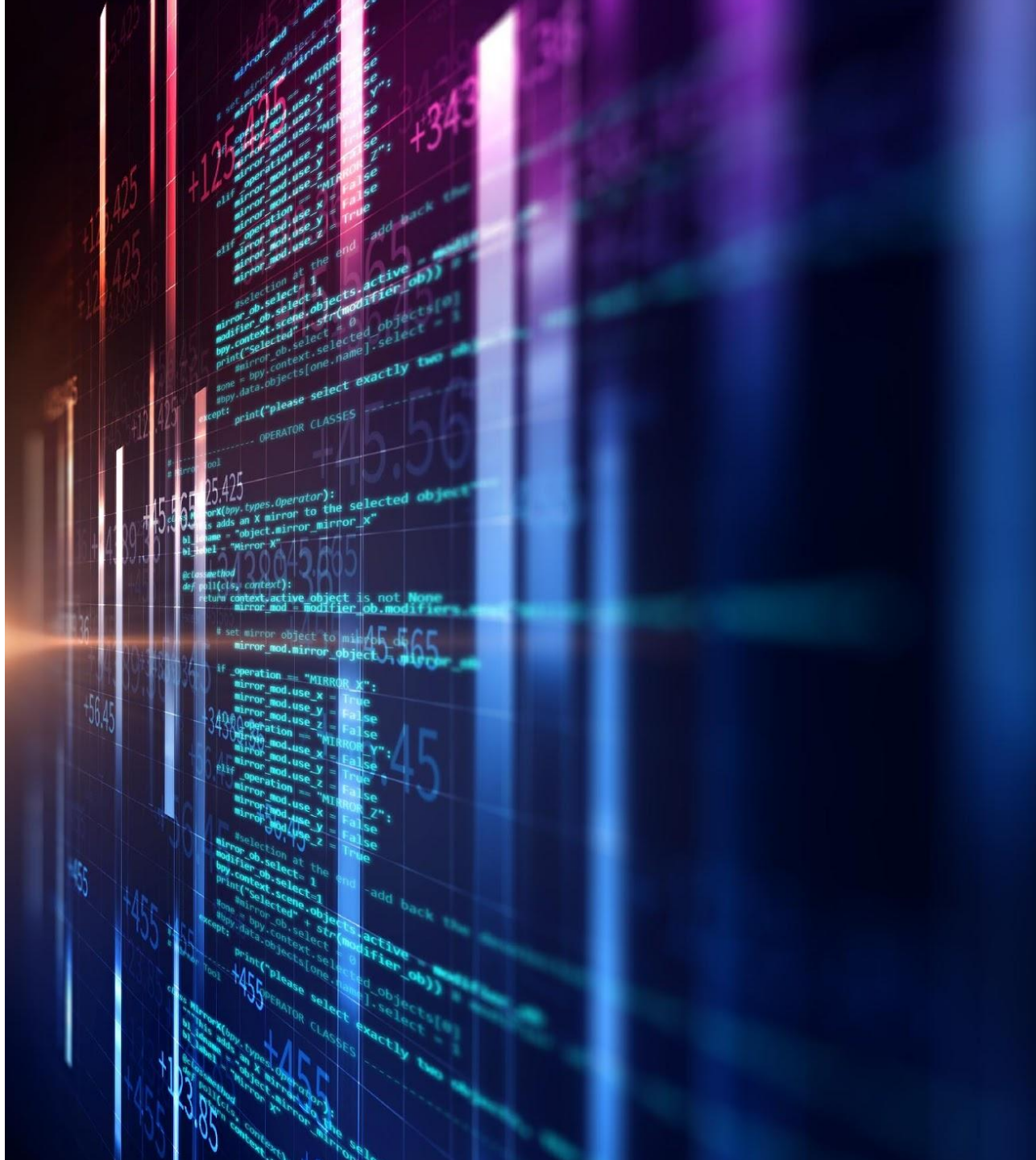
Abstract Classes

Brandon Krakowsky

Penn Engineering



Abstract Classes

Abstract Methods

- You can declare an Object without defining it:

```
Person p; //declares variable p
```

