Class Hierarchies

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Class Hierarchies

- Until now inheritance has been used to add functionality to an existing class.
- let's look at an example where inheritance is used for a different purpose: as part of the original design of a program.
- The next example models a database of employees of a widget company.
- We've simplified the situation so that only three kinds of employees are represented.
- *Managers* manage, *scientists* perform research to develop better widgets, and *labourers* operate the dangerous widget-stamping presses.

Employee Class

- The database stores a name and an employee identification number for all employees, no matter what their category.
- However, for managers, it also stores their titles and golf club dues
- For scientists, it stores the number of scholarly articles they have published.
- Labourers need no additional data beyond their names and identification numbers.

Employee Class

- The example program starts with a base class employee.
- This class handles the employee's last name and employee number.
- From this class three other classes are derived: manager, scientist, and labourer.
- The manager and scientist classes contain additional information about these categories of employee, and member functions to handle this information.
- the labourer class doesn't have any additional data to be introduced.
- See "employ.cpp"

UML class diagram for Employee Class



"Abstract" Base Class

- Notice that we don't define any objects of the base class employee.
- We use this as a general class whose sole purpose is to act as a base from which other classes are derived.
- The labourer class operates identically to the employee class, since it contains no additional data or functions.
- It may seem that the labourer class is unnecessary, but by making it a separate class we emphasise that all classes are descended from the same source, employee.
- Also, if in the future we decided to modify the labourer class, we would not need to change the declaration for employee.
- Classes used only for deriving other classes, as employee is in EMPLOY, are sometimes loosely called abstract classes,
- meaning that no actual instances (objects) of this class are ever created.

Constructors and Member Functions

• There are no constructors in either the base or derived classes, so the compiler creates objects of the various classes automatically when it encounters definitions like

```
manager m1, m2;
```

- using the default constructor for manager calling the default constructor for employee.
- The getdata() and putdata() functions in employee accept a name and number from the user and display a name and number.
- Functions also called getdata() and putdata() in the manager and scientist classes use the functions in employee, and also do their own work.
- In manager, the getdata() function asks the user for a title and the amount of golf club dues, and putdata() displays these values.
- In scientist, these functions handle the number of





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Public and Private Inheritance

- See "pubpriv.cpp"
- The program specifies a base class, A, with private, protected, and public data items.
- Two classes, B and C, are derived from A.
- B is publicly derived and C is privately derived.
- functions in the derived classes can access protected and public data in the base class.
- Objects of the derived classes cannot access private or protected members of the base class.
- What's new is the difference between publicly derived and privately derived classes.
- Objects of the publicly derived class B can access public members of the base class A,
- while objects of the privately derived class C cannot;
- they can only access the public members of their own derived class.

Public and Private Inheritance



If we don't supply any access specifier when creating a class, private

is assumed Saurav Samantaray

Levels of Inheritance

- Classes can be derived from classes that are themselves derived.
- class A
 { };
 class B : public A
 { };
 class C : public B
 { };
- Here B is derived from A, and C is derived from B.
- The process can be extended to an arbitrary number of levels—D could be derived from C, and so on.
- suppose that we decided to add a special kind of labourer called a foreman to the EMPLOY program.
- Since a foreman is a kind of labourer, the foreman class is derived from the labourer class

UML class diagram for New Employee



Constructors in Multiple Inheritance

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Multiple Inheritance

• Constructors in Multiple Inheritance



Multiple Inheritance

- A class can be derived from more than one base class.
- This is called multiple inheritance.



Figure 1: UML class diagram for multiple inheritance.

Multiple Inheritance

- The syntax for multiple inheritance is similar to that for single inheritance.
- the relationship is expressed like this:

```
class A // base class A
{ };
  class B // base class B
{ };
  class C : public A, public B // C is
  derived from A and B
{ };
```

- The base classes from which C is derived are listed following the colon in C's specification;
- they are separated by commas.

Member Functions in Multiple Inheritance

- As an example of multiple inheritance, suppose that we need to record the educational experience of some of the employees in the EMPLOY program.
- Let's also suppose that, perhaps in a different project, we've already developed a class called student that models students with different educational backgrounds.
- We decide that instead of modifying the employee class to incorporate educational data, we will add this data by multiple inheritance from the student class.
- The student class stores the name of the school or university last attended and the highest degree received.
- Two member functions, getedu() and putedu(), ask the user for this information and display it.
- Educational information may not be relevant to every class of employee.

Member Functions in Multiple Inheritance

- See "empmult.cpp".
- Let's suppose, that we don't need to record the educational experience of labourers;
- it's only relevant for managers and scientists.
- We therefore modify manager and scientist so that they inherit from both the employee and student classes.



