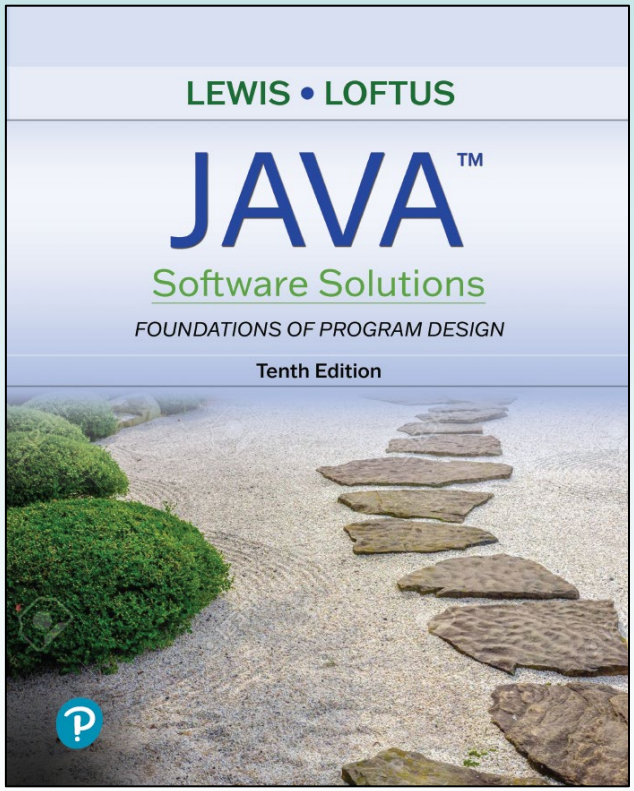
Chapter 9
Inheritance



Java Software Solutions

Foundations of Program Design

10th Edition

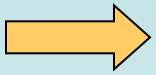
(edits: 05/20/2024)

John Lewis
William Loftus

Inheritance

- Inheritance is a fundamental object-oriented design technique used to create and organize reusable classes
- Chapter 9 focuses on:
  - deriving new classes from existing classes
  - the `protected` modifier
  - creating class hierarchies
  - abstract classes
  - indirect visibility of inherited members
  - designing for inheritance
  - the JavaFX class hierarchy
  - color and date pickers
  - dialog boxes

Outline



Creating Subclasses

Overriding Methods

Class Hierarchies

Visibility

☺ **Designing for Inheritance**

☺ **Inheritance in JavaFX**

☺ **Color and Date Pickers**

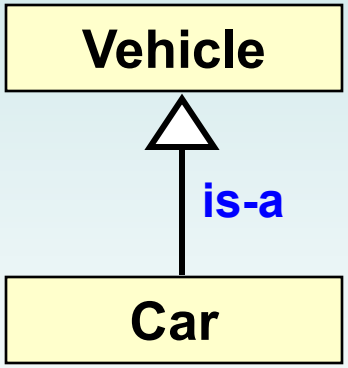
☺ **Dialog Boxes**

Inheritance

- *Inheritance* allows a software developer to derive a new class from an existing one
- The existing class is called the *parent class,* or *superclass*, or *base class*
- The derived class is called the *child class,* or *subclass,* or *derived class*
- As the name implies, the child inherits characteristics of the parent
  - The child class inherits the methods and variables defined by the parent class

Inheritance

- Inheritance in a UML class diagram uses a solid arrow with an unfilled triangular arrowhead pointing to the parent class



- Inheritance creates an *is-a* relationship
- The child *is a* more specific version of the parent

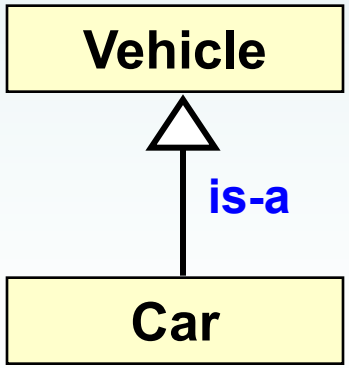
Inheritance

- A programmer can tailor a derived class as needed by adding new variables or methods or by modifying the inherited ones
- One benefit of inheritance is *software reuse*
- By using existing classes to create new ones, we build upon the design, implementation, and testing of the parent class
- Inheritance is between classes, not between objects.

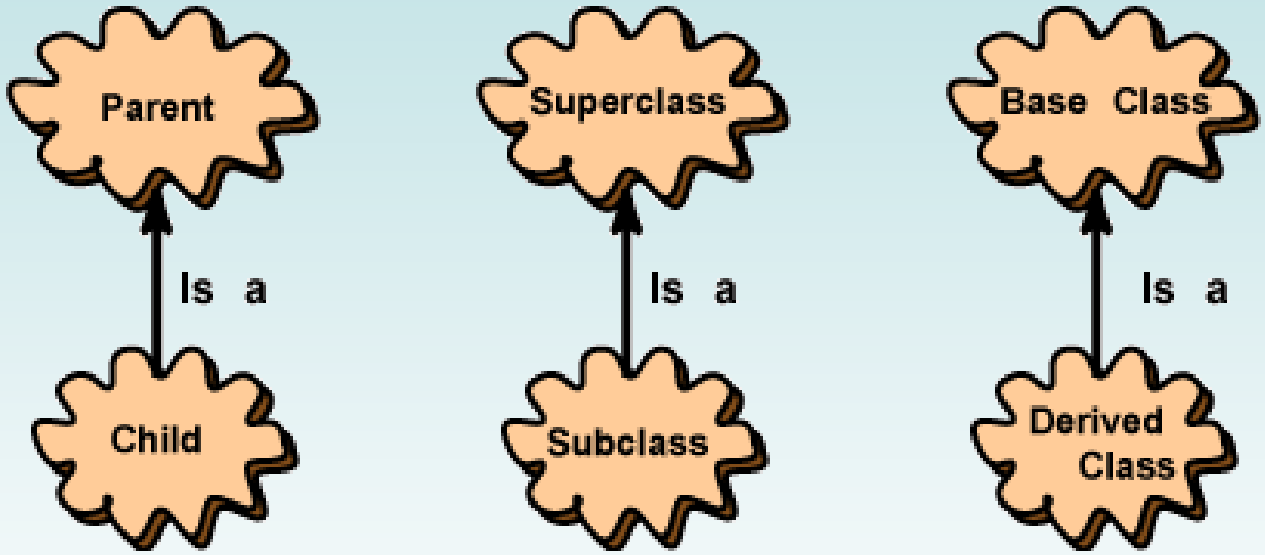
Deriving Subclasses

Use `extends` to establish inheritance

```
public class Car extends Vehicle
{
    // new code for Car goes
    // here.
}
```

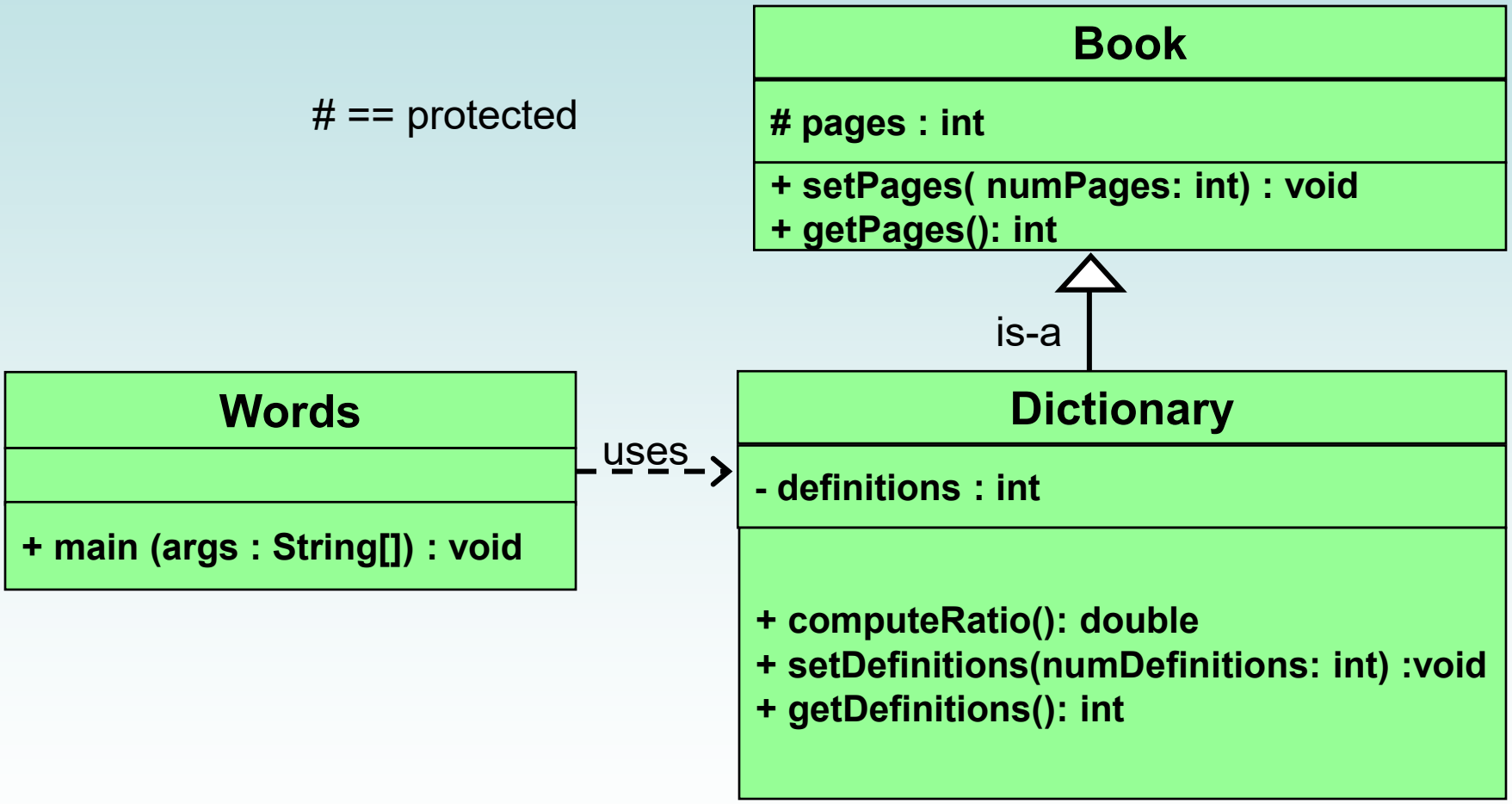


Parent / Child classes



Pairs of names used for inheritance relationships.

