2.3 Accessors & Mutators

Sue can see the value of designing class interfaces with the properties the client has in mind. However, she is very concerned about the resulting performance penalty. If a function call needs to be made every time the data from a class is accessed, won't this be a huge drain on the entire program? While mulling over this dilemma, Sam stops by and reminds Sue of the `inline` construct. "Yes!" she says, "that will definitely solve this problem…"

Objectives

By the end of this chapter, you will be able to:

- Make setters and getters inline to improve program performance
- Make getters constant to reduce the chance of accidentally modifying a member variable

Prerequisites

Before reading this chapter, please make sure you are able to:

- Recite and explain the four design rules for encapsulation (Chapter 2.0)
- Convert a UML class diagram into a class definition (Chapter 2.2)
- Implement member functions (Chapter 2.2)
- Use the `this` pointer to access member variables and methods (Chapte 2.2)
- Make a function inline using the `inline` keyword (Chapter 1.5)

What are accessors and mutators and why you should care

An **accessor** is a method providing the client access to data from member variables. Accessors are also commonly known as "getters" because the function names tend to be variations of `get()`. A `Date` class, for example, might have three accessors: `getDay()`, `getMonth()`, and `getYear()`.

A **mutator** is a method enabling the client to modify or change the data stored in member variables. Mutators are also commonly known as "setters" because the function names tend to be variations of `set()`. A `Date` class, for example, might have four mutators: `set()` taking three parameters, `setDay()`, `setMonth()`, and `setYear()`.

Just about every class you use or write will have some variation of a getter or setter. This should not be surprising: most classes store data and the client will want to have access to the data or change it. Because they are so important, it behooves us to learn how to make our getters and setters as safe and efficient as possible. That is the purpose of this chapter.

There are two tools we commonly use in getters and setters to accomplish these goals: making them inline and making them constant.

Inline

As you may have noticed, most getters and setters tend to be trivial and consist of just a couple lines of code. This makes them great candidates for being `inline` methods. Recall that making a function inline is a signal to the compiler to make a special optimization. Instead of the function being called in the normal way, the compiler copies the function body code directly into that of the caller. While the behavior remains identical, performance is improved.

We can make a method inline though including the `inline` keyword just as we did with a standard function:

```
inline int Card :: getRank()                  // the inline keyword makes this method
{                                             //     inline as it would for any other
   return value % 13;                         //     function
}
```

Remember that inline functions need to go in the header file. This is true whether the inline function is a method or a stand-alone function.

It is so common to want to make a method inline (probably because so many methods are trivial) that C++ has made an easier way to do this. We can provide the body of a member function directly in the class definition, making the method inline.

The inline keyword must be missing! If the method is defined in the class, it is inline automatically

The "`Card ::`" is not used in the class definition

```
class Card
{
   public:
      void display();                         // not inline because it is not trivial

      // CARD :: GET RANK                     // use an abbreviated comment block.
      int getRank()                           // traditionally, getters are even simpler
      {                                       //     than setters because they don't
         return value % 13;                   //     perform any validation
      }

      // CARD :: SET RANK                     // use an abbreviated comment block.
      void setRank(int rank)                  // because setRank() is a trivial function
      {                                       //    consisting of just one statement,
         value = rank + getSuit() * 13;       //    it is a great candidate for inline
      }
... code removed for brevity ...

   private:
      bool validate();                        // not inline because it is not trivial
      int  value;                             // member variables are unchanged
};
```

Sue's Tips

It is not uncommon to have a class consisting completely of inline methods, making it unnecessary to write a source file: everything is in the header!

Constant methods

As we discussed in Chapter 2.2, member variables have much larger scopes than local variables. Local variables are limited to the function in which they are defined but member variables are accessible to all the methods in the class. This is a potential source of bugs: the more accessible a variable is the larger the chance that it will be misused. If, for example, a local variable has an unexpected value that results in a bug, the programmer need only look in the body of the function to find the source. However, if offending variable is a member variable, any of the methods in the class could be to blame.

Wouldn't it be great if we could restrict access to member variables, giving fewer methods access to make changes? That mechanism exists with the `const` method modifier.

When the `const` modifier is applied to a variable, the compiler provides guarantees that the variable will not be changed. When the `const` modifier is applied to a method, the compiler provides guarantees that the member variables will not be changed in the method.

The const modifier makes it illegal to change member variables, such as "value".

```
class Card
{
... code removed for brevity ...
   int getSuit() const                  // because this method has the const modifier,
   {                                    //    it is illegal for it to change the
      return value / 13;                //    member variable "value"
   }
... code removed for brevity ...
   private:
      int value;
};
```

If the programmer made a mistake and attempted to change value in the above function, the following compiler error would result:

```
In file included from cardTest.cpp:8:
card.h: In member function "int Card::getSuit() const":
card.h:50: error: assignment of data-member "Card::value" in read-only structure
```

Warning!

