Lecture 2

Java OOP Revisited

Package in Java

- A package is mapped to a directory

  `utilities/num → utilities.num`

  `java/util → java.util`

- Fully qualified class name
  - FQN = *`package_name.class_name`*
  - Uniquely identifies a class

  `vn.hanu.fit.jsd.HelloWorldApp`

Java CLASSPATH

- Specifies directories for JVM to find classes
- Default value is “.” which is the current directory
- Specified using the JVM option `-cp` or `-classpath`

```
java -cp "D:\area.jar;."
```

- Can be set in the CLASSPATH environment variable (not recommended)

Java Method

- A method is defined in the class to which it belongs
- Method definition consists of *header* and *body*
- Either return a value or `void` (does not return values)
- Invoked using the dot notation:

```
Object_Variable.Method_Name
```

- Return value can be used as an expression:
  - e.g. `int d = date1.getDay();`

Parameters and Arguments

arguments

```
PList obj = new PList();
int age = 24;
Person p = new Person();
obj.add(age, p);
```

parameters

```
class PList {
   public void add(int age, Person p) {

   }
}
```

Parameters and Arguments

- Parameter, a.k.a *formal parameter*:
    - a place holder for input value
    - is used like other local variables
- Argument, a.k.a *actual parameter*:
    - an input value passed in for a parameter
- Parameters and arguments of a method must match:
    - same number
    - param types and arg types must be compatible

Call-by-value rule

- When a method is called:
  - argument values (not arguments) are passed
  - argument and corresponding parameter are two separate variables
- Affects primitive and reference-type arguments differently (how?)

`this` parameter

- An implicit (hidden) parameter available to all methods of a class
- Used to explicilty refer to other instance variables and methods
- The current object is plugged in for `this`

```
public void setDate(int month, int day, int year) {
   this.month = monthString(month);
   this.day = day;
   this.year = year;
}
```

Information hiding and encapsulation

- **Information hiding:** hide internal design details of a class from others
  - a.k.a. separate implementation details from specification
  - modification of implementation does not affect client code
- **Encapsulation:** put data and methods that operate on that data in a single unit
  - Task: to design suitable interface methods of a class
  - observers, mutators, constructors...

Access modifiers

- Access modifiers: `public`, `private`, `protected`
- `public`: no restrictions on where a member (variable or method) may be used
  - used for interface methods
- `private`: cannot be accessed outside of its class
  - used for instance variables
- `protected`: accessible from inside and from sub-classes
- Omitted: default (package) access, accessible from inside class, and other classes in the same package

Copy constructor

- A constructor that creates an object using another object of the same class

```
public class Employee {
   private int id;
   private String name;
   public Employee(Employee employee) {
      this.id = employee.id;
      this.name = employee.name;
   }
}
```

`final` class & methods

- A `final` class is a class that can’t be extended
- A `final` method is a method that can’t be overridden by subclasses

Immutable Class

- Class is declared as `final` so that it can’t be extended
- All fields should be `private` to block direct access to them
- No mutators (setters)
- All mutable fields declared as `final` (constant)
- Immutable classes are thread-safe
- Thread safety
  - A class is thread-safe if its instances functions correctly during simultaneous execution by multiple threads

Static members (variables & methods)

- Belong to the class, not its instances
- Are invoked via the class name
  - Therefore, they’re shared to all instances of the class
- Defined with the keyword `static`
  - Static variables are automatically initialized with default values
- Can only access other `static` members
  - Cannot access instance members (incl. `this`)

Other concepts

- Class, variables, methods
- Comments & javadoc
- Preconditions and postconditions
- Method overloading
- Object cloning
- Mutable and immutable classes

Inner class

- A class defined within another class
  - the enclosing class is the outer class
- Considered a member of the outer class
- Used as a helper class
  - implement some aspects of the outer class
- Has full access to members of the outer class
  - and vice versa

Inner class example

```
public class BankAccount {
    private Money balance;
    public BankAccount() {
        balance = new Money("0.00");
    }
    public String getBalance() {
        return balance.getAmount();
    }
    private class Money {
        private long dollars;
        private int cents;
        public Money(String stringAmount) {
            // ...code omitted...
        }
    } // end Money
}
```