Class Diagram for Words



```
//********************************************
//  Words.java    Author: Lewis/Loftus
//
//  Demonstrates the use of an inherited
//  method.
//********************************************

public class Words
{
   //-----------------------------------------------------------------
   //  Instantiates a derived class and invokes its inherited and
   //  local methods.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      Dictionary webster = new Dictionary(); // uses default constructor

      System.out.println("Number of pages: " +
                         webster.getPages()); // uses method inherited from Book

      System.out.println("Number of definitions: " +
                         webster.getDefinitions()); // uses method in Dictionary

      System.out.println("Definitions per page: " +
                         webster.computeRatio()); // uses method in Dictionary
   }
}
```

Output

```
Number of pages: 1500
Number of definitions: 52500
Definitions per page: 35.0
```

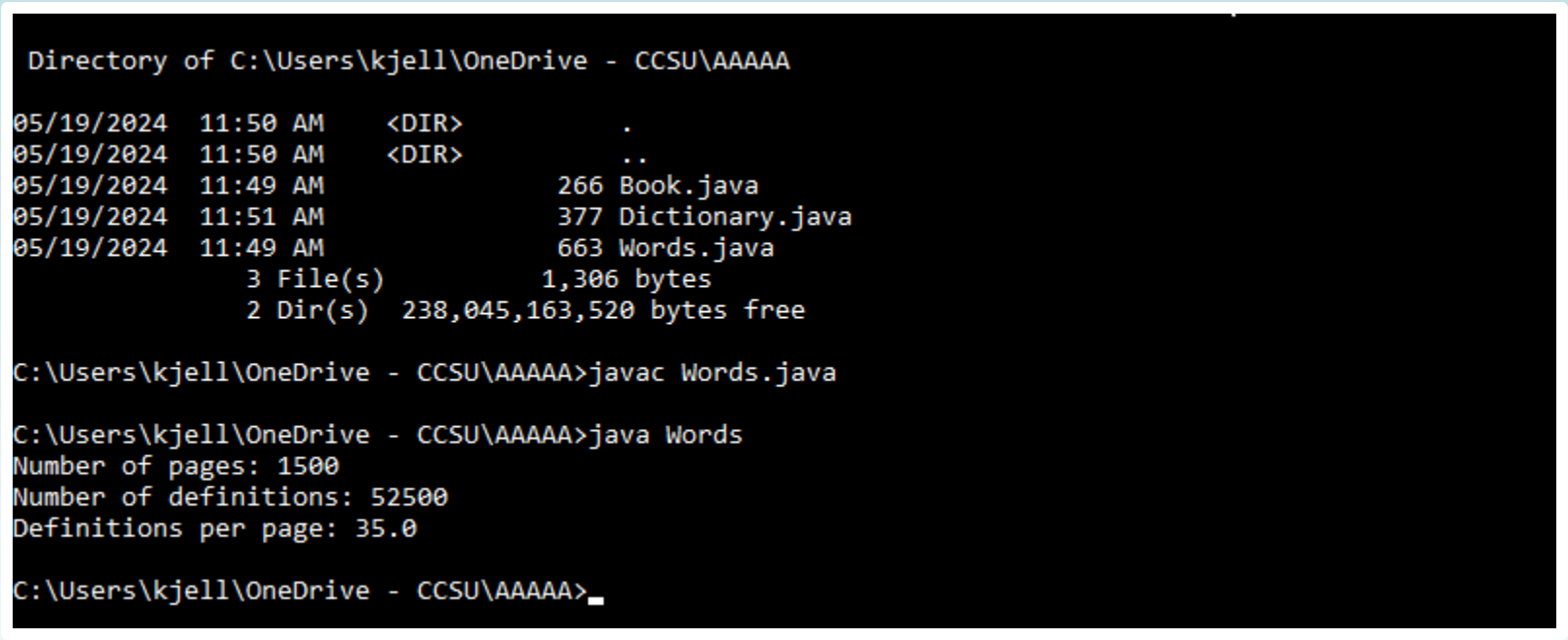
Challenges: add a book; Add another Dictionary

```java
//********************************************************************
//  Book.java       Author: Lewis/Loftus
//
//  Represents a book. Used as the parent of a derived class to
//  demonstrate inheritance.
//********************************************************************

public class Book
{
   protected int pages = 1500;  // protected: children can see this

   //-----------------------------------------------------------------
   //  Pages mutator.
   //-----------------------------------------------------------------
   public void setPages(int numPages)
   {
      pages = numPages;
   }

   //-----------------------------------------------------------------
   //  Pages accessor.
   //-----------------------------------------------------------------
   public int getPages()
   {
      return pages;
   }
}
```

```
public class Dictionary extends Book
{
   private int definitions = 52500;

   //-----------------------------------------------------------------
   //  Prints a message using both local and inherited values.
   //-----------------------------------------------------------------
   public double computeRatio()
   {
      return (double) definitions/pages;
   }

   //-----------------------------------------------------------------
   //  Definitions mutator.
   //-----------------------------------------------------------------
   public void setDefinitions(int numDefinitions)
   {
      definitions = numDefinitions;
   }

   //-----------------------------------------------------------------
   //  Definitions accessor.
   //-----------------------------------------------------------------
   public int getDefinitions()
   {
      return definitions;
   }
}
```

```
//*****************************************
//  Words.java     copy and save to a file
//*****************************************

public class Words
{
   public static void main(String[] args)
   {
      Dictionary webster = new Dictionary(); // uses default constructor

      System.out.println("Number of pages: " +
                  webster.getPages()); // uses method in Book

      System.out.println("Number of definitions: " +
                  webster.getDefinitions()); // uses method in Dictionary

      System.out.println("Definitions per page: " +
                  webster.computeRatio()); // uses method in Dictionary
   }
}
```

```
/* copy and save to Book.java */
public class Book
{
   protected int pages = 1500;  // protected: children can see this

   public void setPages(int numPages)
   {
      pages = numPages;
   }

   public int getPages()
   {
      return pages;
   }
}


/* copy and save to Dictionary.java */
public class Dictionary extends Book
{
   private int definitions = 52500;
   public double computeRatio()
   {
      return (double) definitions/pages;
   }
   public void setDefinitions(int numDefinitions)
   {
      definitions = numDefinitions;
   }
   public int getDefinitions()
   {
      return definitions;
   }
}
```



Javac compiles all files needed by Words.java

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 used in a child class
- Variables and methods declared with public visibility can be used in a child class (and other unrelated classes)
  - but this violates encapsulation
- There is a third visibility modifier: **`protected`**

The protected Modifier

- Variables and methods declared with protected visibility can be used in a child class (but not other classes)
- This provides more encapsulation than public visibility, but not as much as private visibility
- A protected variable is also visible to any class in the same package as the parent class
- Protected variables and methods have a # symbol preceding them in UML diagrams

The super Reference

- Constructors are not inherited,
  even though they have public visibility
- It would make no sense for Dictionary to have an inherited constructor named Book
- Yet we often want to use the parent's constructor to set up the parent's part of the object
- Use the **`super`** reference to refer to the parent class
  - often used to invoke the parent's constructor
- Do this in the first line of a child's constructor

The super Reference

- 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
- See `Words2.java`
- See `Book2.java`
- See `Dictionary2.java`

```
//********************************
//  Words2.java Author: Lewis/Loftus
//
//  Demonstrates the use of the super
//********************************

public class Words2
{
   //-----------------------------------------------------------------
   //  Instantiates a derived class and invokes its inherited and
   //  local methods.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      // uses constructor defined in the class Dictionary2
      Dictionary2 webster = new Dictionary2(1500, 52500);

      System.out.println("Number of pages: " + webster.getPages());

      System.out.println("Number of definitions: " +
                         webster.getDefinitions());

      System.out.println("Definitions per page: " +
                         webster.computeRatio());
   }
}
```

Output

```
Number of pages: 1500
Number of definitions: 52500
Definitions per page: 35.0
```

```java
//********************************************************************
//  Book2.java       Author: Lewis/Loftus
//********************************************************************

public class Book2
{
   protected int pages;

   //-----------------------------------------------------------------
   //  Constructor: Sets up the book with the specified number of
   //  pages. (Original Book did not have a constructor.)
   //-----------------------------------------------------------------
   public Book2(int numPages)
   {
      pages = numPages;
   }

   public void setPages(int numPages)
   {
      pages = numPages;
   }

   public int getPages()
   {
      return pages;
   }
}
```

```
//********************************************************************
//  Dictionary2.java       Author: Lewis/Loftus
//
//  Represents a dictionary, which is a book. Used to demonstrate
//  the use of the super reference.
//********************************************************************

public class Dictionary2 extends Book2
{
   private int definitions;

   //-----------------------------------------------------------------
   //  Constructor: Sets up the dictionary with the specified number
   //  of pages and definitions. Original Dictionary did not have a
   //  constructor.
   //-----------------------------------------------------------------
   public Dictionary2(int numPages, int numDefinitions)
   {
      super(numPages);  // The whole point of this example

      definitions = numDefinitions;
   }
```

