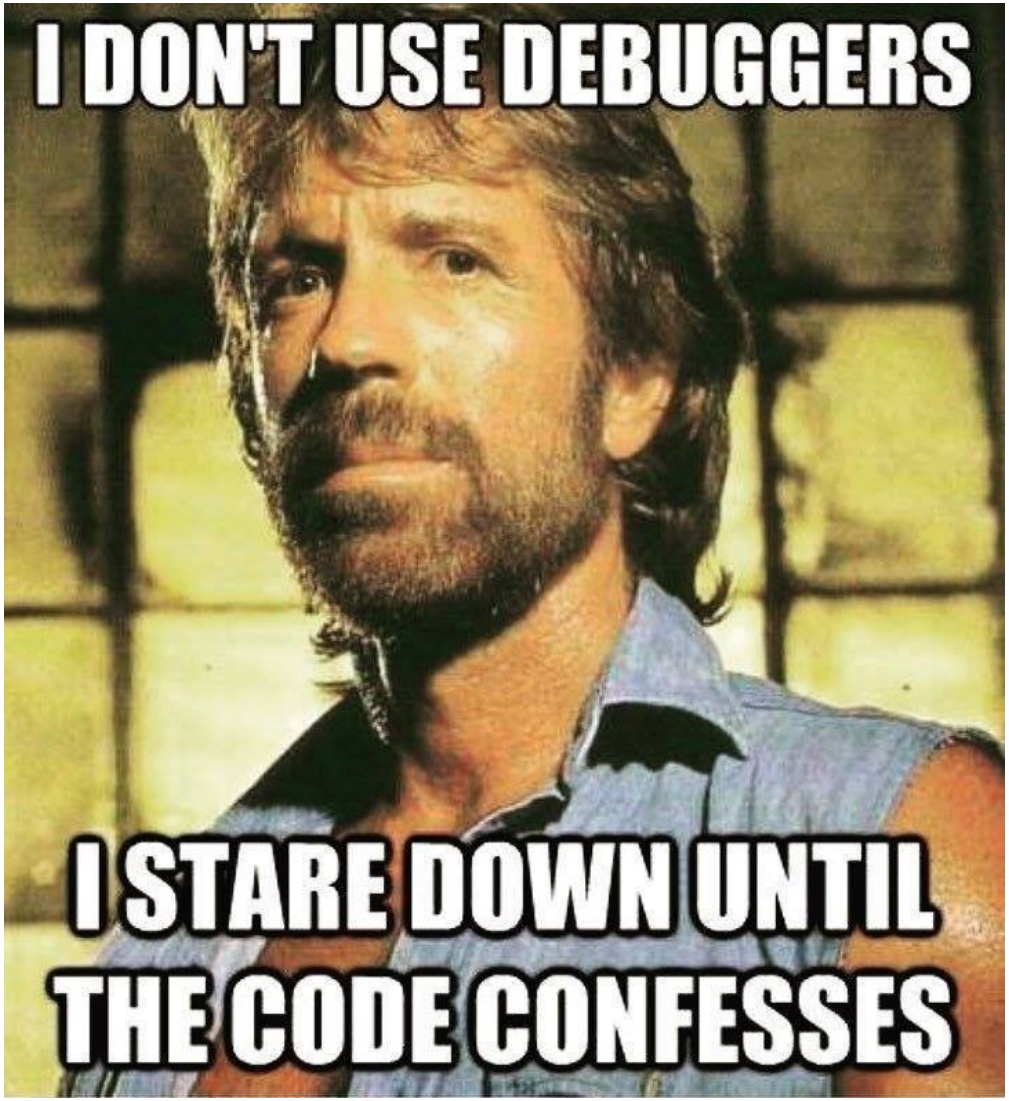
Debugging

"20% of programming is writing code.
The other 80% is debugging"
Anonymous

Debugging

- allows you to step through each line of code, as the program is running
- inspect the current state of the program: variables, call stack, expressions
- breakpoint - stop the program in certain points

Debugging



Structure of a simple C/C++ program

- include directives: for using other modules, libraries

```
#include <iostream>
```

- main() function - the entry point of the program, called by the operating system to run it

```
int main(){
  std::cout<<"Hello world"<<std::endl;
  return 0;
}
```

Lexical elements I

C/C++ is case sensitive.

- **Identifier**: Sequence of letters and digits, start with a letter or (underline). They are names used to identify program elements (which are not built into the language): functions, variables, constants, etc. E.g.: max_value, _parent_obj, my_function, etc.
- **Keywords** (reserved words): Identifier with a special purpose; Words with special meaning to the compiler; E.g.: int, while, class, struct.
- **Operators**: symbols that tell the compiler to perform specific mathematical or logical manipulations. E.g.: +, -, !, *, etc.

