Software Development (cs2500)

Lecture 23: Creating Classes from Other Classes

M. R. C. van Dongen

November 15, 2013

Introduction

Chair Wars Revisited

Inheritance

Fota Challenge

For Monday

About this Document

Outline

- Today we shall study *inheritance*.
    - With inheritance you can share common code.
    - The common code is written in a common superclass.
    - The common superclass implements common behaviour.
    - Subclasses inherit common behaviour from their superclass.
- We shall carry out two case studies.

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Chair Wars Revisited

- Remember Larry and Brad?
- Brad's final solution had five classes:
  - One `Shape` *superclass* for default, common shape behaviour.
  - A dedicated class for each actual shape.
  - Each dedicated class was a *subclass* of the `Shape` class.
  - All, except for `Amoeba`, inherited all behaviour from `Shape`.
  - `Amoeba` *overrode* behaviour for `playSound`, and `rotate`.
  - This let `Amoeba` objects do things differently.
- Larry thought Brad's final class had lots of duplicated code:
  - "Your classes have same code for `playSound` and `rotate`."
  - "This makes it impossible to maintain your code."
  - "For each change, you need to edit 4 classes."
    - Editing *n* class files is *n* times more work than editing 1 file.
    - Each edit increases the probability of errors: more errors.
- But then Brad explained his design.

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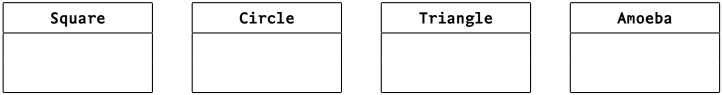
Brad's Final Design



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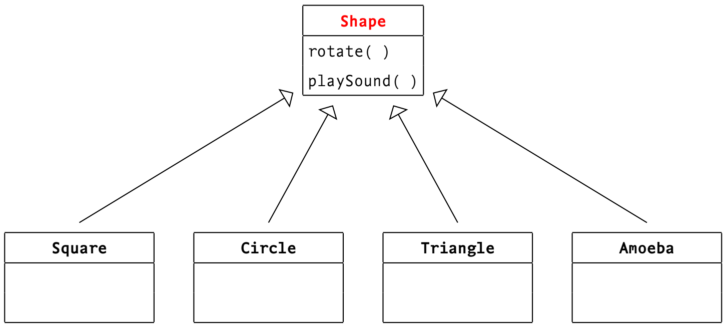

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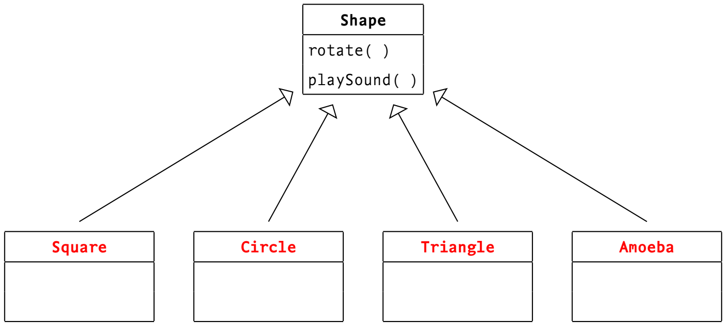
Subclasses



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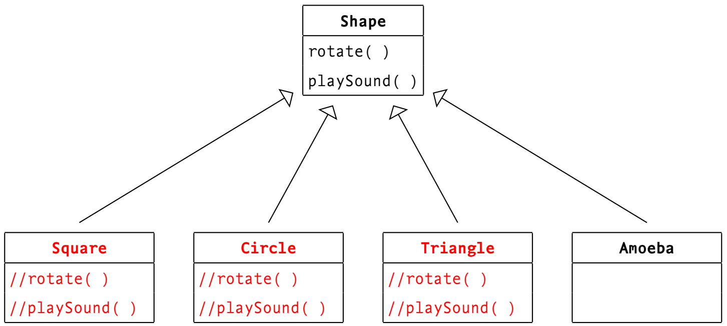

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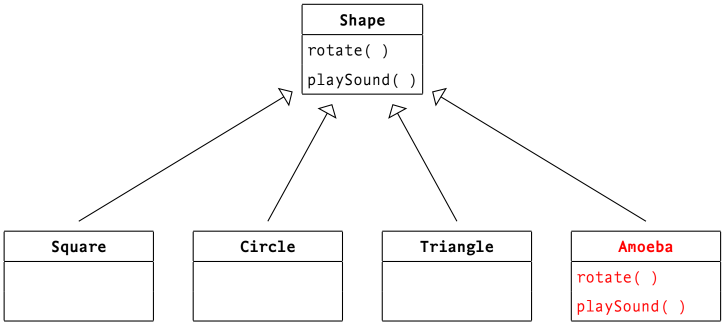

