Overriding Methods & Class Hierarchies

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ComS 207: Programming I (in Java)
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Quick Review of Last Lecture

The protected Modifier

- Visibility modifiers affect the way that class members can be used in a child class
- Variables and methods declared with private visibility cannot be referenced by name in a child class
- They can be referenced in the child class if they are declared with public visibility -- but public variables violate the principle of encapsulation
- There is a third visibility modifier that helps in inheritance situations: `protected`

The protected Modifier

- The `protected` modifier allows a child class to reference a variable or method directly in the child class
- It provides more encapsulation than public visibility, but is not as tightly encapsulated as private visibility
- A protected variable is visible to any class in the same package as the parent class
- The details of all Java modifiers are discussed in Appendix E
- Protected variables and methods can be shown with a # symbol preceding them in UML diagrams

Appendix E

Modifier	Classes and Interfaces	Methods and variables
default (no modifier)	Visible in its package.	Visible to any class in the same package as its class.
public	Visible anywhere.	Visible anywhere.
protected	N/A	Visible by any class in the same package as its class.
private	Visible to the enclosing class only	Not visible by any other class.

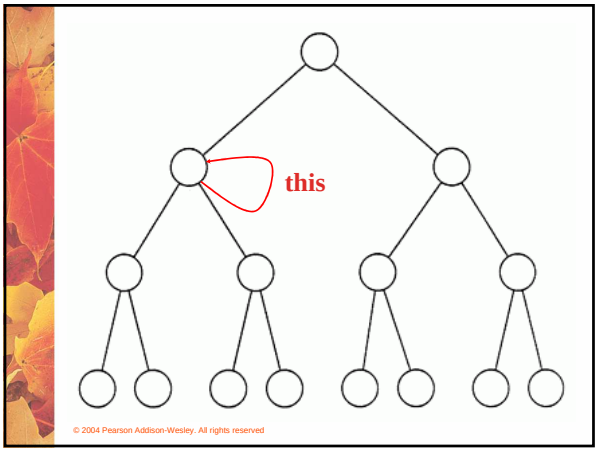
Modifier	Class	Interface	Method	Variable
abstract	The class may contain abstract methods. It cannot be instantiated.	All interfaces are inherently abstract. The modifier is optional.	No method body is defined. The method requires implementation when inherited.	N/A
final	The class cannot be used to drive new classes.	N/A	The method cannot be overridden.	The variable is a constant, whose value cannot be changed once initially set.
native	N/A	N/A	No method body is necessary since implementation is in another language.	N/A
static	N/A	N/A	Defines a class method. It does not require an instantiated object to be invoked. It cannot reference non-static methods or variables. It is implicitly final.	Defines a class variable. It does not require an instantiated object to be referenced. It is shared (common memory space) among all instances of the class.
synchronized	N/A	N/A	The execution of the method is mutually exclusive among all threads.	N/A
transient	N/A	N/A	N/A	The variable will not be serialized.
volatile	N/A	N/A	N/A	The variable is changed asynchronously. The compiler should not perform optimizations on it.

