Module 7

Advanced Class Features

Objectives

- Create static variables, methods, and initializers
- Create final classes, methods, and variables
- Create and use enumerated types
- Use the static import statement
- Create abstract classes and methods
- Create and use an interface

Relevance

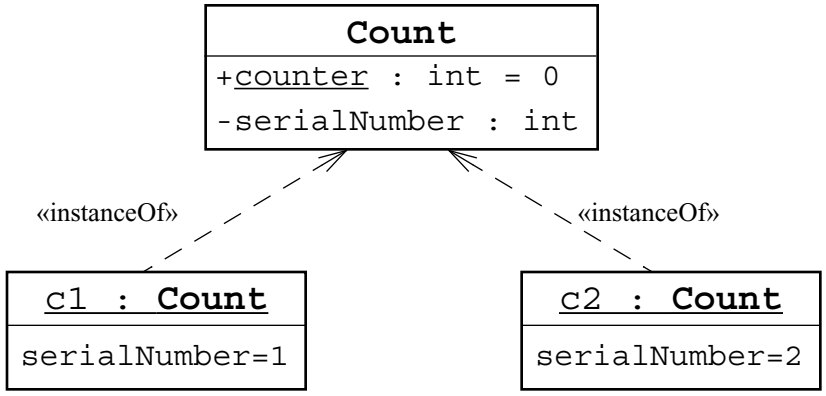
- How can you create a constant?
- How can you declare data that is shared by all instances of a given class?
- How can you keep a class or method from being subclassed or overridden?

The `static` Keyword

- The `static` keyword is used as a modifier on variables, methods, and nested classes.
- The `static` keyword declares the attribute or method is associated with the class as a whole rather than any particular instance of that class.
- Thus static members are often called *class members*, such as *class attributes* or *class methods*.

Class Attributes

Class attributes are shared among all instances of a class:




```
28  public class Count {
29    private int serialNumber;
30    public static int counter = 0;
31
32    public Count() {
33      counter++;
34      serialNumber = counter;
35    }
36  }
```

Class Attributes

If the static member is `public`:

```
1   public class Count1 {
2     private int serialNumber;
3     public static int counter = 0;
4     public Count1() {
5       counter++;
6       serialNumber = counter;
7     }
8   }
```

it can be accessed from outside the class without an instance:

```
1   public class OtherClass {
2     public void incrementNumber() {
3       Count1.counter++;
4     }
5   }
```

Class Methods

You can create `static` methods:

```
1   public class Count2 {
2     private int serialNumber;
3     private static int counter = 0;
4
5     public static int getTotalCount() {
6       return counter;
7     }
8
9     public Count2() {
10      counter++;
11      serialNumber = counter;
12    }
13  }
```

Class Methods

You can invoke `static` methods without any instance of the class to which it belongs:

```
1   public class TestCounter {
2     public static void main(String[] args) {
3       System.out.println("Number of counter is "
4                          + Count2.getTotalCount());
5       Count2 counter = new Count2();
6       System.out.println("Number of counter is "
7                          + Count2.getTotalCount());
8     }
9   }
```

The output of the `TestCounter` program is:

```
Number of counter is 0
Number of counter is 1
```

Class Methods

Static methods cannot access instance variables:

```
1   public class Count3 {
2     private int serialNumber;
3     private static int counter = 0;
4
5     public static int getSerialNumber() {
6       return serialNumber;  // COMPILER ERROR!
7     }
8   }
```

Static Initializers

- A class can contain code in a *static block* that does not exist within a method body.
- Static block code executes once only, when the class is loaded.
- Usually, a static block is used to initialize static (class) attributes.

Static Initializers

```
1   public class Count4 {
2     public static int counter;
3     static {
4       counter = Integer.getInteger("myApp.Count4.counter").intValue();
5     }
6   }
```

```
1   public class TestStaticInit {
2     public static void main(String[] args) {
3       System.out.println("counter = "+ Count4.counter);
4     }
5   }
```

The output of the `TestStaticInit` program is:

```
java -DmyApp.Count4.counter=47 TestStaticInit
counter = 47
```

The `final` Keyword

- You cannot subclass a `final` class.
- You cannot override a `final` method.
- A `final` variable is a constant.
- You can set a `final` variable once only, but that assignment can occur independently of the declaration; this is called a *blank final variable*.
  - A blank final instance attribute must be set in every constructor.
  - A blank final method variable must be set in the method body before being used.