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Inheritance

- There are two main advantages of *inheritance*:
  - Increases ability to reuse implementation effort.
  - Separates class-specific from general code.
- Code is structured in classes so as to maximise reuse.
- *Common* code is put in a common, *more abstract* class.
- The common, more abstract class is called the *superclass*.
- The code in the superclass is shared by *subclasses*.
- The subclasses are more *specific:*
  - Subclass provides same functionality as its superclass.
  - So if the superclass has a method then so does the subclass.
  - Here, the subclass *inherits* the method from its superclass.
  - However, the subclass functionality may be more *specific.*
    - E.g., the subclass may implement a method in a *different* way.
    - Here, the subclass *overrides* the method of its superclass.
  - Subclasses may also have more specific, *additional* behaviour.
- A subclass is said to *extend* its superclass.

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Example

- Let's suppose we have a `Surgeon` and a `GP` class.
- Let's also suppose we have a `Doctor` class.
- *Both* `Surgeons` and `GPs` are `Doctors`, they are more specific:
  - A `Surgeon` *is-a* `Doctor`.
  - A `GP` *is-a* `Doctor`.
  - So the `Surgeon` and `GP` classes *extend* the `Doctor` class.
- *Both* have a method called `treatPatient( )`.
  - *Any* `Doctor` has it.
- *Both* have a property `worksAtHospital` (a `boolean`).
  - *Any* `Doctor` has it.
  - For a `Surgeon` it is `true`.
  - For a `GP` it is `false`.
- `Surgeons` and `GPs` differ from `Doctors` *in general*:

Surgeon:	Has additional `makeIncision( )` method.
	Has *special* implementation for `treatPatient`.
	Overrides default `treatPatient( )` implementation.
GP:	Has additional attribute `makesHouseCalls`.
	Has additional method `giveAdvice( )`.

Example Continued
The Common, More General Code

- We put the *more general* code in the `Doctor` class.
- This is the code that *any* `Doctor` should have:
  - `Surgeons` and `GPs` in particular.

Java

```java
public class Doctor {
    public boolean worksAtHospital;

    public void treatPatient( ) {
        // Default patient treatment.
    }




}
```

Example Continued

The Common, More General Code: Did we Forget Anything?

- We put the *more general* code in the `Doctor` class.
- This is the code that *any* `Doctor` should have:
  - `Surgeon`s and `GP`s in particular.

Java

```java
public class Doctor {
    public boolean worksAtHospital;

    public void treatPatient( ) {
        // Default patient treatment.
    }




}
```

Example Continued

The Common, More General Code: Think of Something Any Doctor Does

- We put the *more general* code in the `Doctor` class.
- This is the code that *any* `Doctor` should have:
    - `Surgeon`s and `GP`s in particular.

Java

```java
public class Doctor {
    public boolean worksAtHospital;

    public void treatPatient( ) {
        // Default patient treatment.
    }




}
```

Example Continued

The Common, More General Code: Right!

- We put the *more general* code in the `Doctor` class.
- This is the code that *any* `Doctor` should have:
    - `Surgeon`s and `GP`s in particular.

Java

```
public class Doctor {
    public boolean worksAtHospital;

    public void treatPatient( ) {
        // Default patient treatment.
    }

    public void chargePatient( ) {
        // Let's face it, they all do.
    }
}
```

Example Continued

The More Specific Code: The Surgeon Class

Java

```
public class Surgeon extends Doctor {
    public Surgeon( ) {
        worksAtHospital = true;
    }

    @Override
    public void treatPatient( ) {
        // Specific patient treatment.
    }

    public void makeIncision( ) {
        // Additional behaviour.
    }
}
```

Example Continued

The More Specific Code: The GP Class

Java

```java
public class GP extends Doctor {
    public boolean makesHouseCalls;

    public GP( boolean makesHouseCalls ) {
        worksAtHospital = false;
        this.makesHouseCalls = makesHouseCalls;
    }

    public void giveAdvice( ) {
        // Additional behaviour.
    }
}
```

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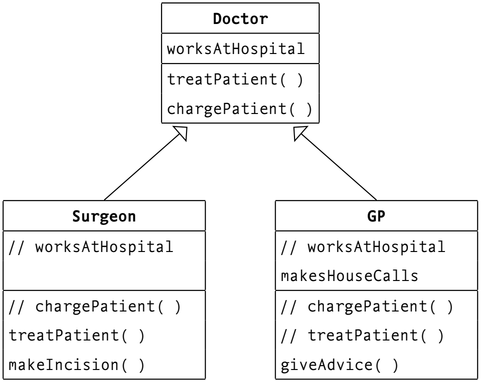

