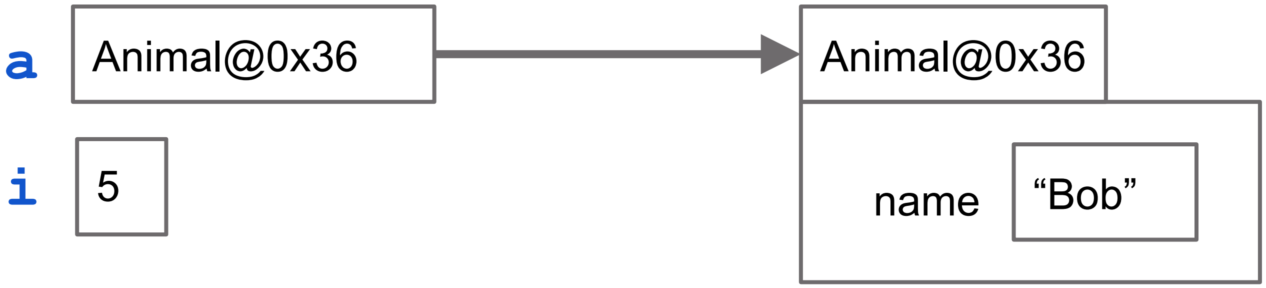
Review Session

CS2110 Prelim #1

Primitive types vs classes

- Variable declarations:
  - `int i = 5;`
  - `Animal a = new Animal(“Bob”);`
- How does “==” behave?



a Animal@0x36

i 5

Animal@0x36

name “Bob”

Default values

- What value does a field contain when it is declared but not instantiated?
  - `Animal a;    //null`
  - `Object ob;   //null`
  - `int i;       //0`
  - `boolean b;   //false`
  - `char c;      //'\0' (null byte)`
  - `double d;    //0.0`

Wrapper Classes (Boxing)

class Character contains useful methods

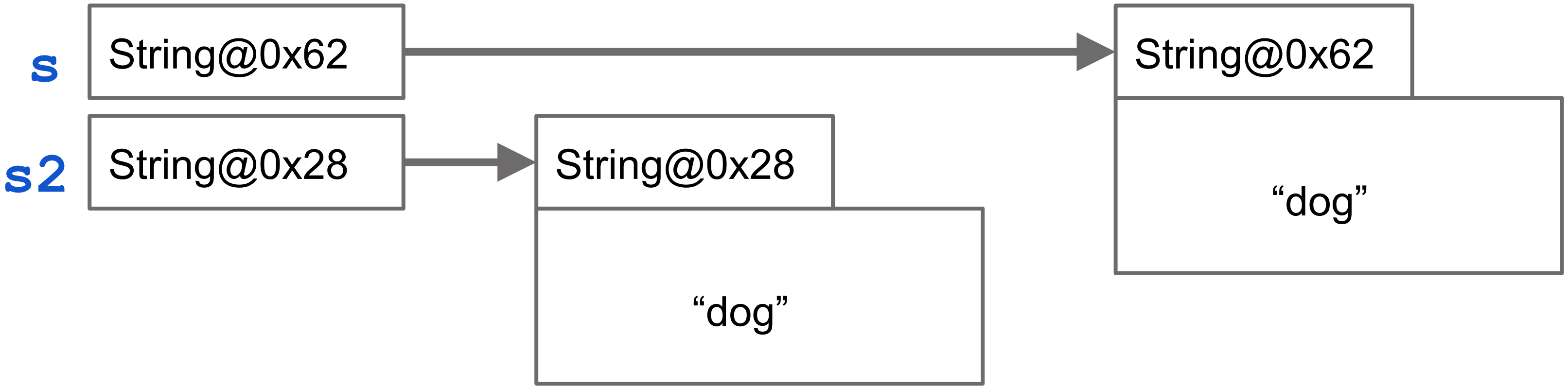
- Examples of useful static `Character` methods:
  - `Character.isDigit(c)`
  - `IntCharacter.isLetter(c)`

- Autoboxing –should be called autowrapping!
  - `Integer x = 100;`
  - `int y = x;`

String literals

String instantiation:

- Constructor: `String s = new String(“dog”);`
- Literal: `String s2 = “dog”;`
- Roughly equivalent, but literal is preferred



Strings are immutable

Once a String is created, it cannot be changed

- Methods such as `toLowerCase` and `substring` return new Strings, leaving the original one untouched
- In order to “modify” Strings, you instead construct a new String and then reassign it to the original variable:
    - `String name = “Gries”;`
    - `name = name + “, “;`
    - `name = name + “David”;`

String catenation

Operator `+` operator is called catenation, or concatenation

- If one operand is a String and the other isn’t, the other is converted to a String
- Important case: Use `“” + exp` to convert `exp` to a String.
- Evaluates left to right. Common mistake:
  - `System.out.println(“sum: “ + 5 + 6);`
    - Prints `“sum: 56”`
  - `System.out.println(“sum: “ + (5 + 6));`
    - Prints `“sum: 11”`

Other String info

- Always use **`equals`** to compare Strings:
  - **`str1.equals(str2)`**

- Very useful methods:
  - **`length`**, **`substring`** (overloaded), **`indexOf`**, **`charAt`**

- Useful methods:
  - **`lastIndexOf`**, **`contains`**, **`compareTo`**

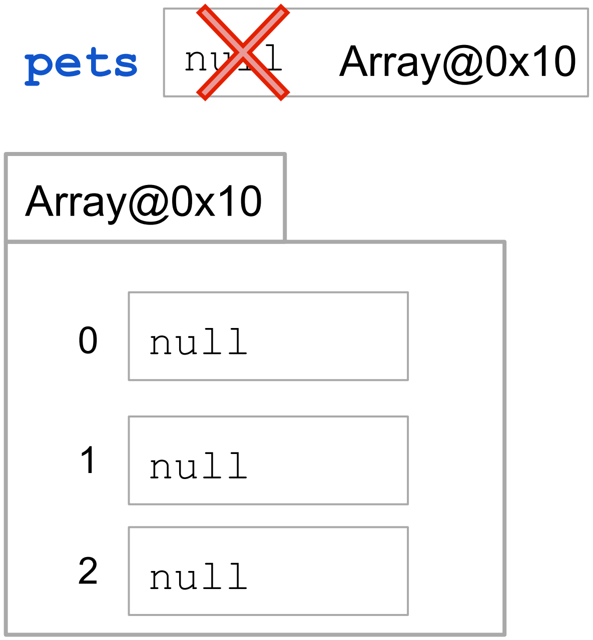
1D Array Review

```
Animal[] pets = new Animal[3];

      pets.length is 3
      pets[0] = new Animal();
      pets[0].walk();
```

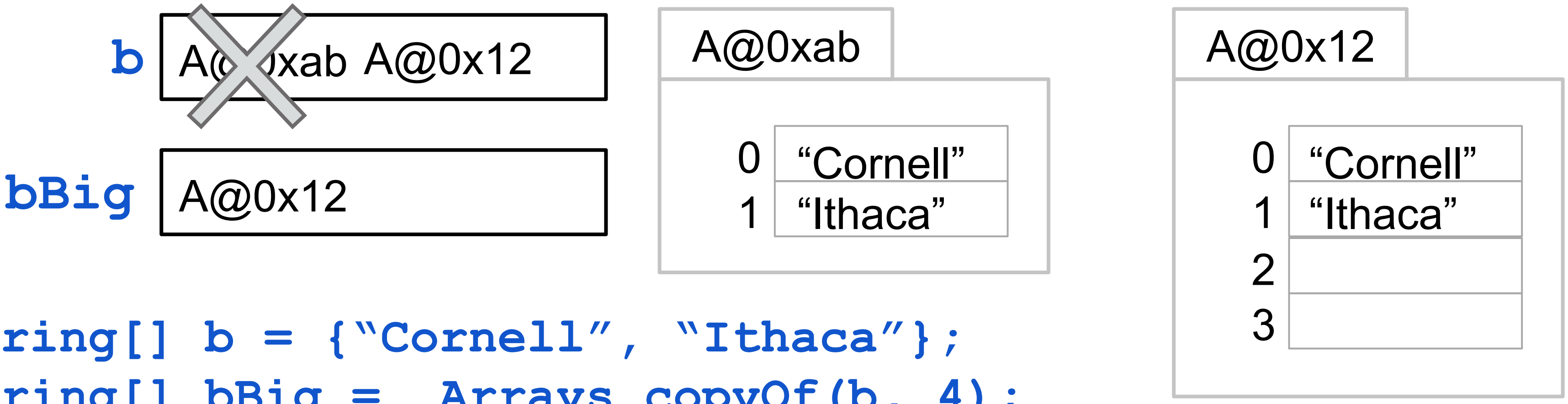
Why is the following illegal?

```
      pets[1] = new Object();
```



Java arrays

Java arrays do not change size!