Lexical elements II

Literals: Basic constant values whose value is specified directly in the source code; E.g.: "Hello", 72, 4.6, 'c'.
Separators: Punctuation defining the structure of a program: e.g. ";", " " , "( )".
Comments: ignored by the compiler, but are used to explain the code, and to make it more readable

```
// This is a single line comment
/* This is a
multi line
comment */
```

C/C++ datatypes

The **type** of a variable determines the **domain of values** and **a set of operations** defined on these values. C/C++ are strongly typed languages.

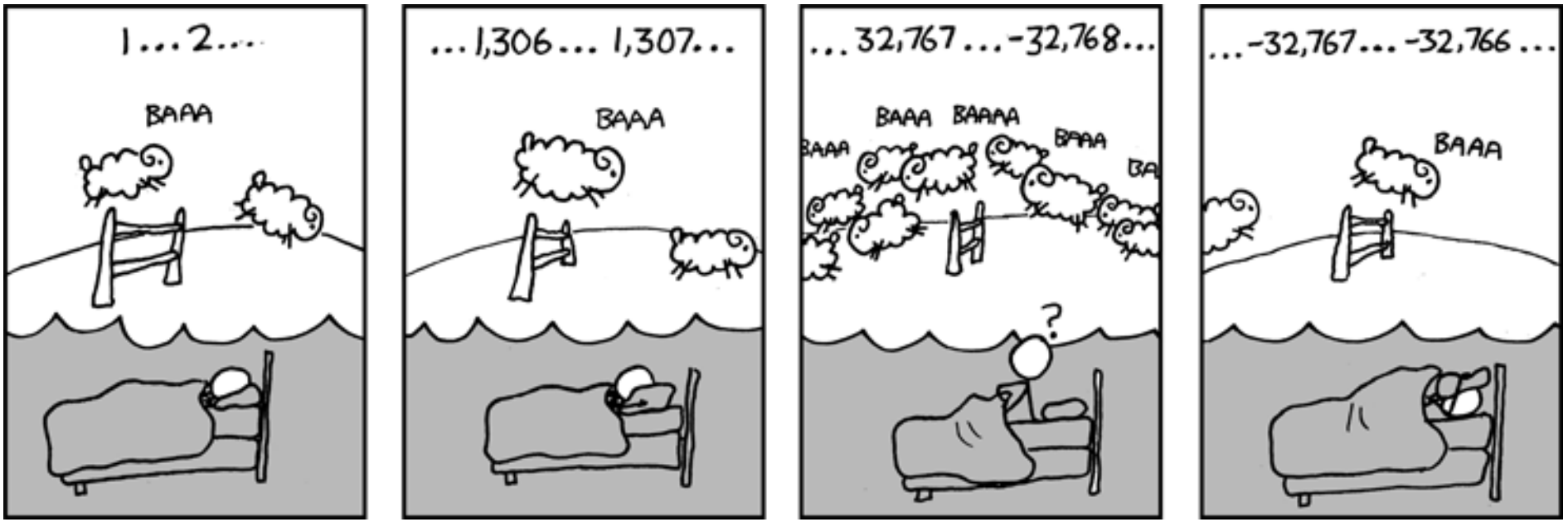
- casting

Demo

C/C++ datatypes (datatypes.cpp)

C++ datatypes

Data type	Bytes	Range of values
char	1byte	-127 to 127 or by default
unsigned char	1byte	0 to 255
int	4bytes	-2147483648 to 2147483647
unsigned int	4bytes	0 to 4294967295
short int	2bytes	-32768 to 32767
unsigned short	2bytes	0 to 65,535
bool	1byte	false or true
long	4bytes	-2,147,483,648 to 2,147,483,647
unsigned long	4bytes	0 to 4,294,967,295
long long	8bytes	-9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
unsigned long long	8bytes	0 to 18,446,744,073,709,551,615
enum	varies	-
float	4bytes	3.4E +/- 38 (7 digits)
double	8bytes	1.7E +/- 308 (15 digits)


1...2...
BAAA
...1,306... 1,307...
BAAA
...32,767...-32,768...
BAAA BAAAA
BAAA
BAAA
?
...-32,767...-32,766...
BAAA

Arrays

- *An array is a series of elements of the same type placed in contiguous memory locations that can be individually referenced by adding an index to a unique identifier.*
- If T is an arbitrary basic C/C++ type: **T arr[N]**: *arr* is an array of length *N* with elements of type *T*;
- indexes are from 0 to n-1;
- indexing operator: [ ];
- multidimensional array: arr[L][C]

C string

- one-dimensional array of characters terminated by a null character '\0'
- standard library functions for string manipulation
  - strcpy(s1, s2) - Copies string s2 into string s1.
  - strcat(s1, s2) - Concatenates string s2 onto the end of string s1.
  - strlen(s1) - Returns the length of string s1.
  - strcmp(s1, s2) - Returns 0 if s1 and s2 are the same; less than 0 if s1<s2; greater than 0 if s1>s2.
  - strchr(s1, ch) - Returns a pointer to the first occurrence of character ch in string s1.
  - strstr(s1, s2) - Returns a pointer to the first occurrence of string s2 in string s1.

