Module 7: Inheritance

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Acknowledgement

- Slides
  - Course CS202: Programming Systems

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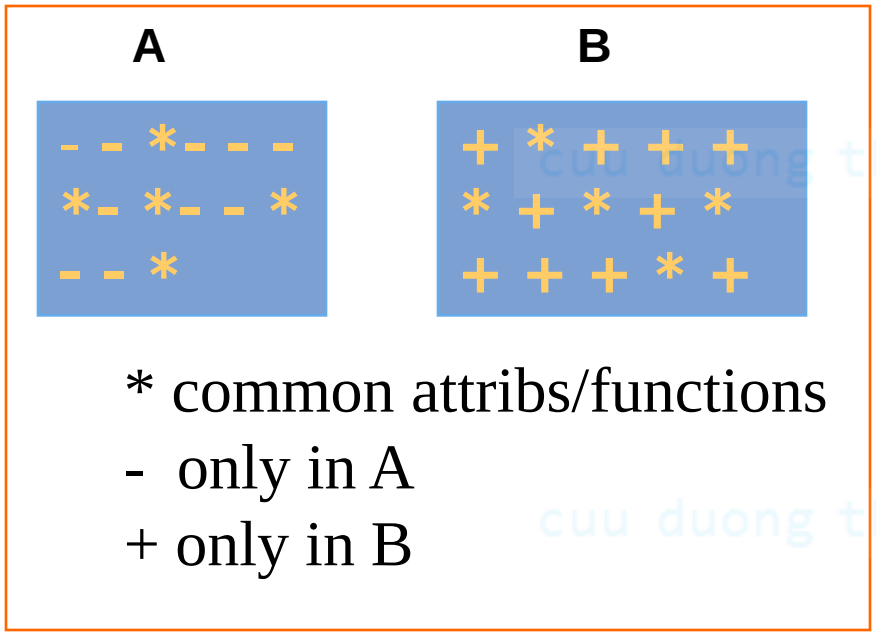
Outline

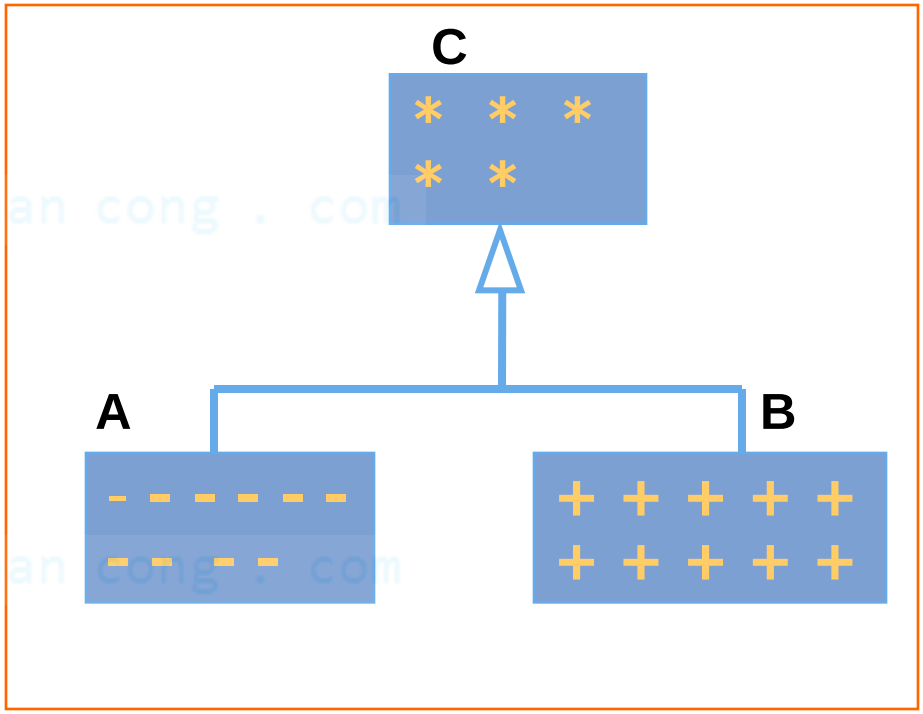
- Introduction to inheritance
- Hierarchical organization of concepts
- Types of inheritance
- Derived class
  - Constructor
  - Destructor
  - Copy constructor & assignment operator

Introduction

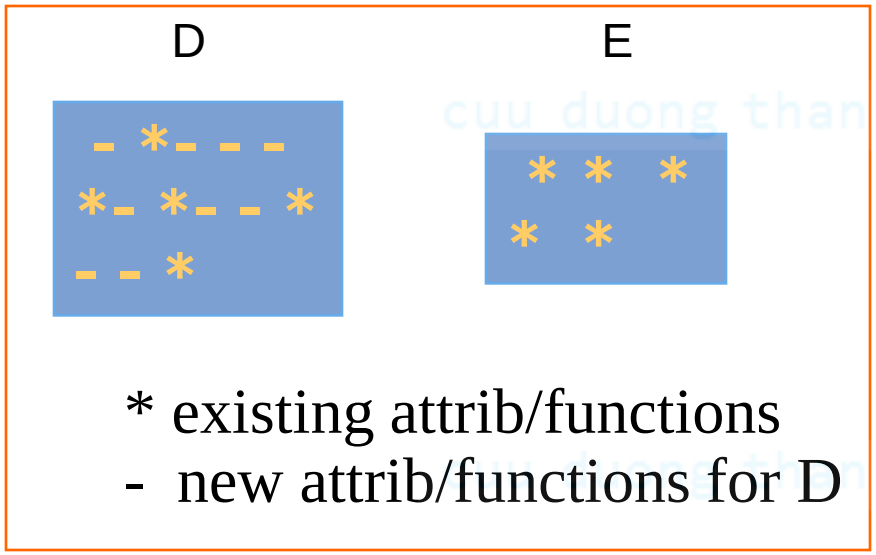
- A new concept does not come alone. When we introduce a class of car or employee for example. It may lead us to describe:
  - wheel, engine, driver etc.
  - Or: manager, director…
- To model them, we can use class. However, how can we model the relationship between them?
- In addition, re-usability of existing classes is one of the features of OOP.

