Friends

C++ Object Oriented Programming

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Classes That Need Other Classes

```
class Data
{
public:
   Data(int x):m_x(x) {}
   int getData() const;
private:
   int m_x;
};
int Data::getData() const
{
   return m_x;
}

void main()
{
   Data data(10);
   General object;
   object.printX(data);
}
```

accessor

```
class General
{
public:
   void printX(Data inputObject);
};
void General::printX(Data inputObject)
{
   cout << inputObject.getData() << " \n";
}
```

```
Output
10
```

Friend Class

```
class Data
{
   friend class General;   // can be put anywhere in the class
public:
   Data(int x):m_x(x) {}
private:
   int m_x;
};

void main()
{
   Data data(10);
   General object;
   object.printX(data);
}
```

```
class General
{
public:
   void printX(Data inputObject);
};
void General::printX(Data inputObject)
{
   cout << inputObject.m_x << " \n";
}
```

- **Note: friendship is granted, not taken**

Friend Member Function

- “Friendship” can be restricted to a specific function
- Suppose we have another function General::printIntro() but we don’t want to grant it the access to Data::m_x

```
class General {
public:
    void printX(Data inputObject);
    void printIntro();
};
void General::printIntro() {
    cout << "Welcome to class General.";
}
```

- Grant only General::printX() as a friend member function

```
class Data {
    friend void General::printX(Data inputObject);
public:
    Data(int x):m_x(x) {}
private:
    int m_x;
};
```

Implication of Friends

- Granting friend classes in C++ essentially breaks the encapsulation of one class. Basically, the class and its friend classes should be considered as a whole body. When you try to modify any implementation of the class, you need to think of all possible usages in its friend classes and friend functions.
- A class is a natural module in C++. However, in some design patterns, several separate class interfaces could capture more precisely the physical operating mechanisms. These classes operate on many common data, have strong coupling, and need to be considered as a whole module.
- If you are not considering such kind of physical operating models, do NOT grant a friend class or a friend function just because it is convenient to write codes or to save the time in designing suitable interfaces and abstractions.

Example: Company Database

- Assume we have a company database program in which a “manager” class needs to access an employee class

```
class Manager {
public:
    void doJob(Employee *worker);
private:
    void fireEmployee(Employee *worker);
};
```

- The Employee class makes the name of the employee public but not the salary. Since the manager class needs information of both, the Employee class will grant partial friendship to Manager::doJob()

```
class Employee {
    friend void Manager::doJob(Employee *worker);
public:
    Employee(const char *name, long salary);
    ~Employee();
    char *getName() const;
private:
    long getSalary() const;
    char *m_name;
    long m_salary;
};
```

Example (cont’d)

```
void Manager::doJob(Employee *worker)  {
    if (worker->getSalary()<100000 && worker->getSalary()>40000)
        fireEmployee(worker);
}
```

getSalary() is a private member function of Employee.

```
void Manager::fireEmployee(Employee *worker)  {
    cout << "Employee " << worker->getName() << " has been terminated.\n";
    delete worker;
}
```

getName() is a public member function, so fireEmployee() need not be a friend

```
void main() {
    Employee *worker;
    Manager *boss;
    worker = new Employee("Wally", 45000);
    boss = new Manager;
    boss->doJob(worker);
}
```

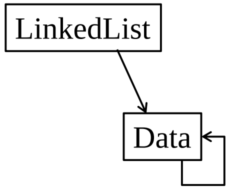
```
Output
Employee Wally has been terminated.
```

Example: Link List

- Suppose we want to implement a linked list class for storing integers. We can do this by means of two classes, one for the data, the other for the linked list itself.

