ĐẠI HỌC TÔN ĐỨC THẮNG
TON DUC THANG UNIVERSITY

Data Structures and Algorithms I

Object Oriented Programming Inheritance

Like father, like son

Acknowledgement

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- We greatly appreciate support from Mr. Aaron Tan Tuck Choy, and Dr. Low Kok Lim for kindly sharing these materials.

Policies for students

- These contents are only used for students PERSONALLY.
- Students are NOT allowed to modify or deliver these contents to anywhere or anyone for any purpose.

Recording of modifications

- Course website address is changed to http://sakai.it.tdt.edu.vn
- Slides “Practice Exercises” are eliminated.
- Course codes cs1010, cs1020, cs2010 are placed by 501042, 501043, 502043 respectively.

Objectives

- Introducing inheritance through creating subclasses
  - Improve code reusability
  - Allowing overriding to replace the implementation of an inherited method

References

Textbook

- Chapter 1: Section 1.4 (pg 54 – 56)
- Chapter 9: Section 29.1 (pg 480 – 490)

IT-TDT Sakai → 501043 website → Lessons

- http://sakai.it.tdt.edu.vn

Outline

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0. Object-Oriented Programming

- Four fundamental concepts of OOP:
  - Encapsulation
  - Abstraction
  - Inheritance
  - Polymorphism
- Inheritance allows new classes to inherit properties of existing classes
- Main concepts in inheritance
  - Subclassing
  - Overriding

1. Overriding Methods (revisit) (1/2)

- Recall in lecture #3 that a user-defined class automatically inherits some methods – such as toString() and equals() – from the Object class
- The Object class is known as the parent class (or superclass); it specifies some basic behaviours common to all kinds of objects, and hence these behaviours are inherited by all its subclasses (derived classes)
- However, these inherited methods usually don’t work in the subclass as they are not customised

1. Overriding Methods (revisit) (2/2)

- Hence, to make them work, we customised these inherited methods – this is called overriding

Lecture #3: MyBall/MyBall.java

```
  /****************** Overriding methods *******************/
  // Overriding toString() method
  public String toString() {
    return "[" + getColour() + ", " + getRadius() + "]";
  }

  // Overriding equals() method
  public boolean equals(Object obj) {
    if (obj instanceof MyBall) {
      MyBall ball = (MyBall) obj;
      return this.getColour().equals(ball.getColour()) &&
        this.getRadius() == ball.getRadius();
    }
    else
      return false;
  }
}
```

2. Creating a Subclass (1/6)

- Object-oriented languages allow inheritance
  - Declare a new class based on an existing class
  - So that the new class may inherit all of the attributes and methods from the other class
- Terminology
  - If class *B* is derived from class *A*, then class *B* is called a **child** (or **subclass** or **derived class**) of class *A*
  - Class *A* is called a **parent** (or **superclass**) of class *B*

2. Creating a Subclass (2/6)

- Recall the BankAcct class in lecture #3

lect3/BankAcct.java

```
class BankAcct {
  private int acctNum;
  private double balance;

  public BankAcct() { }

  public BankAcct(int aNum, double bal) { ... }

  public int getAcctNum() { ... }

  public double getBalance() {... }

  public boolean withdraw(double amount) { ...  }

  public void deposit(double amount) { ... }

  public void print() { ... }
}
```

2. Creating a Subclass (3/6)

- Let’s define a SavingAcct class
- Basic information:
  - Account number, balance
  - Interest rate
- Basic functionality:
  - Withdraw, deposit
  - Pay interest

New requirements

- Compare with the basic bank account:
  - Differences are highlighted above
  - SavingAcct shares more than 50% of the code with BankAcct
- So, should we just cut and paste the code from BankAcct to create SavingAcct?