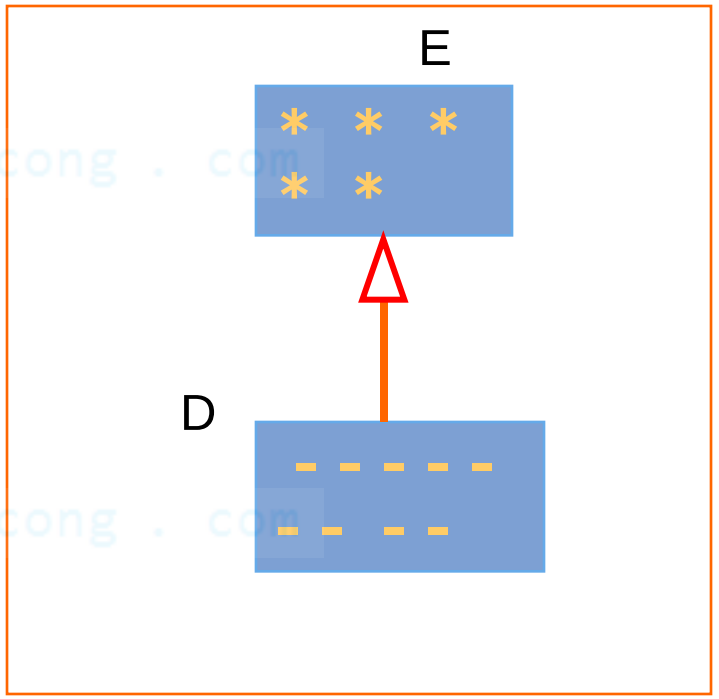
Inheritance



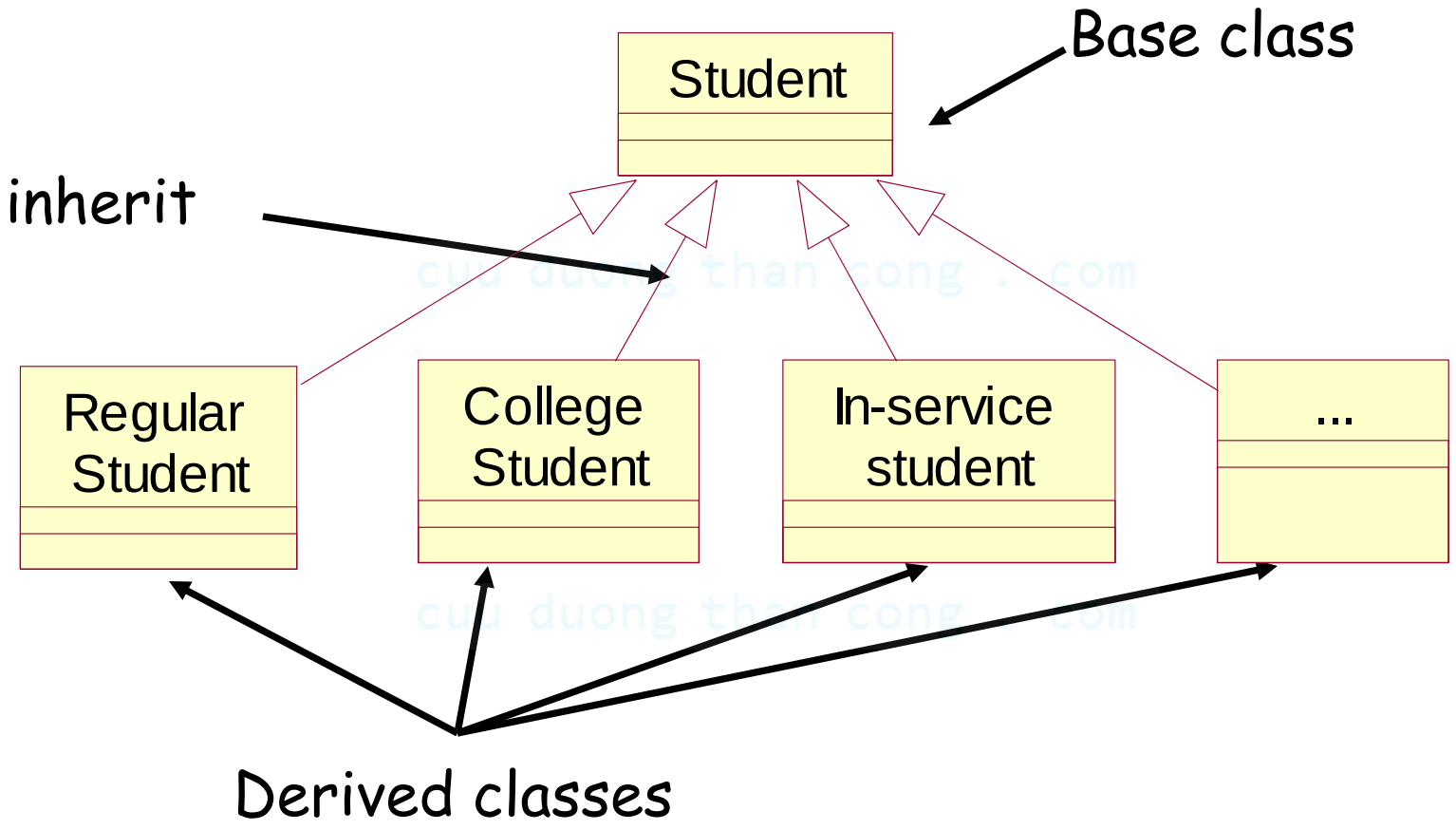


Inheritance





An example



Classify the following types of units into groups and subgroups

Barbarian-Axe Swinger

Catapult

Balloon

Doctor

Cook

Musketeer

Steam Giant

Swordsman

Ram

Gyrocopter

Phalanx

Slinger

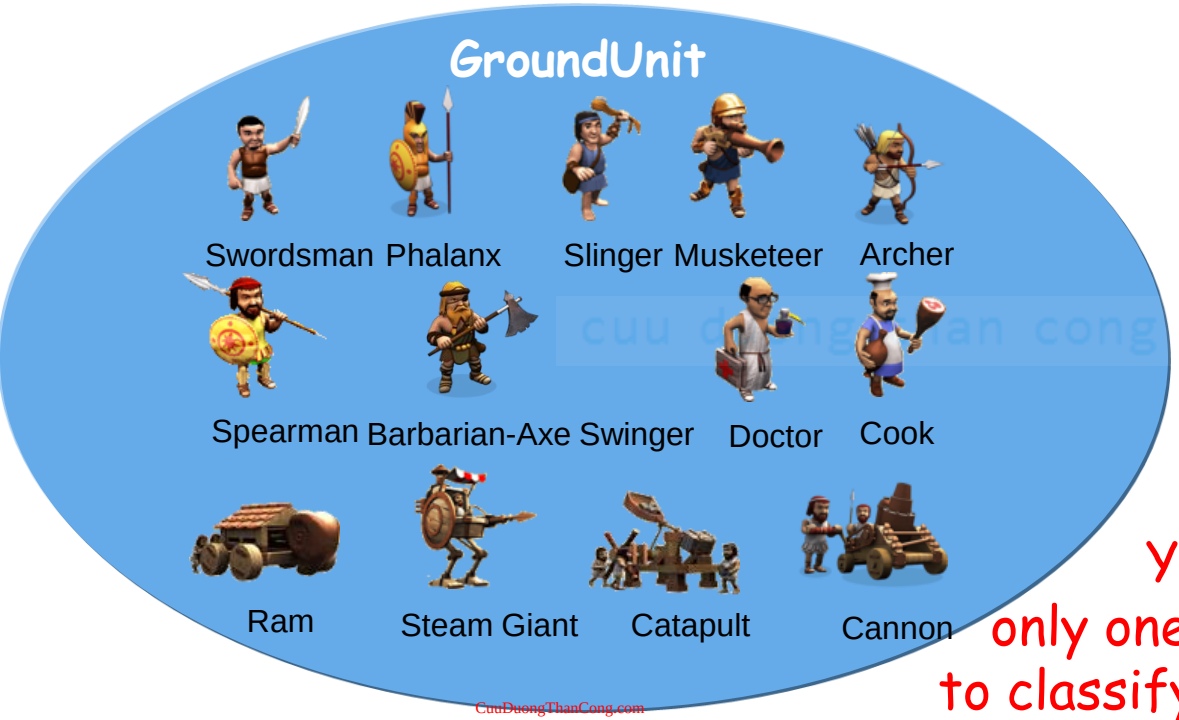
