Module 23: Programming in C++

Inheritance: Part 3 (Constructor & Destructor - Object Lifetime)

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Slides taken from NPTEL course on Programming in C++

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Module Objectives

- Understand `protected` access specifier
- Understand the construction and destruction process on an object hierarchy
- Revisit Object Lifetime for a hierarchy

Module Outline

- ISA Relationship
- Inheritance in C++
    - Semantics
    - Data Members and Object Layout
    - Member Functions
        - Overriding
        - Overloading
    - protected Access
    - Constructor & Destructor
    - Object Lifetime
- Example – Phone Hierarchy
- Inheritance in C++ (private)
    - Implemented-As Semantics

Inheritance in C++: Semantics

- Derived **ISA** Base
- Data Members
  - Derived class *inherits* all data members of Base class
  - Derived class may *add* data members of its own
- Member Functions
  - Derived class *inherits* all member functions of Base class
  - Derived class may *override* a member function of Base class by *redefining* it with the same signature
  - Derived class may *overload* a member function of Base class by *redefining* it with the *same name*; but *different signature*
- Access Specification
  - Derived class *cannot access* private members of Base class
  - Derived class *can access* protected members of Base class
- Construction-Destruction
  - A *constructor* of the Derived class *must first* call a *constructor* of the Base class to construct the Base class instance of the Derived class
  - The *destructor* of the Derived class *must* call the *destructor* of the Base class to destruct the Base class instance of the Derived class

Inheritance in C++: Access Members of Base: `protected` Access

- Derived **ISA** Base
- Access Specification
  - Derived class *cannot access* private members of Base class
  - Derived class *can access* public members of Base class
- protected Access Specification
  - A new protected access specification is introduced for Base class
  - Derived class *can access* protected members of Base class
  - No other class or global function *can access* protected members of Base class
  - A protected member in Base class is like public in Derived class
  - A protected member in Base class is like private in other classes or global functions

Inheritance in C++: protected Access

private Access

```
class B {
private:  // Inaccessible to child
          // Inaccessible to others
    int data_;
public:
    // ...
    void Print() { cout << "B Object: ";
        cout<<data_<<endl;
    }
};
class D: public B { int info_;
public:
    // ...
    void Print() { cout << "D Object: ";
        cout<<data_<<", "; // Inaccessible
        cout<<info_<<endl;
    }
};

B b(0);
D d(1, 2);

b.data_ = 5;  // Inaccessible to all

b.Print();
d.Print();
```

- **D::Print()** cannot access **B::data_** as it is **private**

protected Access

```
class B {
protected: // Accessible to child
           // Inaccessible to others
    int data_;
public:
    // ...
    void Print() { cout << "B Object: ";
        cout<<data_<<endl;
    }
};
class D: public B { int info_;
public:
    // ...
    void Print() { cout << "D Object: ";
        cout<<data_<<", "; // Accessible
        cout<<info_<<endl;
    }
};

B b(0);
D d(1, 2);

b.data_ = 5;  // Inaccessible to others

b.Print();
d.Print();
```

- **D::Print()** can access **B::data_** as it is **protected**

Inheritance in C++: Streaming

Streaming in B

```
class B {
protected: int data_;
public:
    friend ostream& operator<<(ostream& os,
        const B& b) {
        os << b.data_ << endl;
        return os;
    }
};
class D: public B { int info_;
public:
    //friend ostream& operator<<(ostream& os,
    //    const D& d) {
    //    os << d.data_ << endl;
    //    os << d.info_ << endl;
    //    return os;
    //}
};

    B b(0);
    D d(1, 2);

    cout << b; cout << d;
```

```
B Object: 0
B Object: 1
```

- **d** printed as a **B** object; **info_** missing

Streaming in B & D

```
class B {
protected: int data_;
public:
    friend ostream& operator<<(ostream& os,
        const B& b) {
        os << b.data_ << endl;
        return os;
    }
};
class D: public B { int info_;
public:
    friend ostream& operator<<(ostream& os,
        const D& d) {
        os << d.data_ << endl;
        os << d.info_ << endl;
        return os;
    }
};

    B b(0);
    D d(1, 2);

    cout << b; cout << d;
```

```
B Object: 0
D Object: 1 2
```

- **d** printed as a **D** object as expected

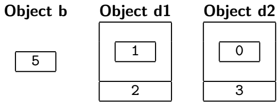
Inheritance in C++: Constructor & Destructor

- Derived **ISA** Base
- Constructor-Destructor
  - Derived class *inherits* the Constructors and Destructor of Base class (but in a different semantics)
  - Derived class *cannot override* or *overload* a Constructor or the Destructor of Base class
- Construction-Destruction
  - A *constructor* of the Derived class *must first* call a *constructor* of the Base class to construct the Base class instance of the Derived class
  - The *destructor* of the Derived class *must* call the *destructor* of the Base class to destruct the Base class instance of the Derived class

Inheritance in C++: Constructor & Destructor

```
class B { protected: int data_;
public:
    B(int d = 0) : data_(d) { cout << "B::B(int): " << data_ << endl; }

    ~B() { cout << "B::~B(): " << data_ << endl; }
    // ...
};
class D: public B { int info_;
public:
    D(int d, int i) : B(d), info_(i) // ctor-1: Explicit construction of Base
    { cout << "D::D(int, int): " << data_ << ", " << info_ << endl; }

    D(int i) : info_(i)              // ctor-2: Default construction of Base
    { cout << "D::D(int): " << data_ << ", " << info_ << endl; }

    ~D() { cout << "D::~D(): " << data_ << ", " << info_ << endl; }
    // ...
};

    B b(5);
    D d1(1, 2);    // ctor-1: Explicit construction of Base
    D d2(3);       // ctor-2: Default construction of Base
```

Object Layout



Inheritance in C++: Object Lifetime

```
class B { protected: int data_;
public:
    B(int d = 0) : data_(d) { cout << "B::B(int): " << data_ << endl; }
    ~B() { cout << "B::~B(): " << data_ << endl; }
    // ...
};
class D: public B { int info_;
public:
    D(int d, int i) : B(d), info_(i) // Explicit construction of Base
    { cout << "D::D(int, int): " << data_ << ", " << info_ << endl; }
    D(int i) : info_(i)              // Default construction of Base
    { cout << "D::D(int): " << data_ << ", " << info_ << endl; }
    ~D() { cout << "D::~D(): " << data_ << ", " << info_ << endl; }
    // ...
};

    B b(0);
    D d1(1, 2);
    D d2(3);
```

Construction O/P

```
B::B(int): 0          // Obj. b
B::B(int): 1          // Obj. d1
D::D(int, int): 1, 2 // Obj. d1
B::B(int): 0          // Obj. d2
D::D(int): 0, 3       // Obj. d2
```

Destruction O/P

```
D::~D(): 0, 3      // Obj. d2
B::~B(): 0         // Obj. d2
D::~D(): 1, 2      // Obj. d1
B::~B(): 1         // Obj. d1
B::~B(): 0         // Obj. b
```

- First construct base class object, then derived class object
- First destruct derived class object, then base class object

Module Summary

- Understood the need and use of `protected` Access specifier
- Discussed the Construction and Destruction process of class hierarchy and related Object Lifetime