Inheritance (Part 2)

Preconditions and Inheritance

- precondition
  - what the method assumes to be true about the arguments passed to it
- inheritance (is-a)
  - a subclass is supposed to be able to do everything its superclasses can do
- how do they interact?

Strength of a Precondition

- to strengthen a precondition means to make the precondition more restrictive

```
// Dog setEnergy
// 1. no precondition
// 2. 1 <= energy
// 3. 1 <= energy <= 10
public void setEnergy(int energy)
{ ... }
```

weakest precondition

strongest precondition

Preconditions on Overridden Methods

- a subclass can change a precondition on a method *but it must not strengthen the precondition*
  - a subclass that strengthens a precondition is saying that it cannot do everything its superclass can do

```
// Dog setEnergy
// assume non-final
// @pre. none

public
void setEnergy(int nrg)
{ // ... }
```

```
// Mix setEnergy
// bad : strengthen precond.
// @pre. 1 <= nrg <= 10

public
void setEnergy(int nrg)
{
  if (nrg < 1 || nrg > 10)
  { // throws exception }
  // ...
}
```

- client code written for **`Dog`**s now fails when given a **`Mix`**

```
// client code that sets a Dog's energy to zero
public void walk(Dog d)
{
  d.setEnergy(0);
}
```

- remember: a subclass must be able to do everything its ancestor classes can do; otherwise, clients will be (unpleasantly) surprised

Postconditions and Inheritance

- postcondition
  - what the method promises to be true when it returns
    - the method might promise something about its return value
      - "returns size where size is between 1 and 10 inclusive"
    - the method might promise something about the state of the object used to call the method
      - "sets the size of the dog to the specified size"
    - the method might promise something about one of its parameters

- how do postconditions and inheritance interact?

Strength of a Postcondition

- to strengthen a postcondition means to make the postcondition more restrictive

```
// Dog getSize
// 1. no postcondition
// 2. 1 <= this.size
// 3. 1 <= this.size <= 10
public int getSize()
{ ... }
```

weakest postcondition

strongest postcondition

Postconditions on Overridden Methods

- a subclass can change a postcondition on a method *but it must not weaken the postcondition*
  - a subclass that weakens a postcondition is saying that it cannot do everything its superclass can do

```
// Dog getSize
//
// @post. 1 <= size <= 10

public
int getSize()
{ // ... }
```

```
// Dogzilla getSize
// bad : weaken postcond.
// @post. 1 <= size

public
int getSize()
{ // ... }
```