Spearman

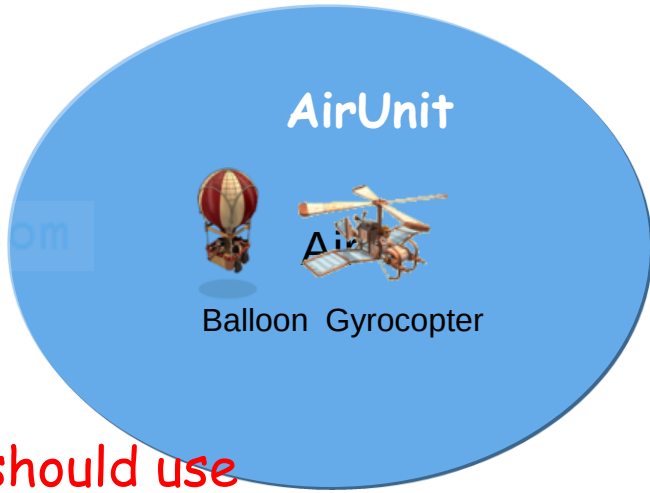
Cannon

Archer

Hierarchical organization of concepts

- A group of concepts is divided into sub-groups according to some criterion.
- Example: Types of units are classified according to their means of transportation





You should use only one criterion at a time to classify a group of concepts.