Final Variables

Constants are static final variables.

```
public class Bank {
  private static final double  DEFAULT_INTEREST_RATE = 3.2;
  ... // more declarations
}
```

Blank Final Variables

```
1   public class Customer {
2
3     private final long customerID;
4
5     public Customer() {
6       customerID = createID();
7     }
8
9     public long getID() {
10      return customerID;
11    }
12
13    private long createID() {
14      return ... // generate new ID
15    }
16
17    // more declarations
18
19  }
```

Old-Style Enumerated Type Idiom

Enumerated types are a common idiom in programming.

```
1   package cards.domain;
2
3   public class PlayingCard {
4
5     // pseudo enumerated type
6     public static final int SUIT_SPADES   = 0;
7     public static final int SUIT_HEARTS   = 1;
8     public static final int SUIT_CLUBS    = 2;
9     public static final int SUIT_DIAMONDS = 3;
10
11    private int suit;
12    private int rank;
13
14    public PlayingCard(int suit, int rank) {
15      this.suit = suit;
16      this.rank = rank;
17    }
```

Old-Style Enumerated Type Idiom

```
22  public String getSuitName() {
23      String name = "";
24      switch ( suit ) {
25        case SUIT_SPADES:
26          name = "Spades";
27          break;
28        case SUIT_HEARTS:
29          name = "Hearts";
30          break;
31        case SUIT_CLUBS:
32          name = "Clubs";
33          break;
34        case SUIT_DIAMONDS:
35          name = "Diamonds";
36          break;
37        default:
38          System.err.println("Invalid suit.");
39      }
40      return name;
41    }
```

Old-Style Enumerated Type Idiom

Old-style idiom is not type-safe:

```
1   package cards.tests;
2
3   import cards.domain.PlayingCard;
4
5   public class TestPlayingCard {
6     public static void main(String[] args) {
7
8       PlayingCard card1
9         = new PlayingCard(PlayingCard.SUIT_SPADES, 2);
10      System.out.println("card1 is the " + card1.getRank()
11                         + " of " + card1.getSuitName());
12
13      // You can create a playing card with a bogus suit.
14      PlayingCard card2 = new PlayingCard(47, 2);
15      System.out.println("card2 is the " + card2.getRank()
16                         + " of " + card2.getSuitName());
17    }
18  }
```

Old-Style Enumerated Type Idiom

This enumerated type idiom has several problems:

- Not type-safe
- No namespace
- Brittle character
- Uninformative printed values

The New Enumerated Type

Now you can create type-safe enumerated types:

```
1   package cards.domain;
2
3   public enum Suit {
4     SPADES,
5     HEARTS,
6     CLUBS,
7     DIAMONDS
8   }
9
```

The New Enumerated Type

Using enumerated types is easy:

```
1   package cards.domain;
2
3   public class PlayingCard {
4
5     private Suit suit;
6     private int rank;
7
8     public PlayingCard(Suit suit, int rank) {
9       this.suit = suit;
10      this.rank = rank;
11    }
12
13    public Suit getSuit() {
14      return suit;
15    }
```

The New Enumerated Type

```
16  public String getSuitName() {
17      String name = "";
18      switch ( suit ) {
19        case SPADES:
20          name = "Spades";
21          break;
22        case HEARTS:
23          name = "Hearts";
24          break;
25        case CLUBS:
26          name = "Clubs";
27          break;
28        case DIAMONDS:
29          name = "Diamonds";
30          break;
31        default:
32        // No need for error checking as the Suit
33        // enum is finite.
34      }
35      return name;
36    }
```

The New Enumerated Type

Enumerated types are type-safe:

```
1   package cards.tests;
2
3   import cards.domain.PlayingCard;
4   import cards.domain.Suit;
5
6   public class TestPlayingCard {
7     public static void main(String[] args) {
8
9       PlayingCard card1
10        = new PlayingCard(Suit.SPADES, 2);
11      System.out.println("card1 is the " + card1.getRank()
12                         + " of " + card1.getSuitName());
13
14      // PlayingCard card2 = new PlayingCard(47, 2);
15      // This will not compile.
16    }
17  }
```

Advanced Enumerated Types

Enumerated types can have attributes and methods:

```
1   package cards.domain;
2
3   public enum Suit {
4     SPADES   (“Spades”),
5     HEARTS   (“Hearts”),
6     CLUBS    (“Clubs”),
7     DIAMONDS (“Diamonds”);
8
9     private final String name;
10
11    private Suit(String name) {
12      this.name = name;
13    }
14
15    public String getName() {
16      return name;
17    }
18  }
```

Advanced Enumerated Types

Public methods on enumerated types are accessible:

```
1   package cards.tests;
2
3   import cards.domain.PlayingCard;
4   import cards.domain.Suit;
5
6   public class TestPlayingCard {
7     public static void main(String[] args) {
8
9       PlayingCard card1
10        = new PlayingCard(Suit.SPADES, 2);
11      System.out.println("card1 is the " + card1.getRank()
12                         + " of " + card1.getSuit().getName());
13
14      // NewPlayingCard card2 = new NewPlayingCard(47, 2);
15      // This will not compile.
16    }
17  }
```