- Similarly, you can declare a method without defining it:

```
public abstract void draw(int size); //declares method draw
```

  - Declares the method with the keyword *abstract*

- Notice that the body of the method is missing
  - Instead of curly braces { } you just have a semi-colon ending the statement

- A method that has been declared but not defined is an abstract method

Abstract Classes

- Any class containing an abstract method is an abstract class
- You must declare the class with the keyword *abstract*:

```
public abstract class Shape { //abstract class

    public abstract void draw(int size); //abstract method WITHOUT body

}
```

- You cannot instantiate (create a new instance of) an abstract class
  - You CANNOT do this:
    `Shape shape = new Shape();`

Extending Abstract Classes

- You can (and usually do) extend (or subclass) an abstract class
  - If the subclass defines all of the inherited abstract methods, it is “complete” and can be instantiated
    - This is also known as a “concrete” class
  - If the subclass does not define all the inherited abstract methods, it too must be abstract
- You can declare a class to be abstract even if it does not contain any abstract methods
  - This prevents the class from being instantiated

Example Abstract Class

- An abstract class can contain both *abstract* and *non abstract* (or concrete) methods
- Here's a sample abstract class for Pet
  - It contains an abstract method WITHOUT a body and a non abstract (concrete) method WITH a body

```
public abstract class Pet { //abstract class

        protected double weight;

        public abstract String makeSound(); //abstract method WITHOUT body

        public void eat(Food food) { //non abstract (concrete) method WITH body
            this.weight += (food.getCalories() / 100);
        }
    }
```

- This class cannot be instantiated because it's abstract

Example Abstract Class

- Subclasses of Pet must provide an implementation of the makeSound method

```
public class Dog extends Pet {

    @Override
    public String makeSound() { //implementation of abstract method
        return “Bark!”;
    }

}

Dog myDog = new Dog();
System.out.println(myDog.makeSound()); //prints “Bark!”
```

Why Have Abstract Classes?

- For this example, we know that all Pets eat
  - The effect on the food is always the same
  - Instead of implementing the eat method for each subclass of Pet, we can implement it once and inherit it
- On the other hand, different Pets make different sounds
  - We want to make sure that each subclass implements the makeSound method
- We don't want to instantiate a Pet object because we don't know what it is (it's abstract!)

Common Syntax Error with Subclasses

- Suppose we have a Shape class

```
class Shape { ... }
```

- And things (“shapes”) that extend Shape

```
class Star extends Shape {
    void draw() { ... }
    ...
}

class Crescent extends Shape {
    void draw() { ... }
    ...
}
```

Common Syntax Error with Subclasses

- Then we CAN actually do this, because a Star is a Shape

```
//declare variable of type Shape to store object of type Star
Shape myShape = new Star();
```

- Unfortunately, we CANNOT do this

```
//trying to call draw on type Shape
myShape.draw();
```

  - This is a syntax error, because myShape (of type Shape) does not have a draw method
  - myShape doesn't know what the draw method is
- So how can we call draw on every thing (or "shape")?
  - Use an abstract class!

Common Syntax Error with Subclasses

- Suppose we are making a GUI, and we want to draw a number of different “shapes” (circles, crescents, etc.)
  - Each class has a draw method
- You want to make the different shapes subclasses of Shape, so that you can create an ArrayList<Shape> shapes to hold the various things to be drawn:

```
ArrayList<Shape> shapes = new ArrayList<Shape>();
shapes.add(star); //add star to shapes
shapes.add(crescent); //add crescent to shapes
```

- Then, you would like to do something like this:

```
for (Shape s : shapes)
    s.draw(); //try to call draw on each type Shape
```

  - Again, this is not legal, because each s (of type Shape) does not have a draw method
- Rule: Every class “knows” its superclass, but a class doesn’t “know” its subclasses
  - *You* may know that every subclass of Shape has a draw method, but *Java* does not!

Possible Solutions to the Syntax Problem

- Solution 1: Put a draw method in the Shape class itself
  - This method will be inherited by all subclasses
  - Then you can call draw method for each shape
  - But what will it actually draw? It will be defined the same way for every subclass.