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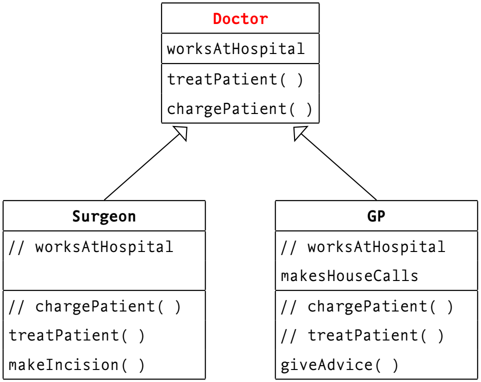
Superclass



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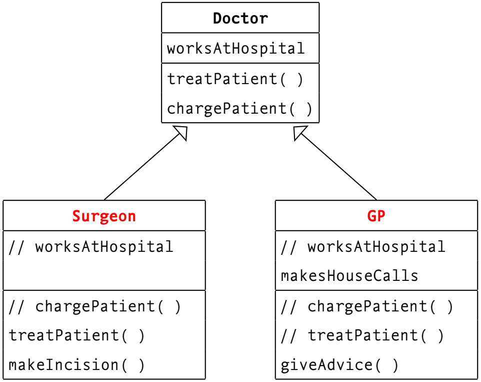

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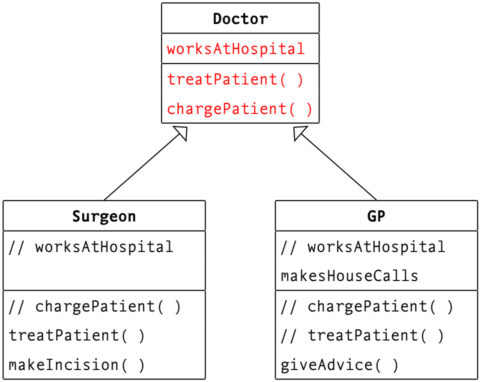

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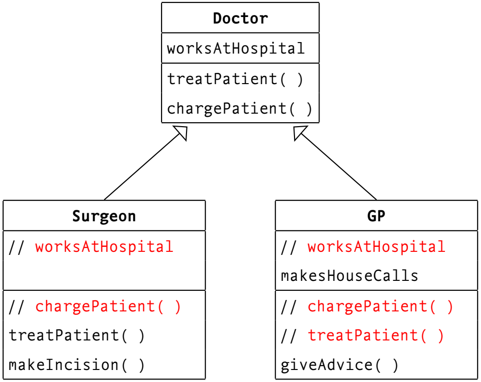

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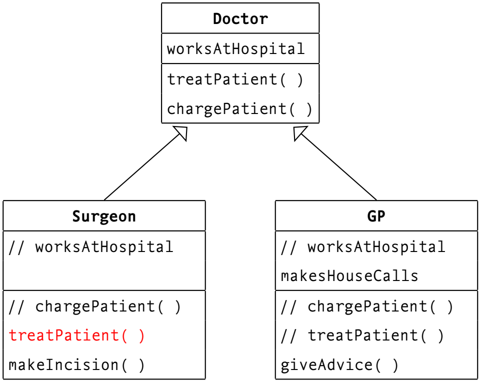

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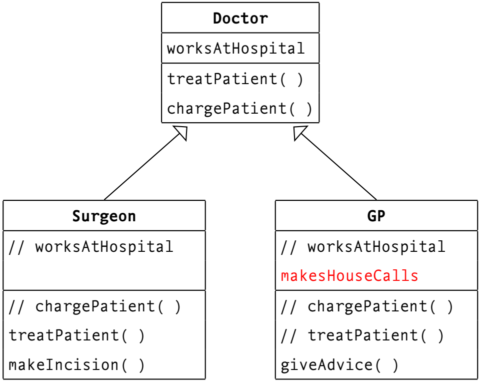
Specific Attribute



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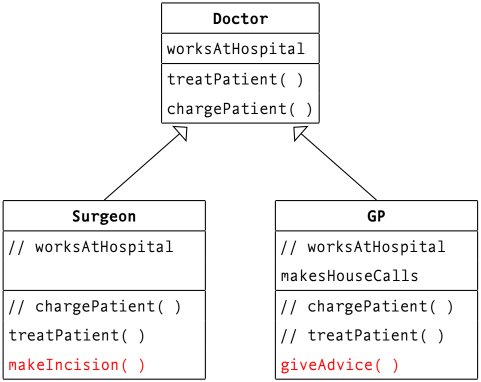
Specific Methods



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The Fota Challenge

A Play in Four Acts

Act I:	The Challenge.
Act II:	Larry Presents his Solution.
Act III:	Brad Presents his Solution.
Act IV:	Collecting the prize.

