Object-Oriented Programming and Data Structures

COMP2012: Const-ness

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const

- const, in its simplest usage, is to express a user-defined constant — a value that can't be changed.

  ```
  const float PI = 3.1416;
  ```

- Some people like to write const identifiers in capital letters.
- In the old days, constants are defined by the #define preprocessor directive:

  ```
  #define PI 3.1416
  ```

  Question: Any shortcomings?
- const actually may be used to represent more than just numerical constants, but also const objects, pointers, and even member functions!
- The const keyword can be regarded as a safety net for programmers: If an object should not change, make it const.

Example: Constants of Basic Types

```
#include <iostream>                                   /* File: const-basic-grades.cpp */
#include <cstdlib>
using namespace std;

int main( )
{
    const int NUM_STUDENTS = 117;
    const int MAX_GRADE = 100;
    int grade[NUM_STUDENTS];

    // Seed the random number generator by current time
    srand(time(0));

    // Assign grades randomly
    for (int i = 0; i < NUM_STUDENTS; ++i)
        grade[i] =
            static_cast<double>(rand())/RAND_MAX*MAX_GRADE + 0.5;

    for (int i = 0; i < NUM_STUDENTS; ++i)
        cout << "grade of the " << i+1 << "th student = " << grade[i] << endl;

    return 0;
}
```

Example: Constant Objects

```
class Date                                          /* File: const-basic-date.cpp */
{
    int year, month, day;
  public:
    Date(int year, int month, int day);
    int difference(const Date&);                    // Incomplete: write this function
    void add_month() { month += 1; };               // Will be an inline function
};

int main( )
{
    const Date job_start(1998, 4, 1);
    int this_year, this_month, this_day;
    cin >> this_year >> this_month >> this_day;
    Date today(this_year, this_month, this_day);

    // How long have I worked in UST in days?
    cout << "I have worked " << today.difference(job_start) << " days.\n";

    // What about next month?
    job_start.add_month( );   // Error caught by compiler; -> today.add_month( )
    cout << today.difference(job_start) << " days by next month\n";
    return 0;
}
```

const Member Functions

- To indicate that a class member function does not modify the class object — its data member(s), one can (and should!) place the const keyword after the argument list.
- A const object can only call const member functions of its class.

```
class Date
{
    int year, month, day;
  public:
    int get_day( ) const { return day; }   // inline + const
    int get_month( ) const { return month; }   // inline + const
    void add_year(int y);                      // non-const function
};
```

const and const Pointers

- When a pointer is used, two objects are involved:
  - the pointer itself
  - the object being pointed to
- The syntax for pointers to constant objects and constant pointers can be confusing. The rule is that
  - any const to the left of the $*$ in a declaration refers to the object being pointed to.
  - any const to the right of the $*$ refers to the pointer itself.
- It can be helpful to read these declarations from right to left.

```
/* File: const-char-ptrs1.cpp */
char c = 'Y';
char *const cpc = &c;
char const* pcc;
const char* pcc2;
const char *const cpcc = &c;
char const *const cpcc2 = &c;
```

Example: const and const Pointers

```
#include <iostream>                                  /* File: const-char-ptrs2.cpp */
using namespace std;

int main( )
{
    char s[ ] = "COMP2012";                  // char *const s = "COMP2012"
    char p[ ] = "MATH1013";                  // char *const p = "MATH1013"

    const char* pcc = s;                     // Pointer to constant char
    pcc[5] = '5';                                                  // Error!
    pcc = p;                                 // OK, but what does that mean?

    char *const cpc = s;                     // Constant pointer
    cpc[5] = '5';                                                  // OK
    cpc = p;                                                       // Error!

    const char *const cpcc = s;              // const pointer to const char
    cpcc[5] = '5';                                                 // Error!
    cpcc = p;                                                      // Error!
}
```

const and const Pointers ..

Having a pointer-to-const pointing to a non-const object doesn't make that object a constant!

```
/* File: const-int-ptr.cpp */
int i = 151;
i += 20;                                          // OK

int* pi = &i;
*pi += 20;                                        // OK

const int* pic = &i;
*pic += 20;                    // Error! Can't change i through pic

pic = pi;                                         // OK
*pic += 20;                    // Error! Can't change *pi thru pic

pi = pic;          // Error: Invalid conversion from const int* to int*
```

const References as Function Arguments

- There are 2 good reasons to pass an argument as a reference. What are they?
- You can (and should!) express your intention to leave a reference argument of your function unchanged by making it const.
- There are 2 advantages:

1. If you accidentally try to modify the argument in your function, the compiler will catch the error.

```
void cbr(Larg_Obj& LO) { LO.height += 10; }   // Fine

void cbcr(const Larg_Obj& LO) { LO.height += 10; }   // Error!
```

const References as Function Arguments ..

2. You can call a function that has a const reference parameter with both const and non-const arguments.

   Conversely, a function that has a non-const reference parameter can only be called with non-const arguments.

```
void cbr(Larg_Obj& LO) { cout << LO.height; }
void cbcr(const Larg_Obj& LO) { cout << LO.height; }

int main( )
{
    Large_Obj dinosaur(50);
    const Large_Obj rocket(100);
    // Which of the following give(s) compilation error?
    cbr(dinosaur);
    cbcr(dinosaur);
    cbr(rocket);
    cbcr(rocket);
}
```

Pointer vs. Reference

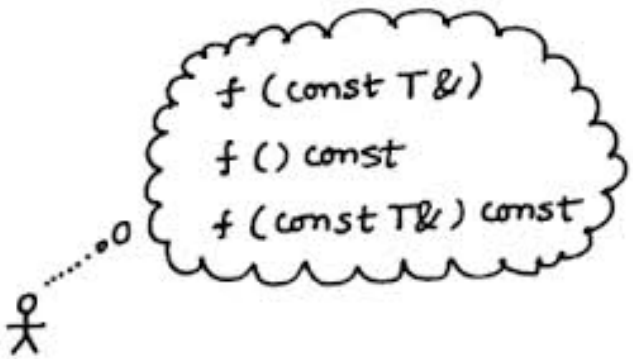
Reference can be thought as a special kind of pointer, but there are 3 big differences:

1. A pointer can point to nothing (`NULL`), but a reference is always bound to an object.
2. A pointer can point to different objects at different times (through assignments). A reference is always bound to the same object.

   Assignments to a reference does not change the object it refers to but only the value of the referenced object.
3. The name of a pointer refers to the pointer object. The `*` or `->` operators have to be used to access the object.

   The name of a reference always refers to the object. There are no special operators.

Summary: Good Practice



- Objects you don't intend to change ⇒ const objects.

  ```
  const double PI = 3.1415927;
  const Date HandOver(1, 7, 1997);
  ```

- Function arguments you don't intend to change
  ⇒ const arguments.

  ```
  void print_height(const Large_Obj& LO){ cout << LO.height(): }
  ```

- Class member functions don't change the data members
  ⇒ const member functions.

  ```
  int Date::get_day() const { return day; }
  ```