Barbarian-Axe Swinger

Catapult

Gyrocopter

Balloon

Ground units VS Air units

Air Units

Swordsman

Cook

Musketeer

Ground Units

Steam Giant

Ram

Doctor

Phalanx

Slinger

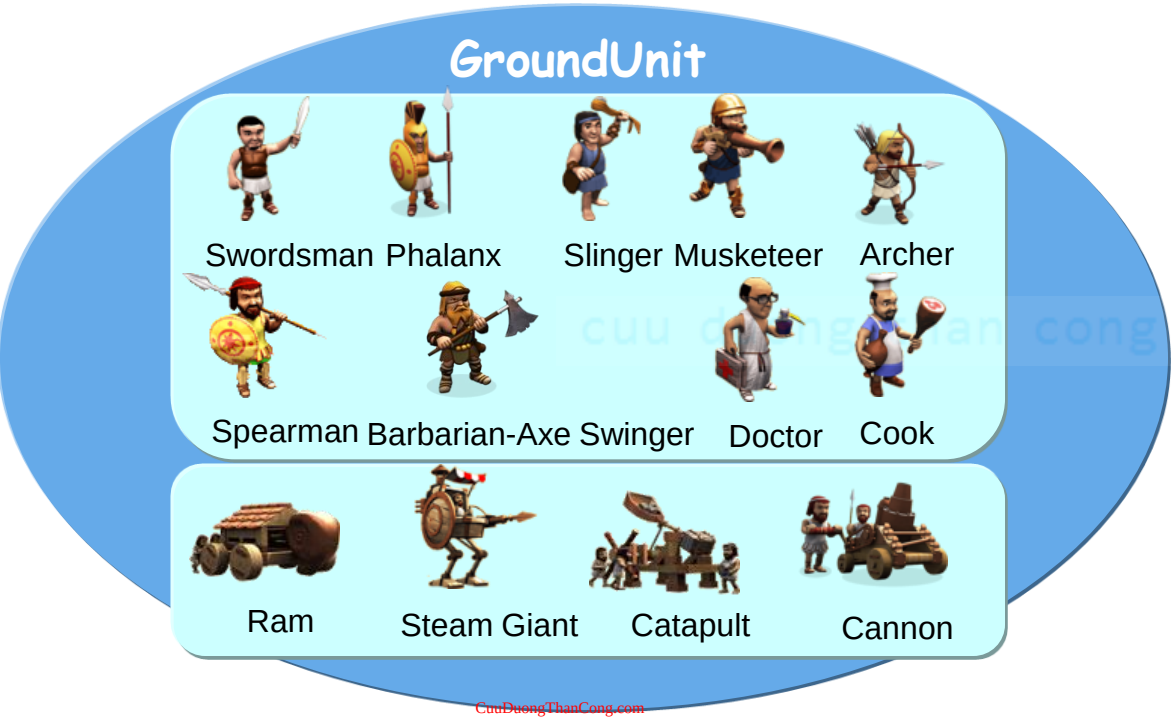
Spearman

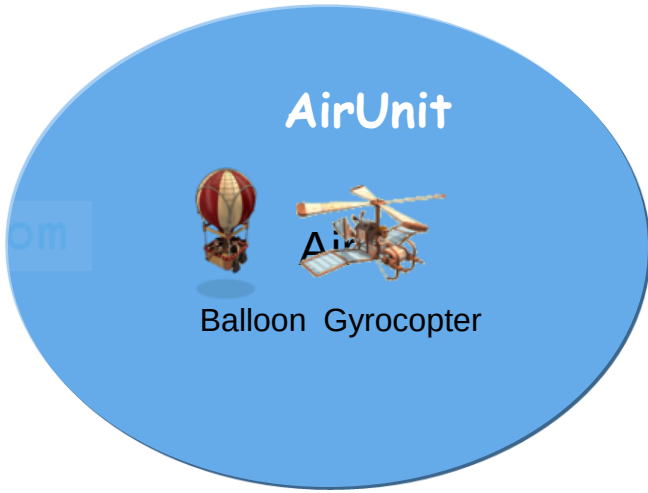
Cannon

Archer

Hierarchical organization of concepts

- Concepts are recursively classified into subgroups






Steam Giant


Catapult

Machine Units


Gyrocopter


Balloon


Cannon


Ram

Machine Units VS Organic Units

Air Units

Organic Units


Doctor


Swordsman


Phalanx


Musketeer


Cook


Archer


Slinger


Spearman


Barbarian-Axe Swinger


Steam Giant


Catapult

Machine Units


Gyrocopter


Balloon


Cannon


Ram

Funtionality of units

Air Units

Support Units

Melee Units


Swordsman


Spearman


Archer

Long-Ranged Units


Cook

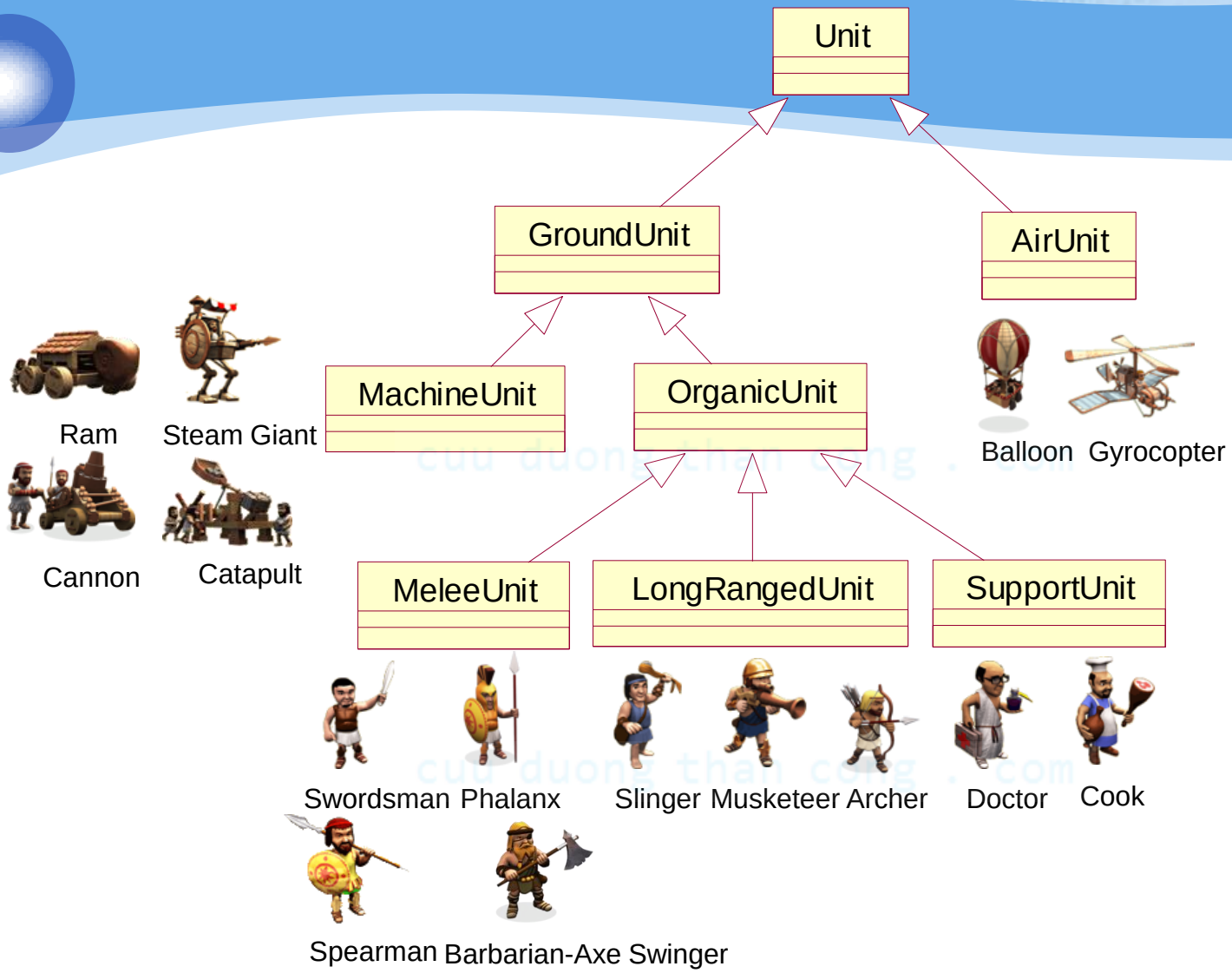

Phalanx


Barbarian-Axe Swinger


Musketeer


Slinger


Doctor



It is possible to have different ways
to create logical hierarchical organization of concepts


