Announcements for This Lecture

Material

- Section 12.1
  - Compare with section 4.7
  - Relevant to assignment
- Next week is wrap up
  - **Tue**: Leaving DrJava
  - **Thu**: Where to from here?
- Review sessions in 2 weeks
  - Details next week

Assignments

- A6 still being graded
  - Done by Saturday
- Work on Assignment A7
  - Should have read by now
  - Keep track of the dates
    - Makes it manageable
    - Major push this weekend
  - Due Saturday after classes

Pascal's Triangle

```
                    1                                    0
                 1     1                                 1
              1     2     1                              2
           1     3     3     1                           3
        1     4     6     4     1                        4
     1     5    10    10     5     1                     5
                                                         …
```

- **Binomial Theorem**: Row r gives the coefficients of $(x + y)^r$
  - $(x + y)^2 = 1x^2 + 2xy + 1y^2$
  - $(x + y)^3 = 1x^3 + 3x^2y + 3xy^2 + 1y^3$
  - $(x + y)^r = \sum_{0 \le k \le r} (k \text{ choose } r)\, x^k y^{r-k}$

Ragged Arrays for Pascal's Triangle

```
/** Yields: ragged array of first n rows of Pascal's triangle. Precondition: 0 ≤ n */
public static int[][] pascalTriangle(int n) {
    int[][] b= new int[n][];     // First n rows of Pascal's triangle
    // invariant: rows 0..i-1 have been created
    for (int i = 0; i != b.length; i=  i+1) {
        b[i]= new int[i+1];     // Create row i of Pascal's triangle
        b[i][0]=  1;            // Calculate row i of Pascal's triangle
        // invariant b[i][0..j-1] have been created
        for (int j= 1; j < i; j= j+1) {
            b[i][j]=  b[i-1][j-1] + b[i-1][j];
        }
        b[i][i]= 1;
    }
    return b;
}
```

A Subclassing Example

- Classes for Shapes:
  - Rectangle: All angles equal
  - Rhombus: All sides same length
  - Square: All angles equal and all sides same length

Rhombus **and** a Rectangle

- A square inherits from both rectangle and rhombus
  - `public class Rectangle { … }`
  - `public class Rhombus { … }`
  - `public class Square extends Rectangle, Rhombus { … }`

Problem: Can Only Extend One Class

public class C extends ~~C1,~~ C2 { … }

```
public class C1 {              public class C2 {
  public int m() {               public int m() {
    return 2;                      return 3;
  }                              }

  public int p() {               public int q() {
    return …;                      return …;
  }                              }
}                              }
```

Which m() is inherited?

Use an Interface

```
public class C implements C1, C2 { … }
```

```
public interface C1 {          public interface C2 {
  public int m();                public int m();
  public int p();                public int q();
}                              }
```

- All methods in an interface are abstract
  - No need for "abstract" keyword
  - Technically, "public" is also redundant (and is optional)
- **Example**: java.awt.event.ActionListener

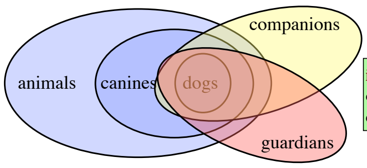
Reading Class Definitions

```
public class Canine extends Animal { … }
public class Dog extends Canine implements Companion, Guardian {…}
```

- Canines **are** animals. Dogs **are** canines.
- Dogs also **can serve as** companions or as guardians.

subclasses: *nested* categories

interfaces: overlapping categories



Application: Generalized Sorting

- Sorting is general, but notion of "<" may change
  - Recommender systems sort by quality, reviews, etc.
  - Travel sites sort by price, departure, etc.
  - Also, ascending vs. descending order
- Do not want to write many sort procedures:
  - `public void sort(int[] arr) {…}`
  - `public void sort(double[] arr) {…}`
  - `public void sort(Movie[] arr) {…}`
  - `public void sort(Flight[] arr) {…}`
- What if they all had a **comparison method**?

Interface java.util.Comparable

```
/** Comparable requires method compareTo*/
public interface Comparable {
   /** Yields: a negative integer if this object < c,
    *  Yields: 0 if this object = c,
    *  Yields: a positive integer if this object > c.
    *  Throws a ClassCastException if c cannot
    *  be cast to the class of this object. */
   int compareTo(Object c);
}
```

abstract method: body replaced by ;

Every class that *implements* Comparable must override compareTo(Object).

Implementing Classes

- Boolean
- Byte
- Double
- Integer
- …
- String
- Calendar
- Time
- Timestamp
- …

Using an Interface as a Type

```
/** Swap b[i] and b[j] to put larger in b[j]  */
public static void swap(Comparable [] b, int i, int j) {
   if (b[j].compareTo(b[i]) < 0) {
         Comparable temp= b[i];
         b[i]= b[j];
         b[j]= temp;
   }
}

public class Movie implements Comparable {
   String name;
   /** Yields -1, 0, or +1 if this Movie's name comes alphabetically before, at, or after c.
    *  Throws a ClassCastException if c cannot be cast to Movie.*/
   public int compareTo(Object c) {
         return this.name.compareTo(((Movie) c).name); // String implements Comparable
   }
}
```

Declaring Your Own Interfaces

```
/** comment */
public interface <interface-name> {
   /** method spec for function*/
   int compareTo(…);
   /** method spec for procedure */
   void doSomething(…);
   /** explanation of constant x*/
   int x= 7;
}
```

Use ";" instead of a body

Methods are implicitly **public**. Can add modifier if you wish.

Every field is implicitly **public**, **static**, and **final**. You can put these modifiers on them if you wish.

Class Can Implement Many Interfaces

```
/** comment */
public class C implements Inter1, Inter2, Inter3{
   …
}
```

- Implements three interfaces: Inter1, Inter2, and Inter3
  - Must implement methods in **all of them**
- **Example**: Recommendation systems
  - Need to determine similarity (Similar interface)
  - Need to sort on this similarity (Comparable interface)