Programming Abstraction in C++

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Chapter 1. An Overview of C++

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You should read Chapter 1. We won't teach the basic syntax and constructs. We'll just highlight some of the common programming idioms and C++ characteristics.

Outline

1. Structure of a C++ program
2. Variables, values, and types
3. Statements
4. Functions

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1 Structure of a C++ program

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Structure of a C++ program

Comments

- Program: Operation of the program as a whole.
- Function: What the function does.

```
/* multiline
 * comments
 */

// single line comments
```

Structure of a C++ program (cont.)

Library inclusions

```
#include "private library"
#include <system library>
```

header files containing definitions.

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Example

Program comments

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 * File: powertab.cpp
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 * This program generates a table comparing
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Library inclusions

```
#include "genlib.h"
#include <iostream>
#include <iomanip>
```

Example (cont.)

section comment

```
/* Constants
 * ---------
 * LOWER_LIMIT -- starting value for the table
 * UPPER_LIMIT -- final value for the table
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Example (cont.)

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 */
```

constant definitions

```
const int LOWER_LIMIT = 0;
const int UPPER_LIMIT = 12;
```

Example (cont.)

function prototype

```
/* Private function prototypes */
int RaiseIntToPower(int n, int k);
```

Example (cont.)

main program

```
int main() {
   cout << "    |   2 |    N " << endl;
   cout << "  N |  N  |   2  " << endl;
   cout << "----|-----|------" << endl;
   for (int n = LOWER_LIMIT; n <= UPPER_LIMIT; n++) {
      cout << setw(3) << n << " |";
      cout << setw(4) << RaiseIntToPower(n, 2) << " |";
      cout << setw(5) << RaiseIntToPower(2, n) << endl;
   }
   return 0;
}
```

Example (cont.)

function comments

```
/*
 * Function: RaiseIntToPower
 * Usage: p = RaiseIntToPower(n, k);
 * ---------------------------------
 * This function returns n to the kth power.
 */
```

Example (cont.)

function definition

```
int RaiseIntToPower(int n, int k) {
   int result;

   result = 1;
   for (int i = 0; i < k; i++) {
      result *= n;
   }
   return result;
}
```

Example (cont.)

function definition

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int RaiseIntToPower(int n, int k) {
   int result;

   result = 1;
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Variables and values

Declaration: four properties

- type: (`int i; double x; char c;` ...)
- name: Naming conventions
  - start with a letter or underscore, others are letters, digits, or underscores, no spaces or special characters
  - No reserved keywords (Table 1-1, p. 11)
  - Case sensitive

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Examples

variables: `totalTime`
functions: `RaiseIntToPower`
constants: `UPPER_LIMIT`

Variables and values

Declaration: four properties (cont.)

- life time: How long a varible persists. The lifetime of a variable declared in a function (local variable) is the time when the function is active
- scope: accessibility. The scope of a local variable extends to the end of the block where it is declared.

Variables and values

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We rarely, if ever, use global variables (declared outside any function).

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Local variable can be declared anywhere with a block of statements.

Example:

```
for (int i = 0; ...) {
    ...
}
```

Data types

Two attributes: Domain and operations.

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Atomic types

- integer: `short`, `int`, `long`
- floating-point: `float`, `double`, `long double`
- text: `char` (ASCII code, Table 1-2, p. 14), `string`
- Boolean: `bool`

Operations

- Precedence and associativity (Table 1-4, p. 17).
  Example:
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  Example: `9 / 4.0`
  Values are promoted to the richer type.
- Type casts: `int num, den; double (num) / den;`

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- Increments and decrements (`i++`, `++i`, `j--`)
  Be sure you understand their meanings. (P. 22)
- Boolean
  relational operators: `==`, `!=`, `<`, `>`, `<=`, `>=`
  short-circuit evaluation:
  `if ((y != 0) && (x % y == 0))`
  logical operators: `!`, `&&`, `||`
  bitwise operators: `&`, `|`
  Don't confuse Boolean logic with bitwise operators.

