Inheritance

Ch 6

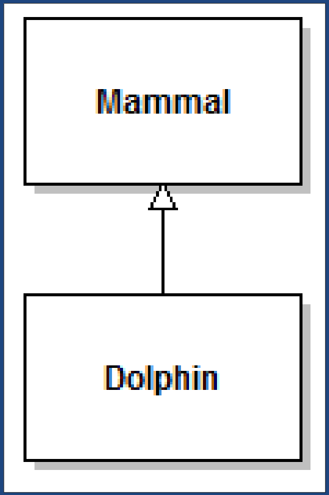
Topics

1) How can Java work with class inheritance?
    1) Creating subclasses
    2) Accessing the base class
    3) Overriding methods
    4) Class hierarchies
    5) Visibility

Creating Subclasses

Inheritance

- Inheritance:
  - Ex: A dolphin is-a mammal.
    - Dolphin inherits from mammal
      (*subclass*) (*superclass*)
      (*derived*) (*base*)

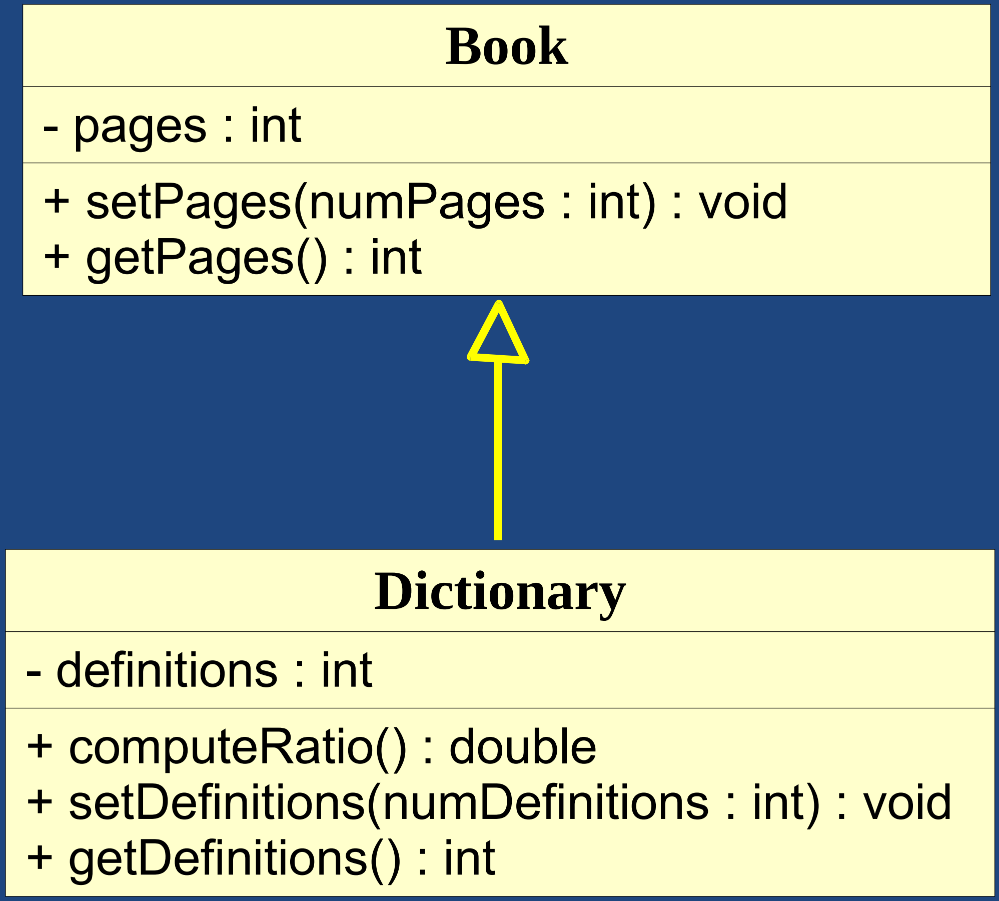


- Motivation:
  - Share code between base class and derived class.
  - Properties of the base are inherited by the derived.
  - ..