No public interface defined for this class

```
class Data {
   friend class LinkedList;
private:
   Data(int value);
   int m_value;
   Data *m_next;
};
```



```
class LinkedList {
public:
   LinkedList();
   ~LinkedList();
   void append(int value);
   void display();
private:
   Data *m_tail, *m_head;
};
```

Link List (Cont'd)

- Member functions

```
Data::Data(int value): m_value(value), m_next(0) {
}
```

```
LinkedList::LinkedList(): m_head(0), m_tail(0) {
}
```

```
void LinkedList::append(int value) {
   Data *temp = new Data(value);
   if (m_head == 0) {
      m_head = temp;
      m_tail = temp;
   }
   else {
      m_tail–>m_next = temp;
      m_tail = temp;
   }
}
```

When do you need a dtor for Data?

Link List (Cont'd)

- Member functions

```
LinkedList::~LinkedList() {
   Data *current, *next;
   current = m_head;
   while (current != 0) {
      next = current–>m_next;
      delete current;
      current = next;
   }
}
```

```
void LinkedList::display() {
   Data *temp;
   for (temp=m_head; temp!=0;
                              temp=temp–>m_next)
      cout << temp–>m_value << " ";
}
```

- Main

```
void main() {
   LinkedList myLinkedList;
   myLinkedList.append(1);
   myLinkedList.append(2);
   myLinkedList.display();
}
```

```
Output
1   2
```

Containers and Iterators

- A container class is a class designed to hold a collection of objects. Typical containers are arrays, linked lists, trees, stacks, and queues.
- Using polymorphic pointers, a container can hold heterogeneous objects.
- An iterator data member allows the client to step through the container.

```
class Array {
public:
   Array(int arraySize);
   ~Array();
   void insertElement(int slot, int element);
   void reset();    // Iterator function
   int next();      // Iterator function
private:
   int m_arraySize;
   int *m_array;
   int m_iterator;
};
```

```
Array::Array(int arraySize)
   : m_arraySize(arraySize), m_iterator(-1) {
   m_array = new int[arraySize];
}
```

Containers and Iterators (cont’d)

```
int Array::next() {
   m_iterator++;
   if (m_iterator<m_arraySize)
      return m_array[m_iterator];
   cout << "There are no additional elements in the array.\n";
   return 0;
}
```

```
void Array::reset() {
   m_iterator = -1;
}
```

```
void main() {
   Array array(2);
   array.insertElement(0, 6);
   array.insertElement(1, 10);
   cout << array.next() << "\n";
   cout << array.next() << "\n";
   cout << array.next() << "\n";
   array.reset();
   cout << array.next() << "\n"; cout << array.next() << "\n";
}
```

```
Output
6
10
There are no additional elements in the array
6
10
```

Containers and Friend Iterators

- ✧ Better implementation with a separate Iterator class declared using a friend function. Why? will show in the next slide.

```
class Array;
class Iterator {
public:
   Iterator();
   void reset();
   int *next(Array &array);
private:
   int m_iterator;
};
```

```
class Array {
   friend int *Iterator::next(Array &array);
public:
   Array(int arraySize);
   ~Array();
   void insertElement(int slot, int element);
private:
   int m_arraySize;
   int *m_array;
};
```

Friend Iterators (Cont’d)

```
int *Iterator::next(Array &array) {
   m_iterator++;
   if (m_iterator < array.m_arraySize)
      return &array.m_array[m_iterator];
   return 0;
}
```

```
Iterator::Iterator(): m_iterator(-1) {
}

void Iterator::reset() {
   m_iterator = -1;
}
```

```
void main() {
   int *i, *j, result = 0;
   Array array(2);
   Iterator iter1, iter2;
   array.insertElement(0, 2);
   array.insertElement(1, 3);
   for (i= iter1.next(array); i!=0; i=iter1.next(array), iter2.reset())
      for (j=iter2.next(array); j!=0; j=iter2.next(array))
         result += pow(j, i);
   cout << "Result = " << result << endl;
}
```

$2^2+3^2+2^3+3^3$

```
Output
Result = 48
```

Friend Iterators (cont’d)

