Advanced Programming

Lecture 5: Inheritance

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Reusable sorting revisited

```
public class Student implements Keyable {
  private String name;
  private int nr;
  public int getKey() {
    return name.length();
  }
}

public class Teacher implements Keyable {
  private String name;
  private String position;
  public int getKey() {
    return name.length();
  }
}
```

Inheritance

- A class can extend another one and add/redefine functionality
- The inheriting class is called the **subclass** and the inherited **superclass**

```
public class Person implements Keyable {
  private String name;
  public Person(String name) {
    this.name = name;
  }
  public int getKey() {
    return name.length();
  }
  public String getName() {
    return name;
  }
}

public class Student extends Person {
  private int nr;
  ...
  public int getNr() {
    return nr;
  }
}
```

```
public class Teacher extends Person {
  private String position;

  ...

  public String getPosition() {
    return position;
  }
}
```

Subclass construction

```
public class Person {
   ...
   public Person(String name) { this.name = name; }
}
public class Student extends Person {
   public Student(String name, int nr) {
      super(name);
      this.nr = nr;
   }
}
```

- Construction starts by calling the most highest level class (`Object`) constructor, then its subclass, etc
- You can define the constructor of the superclass to call with `super()`, but this has to be the first line in the constructor
- If no `super` is called explicitly, the default constructor `super()` is executed

Overriding

```
public class NumberedPerson extends Person {
  private int nr;
  ...
  public String getName() {
    return Integer.toString(nr) + ":"
    + super.getName();
  }
}
```

- `this` = the current object
- `super` = the extended class
- You cannot refer higher than 1 level in the inheritance hierarchy
- You can widen the access specification (e.g. `private` to `public`) but not the other way around

Polymorphism and inheritance

```
Person p = new Student("tommi");
Student s = (Student) p; // ok, as p is a Student
Keyable k = s; // ok
```

- Polymorphism works with inheritance just like it does with interfaces
- In addition, with inheritance you can re-define functionality used in superclasses

Dynamic binding: example

```
public class Sum {
  protected double a;
  public Sum(double a) {
    this.a = a;
  }
  public double getSum(double b) {
    return getVal() + b;
  }
  protected double getVal() { return a; }
}
public class SquareSum extends Sum {
  public SquareSum(double a)
  { super(a); }
  protected double getVal() {
    return a * a;
  }
}
```

Inheritance interface and `protected`

- Subclass inherits all `public` and `protected` methods and fields
- `protected` access specifier defines the fields/methods to be accessible from sub-classes
- **Inheritance interface**: `public` and `protected` methods and fields

Abstract classes

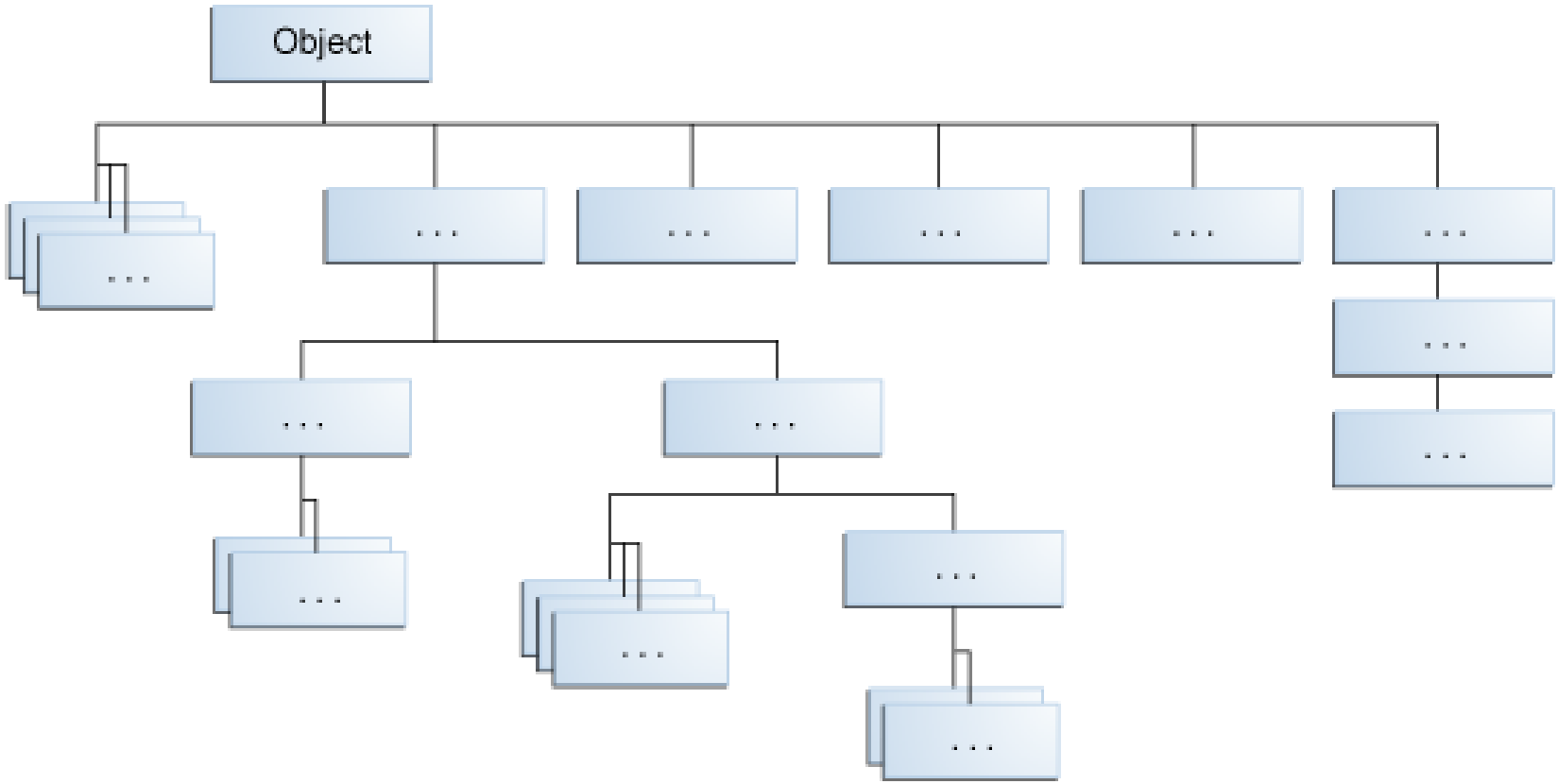
```
public abstract class MCSampler {
  protected int misses;
  ...
  // public interface sampling method
  public Sample sample() {
    misses = 0;
    return doSample();
  }
  // actual sampling method: inheritance interface
  protected abstract Sample doSample();
  // hit function
  protected boolean isHit(Sample s) { ... }
}
```

