
Review of C++ Basics

Reading:

- King, section 19.4
- Your 181 notes
- Your C++ reference book

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Our high-level design should be influenced by several important goals:

- Simple interface.
- Abstraction: The client should not have to know how we implemented the stack in order to use it.
- Information hiding: The client certainly should not be able to touch the data structure directly. We want it to be hidden.
- Encapsulation: The stack code should be self-contained; it shouldn't rely on any other code.
- Plug-out plug-in compatibility: It should be easy to plug in a new and better implementation of stack.
- Easy re-use: It should be easy to use the stack code in another program. Even if we need a slightly different kind of stack.

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Software Design Goals

Suppose we are writing a program that will use several stacks. We are going to implement a stack using

- a struct to hold an array of stack elements plus a counter
- a bunch of functions

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Using a Class

Say we have written a class called `Fraction`, with operations including `print`. We can now create `Fractions` much like we create an ordinary `int`:

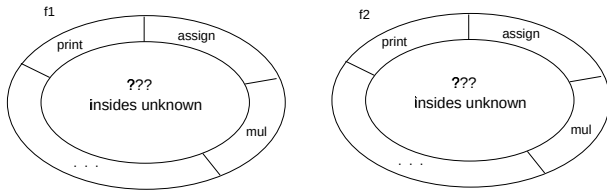
```
Fraction f1, f2;
Fraction arrayOfFracs[10];
```

We apply operations to an instance of `Fraction` using the dot operator:

```
f1.print();           // "f1, Print yourself."
                      // Print has no args.
```

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How to Visualize Instances



- You don't have to know what's going on inside in order to use a Fraction. Just how to push the right buttons to get things done.
- Each instance of a Fraction has its own operations.
- Only f1 knows how to print itself (or assign to itself, and so on). Same for f2.

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Defining a Class

```
class Fraction {
public:
    Fraction (int num = 0, int denom = 1)
        { assign(num, denom); }
    void print();
    void assign(int num, int denom);
    void mul(Fraction f);
private:
    void reduce();
    int numerator;
    int denominator;
};

void Fraction::assign(int num, int denom)
{
    numerator = num;
    denominator = denom;
    reduce();
}

void Fraction::print ()
{
    printf ("%d/%d", numerator, denominator);
}
```

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```
Fraction Fraction::mul (Fraction f)
{
    Fraction result;

    result.numerator = numerator * f.numerator;
    result.denominator = denominator * f.denominator;
    result.reduce();
    return result;
}

void Fraction::reduce()
{
    // details omitted here.
}
```

Using the Class

```
void main()
{
    Fraction f1, f2, f3;
    f1.print();

    f1.assign(3, 8);
    f2.assign(2, 4);
    f1.print();
    f2.print();

    f3 = f1.mul(f2);
    f1.print();
    f2.print();
    f3.print();
}
```

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A Class is Like a Struct

```

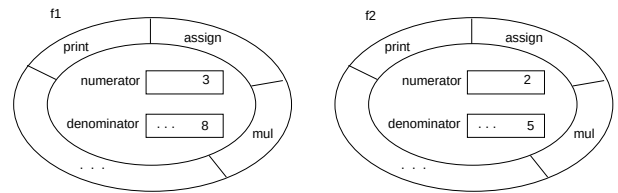
00  class Fraction {
01  public:
02      ...
03  private:
04      ...
05      // Private data members:
06      int numerator;
07      int denominator;
08  };
09
10  void blah ()
11  {
12      Fraction a, b;
13      a.numerator = 3;
14  }

```

- In each case, up to line 09, we have defined what a Fraction *is*. But we have no Fractions.
- In each case, At line 10, we create two instances. Memory is allocated to store them.
- Just as a and b each have their own numerator and denominator members, so do f1 and f2.

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Visualizing (revisited)



- The private data members (numerator and denominator) are hidden inside. (1) You don't have to know about them in order to use a Fraction. (2) You *cannot* access them yourself.
- It is the public member functions that have access to the private data members; they do the work for you.
- f2.print says "f2, go print yourself". No one else can do it but f2.

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Two Ways to Create an Instance

```

// ----- Method 1 -----

struct Tnode {
    // for a BST
    ...
    int num;
}

Tnode t;
t.num = 12;

class Lnode {
    // for a linked list
    ...
    int num;
}

Lnode l;
// (OK if public)
l.num = 12;
l.print();

```

With method (1):

- We immediately get memory for an instance.
- The instance exists only throughout the scope of the variable (in this case, t or l).

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```

// ----- Method 2 -----

struct Tnode {
    // for a BST
    ...
    int num;
}

Tnode *pt;
...
new pt;
pt -> num = 3;

class Lnode {
    // for a linked list
    ...
    int num;
}

Lnode * pl;
...
new pl;
pl -> num = 3;
pl -> print();

```

With method (2):

- We immediately get memory for only a pointer.
- We don't get an instance until we do `new` (like `malloc`).
- That instance exists, even if the pointer no longer does, throughout the entire program; unless we `delete` it (like `free`).

