



Module 12

Instructors: Abir
Das and
Sourangshu
Bhattacharya

Objectives &
Outline

Access Specifiers
Examples

Information
Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary

Module 12: Programming in C++

Access Specifiers

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Slides taken from NPTEL course on Programming in Modern C++

by **Prof. Partha Pratim Das**



Module Objectives

Module 12

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Objectives & Outline

Access Specifiers

Examples

Information Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary

- Understand access specifiers in C++ classes to control the visibility of members
- Learn to design with Information Hiding



Module Outline

Module 12

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Das and
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Bhattacharya

Objectives & Outline

Access Specifiers

Examples

Information Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary

- 1 Access Specifiers
 - Access Specifiers: Examples
- 2 Information Hiding
- 3 Information Hiding: Stack Example
 - Stack (public)
 - Risky
 - Stack (private)
 - Safe
 - Interface and Implementation
- 4 Get-Set Idiom
- 5 Encapsulation
- 6 Class as a Data-type
- 7 Module Summary



Access Specifiers

Module 12

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Das and
Sourangshu
Bhattacharya

Objectives &
Outline

Access Specifiers

Examples

Information
Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary

- Classes provide **access specifiers** for members (data as well as function) to enforce **data hiding** that separates *implementation* from *interface*
 - **private** — accessible inside the definition of the class
 - ▷ member functions of the same class
 - **public** — accessible everywhere
 - ▷ member functions of the same class
 - ▷ member function of a different class
 - ▷ global functions
- The keywords **public** and **private** are the *Access Specifiers*
- Unless specified, the access of the members of a class is considered **private**
- A class may have multiple access specifier. The effect of one continues till the next is encountered



Program 12.01/02: Complex Number: Access Specification

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Objectives &
Outline

Access Specifiers

Examples

Information
Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary

Public data, Public method

```
#include <iostream>
#include <cmath>
using namespace std;
class Complex { public: double re, im;
public:
    double norm() { return sqrt(re*re + im*im); }
};
void print(const Complex& t) { // Global fn.
    cout << t.re << "+j" << t.im << endl;

}
int main() { Complex c = { 4.2, 5.3 }; // Okay

    print(c);
    cout << c.norm();
}
```

- **public** data can be accessed by any function
- **norm** (method) can access (**re**, **im**)
- **print** (global) can access (**re**, **im**)
- **main** (global) can access (**re**, **im**) & initialize

Private data, Public method

```
#include <iostream>
#include <cmath>
using namespace std;
class Complex { private: double re, im;
public:
    double norm() { return sqrt(re*re + im*im); }
};
void print(const Complex& t) { // Global fn.
    cout << t.re << "+j" << t.im << endl;
    // Complex::re / Complex::im: cannot access
    // private member declared in class 'Complex'

}
int main() { Complex c = { 4.2, 5.3 }; // Error
    // 'initializing': cannot convert from
    // 'initializer-list' to 'Complex'
    print(c);
    cout << c.norm();
}
```

- **private** data can be accessed *only* by methods
- **norm** (method) can access (**re**, **im**)
- **print** (global) cannot access (**re**, **im**)
- **main** (global) cannot access (**re**, **im**) to initialize



Information Hiding

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Objectives &
Outline

Access Specifiers
Examples

Information
Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary

- The **private** part of a class (*attributes* and *member functions*) forms its *implementation* because the class alone should be concerned with it and have the right to change it
- The **public** part of a class (*attributes* and *member functions*) constitutes its *interface* which is available to all others for using the class
- Customarily, we put all *attributes* in **private** part and the *member functions* in **public** part. This ensures:
 - The **state** of an object can be changed only through one of its *member functions* (with the knowledge of the class)
 - The **behavior** of an object is accessible to others through the *member functions*
- This is known as **Information Hiding**