continue

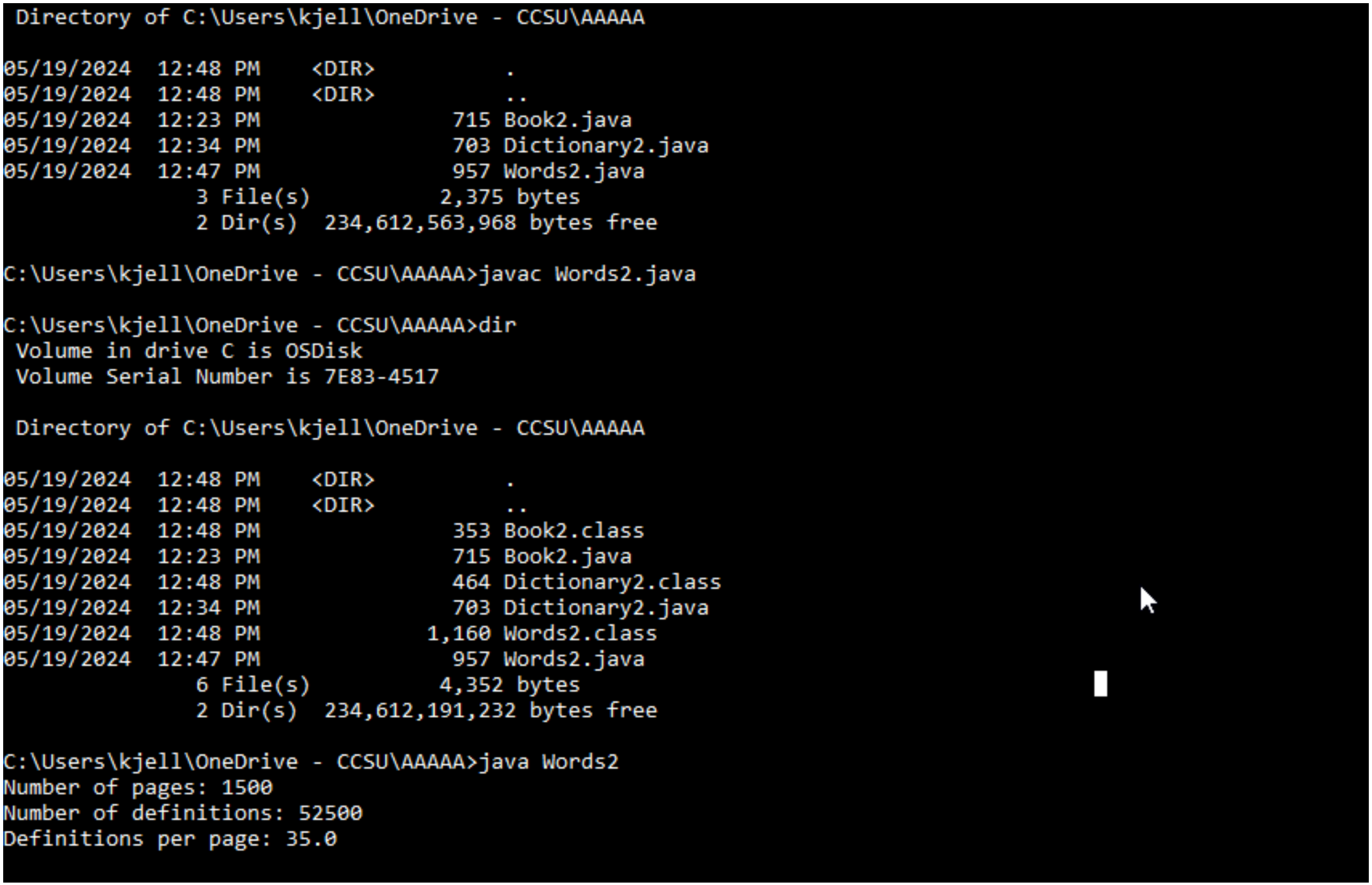
continue

```
    //-----------------------------------------------------------------
    //  Prints a message using both local and inherited values.
    //-----------------------------------------------------------------
    public double computeRatio()
    {
       return (double) definitions/pages;
    }

    //-----------------------------------------------------------------
    //  Definitions mutator.
    //-----------------------------------------------------------------
    public void setDefinitions(int numDefinitions)
    {
       definitions = numDefinitions;
    }

    //-----------------------------------------------------------------
    //  Definitions accessor.
    //-----------------------------------------------------------------
    public int getDefinitions()
    {
       return definitions;
    }
}
```

```
//********************************************************************
//  Words2.java Author: Lewis/Loftus
//
//  Demonstrates the use of the super reference.
//********************************************************************

public class Words2
{
   //-----------------------------------------------------------------
   //  Instantiates a derived class and invokes its inherited and
   //  local methods.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      // uses constructor defined in the class Dictionary2
      Dictionary2 webster = new Dictionary2(1500, 52500);

      System.out.println("Number of pages: " + webster.getPages());

      System.out.println("Number of definitions: " +
                         webster.getDefinitions());

      System.out.println("Definitions per page: " +
                         webster.computeRatio());
   }
}
```

```
//********************************************************************
//  Book2.java       Author: Lewis/Loftus
//********************************************************************

public class Book2
{
   protected int pages;

   //-----------------------------------------------------------------
   //  Constructor: Sets up the book with the specified number of
   //  pages. (Original Book did not have a constructor.)
   //-----------------------------------------------------------------
   public Book2(int numPages)
   {
      pages = numPages;
   }

   public void setPages(int numPages)
   {
      pages = numPages;
   }

   public int getPages()
   {
      return pages;
   }
}
```

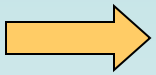
```
//********************************************************************
//  Dictionary2.java       Author: Lewis/Loftus
//********************************************************************

public class Dictionary2 extends Book2
{
   private int definitions;

   public Dictionary2(int numPages, int numDefinitions)
   {
      super(numPages);  // The whole point of this example

      definitions = numDefinitions;
   }

   public double computeRatio()
   {
      return (double) definitions/pages;
   }

   public void setDefinitions(int numDefinitions)
   {
      definitions = numDefinitions;
   }

   public int getDefinitions()
   {
      return definitions;
   }
}
```



Multiple Inheritance

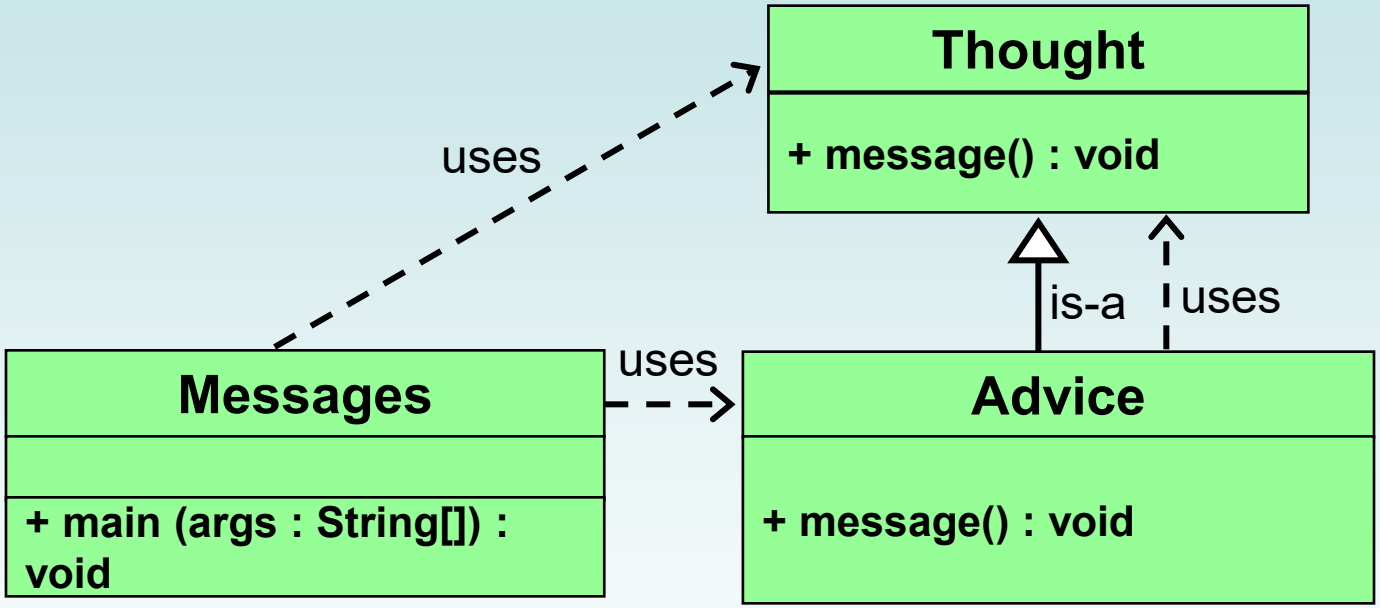
- Java has only *single inheritance*
  - a derived class can have only one parent class
- Java does not support *Multiple inheritance*
  - a derived class can have several parent classes
  - a derived class inherits the members of all parents
  - collisions, such as the same variable name in two parents, cause problems
- Multiple inheritance is not needed, so Java does not support it

Outline

- Creating Subclasses
-  Overriding Methods
- Class Hierarchies
- Visibility
-  Designing for Inheritance
-  Inheritance in JavaFX
-  Color and Date Pickers
-  Dialog Boxes

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 that is executing the method determines which version of the method is invoked
- See `Messages.java`
- See `Thought.java`
- See `Advice.java`



The message() in Advice overrides the message() in Thought.

Also, the message() in Advice invokes the message() in Thought

```
//********************************************************************
//  Messages.java       Author: Lewis/Loftus
//
//  Demonstrates the use of an overridden method.
//********************************************************************

public class Messages
{
   //-----------------------------------------------------------------
   //  Creates two objects and invokes the message method in each.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      Thought parked = new Thought(); // parent class
      Advice  dates  = new Advice();  // child class

      parked.message(); // method of parent is run
      System.out.println("-----------------");

      dates.message();  // method of child is run
   }
}
```

Output

```
I feel like I'm diagonally parked in a parallel universe.
----------------
Warning: Dates in calendar are closer than they appear.

I feel like I'm diagonally parked in a parallel universe.
```

```
//-----------------------------------------------------------------
//  Creates two objects and invokes the message method in each.
//-----------------------------------------------------------------
public static void main(String[] args)
{
   Thought parked = new Thought(); // parent class
   Advice  dates  = new Advice();  // child class

   parked.message(); // method of parent is run
   System.out.println("-----------------");

   dates.message();  // method of child is run
}
}
```

```
//********************************************************************
//  Thought.java       Author: Lewis/Loftus
//
//  Represents a stray thought. Used as the parent of a derived
//  class to demonstrate the use of an overridden method.
//********************************************************************

public class Thought
{
   //-----------------------------------------------------------------
   //  Prints a message.
   //-----------------------------------------------------------------
   public void message()
   {
      System.out.println("I feel like I'm diagonally parked in a " +
                         "parallel universe.");

      System.out.println();
   }
}
```

```java
//********************************************************************
//  Advice.java       Author: Lewis/Loftus
//
//  Represents some thoughtful advice. Used to demonstrate the use
//  of an overridden method.
//********************************************************************

public class Advice extends Thought
{
   //-----------------------------------------------------------------
   //  Prints a message. This method overrides the parent's version.
   //-----------------------------------------------------------------
   public void message()
   {
      System.out.println("Warning: Dates in calendar are closer " +
                         "than they appear.");

      System.out.println();

      super.message();  // explicitly invoke the parent's version
   }
}
```

Overriding and Shadowing

- 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
- Overriding can be applied to data and is called *shadowing variables*
  - a variable in a child class with the same name as a variable in the parent class hides the parent's variable in a shadow
- Avoid shadowing variables because it causes confusing code

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 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

Quick Check

True or False?