Book Inheritance Example

Client Code:

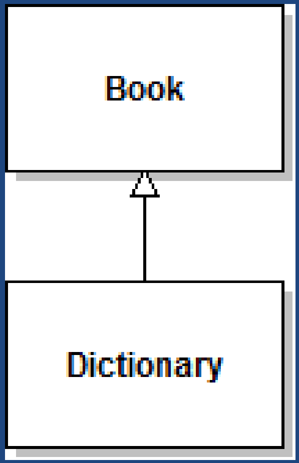
```
Dictionary web = new Dictionary();
web.setPages(25);
web.setDefinitions(2523);
double r = web.computeRatio();
```


Book
- pages : int
+ setPages(numPages : int) : void
+ getPages() : int
Dictionary
- definitions : int
+ computeRatio() : double
+ setDefinitions(numDefinitions : int) : void
+ getDefinitions() : int

- Don't re-implement (or copy-and-paste) the code from Book into Dictionary.
- Makes maintaining shared Book-functionality easier.
  - Why?..

Notes on Inheritance Example

- Instantiating Dictionary does not..
  - Dictionary object has all members from:
    - the Book class (its superclass), and
    - the Dictionary class



- Access:
  - Subclass may call/access..
    of super class.
  - Ex: Dictionary code can call public functions in Book.
  - Base class cannot access members of derived class.

Polymorphism via Class Inheritance

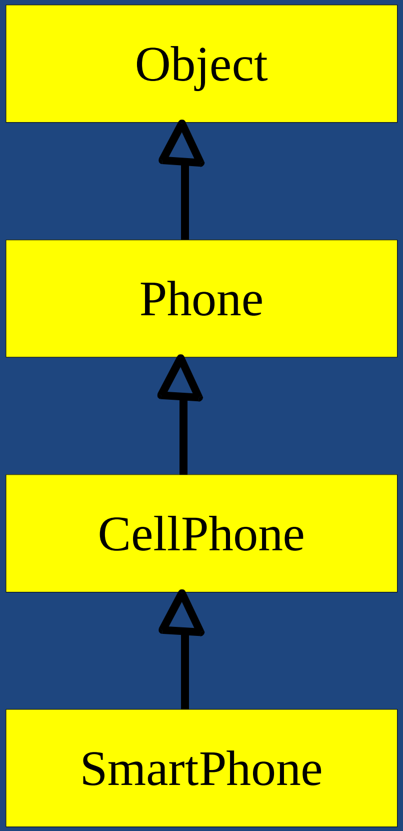
- Polymorphic references can refer to a class, or any derived class:

```
Phone x;
x = new Phone();

// Reference to derived class
CellPhone cell = new CellPhone();
x = new CellPhone();

// Reference to derived-derived class
SmartPhone smart = new SmartPhone();
x = new SmartPhone();

// Cannot reference a base class..
SmartPhone oops = new Phone();
```



