Virtual Functions

- A virtual function is a class member function that is declared within a base class and redefined by a derived class. The term "overriding" is used to describe virtual function redefinition.
- To create a virtual function, precede the function's declaration with the keyword "virtual" such as

    virtual void func();

Virtual Functions (2)

- Implement the "**one interface, multiple methods**" philosophy that underlies "polymorphism".
- When redefined by a derived class, the keyword "virtual" is not needed.
- A redefined virtual function must have precisely the same **type** and **number of parameters** and the same **return type**.

Virtual Functions (3)

```
class Base {
public:
    virtual void func();
}

class Derive1 : public Base {
public:
    void func();
}

class Derive2 : public Base {
public:
    void func();
}
```

Virtual Functions (4)

```
main() {
    Base *p;
    Base ob;
    Derived1 ob1;
    Derived2 ob2;

    p = &ob;  p->func();     // use base's func
    p = &ob1; p->func();     // use Derived1's func
    p = &ob2; p->func();     // use Derived2's func
}
```

Virtual Functions (5)

- Destructor functions may be virtual, constructors may not.
- Virtual functions are accessed only via a base class pointer (or reference).

- The type of the object being pointed to determines which version of an overridden virtual function will be executed when accessed via a base class pointer, and that this decision is made at run time (this is why it is called "dynamic binding").

```
class Base
{
public:
    Base()          { cout << "Constructor: Base“ << endl; }
    ~Base()         { cout << "Destructor: Base“ << endl; }
};

class Derived: public Base
{
public:
    Derived()       { cout << "Constructor: Derived“ << endl; }
     ~Derived()     { cout << "Destructor: Derived“ << endl; }
};

void main()
{
    Base *Var = new Derived();
    delete Var;
}
```

- The destructor of the derived class was not called at all.

```
class Base
{
public:
    Base()                  { cout << "Constructor: Base“ << endl; }
    virtual ~Base()         { cout << "Destructor: Base“ << endl; }
};

class Derived: public Base
{
public:
    Derived()       { cout << "Constructor: Derived“ << endl; }
    ~Derived()      { cout << "Destructor: Derived“ << endl; }
};

void main() {
    Base *Var = new Derived();
    delete Var; }
```

- We cannot declare pure virtual destructor. Even if a virtual destructor is declared as pure, it will have to implement an empty body (at least) for the destructor.

Virtual Functions (6)

- When a virtual function is called by a specific object by name and using the dot member selection operator, the call is resolved at compile time (this is called "static binding").
- A virtual function is resolved "statically" when it is called with an explicitly scope operator, even if a pointer or reference is used. For example,

```
p->Base::func();
        // not virtual; call base-class version
```

Virtual Functions (7)

- Do not make a function virtual unless you want the derived class to be able to get control of it.

Pure Virtual Functions

- Has no definition relative to the base class. Only the function's prototype is included. For example,

  virtual void func() = 0;

- Forces the derived class to override it. If a derived class does not, a compile-time error results.

Pure Virtual Functions (cont)

- Defer the implementation decision of the function. In OOP terminology, it is called a "deferred method".

Abstract Class

- A class that has at least one pure virtual function.

- Technically it is an incomplete type, and no objects of an abstract base class can be created.
- However, pointers and references to abstract base class are okay.

Early (or Static) Binding

- Early binding refers to those events that can be known at compile time, which include "normal" functions, **overloaded functions**, and non-virtual member and friend functions.

1. advantages: efficient.
2. disadvantages: lack of flexibility.

Late (or Dynamic) Binding

- Late binding may have more overhead associated with a function call, thus is generally slower.