Static Imports

- A *static import* imports the static members from a class:

```
import static <pkg_list>.<class_name>.<member_name>;
OR
import static <pkg_list>.<class_name>.*;
```

- A static import imports members individually or collectively:

```
import static cards.domain.Suit.SPADES;
OR
import static cards.domain.Suit.*;
```

- There is no need to qualify the static constants:

```
PlayingCard card1 = new PlayingCard(SPADES, 2);
```

- *Use this feature sparingly.*

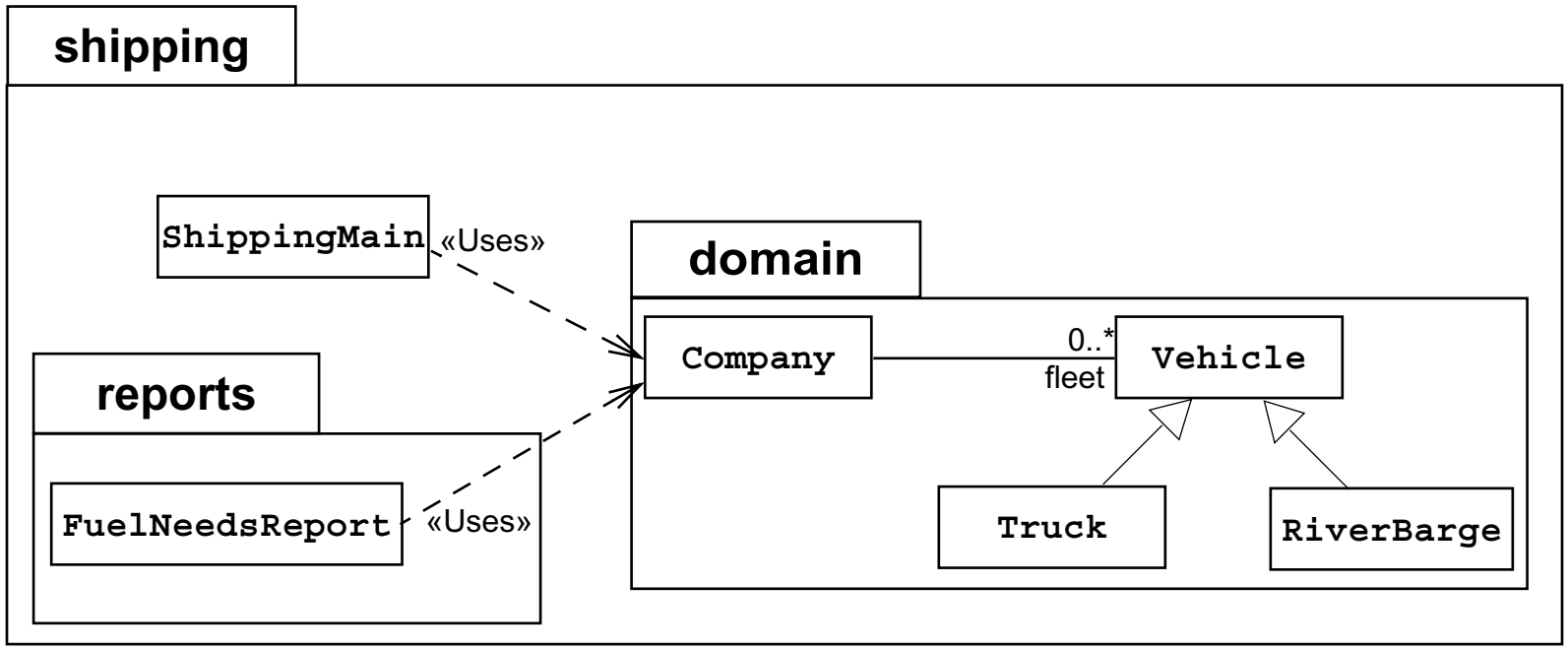
Static Imports

An example of a static import is:

```
1   package cards.tests;
2
3   import cards.domain.PlayingCard;
4   import static cards.domain.Suit.*;
5
6   public class TestPlayingCard {
7     public static void main(String[] args) {
8
9       PlayingCard card1 = new PlayingCard(SPADES, 2);
10      System.out.println("card1 is the " + card1.getRank()
11                         + " of " + card1.getSuit().getName());
12
13      // NewPlayingCard card2 = new NewPlayingCard(47, 2);
14      // This will not compile.
15    }
16  }
```

Abstract Classes

The design of the Shipping system looks like this:



