CSE 143

Classes

[Chapter 3, pp. 125-131]

ADTs: Great Idea, but...

- How do we actually get modularity, abstraction, ADTs, black boxes, etc. in our programs?
- How do we actually encapsulate?
- Main programming construct: the **class**
  - New and major difference between C++ and C
  - Based on C struct.

Classes vs. Structs

- A lot like a C `struct` in syntax:

```
class GradeTranscript {
 // Class member declarations
};
```

- Two big enhancements to support encapsulation
  - Members (= components) can be functions

    `not just data`
  - Can specify *private* vs. *public* members

A Bank Account Class

```
// Representation of a bank account
class BankAccount {
public:
  // set account owner to given name
   void init(char name[]);
  // add amount to account balance
   void deposit(double amount);
  // = current account balance
   double amount();
private:
   char owner[30];    // account holder's name
   double balance;    // current account balance
};
```

- Inside the BankAccount declaration, you can see variables (*data members*) and function prototypes (*member functions* or *methods*)
- Some members are *public,* some are *private*

Public vs. Private

- By default, "private" is assumed for classes
- Members in the private interface are hidden from clients.
  - The compiler will *not* allow client code to access them.
  - There's a "wall" around them
- Public members may be used directly by clients
  - Windows or holes through the wall
- For the BankAccount class,
  - How many data members? private? public?
  - How many "methods"?
  - What can the client use directly?

How Clients Use a Class

- A class is treated like any programmer-defined type. For example, you can:
  - Declare variables of that type:

    `BankAccount anAccount;`
  - Can have arguments (parameters) of that type:

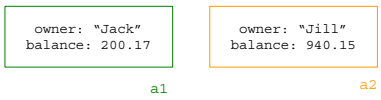
    `void doSomething (BankAccount anotherAccount);`
  - Use one type to build other types:

```
class Bank {
public:
   . . .
private:
   BankAccount accounts[100];
};
```

A Class is a Type

```
BankAccount a1, a2;
```

- The code above creates two instances of the BankAccount class.
- Each instance has its own copy of the data members of the class:

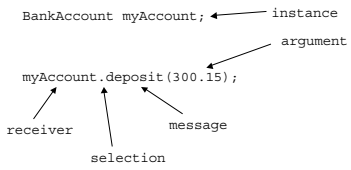


Operations on instances

- Most built-in operations DO NOT apply to class instances
- You cannot (for example):
  - use the "+" to add two BankAccount instances
  - use the "==" to compare to accounts for equality
- To the client, the only valid operations on instances are
  - assignment ("=")
  - member selection (".")
  - plus, can use any operations defined in the public interface of the class.

Terminology

- Think of a class as a cookie cutter, used to stamp out concrete objects (instances)
- Another view: objects as simple creatures that we communicate with via "messages." (function calls)



Information Hiding

- The *private* access modifier supports and enforces information hiding

```
// A client program . . .

BankAccount account;

account.balance = 10000.0;  // NO!  why?
cout << account.balance;    // NO!  why?

account.init("Jill");        // ok?
account.deposit(40.0);       // ok?
cout << account.amount();    // ok?
cout << account.amount;      // ????
cout << account;             // ????
```


Class Packaging

- C++ allows many legal ways to "package" classes. In CSE143 we generally follow this pattern:
- For each class named X, a pair of files: X.cpp and X.h
- X.h (specification file)
  - the declaration of only one class X
  - maybe some constants
- X.cpp (implementation file)
  - #include "X.h"
  - contains all the member function definitions and any other functions needed to implement them
- Client programs have #include "X.h"
- Sometimes very closely related classes are packaged together

Interface as Contract

*The public parts of a class declaration define the **interface** that clients can use.*

Module interface acts as a contract between client and implementer

- Client depends on interface not changing
- Doesn't need to know any details of how module works, just what it does
- Implementer can change anything not in the interface, (e.g. to improve performance)
- Implementation is a "black box" (***encapsulation***), providing ***information hiding***

Class Declaration: Interface

```
#ifndef BANKACCOUNT_H          <- Multiple inclusion hack – more below
#define BANKACCOUNT_H

// Representation of a bank account
class BankAccount {
public:
  // set account owner to given name
   void init(char name[]);
  // add amount to account balance
   void deposit(double amount);
  // = current account balance
   double amount();
private:
   char owner[30];     // account holder's name
   double balance;     // current account balance
};

#endif
```

BankAccount.h

Building the Class: Implementation (Code)

```
#include "BankAccount.h"
// set account owner to given name
void BankAccount::init(char name[]) {
   balance = 0.0;
   strcpy(owner, name);
}
// = current account balance
double BankAccount::amount() {
   return balance;
}
// add amount to account balance
void BankAccount::deposit(double amount) {
   balance = balance + amount;
}
```

need class name here

scope resolution operator

BankAccount.cpp

Implementing Member Functions

- Implementations of member functions use `classname::` prefix
  - indicate which class the member belongs to
  - " `::` " is called the *scope resolution operator*
- Within member function body:
  - Refer to members directly
  - Can access any member, whether public or private!
  - Don't reuse class member names for formal parameters and local variables (bad style)

Declaration vs Definition

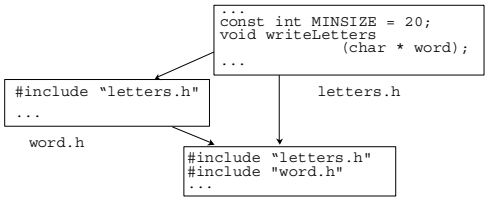
- In C++ (and C) there is a careful distinction between declaring and defining an item.
- Declaration: A specification that gives the information needed to use an item
  - function prototype
  - class declaration (specification in header file)
- Definition: The C++ construct that actually creates the item.
  - full function w/body

One-Definition Rule (ODR)

- An item (class, function, etc.) may be *declared* as many times as needed in a program (i.e., the same declaration may be #included in many files), but…
- An item must be *defined* (actually created or implemented) ***exactly once*** in a program.

Multiple Inclusion

Although an item may be declared in many different compilation units, it is a compile-time error if identifiers (function names, constants, etc.) are declared multiple times in one compilation unit:



Multiple Inclusion Hack

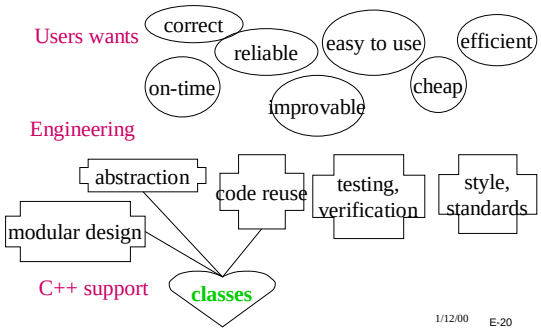
- To avoid this problem, use preprocessor directives:

```
// letters.h
#ifndef LETTERS_H
#define LETTERS_H
...
const int MINSIZE = 20;
void writeLetters (char *word);
...
#endif
```

Preprocessor directive

- Read the above as:
  - "If the symbol `LETTERS_H` has not been defined, compile the code through `#endif` (and define `LETTERS_H`), otherwise skip that code"
- Effect: the header is only processed the first time it encountered (#included) when compiling a particular source file

Classes in the Big Picture



Summary

- `class` construct for Abstract Data Types
  - Function members (operations)
  - Data members (representation)
- `public` vs. `private` members
- Specification vs Implementation
  - Related concept: Declaration vs Definition
  - Implementation signaled by `classname::`
  - Implementations can access all members, public or private
- Clients generally have multiple instances of a few classes