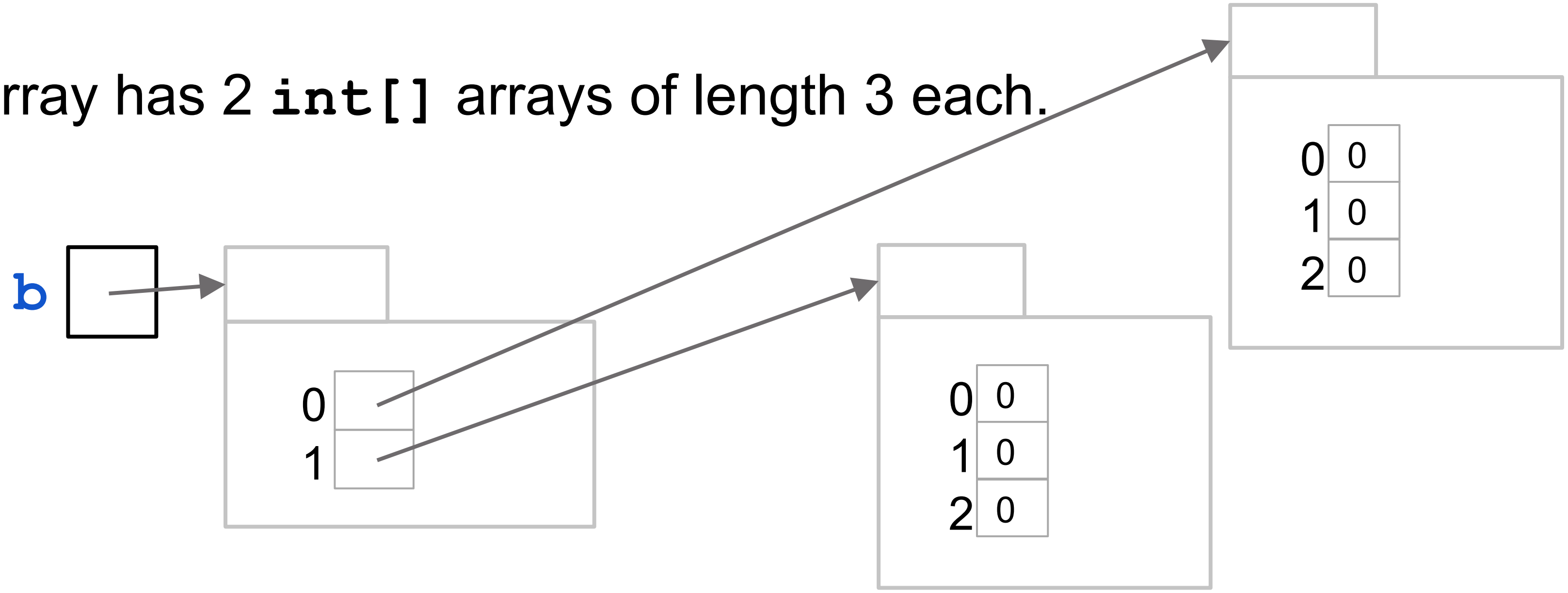
```
String[] b = {"Cornell", "Ithaca"};
String[] bBig =  Arrays.copyOf(b, 4);
b = bBig;
```

2D arrays: An array of 1D arrays.

Java only has 1D arrays, whose elements can also be arrays.

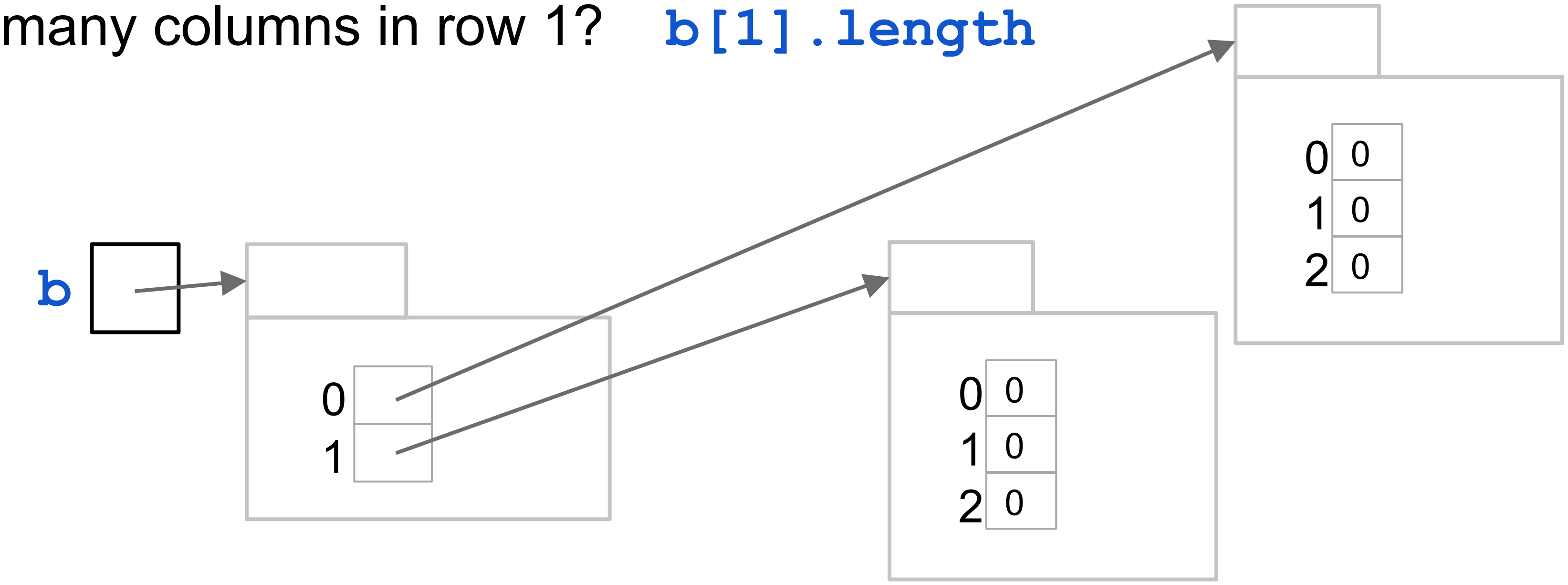
```
int[][] b = new int[2][3];
```

This array has 2 **`int[]`** arrays of length 3 each.



2D arrays: An array of 1D arrays.