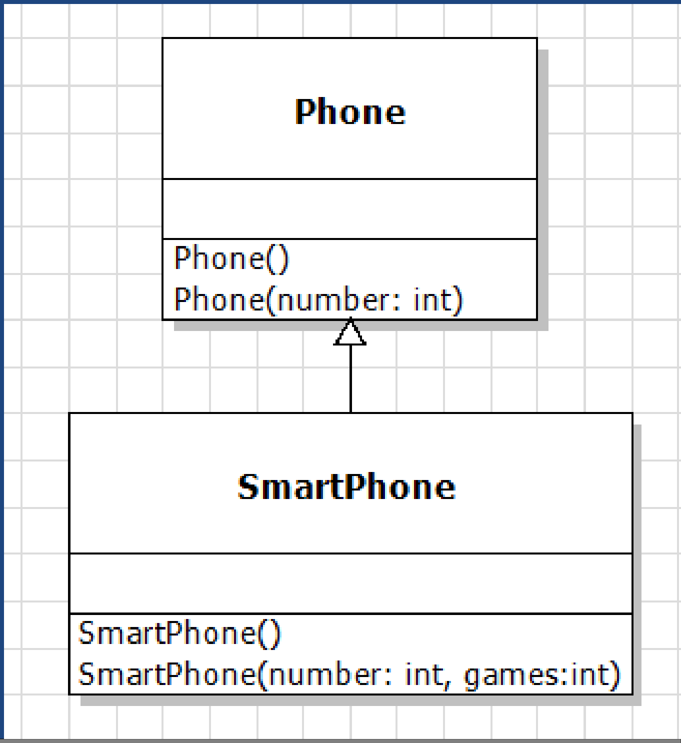
Overriding Methods

(Not over**loading**, over**riding**)

super

- super: refers to..
- this: refers to current object, not superclass.
- Subclass's constructor can “call” superclass constructor:

```
public class SmartPhone extends Phone {
	int numGames = 0;
	public SmartPhone () {          ..
		super();
	}
	public SmartPhone (int number, int games) {
		super(number);
		numGames = games;     ..
	}
}
```



super Notes

- super() must be the..
  - If missing, super(); automatically added as first line (unless using constructor chaining via this(...))
- Constructor Chaining
  - Each subclass calls its superclass's constructor.
  - Creates a chain of constructor calls.
  - Ensures base-classes are..

    (Except if base class calls a method which is overridden in derived class.)
  - Can chain to constructors of current class using this()

Chaining Constructors

- Ex: Chain constructors in current class, or super class.

```java
public class Base {
    int count = 0;

    public Base() {
        this(5);
        // Do anything...
    }

    public Base(int count) {
        this.count = count;
        // Do anything...
    }
}
```

```java
public class Derived extends Base {
    private final double DEFAULT = 42.0;
    private double other;

    public Derived(int count) {
        this(count, DEFAULT);
        // Do anything...
    }

    public Derived(int count, double other)
    {
        super(count);
        this.other = other;
        // Do anything...
    }
}
```

= DerivedConstructor

Overriding

- Subclass can override a method of superclass if same signature as base:
  - Same name
  - Same argument # and types

```
public static void main(String[] args) {
	Fruit apple = new Fruit("Apple");
	System.out.println(apple.getType());

	Fruit deluxe = new DeluxeFruit("Apple");
	System.out.println(deluxe.getType());
}
```

```
Class: class ca.cmpt213.fruit.Fruit
Type:  Apple
Class: class ca.cmpt213.fruit.DeluxeFruit
Type:  Deluxe Apple
```

```
public class Fruit {
	private String type;

	public Fruit(String type) {
		this.type = type;
	}
	public String getType() {
		return type;
	}
}

public class DeluxeFruit extends Fruit {
	public DeluxeFruit(String type) {
		super(type);
	}

	@Override
	public String getType() {
		return "Deluxe " + super.getType();
	}
}
```

= DeluxeFruitExample

Overriding Details

- To override a method, derived class's method must:
  - Have identical signature
  - Not throw any extra checked exceptions (more later)
  - ..
    - Ex: Can go from protected to public, but not public to protected/private.
  - Cannot override a private, a static, or a final method.
  - Not change return type of method.
    - But you can return a subtype of original return type

final vs Overriding

- final method:..
  - In superclass:

```
public final String MCHammerSays() {
    return “Can't touch this.”;
}
```

  - In subclass:

```
public String MCHammerSays() {
    return “Who's MC Hammer?”;
}
```

..

- final class:..