A child class may define a method with the same name as a method in the parent.

A child class can override the constructor of the parent class.

A child class cannot override a `final` method of the parent class.

It is considered poor design when a child class overrides a method from the parent.

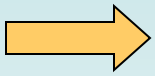
A child class may define a variable with the same name as a variable in the parent.

Quick Check

True or False?

A child class may define a method with the same name as a method in the parent.	True
A child class can override the constructor of the parent class.	False
A child class cannot override a `final` method of the parent class.	True
It is considered poor design when a child class overrides a method from the parent.	False
A child class may define a variable with the same name as a variable in the parent.	True, but unwise

Outline

- Creating Subclasses
- Overriding Methods
-  Class Hierarchies
- Visibility
-  Designing for Inheritance
-  Inheritance in JavaFX
-  Color and Date Pickers
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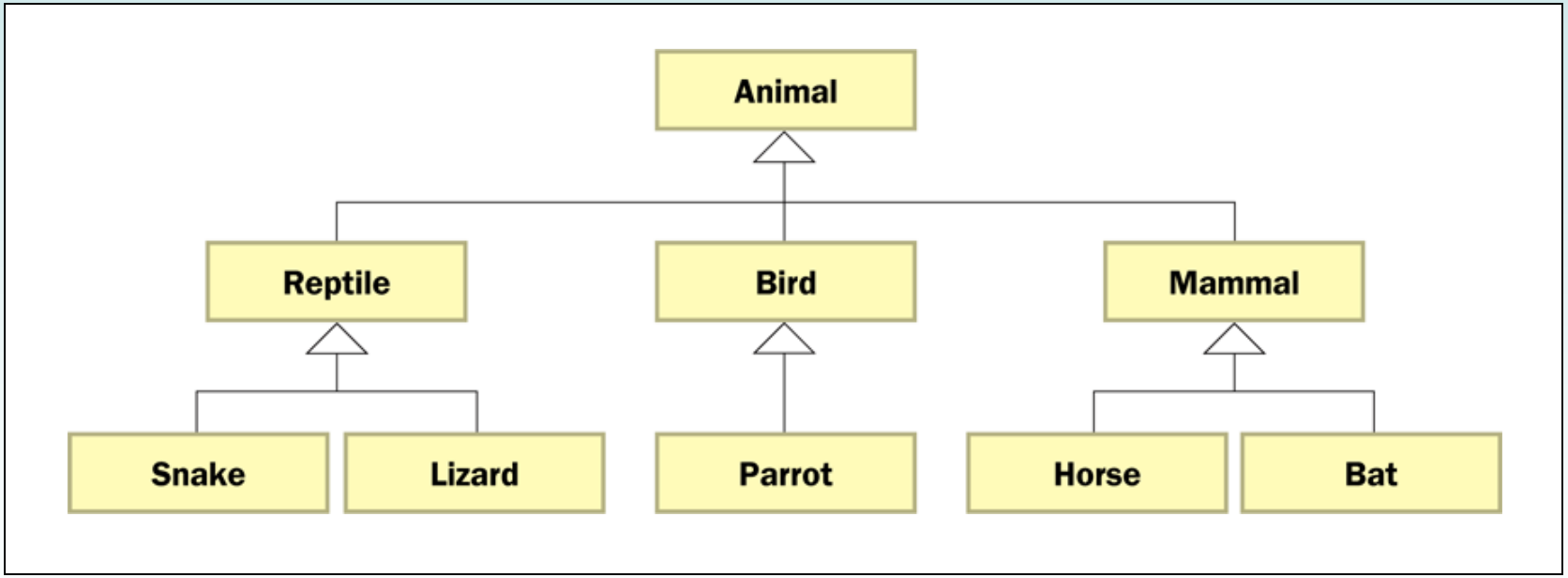
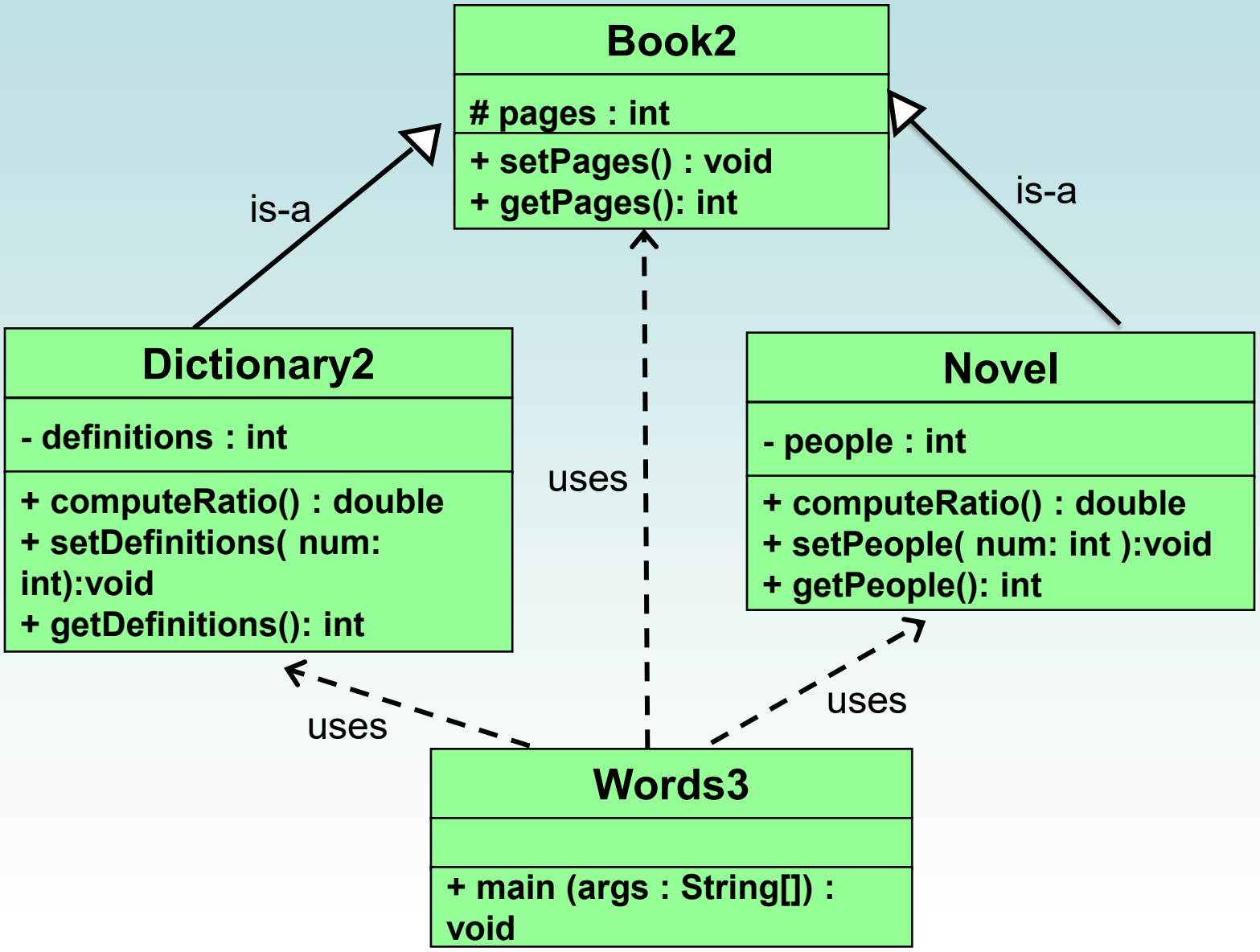
Class Hierarchies

A child class of a parent can be the parent of a child, forming a *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



```
//********************************************
//  Words3.java       Author: Lewis/Loftus, H
//********************************************

public class Words3
{
   public static void main(String[] args)
   {
      Book2 book = new Book2( 523 );
      System.out.println ("Number of pages:"

      Dictionary2 webster = new Dictionary2(1500, 52500);
      System.out.println("webster pages:" + webster.getPages());
      System.out.println("webster definitions:" + webster.getDefinitions());
      System.out.println("Definitions per page:" + webster.computeRatio());
      System.out.println("---------- " );

      Novel dickens = new Novel( 320, 32 );
      System.out.println("dickens pages: " + dickens.getPages());
      System.out.println("dickens people:" + dickens.getPeople());
      System.out.println("Pages per person:" + dickens.computeRatio());
   }
}
```

Output

```
Number of pages: 523
webster pages: 1500
webster definitions: 52500
Definitions per page: 35.0
-----------
dickens pages: 320
dickens people: 32
Pages per person: 10
```