2. Creating a Subclass (4/6)

- Duplicating code is **undesirable** as it is hard to maintain
  - Need to correct all copies if errors are found
  - Need to update all copies if modifications are required
- Since the classes are logically unrelated if the codes are separated:
  - Code that works on one class cannot work on the other
- Compilation errors due to incompatible data types
- Hence, we should create SavingAcct as a subclass of BankAcct

2. Creating a Subclass (5/6)

BankAcct.java

```
class BankAcct {
  protected int acctNum;
  protected double balance;

  //Constructors and methods not shown

}
```

The "protected" keyword allows subclass to access the attributes directly

```
class SavingAcct extends BankAcct {

  protected double rate;    // interest rate

  public void payInterest() {
      balance += balance * rate;
  }

}
```

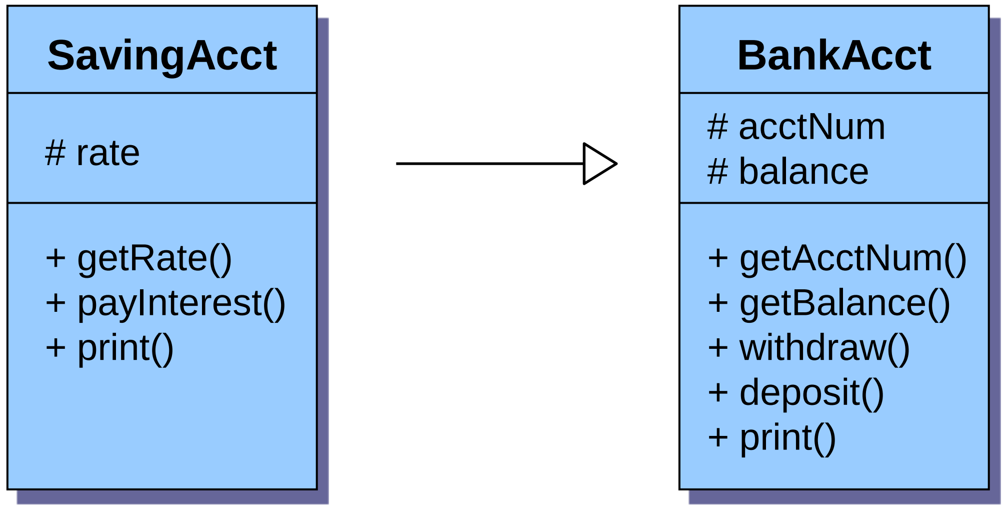
The "extends" keyword indicates inheritance

This allows subclass of SavingAcct to access rate. If this is not intended, you may change it to "private".

SavingAcct.java

2. Creating a Subclass (6/6)

- The subclass-superclass relationship is known as an "is-a" relationship, i.e. SavingAcct is-a BankAcct
- In the UML diagram, a solid line with a closed unfilled arrowhead is drawn from SavingAcct to BankAcct
- The symbol # is used to denoted protected member



2.1 Observations

- Inheritance greatly reduces the amount of redundant coding
- In SavingAcct class,
  - No definition of `acctNum` and `balance`
  - No definition of `withdraw()` and `deposit()`
- Improve maintainability:
  - Eg: If a method is modified in BankAcct class, no changes are needed in SavingAcct class
- The code in BankAcct remains untouched
  - Other programs that depend on BankAcct are unaffected ← very important!

2.2 Constructors in Subclass

- Unlike normal methods, constructors are NOT inherited
  - You need to define constructor(s) for the subclass

```
class SavingAcct extends BankAcct {

  protected double rate;    // interest rate

  public SavingAcct(int aNum, double bal, double rate){
      acctNum = aNum;
      balance = bal;
      this.rate = rate;
  }

  //......payInterest() method not shown
}
```

SavingAcct.java

2.3 The "super" Keyword

- The "super" keyword allows us to use the methods (including constructors) in the superclass directly
- If you make use of superclass' constructor, it must be the **first statement** in the method body

```java
class SavingAcct extends BankAcct {

  protected double rate;    // interest rate

  public SavingAcct(int aNum, double bal, double rate){
      super(aNum, bal);
      this.rate = rate;
  }

  //......payInterest() method not shown
}
```

Using the constructor in BankAcct class

SavingAcct.java

2.4 Using SavingAcct

TestSavingAcct.java

```
public class TestSavingAcct {

  public static void main(String[] args) {

     SavingAcct sa1 = new SavingAcct(2, 1000.0, 0.03);

     sa1.print();
     sa1.withdraw(50.0);

     sa1.payInterest();
     sa1.print();
  }
}
```

Inherited method from BankAcct

Method in SavingAcct

How about print()?
Should it be the one in BankAcct class,
or should SavingAcct class override it?

