순서

- Inheritance
  - Public
  - Protected
  - Private
- Constructors under Inheritance
- Destructors under Inheritance
- Q&A
Inheritance

- Software reusability
- Create new class from existing class instead of building it entirely from the scratch
  - Existing class’s data and behaviors
  - Adding new capabilities
  - Derived class inherits from base class
Class hierarchy

- Direct base class
  - Inherited explicitly (one level up hierarchy)

- Indirect base class
  - Inherited two or more levels up hierarchy

- Single inheritance
  - Inherits from one base class

- Multiple inheritance
  - Inherits from multiple base classes
    - Base classes possibly unrelated
Three Types of Inheritance

public

- Every object of derived class is also an object of base class
  - Base-class objects are not objects of derived classes
    - All cars are vehicles, but not all vehicles are cars

- Can access non-private members of base class
  - To access private base-class members
    - Derived class must use inherited non-private member functions

private (later)

- Alternative to composition

protected (later)

- Rarely used

“is-a” vs “has-a”

“is-a”

- Inheritance
- Derived class object can be treated as base class object
  - Car is a vehicle
    - Vehicle properties/behaviors also apply to a car

“has-a”

- Composition
- Object contains one or more objects of other classes as members
  - Car has a steering wheel
Base Classes and Derived Classes

- Object of one class “is an” object of another class
  - Rectangle is quadrilateral
    - Class Rectangle inherits from class Quadrilateral
      - base class: quadrilateral
      - derived class: rectangle

- Base class typically represents larger set of objects than derived classes
  - Base class: Vehicle
  - Derived class: Car
Base Classes and Derived Classes Cont’d

- GraduatedStudent class is derived from Student class
- GraduatedStudent class is inherited from Student class
- Student class is super class of GraduatedStudent
- Graduated class is child class or subclass of Student class
Public Inheritance

class TwoDimensionalShape : public Shape

- Class TwoDimensionalShape inherits from class Shape

- Base class private members
  - Not accessible directly, but still inherited
  - Accessed through inherited public member functions

- Base class public and protected members
  - Inherited with original member access

- friend functions
  - Not inherited
    class BaseClass {
        // ...
    };
    class DerivedClass : public BaseClass {
        // ...
    };

Public Inheritance Cont’d

class BaseClass {
   public:
      void public_method();
   protected:
      void protected_method();
   private:
      void private_method();
};

class DerivedClass : public BaseClass {
   public:
      void public_method();
   protected:
      void protected_method();
};
Protected Access Specifier

- Intermediate level of protection between public and private
- Protected methods/data cannot be accessible by other classes except for subclasses
- Other classes consider protected members as normal “private” members
- Subclasses consider protected members as normal “public” members
Protected Access Specifier Cont’d

- Protected members are accessible to
  - Base class members
  - Base class friends
  - Derived class members
  - Derived class friends
Protected Access Specifier Cont’d

- Public members in base class is public in derived class.
- Protected members in base class are protected in derived class.
- Derived-class members
  - Refer to public and protected members of base class
    - Simply use member names
  - Redefined base class members can be accessed by using base-class name and binary scope resolution operator (::)

Protected Inheritance

public and protected members in base class become protected in derived class

class BaseClass {
  public:
    void public_method();
  protected:
    void protected_method();
  private:
    void private_method();
};

class DerivedClass : protected BaseClass {
  protected:
    void public_method();
  protected:
    void protected_method();
};

Private Inheritance

class BaseClass {
    public:
        void public_method();
    protected:
        void protected_method();
    private:
        void private_method();
};

class DerivedClass : private BaseClass {
    private:
        void public_method();
    private:
        void protected_method();
};
Protected Data Members

- **Advantages**
  - Derived class can modify values directly
    - No set/get method call overhead

- **Disadvantages**
  - No validity checking
    - Derived class can assign invalid value
  - Implementation dependent
    - Derived class more likely dependent on base class implementation
    - Base class implementation may result in derived class’s modification
  - Fragile software
#ifndef COMMISSION_H
#define COMMISSION_H

#include <string>
using std::string;

class CommissionEmployee
{
public:
    CommissionEmployee( const string &, const string &, const string &, double = 0.0, double = 0.0 );
    void setFirstName( const string & );
    string getFirstName() const;
    void setLastName( const string & );
    string getLastName() const;
    void setSocialSecurityNumber( const string & );
    string getSocialSecurityNumber() const;
    void setGrossSales( double );
    double getGrossSales() const;
    void setCommissionRate( double );
    double getCommissionRate() const;
    double earnings() const;
    void print() const;

protected:
    string firstName;
    string lastName;
    string socialSecurityNumber;
    double grossSales;
    double commissionRate;

};
#endif

double CommissionEmployee::earnings() const
{
    return commissionRate * grossSales;
}
```cpp
#ifndef BASEPLUS_H
#define BASEPLUS_H

#include <string> // C++ standard string class
using std::string;

#include "CommissionEmployee.h"

class BasePlusCommissionEmployee :
public CommissionEmployee
{

public:

BasePlusCommissionEmployee( const string &, const string &, const string &, double = 0.0, double = 0.0, double = 0.0 );

void setBaseSalary( double );

double getBaseSalary() const;

double earnings() const;

void print() const;

private:

double baseSalary;

};

#endif

double BasePlusCommissionEmployee::earnings() const
{
return baseSalary +
(commissionRate * grossSales );
}
```
The Best Software Engineering Practice