More about inner classes

- Static inner class
- Public inner class
- Nesting inner class

Static inner class

- Defined by including the `static` modifier in the class header
- Unlike (non-static) inner classes which allow us to access its outer class’ members, static inner classes <u>do not</u> allow that
    - i.e. an object of a static inner class has no connection to an object of the outer class

public inner class

- Defined with the `public` modifier instead of the `private` modifier
- Can be used outside of the outer class
- To create an object of the public inner class, you must start with an object of its outer class.

```
BankAccount.Money amount =
        account.new Money("41.99");
```

Nesting inner classes

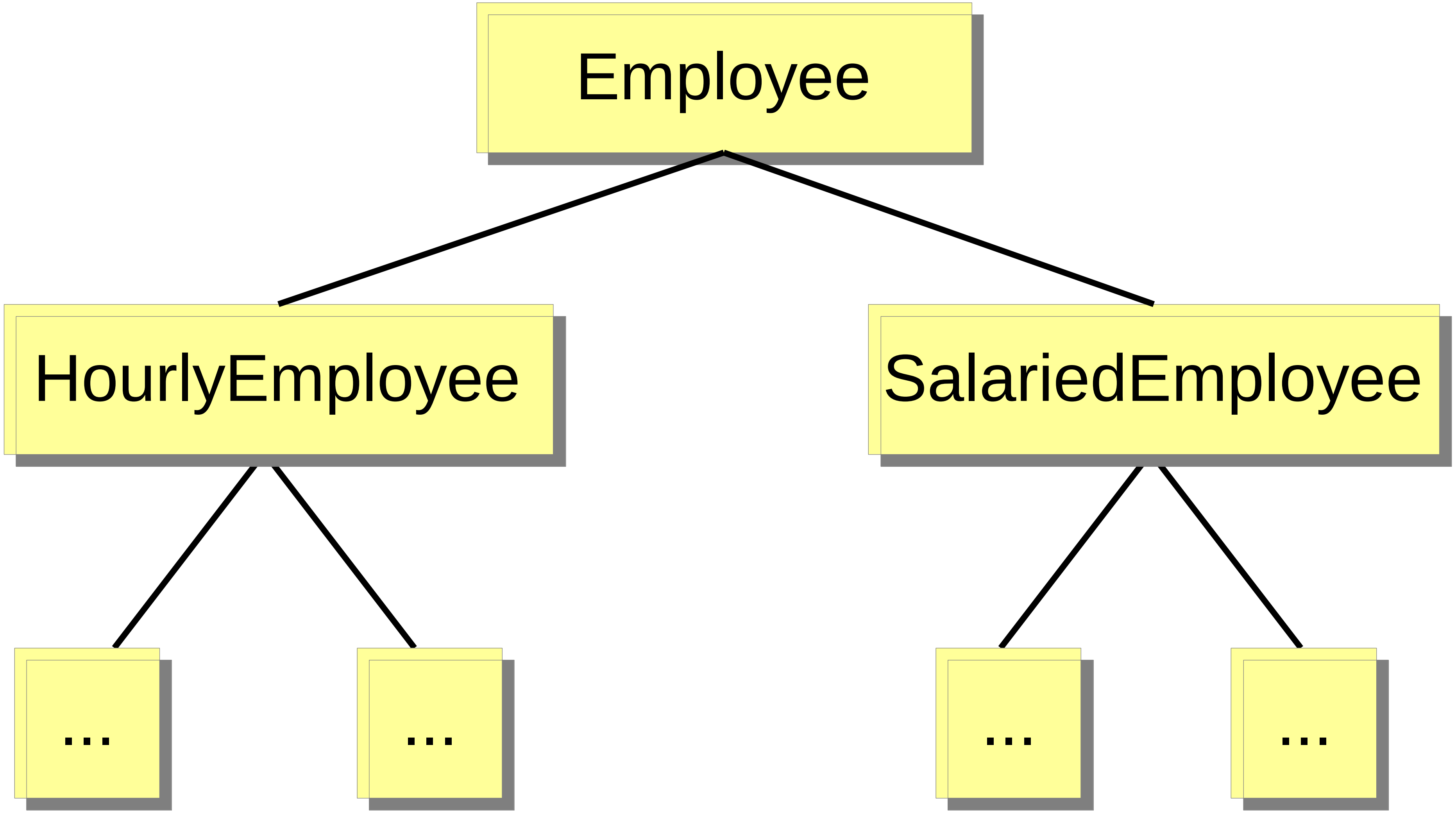
- It is legal to nest inner classes within inner classes
- E.g. If A has a public inner class B, and B has a public inner class C, then the following is valid code:

```
A aObject = new A();
A.B bObject =
    aObject.new B();
A.B.C cObject =
    bObject.new C();
```

