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# C/C++ Program Design

## Lab 15, Friend classes, Nested classes and RTTI

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# Friend classes,Nested classes and RTTI

- Friend class
- Nested class
- RTTI


# Friend Classes

Entire classes or member functions of other classes may be declared to be friends of another class.

To declare all member functions of **ClassTwo** as friend of **ClassOne**, place a declaration of the form

```
friend class ClassTwo;
```

in the definition of **ClassOne**. That means all member functions of **ClassTwo** have the right to access the private and protected class members of **ClassOne**.

The **friend** declaration(s) can appear anywhere in a class and are not affected by access specifiers public or private or protected.


Let's consider an example: we have a **Circle** class in which it has a subobject (center point) of **Point** class--class containment(composition). Can we access the center's private member in the **Point** class?

```
class Circle
{
private:
    Point center;
    double radius;

public:
    Circle():center(0,0),radius(1.0) { }
    Circle(Point &p, double r):center(p),radius(r) { }

    Circle& move(Point& p)
    {
        center.x = p.getX();
        center.y = p.getY();

        return *this;
    }

    void show() const
    {
        center.show();
        cout << "radius:" << radius << endl;
    }
};
```

class containment(or class composition)

In **move** function we want to set the center to the new point p. But you cannot access the center's private members x and y.

You can access the public members of the center.

This time you can declare the **Circle** class as a **friend class** of the **Point** class.

```
class Circle;
```

This declaration is necessary which is called **forward declaration**.

```
class Point
{
    friend class Circle;

private:
    double x;
    double y;

public:
    Point(double xx = 0, double yy = 0)
    {
        x = xx;
        y = yy;
    }

    Point(Point& p)
    {
        x = p.x;
        y = p.y;
    }

    double getX() { return x; }
    double getY() { return y; }

    void show() const
    {
        cout << x << "," << y << endl;
    }
};
```

Declare the **Circle** class as a friend of the **Point** class. That means in **Circle** class, its member functions can access the private members of the **Point** class.

```
class Circle
{
private:
    Point center;
    double radius;

public:
    Circle():center(0,0),radius(1.0) { }
    Circle(Point &p, double r):center(p),radius(r) { }

    Circle& move(Point& p)
    {
        center.x = p.x;
        center.y = p.y;

        return *this;
    }

    void show()  const
    {
        center.show();
        cout << "radius:" << radius << endl;
    }
};
```

Member function of the **Circle** class can access the private member of the **Point** class.

```
int main()
{
    Point p1(1,1),p2(4,5);
    Circle c1;
    Circle c2(p1, 12);

    cout << "Before move:" << endl;
    c1.show();
    c2.show();

    cout << "After move:" << endl;
    c1.move(p1);
    c2.move(p2);
    c1.show();
    c2.show();

    return 0;
}
```

```
Before move:
The center is: 0,0
The radius is:1
The center is: 1,1
The radius is:12
After move:
The center is: 1,1
The radius is:1
The center is: 4,5
The radius is:12
```


# Notes:

- Friendship ***is not symmetric***– if class A is a friend of class B, you cannot infer that class B is a friend of class A.
- Friendship ***is not transitive*** ---if class A is a friend of class B and class B is a friend of class C, you cannot infer that class A is a friend of class C.

When to use friend class?

If one class(or object) is not another class(or object) and vice versa, so the ***is-a relationship*** of public inheritance doesn't apply. Nor it is either a component of the other, so the ***has-a relationship*** of containment or of private or protected inheritance doesn't apply. This suggests making the one class **a friend** to the other class.


# Nested Class

A nested class is a class which is declared in another enclosing class. Nested class can be defined in private as well as in the public section of the Enclosing class. A nested class is a member and as such has the same access rights as any other member. The members of an enclosing class have no special access to members of a nested class; the usual access rules shall be obeyed.

```cpp
#include<iostream>
using namespace std;
class Outer
{
public:
    class Inner
    {
    public:
        void Fun();
    };
public:
    Inner obj_;
    void Fun()
    {
        cout << "Outer::Fun...." << endl;
        obj_.Fun();
    }
};

void Outer::Inner::Fun()
{
    cout << "Inner::Fun..." << endl;
}

int main()
{
    Outer o;
    o.Fun();
    Outer::Inner i;
    i.Fun();

    return 0;
}
```

Declare a nested class **Inner** inside the **Outer** class

Define an object of the nested class **Inner**

Invoke the function of **Inner** object

Define the function of the nested class **Inner**, using a class qualifier in the outside