Abstract Classes

Fleet initialization code is shown here:

```
1   public class ShippingMain {
2     public static void main(String[] args) {
3       Company c = new Company();
4
5       // populate the company with a fleet of vehicles
6       c.addVehicle( new Truck(10000.0) );
7       c.addVehicle( new Truck(15000.0) );
8       c.addVehicle( new RiverBarge(500000.0) );
9       c.addVehicle( new Truck(9500.0) );
10      c.addVehicle( new RiverBarge(750000.0) );
11
12      FuelNeedsReport report = new FuelNeedsReport(c);
13      report.generateText(System.out);
14    }
15  }
```

Abstract Classes

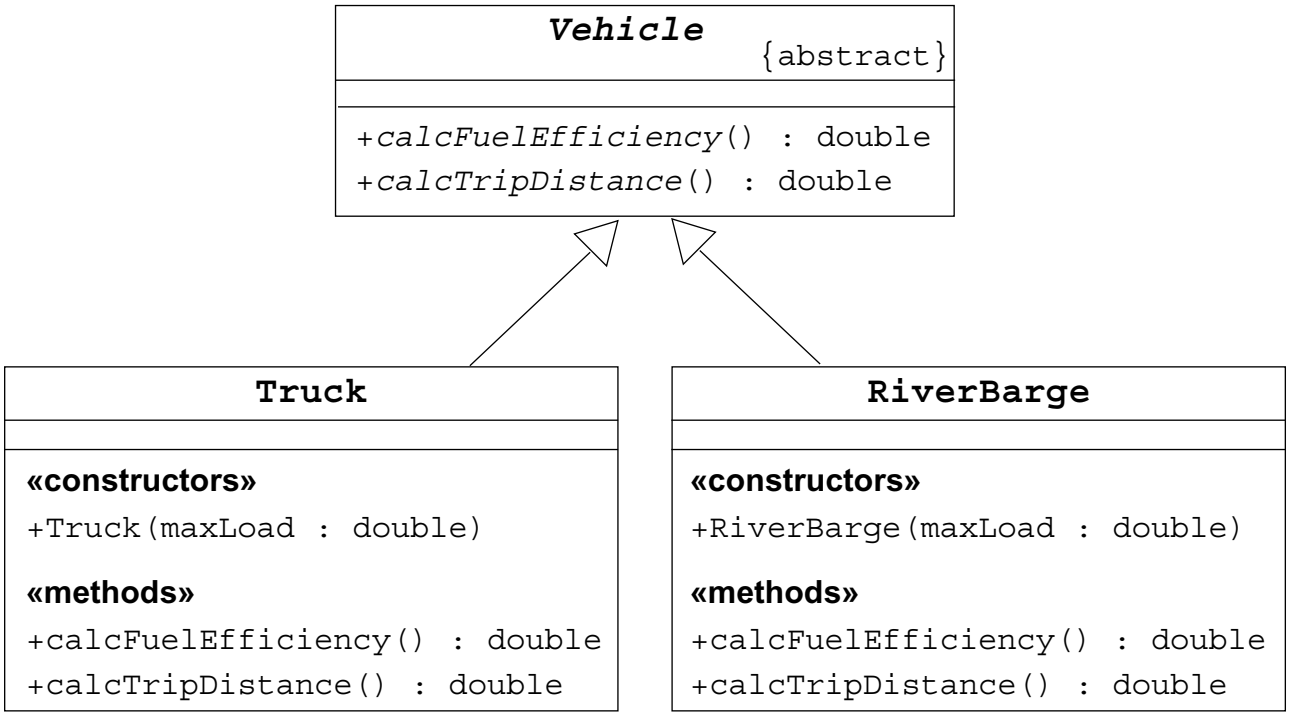
```
1   public class FuelNeedsReport {
2     private Company company;
3
4     public FuelNeedsReport(Company company) {
5       this.company = company;
6     }
7
8     public void generateText(PrintStream output) {
9       Vehicle1 v;
10      double fuel;
11      double total_fuel = 0.0;
12
13      for ( int i = 0; i < company.getFleetSize(); i++ ) {
14        v = company.getVehicle(i);
15
```

Abstract Classes

```
16        // Calculate the fuel needed for this trip
17        fuel = v.calcTripDistance() / v.calcFuelEfficency();
18
19        output.println("Vehicle " + v.getName() + " needs "
20                       + fuel + " liters of fuel.");
21        total_fuel += fuel;
22      }
23      output.println("Total fuel needs is " + total_fuel + " liters.");
24    }
25  }
```

The Solution

An abstract class models a class of objects in which the full implementation is not known but is supplied by the concrete subclasses.