- ✧ Better implementation with a separate Iterator class declared using a friend function. Each iterator instance is associated with a specific container.

```
class Array;
class Iterator {
public:
   Iterator(Array &array);
   void reset();
   int *next();
private:
   int m_iterator;
   Array &m_array;
};
```

```
class Array {
   friend int *Iterator::next();
public:
   Array(int arraySize);
   ~Array();
   void insertElement(int slot, int element);
private:
   int m_arraySize;
   int *m_array;
};
```

Friend Iterators (Cont'd)

```
int *Iterator::next() {
    m_iterator++;
    if (m_iterator < m_array.m_arraySize)
        return &m_array.m_array[m_iterator];
    return 0;
}
```

```
Iterator::Iterator(Array &array)
 : m_iterator(-1),
   m_array(array) {
}

void Iterator::reset() {
    m_iterator = -1;
}
```

```
void main() {
    int *i, *j, result = 0;
    Array array(2);
    Iterator iter1(array), iter2(array);
    array.insertElement(0, 2);
    array.insertElement(1, 3);
    for (i= iter1.next(); i!=0; i=iter1.next(), iter2.reset())
        for (j=iter2.next(); j!=0; j=iter2.next())
            result += pow(j, i);
    cout << "Result = " << result << endl;
}
```

$2^2+3^2+2^3+3^3$

```
Output
Result = 48
```

Inner Class Implementation

do not need to specify Array::

```
class Array {
    friend int *Iterator::next();
public:
    class Iterator {
    public:
        Iterator(Array &array);
        void reset();
        int *next();
    private:
        int m_iterator;
        Array &m_array;
    };
    Array(int arraySize);
    ~Array();
    void insertElement(int slot, int element);
private:
    int m_arraySize;
    int *m_array;
};
```

Array::Iterator

public/private specifies whether codes outside Array can use Iterator inner class definition or not.

Note: An inner class is basically an independent class from its host class, it is not allowed to access the private parts of the host class and vice versa.

Inner Class Implementation (cont'd)

```
int *Array::Iterator::next() {
    m_iterator++;
    if (m_iterator < m_array.m_arraySize)
        return &m_array.m_array[m_iterator];
    return 0;
}
```

```
Array::Iterator::Iterator(Array &array)
    : m_iterator(-1), m_array(array) {
}
```

```
void Array::Iterator::reset() {
    m_iterator = -1;
}
```

```
void main() {
    int *i, *j, result = 0;
    Array array(2);
    Array::Iterator iter1(array), iter2(array);
    array.insertElement(0, 2);
    array.insertElement(1, 3);
    for (i= iter1.next(); i!=0; i=iter1.next(), iter2.reset())
        for (j=iter2.next(); j!=0; j=iter2.next())
            result += pow(j, i);
    cout << "Result = " << result << endl;
}
```

$2^2+3^2+2^3+3^3$

```
Output
Result = 48
```

Friends and Inheritance

- Friends of Base class are not automatically friends of Derived class (i.e. **friendship relationship is not inheritable**)

```
class Base {
    friend class Friend;
private:
    int m_baseData;
};
```

```
class Derived: public Base {
    friend class Friend;
private:
    int m_derivedData;
};
```

```
class Friend {
public:
    void func1(Base &base);
    void func2(Derived &derived);
};
```

```
void Friend::func1(Base &base) {
    cout << base.m_baseData << endl;
}
```

```
void Friend::func2(Derived &derived) {
    cout << derived.m_derivedData << endl;
}
```

error C2248: 'm_derivedData' : cannot access private member declared in class 'Derived'

Friend and Factory

- A class can be designed to have a creation rule, such as:

All new Product **must be created indirectly**
through a ProductFactory.

  - So that all clients can be unaware of the actual class of the object used, only concentrated on the required abstract interface.
  - This rule can be enforced by non-public (protected or private) constructors, copy constructors, and assignment operators.
  - With friend class or friend function, only the ProductFactory class or the specific factory method can access the constructor of the class Product .