- Solution 2: Put an abstract draw method in the Shape class
  - This will also be inherited by all subclasses, but you won't have to define it in the Shape class
  - You do, however, have to make the Shape class abstract
  - And implement draw in each subclass
  - This way, Java knows that each subclass has a draw method

Use Case for Abstract Class

- Make the Shape class abstract and add the abstract draw method with no body
  - Every subclass of Shape will HAVE TO implement draw

```
abstract class Shape {
    abstract void draw();
}

class Star extends Shape {
    @Override
    void draw() { ... } //implement abstract draw method
    ...
}

class Crescent extends Shape {
    @Override
    void draw() { ... } //implement abstract draw method
    ...
}

Shape myShape = new Star();
```

- This is legal, because a Star is a Shape
- However, Shape myShape = new Shape(); is no longer legal

```
myShape.draw(); //call draw method on type Shape
```

Abstract Pet Project

Pet Class

Pet.java

```
1  package pet;
2
3  import java.util.ArrayList;
4
5  /**
6   * Abstract class Pet to represent a generic (or abstract) pet.
7   * @author wcauser
8   *
9   */
10 public abstract class Pet {
11
12     //instance variables
13
14     /**
15      * Age of pet.
16      * Default (package-private) access.  Accessible anywhere in same package.
17      */
18     int age;
19
20     /**
21      * Name of pet.
22      * Default (package-private) access.  Accessible anywhere in same package.
23      */
24     String name;
25
26     /**
27      * Weight of pet.
28      * Default (package-private) access.  Accessible anywhere in same package.
29      */
30     double weight;
31
```

Pet Class

```
31
32      //constructor(s)
33
34      /**
35       * Called by subclasses of Pet to create instances of different types of pets.
36       * @param name of pet
37       * @param age of pet
38       * @param weight of pet
39       */
40      public Pet(String name, int age, double weight) {
41          this.name = name;
42          this.age = age;
43          this.weight = weight;
44      }
45
46      //getters and setters
47
48      /**
49       * @return the weight
50       */
51      public double getWeight() {
52          return this.weight;
53      }
54
55      /**
56       * @param weight the weight to set
57       */
58      public void setWeight(double weight) {
59          this.weight = weight;
60      }
61
```

Pet Class

```
62      //non-abstract method(s)
63
64      /**
65       * Tells pet to eat given food.
66       * @param food to eat
67       */
68      public void eat(Food food) {
69          this.weight += (food.getCalories() / 100);
70      }
71
```

Pet Class

```
72      //abstract method(s)
73
74      /**
75       * Forces all pets to make their own sound.
76       * All subclasses of Pet MUST implement this method.
77       */
78      public abstract void makeSound();
79
80      /**
81       * Every subclass must implement toString for printing/debugging.
82       */
83      @Override
84      public abstract String toString();
85
```

Food Class

Pet.java | Food.java

```
1  package pet;
2
3  /**
4   * Represents generic food for pet.
5   * @author lbrandon
6   *
7   */
8  public class Food {
9
10     //instance variables
11
12     /**
13      * Calories for food.
14      */
15     private int calories;
16
```

Food Class

```
16
17      //constructor(s)
18
19      /**
20       * Creates instance of Food.
21       * @param calories for food
22       */
23      public Food(int calories) {
24          this.calories = calories;
25      }
26
27      //getters/setters
28
29      /**
30       * @return the calories
31       */
32      public int getCalories() {
33          return calories;
34      }
35
36      /**
37       * @param calories the calories to set
38       */
39      public void setCalories(int calories) {
40          this.calories = calories;
41      }
42
```

Cat Class

Pet.java | Cat.java

```
1  package pet;
2
3  /**
4   * Represents a Cat, subclass of abstract class Pet.
5   * @author lbrandon
6   *
7   */
8  public class Cat extends Pet {
9
10     //static variables
11
12     /**
13      * Default sound for all cats.
14      * Private access.  Only accessible within this class.
15      */
16     private static String SOUND = "Meow!";
17
18     //instance variables
19
20     /**
21      * Type of this cat.
22      * Private access.  Only accessible within this class.
23      */
24     private String type;
25
```