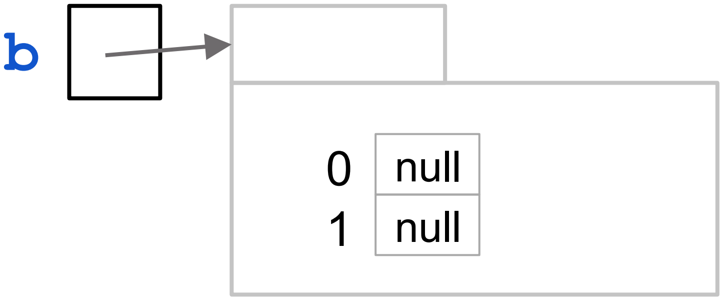
How many rows in b? `b.length`
How many columns in row 0? `b[0].length`
How many columns in row 1? `b[1].length`



2D arrays: An array of 1D arrays.

```
int[][] b = new int[2][];
```

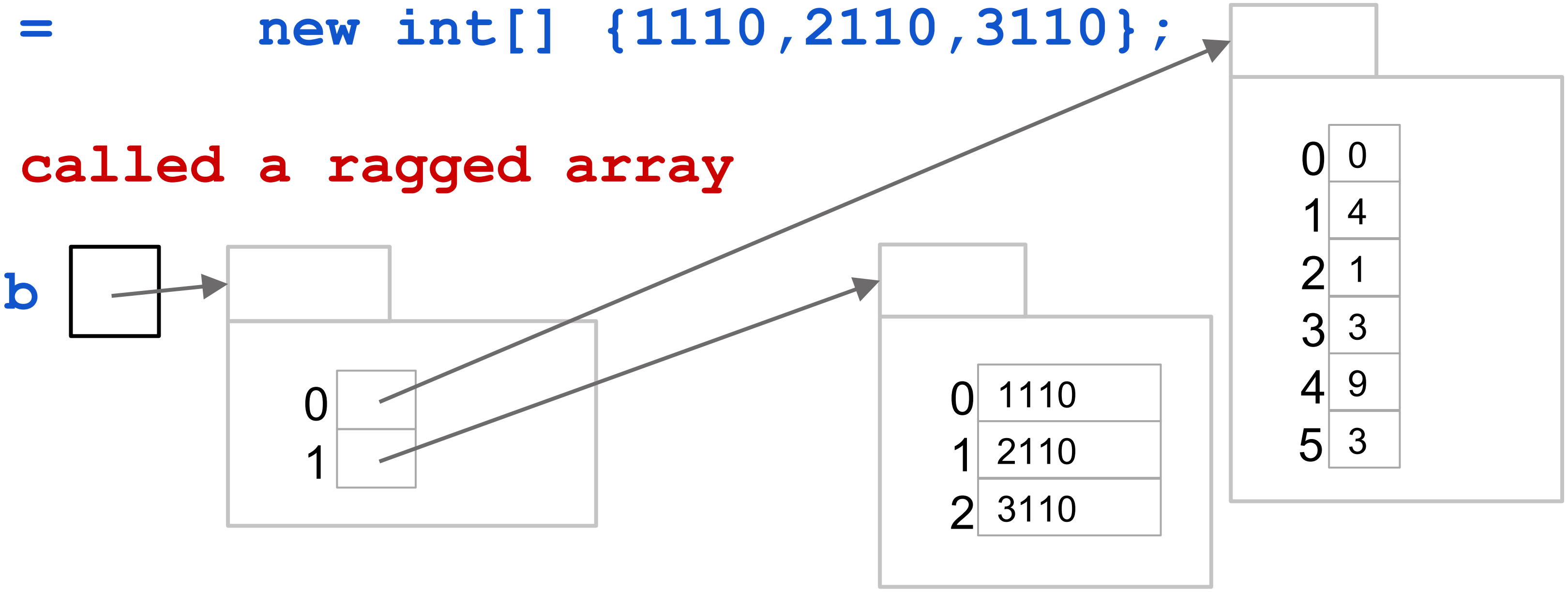
The elements of b are of type `int[]`.



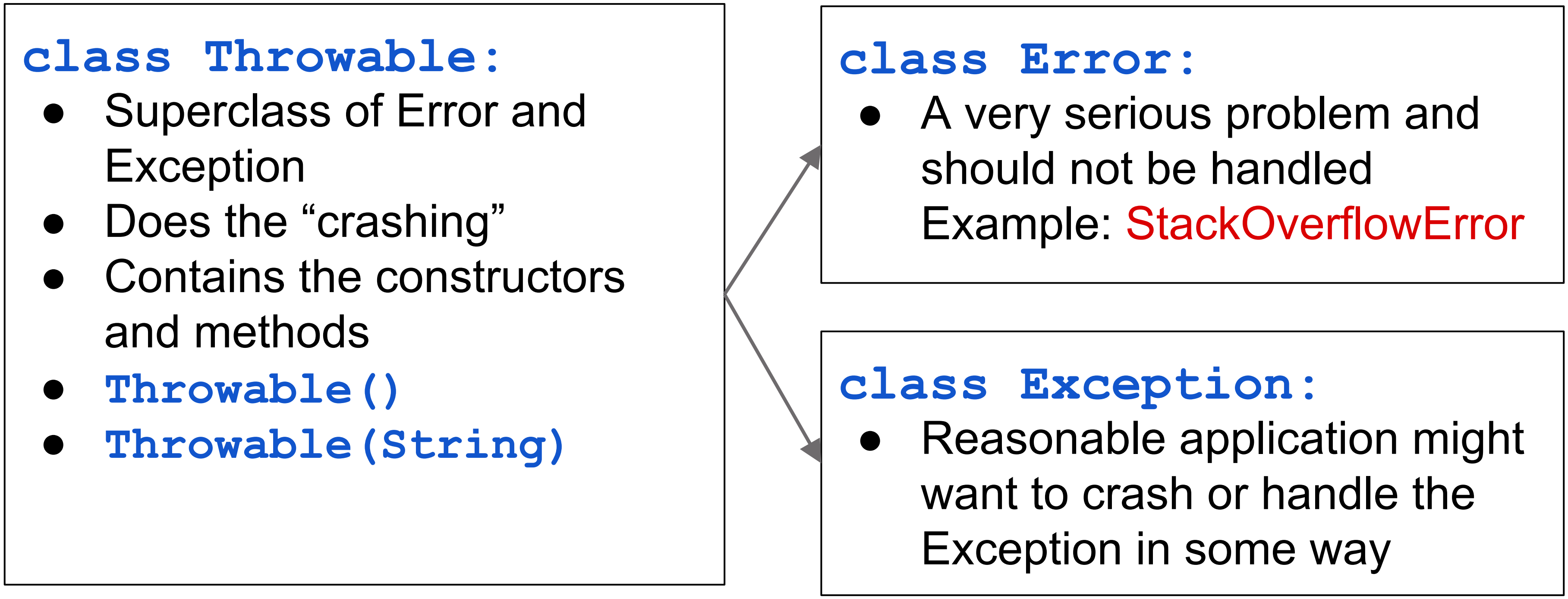
2D arrays: An array of 1D arrays.

```
int[][] b = new int[2][];
b[0] =      new int[] {0,4,1,3,9,3};
b[1] =      new int[] {1110,2110,3110};
```

b is called a ragged array



The superclass of exceptions: Throwable



class Throwable:

- Superclass of Error and Exception
- Does the "crashing"
- Contains the constructors and methods
- `Throwable()`
- `Throwable(String)`