! None of these string routines allocate memory or check that the passed memory is the right size.

Demo

C string (cstring.cpp)

Structures

- Record/structure - a linear, direct-access data structure with heterogeneous components
  - declared using struct
  - dot . operator

Demo

Structures (structures.cpp)

Pointers

- Every variable is a named memory location;
- **A pointer** is a variable whose value is a memory location (the address of another variable).
- **Declaration** same as declaring a normal variable, except an asterisk (*) must be added in front of the variable's identifier.

```
int *x;
char *str;
```

- Operators
  - *address of* operator & - take the address of a variable;
  - *dereferencing* operator * - get the value at the memory address pointed to.

Demo

Pointers (pointers.cpp)

Variables

- A variable is a named location in memory;
- Memory is allocated according to the type of the variable;
- The types tell the compiler how much memory to reserve;
- The value of the variable is undefined until the variable is initialized for it and what kinds of operations may be performed on it;
- It is recommended to initialise the variables (with meaningful values) at declaration;
- Use suggestive names for variables.

Constants

- Fixed values that the program may not alter during its execution;
- Can be defined using the #define *preprocessor* directive, or the const keyword;
- Examples

```
#define PI 3.1415
const float PI = 3.1415;
```

? What are the differences of using const vs. #define for constants?

C++ operators

1. Assignment Operator: $=$
2. Mathematical Operators: $+$, -, *, $+=$, -=, etc.
3. Relational Operators: $<, <=, ==, >=, >$
4. Logical Operators: $\&\&, ||$
5. Bitwise Operators:
6. Shift Operators: $<<, >>$

C++ operators

8. Unary Operators: -,++,!
9. Ternary Operator:

```
cond ? condition_true : condition_false
```

10. Comma Operator: to separate variable names/ expressions. (the value of last expression is produced and used)

Demo

Operators example (operators.cpp)

C++ Statements

Statement:

- each of the individual instructions of a program
- all statements, except the compound statement, always end with a semicolon (;)
- are executed in the same order in which they appear in a program.

Type of C++ statements:

- Empty statement
- Compound statement
- Conditional statement: if, switch
- Loops: while, do-while, for

Demo

Statements (statements.cpp)


while (not edge) {
run();
}
do {
run();
} while (not edge);

Functions I

- **Function** - group of statements that is given a name, and which can be called from some point of the program.
  - **Declaration**
  - **Definition**
    - Actual and formal parameters
  - **Invocation**

Demo

Functions (function.cpp)

Functions - specification

- meaningful name for the function;
- short description of the function (the problem solved by the function);
- meaning of each input parameter;
- conditions imposed over the input parameters (precondition);
- meaning of each output parameter;
- conditions imposed over the output parameters (post condition).

```
/*
Computes the maximum value of vector v.
Inputs: v - 1D array, n > 0 size of the array
Output: returns the value of the maximum element from v */
float max_val(float v[], int n);
```

Functions - design guidelines

- Single responsibility principle.
- Use meaningful names (function name, parameters, variables).
- Use naming conventions (add_rational, addRational, CONSTANT), be consistent.
- Specify and test functions.
- Use test driven development.
- Include comments in the source code.
- Avoid functions with side efects (if possible).

Pass by value vs pass by pointer

- **Pass by value**
  - Default parameter passing mechanism in C/C++.
  - On function call C/C++ makes a copy of the actual parameter.
  - The original variable is not affected by the changes made inside the function.

```
void byValue(int a);
```

- **Pass by address**
  - Changes made to the parameter will be reflected in the invoker.
  - In C: there is no pass by reference; it is simulated with pointers;
  - Pointers are passed by value;
  - Arrays are passed "by reference".

```
void byPointer(int * a);
```

Variables scope and lifetime I

- **Scope**: the place where a variable was declared determines where it can be accessed from.
- **Local variables**
  - Functions have their own scopes: variables defined inside the function will be visible only in the function, and destroyed after the function call.
  - Loops and if/else statements also have their own scopes.
  - Cannot access variables that are out of scope (compiler will signal an error).
  - A variable lifetime begins when it is declared and ends when it goes out of scope (destroyed).

Variables scope and lifetime I

- **Global variables**
  - Variables defined outside of any function. Can be accessed from any function.
  - The scope is the entire application.
  - Do not use global variables unless you have a very good reason to do so (usually you can find better alternatives).

Q: What's the best prefix for a global variable?
A: //

Input/Output functions

- read from the command line scanf , cin:
  `http://www.cplusplus.com/reference/cstdio/scanf/`
- write to the console (standard output) printf , cout
  `http://www.cplusplus.com/reference/cstdio/printf/`

Demo

Input-output operations (input_output.cpp)

Summary

- Both C and C++ are compiled languages.
- All C/C++ programs must contain a main function.
- All variables must have types and are recommended to be initialised.
- A variable lifetime begins when it is declared and ends when it goes out of scope (destroyed).
- C/C++ allow the use of pointers.
- Function parameters can be passed by value or by reference (C++).