Lab 3: Inheritance, Hash, Design Pattern and Big Number

Objectives

- Learn how to use inheritance concept in Java programming
- Learn how to use interface concept in Java programming
- Learn the importance of `equals` and `hashCode`
- Get familiar with Java design patterns
- Learn how to calculate with big numbers in Java

Source files

- Printable.java
- SalaryRaisable.java
- JavaDPExample.java

1 Introduction

1.1 Inheritance in Java

Different kinds of objects often have a certain amount in common with each other. Employees, customers, and managers, for example, all share the characteristics of a person (name, etc.). Yet each also defines additional features that make it different. Object-oriented programming allows such different classes to inherit commonly used state and behavior from other classes. In this example, `Person` is the superclass of `Employee` and `Customer`; `Employee` is the super class of `SwEngineer` and `HwEngineer`; `SwEngineer` is the superclass of `ProjectManager`.

In Java, each class is allowed to **have and only have one direct superclass**, and each superclass has the potential for an unlimited number of subclasses. A subclass contains all the methods (functions) and attributes (variables) defined in the superclass plus the subclass's own methods and variables.

Java implements inheritance through the `extends` keyword.

Example: a software engineer has all the attributes of an employee plus attributes picked up from a person, which means the software engineer is an employee, and an employee is a person, and therefore the software engineer is also a person. In Java we would represent this as:

```
class SwEngineer extends Employee
class Employee extends Person
```

By doing so, `SwEngineer` gets all the attributes and methods defined in: `SwEngineer`, `Employee` and `Person`.

NOTE: A method is usually `public`/`private`. An attribute is usually `private`, meaning that it cannot be directly accessed outside of the class. A "getter" and "setter" method enables such access. For example:

```
Person person = new Person();
person.setName("John Doe");
int age = person.getAge();
```

1.2 Interface

Interfaces define a standardized set of commands that a class will obey. The commands are a set of methods. The interface definition states: the names of the methods; the return types; and the signatures (argument lists). There is no executable body for any method. The body is left to each class to implement.

A class can implement **multiple interfaces**. Once a class implements an interface, you are able to invoke the corresponding method. That is, implementing an interface enables a class to be "plugged in" to any situation that requires a specific behavior (manifested through the set of methods).

Java implements interface through the `implements` keyword.

```
interface SalaryRaisable {
    public double RaiseSalary();
}

class Employee implements SalaryRaisable {
    double baseSalary;
    @Override
    public double RaiseSalary() {
        return baseSalary *= 1.2;
    }
}
```

2 Deliverable 1 -- Inheritance and Interfaces

In this part you will write a program to represent people who are involved in a software production company (name, department, related projects...), as mentioned at the beginning of this lab.

Step 1: create classes

Please refer to the following *UML class diagram*. Your program will **only** have the classes and interfaces mentioned in the diagram (you can put the main entry `public static void main(String[] args)` and test cases anywhere you like), where the two interfaces `Printable` and `SalaryRaisable` are already provided. Also, your classes will **only** have the attributes and methods mentioned in the diagram.