Define an object of the **Outer** class

Define an object of the **Inner** class using a class qualifier

```
Outer::Fun....
Inner::Fun...
Inner::Fun...
```

If a nested class is declared in a ***public section*** of a second class(in the example **Outer** class), it is available to the second class, to classes derived from the second class, and, because it's public, to the outside world. However, because the nested class has class scope, it has to be used with a **class qualifier** in the outside world.

```
// template class
template <class Item>
class QueueTP
{
private:
    enum { Q_SIZE = 10 };
    // define a nested class Node
    class Node
    {
    public:
        Item item;
        Node* next;
        Node(const Item& i) :item(i), next(0) {}
    };
    Node* front;    // pointer to front of Queue
    Node* rear;     // pointer to rear of Queue
    int items;     // current number of items in Queue
    const int qsize;     // maximum number of items in Queue
    QueueTP(const QueueTP& q) : qsize(0) {}
    QueueTP& operator=(const QueueTP& q) { return *this; }

public:
    QueueTP(int qs = Q_SIZE);
    ~QueueTP();
```

If a nested class is declared in a ***private section*** of a second class, it is known only to that second class. This applies, for example, to the **Node** class nested in the **QueueTP** declaration . Hence, **QueueTP** members can use **Node** objects and pointers to **Node** objects, but other parts of a program don't even know that the **Node** class exists. If you were to derive a class from **QueueTP**, **Node** would be invisible to that derived class, too, because a derived class can't directly access the private parts of a base class.

If the nested class is declared in a ***protected section*** of a second class, it is visible to that class but invisible to the outside world. However, in this case, a derived class would know about the nested class and could directly create objects of that type.

# RTTI(Run-Time Type Identification)

**Type conversion** A type cast is basically a conversion from one type to another. C++ supports four types of casting: Static Cast, Dynamic Cast, Const Cast, Reinterpret Cast.

```
static_cast<type> (expression)
```

```
int firstNumber, secondNumber;
double result = ((double)firstNumber)/secondNumber;
double result = static_cast<double> (firstNumber)/secondNumber;
```

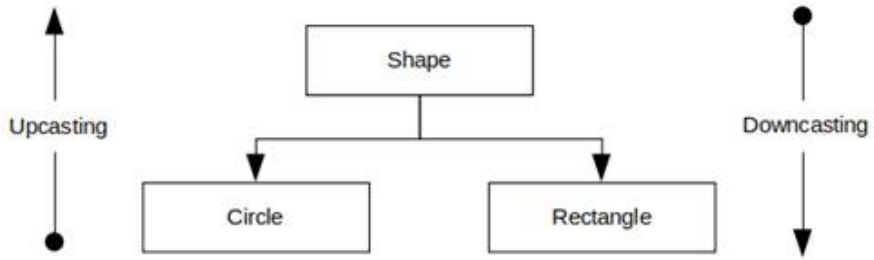
C-style cast

C++ cast

**static_cast** has basically the same power and meaning as the general-purpose C-style cast. It also has the same kind of restrictions. For example, you can't cast a **struct** into an **int** or a **double** into a pointer. Furthermore, **static_cast** can't remove constness from an expression.

**RTTI** stands for **Runtime Type Identification**. It is a mechanism to find the type of an object dynamically(in runtime) from an available **pointer** or **reference** to the base type. The RTTI provides an explicit way to identify the runtime type separately from what is possible with the virtual function mechanism.

The casting of an object is mainly required when dealing with the inheritance hierarchy of classes.




- **Upcasting** is the process where we treat a pointer or a reference of a derived class object as a base class pointer. It is automatically accomplished by assigning a derived class pointer or a reference to its base class pointer.

```
Shape *shape_ptr = nullptr;
Rectangle rec(10, 20);
shape_ptr = &rec;    //upcasting, need not explicitly cast
```

- **Down casting** is converting a base class pointer or reference to a derived class. It requires explicit cast.

```
Shape *shape_ptr = nullptr;
Rectangle rec(10, 20);
shape_ptr = &rec;
Rectangle *rec_ptr = nullptr;
rec_ptr = (Rectangle *)shape_ptr;
rec_ptr = static_cast<Rectangle *> (shape_ptr);
```

Using C-style cast or C++ static_cast, neither conversion is safety


***dynamic_cast*** is used to perform safe casts down or across an inheritance hierarchy. That is, you use **dynamic_cast** to cast pointers or references to base class objects into pointers or references to derived or sibling base class objects.