2.5 Method Overriding (1/2)

- Sometimes we need to modify the inherited method:
  - To change/extend the functionality
  - As you already know, this is called **method overriding**
- In the SavingAcct class:
  - The print() method inherited from BankAcct should be modified to include the interest rate in output
- To override an inherited method:
  - Simply recode the method in the subclass using the same method header
  - Method header refers to the name and parameters type of the method (also known as **method signature**)

2.5 Method Overriding (2/2)

SavingAcct.java

```
class SavingAcct extends BankAcct {

  protected double rate;    // interest rate

  public double getRate() { return rate; }

  public void payInterest() { ... }

  public void print() {
    System.out.println("Account Number: " + getAcctNum());
    System.out.printf("Balance: $%.2f\n", getBalance());
    System.out.printf("Interest: %.2f%%\n", getRate());
  }
}
```

- The first two lines of code in print() are exactly the same as print() of BankAcct
  - Can we reuse BankAcct's print() instead of recoding?

2.6 Using “super” Again

- The super keyword can be used to invoke superclass’ method
  - Useful when the inherited method is overridden

SavingAcct.java

```
class SavingAcct extends BankAcct {

  . . .

  public void print() {
    super.print();
    System.out.printf("Interest: %.2f%%\n", getRate());
  }
}
```

To use the print() method from BankAcct

3. Subclass Substitutability (1/2)

- An added advantage for inheritance is that:
  - Whenever a super class object is expected, a sub class object **is acceptable as substitution!**
    - **Caution:** the **reverse is NOT true** (Eg: A cat is an animal; but an animal may not be a cat.)
  - Hence, all existing functions that works with the super class objects will work on subclass objects with **no modification**!
- Analogy:
  - We can drive a car
  - Honda is a car (Honda is a subclass of car)
  - We can drive a Honda

3. Subclass Substitutability (2/2)

TestAcctSubclass.java

```
public class TestAcctSubclass {

  public static void transfer(BankAcct fromAcct,
                              BankAcct toAcct, double amt) {
     fromAcct.withdraw(amt);
     toAcct.deposit(amt);
  };

  public static void main(String[] args) {

     BankAcct ba = new BankAcct(1, 234.56);
     SavingAcct sa = new SavingAcct(2, 1000.0, 0.03);

     transfer(ba, sa, 123.45);

     ba.print();
     sa.print();
  }
}
```

transfer() method can work on the SavingAcct object sa!

4. The "Object" Class

- In Java, all classes are descendants of a predefined class called `Object`
  - `Object` class specifies some basic behaviors common to all objects
  - Any methods that works with `Object` reference will work on **object of any class**
  - Methods defined in the `Object` class are inherited in all classes
  - Two inherited `Object` methods are
    - `toString()` method
    - `equals()` method
  - However, these inherited methods usually don't work because they are not customised

5. “is-a” versus “has-a” (1/2)

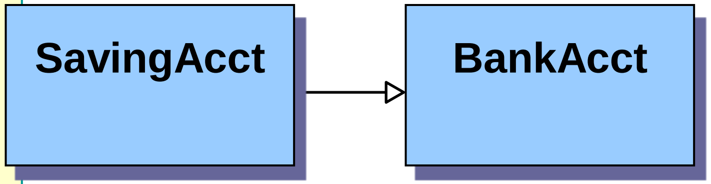
- Words of caution:
  - Do not overuse inheritance
  - Do not overuse `protected`
    - Make sure it is something inherent for future subclass
- To determine whether it is correct to inherit:
  - Use the “**is-a**” rules of thumb
    - If “B is-a A” sounds right, then ***B is a subclass of A***
  - Frequently confused with the “**has-a**” rule
    - If “B has-a A” sounds right, then ***B should have an A attribute*** (hence B depends on A)