Challenges: `add another book; add a title`

```
//********************************************************************
//  Book2.java     SAME AS PREVIOUS EXAMPLE
//
//  Represents a book. Used as the parent of a derived class to
//  demonstrate inheritance and the use of the super reference.
//********************************************************************

public class Book2
{
   protected int pages;

   //-----------------------------------------------------------------
   //  Constructor: Sets up the book with the specified number of
   //  pages.
   //-----------------------------------------------------------------
   public Book2(int numPages)
   {
      pages = numPages;
   }
```

continue

continue

```
    //-----------------------------------------------------------------
    //  Pages mutator.
    //-----------------------------------------------------------------
    public void setPages(int numPages)
    {
       pages = numPages;
    }

    //-----------------------------------------------------------------
    //  Pages accessor.
    //-----------------------------------------------------------------
    public int getPages()
    {
       return pages;
    }
}
```

```
//********************************************************************
//  Dictionary2.java       SAME AS PREVIOUS EXAMPLE
//
//  Represents a dictionary, which is a book. Used to demonstrate
//  the use of the super reference.
//********************************************************************

public class Dictionary2 extends Book2
{
   private int definitions;

   //-----------------------------------------------------------------
   //  Constructor: Sets up the dictionary with the specified number
   //  of pages and definitions.
   //-----------------------------------------------------------------
   public Dictionary2(int numPages, int numDefinitions)
   {
      super(numPages); // Invoke the parent's constructor

      definitions = numDefinitions;
   }
```

continue

continue

```
    //-----------------------------------------------------------------
    //  Prints a message using both local and inherited values.
    //-----------------------------------------------------------------
    public double computeRatio()
    {
       return (double) definitions/pages;
    }

    //-----------------------------------------------------------------
    //  Definitions mutator.
    //-----------------------------------------------------------------
    public void setDefinitions(int numDefinitions)
    {
       definitions = numDefinitions;
    }

    //-----------------------------------------------------------------
    //  Definitions accessor.
    //-----------------------------------------------------------------
    public int getDefinitions()
    {
       return definitions;
    }
}
```

```java
//*************************************************************************
//  Novel.java
//*************************************************************************
public class Novel extends Book2
{
   private int people;

   public Novel(int numPages, int numPeople)
   {
      super(numPages); // Invoke the parent's constructor

      people = numPeople;
   }

   public double computeRatio()
   {
      return (double) pages/people;
   }

   public void setPeople(int numPeople)
   {
      people = numPeople;
   }

   public int getPeople()
   {
      return people;
   }
}
```

```
//*****************************************************************
//  Novel.java
//*****************************************************************
public class Novel extends Book2
{
   private int people;

   public Novel(int numPages, int numPeople)
   {
      super(numPages); // Invoke the parent's constructor

      people = numPeople;
   }

   public double computeRatio()
   {
      return (double) pages/people;
   }

   public void setPeople(int numPeople)
   {
      people = numPeople;
   }

   public int getPeople()
   {
      return people;
   }
}
```

```
/* copy to Words3.java */

public class Words3
{
   public static void main(String[] args)
   {
      Book2 book = new Book2( 523 );
      System.out.println ("Number of pages:" + book.getPages() );

      Dictionary2 webster = new Dictionary2(1500, 52500);
      System.out.println("webster pages:" + webster.getPages());
      System.out.println("webster definitions:" + webster.getDefinitions());
      System.out.println("Definitions per page:" + webster.computeRatio());
      System.out.println("---------- " );

      Novel dickens = new Novel( 320, 32 );
      System.out.println("dickens pages: " + dickens.getPages());
      System.out.println("dickens people:" + dickens.getPeople());
      System.out.println("Pages per person:" + dickens.computeRatio());
   }
}
```

```
C:\Users\kjell\OneDrive - CCSU\AAAAA>javac Words3.java

C:\Users\kjell\OneDrive - CCSU\AAAAA>dir
 Volume in drive C is OSDisk
 Volume Serial Number is 7E83-4517

 Directory of C:\Users\kjell\OneDrive - CCSU\AAAAA

05/19/2024  12:38 PM    <DIR>          .
05/19/2024  12:38 PM    <DIR>          ..
05/19/2024  12:38 PM               353 Book2.class
05/19/2024  12:23 PM               715 Book2.java
05/19/2024  12:38 PM               464 Dictionary2.class
05/19/2024  12:34 PM               703 Dictionary2.java
05/19/2024  12:38 PM               437 Novel.class
05/19/2024  12:19 PM               609 Novel.java
05/19/2024  12:38 PM             1,490 Words3.class
05/19/2024  12:19 PM               765 Words3.java
               8 File(s)          5,536 bytes
               2 Dir(s)  235,089,350,656 bytes free

C:\Users\kjell\OneDrive - CCSU\AAAAA>java Words3
Number of pages:523
webster pages:1500
webster definitions:52500
Definitions per page:35.0
----------
dickens pages: 320
dickens people:32
Pages per person:10.0

C:\Users\kjell\OneDrive - CCSU\AAAAA>
```

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 a child of the `Object` class
- Therefore, the `Object` class is the ultimate root of all class hierarchies

The Object Class

- The `Object` class contains 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 returns a string that contains the name of the object's class along with a hash code

The Object Class

- The **`equals`** method of the `Object` class returns true if two references are aliases

  This is the same as what `==` does

- 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` to be more useful

```
//********************************************************************
//  Words4.java       Author: Lewis/Loftus, Hacked
//********************************************************************

public class Words4
{
   public static void main(String[] args)
   {
      Book4 bookA = new Book4( 523 );
      Book4 bookB = new Book4( 523 );

      if ( bookA == bookB ) // check if the two pointers are the same
        System.out.println("One object, two aliases" ) ;
      else
        System.out.println("Two objects") ; // they are

      if ( bookA.equals( bookB ) ) // using method defined in book
        System.out.println("Equivalent objects (or one object)") ;
      else
        System.out.println("Two non-equivalent objects") ;
   }
}
```

Output

```
Two objects
Equivalent objects
```

```
//********************************************************************
//  Book4.java       Author:
//
//********************************************************************

public class Book4
{
   protected int pages;

   //-----------------------------------------------------------------
   //  Constructor: Give the book the specified number of pages.
   //-----------------------------------------------------------------
   public Book4(int numPages)
   {
      pages = numPages;
   }

   //-----------------------------------------------------------------
   //  This method overrides
   //  the method inherited from Object
   //-----------------------------------------------------------------
   public boolean equals( Book4 other)
   {
      return pages == other.pages;
   }
}
```

Abstract Classes

- An *abstract class* is a placeholder in a class hierarchy that represents a generic concept
  - might have an abstract class Animal that includes features all animals must have
  - but don't want an object that is only Animal and nothing else
  - classes derived from Animal can be instantiated
    - Dog, Cat, Spider
- An abstract class cannot be instantiated

Abstract Classes

The modifier `abstract` on the class header declares a class as abstract:

```
public abstract class Animal
{
    // class 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`
- Abstract classes are an important element of software design
  - used to establish common features in a hierarchy that are too general to instantiate

Interface Hierarchies

- Inheritance can be applied to interfaces
- 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 interfaces
- Class hierarchies and interface hierarchies are distinct (they do not overlap)

Quick Check

What are some methods defined by the `Object` class?

What is an abstract class?

Quick Check

What are some methods defined by the `Object` class?

```
String toString()
boolean equals(Object obj)
```

What is an abstract class?

An abstract class is a placeholder in the class hierarchy, defining a general concept and gathering elements common to all derived classes.

An abstract class cannot be instantiated.

Outline

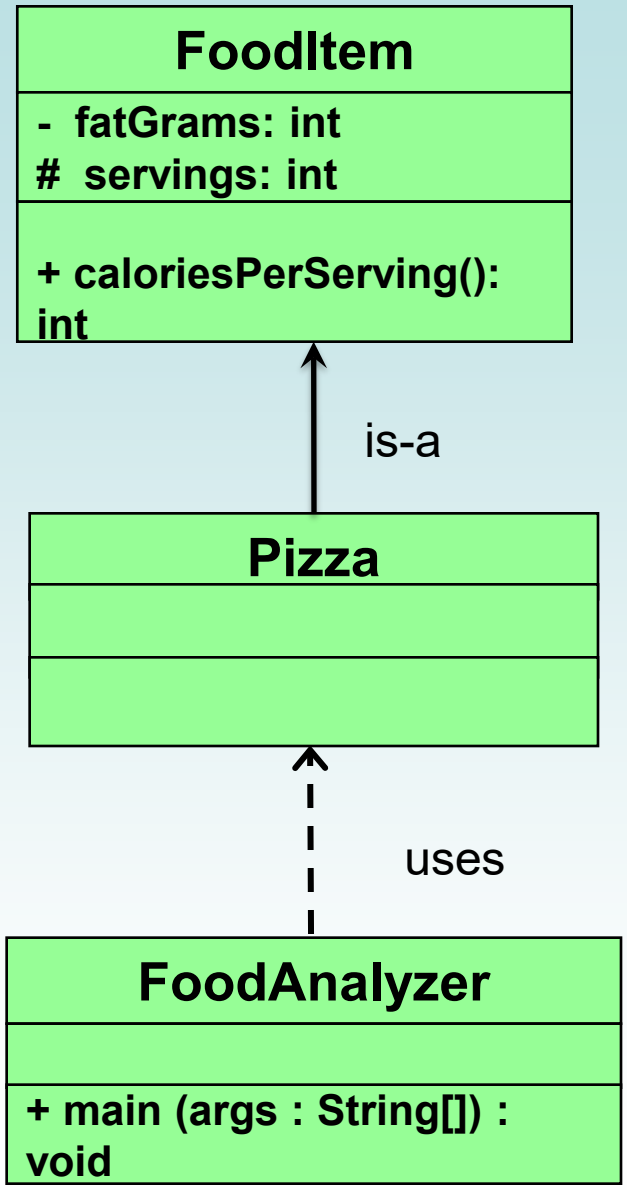
- Creating Subclasses
- Overriding Methods
- Class Hierarchies
- Visibility
- Designing for Inheritance
- Inheritance in JavaFX
- Color and Date Pickers
- Dialog Boxes

Visibility Revisited

- A subtle issue related to inheritance and visibility:
- All variables and methods of a parent class, even private members, are inherited by its children
  - but the child might not see them directly
- Private members in a parent class 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 a parent can refer to its private member, a 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
- See `FoodAnalyzer.java`
- See `FoodItem.java`
- See `Pizza.java`



```
//********************************************************************
//  FoodAnalyzer.java       Author: Lewis/Loftus
//
//  Demonstrates indirect access to inherited private members.
//********************************************************************

public class FoodAnalyzer
{
   //-----------------------------------------------------------------
   //  Instantiates a Pizza object and prints its calories per
   //  serving.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      Pizza special = new Pizza(275);