The Solution

The declaration of the `Vehicle` class is:

```
1   public abstract class Vehicle {
2     public abstract double calcFuelEfficiency();
3     public abstract double calcTripDistance();
4   }
```

The `Truck` class must create an implementation:

```
1   public class Truck extends Vehicle {
2     public Truck(double maxLoad) {...}
3     public double calcFuelEfficiency() {
4       /* calculate the fuel consumption of a truck at a given load */
5     }
6     public double calcTripDistance() {
7       /* calculate the distance of this trip on highway */
8     }
9   }
```

The Solution

Likewise, the `RiverBarge` class must create an implementation:

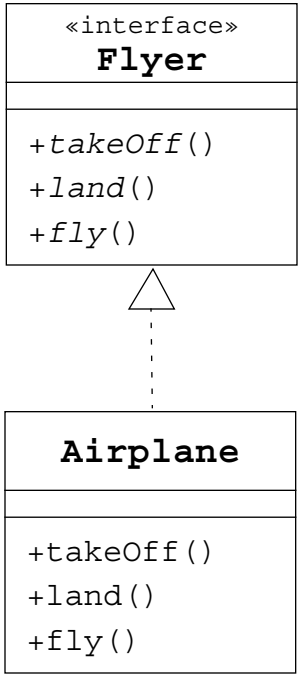
```
1   public class RiverBarge extends Vehicle {
2     public RiverBarge(double maxLoad) {...}
3     public double calcFuelEfficiency() {
4       /* calculate the fuel efficiency of a river barge */
5     }
6     public double calcTripDistance() {
7       /* calculate the distance of this trip along the river-ways */
8     }
9   }
```

Interfaces

- A *public interface* is a contract between *client code* and the class that implements that interface.
- A Java *interface* is a formal declaration of such a contract in which all methods contain no implementation.
- Many unrelated classes can implement the same interface.
- A class can implement many unrelated interfaces.
- Syntax of a Java class is as follows:

```
<modifier> class <name> [extends <superclass>]
           [implements <interface> [,<interface>]* ] {
  <member_declaration>*
}
```

The Flyer Example

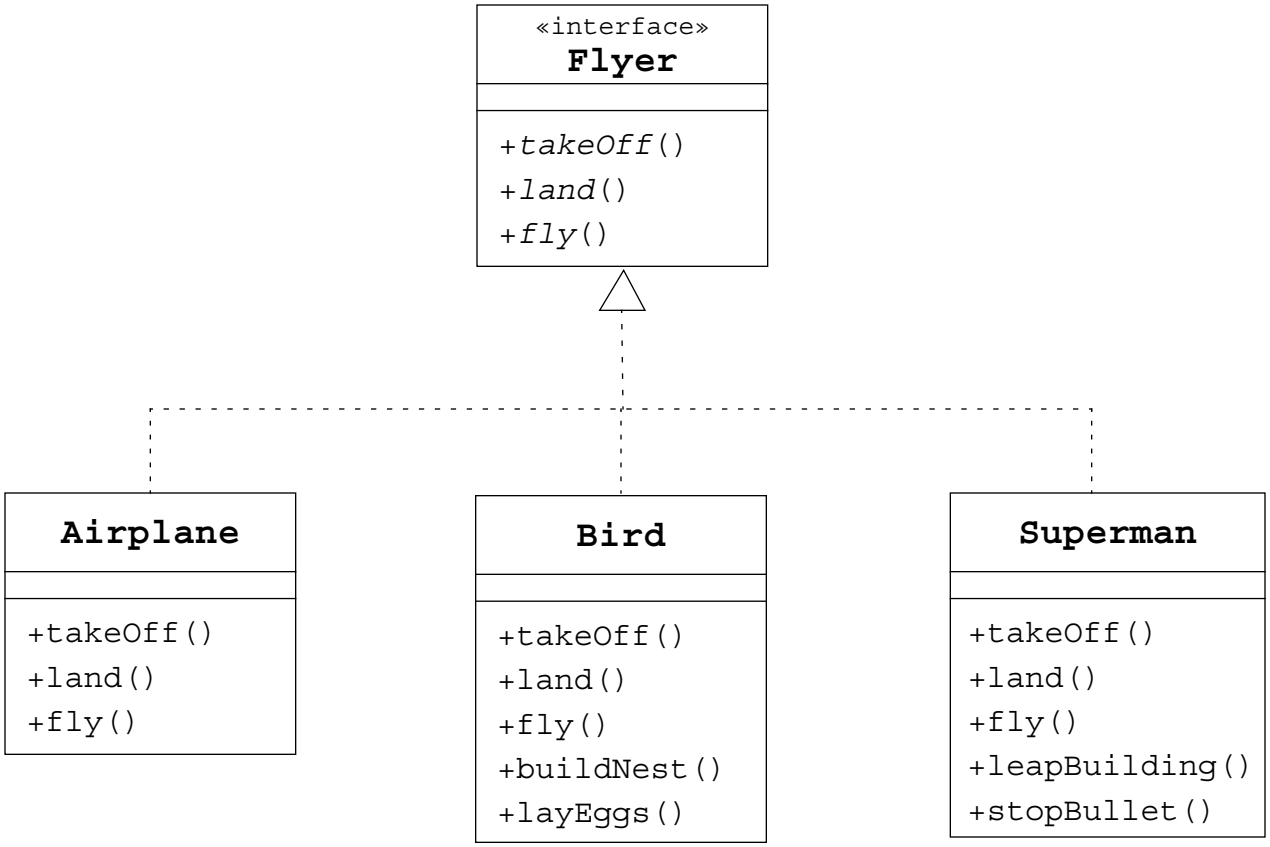



```
public interface Flyer {
  public void takeOff();
  public void land();
  public void fly();
}
```