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The Spec

- Fota Wildlife Park has lots of animals:
  - A lion;
  - A cat;
  - A wolf;
  - A tiger;
  - A dog; and
  - They’re expecting a hippo.
- Each animal:
  - Has a picture `String`;
  - Has a certain kind of food: grass or meat;
  - Has an integer hunger level;
  - Eats;
  - Makes noise; and
  - Has a roaming behaviour.

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Act I: The Challenge

Oh yeah.

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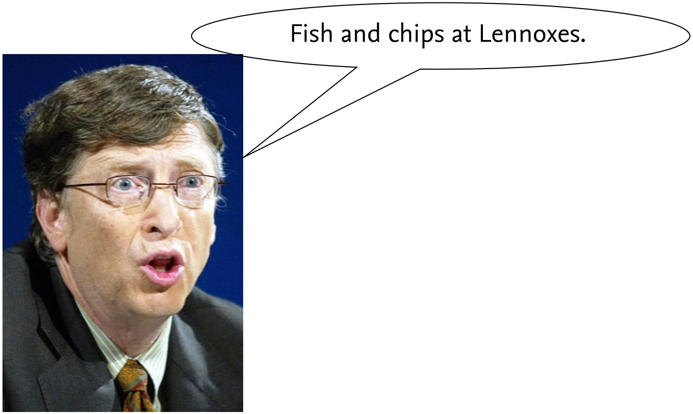

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Introducing the Contestants: Meet Larry

- Larry has been taking `Java` lessons with Amy.
- He has just started learning about inheritance.
- He knows inheritance is the key to solving this problem.
- He just knows he will beat Brad.

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Introducing the Contestants: Meet Brad

- Brad is just delighted with this application.
- This is a textbook example of an inheritance application.
- He knows this can't be too difficult.

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Meanwhile in Larry's Cubicle

- Larry quickly identifies the objects: the animals.
- Following Brad's example, he creates an `Animal` class.
- He puts all the common methods and attributes in this class.

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Meanwhile in Larry's Cubicle

- Larry quickly identifies the objects: the animals.
- Following Brad's example, he creates an `Animal` class.
- He puts all the common methods and attributes in this class.

Java

```
public class Animal {
    public String  picture;
    public boolean eatsGrass;
    public int     hunger;

    ⟨more⟩
}
```

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Meanwhile in Larry’s Cubicle

Java

```
public Animal( String picture,
               boolean eatsGrass,
               int hunger ) {
    this.picture   = picture;
    this.eatsGrass = eatsGrass;
    this.hunger    = hunger;
}

public void eat( ) {           // Default eating behaviour.
    System.out.println( "Eating " + hunger + " portions of " + food( ) + "." );
}
private String food( ) {
    return (eatsGrass ? "grass" : "meat");
}
public void makeNoise( ) { } // Should be overridden.
public void roam( ) { }      // Should be overridden.
public String toString( ) {
    ⟨omitted⟩
}
```

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Meanwhile in Larry's Cubicle

Java

```
public class Hippo extends Animal {
    private static final int HIPPO_HUNGER_LEVEL = 10;
    private static final String HIPPO_PICTURE = "hippo.jpg";

    public Hippo( ) {
        picture = HIPPO_PICTURE;
        eatsGrass = true;
        hunger = HIPPO_HUNGER_LEVEL;
    }

    public void roam( ) {
        System.out.println( "I'm Lazy: not roaming." );
    }

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

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Meanwhile in Larry's Cubicle

Java

```
import java.util.ArrayList;

public class Main {
    public static void main( String[] args ) {
        ArrayList<Animal> animals = new ArrayList<Animal>( );

        animals.add( new Dog( ) );
        animals.add( new Cat( ) );
        animals.add( new Hippo( ) );
        for (Animal animal : animals) {
            System.out.println( "next: " + animal );
            animal.roam( );
            animal.eat( );
            animal.makeNoise( );
        }
    }
}
```

Larry Presents His Solution

Unix Session

```
$
```

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```
$ java Main
```