Balloon


Gyrocopter


Cook


Doctor


Ram


Catapult


Slinger


Archer


Barbarian-Axe Swinger


Phalanx

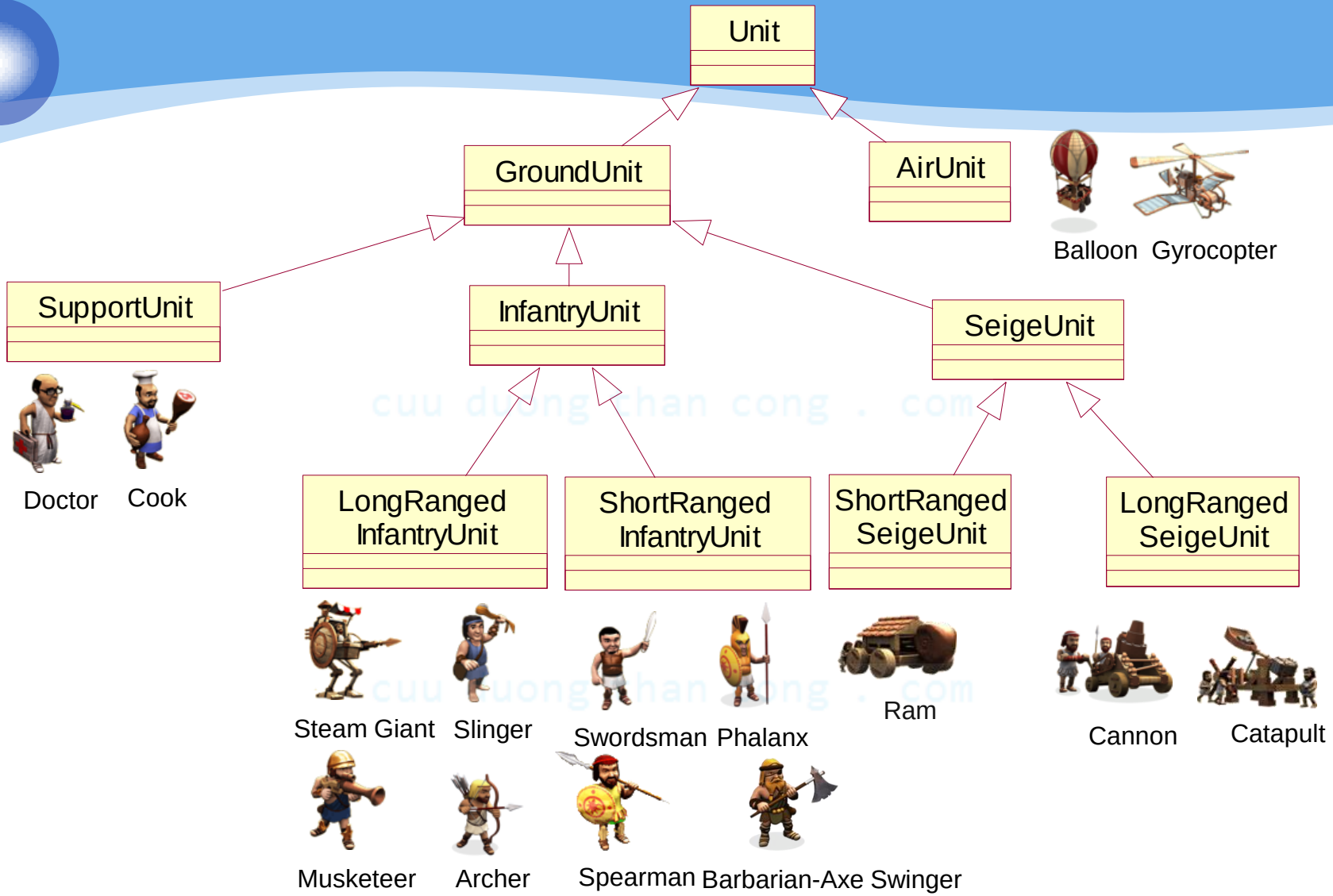

Cannon


Steam Giant


Musketeer


Spearman


Swordsman



It is possible to have different ways
to create logical hierarchical organization of concepts

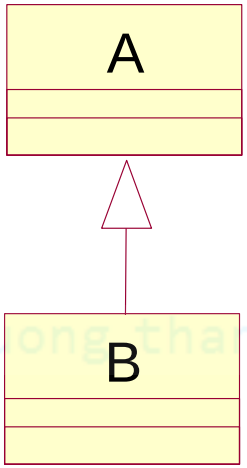
Syntax

- In C++, the inheritance is described as:

```
class <Derived Class> : <TypeOfInheritance> <Base class>
{
        public:
                <public attributes/functions>

        private:
                <private attributes/functions>
};
```

Inheritance: notes



- Attributes/functions in **public** of A will become attributes/functions in B
- **Private** attributes/functions of A will be part of B but it is only accessible via **public** or **protected** functions of A

protected keyword

- **protected** attributes/functions of A is accessible from the derived class B but not from outside

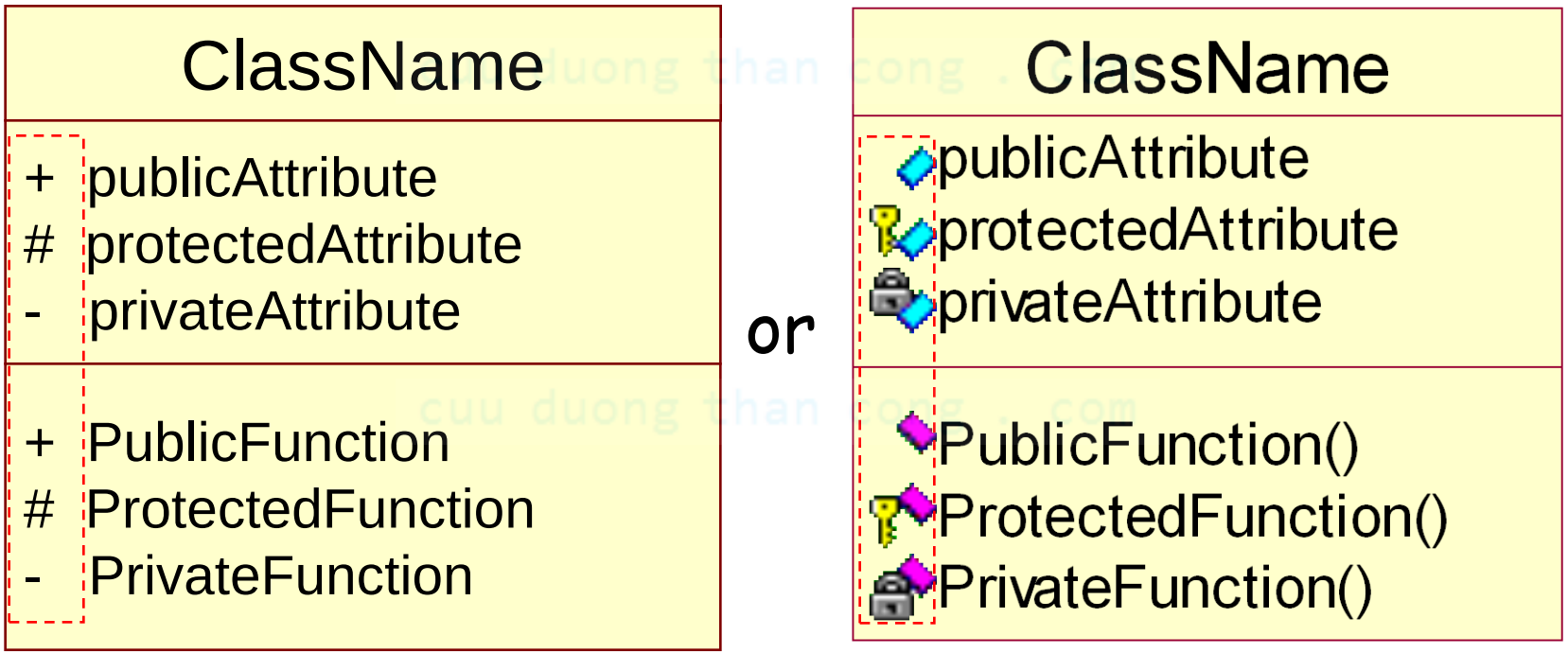
```
class A
{
  public:
     ...
  protected:
       int     t;
};
```

```
class B: public A
{
  public:
       void Test()
       {
          cout << t;
       }
       ...
};
```