      System.out.println("Calories per serving: " +
                         special.caloriesPerServing());
   }
}
```

```
//********************************************************************
//  FoodAnalyzer.java       Author: Lewis/Loftus
//
//  Demonstrates indirect access to
//********************************                                  **

public class FoodAnalyzer
{
   //-----------------------------------------------------------------
   //  Instantiates a Pizza object and prints its calories per
   //  serving.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      Pizza special = new Pizza(275); // No FoodItem object exists

      System.out.println("Calories per serving: " +
                         special.caloriesPerServing());
                         // but we can use this method defined in it
   }
}
```

Output

```
Calories per serving: 309
```

```java
//********************************************************************
//  FoodItem.java       Author: Lewis/Loftus
//
//********************************************************************

public class FoodItem
{
   final private int CALORIES_PER_GRAM = 9;
   private int fatGrams;
   protected int servings;

   public FoodItem(int numFatGrams, int numServings)
   {
      fatGrams = numFatGrams;
      servings = numServings;
   }

   private int calories()
   {
      return fatGrams * CALORIES_PER_GRAM;
   }

   public int caloriesPerServing()
   {
      return (calories() / servings);
   }
}
```

```
//********************************************************************
//  Pizza.java       Author: Lewis/Loftus
//
//  Represents a pizza, which is a food item. Demonstrates
//  indirect referencing through inheritance.
//********************************************************************

public class Pizza extends FoodItem
{
   //-----------------------------------------------------------------
   //  Sets up a pizza with the specified amount of fat (assumes
   //  eight servings).
   //
   //  fatGrams in the parent class is private, so Pizza objects
   //  cannot use it directly.
   //-----------------------------------------------------------------
   public Pizza(int fatGrams)
   {
      super(fatGrams, 8);
   }
}
```

Outline

Creating Subclasses

Overriding Methods

Class Hierarchies

Visibility

Designing for Inheritance

Inheritance in JavaFX

Color and Date Pickers

Dialog Boxes

Designing for Inheritance

- Take the time to create a good software design
- Inheritance is an important part of an object-oriented design
- Properly designed inheritance contribute to the elegance, maintainability, and reuse of the software

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 avoid (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
- Override general methods such as `toString` and `equals` with appropriate definitions
- Use abstract classes to represent general concepts that derived classes have in common
- Use visibility modifiers carefully to provide needed access without violating encapsulation

Restricting Inheritance

- If the **`final`** modifier is applied to a method, that method cannot be overridden in any derived classes
- If the **`final`** modifier is applied to an entire class, then that class cannot be used to derive any children at all
- Therefore, an abstract class cannot be declared as final

Outline

Creating Subclasses

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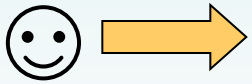
Visibility

Designing for Inheritance

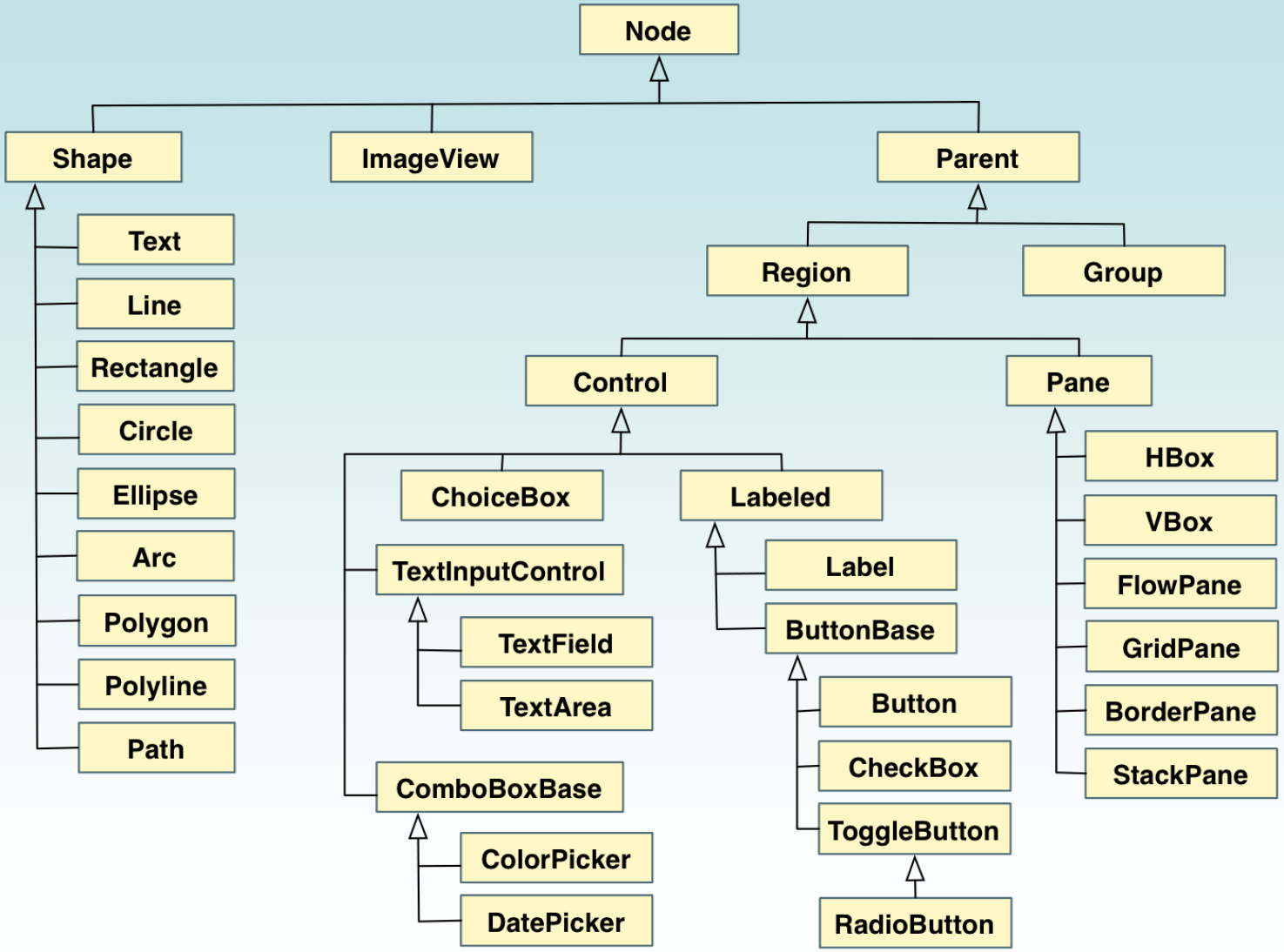


Inheritance in JavaFX

Color and Date Pickers

Dialog Boxes

Inheritance in JavaFX



Inheritance in JavaFX

- All shape classes are derived from `Shape`, which manages stroke and fill
- Nodes derived from **`Parent`** can hold other nodes
  - So shapes cannot hold other nodes
- Any `Region` can be styled with CSS
- All layout panes are derived from `Pane`
- Controls have various intermediate classes to organize common characteristics

Inheritance in JavaFX

- Note the difference between the scene graph (containment) and the inheritance hierarchy
- Only a `Parent` can be a root node of a scene
- So a `Pane` can be the root node of a scene, and could contain a `Circle` and a `Button`
  - `Pane` isa `Region` isa `Parent`
- A `ChoiceBox` could be the root node of a scene, but a `Rectangle` could not

Outline

- Creating Subclasses
- Overriding Methods
- Class Hierarchies
- Visibility
-  Designing for Inheritance
-  Inheritance in JavaFX
-   Color and Date Pickers
-  Dialog Boxes

Color and Date Pickers

- A *color picker* is a control that allows the user to select a color from a palette or other model
- A *date picker* allows the user to select a calendar date
- Both appear as a single field and use drop-down panes for the selection
- See `PickerDemo.java`

```
import java.time.LocalDate;
import javafx.application.Application;
import javafx.event.ActionEvent;
import javafx.geometry.Pos;
import javafx.scene.Scene;
import javafx.scene.control.ColorPicker;
import javafx.scene.control.DatePicker;
import javafx.scene.layout.HBox;
import javafx.scene.layout.VBox;
import javafx.scene.paint.Color;
import javafx.scene.text.Font;
import javafx.scene.text.FontPosture;
import javafx.scene.text.FontWeight;
import javafx.scene.text.Text;
import javafx.stage.Stage;

//*******************************************************************
//  PickerDemo.java       Author: Lewis/Loftus
//
//  Demonstrates the use of color picker and date picker controls.
//*******************************************************************

public class PickerDemo extends Application
{
    private Text message;
    private DatePicker datePicker;
    private ColorPicker colorPicker;
```

continue

continue

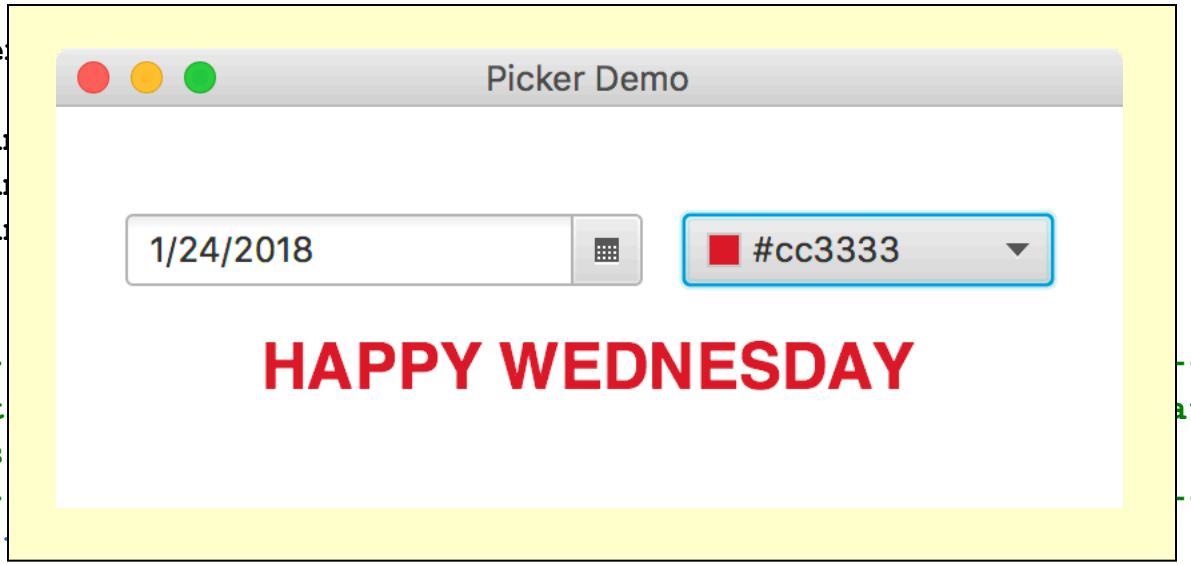
```
    //-----------------------------------------------------------------
    //  Allows the user to select a date and a color. A Text object
    //  displays the day of the week in the color specified.
    //-----------------------------------------------------------------
    public void start(Stage primaryStage)
    {
        datePicker = new DatePicker(LocalDate.now());
        datePicker.setOnAction(this::processDateChoice);

        colorPicker = new ColorPicker(Color.BLACK);
        colorPicker.setOnAction(this::processColorChoice);

        message = new Text("HAPPY " + LocalDate.now().getDayOfWeek());
        message.setFont(Font.font("Helvetica", FontWeight.BOLD,
            FontPosture.REGULAR, 24));