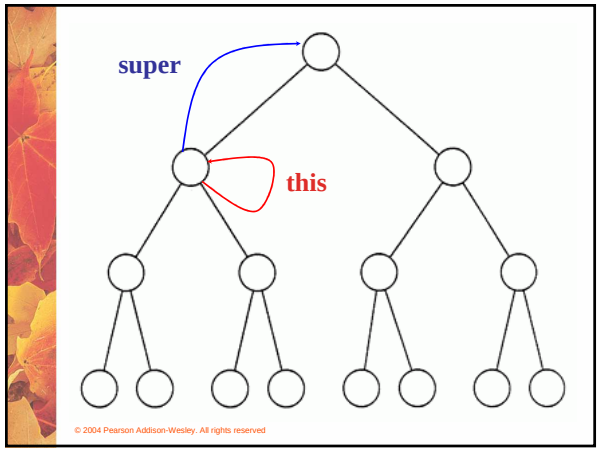
The super Reference

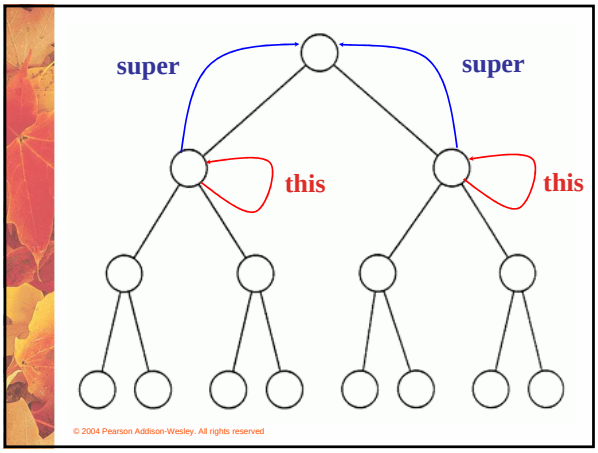
- Constructors are not inherited, even though they have public visibility
- Yet we often want to use the parent's constructor to set up the "parent's part" of the object
- The `super` reference can be used to refer to the parent class, and often is used to invoke the parent's constructor

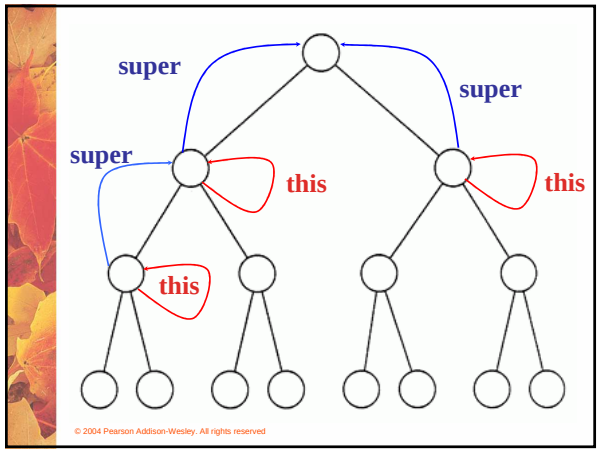
The super Reference

- A child's constructor is responsible for calling the parent's constructor
- The first line of a child's constructor should use the `super` reference to call the parent's constructor
- The `super` reference can also be used to reference other variables and methods defined in the parent's class







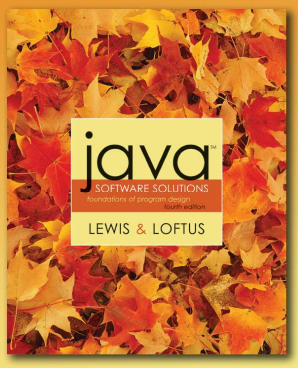


Modified Book Example

- See `Words2.java` (page 445)
- See `Book2.java` (page 446)
- See `Dictionary2.java` (page 447)

Chapter 8

Sections 8.1 & 8.2



Overriding Methods

- A child class can *override* the definition of an inherited method in favor of its own
- The new method must have the same signature as the parent's method, but can have a different body
- The type of the object executing the method determines which version of the method is invoked

Overriding

- A method in the parent class can be invoked explicitly using the `super` reference
- If a method is declared with the `final` modifier, it cannot be overridden
- The concept of overriding can be applied to data and is called *shadowing variables*
- Shadowing variables should be avoided because it tends to cause unnecessarily confusing code

Overloading vs. Overriding?