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Simple I/O

Simplified I/O

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Stream manipulators, Table 1-3, p. 16

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#include <iomanip>
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Stream manipulators, Table 1-3, p. 16

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```
cout << "Enter an integer: " << endl;
int n1 = GetInteger();
cout << "Enter a floating-point: " << endl;
float x = GetReal();
```

Statements

- Simple statements

```
a = b + c;
```

- Compound statements (blocks): indentation (four spaces)

```
{
    y = x;
    x += 1;
}
```

- Terminator `;`

Control statements: `if`

`if` (condition) statement
The test must always be enclosed in parentheses.

`if` (condition) statement `else` statement

```
if (n % 2 == 0) {
    cout << "That number is even." << endl;
} else {
    cout << "That number is odd." << endl;
}
```

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}
```

Any non-zero expression is true

`if (x)` means the same as `if (x != 0)`

Control statements: switch

```
switch (d) {
  case 0: cout << "zero"; break;
  case 1: cout << "one"; break;
  case 2: cout << "two"; break;
  case 3: cout << "three"; break;
  case 4: cout << "four"; break;
  case 5: cout << "five"; break:
  case 6: cout << "six"; break;
  case 7: cout << "seven"; break;
  case 8: cout << "eight"; break;
  case 9: cout << "nine"; break;
  default: Error("Illegal call to PrintOneDigit");
}
```

Control statements: `switch`

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  case 0: cout << "zero"; break;
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  case 6: cout << "six"; break;
  case 7: cout << "seven"; break;
  case 8: cout << "eight"; break;
  case 9: cout << "nine"; break;
  default: Error("Illegal call to PrintOneDigit");
}
```

use `break` and `default`

Control statements: `while`

Digit sum

```
sum = 0;
while (n > 0) {
    sum += n % 10;
    n /= 10;
}
```

Control statements: `while`

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Solving the loop-and-half problem with `while (true)` and `break`

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while (true) {
    ...
    if (value == sentinel) break;
    ...
}
```

Control statements: `while`

Digit sum

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sum = 0;
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    n /= 10;
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Solving the loop-and-half problem with `while (true)` and `break`

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while (true) {
    ...
    if (value == sentinel) break;
    ...
}
```

Programming style: Use at most one `break` in any given loop.

Example

Echo an integer until -1

```
const int SENTINEL = -1;

while (true) {
    cout << " ? ";
    int value = GetInteger();
    if (value == SENTINEL) break;
    cout << value << endl;
}
```

Control statements: `for`

```
for (int t = 10; t >= 0; t--) {
    cout << t << endl;
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The expressions *init*, *test*, and *step* are each optional, but the semicolons must appear.

- If `init` is missing, no initialization;
- If `test` is missing, assumed to be `true`;
- If `step` is missing, no action between loop cycles.

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- If `init` is missing, no initialization;
- If `test` is missing, assumed to be `true`;
- If `step` is missing, no action between loop cycles.

Use `for` loop for straightforward iterative tasks;
`while` loop for indefinite iteration.

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Functions

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function-calling mechanism

1. Evaluate arguments;
2. Creat a frame on the stack for local variables, including arguments;
3. Copy the values of the arguments in order;
4. Execute the function;
5. Return the value of the function, if any;
6. Discard the frame for the function;
7. Continue the calling function with the returned value, if any.

Function (cont.)

Call by value.

```
void SetToZero(int x) {
    x = 0;
}

...
x = 1;
SetToZero(x);
cout << x << endl;
```

Function (cont.)

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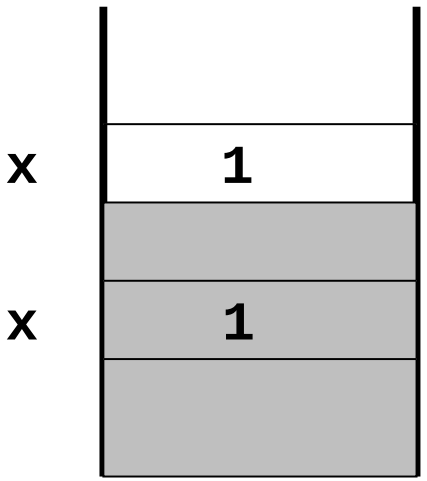