5. “is-a” versus “has-a” (2/2)

- UML diagrams

```
class BankAcct {
    ...
}

class SavingAcct extends BankAcct {
     ...
}
```

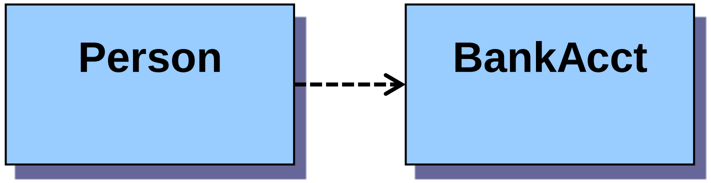


Solid arrow

Inheritance: SavingAcct IS-A BankAcct

```
class BankAcct {
    ...
};

class Person {
    private BankAcct myAcct;
};
```



Dotted arrow

Attribute: Person HAS-A BankAcct

6. Preventing Inheritance ("final")

- Sometimes, we want to prevent inheritance by another class (eg: to prevent a subclass from corrupting the behaviour of its superclass)
- Use the final keyword
  - Eg: final class SavingAcct will prevent a subclass to be created from SavingAcct
- Sometimes, we want a class to be inheritable, but want to prevent some of its methods to be overridden by its subclass
  - Use the final keyword on the particular method:

    public final void payInterest() { … }

    will prevent the subclass of SavingAcct from overriding payInterest()

7. Constraint of Inheritance in Java

- Single inheritance: Subclass can only have a single superclass
- Multiple inheritance: Subclass may have more than one superclass
- In Java, only single inheritance is allowed
- (Side note: Java's alternative to multiple inheritance can be achieved through the use of interfaces – to be covered later. A Java class may implement multiple interfaces.)

8. Quick Quiz #1 (1/2)

ClassA.java

```
class ClassA {
  protected int value;

  public ClassA() {  }

  public ClassA(int val) { value = val; }

  public void print() {
    System.out.println("Class A: value = " + value);
  }
}
```

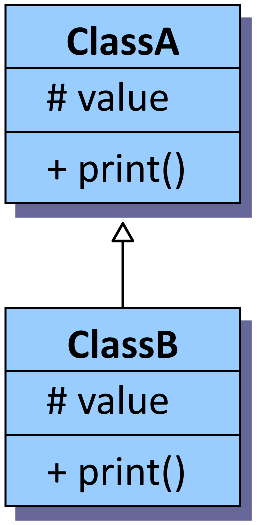
```
class ClassB extends ClassA {
  protected int value;

  public ClassB() {  }

  public ClassB(int val) {
    super.value = val - 1;
    value = val;
  }

  public void print() {
    super.print();
    System.out.println("Class B: value = " + value);
  }
}
```

ClassB.java



8. Quick Quiz #1 (2/2)

ClassC.java

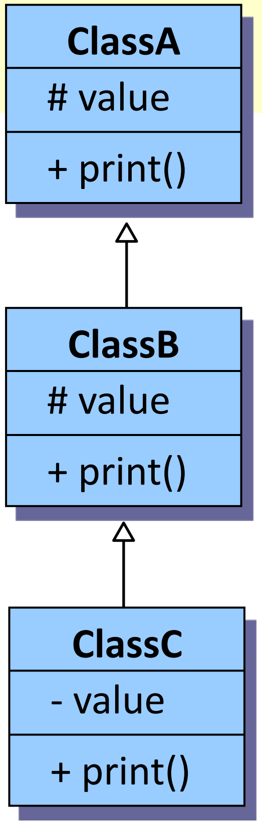
```
final class ClassC extends ClassB {
  private int value;

  public ClassC() {   }

  public ClassC(int val) {
    super.value = val – 1;
    value = val;
  }

  public void print() {
    super.print();
    System.out.println("Class C: value = " + value);
  }
}
```

What is the output?