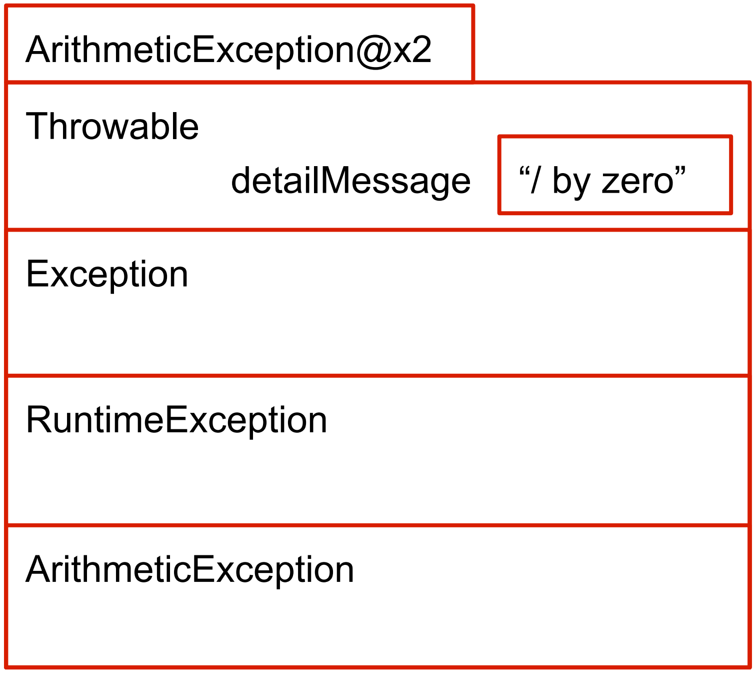
class Error:

- A very serious problem and should not be handled
  Example: StackOverflowError

class Exception:

- Reasonable application might want to crash or handle the Exception in some way

A Throwable instance: ArithmeticException



ArithmeticException@x2

Throwable

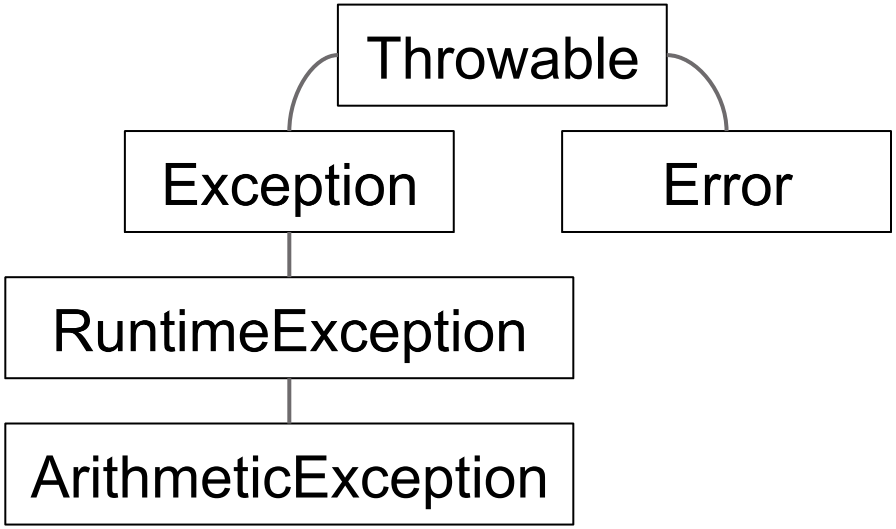
detailMessage “/ by zero”

Exception

RuntimeException

ArithmeticException

There are so many exceptions we need to **organize** them.



Throwable

Exception

Error

RuntimeException

ArithmeticException

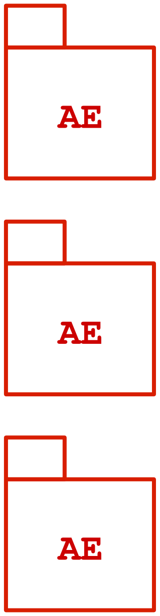
Bubbling up exceptions

Exceptions will bubble up the call stack and crash the methods that called it.

Method call: `first();`

Console:

```
Exception in thread “main”
  java.lang.ArithmeticException:
        at Ex.third(Ex.java:11)
        at Ex.second(Ex.java:7)
        at Ex.first(Ex.java:3)
```



```
1  class Ex {
2      void first() {
3                 second();
4          }
5
6          void second() {
7              third();
8      }
9
10     void third() {
11             int c = 5/0;
12     }
13 }
```

AE = ArithmeticException

Try-catch blocks

An exception will bubble up the call stack and crash the methods that called it

… unless it is caught.

catch will handle any exceptions of type *Exception* (and its subclasses) that happened in the **try** block

```
Console:
 in
 error
```

```
class Ex {
    void first() {
              second();
        }
        void second() {
              try {

        System.out.println("in");
              third();

        System.out.println("out");
              } catch (Exception e){

        System.out.print("error");
              }
}

    void third() {
        int c = 5/0;
```

Exception Type

ArithmeticException!

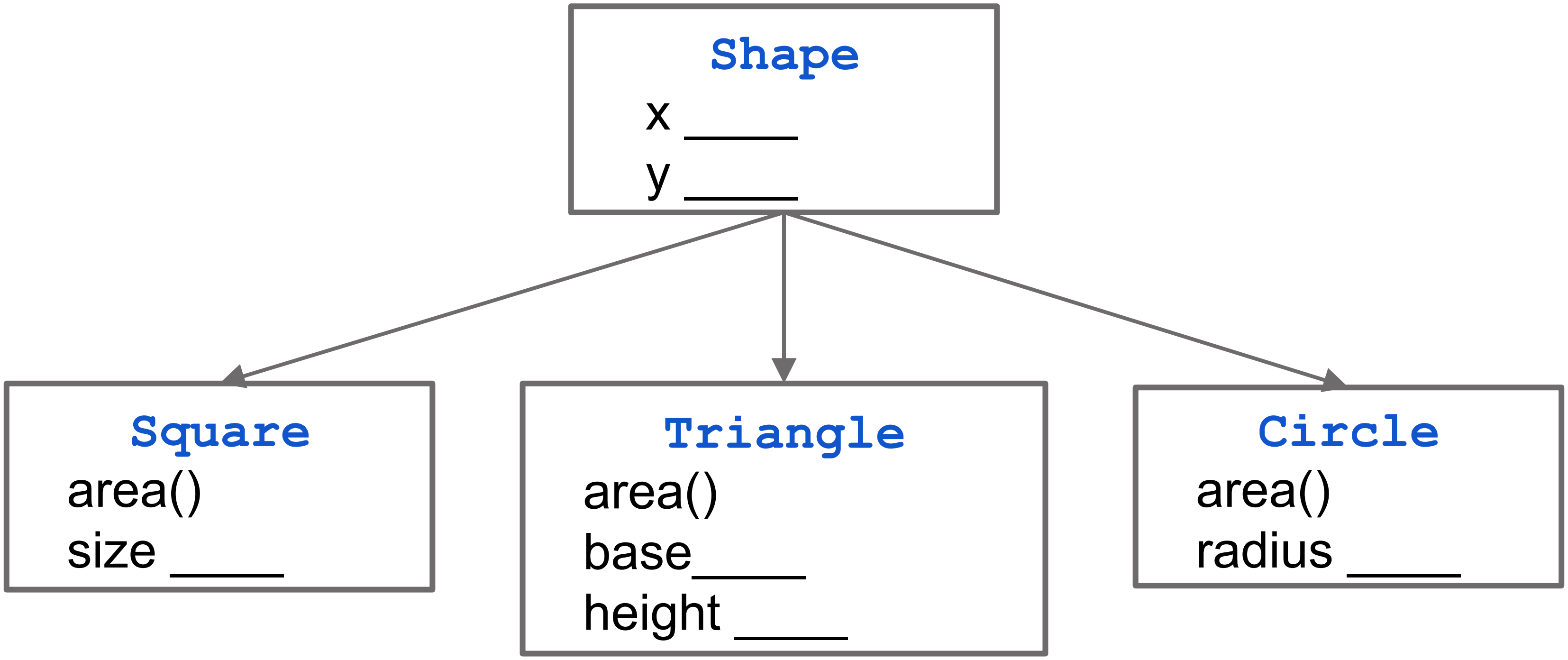
How to write an exception class

```
/** An instance is an exception */
public class OurException extends Exception {

       /** Constructor: an instance with message m*/
       public OurException(String m) {
       super(m);
       }

       /** Constructor: an instance with default message */
       public OurException() {
       this(“Default message!”);
       }
}
```

A Little More Geometry!