Inheritance

- A new (sub) class is derived from another (super) class
  - superclass is the base class
- Subclass has (or inherits) all members of the superclass
- Subclass access non-static members of superclass using `super`
- A subclass object has multiple types:
  - subclass, superclass, and other ancestors of the superclass

Inheritance hierarchy


Employee

HourlyEmployee

SalariedEmployee

...

...

...

...

Inheritance & encapsulation

- `private` members are inherited but not directly accessible in the subclass
- Example:

```
joe.setName("Josephine"); // ok

joe.getName(); // ok

joe.name = "Josephine"; // error
```

- To allow access in a subclass, use `protected`
  - for setters/getters (rather than for variables)

Method overriding

- Subclass overrides a superclass method with:
  - same name and parameter list, compatible return type (and exceptions)
- Return type can be a subclass or a descendant

Method overriding

- Access modifier can be “wider” but not “narrower”
  - e.g. `private` → `default`, `protected` or `public`, etc.

```
public class BaseClass {
   protected Employee getSomeone(int someKey) {
      // code omitted
   }
}

public class DerivedClass extends BaseClass {
   private HourlyEmployee getSomeone(int someKey){
      // code omitted
   } // error
}
```

Constructor overloading

- Constructors of the same class can overload
- Overloading constructor invokes another using `this`
    - must be the first line

```
// default constructor
public HourlEmployee() {
   this("No name", new Date("January", 1, 1000), 0, 0);
}
```

The `super` constructor

- May be invoked by a constructor of a subclass
- The default constructor, `super()`, is invoked by default
- Other constructors need to be invoked explicitly if required
- The `super` call must be the first line in the subclass constructor
- Cannot use subclass’ instance variables as arguments

Example

```java
public class HourlyEmployee {
    public HourlyEmployee(String theName, Date theDate,
                          double theWageRate, double theHours) {
        super(theName, theDate);
        // ...
    }
}
```

Polymorphism (`i`)

- Applied to classes in an inheritance hierarchy
- Means “multiple forms”:
  - a superclass variable can refer to any subclass object
- Used to define *polymorphic methods*:
  - parameter type is a superclass
  - invoked with a subclass object

Polymorphic method example (1)

```
public class Sale {
   private String name; // A nonempty string private
   double price;        // nonnegative
   ...
   public double bill() {
      return price;
   }
   public boolean lessThan(Sale other) {
      ...
      return (bill() < other.bill());
   }
   ...
}
```

Polymorphic method example (2)

```
public class DiscountSale extends Sale {
   private double discount;
   ...
   public double bill() {
      double fraction = discount / 100;
      return (1 - fraction) * getPrice();
   }
   ...
}
```

Polymorphic method example (3)

```
public class Sale {
   private String name; // A nonempty string private
   double price;        // nonnegative
   ...
   public double bill() {
      return price;
   }
   public boolean lessThan(Sale other) {
      ...
      return (bill() < other.bill());
   }
   ...
}
```

Polymorphic method

Polymorphism (`ii`)

- Polymorphic methods have multiple behaviors
  - depending on the actual type of input object
- *Polymorphic call* is an invocation of a polymorphic method
  - a superclass variable can refer to any subclass object
- Late binding:
  - method definition is determined at run-time based on the actual type of the object invoked
  - Late binding does not apply to `final` methods

Late binding example

```
public class Sale {
   private String name; // A nonempty string private
   double price; // nonnegative
   ...
   public double bill() {
      return price;
   }
   public boolean lessThan(Sale other) {
      ...
      return (bill() < other.bill());
   }
   ...
```

late binding

Static binding

- Binding at compile-time (when code is compiled)
- Static binding is applied to these members:

  `private`, `static`, and `final`
- `private` methods are local and thus cannot take different meanings at run-time
- `static` methods are bound to the class and thus cannot take different meanings
- Members or classes marked with `final` cannot be overridden

Other concepts

- Abstract vs. concrete class
- Interface, interface implementation, multiple inheritance
- Anonymous class