

Class inheritance: is-a

Victor Eijkhout, Susan Lindsey

Fall 2023

last formatted: September 12, 2023

1. Hierarchical object relations

Hierarchical relations between classes:

- each object in class A is also in class B.
but not conversely
- Example: each manager is an employee
- Example: each square is a rectangle

2. Example of class hierarchy

- Class *Employee*:

```
class Employee {  
private:  
    int number, salary;  
    /* ... */  
};
```

- class *Manager* is subclass of *Employee*
(every manager is an employee, with number and salary)
- Manager has extra field *n_minions*

How do we implement this?

3. Another example: multiple subclasses

- Example: both triangle and square are polygons.
- You can implement a method `draw` for both triangle/square
- ... or write it once for polygon, and then use that.

4. Terminology

Derived classes *inherit* data and methods from the base class: base class data and methods are accessible in objects of the derived class.

- Example: *Polygon* is the *base class*
Triangle is a *derived class*
Triangle has *corners* method because Polygon has
- *Employee* is the *base class*.
Manager is a *derived class*. Manager has *employee_number* because Employee has

5. Base/Derived example

```
class Polygon {  
protected:  
    vector<Point> corners;  
public:  
    int ncorners() { return corners.size(); };  
};  
class Triangle : public Polygon {  
    /* constructor omitted */  
};  
int main () {  
    Triangle t;  
    cout << t.ncorners(); // prints 3, we hope
```

6. Examples for base and derived cases

General *FunctionInterpolator* class with method *value_at*. Derived classes:

- *LagrangeInterpolator* with *add_point_and_value*;
- *HermiteInterpolator* with *add_point_and_derivative*;
- *SplineInterpolator* with *set_degree*.

7. General case, special case

You can have classes where an object of one class is a special case of the other class. You declare that as

```
1 class General {
2     protected: // note!
3     int g;
4     public:
5     void general_method() {};
6 };
7
8 class Special : public General {
9     public:
10    void special_method() { g = ... };
11 };
```


8. Inheritance: derived classes

Derived class *Special* inherits methods and data from base class

General:

```
1 int main() {  
2     Special special_object;  
3     special_object.general_method();  
4     special_object.special_method();  
5 }
```

Members of the base class need to be **protected**, not **private**, to be inheritable.

9. Constructors

When you run the special case constructor, usually the general constructor needs to run too. Here we invoke it explicitly:

```
1 class General {  
2 public:  
3   General( double x,double y ) {};  
4 };  
5 class Special : public General {  
6 public:  
7   Special( double x ) : General(x,x+1) {};  
8 };
```

10. Access levels

Methods and data can be

- `private`, because they are only used internally;
- `public`, because they should be usable from outside a class object, for instance in the main program;
- `protected`, because they should be usable in derived classes.

Exercise 1

Take your code where a `Rectangle` was defined from one point, width, and height.

Make a class `Square` that inherits from `Rectangle`. It should have the function `area` defined, inherited from `Rectangle`.

First ask yourself: what should the constructor of a `Square` look like?

Exercise 2

Revisit the `LinearFunction` class. Add methods `slope` and `intercept`.

Now generalize `LinearFunction` to `StraightLine` class. These two are almost the same except for vertical lines. The `slope` and `intercept` do not apply to vertical lines, so design `StraightLine` so that it stores the defining points internally. Let `LinearFunction` inherit.

11. Overriding methods

- A derived class can inherit a method from the base class.
- A derived class can define a method that the base class does not have.
- A derived class can *override* a base class method:

```
1 class Base {  
2 public:  
3     virtual f() { ... };  
4 };  
5 class Deriv : public Base {  
6 public:  
7     virtual f() override { ... };  
8 };
```

12. More

- Multiple inheritance: an X is-a A, but also is-a B.
This mechanism is somewhat dangerous.
- Virtual base class: you don't actually define a function in the base class, you only say 'any derived class has to define this function'.