Basic Language Constructs for C++03 and C++11

August 22, 2017

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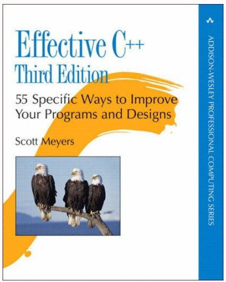
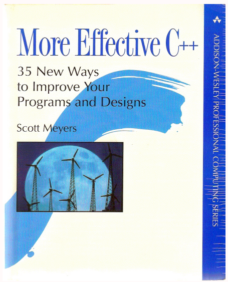
1. Overview

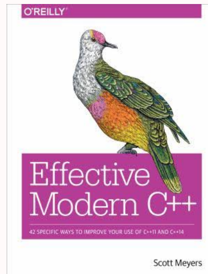
- These slides review basic C++ language constructs up to, but not including, **classes**.
- In the review, we discuss both C++03 and C++11
- In some cases, we compare and contrast the two versions
- The slides are accompanied by videos that further elicidate the concepts found here.

2. References

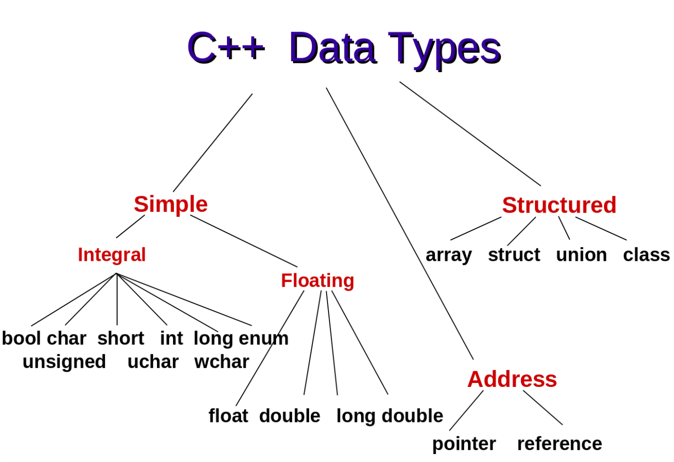
- Any Intro C++ text
- http://en.cppreference.com/w/cpp
- The C++ ISO Standard







3. Data and Expressions



bool ⇒ true or false

3.1. Operators

- Expressions are composed of operators, variables, constants and parentheses
- Logical operators: `&&`, `||`, `!`
- Relational operators: `<`, `>`, `==`, `!=`, `<=`, `>=`
- However, an expression can be considered as a Boolean condition where `0` is false and all other values are true:

```
int x = rand();
if (x) ...
```

- Of course, the rules for mixed types still apply, so `2/4` evaluates to `0`

3.2. Operators

- unary, binary, and ternary describe the number of operands that an operator uses.
- For example, `-7` is **unary** minus; i.e., one operand
- `3 - 7` is **binary** minus; i.e., two operands
- There is only one **ternary** operator and it's very useful; for example, the following expression evaluates to the larger of the two operands: `(a > b) ? a : b`

3.3. Prefix and Postfix Operators

- Prefix operators are evaluated in place.
- Postfix operators are evaluated at the end of the statement

```
#include <iostream>
int main() {
  int i = 0, j = 0;
  std::cout << ++i << std::endl;    //output is 1
  std::cout << j++ << std::endl;    //output is 0
  std::cout << i << j << std::endl; //output is 11
  return 0;
}
```

3.4. Insertion/Extraction Operators

- They are binary, left associative operators that evaluate to the operator
- For example, the stream insertion operator, *operator* $\ll$ evaluates to *operator* $\ll$, which is why the following expression works:

```
The expression:
   cout << x << y << endl;
is actually:
   (((cout << x) << y) << endl);
where (cout << x) places the value of x into the
output stream and evaluates to cout <<
so that the expression becomes:
   ((cout << y) << endl);
which places y into the output stream and evaluates to
   (cout << endl);
```

3.5. constants and constant expressions

- **const**: named constants are preferable to # **define**, which is a C artifact
  - const char STAR = '*';
  - const unsigned MAX = 100;
- **constexpr**: value known at compile time

```
constexpr int n1 = 10;
std::array<int, n1> a1;  // fine
constexpr int n2 = 10;
int a2[n2];              // fine
int n3 = 10;
int a3[n3];              // warning
int n = 10;
std::array<int, n> a2;   // error
```

3.6. NULL, 0, and nullptr

- NULL and 0 are integers
- nullptr is a pointer of all types
- prefer nullptr

```
void f(int i)   { std::cout << "int" << std::endl; }
void f(char* c) { std::cout << "pointer" << std::endl; }

int main() {
  f(NULL);      // error ambiguous call
  f(0);         // error ambiguous call
  f(nullptr);   // prints pointer
}
```

3.7. Mixed Type Expressions

- Are promoted or truncated:
  1. $5/2 \Rightarrow$ 2
  2. int(2.3) $\Rightarrow$ 2
  3. float(2/4) $\Rightarrow$ 0.0
  4. $4/8 \Rightarrow$ 0
  5. float(4)/8 $\Rightarrow$ 0.5
  6. $2.0/4 \Rightarrow$ t0.5
- Prefer C++ cast $\rightarrow$ easier to find in code
  static_cast<float>(5/10) evaluates to 0.0