A Partial Solution:

Add method area to class Shape:

```
public double area() {
        return 0;
}
```

```
public double area() {
        throw new RuntimeException(“area not
overridden”);
}
```

Problems not solved

1. What is a Shape that isn’t a Circle, Square, Triangle, etc? What is *only* a shape, nothing more specific?
   a. `Shape s = new Shape(...);` Should be disallowed

2. What if a subclass doesn’t override area()?
   a. Can’t force the subclass to override it!
   b. Incorrect value returned or exception thrown.

Solution: Abstract classes

Abstract class
Can’t be instantiated.
(`new Shape()` illegal)

```
public abstract class Shape {

      public double area() {
      return 0;
   }
}
```

Solution: Abstract methods

```
public abstract class Shape {

    public abstract double area();

}
```

Abstract method
Subclass must override.

- Can have implemented methods, too
- Place abstract method only in abstract class.
- Semicolon instead of body.

Abstract Classes, Abstract Methods

1. **Cannot instantiate an object of an abstract class.**

   (Cannot use new-expression)

1. **A subclass must override abstract methods.**

(but no multiple inheritance in Java, so…)

Interfaces

```
public interface Whistler {
     void whistle();
     int MEANING_OF_LIFE= 42;
}

class Human extends Mammal implements Whistler {
}
```

- methods are automatically `public` and `abstract`
- fields are automatically `public`, `static`, and `final` (i.e. constants)

Must implement all methods in the implemented interfaces

Multiple interfaces

```
public interface Singer {
      void singTo(Human h);
}
```

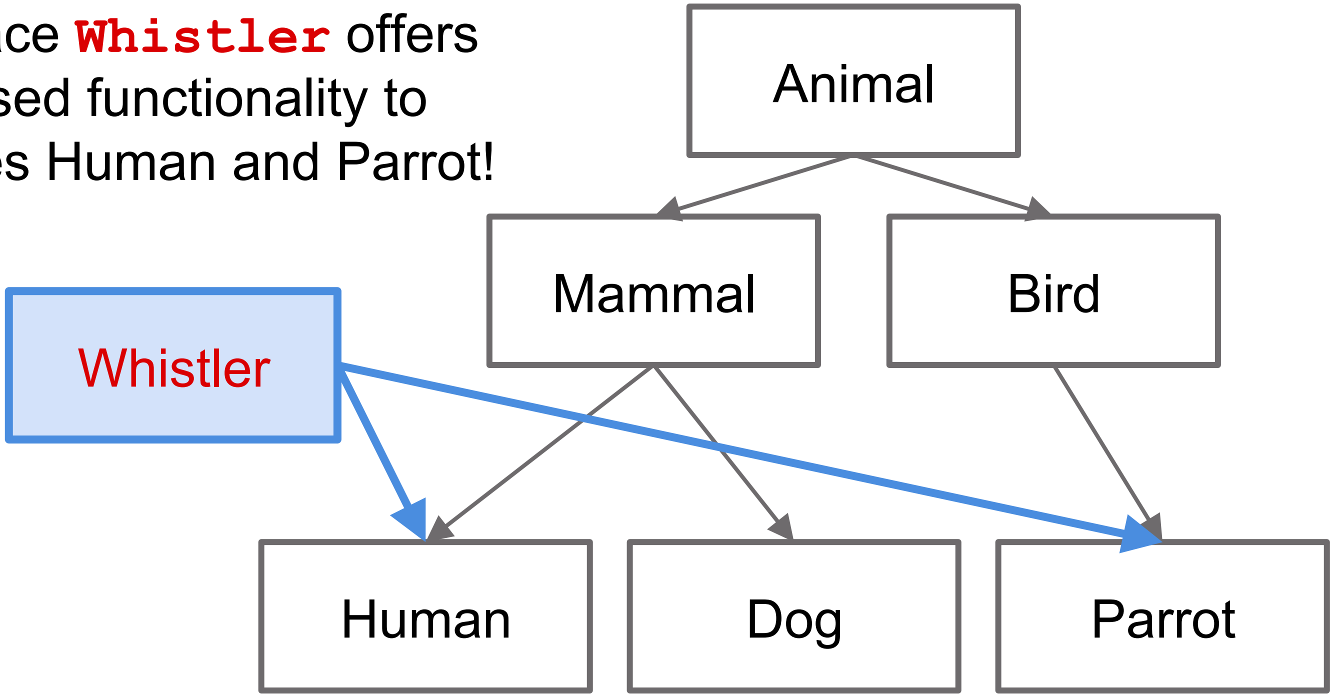
Classes can implement several interfaces! They must implement all the methods in those interfaces they implement.

```
class Human extends Mammal implements Whistler, Singer {
}
```

Must implement `singTo(Human h)` and `whistle()`

Solution: Interfaces

Interface `Whistler` offers promised functionality to classes Human and Parrot!

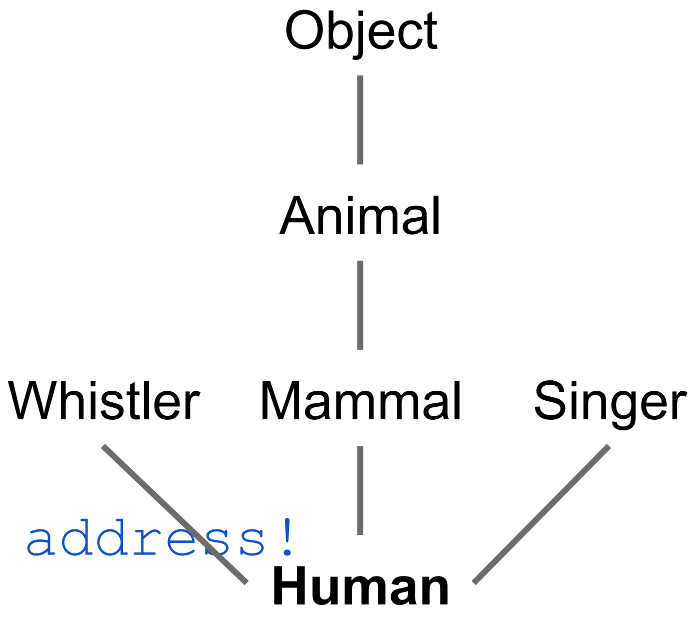


Casting

```
Human h   = new Human();
Object o = (Object) h;
Animal a = (Animal) h;
Mammal m = (Mammal) h;

Singer s = (Singer) h;
Whistler w = (Whistler) h;
```

All point to the same memory address!



