Inheritance

- Many people are of the opinion that inheritance is what object-oriented programming is all about.

35. "public" Inheritance Models "isa"

- ***class Person {…};***
  class Student : public Person {…};
- ***void dance(const Person& p);*** // anyone can dance
  void study(const Student& s); // only students study
- ***Person p;*** // ***p*** is a ***Person***
  Student s; // ***s*** is a ***Student***
  dance(p); // fine, ***p*** is a ***Person***
  dance(s); // fine, ***s*** is a ***Student***
  // and a ***Student*** isa ***Person***
  study(s); // fine
  study(p); // error! ***p*** is not a ***Student***

36. Interface & Implementation

- Declaring a **pure virtual function** is to have derived classes inherit a function interface only.

- Declaring a **simple virtual function** is to have derived classes inherit a function interface as well as a default implementation.

- Declaring a **nonvirtual function** is to have derived classes inherit a function interface as well as a mandatory implementation.

37. Inherited Non-Virtual Function

- Never redefine an inherited nonvirtual function.
- ***class B { public: void mf(); };***
  class D: public B { void mf(); };
- ***D x;*** // ***x*** is an object of type ***D***
  B *pB = &x; // get pointer to ***x***
  pB->mf(); // call ***mf*** through pointer
  D *pD = &x; // get pointer to ***x***
  pD ->mf(); // call ***mf*** through pointer

- Two-faced behavior…

38. Inherited Default Parameters

- Never redefine an inherited default parameter value (of a virtual function, of course).
- ***class B {***

  public:

  virtual void f(int i=1) const = 0;

  };
- ***class D: public B {***

  void f(int i=2) const;

  };

Inherited Default Parameters (2)

- ***B *pd = new D;***

  pd->f(); // calls ***D::f(2)*** or ***D::f(1)***?

- Virtual functions are dynamically bound, but default parameters are statically bound.

Inherited Default Parameters (3)

- A virtual function call uses the default arguments in the declaration of the virtual function determined by the static type of the pointer or reference denoting the object.

- An overriding function in a derived class does not acquire default arguments from the function it overrides.

39. Down Casting

- Avoid casts down the inheritance hierarchy.

- ***class B {};***
- ***class D: public B {***

  public:

  void f();

  };

Down Casting (2)

- ***template<class T>***
  class A {
  public:
  T x;
  };
- ***A<B> AB;***
  B *p0 = &(AB.x), *p1 = new D;
  p0->f(); // error!
  p1->f(); // okay
  static_cast<D*>(p0)->f();
  // works, but leads to a nightmare.

Down Casting (3)

- ***D d;***
  B &r1 = d, r2 = d;
  static_cast<D>(r1).f(); // ??
  static_cast<D>(r2).f(); // ??

- ***class E: public B {***
  public:
  void f();
  };

Down Casting (4)

- You need to write code like:

```
if (*p points to a D)
    static_cast<D*>(p)->f();
else
    static_cast<E*>(p)->f();
```

41. Inheritance & Template

- You need a collection of classes with many shared characteristics.

- Should you use "inheritance" and have all the classes derived from a common base class?
- Or should you use "templates" and have them all generated from a common code skeleton?

Inheritance & Template (cont)

- A template should be used to generate a collection of classes when the type of the objects does not affect the behavior of the class's functions.

- Inheritance (and virtual functions) should be used for a collection of classes when the type of the objects does affect the behavior of the class's functions.

42. Private Inheritance

- Members inherited from a private base class become private members of the derived class, even if they were protected or public in the base class.

- In contrast to public inheritance, compilers will generally "not“ convert a derived class object into a base class object if the inheritance relationship between the classes is private.

Private Inheritance (2)

- ***class Person {…};***
  class Student : private Person {…};

- ***void dance(const Person& p);*** // anyone can dance
  void study(const Student& s); // only students study

- ***Person p;*** // ***p*** is a ***Person***
  Student s; // ***s*** is a ***Student***
  dance(p); // fine, ***p*** is a ***Person***
  dance(s); // error! A ***Student*** is not a ***Person***

Private Inheritance (3)

- Private inheritance means that implementation only should be inherited; interface should be ignored.

- If D privately inherits from B, D objects are implemented ***in terms of*** B objects; no conceptual relationship exists between objects of types B and D.