Protected attribute of A

UML Notation of Visibility

- Visibility of an attribute/function can be public, protected, or private



Types of inheritance (in C++)

There are 3 types of inheritance in C++:

- **public** inheritance
- **protected**
- **private**

Notes: from now on, if there is no mention of what type of inheritance, it means public inheritance

Types of inheritance (in C++)

- **public**: public and protected of the base class become public and protected of the derived class.
- **protected**: public and protected of the base class become protected of the derived class.
- **private**: public and protected of the base class become private of the derived class.

Types of inheritance (in C++)

class B: public A

Public attributes/functions	→	Public attributes/functions
Protected attributes/functions	→	Protected attributes/functions
Private attributes/functions	X	Private attributes/functions

Types of inheritance (in C++)

class B: protected A

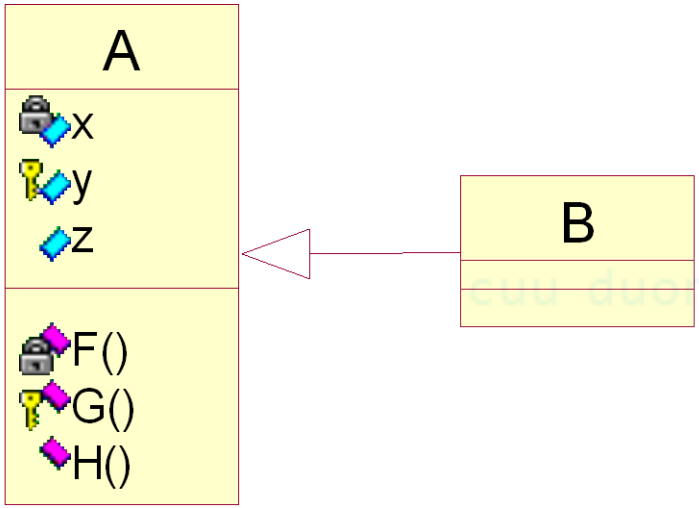
Public attributes/functions	→	Public attributes/functions
Protected attributes/functions	→	Protected attributes/functions
Private attributes/functions	X	Private attributes/functions

Types of inheritance (in C++)

class B: private A

Public attributes/functions	→	Public attributes/functions
Protected attributes/functions	→	Protected attributes/functions
Private attributes/functions	X	Private attributes/functions

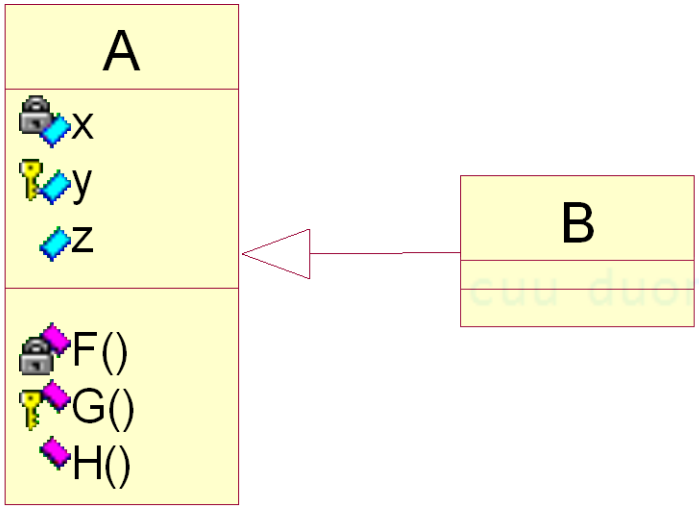
Types of inheritance (in C++)



- Class B has:
  - Attribute y (protected)
  - Attribute z (public)
  - Function G (protected)
  - Function H (public)

Type of inheritance: **public**

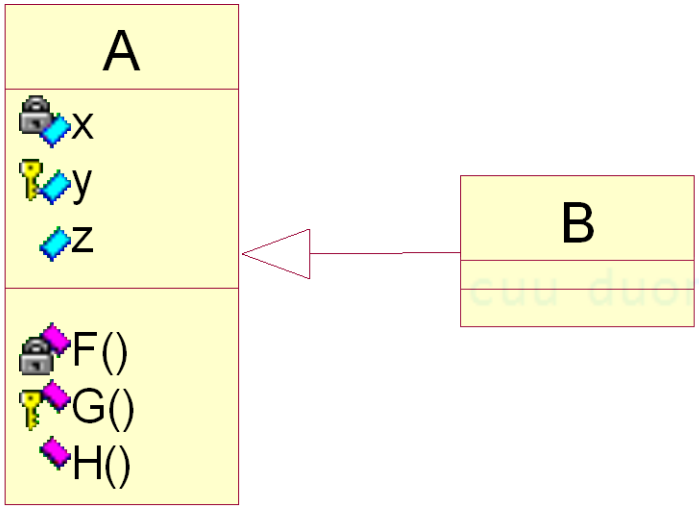
Types of inheritance (in C++)



- Class B has:
  - Attribute y (protected)
  - Attribute z (protected)
  - Function G (protected)
  - Function H (protected)