        HBox pickers = new HBox(datePicker, colorPicker);
        pickers.setSpacing(15);
        pickers.setAlignment(Pos.CENTER);

        VBox root = new VBox();
        root.setStyle("-fx-background-color: white");
        root.setSpacing(20);
        root.setAlignment(Pos.CENTER);
        root.getChildren().addAll(pickers, message);
```

continue

continue

```
        Scene scene = new Scene(root, 400, 150);

        primaryStage.setTitle("Picker Demo");
        primaryStage.setScene(scene);
        primaryStage.show();
    }

    //-----------------------------------------------------------------
    //  Gets the value of the date from the date picker and updates the
    //  message with the corresponding day of the week.
    //-----------------------------------------------------------------
    public void processDateChoice(ActionEvent event)
    {
        LocalDate date = datePicker.getValue();
        message.setText("HAPPY " + date.getDayOfWeek());
    }

    //-----------------------------------------------------------------
    //  Gets the color specified in the color picker and sets the
    //  color of the displayed message.
    //-----------------------------------------------------------------
    public void processColorChoice(ActionEvent event)
    {
        message.setFill(colorPicker.getValue());
    }
}
```

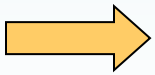
continue




```
        Sce
        pri
        pri
        pri
    }

    //-----                                                    ----------
    //  Get                                                   ates the
    //  mes
    //-----                                                    ----------
    public
    {
        LocalDate date = datePicker.getValue();
        message.setText("HAPPY " + date.getDayOfWeek());
    }

    //-----------------------------------------------------------------
    //  Gets the color specified in the color picker and sets the
    //  color of the displayed message.
    //-----------------------------------------------------------------
    public void processColorChoice(ActionEvent event)
    {
        message.setFill(colorPicker.getValue());
    }
}
```

Outline

- Creating Subclasses
- Overriding Methods
- Class Hierarchies
- Visibility
- ☺ Designing for Inheritance
- ☺ Inheritance in JavaFX
- ☺ Color and Date Pickers
- ☺ Dialog Boxes



Dialog Boxes

- A *dialog box* is a window that pops up to provide brief user interaction with a specific purpose
- The `Alert` class provides support for several basic dialog box types:
  - **`AlertType.INFORMATION`**
  - **`AlertType.CONFIRMATION`**
  - **`AlertType.WARNING`**
  - **`AlertType.ERROR`**

Dialog Boxes

- Two other dialog box classes are `TextInputDialog` and `ChoiceDialog`
- They allow the user to enter input using a text field or a drop-down choice box, respectively
- See `EventOdd.java`

```
import java.util.Optional;
import javafx.application.Application;
import javafx.scene.control.Alert;
import javafx.scene.control.Alert.AlertType;
import javafx.scene.control.ButtonType;
import javafx.scene.control.TextInputDialog;
import javafx.stage.Stage;

//*****************************************************************
//  EvenOdd.java       Author: Lewis/Loftus
//
//  Demonstrates the use of information and confirmation alerts, as well
//  as text input dialog boxes.
//*****************************************************************

public class EvenOdd extends Application
{
    //-----------------------------------------------------------------
    //  Prompts the user for an integer, informs the user if that value
    //  is even or odd, then asks if the user would like to process
    //  another value. All interaction is performed using dialog boxes.
    //-----------------------------------------------------------------
    public void start(Stage primaryStage) throws Exception
    {
        boolean doAnother = true;
```

continue

continue

```
while (doAnother)
{
    TextInputDialog inputDialog = new TextInputDialog();
    inputDialog.setHeaderText(null);
    inputDialog.setTitle(null);
    inputDialog.setContentText("Enter an integer:");
    Optional<String> numString = inputDialog.showAndWait();

    if (numString.isPresent())
    {
        int num = Integer.parseInt(numString.get());

        String result = "That number is " +
            ((num % 2 == 0) ? "even." : "odd.");

        Alert answerDialog = new Alert(AlertType.INFORMATION);
        answerDialog.setHeaderText(null);
        answerDialog.setContentText(result);
        answerDialog.showAndWait();

        Alert confirmDialog = new Alert(AlertType.CONFIRMATION);
        confirmDialog.setHeaderText(null);
        confirmDialog.setContentText("Do another?");
        Optional<ButtonType> another = confirmDialog.showAndWait();
```

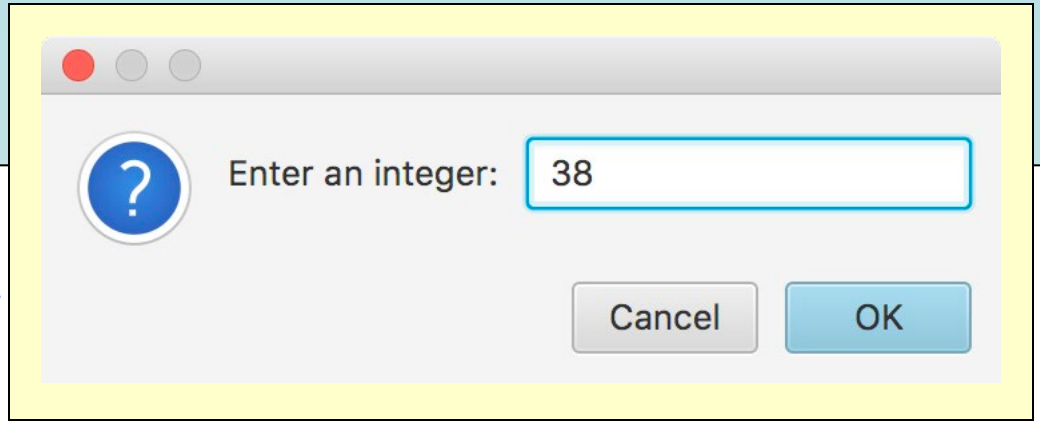
continue

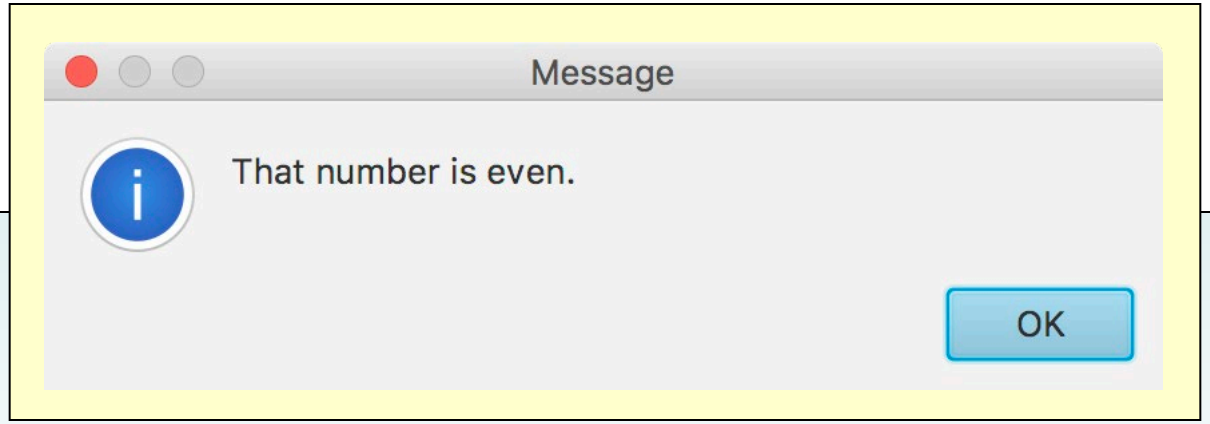
continue

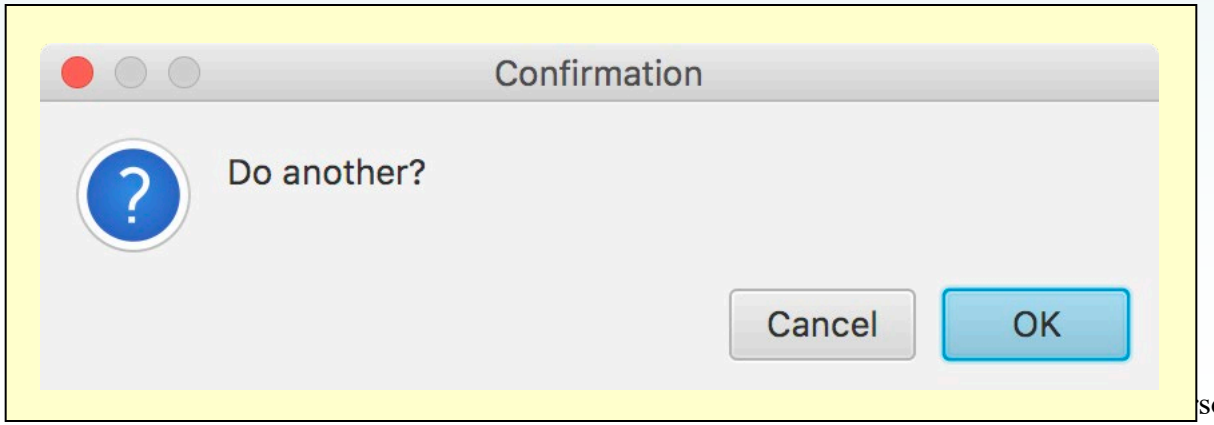
```
                if (another.get() != ButtonType.OK)
                    doAnother = false;
            }
            else
                doAnother = false;
        }
    }
}
```

continue