**dynamic_cast < type-name > ( expression )**

In all cases, the type of ***expression*** must be either a class type that is publicly derived from the type-name type, a public base class of the type-name which points to the type-name, or the same as the type-name. If expression has one of these types, then the cast will succeed. Otherwise, the cast fails. If a ***dynamic_cast*** to a pointer type fails, the result is 0. If a ***dynamic_cast*** to a reference type fails, the operator throws an exception of type **bad_cast**.

```
Shape *shape_ptr = nullptr;
Rectangle rec(10, 20);
shape_ptr = &rec;
Rectangle *rec_ptr = nullptr;
rec_ptr = dynamic_cast<Rectangle *> (shape_ptr);
```

```
Rectangle rec(10, 20);
Shape &shape_sr = rec;
try{
    Rectangle &rectangle_rr = dynamic_cast<Rectangle &> (shape_sr);
}catch(std::bad_cast &bc){
    cerr << bc.what() << endl;
}
```

When failing to cast a reference, dynamic_cast throws ***std::bad_cast*** exception defined in the ***typeinfo*** header.

**Note:** ***dynamic_cast***s cannot be applied to types lacking virtual functions, nor can they cast away constness.


There must be at least one virtual function in the class B, otherwise it fails to compile.

```
class B { ... };
class D : public B { ... };
void f()
{
  B* pb = new D;
  B* pb2 = new B;
  D* pd = dynamic_cast<D*>(pb);      // ok: pb points to D
  ...
  D* pd2 = dynamic_cast<D*>(pb2);   // fail,pb2 points to B not D
                                    //  pd2 is NULL
  ...
}
```

You can check whether the downcast is successful by if statement.

```
if (Derived *dp = dynamic_cast<Derived*>(bp))   //bp is a base class pointer
{
}
```

If **bp** points to a Derived object, then the cast will initialize dp to point to the Derived object to which bp points. In this case, it is safe for the code inside the if to use Derived operations. Otherwise, the result of the cast is 0.

```
#include <iostream>

#ifndef _CAST_H_
#define _CAST_H_

class Base
{
public:
    Base(){}
    virtual ~Base(){}

    void show()
    {std::cout << "Base funtion" << std::endl;}
};

class Inherit :public Base
{
public:
    Inherit(){}
    ~Inherit(){}

    void show()
    { std::cout << "Inherit funtion" << std::endl;}
};

#endif
```

```
#include <iostream>
#include "casttype.h"

int main()
{
    Base* pBase = new Inherit();

    pBase->show();

    delete pBase;

    return 0;
}
```

Invoke the show() of base class, though pBase points to the derived object.

```
#include <iostream>
#include "casttype.h"

int main()
{
    Base* pBase = new Inherit();

    if(Inherit* pInherit = dynamic_cast<Inherit*>(pBase))
    {
        pInherit->show();
    }

    delete pBase;

    return 0;
}
```

Invoke the show() of derived class, because pBase is converted to the derived pointer.


# typeid operator

***typeid*** operator can tell you what type is the object.

**typeid(expression)**

The operand can be any expression or type name.

The ***typeid*** operator returns a reference to a **type_info** object, where type_info is a class defined in the typeinfo header file. The type_info class overloads the **==** and **!=** operators so that you can use these operators to compare types.
If the expression's type is a class and contains at least one virtual function, the ***typeid*** operator returns the dynamic type of the expression; otherwise, it provides static type information.

Suppose there is at least one virtual function in the class B.

```
class Base { ... };
class Derived : public Base { ... };
Derived *dp = new Derived;
Base *bp = dp;

// compare the type of two objects at run time
if (typeid(*bp) == typeid(*dp))
 {  ...                          }

 // test whether the run-time type is a specific type
 if (typeid(*bp) == typeid(Derived))
{ ...                                                }
```

the operands of the typeid are objects, so use *dp not dp

**type_info** class includes a ***name()*** member that returns an string that is typically the name of the class.

```cpp
#include <iostream>
#include <typeinfo>

using namespace std;

class Base_A {
public:
   virtual ~Base_A(){}
};

class Derived_A: public Base_A{
public:
   Derived_A(){}
};

class Base_B{

};

class Derived_B: public Base_B{
public:
   Derived_B(){}
};
```