Type of inheritance: **protected**

Types of inheritance (in C++)



- Class B has:
  - Attribute y (private)
  - Attribute z (private)
  - Function G (private)
  - Function H (private)

Type of inheritance: **private**

Inheritance: member functions

- Member functions of the base class are inherited in the derived class, except:
  - Constructors
  - Destructors
  - Assignment operators

- Notes: private member functions of the base class are inherited but only accessible via other public/protected functions of A

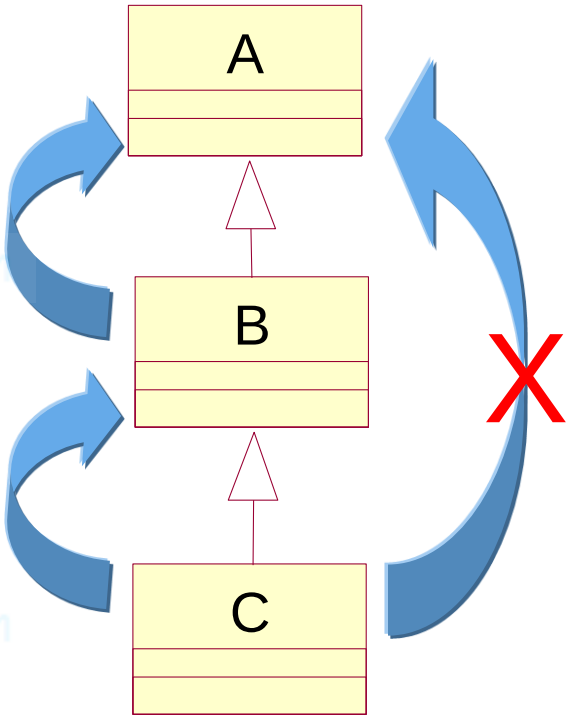
Constructors in inheritance

- When a new object of a derived class is created
  - The constructor of the base class is invoked first.
  - Then, the constructor of the derived class is invoked.
  - In the constructor of the derived class, we can specify which constructor of the base class is called. Otherwise, the default constructor of the base class will be invoked.

Constructors in inheritance

Notes:

- The constructor of the derived class is able to specify the constructor of the **immediate** base class to be called.

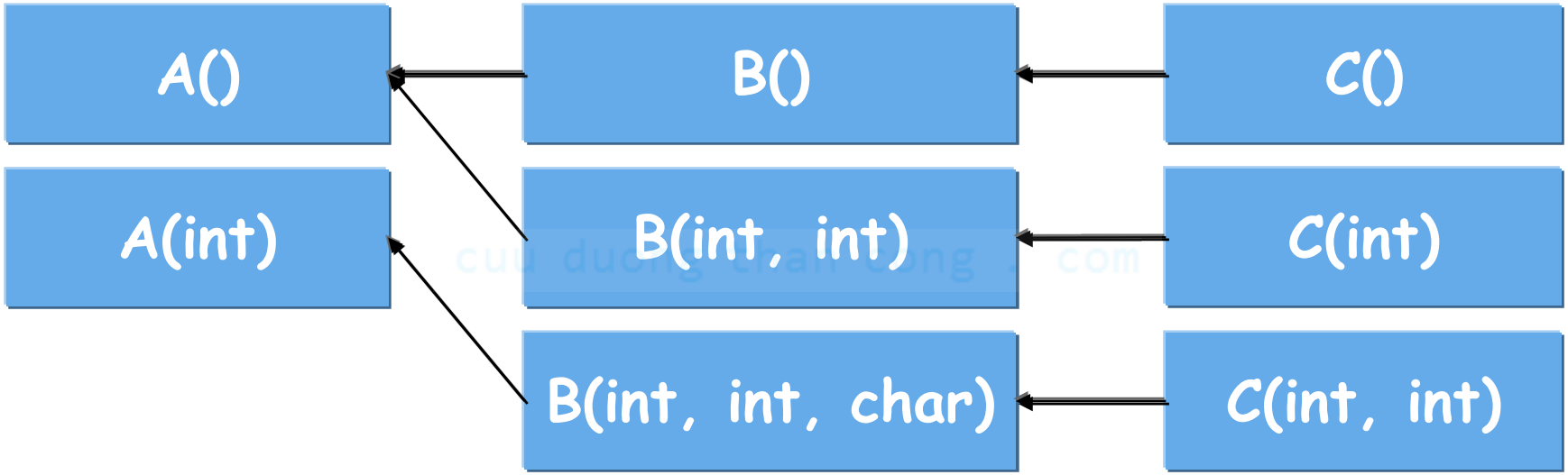


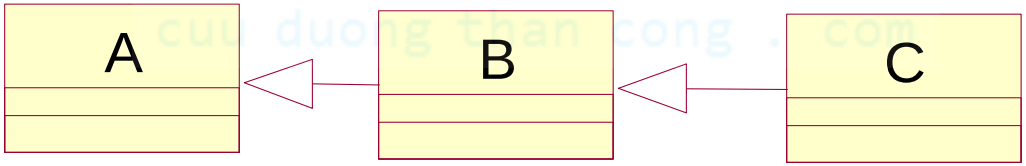
An example

```
class A
{
public:
        A();
        A(int);
};
class B : public A
{
public:
        B(int);
};
```