Cat Class

```
26      //constructor(s)
27
28      /**
29       * Creates cat with given name, age, weight, and type.
30       * @param name for cat
31       * @param age for cat
32       * @param weight for cat
33       * @param type for cat
34       */
35      public Cat(String name, int age, double weight, String type) {
36          //must call constructor in superclass Pet
37          super(name, age, weight);
38
39          //set type
40          this.type = type;
41      }
42
43      //getters/setters
44
45      /**
46       * @return the type
47       */
48      public String getType() {
49          return type;
50      }
51
52      /**
53       * @param type the type to set
54       */
55      public void setType(String type) {
56          this.type = type;
57      }
```

Cat Class

```
59      //inherited abstract methods
60      //MUST override and implement these (provide bodies)
61
62      /**
63       * Makes cat sound.
64       */
65      @Override
66      public void makeSound() {
67          System.out.println(Cat.SOUND);
68      }
69
70      /**
71       * Returns string for printing/debugging this cat.
72       */
73      @Override
74      public String toString() {
75          return this.name + " is a " + this.type;
76      }
77
```

Dog Class

Pet.java | Cat.java | Dog.java

```
1  package pet;
2
3  /**
4   * Represents a Dog, subclass of abstract class Pet.
5   * @author lbrandon
6   *
7   */
8  public class Dog extends Pet {
9
10     //static variables
11
12     /**
13      * Default sound for all dogs.
14      * Private access.  Only accessible within this class.
15      */
16     private static String SOUND = "Bark!";
17
18     //instance variables
19
20     /**
21      * Breed for this dog.
22      * Private access.  Only accessible within this class.
23      */
24     private String breed;
25
```

Dog Class

```
27
28      /**
29       * Creates dog with given name, age, weight, and breed.
30       * @param name of dog
31       * @param age of dog
32       * @param weight of dog
33       * @param breed of dog
34       */
35      public Dog(String name, int age, double weight, String breed) {
36          //must call constructor in superclass Pet
37          super(name, age, weight);
38
39          //set breed
40          this.breed = breed;
41      }
42
43      //getters/setters
44
45      /**
46       * @return the breed
47       */
48      public String getBreed() {
49          return breed;
50      }
51
52      /**
53       * @param breed the breed to set
54       */
55      public void setBreed(String breed) {
56          this.breed = breed;
57      }
```

Dog Class

```
59      //inherited abstract methods
60      //MUST override and implement these (provide bodies)
61
62      /**
63       * Makes dog sound.
64       */
65      @Override
66      public void makeSound() {
67          System.out.println(Dog.SOUND);
68      }
69
70      /**
71       * Returns string for printing/debugging this dog.
72       */
73      @Override
74      public String toString() {
75          return this.name + " is a " + this.breed;
76      }
```

Pet Class

```
86
87      public static void main(String[] args) {
88
89          //create list of pets
90          ArrayList<Pet> pets = new ArrayList<Pet>();
91
92          //create a dog
93          Dog dog = new Dog("Buster", 14, 100, "German Shepherd");
94
95          //create a cat
96          Cat cat = new Cat("Snuggles", 3, 40, "House Cat");
97
98          //add pets to list
99          pets.add(dog);
100         pets.add(cat);
101
```

Pet Class

```
102         //iterate over list of pets
103         for (Pet p : pets) {
104             //call makeSound, abstract method in pet class
105             //every subclass of pet MUST have this defined
106             p.makeSound();
107         }
108
109         //iterate over list of pets
110         for (Pet p : pets) {
111             //print each pet
112             //calls toString method implemented in each subclass of pet
113             System.out.println(p);
114         }
115
116         //call specific method in dog class
117         String breed = dog.getBreed();
118         System.out.println("dog breed: " + breed);
119
120         //call specific method in cat class
121         String type = cat.getType();
122         System.out.println("cat type: " + type);
123
```

Pet Class

```
23
24          //get dog weight before eating
25          //getWeight defined as non-abstract method in pet class
26          System.out.println(dog.getWeight());
27
28          //create some food
29          Food food = new Food(1000);
30
31          //dog will eat
32          //eat defined as non-abstract method in pet class
33          dog.eat(food);
34
35          //get dog weight after eating
36          System.out.println(dog.getWeight());
37
```