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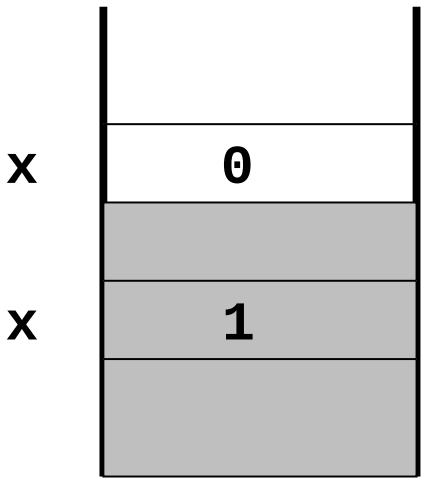

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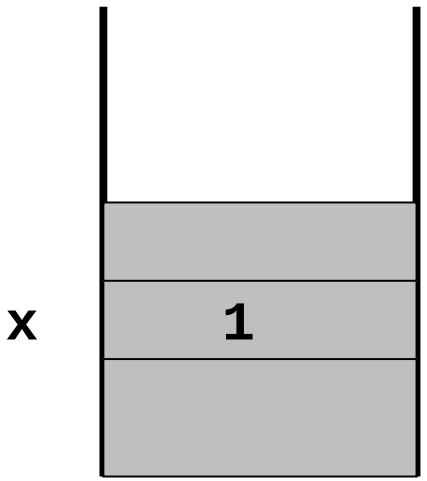

Function (cont.)

Call by reference.

```
void SetToZero(int & x) {
    x = 0;
}


...
x = 1;
SetToZero(x);
cout << x << endl;
```

Function (cont.)

Call by reference.

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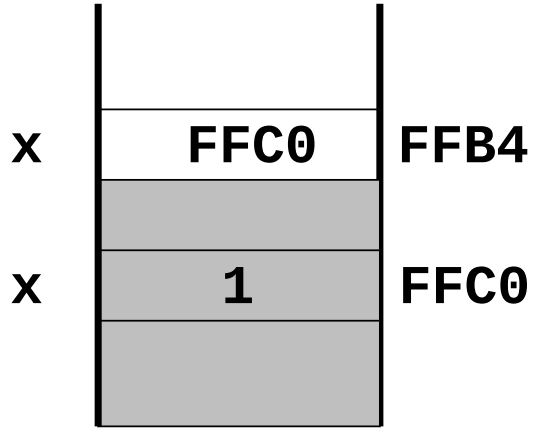

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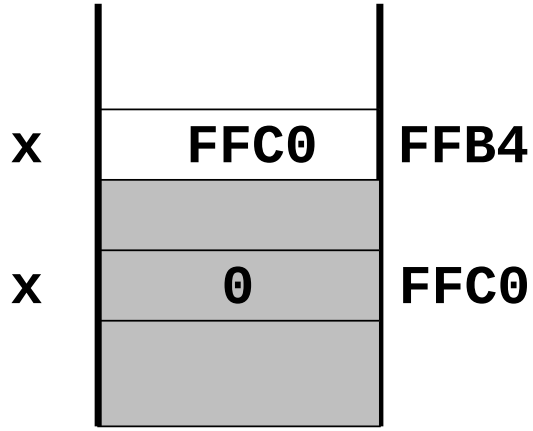

Function (cont.)

In general

- If you only use the value of an argument in the function (on the right-side of assignments), call it by value.
- If you want to reflect the change of the value of an argument in the function to the caller (on the left-side of assignments), call it by reference.

Example

Program decomposition: Input-Computation-Output

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Solving quadratic equations

$$ax^2 + bx + c = 0, \quad a \neq 0.$$

Textbook formula

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

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Computer method

$$x_1 = \frac{2c}{-b - \text{sign}(b)\sqrt{b^2 - 4ac}}, \quad x_2 = \frac{c}{ax_1}.$$

Example (cont.)

```
void SolveQuadEqn(double a, doule b, double c,
                  double &x1, double &x2) {
    if (a == 0)
        Error("Coefficient a is zero.");

    double disc = b * b - 4 * a * c;
    if (disc < 0)
        Error("Solutions are complex.");
    if (disc == 0) {
        x1 = x2 = -b / (2 * a);
    } else {
        x1 = 2*c / (-b - sign(b)*sqrt(disc));
        x2 = c / (a * x1);
    }
}
```