Information Hiding

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Sourangshu
Bhattacharya

Objectives &
Outline

Access Specifiers
Examples

Information
Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary

- For the sake of efficiency in design, we at times, put *attributes* in *public* and / or *member functions* in *private*. In such cases:
 - The *public attributes should not* decide the *state* of an object, and
 - The *private member functions* cannot be part of the *behavior* of an object

We illustrate information hiding through two implementations of a stack



Program 12.03/04: Stack: Implementations using public data

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Objectives &
Outline

Access Specifiers
Examples

Information
Hiding

Stack Example
Stack (public)

Risky
Stack (private)
Safe
Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary

Using dynamic array

```
#include <iostream>
#include <cstdlib>
using namespace std;
class Stack { public: char *data_; int top_;
    public: int empty() { return (top_ == -1); }
    void push(char x) { data_[++top_] = x; }
    void pop() { --top_; }
    char top() { return data_[top_]; }
};
int main() { Stack s; char str[10] = "ABCDE";
    s.data_ = new char[100]; // Exposed Allocation
    s.top_ = -1;             // Exposed Init

    for(int i = 0; i < 5; ++i) s.push(str[i]);
    // Outputs: EDCBA -- Reversed string
    while(!s.empty()) { cout << s.top(); s.pop(); }
    delete [] s.data_;      // Exposed De-Allocation
}
```

Using vector

```
#include <iostream>
#include <vector>
using namespace std;
class Stack { public: vector<char> data_; int top_;
    public: int empty() { return (top_ == -1); }
    void push(char x) { data_[++top_] = x; }
    void pop() { --top_; }
    char top() { return data_[top_]; }
};
int main() { Stack s; char str[10] = "ABCDE";
    s.data_.resize(100); // Exposed Sizing
    s.top_ = -1;         // Exposed Init

    for(int i = 0; i < 5; ++i) s.push(str[i]);
    // Outputs: EDCBA -- Reversed string
    while(!s.empty()) { cout << s.top(); s.pop(); }
}
```

- **public** data reveals the *internals of the stack* (no information hiding)
- Spills data structure codes (Exposed Init / De-Init) into the application (**main**)
- To switch from array to vector or vice-versa the application needs to change



Program 12.03/04: Stack: Implementations using public data

Risky

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Objectives &
Outline

Access Specifiers

Examples

Information
Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary

Using dynamic array

```
#include <iostream>
#include <cstdlib>
using namespace std;
class Stack { public: char *data_; int top_;
    public: int empty() { return (top_ == -1); }
    void push(char x) { data_[++top_] = x; }
    void pop() { --top_; }
    char top() { return data_[top_]; }
};
int main() { Stack s; char str[10] = "ABCDE";
    s.data_ = new char[100]; // Exposed Allocation
    s.top_ = - 1;             // Exposed Init

    for(int i=0; i<5; ++i) s.push(str[i]);
    s.top_ = 2; // STACK GETS INCONSISTENT
    // Outputs: CBA -- WRONG!!!
    while (!s.empty()) { cout << s.top(); s.pop(); }
    delete [] s.data_; // Exposed De-Init
}
```

Using vector

```
#include <iostream>
#include <vector>
using namespace std;
class Stack { public: vector<char> data_; int top_;
    public: int empty() { return (top_ == -1); }
    void push(char x) { data_[++top_] = x; }
    void pop() { --top_; }
    char top() { return data_[top_]; }
};
int main() { Stack s; char str[10] = "ABCDE";
    s.data_.resize(100); // Exposed Sizing
    s.top_ = -1;         // Exposed Init

    for(int i=0; i<5; ++i) s.push(str[i]);
    s.top_ = 2; // STACK GETS INCONSISTENT
    // Outputs: CBA -- WRONG!!!
    while (!s.empty()) { cout << s.top(); s.pop(); }
}
```

- Application may intentionally or inadvertently tamper the value of `top_` – this corrupts the stack!
- `s.top_ = 2;` destroys consistency of the stack and causes wrong output