Member Functions in Multiple Inheritance

- The getdata() and putdata() functions in the manager and scientist classes incorporate calls to functions in the student class, such as student::getedu(); and student::putedu();
- These routines are accessible in manager and scientist because these classes are descended from student.

- Imagine that we're writing a program for building contractors, and that this program models lumber-supply items.
- It uses a class that represents a quantity of lumber of a certain type: 108-foot-long construction grade 2×4s, for example.
- The class should store various kinds of data about each such lumber item.
- We need to know the length (3'-6", for example) and we need to store the number of such pieces of lumber and their unit cost.
- We also need to store a description of the lumber we're talking about.
- This has two parts.
- The first is the nominal dimensions of the cross-section of the lumber.
- This is given in inches.
- For instance, lumber 2 inches by 4 inches is called a two-by-four. This is usually written 2×4.

- We also need to know the grade of lumber—rough-cut, construction grade, surfaced-four-sides, and so on.
- We find it convenient to create a Type class to hold this data.
- This class incorporates member data for the nominal dimensions and the grade of the lumber, both expressed as strings, such as 2×6 and construction.
- Member functions get this information from the user and display it.
- We'll use the Distance class from previous examples to store the length.
- Finally we create a Lumber class that inherits both the Type and Distance classes.
- "englmult.cpp".

- The major new feature in this program is the use of constructors in the derived class Lumber.
- These constructors call the appropriate constructors in Type and Distance.

No-Argument Constructor

• The no-argument constructor in Type looks like this:

```
Type()
{ strcpy(dimensions, \N/A");
strcpy(grade, \N/A"); }
```

• and in Distance class looks like:

```
Distance() : feet(0), inches(0.0) \{ \}
```

• The no-argument constructor in Lumber calls both of these constructors.

```
Lumber():Type(), Distance(), quantity(0),
price(0.0) { }
```

The names of the base-class constructors follow the colon and

Multi-Argument Constructors

- The two-argument constructor for Type: Type(string di, string gr) : dimensions(di), grade(gr) { }
- The constructor for Distance: Distance(int ft, float in) : feet(ft), inches(in) { }
- The constructor for Lumber takes in values for their arguments.
- In addition it has two arguments of its own: the quantity of lumber and the unit price.

```
Lumber( string di, string gr, //args for Type
int ft, float in, //args for Distance
int qu, float prc ) : //args for our data
```

• The constructor for Lumber calls both of the constructors i.e. of Type and Distance.

```
• ....
```

```
Type(di, gr), //call Type ctor
Distance(ft, in), //call Distance ctor
quantity(qu), price(prc) //initlize our data
{ }
```

- It makes two calls to the two constructors;
- each of which takes two arguments,
- and then initializes its own two data items.

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2 Multiple Inheritance

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Ambiguity in Multiple Inheritance

- Odd sorts of problems may surface in certain situations involving multiple inheritance.
- Here's a common one.
- Two base classes have functions with the same name, while a class derived from both base classes has no function with this name.
- How do objects of the derived class access the correct base class function?
- The name of the function alone is insufficient, since the compiler can't figure out which of the two functions is meant.
- See "ambigu.cpp".
- Both base classes A and B have a function void show () {} each.

Ambiguity in Multiple Inheritance

- Even though the body of each of the function is different, they have the same protype.
- If one uses the following command for an object obje of Class C:

```
objc.show();
```

it leaves the compiler dumbfound.

- The compiler is caught between the classes A and B, and there is no extra information provided, so that it can make a choice.
- In such a scenario the compiler wil throw out an error.
- The problem is resolved using the scope-resolution operator to specify the class in which the function lies.
- objC.A::show(); refers to the version of show() that's in the A class, and;
- objC.B::show(); refers to the version of show() that's in the B

Ambiguity in Multiple Inheritance

- Another kind of ambiguity arises if we derive a class from two classes that are each derived from the same class.
- Classes B and C are both derived from class A, and class D is derived by multiple inheritance from both B and C.
- Trouble starts if we try to access a member function in class A from an object of class D.
- In this example objD tries to access func ().
- However, both B and C contain a copy of func(), inherited from A.
- The compiler can't decide which copy to use, and signals an error.
- The fact that such ambiguities can arise causes many experts to recommend avoiding multiple inheritance altogether.
- We should certainly not use it in serious programs unless we have considerable experience.

Ambiguity in Multiple Inheritance

```
//diamond.cpp
//investigates diamond-shaped multiple inheritance
#include <iostream>
using namespace std;
class A
  public:
    void func();
};
class B : public A { };
class C : public A { };
class D : public B, public C { };
int main()
  D objD;
  objD.func(); //ambiguous: won't compile
  return 0;
```