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Reasons for Using Classes

- Adding a new simple type not in the language.
E.g., Fractions, complex numbers.
- Creating a variation on a type that *is* in the language.
E.g., arrays with bounds checking; unlimited-length strings.
- Defining a new kind of composite object — an ADT.
E.g., stack.
- Separating the “interface” of an ADT from any implementations.
- Using inheritance to define a variation on some other class that we've defined.
E.g., a searchable stack.

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Object-Oriented Programming

In C, we write programs in the “procedural” paradigm.

OOP is more than using classes to support encapsulation. It is a new paradigm.

- We focus on data objects, and the relationships among them
(vs focusing on tasks).
- We think of data as active — it does things
(vs having things done *to* it).

Object-oriented programming languages have features that support this vision, and provide some very nice advantages.

Two key features: inheritance and polymorphism.

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Describing an ADT's interface

```
// ----- PriorityQueue.h

# ifndef PRIORITYQUEUE_H
# define PRIORITYQUEUE_H

#include "TodoItem.h"

// A priority queue of TodoItems.
// Limitation: Cannot be used to store objects of any type
// other than TodoItems.

class PriorityQueue {
public:
    // Add td to me, in priority order.
    virtual void enqueue(TodoItem* td) = 0;

    // Return my highest priority item, and
    // remove it from me.
    // Precondition: I am not empty.
    virtual TodoItem* dequeue(void) = 0;

    // Return the number of items in me.
    virtual int size() = 0;
};

# endif
```

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```
// ----- LinkedPQ.h

# ifndef LINKEDPQ_H
# define LINKEDPQ_H

#include "PriorityQueue.h"
#include "TodoItem.h"

// Implementation for class PriorityQueue.

class LinkedPQ : public PriorityQueue {
private:
    // Instance variables go here.
public:
    LinkedPQ();

    ~LinkedPQ();

    // Add td to me, in priority order.
    virtual void enqueue(TodoItem *td);

    // Return my highest priority item,
    // and remove it from me.
    // Precondition: I am not empty.
    virtual TodoItem* dequeue();

    // Return the number of items in me.
    virtual int size();
};

# endif
```

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```
// ----- LinkedPQ.cc

#include "LinkedPQ.h"

// Constructor.
LinkedPQ::LinkedPQ() {
    // body omitted
}

// Destructor.
LinkedPQ::~LinkedPQ() {
    // body omitted
}

// Add td to me, in priority order.
void LinkedPQ::enqueue(ToDoItem *td) {
    // body omitted
}

// Return my highest priority item,
// and remove it from me.
// Precondition: I am not empty.
ToDoItem* LinkedPQ::dequeue() {
    // body omitted
}

// Return the number of items in me.
int LinkedPQ::size() {
    // body omitted
}
```

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```
// ----- ToDoItem.h

# ifndef TODOITEM_H
# define TODOITEM_H

#include <iostream.h>

class ToDoItem {
private:
    static const int DESCR_LENGTH = 10;
    char description[DESCR_LENGTH];
    int priority;

public:
    ToDoItem::ToDoItem(const int p, const char* d);
    ToDoItem::~ToDoItem();
    int compareTo(ToDoItem other);
    friend ostream &operator<< (ostream& os,
                                const ToDoItem& td);
};

# endif
```

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```
// ----- Driver.cc

#include <iostream.h>
#include "LinkedPQ.h"
#include "ToDoItem.h"

int main() {
    ToDoItem td(1, "Fix broken link on 191 web page");
    ToDoItem td2(10, "Email Ronnie re Saturday");
    ToDoItem td3(3, "Prepare next week's lectures");
    PriorityQueue *pq;
    pq = new LinkedPQ();
    pq->enqueue(&td);
    pq->enqueue(&td2);
    pq->enqueue(&td3);
    int queueSize = pq->size();
    while(queueSize > 0) {
        cout << "Size is: " << pq->size() << endl;
        cout << *pq->dequeue();
        queueSize = pq->size();
    }
}

#include <iostream.h>
#include "ToDoItem.h"

// Constructor.
ToDoItem::ToDoItem(const int p, const char* d) {
    priority = p;
    strcpy(description, d);
}

// Destructor.
ToDoItem::~ToDoItem() {
    // Nothing to do?
}

int ToDoItem::compareTo(const ToDoItem other) {
    if (priority < other.priority) {
        // I have higher priority (== a lower priority value)
        return 1;
    } else if (priority > other.priority) {
        return -1;
    } else {
        return 0;
    }
}

ostream& operator<< (ostream& os, const ToDoItem& td){
    cout << "Priority: " << td.priority <<
        " "; Description: " << td.description;
    cout << endl;
    return os;
}
```

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