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```
$ java Main
next: Animal[ picture = dog.jpg, eatsGrass = meat, hunger = 4 ]
Roaming in my pack.
Eating 4 portions of meat.
Arf. Arf.
next: Animal[ picture = cat.jpg, eatsGrass = meat, hunger = 1 ]
Roaming alone.
Eating 1 portions of meat.
Mew. Mew.
next: Animal[ picture = hippo.jpg, eatsGrass = grass, hunger = 10 ]
I'm Lazy: not roaming.
Eating 10 portions of grass.
```

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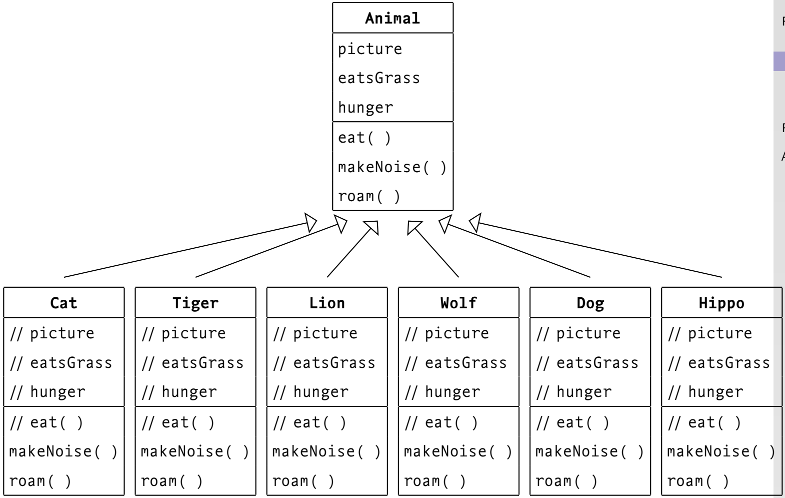

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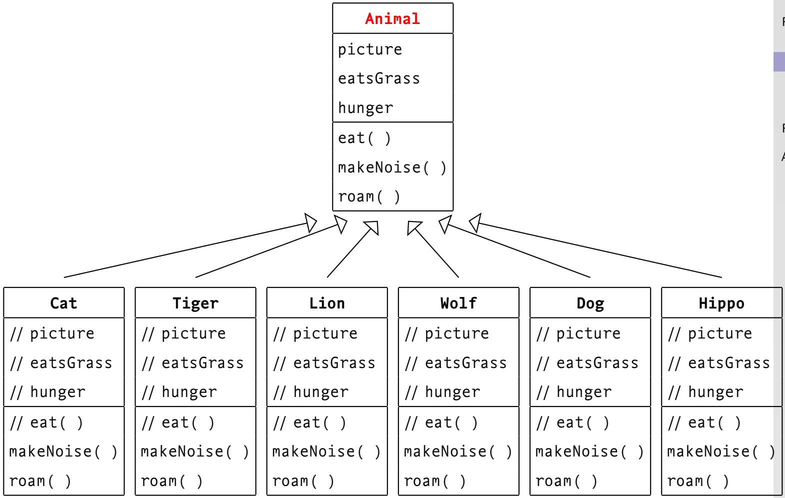

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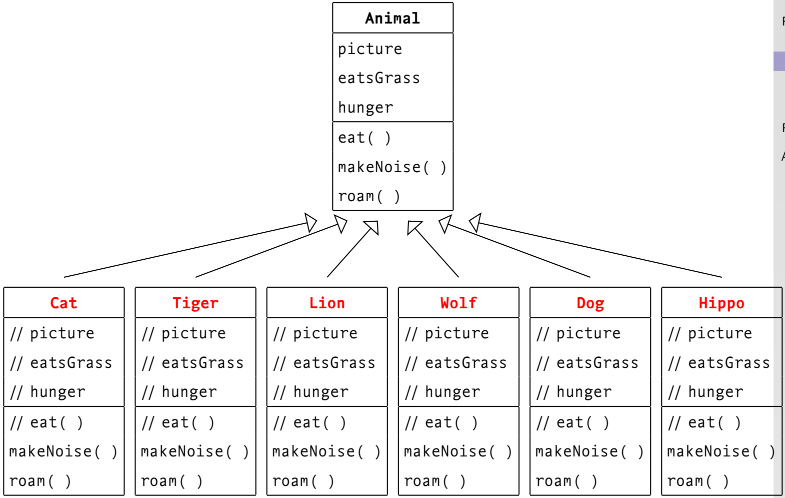

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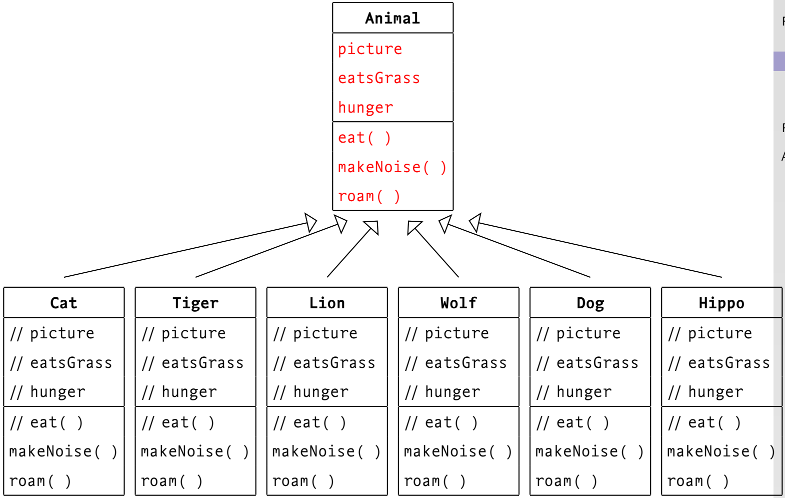

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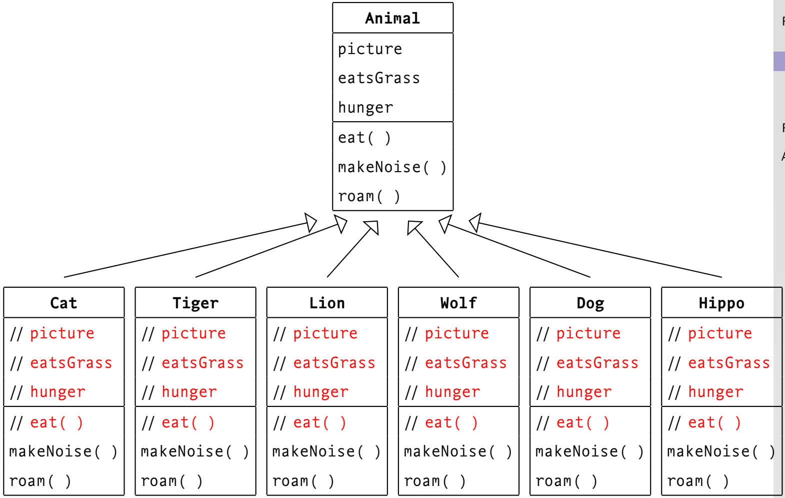

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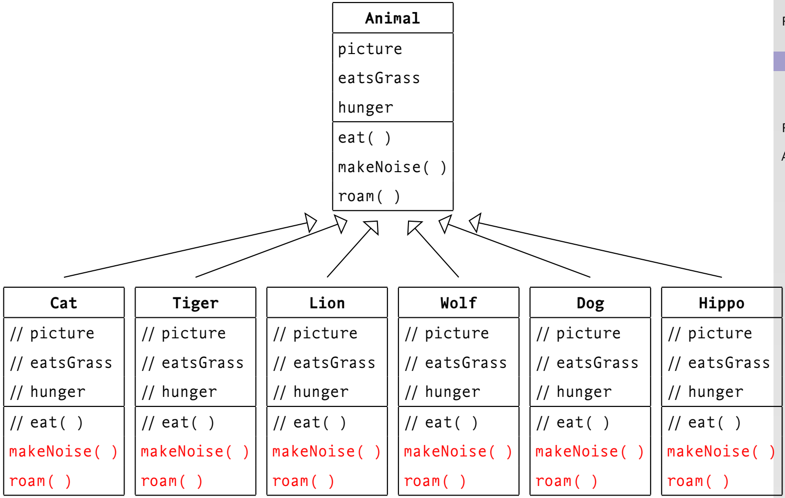
Override



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Did Larry Win?

Unix Session