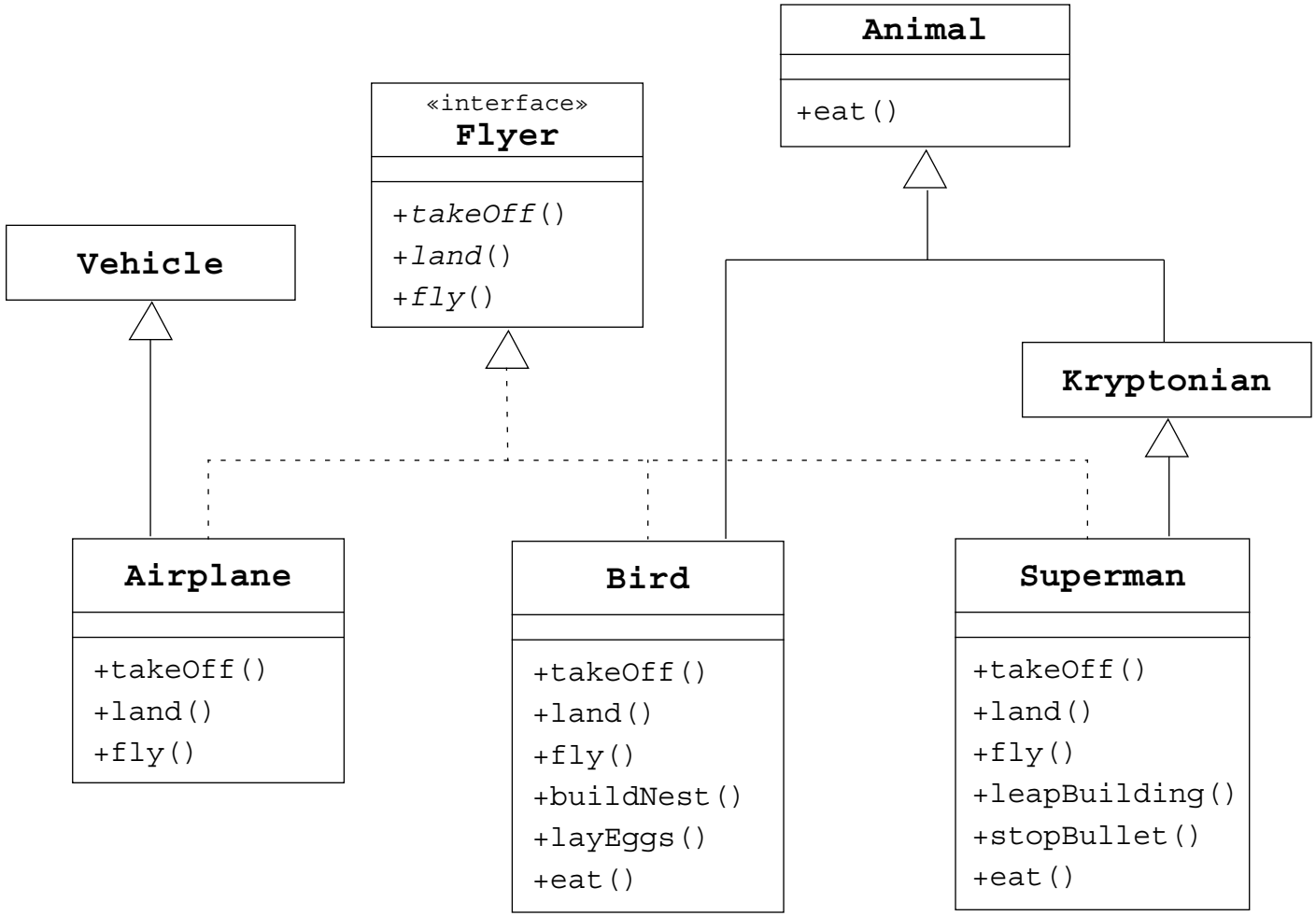
The Flyer Example

```
public class Airplane implements Flyer {
  public void takeOff() {
    // accelerate until lift-off
    // raise landing gear
  }
  public void land() {
    // lower landing gear
    // decelerate and lower flaps until touch-down
    // apply brakes
  }
  public void fly() {
    // keep those engines running
  }
}
```