- Can leave some of the implementation to be defined in the subclasses
- Cannot be instantiated (like interfaces)

```
public class RejectionSampler extends MCSampler {
  ...
  protected Sample doSample() {
    while (true) {
      Sample s = drawSample();
      if (isHit(s)) {
        return s;
      } else {
        misses++;
      }
    }
  }
  private Sample drawSample() { ... }
  ...
}
```

```
public class MCMCSampler extends MCSampler {
  private Sample curSample;
  ...
  protected Sample doSample() {
    Sample newSample = drawMCMCSample(prevSample);
    if (isHit(newSample)) {
      curSample = newSample;
    } else {
      misses++;
    }
    return curSample;
  }
  private Sample drawMCMCSample(Sample s) { ... }
  ...
}
```

Inheritance hierarchies



(Super)$^{\infty}$ class `Object`

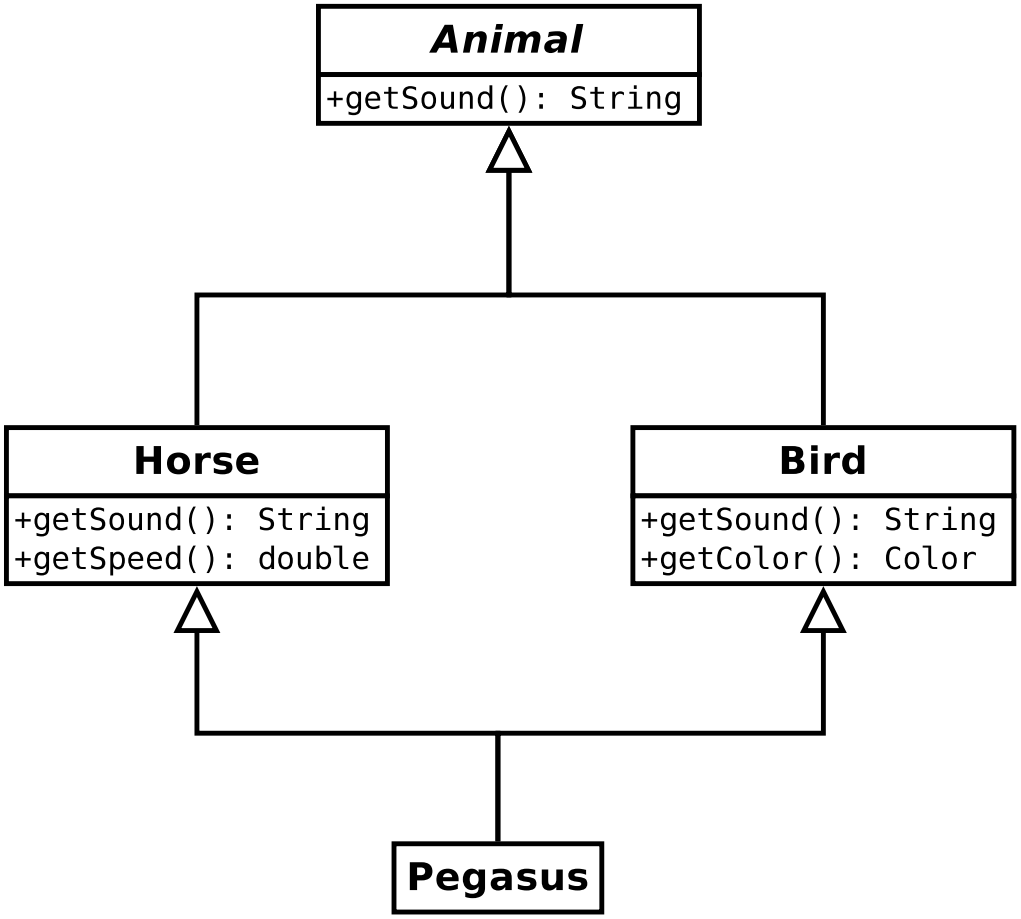
- All objects inherit `Object` implicitly unless they inherit another class
- `Object` defines a few useful methods you can override that are used widely in the standard library:
  - `public String toString()` - for obtaining the object's `String` representation
  - `protected clone()` - makes a shallow copy of the object. Can be overriden to provide an implementation. DO NOT USE.
  - `public boolean equals(Object other)` - returns `true` if this object is equal to `other`, false otherwise (implementation in `Object` is of reference equality)
  - `public int hashCode()` - gives hash value of the object, used in e.g. hash maps of the standard library (next lecture)