Program 12.05/06: Stack: Implementations using private data

Safe

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Objectives & Outline

Access Specifiers

Examples

Information Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and Implementation

Get-Set Idiom

Encapsulation

Class as a Data-type

Module Summary

Using dynamic array

```
#include <iostream>

using namespace std;
class Stack { private: char *data_; int top_;
public: // Initialization and De-Initialization
    Stack(): data_(new char[100]), top_(-1) { }
    ~Stack() { delete[] data_; }
    // Stack LIFO Member Functions
    int empty() { return (top_ == -1); }
    void push(char x) { data_[++top_] = x; }
    void pop() { --top_; }
    char top() { return data_[top_]; }
};

int main() { Stack s; char str[10] = "ABCDE";
    for (int i=0; i<5; ++i) s.push(str[i]);
    while (!s.empty()) { cout << s.top(); s.pop(); }
}
```

Using vector

```
#include <iostream>
#include <vector>
using namespace std;
class Stack { private: vector<char> data_; int top_;
public: // Initialization and De-Initialization
    Stack(): top_(-1) { data_.resize(100); }
    ~Stack() { };
    // Stack LIFO Member Functions
    int empty() { return (top_ == -1); }
    void push(char x) { data_[++top_] = x; }
    void pop() { --top_; }
    char top() { return data_[top_]; }
};

int main() { Stack s; char str[10] = "ABCDE";
    for (int i=0; i<5; ++i) s.push(str[i]);
    while (!s.empty()) { cout << s.top(); s.pop(); }
}
```

- **private** data hides the *internals* of the stack (information hiding)
- Data structure codes *contained within itself* with *initialization* and *de-initialization*
- To switch from array to vector or vice-versa the application needs **no change**
- **Application cannot tamper stack – any direct access to `top_` or `data_` is compilation error!**



Program 12.07: Interface and Implementation

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Objectives &
Outline

Access Specifiers

Examples

Information
Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary

Interface

```
// File: Stack.h -- Interface
class Stack { private: // Implementation
    char *data_; int top_;
public: // Interface
    Stack();
    ~Stack();
    int empty();
    void push(char x);
    void pop();
    char top();
};
```

Implementation

```
// File: Stack.cpp -- Implementation
#include "Stack.h"

Stack::Stack(): data_(new char[100]), top_(-1) { }
Stack::~Stack() { delete[] data_; }
int Stack::empty() { return (top_ == -1); }
void Stack::push(char x) { data_[++top_] = x; }
void Stack::pop() { --top_; }
char Stack::top() { return data_[top_]; }
```

Application

```
#include <iostream>
using namespace std;
#include "Stack.h"
int main() {
    Stack s; char str[10] = "ABCDE";
    for (int i = 0; i < 5; ++i) s.push(str[i]);
    while (!s.empty()) {
        cout << s.top(); s.pop();
    }
}
```



Get-Set Methods: Idiom for fine-grained Access Control

- We put *attributes* in *private* and the *methods* in *public* to restrict the access to data
- *public* methods to *read* (*get*) and / or *write* (*set*) data members provide fine-grained control

```
class MyClass { // private
    int readWrite_; // Like re_, im_ in Complex -- common aggregated members

    int readOnly_; // Like DateOfBirth, Emp_ID, RollNo -- should not need a change

    int writeOnly_; // Like Password -- reset if forgotten

    int invisible_; // Like top_, data_ in Stack -- keeps internal state

public:
    // get and set methods both to read as well as write readWrite_ member
    int getReadWrite() { return readWrite_; }
    void setReadWrite(int v) { readWrite_ = v; }

    // Only get method to read readOnly_ member - no way to write it
    int getReadOnly() { return readOnly_; }

    // Only set method to write writeOnly_ member - no way to read it
    void setWriteOnly(int v) { writeOnly_ = v; }

    // No method accessing invisible_ member directly - no way to read or write it
}
```