3.8. Structured Data Types

- Arrays, like C, are passed by reference
- **union**s: obviated by inheritance
- **struct**s: same as classes except for default protection:
  - Default protection of class is **private**
  - Default protection of struct is **public**
  - structs are useful for storing global data: I prefer Singleton
- Classes are covered in slides about classes

4. Control Structures

- selection: **if**, **if/else**, **switch**
- repetition: **for**, **while**, **do/while**
- In general, I much prefer clarity and readability to obfuscated, hacked, terse code. Thus, I prefer the use of brackets because they promote readability. The first example below is preferable to the second:

```
int sum = 0;
for (unsigned i = 0; i < MAX; ++i) {
  sum += i;
}

int sum = 0;
for (unsigned i = 0; i < MAX; ++i) sum += i;
```

4.1. switch

- If a **switch** value matches a **case** value, then it matches all cases until a **break** is encountered:

```
int count = 0;
int index = 1;
switch (index) {
  case 0: ++count;
  case 1: ++count;
  case 2: ++count;
  case 3: ++count;
  case 4: ++count;
  case 5: ++count;
  default: ++count;
}
cout << count << endl;  // prints 6
```

4.2. switch/case/break is useful

- We may wish to match several values, so multiple case values w/out a break are like logical or. In the next example, we can match either upper or lower case letters:

```
int count = 0;
char ch = 'b';
switch (ch) {
  case 'A' : case 'a': ++count; break;
  case 'B' : case 'b': ++count; break;
  case 'C' : case 'c': ++count; break;
  default: cout << "Oops" << endl;;
}
```

4.3. Short-circuit Evaluation

- If evaluation of the first operand obviates evaluation of the second, then the second operand is not evaluated.
- Short-circuit evaluation can be useful. If number happens to be zero, then we won't get a division by zero error in the following example:

```
float sum = 0.0;
int number = rand();
if ( number != 0 && sum/number > 90.0) {
  ...
}
```

4.4. for

- The scope of the loop control variable (LCV) (in this case i) is the loop body:

```
for (int i = 0; i < MAX; ++i) {
  cout << i;
}
i is out of scope here
```

- The following hack would be more readable if the programmer used **while** (true)

```
// Obfuscated code; great for job security!
i = 0;
for ( ; ; ) {
  if (i > MAX) break;
  cout << ++i;
}
```

- **ranged for loops**: We will discuss later w/ vectors

5. Functions

- Can be void or return a value.
- Each C++ program contains a function called main, which returns an integer.
- There are two acceptable forms of main:

```
************************************
int main() {
  return 0;
}
************************************
int main(int argc, char* argv[]) {
  return 0;
}
************************************
and the return statement is optional
```

5.1. Parameter Transmission Modes

- The C language has **one** mode
- C++ has four modes:

  1. **value**: default; makes local copy
  2. **reference**: use &; pass the address
  3. **const reference**: for large objects
  4. **rvalue reference**: later: ref v ptr

```cpp
#include <iostream>
void f(int x) { ++x; }
void g(int& x) { ++x; }
int main() {
  int i = 0, j = 0;
  f(i);
  g(j);
  std::cout << i << j << std::endl; //output is 01
}
```

5.2. Arrays are passed by reference

```cpp
#include <iostream>
const int MAX = 3;
void f(int a[]) {
  for (int i = 0; i < MAX; ++i) {
    a[i] = i;
  }
}
int main() {
  int a[3];
  f(a);
  std::cout << a[2] << std::endl; //output is 2
}
```

5.3. Static Function Variables

- Initialized upon first entry to the function
- Usually stored in global data segment

```
#include <iostream>
void f() {
  static int count = 0;
  int index = 0;
  std::cout << ++count << ++index << std::endl;
}
int main() {
  f();
  f();
}
************ output ****************
11
21
```

5.4. Default Parameter Values

- If no value is passed to formal parameter, a default value is assigned, left to right.
- Thus, x, on line 2, is assigned the ascii code for 'A', which is 65, on line 7:

```
1 #include <iostream>
2 void f(int x = 0, char ch = 'Z') {
3   std::cout << x << ", " << ch << std::endl;
4 }
5 int main() {
6   f(17, 'B');
7   f('A');
8   f();
9 }
************ output ****************
17, B
65, Z
0, Z
```

5.5. Function Overload

- Two functions with same name but different parameter types
- The function return value cannot be used to resolve overload

```
#include <iostream>
void write(double x) {
  std::cout << "x is " << x << std::endl;
}
void write(int i) {
  std::cout << "i is " << i << std::endl;
}
int main() {
  double x = 2.5;
  write(7);  // output: i is 7
  write(x);  // output: x is 2.5
}
```

5.6. Command Line Parameters

- You can pass values into function main
- argc is number of parameters passed; argv is an array of C strings containing the values
- There's always at least one parameter passed: the name of the executable

```
#include <iostream>
int main(int argc, char* argv[]) {
  for (int i = 0; i < argc; ++i) {
    std::cout << argv[i] << '\t';
  }
  std::cout << std::endl;
}
************ invocation ************
$ ./a.out 2 4 cat
************ output ****************
./a.out 2 4 cat
```

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Namespaces

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6. Namespaces

- We can use the scope operator (colon $\rightarrow$ ::) to access all three instances of number:

```
#include <iostream>
int number = 99;
namespace A {
  int number = 23;
}
int main() {
  int number = 0;
  std::cout << ::number << std::endl;
  std::cout << A::number << std::endl;
  std::cout << number << std::endl;
  return 0;
}
```