Method Overloading

- The compiler determines which method is being invoked by analyzing the parameters

```
float tryMe(int x)
{
   return x + .375;
}
```

[signature 1] tryMe: int

```
float tryMe(int x, float y)
{
   return x*y;
}
```

[signature 2] tryMe: int, float

Method Overriding

```
public class Parent
{
   public float tryMe(int x)
   {
      return x + .375;
   }
}

public class Child extends Parent
{
   public float tryMe(int x)
   {
      return x*x;
   }
}
```

Same Signatures

Different Method Bodies

Overloading vs. Overriding

- Overloading deals with multiple methods with the same name in the same class, but with different signatures
- Overriding deals with two methods, one in a parent class and one in a child class, that have the same signature

Overloading vs. Overriding

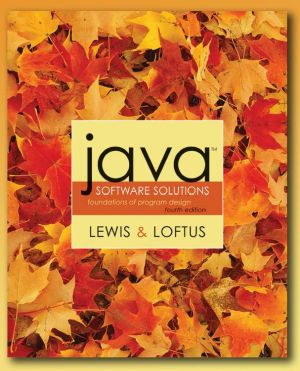
- Overloading lets you define a similar operation in different ways for different parameters
- Overriding lets you define a similar operation in different ways for different object types

Overriding Example

- See `Messages.java` (page 450)
- See `Thought.java` (page 451)
- See `Advice.java` (page 452)

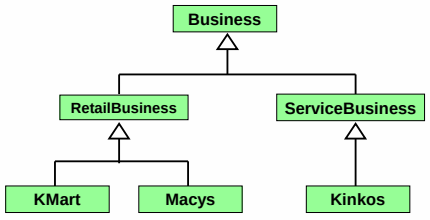
Chapter 8

Section 8.3



Class Hierarchies

- A child class of one parent can be the parent of another child, forming a *class hierarchy*



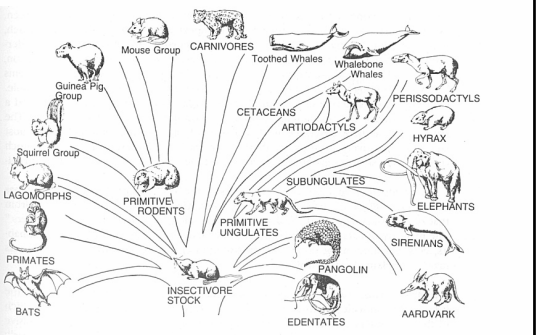
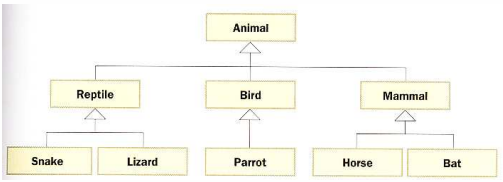


Figure 55. Diagrammatic family tree of the major orders (and some suborders) of eutherian (placental) mammals. Separate diagrams (Figs. 57–61) give in more detail the evolution of primates, carnivores, and odd- and even-toed ungulates.

[http://cas.bellarmine.edu/tietjen/images/Mammal_order_tree.jpg]

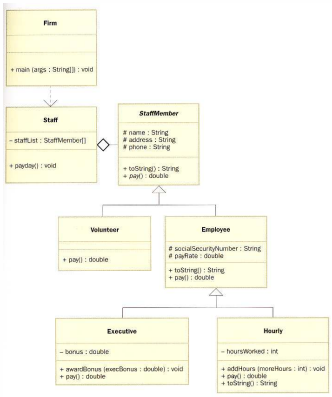
Animals Class Hierarchy



Class Hierarchies

- Two children of the same parent are called *siblings*
- Common features should be put as high in the hierarchy as is reasonable
- An inherited member is passed continually down the line
- Therefore, a child class inherits from all its ancestor classes
- There is no single class hierarchy that is appropriate for all situations

Employee Class Hierarchy



The Object Class

- A class called `Object` is defined in the `java.lang` package of the Java standard class library
- All classes are derived from the `Object` class
- If a class is not explicitly defined to be the child of an existing class, it is assumed to be the child of the `Object` class
- Therefore, the `Object` class is the ultimate root of all class hierarchies

The Object Class

- The `Object` class contains a few useful methods, which are inherited by all classes
- For example, the `toString` method is defined in the `Object` class
- Every time we define the `toString` method, we are actually overriding an inherited definition
- The `toString` method in the `Object` class is defined to return a string that contains the name of the object's class along with some other information

