COMPUTER PROGRAMMING
INHERITANCE
10TH WEEK LECTURE

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Outline

- 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 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
• 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 {
  // ...
};
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

```cpp
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
```cpp
#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;
}
```
### Class

**BasePlusCommissionEmployee**

```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;

    double earnings() const
    {
        return baseSalary + ( commissionRate * grossSales );
    }

};//
#endif
```
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
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; } // error
private:
    int x;
};

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

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

class DerivedClass : public BaseClass {
public:
    DerivedClass() { y = 2; } // error
private:
    int y;
};
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
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>
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</thead>
<tbody>
<tr>
<td></td>
<td>public inheritance</td>
</tr>
<tr>
<td>public</td>
<td>public in derived class. Can be accessed directly by member functions, friend functions and nonmember functions.</td>
</tr>
<tr>
<td>protected</td>
<td>protected in derived class. Can be accessed directly by member functions and friend functions.</td>
</tr>
<tr>
<td>private</td>
<td>Hidden in derived class. Can be accessed by member functions and friend functions through public or protected member functions of the base class.</td>
</tr>
</tbody>
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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