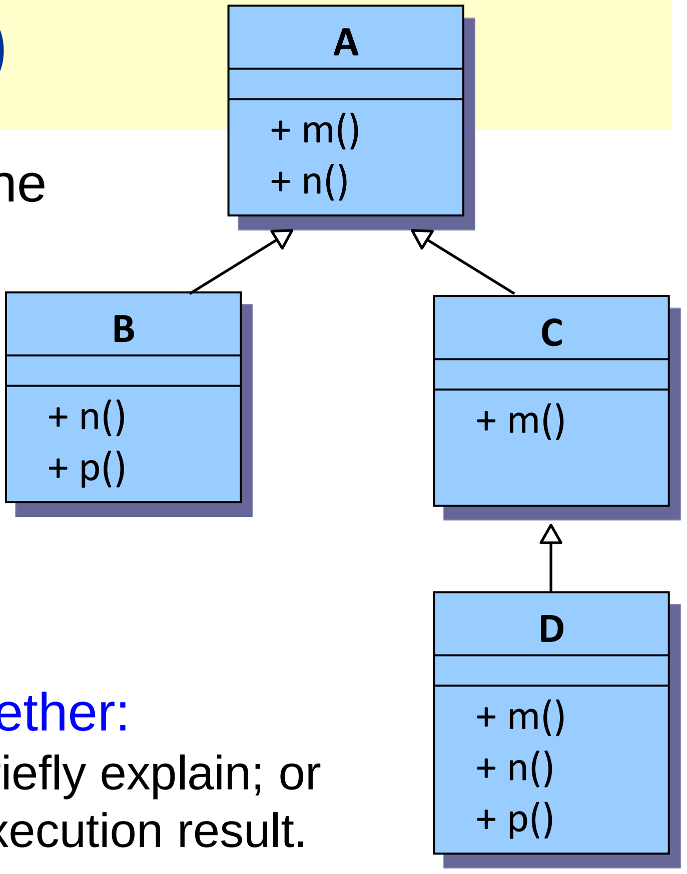


```
public class TestSubclasses {
  public static void main(String[] args) {
    ClassA objA = new ClassA(123);
    ClassB objB = new ClassB(456);
    ClassC objC = new ClassC(789);

    objA.print(); System.out.println("---------");
    objB.print(); System.out.println("---------");
    objC.print();
  }
}
```

TestSubclasses.java

8. Quick Quiz #2 (1/2)



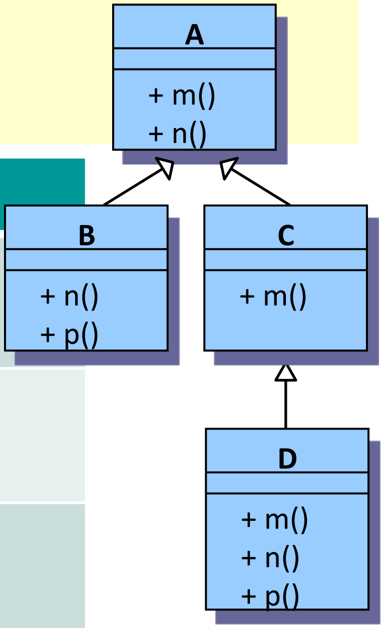
- Assume all methods print out message of the form <class name>,<method name>
- Eg: method m() in class A prints out "A.m".
- If a class overrides an inherited method, the method's name will appear in the class icon. Otherwise, the inherited method remains unchanged in the subclass.
- For each code fragment below, indicate whether:
  - The code will cause compilation error, and briefly explain; or
  - The code can compile and run. Supply the execution result.

Code fragment (example)	Compilation error? Why?	Execution result

`A a = new A();`
`a.m();`
		`A.m`

`A a = new A();`
`a.k();`
	Method k() not defined in class A	

8. Quick Quiz #2 (2/2)



Code fragment	Compilation error?	Execution result

`A a = new C();`
`a.m();`		

`B b = new A();`
`b.n();`		

`A a = new B();`
`a.m();`		

`A a;`
`C c = new D();`
`a = c;`
`a.n();`		

`B b = new D();`
`b.p();`		

`C c = new C();`
`c.n();`		

`A a = new D();`
`a.p();`		

Summary

- Inheritance:
  - Creating subclasses
  - Overriding methods
  - Using “super” keyword
  - The “Object” class

End of file