```
next: Animal[ picture = hippo.jpg, eatsGrass = grass, hunger = 10 ]
I’m Lazy: not roaming.
Eating 10 portions of grass.
```

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Larry Doesn't Get It

- Larry couldn't understand it.
- He had overridden the Hippo's noise method.

Java

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

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Larry Doesn't Get It

- Larry couldn't understand it.
- He had overridden the `Hippo`'s noise method.
- But Amy discovered the error.

Java

```java
public void makenoise( ) {
    System.out.println( "Grunt." );
}
```

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Larry Doesn't Get It

- Larry couldn't understand it.
- He had overridden the `Hippo`'s noise method.
- But Amy discovered the error.
- There was a typo in his `Hippo` class.

Java

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

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- But Amy discovered the error.
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Java

```
public void makeNoise( ) {
    System.out.println( "Grunt." );
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```

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Larry Doesn’t Get It

- Larry couldn’t understand it.
- He had overridden the `Hippo`’s noise method.
- But Amy discovered the error.
- There was a typo in his `Hippo` class.

Java

```java
@Override // Makes sure we override the right method
public void makeNoise( ) {
    System.out.println( "Grunt." );
}
```

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Meanwhile at Brad’s Laptop

- Brad had read about Lennoxes in the *Lonely Planet*.
- Eating there is supposed to be a lifetime experience.
- He is very keen on winning this prize.
- Brad’s design is completely different from Larry’s.