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Sourangshu
Bhattacharya

Objectives &
Outline

Access Specifiers

Examples

Information
Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary



Get, Set Methods

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Bhattacharya

Objectives &
Outline

Access Specifiers

Examples

Information
Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary

- Get, Set methods of a class are the interface defined for accessing and using the private data members. The implementation details of the data members are hidden.
- Not all data members are allowed to be updated or read, hence based on the requirement of the interface, data members can be read only, write only, read and write both or not visible at all.
- Let get and set be two variables of `bool` type which signifies presence of get and set methods respectively. In the below table, T denotes true (that is, method is present) and F denotes False (that is, method is absent)

Variables	get	set
Non Visible	F	F
Read Only	T	F
Write Only	F	T
Read - Write	T	T



Program 12.08: Get - Set Methods: Employee Class

Get-Set Methods

```
// File Name:Employee_c++.cpp:
#include <iostream>
#include <string>
using namespace std;

class Employee { private:
    string name;           // read and write: get_name() and set_name() defined
    string address;        // write only: set_addr() defined. No get method
    double sal_fixed;      // read only: get_sal_fixed() defined. No set method
    double sal_variable;   // not visible: No get-set method

public: Employee() { sal_fixed = 1200; sal_variable = 10; } // Initialize
    string get_name() { return name; }
    void set_name(string name) { this->name = name; }
    void set_addr(string address) { this->address = address; }
    double get_sal_fixed() { return sal_fixed; }
    // sal_variable (not visible) used in computation method salary()
    double salary() { return sal_fixed + sal_variable; }
};

int main() {
    Employee e1; e1.set_name("Ram"); e1.set_addr("Kolkata");
    cout << e1.get_name() << endl;  cout << e1.get_sal_fixed() << endl <<  e1.salary() << endl;
}
```



Encapsulation

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Sourangshu
Bhattacharya

Objectives &
Outline

Access Specifiers
Examples

Information
Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary

- classes wrap data and functions acting on the data together as a single data structure. This is **Aggregation**
- The important feature introduced here is that members of a class has a **access specifier**, which defines their visibility outside the class
- This helps in **hiding information** about the implementation details of data members and methods
 - If properly designed, any change in the **implementation**, should not affect the **interface** provided to the users
 - Also hiding the implementation details, prevents unwanted modifications to the data members.
- This concept is known as **Encapsulation** which is provided by classes in C++.



Class as a Data-type

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Sourangshu
Bhattacharya

Objectives &
Outline

Access Specifiers

Examples

Information
Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary

- We can conclude now that class is a composite data type in C++ which has similar behaviour to built in data types. We explain below with the Complex class (representing complex number) as an example

```
// declare i to be of int type  
int i;
```

```
// initialise i  
int i = 5;
```

```
// print i  
cout << i;
```

```
// add two ints  
int i = 5, j = 6;  
i+j;
```

```
// declare c to be of Complex type  
Complex c;
```

```
// initialise the real and imaginary components of c  
Complex c = { 4, 5 };
```

```
// print the real and imaginary components of c  
cout << c.re << c.im;  
OR c.print(); // Method Complex::print() defined for printing  
OR cout << c; // operator<<() overloaded for printing
```

```
// add two Complex objects  
Complex c1 = { 4, 5 }, c2 = { 4, 6 };  
c1.add(c2); // Method Complex::add() defined to add  
OR c1+c2; // operator+() overloaded to add
```




Module Summary

Module 12

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Bhattacharya

Objectives &
Outline

Access Specifiers
Examples

Information
Hiding

Stack Example

Stack (public)

Risky

Stack (private)

Safe

Interface and
Implementation

Get-Set Idiom

Encapsulation

Class as a
Data-type

Module Summary

- Access Specifiers help to control visibility of data members and methods of a class
- The private access specifier can be used to hide information about the implementation details of the data members and methods
- Get, Set methods are defined to provide an interface to use and access the data members