Object – the mother of all objects in Java

```
boolean equals (Object obj)
    Returns true if this object is an alias of the specified object.
String toString ()
    Returns a string representation of this object.
Object clone ()
    Creates and returns a copy of this object.
```

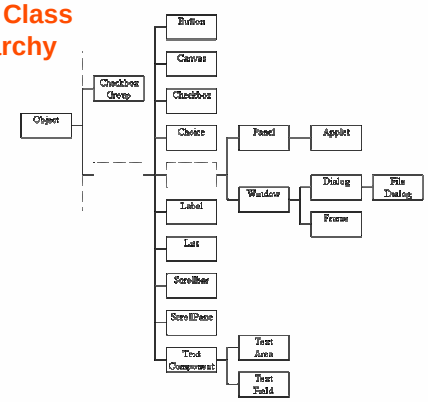

Object.java

- In fact, Object has more methods as can be seen from the source file.
- java/lang/Object.java

The Object Class

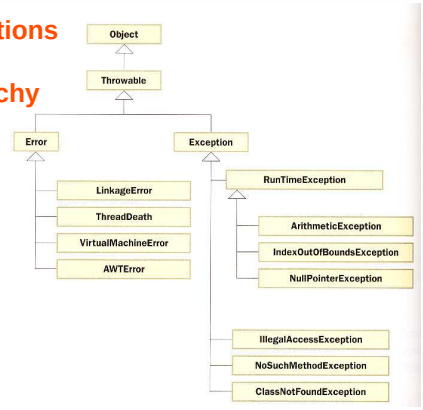
- The `equals` method of the `Object` class returns true if two references are aliases
- We can override `equals` in any class to define equality in some more appropriate way
- As we've seen, the `String` class defines the `equals` method to return true if two `String` objects contain the same characters
- The designers of the `String` class have overridden the `equals` method inherited from `Object` in favor of a more useful version

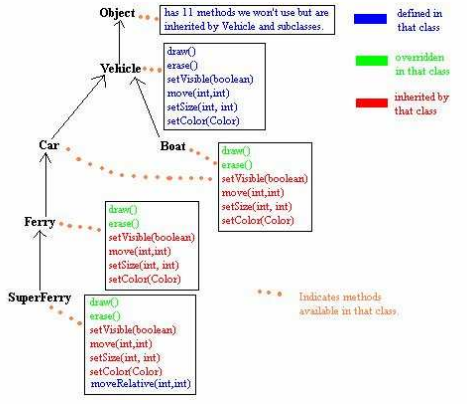
AWT Class Hierarchy



[http://www.scism.sbu.ac.uk/jfl/jibook/ch2/ch22.html]

Exceptions Class Hierarchy





[http://www.holtsoft.com/java/resources/inherit_tutorial/Inheritance/methods.jpg]

Abstract Classes

- An *abstract class* is a placeholder in a class hierarchy that represents a generic concept
- An abstract class cannot be instantiated
- We use the modifier `abstract` on the class header to declare a class as abstract:

```
public abstract class Product
{
   // contents
}
```


Abstract Classes

- An abstract class often contains abstract methods with no definitions (like an interface)
- Unlike an interface, the `abstract` modifier must be applied to each abstract method
- Also, an abstract class typically contains non-abstract methods with full definitions
- A class declared as abstract does not have to contain abstract methods -- simply declaring it as abstract makes it so

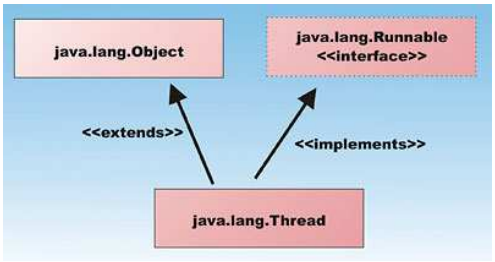
Abstract Classes

- The child of an abstract class must override the abstract methods of the parent, or it too will be considered abstract
- An abstract method cannot be defined as `final` or `static`
- The use of abstract classes is an important element of software design – it allows us to establish common elements in a hierarchy that are too generic to instantiate