```
                    if
                }
                else

            }
        }
}
```







File Choosers

- A *file chooser* is a specialized dialog box that allows the user to select a file from the hard drive
- The following example opens a text file using a file chooser and displays its contents in a *text area*
- See `DisplayFile.java`

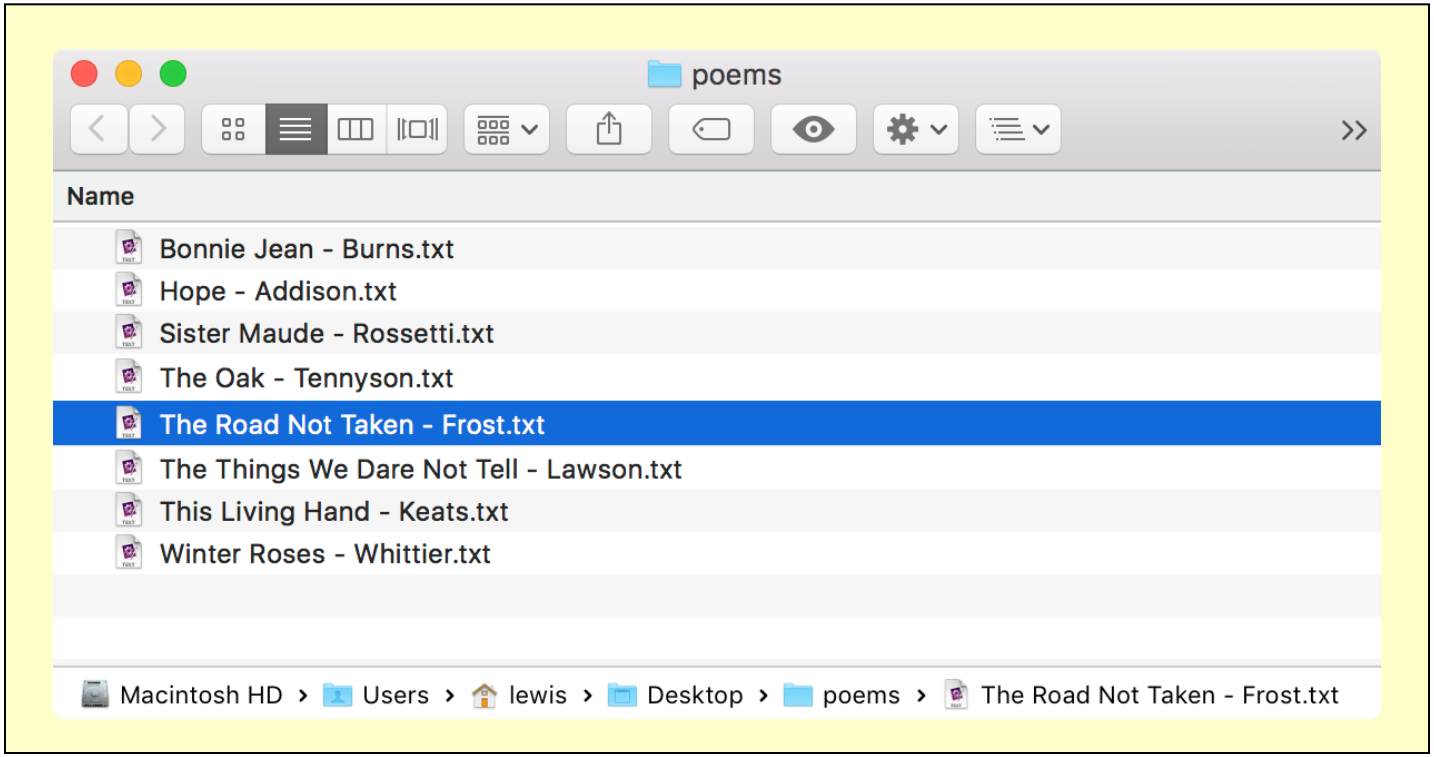
```
import java.io.File;
import java.io.IOException;
import java.util.Scanner;
import javafx.application.Application;
import javafx.scene.Scene;
import javafx.scene.control.TextArea;
import javafx.scene.text.Font;
import javafx.stage.FileChooser;
import javafx.stage.Stage;

//*****************************************************************
//  DisplayFile.java       Author: Lewis/Loftus
//
//  Demonstrates the use of a file chooser dialog box and a text area.
//*****************************************************************

public class DisplayFile extends Application
{
    //-----------------------------------------------------------------
    //  Presents a file chooser dialog, reads the selected file and
    //  loads it into a text area.
    //-----------------------------------------------------------------
    public void start(Stage primaryStage) throws IOException
    {
        FileChooser chooser = new FileChooser();
        File selectedFile = chooser.showOpenDialog(primaryStage);
```

continue

continue

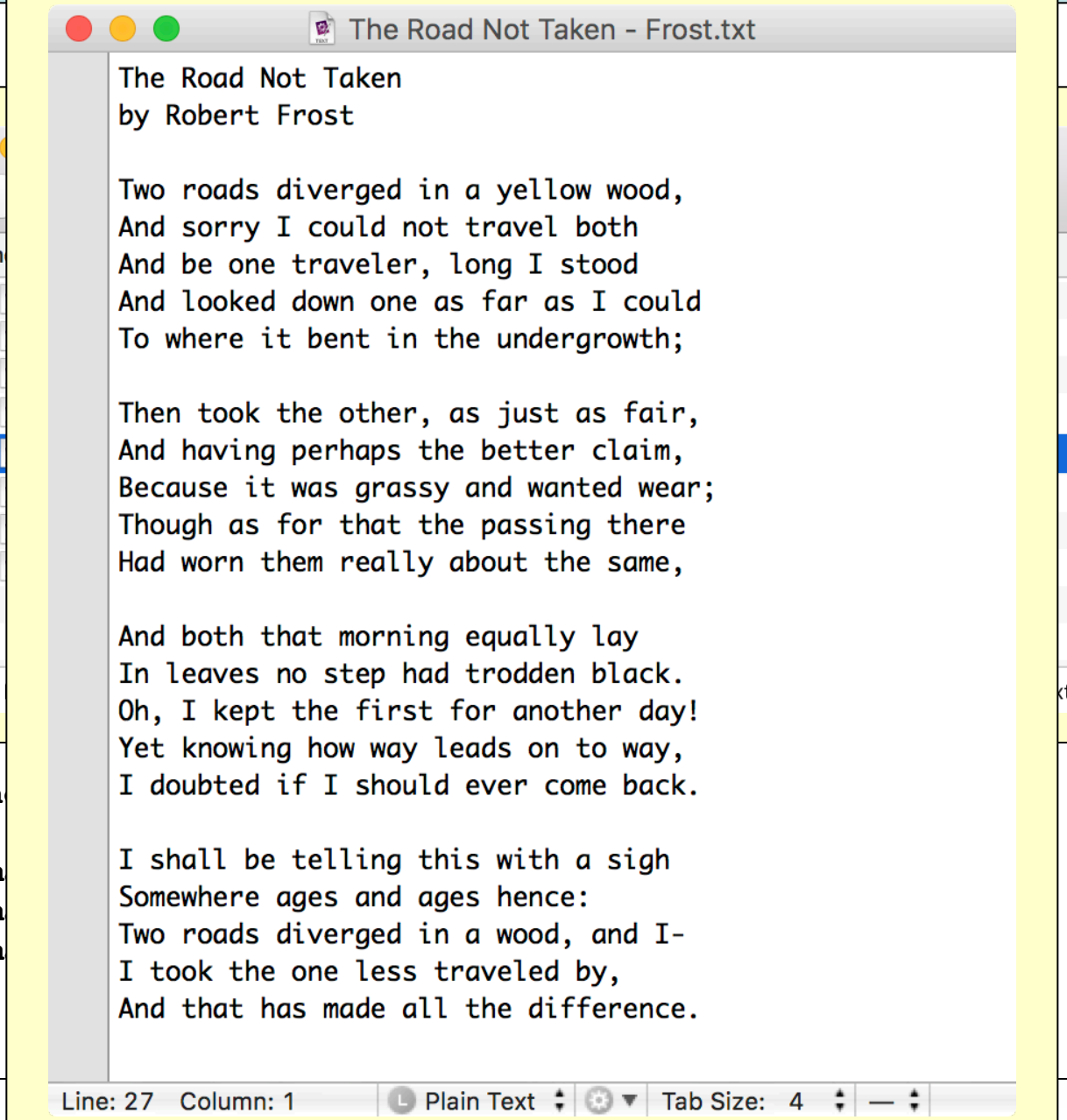
```
        TextArea content = new TextArea();
        content.setFont(new Font("Courier", 12));
        content.setEditable(false);

        if (selectedFile == null)
            content.setText("No file chosen.");
        else
        {
            Scanner scan = new Scanner(selectedFile);

            String info = "";
            while (scan.hasNext())
                info += scan.nextLine() + "\n";

            content.setText(info);
        }

        Scene scene = new Scene(content, 500, 500);

        primaryStage.setTitle("Display File");
        primaryStage.setScene(scene);
        primaryStage.show();
    }
}
```

continue




```
        Scene scene = new Scene(content, 500, 500);

        primaryStage.setTitle("Display File");
        primaryStage.setScene(scene);
        primaryStage.show();
    }
}
```

continue




```
        Scen

        prim
        prim
        prim
    }
}
```

Summary

- Chapter 9 focused on:
  - deriving new classes from existing classes
  - the `protected` modifier
  - creating class hierarchies
  - abstract classes
  - indirect visibility of inherited members
  - designing for inheritance
  - the JavaFX class hierarchy
  - color and date pickers
  - dialog boxes