Shadow Variables - a Bad Idea

- Shadow Variables:
  - Subclass declares a variable of the..

```
public class Pet {
        private String name;
        // ...
}
public class PetRock extends Pet
{
        private String name;
        // ...
}
```

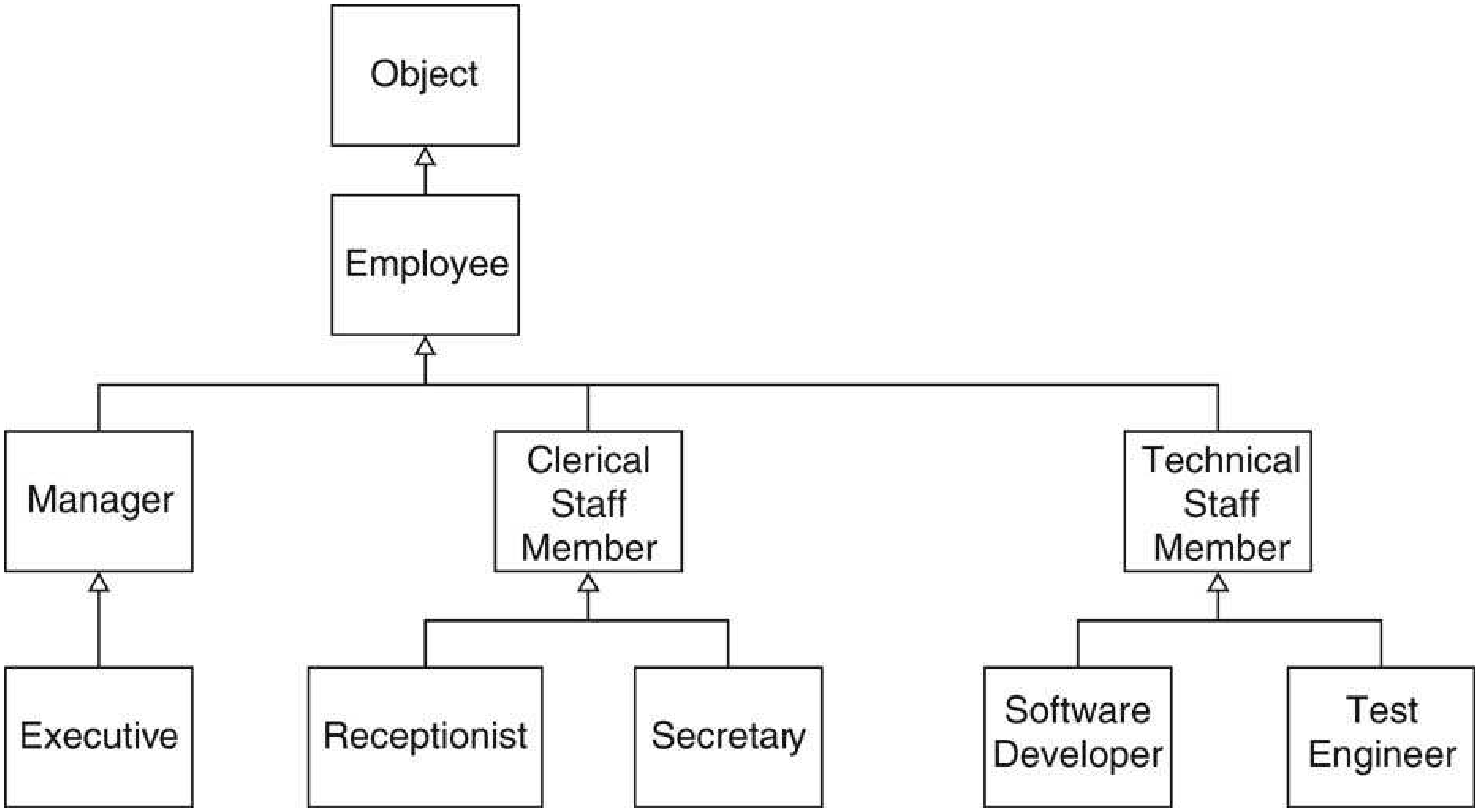
- ..
  only creates confusion for programmers!
  - No good reason to use a shadow variable.
  - Pick good, unique names!