Interface Hierarchies

- Inheritance can be applied to interfaces as well as classes
- That is, one interface can be derived from another interface
- The child interface inherits all abstract methods of the parent
- A class implementing the child interface must define all methods from both the ancestor and child interfaces
- Note that class hierarchies and interface hierarchies are distinct (they do not overlap)

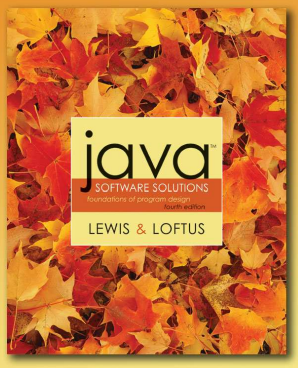
This example shows how multiple inheritance can be faked in java



[http://www.vsj.co.uk/pix/articleimages/may05/javathread3.jpg]

Chapter 8

Section 8.4



Visibility Revisited

- It's important to understand one subtle issue related to inheritance and visibility
- All variables and methods of a parent class, even private members, are inherited by its children
- As we've mentioned, private members cannot be referenced by name in the child class
- However, private members inherited by child classes exist and can be referenced indirectly

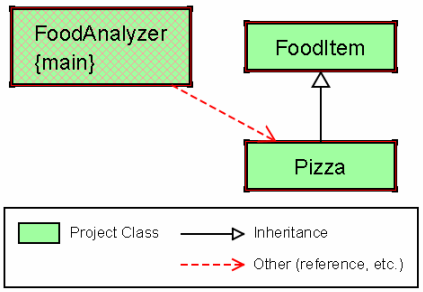
Visibility Revisited

- Because the parent can refer to the private member, the child can reference it indirectly using its parent's methods
- The `super` reference can be used to refer to the parent class, even if no object of the parent exists

Example

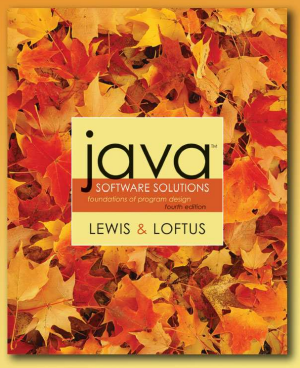
- See `FoodAnalyzer.java` (page 459)
- See `FoodItem.java` (page 460)
- See `Pizza.java` (page 461)

You can use jGrasp to draw diagram like this one



Chapter 8

Section 8.5



Designing for Inheritance

- As we've discussed, taking the time to create a good software design reaps long-term benefits
- Inheritance issues are an important part of an object-oriented design
- Properly designed inheritance relationships can contribute greatly to the elegance, maintainability, and reuse of the software
- Let's summarize some of the issues regarding inheritance that relate to a good software design

Inheritance Design Issues

- Every derivation should be an is-a relationship
- Think about the potential future of a class hierarchy, and design classes to be reusable and flexible
- Find common characteristics of classes and push them as high in the class hierarchy as appropriate
- Override methods as appropriate to tailor or change the functionality of a child
- Add new variables to children, but don't redefine (shadow) inherited variables

Inheritance Design Issues

- Allow each class to manage its own data; use the `super` reference to invoke the parent's constructor to set up its data
- Even if there are no current uses for them, override general methods such as `toString` and `equals` with appropriate definitions
- Use abstract classes to represent general concepts that lower classes have in common
- Use visibility modifiers carefully to provide needed access without violating encapsulation

Restricting Inheritance

- The `final` modifier can be used to curtail inheritance
- If the `final` modifier is applied to a method, then that method cannot be overridden in any descendent classes
- If the `final` modifier is applied to an entire class, then that class cannot be used to derive any children at all
  - Thus, an abstract class cannot be declared as final
- These are key design decisions, establishing that a method or class should be used as is

THE END