Dogzilla: a made-up breed of dog that has no upper limit on its size

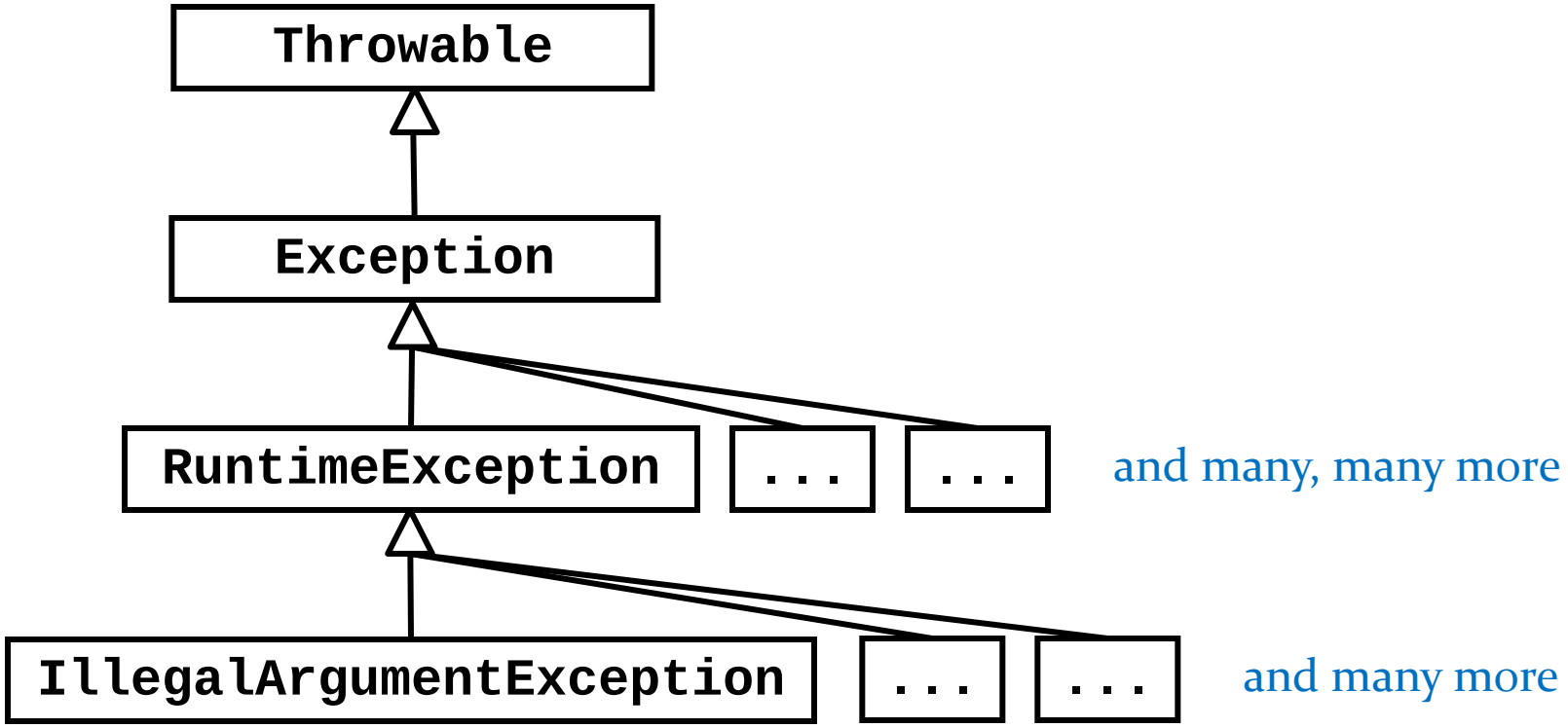
- client code written for **`Dog`**s can now fail when given a **`Dogzilla`**

```
// client code that assumes Dog size <= 10
public String sizeToString(Dog d)
{
  int sz = d.getSize();
  String result = "";
  if (sz < 4)        result = "small";
  else if (sz < 7)   result = "medium";
  else if (sz <= 10) result = "large";
  return result;
}
```

- remember: a subclass must be able to do everything its ancestor classes can do; otherwise, clients will be (unpleasantly) surprised