- Declare data members as private
  - Enables programmers to change the base-class implementation without having to change derived-class implementations
  - Use the protected access specifier when a base class should provide a service (i.e., a member function) only to its derived classes (and friends), not to other clients

- Provide public get and set functions
- Use get method to obtain values of data members

Set/get method slightly slower than direct access

- But today’s optimizing compiler inlines set/get methods
- Or you can explicitly specify “inline” keyword

```cpp
class BaseClass
{
    public:
        inline int  getx()const{ return x; } 
        inline void setx( int v )
        {
            if( v > 100 ) error();
            else x = v;
        }
    private:
        int x;
};
```
Selection of public/protected/private Methods

- According to the service range
  - for all other classes: public
  - for itself and subclasses: protected
  - only for itself: private
Constructors under Inheritance

- **Constructor in base class**
  - Does not construct derived class specific parts

- **Constructor in derived class**
  - Initialize its own data members
  - Invokes the constructor of the base class
    - Implicitly or explicitly
Constructors under Inheritance Cont’d

- **Base of inheritance hierarchy**
  - Last constructor called in chain
  - First constructor body to finish executing
  - `CommissionEmployee/BasePlusCommissionEmployee` hierarchy
    - `CommissionEmployee` constructor called last
    - `CommissionEmployee` constructor body finishes execution first

- **Initializing data members**
  - Each base-class constructor initializes its data members that are inherited by derived class
Constructors under Inheritance
Cont’d

class BaseClass
{
    public:
        BaseClass() { x = 1; }
        BaseClass( int a ) { x = a; }
    private:
        int x;
};

class DerivedClass : public BaseClass
{
    public:
        DerivedClass() { y = 2; }
        DerivedClass( int x ) :
            BaseClass( x ) { y = 2; }
    private:
        int y;
};

class BaseClass
{
public:
    // BaseClass() { x = 1; }
    BaseClass( int a ) { x = a; }

private:
    int x;
};
class DerivedClass : public BaseClass
{
public:
    DerivedClass() { y = 2; }
    // error

private:
    int y;
};

class BaseClass
{
    public:
        BaseClass() {
            cout << "base";
            cout << endl;
        }
};
class DerivedClass : public BaseClass
{
    public:
        DerivedClass() {
            cout << "derived";
            cout << endl;
        }
    private:
        base
        derived

Destructors under Inheritance

- Destroying derived-class object
  - Chain of destructor calls
    - Reverse order of constructor chain
    - Destructor of derived-class called first
    - Destructor of next base class up hierarchy next
      - Continue up hierarchy until final base reached
      - After final base-class destructor, object removed from memory
Destructors under Inheritance
Cont’d

```cpp
class BaseClass
{
    public:
        BaseClass() { x = new int[100]; }
        ~BaseClass() { delete[] x; }
    private:
        int* x;
};

class DerivedClass : public BaseClass
{
    public:
        DerivedClass() { y = new int[10]; }
        ~DerivedClass() { delete[] y; }
    private:
        int* y;
};
```

# Base-class Member Accessibility in a Derived Class

<table>
<thead>
<tr>
<th>Base-class member-access specifier</th>
<th>Type of inheritance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>public inheritance</td>
</tr>
<tr>
<td></td>
<td>protected inheritance</td>
</tr>
<tr>
<td></td>
<td>private inheritance</td>
</tr>
<tr>
<td>public</td>
<td>public in derived class.</td>
</tr>
<tr>
<td></td>
<td>Can be accessed directly by member functions, friend functions and nonmember functions.</td>
</tr>
<tr>
<td>protected</td>
<td>protected in derived class.</td>
</tr>
<tr>
<td></td>
<td>Can be accessed directly by member functions and friend functions.</td>
</tr>
<tr>
<td>private</td>
<td>private in derived class.</td>
</tr>
<tr>
<td></td>
<td>Can be accessed directly by member functions and friend functions.</td>
</tr>
<tr>
<td></td>
<td>Hidden in derived class.</td>
</tr>
<tr>
<td></td>
<td>Can be accessed by member functions and friend functions through public or protected member functions of the base class.</td>
</tr>
<tr>
<td></td>
<td>Hidden in derived class.</td>
</tr>
<tr>
<td></td>
<td>Can be accessed by member functions and friend functions through public or protected member functions of the base class.</td>
</tr>
<tr>
<td></td>
<td>Hidden in derived class.</td>
</tr>
<tr>
<td></td>
<td>Can be accessed by member functions and friend functions through public or protected member functions of the base class.</td>
</tr>
</tbody>
</table>
Customizing and Reusing Existing Software

- Derived class can
  - re-implement the behaviors of the base class
    - Known as “method overriding”
  - add new behaviors or data
    - We can use not only new behaviors but also the existing behaviors

- Factor out common attributes and behaviors and place these in a base class

- Use inheritance to form derived classes, endowing them with capabilities beyond those inherited from the base class

- The creation of a derived class does not affect its base class’s source code