The Flyer Example



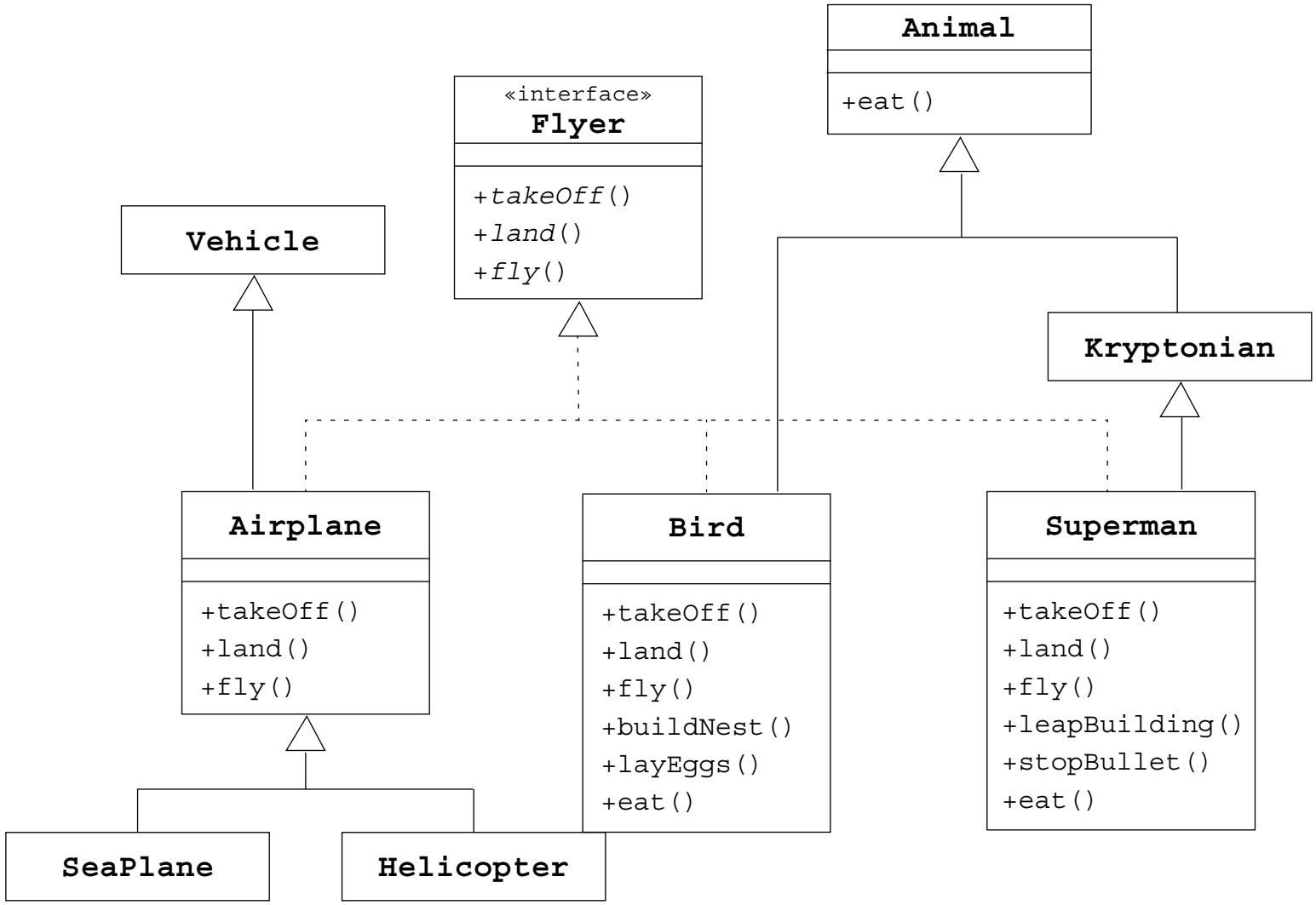
The Flyer Example



The Flyer Example

```
public class Bird extends Animal implements Flyer {
  public void takeOff()   { /* take-off implementation  */ }
  public void land()      { /* landing implementation   */ }
  public void fly()       { /* fly implementation       */ }
  public void buildNest() { /* nest building behavior   */ }
  public void layEggs()   { /* egg laying behavior      */ }
  public void eat()       { /* override eating behavior */ }
}
```