The `const` modifier is a two-edged sword. It is a great help for finding bugs because the compiler will point to an unintended assignment (such as "`if (value = 0)`" where "`if (value == 0)`" was intended). However, it can also be really annoying. Consider the following function:

```
... code removed for brevity ...
   bool Card :: validate();             // NOT const…
   int getSuit() const                  // const so we cannot change value
   {
      assert(validate());               // because validate() is not const, we cannot
      return value / 13;                //     guarantee that "value" isn't changed in
   }                                    //     getSuit().  This will be a compile error
... code removed for brevity ...
```

We get a very cryptic error message:

```
In file included from cardTest.cpp:8:
card.h: In member function "int Card::getSuit() const":
card.h:50: error: passing "const Card" as "this" argument of "bool Card::validate()"
discards qualifiers
```

The problem here is that `validate()` is not a `const` method! Thus using `const` is an all-or-nothing proposition. A `const` method cannot call a method in the class that is not `const`.

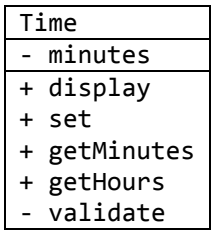
Example 2.3 – Time

Demo

This example will demonstrate how to use the `const` and `inline` modifiers in a simple class definition. Most getters and setters should follow this pattern.

Problem

With the same UML diagram we used from Example 2.2, implement the getters and setters as `inline` and `const` as appropriate.



Solution

All the code will be in the class definition so all the methods will be inline. Note that the functionality of the class will remain unchanged.

```
class Time
{
   public:
     // TIME :: SET : Set the time according to user input
     void set(int hours = 0, int minutes = 0)
     {
        // first just trust them
        this->minutes = hours * 60 + minutes;

        // set to midnight if invalid
        if (!validate())
           this->minutes = 0;
      }
... code removed for brevity...
      // TIME :: GET MINUTES : Fetch the minutes since midnight
      int  getMinutes() const
      {
         // more paranoia...
         assert(validate());
         return minutes % 60;
      }
... code removed for brevity ...
      // TIME :: VALIDATE : Ensure that the member variable is set correctly
      bool validate() const        // this must be const or it cannot be called by
      {                            //     getMinutes() which is const!
         return (minutes >= 0 && minutes < 24 * 60);
      }
};
```

Challenge

As a challenge, modify the class so it also stores seconds as we did in Chapter 2.2. This means that the internal data representation will be "seconds since midnight" rather than "hours since midnight."

See Also

The complete solution is available at 2-3-time.html or:

```
/home/cs165/examples/2-3-time.cpp
```

Example 2.3 – Card

Demo

This example will demonstrate how to use the `const` and `inline` modifiers in a more complex class definition.

Problem

Write a class to represent a playing card. Include all the convenient getters and setters that the client may need to use this class.

Solution

The most interesting code for this problem is in the class definition in the `card.h` header.

```
#ifndef CARD_H
#define CARD_H
... code removed for brevity...
class Card
{
  public:
   // initialize
   void initialize()   { value = 0; }   // trivial functions can be on one line

   // getters and setters
   bool setSuit(char chSuit);
   bool setRank(char chRank);

   //  CARD :: GET SUIT fetch the suit {s,h,c,d}
   char getSuit() const
   {
      // paranoia
      assert(this->validate());
      return SUITS[value / 13];
   }

   //  CARD :: GET RANK fetch the rank {2,3,4,...j,q,k,a}
   char getRank() const
   {
      // paranoia
      assert(this->validate());
      return RANKS[value % 13];
   }

   bool isInvalid() const { return value == INVALID; }
   void display();

  private:
   // holds the value.  Though there are 256 possible, only 52 are used
   unsigned char value;                //internal representation

};
... code removed for brevity...
#endif // CARD_H
```

See Also

The complete solution is available at 2-3-card.html or:

```
/home/cs165/examples/2-3-card/
```

Review 1

Given the following class:

```
class Coordinate
{
   public:
      int x;
   private:
      int y;
};

int main()
{
   Coordinate coord;

   coord.y = 3;
   cout << coord.y << endl;

   return 0;
}
```

What is the output?

Please see page 128 *for a hint.*

Review 2

In the following class:

```
class Number
{
public:
   void set(int num)
   {
   <code goes here>
   }
private:
   int num;
};
```

What code will complete `set()`?

Please see page 131 *for a hint.*

Problem 3 - 6

All four of these problems are to solve the same problem: create a class to hold an individual's grade on a test: (0 → 100% or F → A+). Not that the properties must be both number and letter grades. It is up to the author of the class to determine the best data representation.

3. Create the UML class diagram to describe a class to hold an individual's grade

4. Write the class definition to match the above UML class diagram

5. Implement the method `set()` from your class definition

6. Write a driver program to exercise your `Grade` class

Please see page 139 *for a hint.*