Object

Animal

Whistler

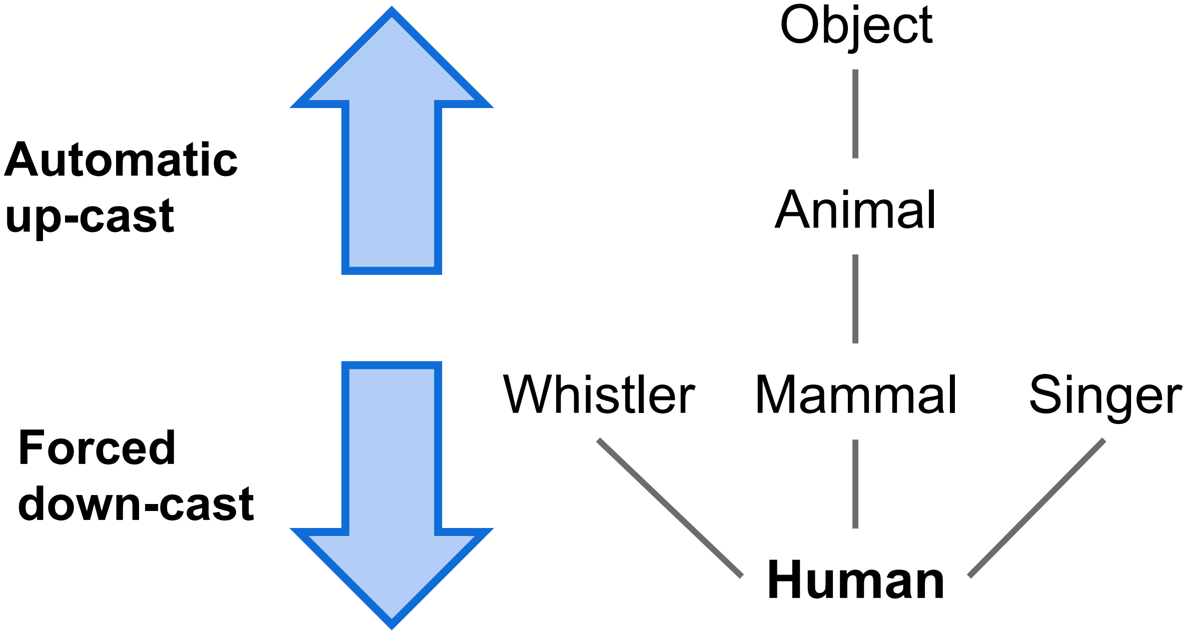
Mammal

Singer

Human

Casting

```
Human h   = new Human();
Object o = h;
Animal a = h;
Mammal m = h;
Singer s = h;
Whistler w = h;
```



Automatic up-cast

Forced down-cast

Object

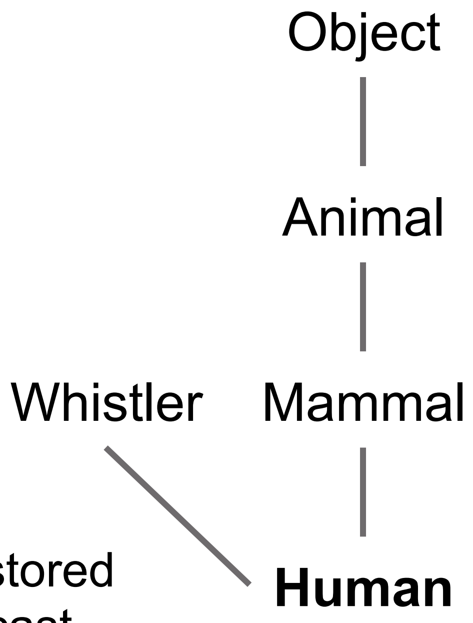
Animal

Whistler Mammal Singer

Human

Casting up to an interface automatically

```
class Human … implements Whistler {
   void listenTo(Whistler w) {...}
}
Human h = new Human(...);
Human h1 = new Human(...);
h.listenTo(h1);
Parrot p = new Parrot(...);
h.listenTo(p);
```



Arg h1 of the call has type Human. Its value is being stored in w, which is of type Whistler. Java does an upward cast automatically. Same thing for p of type Parrot.

Shape implements Comparable<T>

```
public class Shape implements Comparable<Shape> {
    ...
    /** … */
    public int compareTo(Shape s) {
       double diff= area() - s.area();
       return (diff == 0 ? 0 : (diff < 0 ? -1 : +1));
    }
}
```

Beauty of interfaces

`Arrays.sort` sorts an array of *any* class C, as long as C implements interface `Comparable<T>` without needing to know any implementation details of the class.

Classes that implement Comparable:

```
Boolean    Byte       Double     Integer
String     BigDecimal BigInteger Calendar
Time       Timestamp  and 100 others
```

String sorting

`Arrays.sort(Object[] b)` sorts an array of *any* class C, as long as C implements interface **`Comparable<T>`**.

`String` implements `Comparable`, so you can write

```
    String[] strings= ...;   ...
    Arrays.sort(strings);
```

During the sorting, when comparing elements, a String’s compareTo function is used

Abstract Classes vs. Interfaces

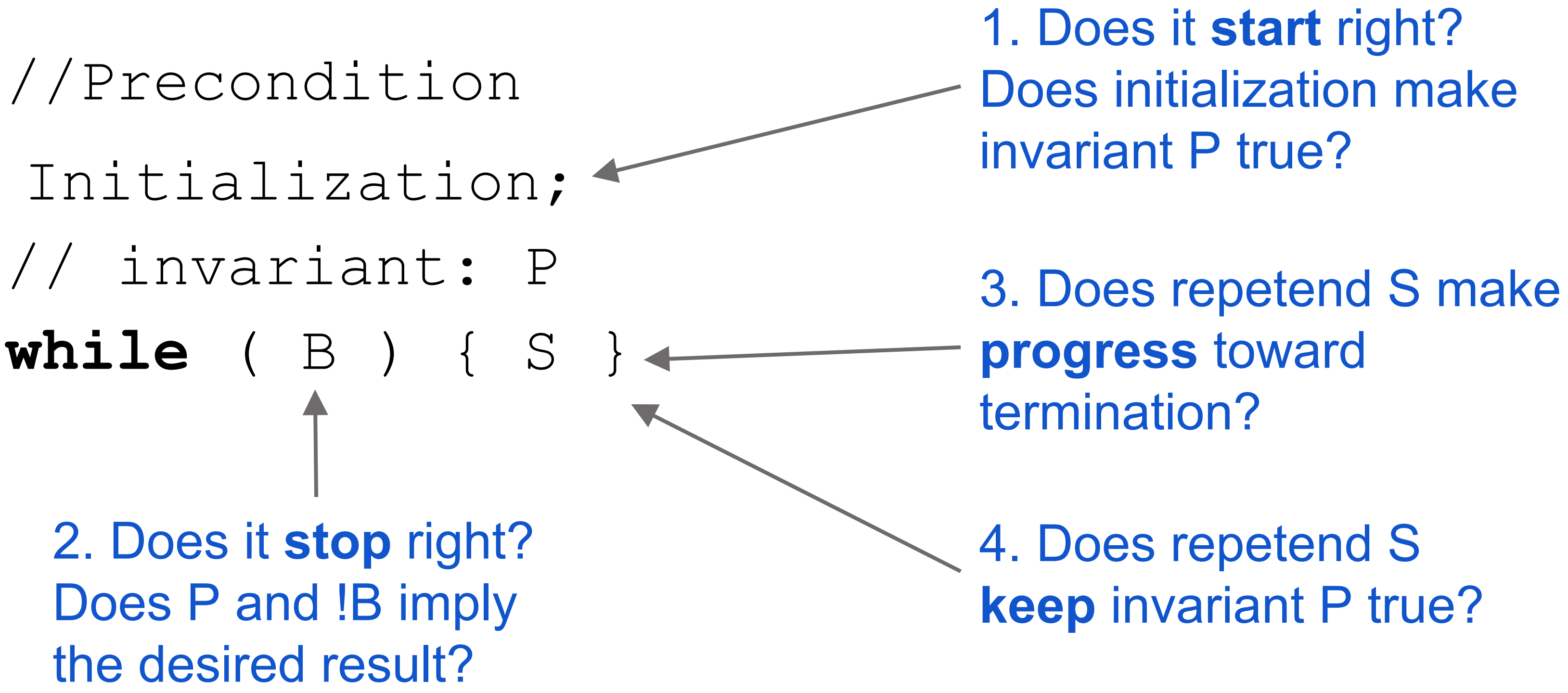
- Abstract class represents something
- Sharing common code between subclasses

- Interface is what something can do
- A contract to fulfill
- Software Engineering purpose

Similarities:

- Can’t instantiate
- Must implement abstract methods

Four loopy questions



```
//Precondition
 Initialization;
// invariant: P
while ( B ) { S }
```

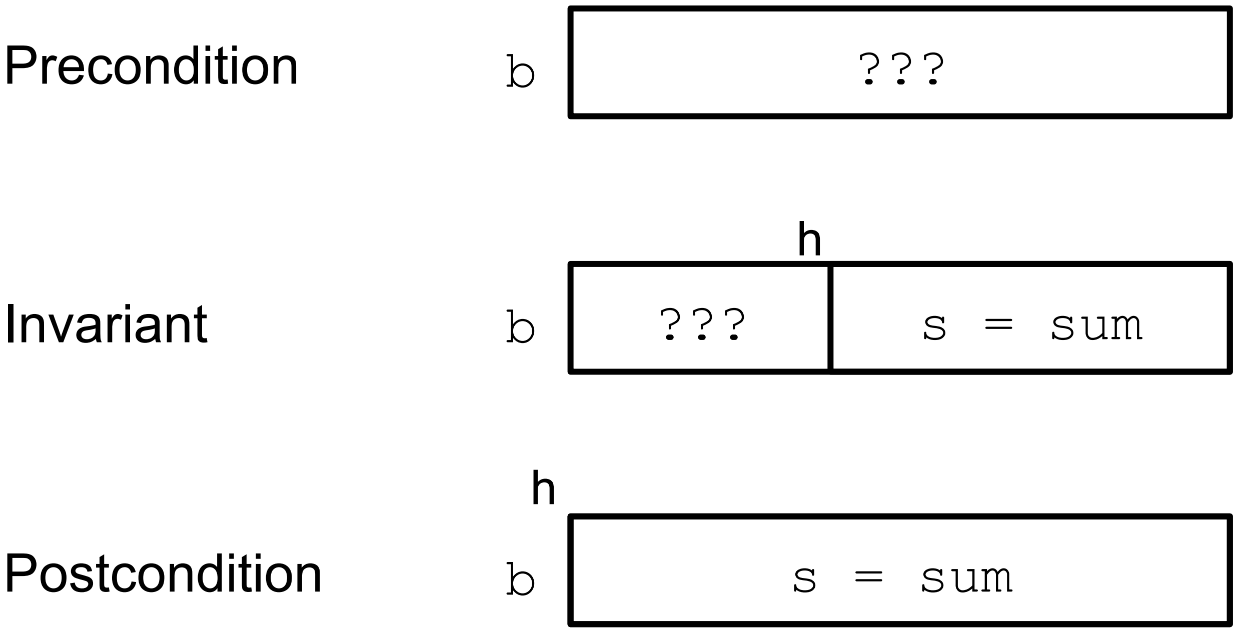
1. Does it **start** right? Does initialization make invariant P true?

2. Does it **stop** right? Does P and !B imply the desired result?

3. Does repetend S make **progress** toward termination?

4. Does repetend S **keep** invariant P true?

Add elements backwards



Precondition

b | ???

Invariant

h

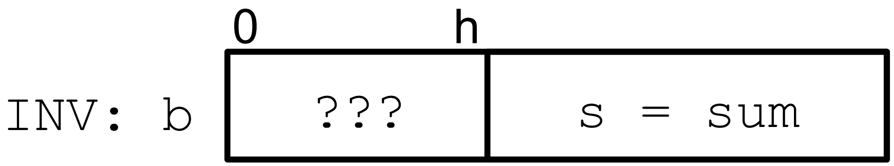
b | ??? | s = sum

Postcondition

h

b | s = sum

Add elements backwards


0 h

INV: b ??? s = sum

```
int s = 0;
int h = b.length-1;
while (h >= 0) {
     s = s + b[h];
     h--;
}
```

1. ✓ Does it **start** right?
2. ✓ Does it **stop** right?
3. ✓ Does it **keep** the invariant true?
4. ✓ Does it make **progress** toward termination?

What method calls are legal

```
Animal an; …  an.m(args);
```

legal ONLY if Java can guarantee that method m exists. How to guarantee?

m must be declared in Animal or inherited.

Java Summary

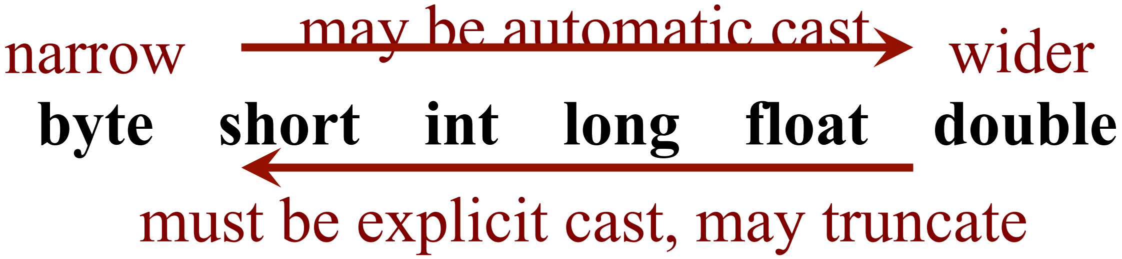
- On the “Resources” tab of the course website
- We have selected some useful snippets
- We recommend going over all the slides

Casting among types

(**int**) 3.2 casts **double** value 3.2 to an **int**

any number type

any number expression



narrow

may be automatic cast

wider

byte **short** **int** **long** **float** **double**

must be explicit cast, may truncate

char is a number type: (**int**) **'V'** (**char**) 86

Unicode representation: 86

'V'

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Declaration of class Circle

Multi-line comment starts with /* ends with */

```
/** An instance (object) represents a circle */
public class Circle {

}
```

Precede every class with a comment

Put declarations of fields, methods in class body: { … }

Put class declaration in file Circle.java

public: Code everywhere can refer to Circle. Called **access modifier**

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Overloading

Possible to have two or more methods with same name

```
/** instance represents a rectangle */
public class Rectangle {
  private double sideH, sideV; // Horiz, vert side lengths

  /** Constr: instance with horiz, vert side lengths sh, sv */
  public Rectangle(double sh, double sv) {
    sideH= sh; sideV= sv;
  }

  /** Constructor: square with side length s */
  public Rectangle(double s) {
    sideH= s; sideV= s;
  }
  …
}
```

Lists of parameter types must differ in some way

Use of this

this evaluates to the name of the object in which is appears

Memorize this!

```
/** Constr: instance with radius radius*/
public Circle(double radius) {
      this.radius= radius;
}
```

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Class Shape

```
/** An instance represents a shape at a point in the plane */
public class Shape {
    private double x, y; // top-left point of bounding box
    /** Constructor: a Shape at point (x1, y1) */
    public Shape (double x1, double y1) {
        x= x1;  y= y1;
    }
    /** return x-coordinate of bounding box*/
    public double getX() {
        return x;
    }
    /** return y-coordinate of bounding box*/
    public double getY() {
        return y;
    }
}
```

Object: superest class of them all

Class doesn’t explicitly extend another one? It automatically extends class Object. Among other components, Object contains:

Constructor: **public** Object() {}

/** return name of object */
public String toString()

c.toString() is “Circle@x1”

/** return value of “this object and ob
are same”, i.e. of **this** == ob */
public boolean equals(Object ob)

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Java has 4 kinds of variable

```
public class Circle {
   private double radius;

   private static int t;

   public Circle(double r) {
      double r1= r;
      radius= r1;
}
```

Field: declared non-static. Is in every object of class. Default initial val depends on type, e.g. 0 for **int**

Class (static) var: declared **static**. Only one copy of it. Default initial val depends on type, e.g. 0 for **int**

Parameter: declared in () of method header. Created during call before exec. of method body, discarded when call completed. Initial value is value of corresp. arg of call. Scope: body.