The Flyer Example



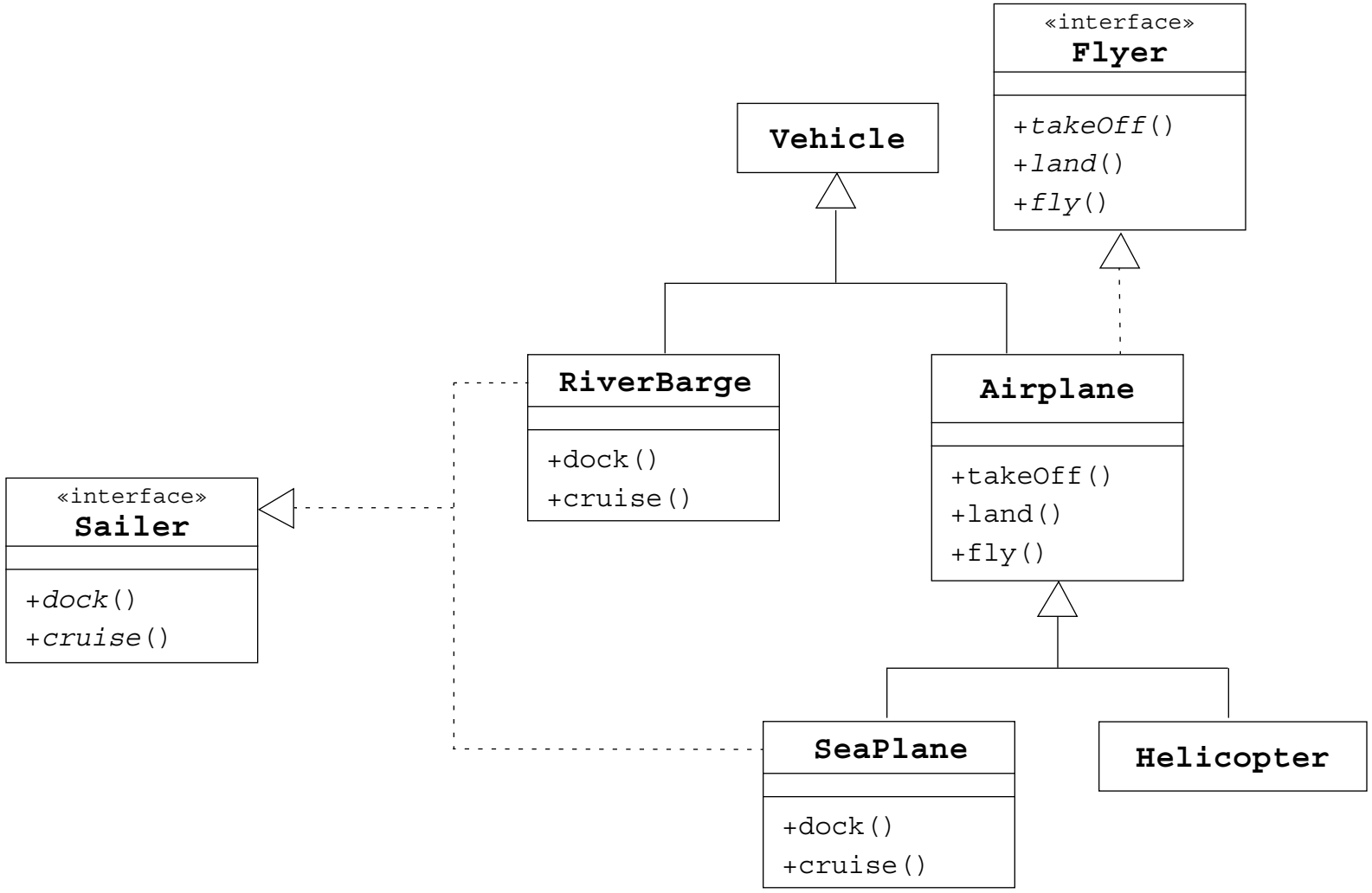
The Flyer Example

```
public class Airport {
  public static void main(String[] args) {
    Airport metropolisAirport = new Airport();
    Helicopter copter = new Helicopter();
    SeaPlane sPlane = new SeaPlane();

    metropolisAirport.givePermissionToLand(copter);
    metropolisAirport.givePermissionToLand(sPlane);
  }

  private void givePermissionToLand(Flyer f) {
    f.land();
  }
}
```

Multiple Interface Example



Multiple Interface Example

```
public class Harbor {
  public static void main(String[] args) {
    Harbor bostonHarbor = new Harbor();
    RiverBarge barge = new RiverBarge();
    SeaPlane sPlane = new SeaPlane();

    bostonHarbor.givePermissionToDock(barge);
    bostonHarbor.givePermissionToDock(sPlane);
  }

  private void givePermissionToDock(Sailer s) {
    s.dock();
  }
}
```

Uses of Interfaces

Interface uses include the following:

- Declaring methods that one or more classes are expected to implement
- Determining an object's programming interface without revealing the actual body of the class
- Capturing similarities between unrelated classes without forcing a class relationship
- Simulating multiple inheritance by declaring a class that implements several interfaces