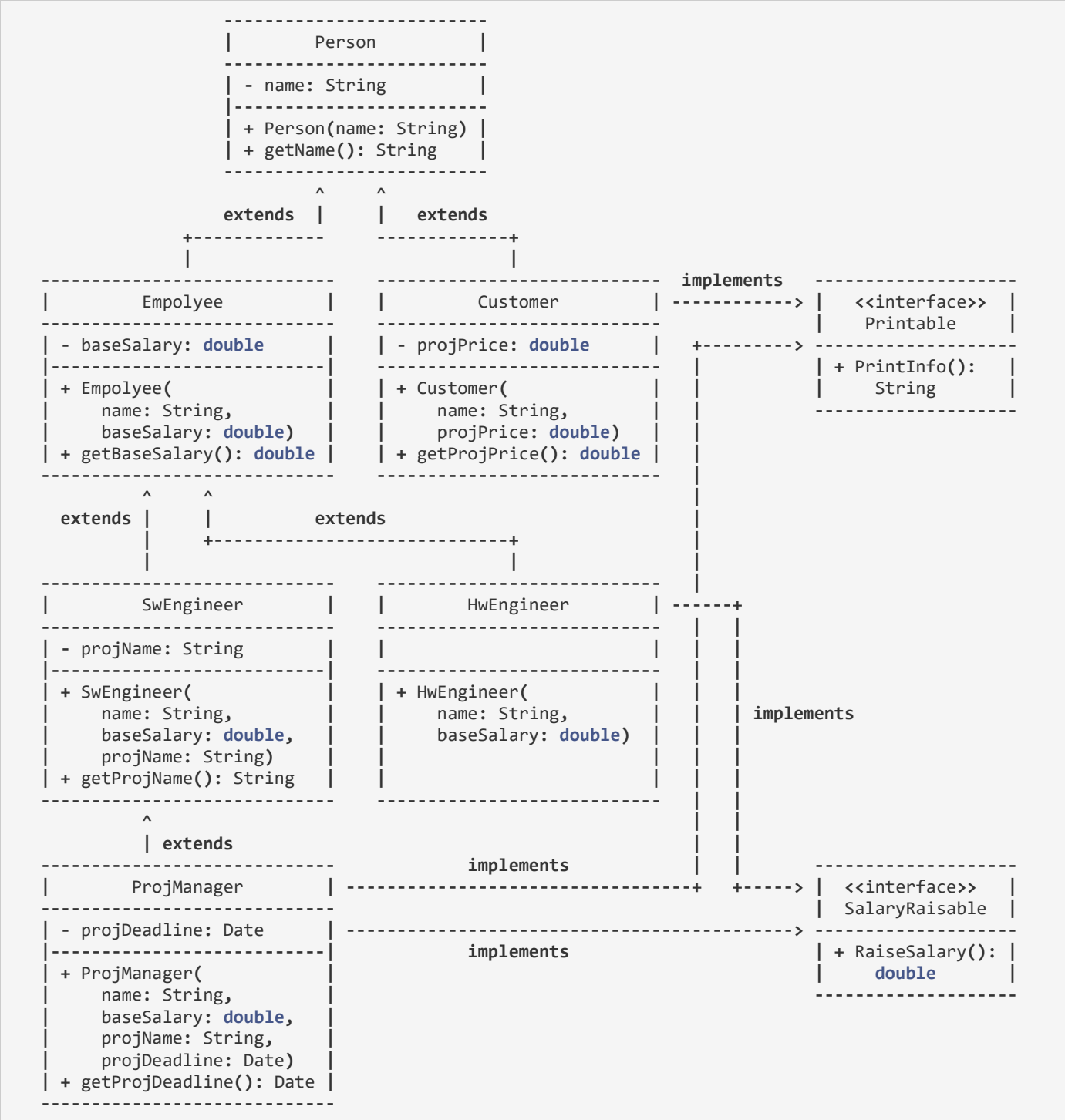
HINT: You can use `super` to call the constructor of the super class.

Step 2: implement `SalaryRaisable`

The `RaiseSalary` method raises the salary in a certain rate and returns the raised salary amount:

Role	Rate
`HwEngineer`	0.18
`ProjManager`	0.24

Create an instance of `HwEngineer` with base salary of $3000, and an instance of `ProjManager` with base salary of $6000. Display their final (raised) salaries -- they should be different.



Step 3: implement `PrintInfo`

The printed information shall be:

- `Customer`: name + project price;
- `ProjManager`: name + project name + final salary + project deadline.

DEMO this deliverable to the lab instructor.

3 Deliverable 2 -- `equals` and `hashCode`

Comparison is a common activity, hence nearly every class has its own definition of `equals` and `hashCode`.

Override the two methods for `SwEngineer` and `ProjManager`. Your implementations must follow the best practice as discussed in the lecture.

Note 1: even if you only need a customized `equals`, you still need to override `hashCode` -- this is important.

Note 2: if you override `equals` and `hashCode` of a subclass, you may need to override the superclass, too. This is because the hash code of the subclass relies on that of its superclass.

DEMO this deliverable to the lab instructor.

4 Deliverable 3 -- Java Design Pattern

Consider the code from *JavaDPExample.java* and provide answers to these questions (google useful clues if you need):

1. Why do we use a static method in this situation?
2. The code implements a class-level (involving multiple classes) programming "good practice", commonly these practices are called design patterns in Java. Which design pattern is implemented?
3. Explain why this is considered a good practice.

DISCUSS this deliverable with the lab instructor.

5 Deliverable 4 -- Big Numbers

Consider the following piece of C code. What is it doing? Convert it into Java codes.

```
uint64_t fnv(void *b, int c) {
    unsigned char *p = b;
    uint64_t h = 14695981039346656037;
    int i;
    for (i = 0; i < c; i++)
        h = (h * 1099511628211) ^ p[i];
    return h;
}
```

Hint 1: `h` is too big even for `long`, because Java doesn't have unsigned version of `int`/`long`. So you may need `BigInteger`.

Hint 2: `^` in C is "bitwise AND", not `Math.pow`.

Hint 3: Don't forget the overflow of higher bits, or you may get incredibly large number. Such number is incorrect, and what's more, it may crash Eclipse.

Demo and discuss this deliverable with the lab instructor.