Class Hierarchies

Multiple Inheritance

- Single Inheritance:
  A class may inherit from..
  - Ex: A Car is a Vehicle.
  - Java uses this approach.
- Multiple Inheritance:
  A class may inherit from many superclasses.
  - Ex: A TA is both a Student and a Teacher.
    - ..
  - Impossible in Java (specifically forbidden).
- Use.. to get some benefits of multiple inheritance using only single inheritance.

Inheritance Hierarchy



Object

- All Java classes ultimately derive from the Object class.
  - If a class does not extend another a class,..

  - If a class extends some other class,
    its superclass must ultimately derive from Object.
- Object's public methods are inherited by all classes.

```
boolean equals(Object obj)     // Is this same as obj
String toString()              // Express as a string.
Object clone()                 // Return a copy of this obj.
int hashCode()                 // For hashing collections
```

- Object has an implements for each, but a class may..
  with a more meaningful implementation.

Abstract Class

Abstract Classes

- Abstract class: (basic idea)
  - Un-implemented method. Concrete derived classes must..
  - Classes with abstract methods must be abstract.
  - Abstract class cannot be instantiated: it's incomplete; not concrete.
- Make a class abstract:
  public abstract class Plant { ... }
- Make a method abstract:
  public abstract void doSomethingAmazing();

Abstract Class Example

```
abstract class GraphicObject {
    int x, y;
    ...
    void moveTo(int newX, int newY) {
        ...
    }
    abstract void draw();
    abstract void resize();
}

class Circle extends GraphicObject {
   @Override
    void draw() {
        ...
    }
   @Override
    void resize() {
        ...
    }
}
```

..

Abstract class...

..

Abstract method has no implementation.

..

draw() and resize() must be..

Example source: Java Tutorial.

Abstract Class vs Interface

Similarities

Abstract class: Java interfaces:

- Force derived concrete class to..
- Supports constants

Differences

Abstract class:

- (non-abstract)
- (non-constant fields)
- Extend classes

Java interfaces:

- Class can implement..

In Java 8, interfaces can have default ("defender") methods, but these can only call other methods of the interface.

- In UML, abstract classes shown in *italics*.
  - Sometimes decorated with {abstract}

Abstract Questions

- Can a method be both abstract and final?
  -

- Can an abstract class have a static method?
  -
- Can a method be both abstract and static?
  -

- Can a class be both final and abstract?
  -

Note:
Math is final with a private constructor.

Visibility

Indirect Access to Private Base Members

- Subclass **cannot** access superclass's private members.
- Can access a non-private method of the superclass, which..

```
public class Parent {
    private int amountWine = 100;
    protected void homeAlone() {
        drinkWine();        // Call a private method.
    }

    private void drinkWine() {
        amountWine--;
    }
}

class Child extends Parent {
    public void goodTimes() {
        homeAlone();        //..
        drinkWine();        //..
    }
}
```

protected

- protected
  - allows..
    Crates a “protected” interface.
  - unrelated classes cannot access the protected members.
- Not a great idea:
  -

    you have no control over which classes extend your class in the future.
  - Create a “protected” interface to expose just those things that only derived classes will need (“template method”)
    Often better to use public interface.

Class Member Visibility

- Visibility Modifies and member accessibility:
  - public: anywhere
  - protected: in the class, package, and derived classes
  - default:
    - default is without any modifiers; called package-private
  - private:

	Inside Own Class	Inside Same Package	Inside Inherited Classes	Rest of the world
public	Visible	Visible	Visible	Visible
protected	Visible	Visible	Visible	
“default” no modifier	Visible	Visible		
private	Visible			

Summary

- Inheritance (is-a) used to create subclasses
- Child uses super in constructor
- Child overrides methods of parents to change behaviour
- Class hierarchies all start from Object, and each class may have at most one parent.
- Visibility modifiers affect inheritance