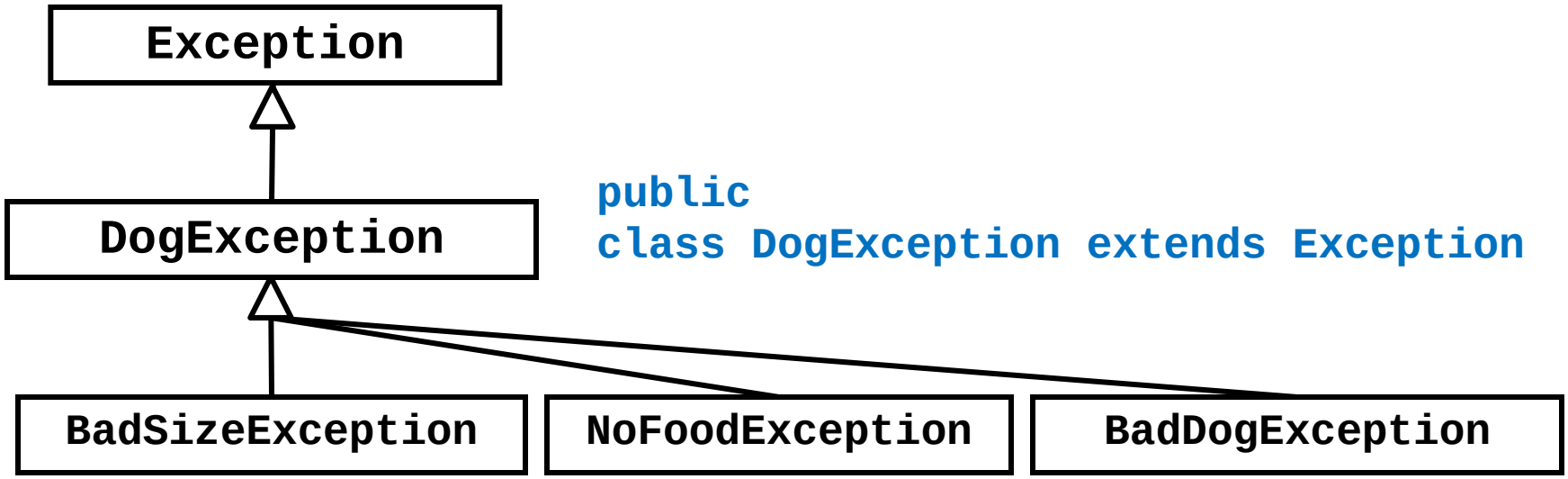
Exceptions

- all exceptions are objects that are subclasses of **`java.lang.Throwable`**



User Defined Exceptions

- you can define your own exception hierarchy
  - often, you will subclass Exception




```
public
class DogException extends Exception
```

Exceptions and Inheritance

- a method that claims to throw a *checked* exception of type **X** is allowed to throw any checked exception type that is a subclass of **X**
  - this makes sense because exceptions are objects and subclass objects are substitutable for ancestor classes

```
// in Dog
public void someDogMethod() throws DogException
{
  // can throw a DogException, BadSizeException,
  //             NoFoodException, or BadDogException
}
```

- a method that overrides a superclass method that claims to throw a checked exception of type **X** can also claim to throw a checked exception of type **X** or a subclass of **X**
  - remember: a subclass is substitutable for the parent type

```
// in Mix
@Override
public void someDogMethod() throws DogException
{
  // ...
}
```

Which are Legal?

- in Mix

```
@Override
public void someDogMethod() throws BadDogException
```

```
@Override
public void someDogMethod() throws Exception
```

```
@Override
public void someDogMethod()
```

```
@Override
public void someDogMethod()
      throws DogException, IllegalArgumentException
```

Review

1. Inheritance models the _____ relationship between classes.
2. Dog is a _____ of Object.
3. Dog is a _____ of Mix.
4. Can a Dog instance do everything a Mix instance can?
5. Can a Mix instance do everything a Dog instance can?
6. Is a Dog instance substitutable for a Mix instance?
7. Is a Mix instance substitutable for a Dog instance?

8. Can a subclass use the private fields of its superclass?
9. Can a subclass use the private methods of its superclass?
10. Suppose you have a class X that you do not want anyone to extend. How do you enforce this?
11. Suppose you have an immutable class X. Someone extends X to make it mutable. Is this legal?
12. What do you need to do to enforce immutability?

13. Suppose you have a class Y that extends X.
    a. Does each X instance have a Y instance inside of it?
    b. How do you construct the Y subobject inside of the X instance?
    c. What syntax is used to call the superclass constructor?
    d. What is constructed first–the Y subobject or the X object?
    e. Suppose Y introduces a brand new method that needs to call a public method in X named xMethod. How does the new Y method call xMethod?
    f. Suppose Y overrides a public method in X named xMethod. How does the overriding Y method call xMethod?