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About this Document

Meanwhile at Brad's Laptop

- Brad had read about Lennoxes in the *Lonely Planet.*
- Eating there is supposed to be a lifetime experience.
- He is very keen on winning this prize.
- Brad's design is completely different from Larry's.
- He notices there are really three kinds of animals:

Canines	animals with dog-like behaviour;
Felines	animals with cat-like behaviour; and
Others	animals with other behaviour.

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Meanwhile at Brad's Laptop

- Brad had read about Lennoxes in the *Lonely Planet.*
- Eating there is supposed to be a lifetime experience.
- He is very keen on winning this prize.
- Brad's design is completely different from Larry's.
- He notices there are really three kinds of animals:

Canines	animals with dog-like behaviour;
Felines	animals with cat-like behaviour; and
Others	animals with other behaviour.

- He decides to build this into his class design.

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Meanwhile at Brad's Laptop

- Brad creates two additional classes: Canine and Feline.
- Both *extend* the Animal class.

Java

```
public class Canine extends Animal {
    public Canine( )    { eatsGrass = false; }

    @Override
    public void roam( ) { System.out.println( "Roaming in my pack." ); }
}
```

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About this Document

Meanwhile at Brad’s Laptop

- Brad creates two additional classes: Canine and Feline.
- Both *extend* the Animal class.
- All Canines eat meat.

Java

```
public class Canine extends Animal {
    public Canine( )    { eatsGrass = false; }

    @Override
    public void roam( ) { System.out.println( "Roaming in my pack." ); }
}
```

Software Development

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About this Document

Meanwhile at Brad's Laptop

- Brad creates two additional classes: Canine and Feline.
- Both *extend* the Animal class.
- All Canines eat meat.
- All Canines roam in packs.

Java

```
public class Canine extends Animal {
    public Canine( )    { eatsGrass = false; }

    @Override
    public void roam( ) { System.out.println( "Roaming in my pack." ); }
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```

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Meanwhile at Brad's Laptop

- Brad creates two additional classes: `Canine` and `Feline`.
- Both *extend* the `Animal` class.
- All `Canine`s eat meat.
- All `Canine`s roam in packs.

Java

```
public class Canine extends Animal {
    public Canine( )    { eatsGrass = false; }

    @Override
    public void roam( ) { System.out.println( "Roaming in my pack." ); }
}
```

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Meanwhile at Brad's Laptop

- Brad creates two additional classes: `Canine` and `Feline`.
- Both *extend* the `Animal` class.

Java

```
public class Feline extends Animal {
    public Feline( )    { eatsGrass = false; }

    @Override
    public void roam( ) { System.out.println( "Roaming alone." ); }
}
```

Meanwhile at Brad's Laptop

- Brad creates two additional classes: `Canine` and `Feline`.
- Both *extend* the `Animal` class.
- All `Felines` eat meat.

Java

```java
public class Feline extends Animal {
    public Feline( )    { eatsGrass = false; }

    @Override
    public void roam( ) { System.out.println( "Roaming alone." ); }
}
```

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Meanwhile at Brad’s Laptop

- Brad creates two additional classes: `Canine` and `Feline`.
- Both *extend* the `Animal` class.
- All `Feline`s eat meat.
- All `Feline`s roam alone.

Java

```
public class Feline extends Animal {
    public Feline( )    { eatsGrass = false; }

    @Override
    public void roam( ) { System.out.println( "Roaming alone." ); }
}
```

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Meanwhile at Brad's Laptop

- Brad's design is really clever.
- His design *factors out all common `Canine` behaviour.*
- This simplifies the `Canine` subclasses.
  - All `Canine`s inherit the roaming behaviour.
  - By default, `eatsGrass` is `false` for all `Canine`s.

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Meanwhile at Brad's Laptop

Java

```
public class Dog extends Canine {
    private static final int DOG_HUNGER_LEVEL = 4;
    private static final String DOG_PICTURE = "dog.jpg";
    public Dog( ) {
        picture = DOG_PICTURE;
        // eatsGrass is false by default.
        hunger = DOG_HUNGER_LEVEL;
    }
    // Inherits eating  behaviour from Aninmal class.
    // Inherits roaming behaviour from Canine  class.
    @Override
    public void makeNoise( ) { System.out.println( "Arf. Arf." ); }
}
```

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Meanwhile at Brad’s Laptop

Java