Inheritance in exceptions

- Unchecked exceptions extend `RuntimeException` or `Error`
- Checked exceptions extend `Exception` (but not `RuntimeException`)
- Thus your own checked exceptions should extend `Exception`:

```
public class MyException extends Exception {
  public MyException(String reason) {
    super(reason);
  }
  public MyException() {
    // super() called implicitly
  }
}
```

Multiple inheritance



- Not allowed in Java
- Use interfaces instead - you can extend only 1 class but implement multiple interfaces

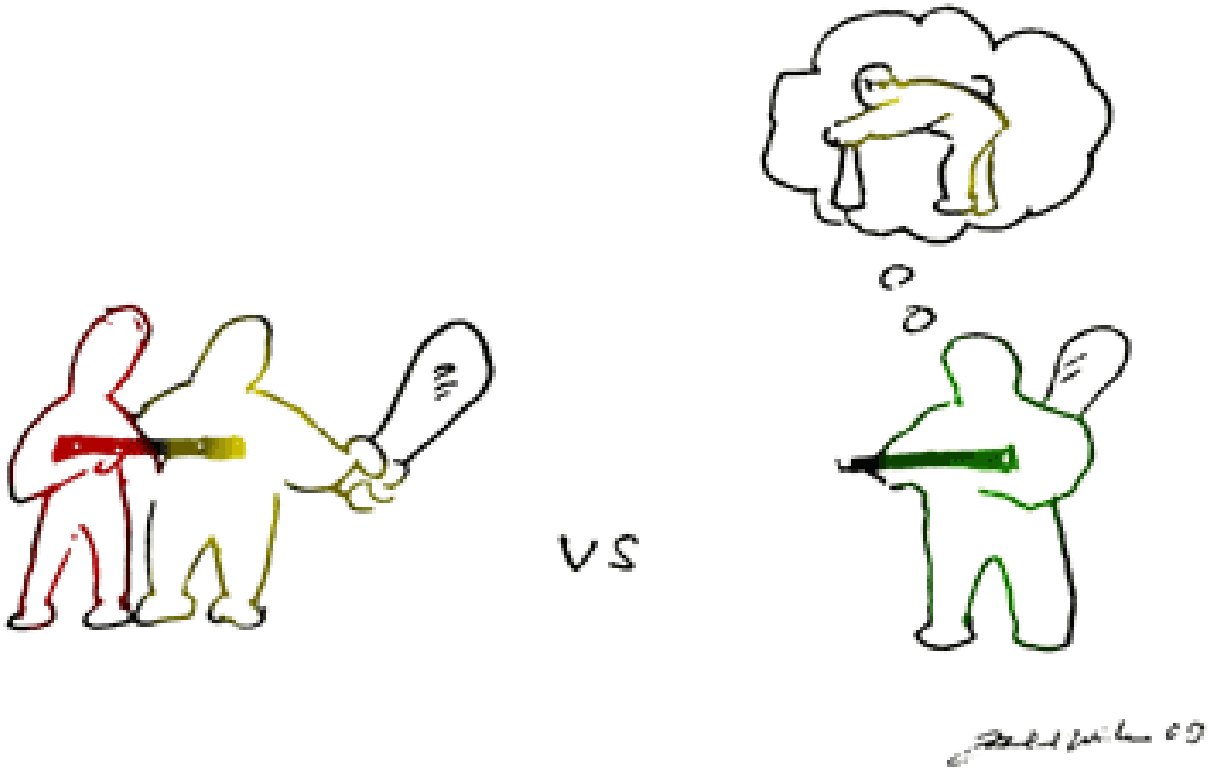
Inheritance with interfaces

```
public interface Collection {
  public void add(Object o);
  public void remove(Object o);
}

public interface List extends Collection {
  public void add(int index, Object o);
  public void remove(int index);
}
```

- Simply adds methods to be implemented (+ type information)

Inheritance vs composition



- You can in many cases choose between inheritance (is-a) and composition (has-a)
- Inheritance is not a silver bullet

Next exercise