43. Multiple Inheritance

- ***class A {***

  virtual void mf();

  };

- ***class B: public A {};***

  // or ***class B: virtual public A {};***

Multiple Inheritance (2)

- ***class C: public A {***

  // or ***class C: virtual public A {***

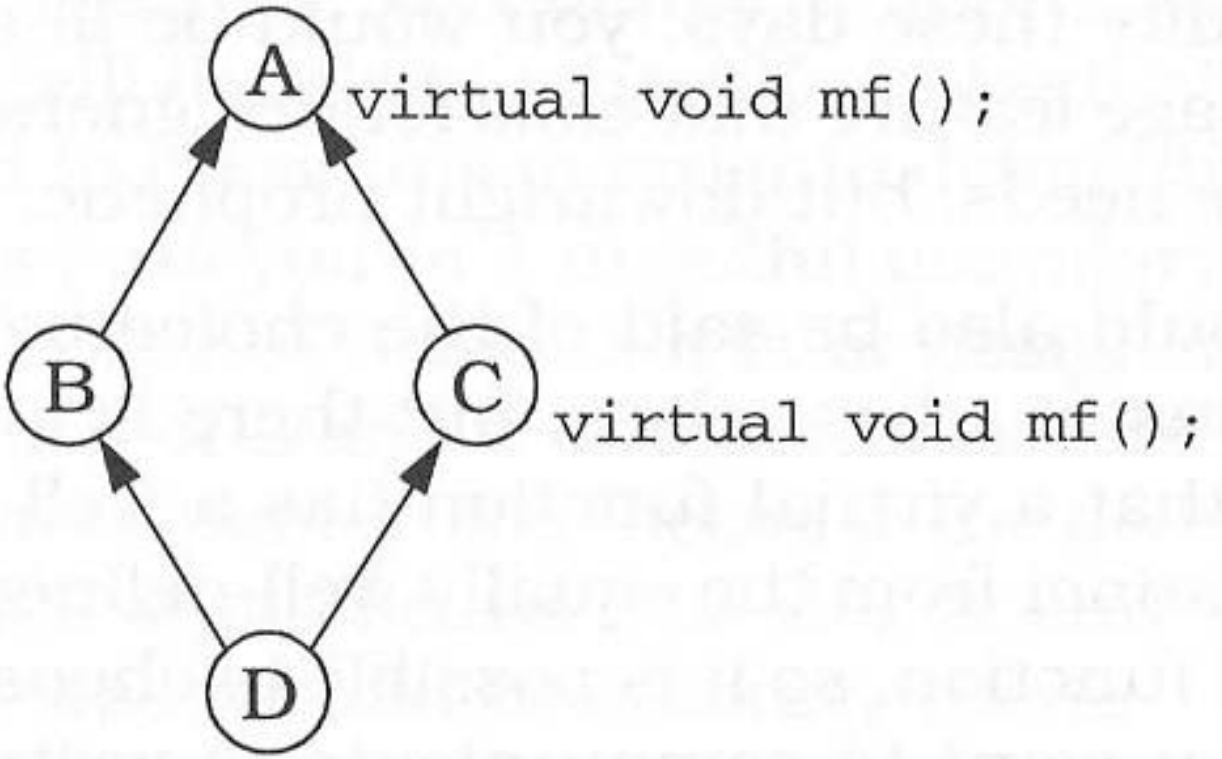
  virtual void mf(); // redefinition of ***mf***

  };

- ***class D: public B, public C {};***

Multiple Inheritance (3)

- ***D *pd = new D;***
  pd->mf(); *// A::mf* or *C::mf*?



Multiple Inheritance (4)

- If *A* is a nonvirtual base of *B* or *C*, the call is ambiguous.

- If *A* is virtual base of both *B* and *C*, the call is *C::mf*

45. When is an empty class not an empty class?

- Know what functions C++ silently writes and calls.
- If you write this:

  class Empty{};

- It is the same as if you have written this (note these functions are generated only if they are needed):

When is an empty class not an empty class? (2)

```
class Empty {
public:
    Empty() {};                                  // default constructor
    Empty(const Empty& rhs);                     // copy constructor
    ~Empty() {};                                 // destructor

    Empty& operator=(const Empty& rhs);
        // assignment operator

    Empty* operator&() { return this; };
        // address-of operators
    const Empty* operator&() const;
};
```

When is an empty class not an empty class? (3)

- The following code will cause each function to be generated:

```
const Empty e1;          // default constructor
                         // destructor
Empty e2(e1);            // copy constructor
e2 = e1;                 // assignment operator
Empty *pe2= &e2;         // address-of-operator (non-const)
const Empty *pe1 = &e1;
                         // address-of operator (const)
```

Last Example

```
class Base {
        public: virtual void f(int x); };
class Derived: public Base {
        public: virtual void f(double *pd); };

Derived *pd = new Derived;
pd->f(10);          // error!
```