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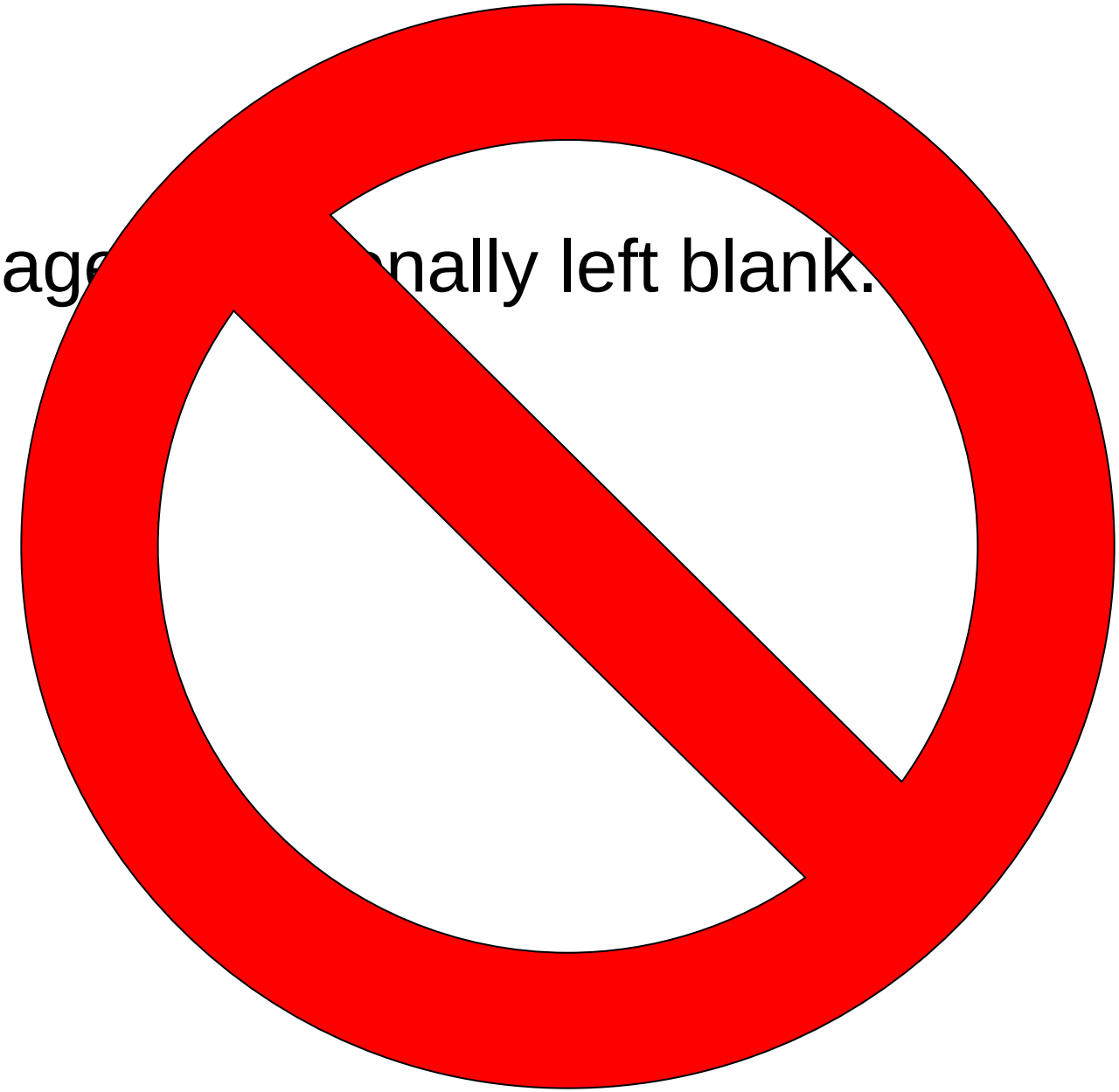

Chapter 10- Virtual Functions and Polymorphism

Outline

10.2 Type Fields and `switch` Statements

- **`switch`** statement
  - Take an action on a object based on its type
  - **`virtual`** functions and polymorphic programming can eliminate the need for **`switch`** logic

10.3 `virtual` Functions

- **`virtual`** functions
  - Suppose a set of shape classes such as **`Circle`**, **`Triangle`**, etc.
  - Every shape has own unique draw function but possible to call them by calling the **`draw`** function of base class **`Shape`**
    - Compiler determines dynamically (i.e., at run time) which to call
  - In base-class declare **`draw`** to be **`virtual`**
  - Override **`draw`** in each of the derived classes
  - **`virtual`** declaration:
    - Keyword **`virtual`** before function prototype in base-class

```
virtual void draw() const;
```

10.3 Virtual Functions

```
ShapePtr->Draw();
```

– Compiler implements dynamic binding
– Function determined during execution time

```
ShapeObject.Draw();
```

– Compiler implements static binding
– Function determined during compile-time

10.4 Abstract and Concrete Classes

- Abstract classes
  - Sole purpose is to provide a base class for other classes
  - No objects of an abstract base class can be instantiated
    - Too generic to define real objects
    - Can have pointers and references
- Making abstract classes
  - Declare one or more **`virtual`** functions as "pure" by initializing the function to zero
  - Example of a pure **`virtual`** function:

```
virtual double earnings() const = 0;
```

10.5 Polymorphism

- Polymorphism
  - If non-**`virtual`** member function defined in multiple classes and called from base-class pointer then the base-class version is used
  - Suppose **`print`** is not a **`virtual`** function

```
Employee e, *ePtr = &e;
HourlyWorker h, *hPtr = &h;
ePtr->print();    // call base-class print function
hPtr->print();    // call derived-class print
function
ePtr=&h;          // allowable implicit conversion
ePtr->print();    // still calls base-class print
```

10.8 Virtual Destructors

- Problem:
  - If a base-class pointer to a derived object is deleted, the base-class destructor will act on the object
- Solution:
  - declare a **`virtual`** base-class destructor to ensure that the appropriate destructor will be called

10.10 Polymorphism, `virtual` Functions and Dynamic Binding "Under the Hood"

- When to use polymorphism
  - Polymorphism requires a lot of overhead
  - Polymorphism is not used in STL (Standard Template Library) to optimize performance
- **`virtual`** function table (vtable)
  - Every class with a **`virtual`** function has a vtable
  - For every **`virtual`** function, its vtable has a pointer to the proper function
    - If a derived class has the same function as a base class, then the function pointer points to the base-