```
public class Cat extends Feline {
    private static final int CAT_HUNGER_LEVEL = 1;
    private static final String CAT_PICTURE = "cat.jpg";
    public Cat( ) {
        picture = CAT_PICTURE;
        // eatsGrass is false by default.
        hunger = CAT_HUNGER_LEVEL;
    }
    // Inherits eating  behaviour from Aninmal class.
    // Inherits roaming behaviour from Feline  class.
    @Override
    public void makeNoise( ) { System.out.println( "Mew. Mew." ); }
}
```

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Meanwhile at Brad’s Laptop

Java

```
public class Hippo extends Animal {
    // ⟨constants omitted⟩
    public Hippo( ) {
        picture = HIPPO_PICTURE;
        eatsGrass = true;
        hunger = HIPPO_HUNGER_LEVEL;
    }
    // Inherits eating  behaviour from Aninmal class.
    @Override
    public void roam( ) { System.out.println( "I’m lazy: not roaming." ); }
    @Override
    public void makeNoise( ) { System.out.println( "Grunt." ); }
}
```

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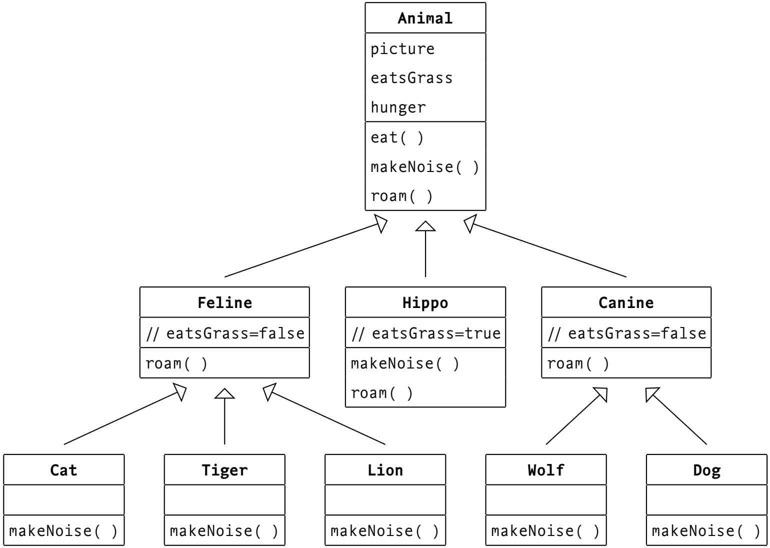
Brad's Class Diagram



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How Brad Implemented the Canine Class

Poor Style

Java

```
public class Canine extends Animal {
    public Canine( ) {
        eatsGrass = false;
    }

    @Override
    public void roam( ) {
        System.out.println( "Roaming in my pack." );
    }
}
```

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How Brad Implemented the Canine Class

Poor Style

Java

```
public class Canine extends Animal {
    public Canine( ) {
        eatsGrass = false;
    }

    @Override
    public void roam( ) {
        System.out.println( "Roaming in my pack." );
    }
}
```

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How Brad Implemented the Canine Class

Superclass Implementation Violates Encapsulation

Java

```
public class Canine extends Animal {
    public Canine( ) {
        eatsGrass = false;
    }

    @Override
    public void roam( ) {
        System.out.println( "Roaming in my pack." );
    }
}
```

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How Brad Implemented the Canine Class

Superclass Attributes are Mutable and Cannot be Private

Java

```
public class Canine extends Animal {
    public Canine( ) {
        eatsGrass = false;
    }

    @Override
    public void roam( ) {
        System.out.println( "Roaming in my pack." );
    }
}
```

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Calling the Superclass Constructor

Should be First Call in Constructor

Java

```java
public class Canine extends Animal {
    private static final boolean EATS_GRASS = false;

    public Canine( final String picture, final int hungerLevel ) {
        super( picture, EATS_GRASS, hungerLevel );
    }

    @Override
    public void roam( ) {
        System.out.println( "Roaming in my pack." );
    }
}
```

Calling the Superclass Constructor

Superclass Implementation Respects Encapsulation

Java

```
public class Canine extends Animal {
    private static final boolean EATS_GRASS = false;

    public Canine( final String picture, final int hungerLevel ) {
        super( picture, EATS_GRASS, hungerLevel );
    }

    @Override
    public void roam( ) {
        System.out.println( "Roaming in my pack." );
    }
}
```

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Calling the Superclass Constructor

Superclass Attributes are *Private* and *Immutable*

Java

```
public class Canine extends Animal {
    private static final boolean EATS_GRASS = false;

    public Canine( final String picture, final int hungerLevel ) {
        super( picture, EATS_GRASS, hungerLevel );
    }

    @Override
    public void roam( ) {
        System.out.println( "Roaming in my pack." );
    }
}
```

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For Monday:

- Read the presentation.

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About this Document

- This document was created with `pdflatex`.
- The LaTeX document class is `beamer`.