CS202 Java Object Oriented Programming

Encapsulation, Inheritance, and Polymorphism

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Access Modifiers

- `public` – can be accessed from anywhere
- `private` – can be accessed only within the class
- `protected` – can be accessed within the class, in subclasses, or within the same package
- No modifier – can be accessed within the same package

Access Control Example

```
public class Foo {

    public int a;
    private int b;
    protected int c;

    public Foo()
    {
        a = 1;
        b = 2;
        c = 3;
    }


}
```

```
public class Bar {

    public Bar () {}

    public void print( Foo f )
    {
        System.out.println(f.a); // ??
        System.out.println(f.b); // ??
        System.out.println(f.c); // ??
    }

    public static void main( String args[] )
    {
        (new Bar()).print( new Foo() );
    }
}
```

Encapsulation

- Separate implementation details from interface
  - Control access to internal data
    - Account class
  - Change class implementation without breaking code that uses the class
    - Point class

Access to Private Fields

- *Getter* and *Setter* methods
  - Point
    - getX(), getY()
    - setX(), setY()
- What not just make x, y public??

Package

- A collection of related classes and interfaces providing access protection and name space management
  - Group related classes together so they are easier to find and to use
  - Package level access finds a middle ground between `public` and `private` access
  - Avoid name conflicts
    - cs202.cysun.Account and com.boa.Account

Creating Packages

```
package cs202.cysun;

…
```

- Package names
  - The "reverse-URL" naming convention

Using Package Members

- Only public classes of a package are accessible from outside the package
- Import all classes in a package
  - E.g. `import javax.swing.*;`
- Import one class from a package
  - E.g. `import javax.swing.JOptionPane;`

Package and Directory

- Package name must match directory structure
  - E.g. all classes in the package cs202.cysun must be under a directory cs202\cysun
- Classpath – directories where Java searches for classes
  - Some default classpaths
  - Current working directory
  - Additional directories specified by the *–classpath* option

Package and Directory Example

- package cs202
  - Class Foo
- java Foo
- java cs202.Foo
- java –classpath .. cs202.Foo

Account Revisited

Account

- Attributes
  - Account number
  - Owner's name
  - Balance (>=0)
- Operations
  - Check balance
  - Deposit
  - Withdraw
  - Transfer

More Accounts

- Checking Account
  - No restriction on deposit or withdraw
- Savings Account
  - Limited 2 withdraws per month
- CD Account
  - 30-day term
  - Deposit or withdraw only during a 7 day grace period

Inheritance

- Code re-use
- *Subclass* inherits members of a *superclass*
  - Class variables
  - Methods
  - *Except constructors*
- Inherits != Can Access
  - `public` and `protected`
  - Subclass may have more members than the superclass

CheckingAccount Class

```
public class CheckingAccount extends Account {

   public CheckingAccount( String owner )
   {
      super(owner);
   }

   public CheckingAccount( String owner, double balance )
   {
      super(owner, balance);
   }
}
```

Keyword `super`

- A reference to the superclass
- A reference to a constructor of the superclass

SavingsAccount Class

- Restrictions on withdraw
  - No more than 2 withdraws per month
- Have to re-write the withdraw() method
  - ??

Overriding

- A subclass method has the same *signature* as a method of the superclass
- Method *signature*
  - Access modifier
  - Return Type
  - Name
  - List of parameters

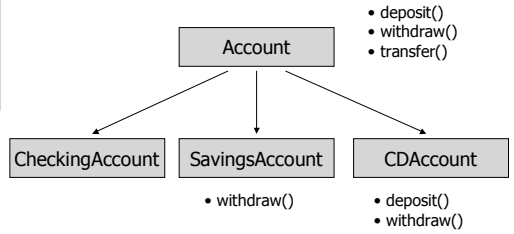
Overriding Examples

- public double withdraw(double amount)
- public String toString()
  - All Java classes implicitly inherits from the `Object` class
  - toString() is one of the methods defined in the `Object` class

Inheritance vs. Encapsulation

- Inheritance – subclass wants to reuse code
- Encapsulation – changes to the implementation of one class should not affect other code, including the code of subclasses
- In practice – pragmatic balance

Class Hierarchy of Account



Keyword `final`

- A final class cannot be inherited
  - public `final` class Classname {…}
- A final variable cannot changes its value
  - Similar to *constants* in other languages
  - Convenience
  - Readability
  - `final double PI = 3.1415926;`

More about Account

Account

- Attributes
  - Account number
  - Owner's name
  - Balance (>=0)
- Operations
  - Check balance
  - Deposit
  - Withdraw
  - **Transfer**

A Closer Look at transfer()

```
public double transfer( double amount, Account other )
{
   return other.deposit( withdraw(amount) );
}
```

- What happens if we want to transfer from a CheckingAccount to a SavingsAccount?
  - Type mismatch?

Things Could Get Messy

- CheckingAccount
  - double transfer(double amount, CheckingAccount a)
  - double transfer(double amount, SavingsAccount a)
  - double transfer(double amount, CDAccount a)
- SavingsAccount
  - double transfer(double amount, CheckingAccount a)
  - double transfer(double amount, SavingsAccount a)
  - double transfer(double amount, CDAccount a)
- CDAccount
  - double transfer(double amount, CheckingAccount a)
  - double transfer(double amount, SavingsAccount a)
  - double transfer(double amount, CDAccount a)

Polymorphism

- An object of a subclass can be used as an object of the superclass
  - E.g. `Account a = new CheckingAccount( "Chengyu", 10.0);`
- The reverse is not true
  - E.g. `CheckingAccount a = new Account( "Chengyu", 10.0); // Error!`
- Why??

Polymorphism Example

```
public class A {

   public A() {}

   public void afunc()
   {
      System.out.println( "afunc" );
   }
}

public class B extends A {

   public B() {}

   public void bfunc()
   {
      System.out.println( "bfunc" );
   }
}
```

```
A a1 = new A();
B b1 = new B();

A a2 = new B();  // ??
B b2 = new A();  // ??

a2.afunc(); // ??

a2.bfunc(); // ??
```

Polymorphism Example

```
public class A {

   public A() {}

   public void afunc()
   {
      System.out.println( "afunc" );
   }
}

public class B extends A {

   public B() {}

   public void bfunc()
   {
      System.out.println( "bfunc" );
   }
}
```

```
A a1 = new A();
B b1 = new B();

A a2 = new B();  // OK
B b2 = new A();  // Error!

a2.afunc(); // OK

a2.bfunc(); // Error!

((B) a2).bfunc(); // OK

((B) a1).bfunc(); // Error!
```

Dynamic Dispatching

- When multiple implementations of the same method exist due to overriding, which method to invoke is determined by the actual class of the object
- *Dynamic* means the decision is make at runtime (as oppose to compile time)

Dynamic Dispatching Example

```
public class A {

   public A() {}

   public void afunc()
   {
      System.out.println( "afunc" );
   }
}
```

```
public class B extends A {

   public B() {}

   public void afunc()
   {
      System.out.println( "b's afunc" );
   }

   public void bfunc()
   {
      System.out.println( "bfunc" );
   }
}
```

```
A a = new A();
B b = new B();

A a2 = new B();

a.afunc(); // ??
b.afunc(); // ??
a2.afunc(); // ??
```