14. Suppose you have a class Y that extends X. X has a method with the following precondition:

```
@pre. value must be a multiple of 2
```

If Y overrides the method which of the following are acceptable preconditions for the overriding method:

a. `@pre. value must be a multiple of 2`
b. `@pre. value must be odd`
c. `@pre. value must be a multiple of 2 and must be less than 100`
d. `@pre. value must be a multiple of 10`
e. `@pre. none`

14. Suppose you have a class Y that extends X. X has a method with the following postcondition:

```
@return – A String of length 10
```

If Y overrides the method which of the following are acceptable postconditions for the overriding method:

a. `@return – A String of length 9 or 10`
b. `@return – The String "weimaraner"`
c. `@return – An int`
d. `@return – The same String returned by toString`
e. `@return – A random String of length 10`

15. Suppose Dog toString has the following Javadoc:

```
/*
 * Returns a string representation of a dog.
 * The string is the size of the dog followed by a
 * a space followed by the energy.
 * @return The string representation of the dog.
 */
```

Does this affect subclasses of Dog?

Inheritance Recap

- inheritance allows you to create subclasses that are substitutable for their ancestors
  - inheritance interacts with preconditions, postconditions, and exception throwing
- subclasses
  - inherit all non-private features
  - can add new features
  - can change the behaviour of non-final methods by *overriding* the parent method
  - contain an instance of the superclass
    - subclasses must construct the instance via a superclass constructor

Puzzle 3

- Write the class **`Enigma`**, which extends **`Object`**, so that the following program prints false:

```
public class Conundrum
{
  public static void main(String[] args)
  {
    Enigma e = new Enigma();
    System.out.println( e.equals(e) );
  }
}
```

- You must not override **`Object.equals()`**

[*Java Puzzlers* by Joshua Block and Neal Gaffer]

Polymorphism

- inheritance allows you to define a base class that has fields and methods
  - classes derived from the base class can use the public and protected base class fields and methods
- polymorphism allows the implementer to change the behaviour of the derived class methods

```
// client code
public void print(Dog d) {
  System.out.println( d.toString() );
}

// later on...
Dog           fido = new Dog();
CockerSpaniel lady = new CockerSpaniel();
Mix           mutt = new Mix();
this.print(fido);
this.print(lady);
this.print(mutt);
```

```
Dog toString
CockerSpaniel toString
Mix toString
```

- notice that **`fido`**, **`lady`**, and **`mutt`** were declared as **`Dog`**, **`CockerSpaniel`**, and **`Mutt`**
- what if we change the declared type of **`fido`**, **`lady`**, and **`mutt`** ?

```
// client code
public void print(Dog d) {
  System.out.println( d.toString() );
}
                          Dog toString
                          CockerSpaniel toString
                          Mix toString
// later on...
Dog           fido = new Dog();
Dog           lady = new CockerSpaniel();
Dog           mutt = new Mix();
this.print(fido);
this.print(lady);
this.print(mutt);
```

- what if we change the **`print`** method parameter type to **`Object`** ?

```
// client code
public void print(Object obj) {
  System.out.println( obj.toString() );
}

// later on...
Dog           fido = new Dog();
Dog           lady = new CockerSpaniel();
Dog           mutt = new Mix();
this.print(fido);
this.print(lady);
this.print(mutt);
this.print(new Date());
```

```
Dog toString
CockerSpaniel toString
Mix toString
Date toString
```

Late Binding

- polymorphism requires *late binding* of the method name to the method definition
  - late binding means that the method definition is determined at run-time

non-static method

```
obj.toString()
```

run-time type of the instance **`obj`**

Declared vs Run-time type

```
Dog lady = new CockerSpaniel();
```

declared type

run-time or actual type

- the declared type of an instance determines what methods can be used

```
Dog lady = new CockerSpaniel();
```

  - the name **`lady`** can only be used to call methods in **`Dog`**
  - **`lady.someCockerSpanielMethod()`** won't compile

- the actual type of the instance determines what definition is used when the method is called

```
Dog lady = new CockerSpaniel();
```

  - **`lady.toString()`** uses the **`CockerSpaniel`** definition of **`toString`**