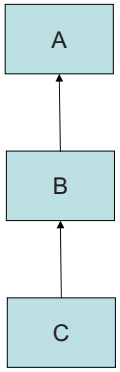
C++

Inheritance: initialization and substitution principle

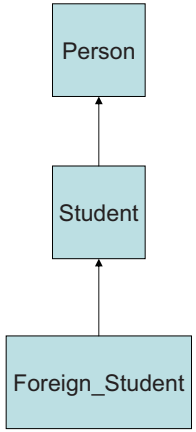
Inheritance and initialization

- If class C inherits from B which inherits from A, then C can only call its direct base class constructors (i.e. of B)
- It is the responsibility of each derived class to initialize properly its direct base class



Example

- Before a **Student** object can exist, its **Person** part needs to be created:
  - Student::Student(string n, int id, int y) : **Person(n)**, student_id(id), year(y) {}
- Before a **Foreign_student** object can exist, its **Student** part needs to be created:
  - Foreign_student::Foreign_student(string n, int id, int y, string c) : **Student(n, id, y)**, country(c) {}
- **Foreign_student** object does not need to create its **Person** part. It is the responsibility of Student to do so



Order of construction / destruction

```
class A {
 public:
  A() {cout << "A()" << endl;}
  ~A() {cout << "~A()" << endl;}
};

class B {
  public:
   B() {cout << "B()" << endl;}
   ~B() {cout << "~B()" << endl;}
};

class C : public B {
  private:
    A a;
  public:
    C() {cout << "C()" << endl;}
   ~C() {cout << ~C()" << endl;}
};
```

```
int main() {
  C c;
}
```

Result:

```
B()
A()
C()
~C()
~A()
~B()
```

Initialization of base class

```
class A {
private:
 int a;
public:
 A() : a(1) {};
 void dispa() {cout << a << endl;}
};

class B : public A {
 private:
  int b;
 public:
  B() : b(2) {};
  void dispb() {cout << b << endl;}
};

int main(){
  B b; b.dispa(); b.dispb();
}
```

Implicitly call A()

Prints: 1 then 2

Initialization of base class

```
class A {
private:
 int a;
public:
 A(int x) : a(x) {};
 void dispa() {cout << a << endl;}
};

class B : public A {
 private:
  int b;
 public:
  B(int x, int y) : A(x), b(y) {};
  void dispb() {cout << b << endl;}
};

int main(){
  B b(1,2); b.dispa(); b.dispb();
}
```

explicitly call A(int x)

Prints: 1 then 2

Initialization of base class

```
class A {
private:
 int a;
public:
 A(int x) : a(x) {};
 void dispa() {cout << a << endl;}
};

class B : public A {
 private:
  int b;
 public:
  B() : b(2) {};
  void dispb() {cout << b << endl;}
};

int main(){
  B b; b.dispa(); b.dispb();
}
```

It does not compile because:
when a B object is created the compiler will try to create an A object by calling the default constructor of A, which does not exist because we have provided a user-defined constructor for A.

Inheritance and initialization

- Contrary to other members (data and methods), the following are not inherited:
  - Constructors (including the copy constructors)
  - Assignment operators
  - Destructors
- In the previous slides we illustrated that derived classes are in charge of calling the direct base class constructors if needed
- Same happens for copy constructors and assignment operators

Example: Inheritance and copy constructor

```
class A {
 public:
  int a_;
  A(int a) : a_(a) {}
  A(const A& an) : a_(an.a_) {}
  ~A() {}
};

class B : public A{
  public:
   B() : A(1) {}
   B(const B& b) : A(b) {}
   ~B() {}
};
```


Example: Inheritance and assignment operator

```
class A {
 public:
  int a_;
  A(int a) : a_(a) {}
  ~A() {}
  A& operator= (const A& an) {
    a_ = an.a_;
    return *this;
  }
};
```

```
class B : public A{
  public:
    B() : A(1) {}
    ~B() {}
    B& operator= (const B& b) {
      A::operator=(b);
      return *this;
    }
};
```

Explicitly calls the assignment operator of the base class

Substitution principle

- **Liskov** substitution principle: if class D inherits from B then:

Any function accepting an arg. of type:	**Will also accept an arg. of type:**
B	D
Reference to B	Reference to D
Pointer to B	Pointer to D

Substitution: example

```
void print_name(const Person& p) {
 cout << p.get_name() << endl;
}
void print_name_ptr (Person* p) {
 cout << p->get_name() << endl;
}

// …

Teacher t("Yamamoto", 123, "CG");
Student s("Yamamoto", 456);
print_name(t);
print_name(s);
print_name_ptr(&t);
print_name_ptr(&s);
```

Name hiding

```
class B {
 private:
   int x;
 public:
   B() : x(1) { };
   void display() { cout<< "x = " << x << endl; }
 };

class D : public B {
 private:
   int y;
 public:
   D() : y(2) { };
   void display() { cout<< "y = " << y << endl; }
};

int main() {
D derived;
derived.display();          // D::display() called -> prints 2
derived.B::display();       // force to call B::display() -> prints 1
}
```


Name hiding - 2

```
class B {
 protected:
   int x;
 public:
   B() : x(1) { };
   void display() { cout<< "x = " << x << endl; }
 };

class D : public B {
 private:
   int x;
 public:
   D() : x(2) { };
   void display() { cout<< "x = " << B::x << " " << x << endl; }
};

int main() {
D derived;
derived.display();          // D::display() called -> prints 1 2
derived.B::display();       // force to call B::display() -> prints 1
}
```


Name hiding

```
class B {
 public:
  B() { cout << "B()" << endl; }
  void f() { cout << "B::f()" << endl; }
};

class D : public B {
  public:
    D() { cout << "D()" << endl; }
    void f() { cout << "D::f()" << endl; }
};

void g (B* b) { b->f(); }

int main() {
  B b1;
  D d1;
  b1.f(); d1.f();
  B* b2 = &d1; b2->f();
  g(&b1); g(&d1);
}
```

Prints B::f() D::f()

Prints B::f()

Prints B::f() B::f()

Name hiding

- You can define in the derived classes new (un-inherited) members with the same name as members in the base class
  - This is called **name hiding**
- These members are distinct from the members inherited from the base class
- When this occurs, the compiler is selecting the member corresponding to the static type of the object
- In order to override this behavior and access the base class member, the base class member type needs to be specified:
  - Example 1: d.B::display() in main
  - Example 2: B::x in D::display()
  - Or outside of the class D, it would be d.B::x

Slicing

- Slicing: an assignment from a derived class to a base class
- Example:
  D d; B* b = &d; // this is from the previous example
- After slicing, information is lost
  - It should be used carefully

Summary

- Members (data and code) of a base class are inherited by its derived classes (access is defined by access control though)
- Exception is: constructor (including copy constructor), assignment operator and destructor which are never inherited
- Derived classes are in charge of properly initializing their base class (by calling an appropriate constructor)
- Base class is constructed first
- Base class is destructed last
- Substitution principle: a derived class “is-a” base class