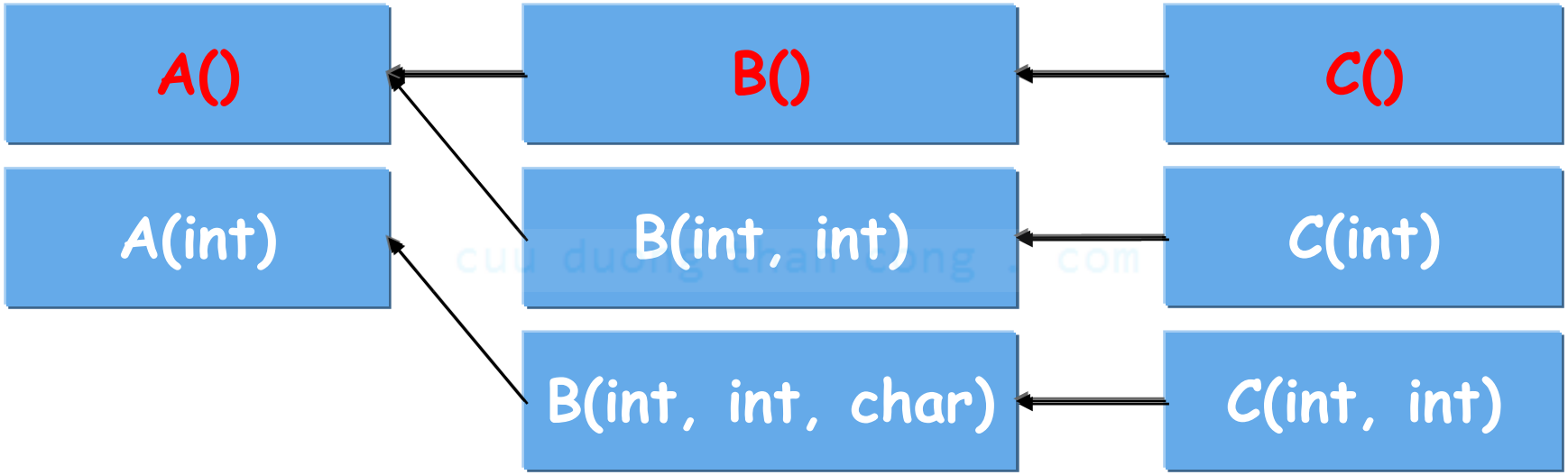
```
class A
{
public:
        A();
        A(int);
};
class B : public A
{
public:
        B(int t) : A(t)
        { //...
        }
};
```

An example





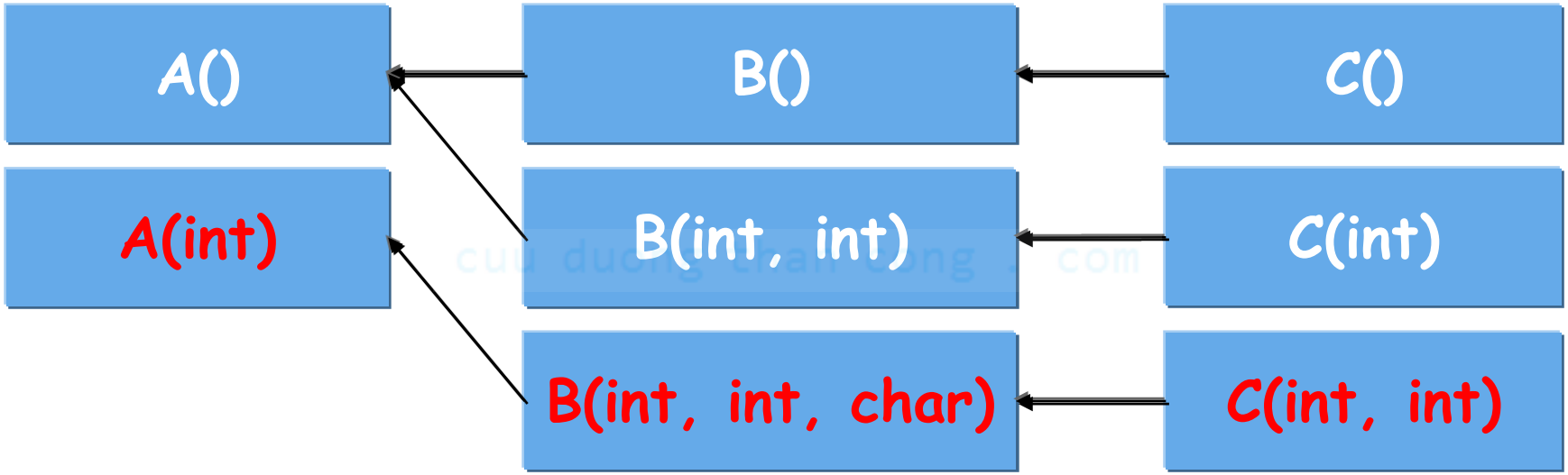
An example



C myObj;

1. The constructor of A is invoked: A()
2. The constructor of B is invoked: B()
3. The constructor of C is invoked: C()

An example

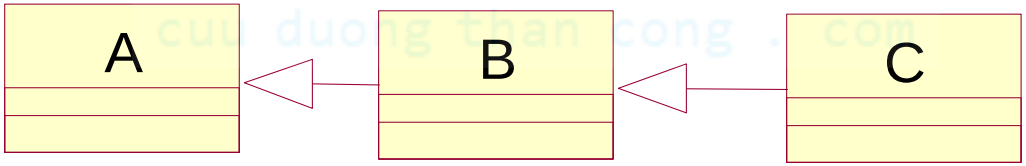


C myObj(5, 7);

1. The constructor of A is invoked: A(int)
2. The constructor of B is invoked: B(int, int, char)
3. The constructor of C is invoked: C(int, int)

Destructor in inheritance

- When an object of the derived class finishes its lifespan:
  - The destructor of the derived class is invoked first.
  - Then, the destructor of the base class is called later.
- Example:



  - when an object of C is destroyed, the following functions will be invoked: ~C() → ~B() → ~A()

"Re-define" member functions

- Sometimes, we need to "re-define" the member functions of the base class in the derived class.
  - It can be done by re-defining the functions inside the derived class

Notes: this re-definition will hide other overloading member functions of this function from the base class.

An example

```
class A {
public:
   void test();
   void test(int);
   void test(int, int);
   ...
};

class B : public A
{
public:
   void test(int);
};
```

```
int main()
{
   B b;
   int x, y;
   ...
   b.test(x); // OK
   b.test(x, y); //error
   ...
}
```

This function will hide other overloading functions inherited from A

using keyword

```
class A {
public:
   void test();
   void test(int);
   void test(int, int);
   …
};

class B : public A
{
public:
   using A::test;
   void test(int);
};
```

```
int main()
{
   B b;
   int x, y;
   …
   b.test(x); // OK
   b.test(x, y); //OK
   …
}
```

B uses overloading functions inherited from A

Assignment operator

- It is not inherited from the base class
- To implement the assignment operator for the derived class:
  - Calling the assignment operator of the base class to assign data members of the base class part in the two objects first.
  - Then, implement the assignment for data member of the derived class part.

An example

```
B& B::operator=(const B& src)
{
   if (this == &src)
         return *this;
   A::operator=(src);
   delete [] ptr;
   iSize = src.iSize;
   ptr = new int [iSize];
   for (int i=0; i<iSize; ++i)
         ptr[i] = src.ptr[i];
   return *this;
}
```