has no virtual function

```cpp
int main()
{
   const Derived_A ref_da;
   const Base_A *pa = &ref_da;
   cout<<"typeid(pa) is: " << typeid (pa).name()<< ", "
      <<"typeid(*pa) is: " << typeid (*pa).name()<<endl;

   cout<<"typeid(*pa) == typeid(ref_da)? "
      << (typeid (*pa)==typeid (ref_da) ? "true":"false")<<endl;
   cout <<"typeid(Devrived_A) == typeid(const Derived_A)? "
      <<(typeid(Derived_A) == typeid(const Derived_A)? "true":"false")<< endl;

   const Derived_B ref_db;
   const Base_B *pb = &ref_db;

   cout <<"typeid(pb) is: " << typeid (pb).name() << ", "
      << "typeid(*pd) is: " << typeid (*pb).name()<<endl;

   cout << "typeid(*pb) == typeid(ref_db)? "
      <<(typeid (*pb)==typeid (ref_db) ? "true":"false")<<endl;
   cout << "typeid(Derived_B) == typeid(ref_db)? "
      <<(typeid(Derived_B) == typeid(const Derived_B) ? "true":"false")<< endl;

   return 0;
}
```

```
typeid(pa) is: PK6Base_A, typeid(*pa) is: 9Derived_A
typeid(*pa) == typeid(ref_da)? true
typeid(Devrived_A) == typeid(const Derived_A)? true
typeid(pb) is: PK6Base_B, typeid(*pd) is: 6Base_B
typeid(*pb) == typeid(ref_db)? false
typeid(Derived_B) == typeid(ref_db)? true
```

**P**:pointer, **K**: const,

**6**: numbers of the characters of the type

# Exercise

1. There are two classes named Car and Driver, suppose the car can drive automatically, and driver also can drive the car. The declarations of car and driver are as follows:

```
class Car
{
private:
   enum {Off, On};  //Off- non automatically drive, On-automatically
drive
   enum {Minvel, Maxvel = 200}; //range of velocity from 0  to 200
   int mode;     //mode of car, Off or On
   int velocity;

public:
   friend class Driver;
   Car(int m = On, int v = 50):mode(m),velocity(v){ }
   bool velup(int v);      //increase  velocity by v
   bool veldown(int v);    //decrease velocity by v
   bool ison() const;    //Check whether the mode is on
   int getvel() const;   //get the velocity
   void showinfo() const; // show the mode and velocity of car
};
```

```
class Driver
{
public:

   bool velup(Car& car,int v);      //increase velocity by v
   bool veldown(Car& car, int v);    //decrease velocity by v
   void setmode(Car& car);      //If the mode is On, set it to Off,otherwise set it to Off
   bool ison(Car& car) const;  //Check whether the mode is on
};
```

Implement all the member functions of the two classes and make Driver as Car's friend class so that it can access the members of Car. Write a program to test the two classes.

Output sample:

```
The infomation of car:mode is On,velocity is 50
Increase velocity by car,its mode is On,velocity is 170
Set the mode of car by driver:
The mode of car is:On.
The infomation of car:mode is Off,velocity is 170
Decrease velocity by driver:mode is Off,velocity is 70
Increase velocity by driver: The velocity is 220. It is out of Maxvel.
```

# Exercise

2. There are two declarations of two classes, Base and Derived. You are required to implement the three kind of functions:

(1) **Equality operator ==** is declared as a friend function of the Base class. Two objects are equal if they have the same type and same value for a given set of their data members. If two objects have different types, throw a message ”The two objects have different types, they can not be compared.” as an exception.

(2) Virtual **equal member functions** in Base and Derived class which check whether the data members have the same values in its own objects respectively.

(3) **void process(const Base&, const Base&) function** is a normal function who checks if the two objects are equal and handles the exception.

```
#include <iostream>
#include <typeinfo>
using namespace std;

class Base
{
protected:
   int bvalue;
public:
   Base(int i ) : bvalue(i) {}

   virtual bool equal(const Base& b) const;

   friend bool operator == (const Base&, const Base&);
};
```

```
class Derived : public Base
{
private:
   int dvalue;
public:
   Derived(int a, int b):Base(a), dvalue(b){}

   virtual bool equal(const Base& b) const override;

};
```

# Exercise

Run the main function to check your defined functions.

```
int main()
{
   Base b1(2);
   Base b2(2);

   Derived d1(1,2);
   Derived d2(2,2);

   process(b1,b2);
   process(d1,d2);
   process(b1,d1);

   return 0;
}
```

```
Two Base type objects are equal.
Two Derived type objects are not equal because they have different values.
The two objects have different types, they can not be compared.
```