Local variable: declared in method body. Created during call before exec. of body, discarded when call completed. No initial value. Scope: from declaration to end of block.

Basic class Box

```
public class Box {
   private Object object;

   public void set(Object ob) {
      object = ob;
   }
   public Object get() {
     return object;
   }
```

New code

```
Box<Integer> b= new Box<Integer>();
b.set(new Integer(35));
Integer x= b.get();
```

parameter T (you choose name)

Written using generic type

```
public class Box<T> {
   private T object;

   public void set(T ob) {
      object = ob;
   }
   public T get() {
     return object;
   }   …
```

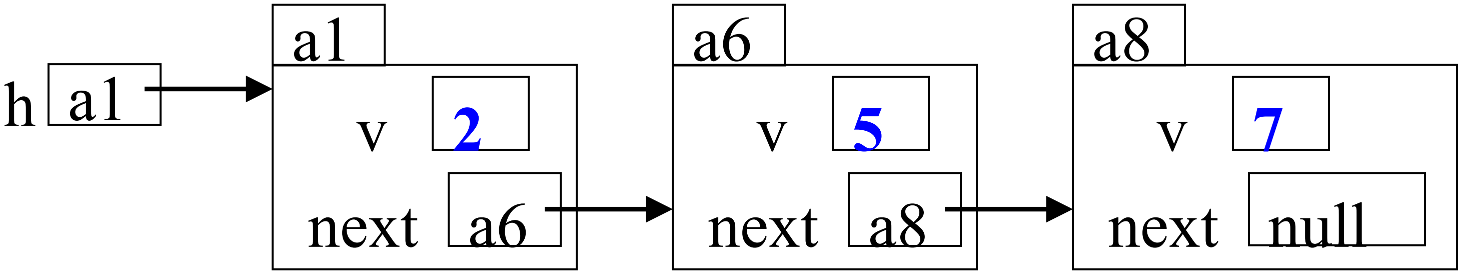
Replace type Object everywhere by T

Linked Lists

(These slides are from the class lectures and available on the website as well)

Linked Lists

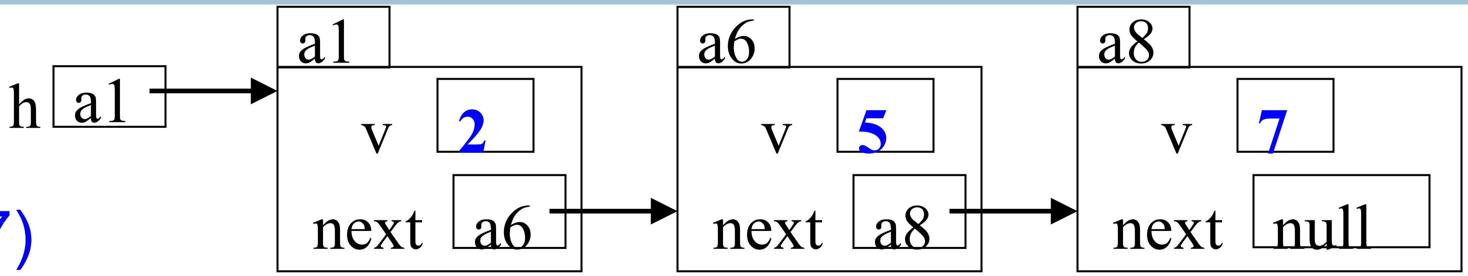
Idea: maintain a list (**2**, **5**, **7**) like this:



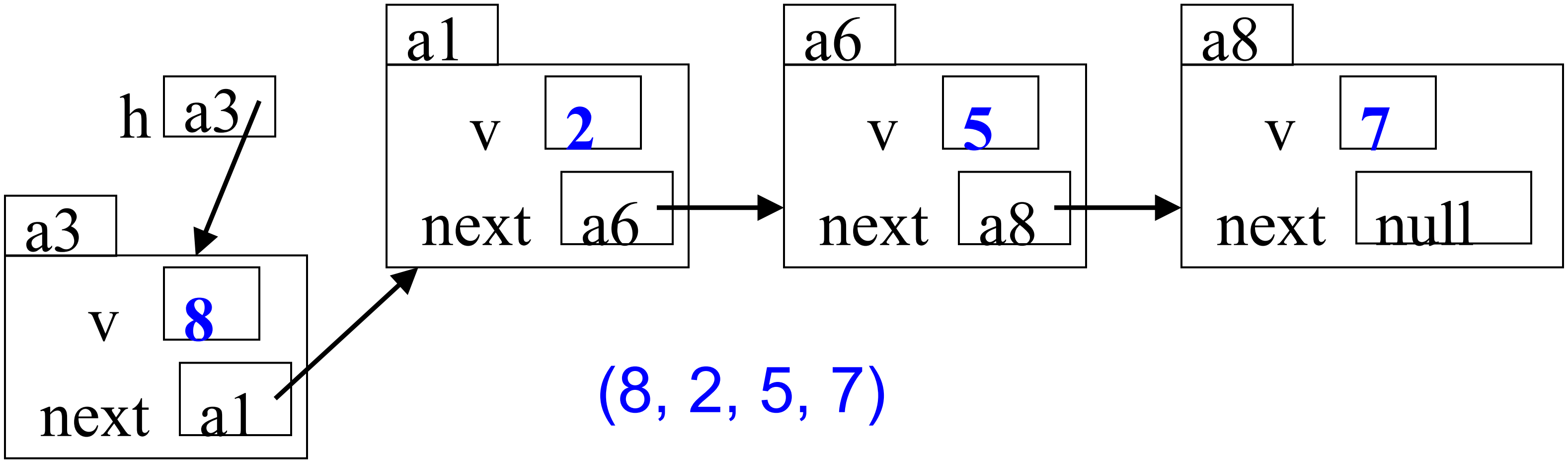
This is a singly linked list

To save space we write names like a6 instead of N@35abcd00

Easy to insert a node in the beginning!

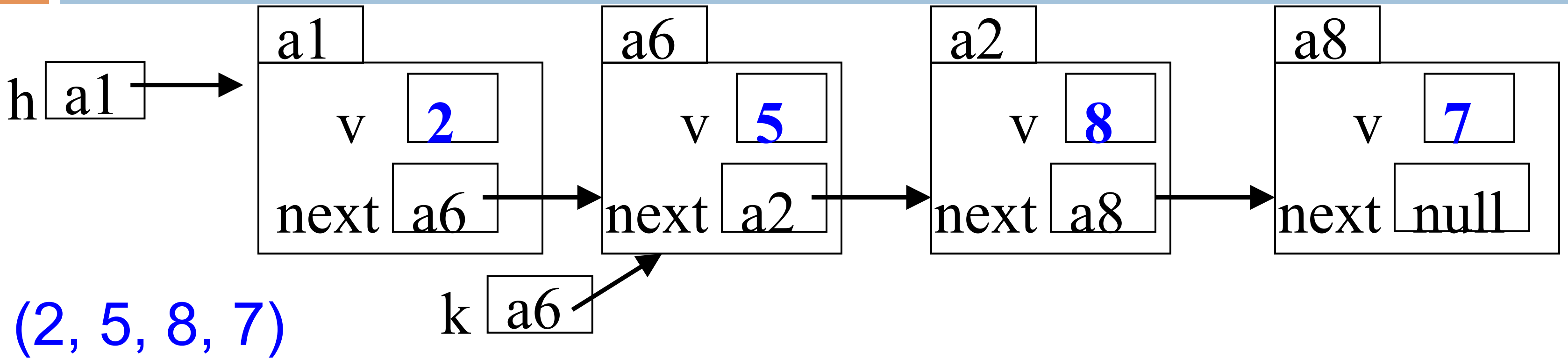


(2, 5, 7)

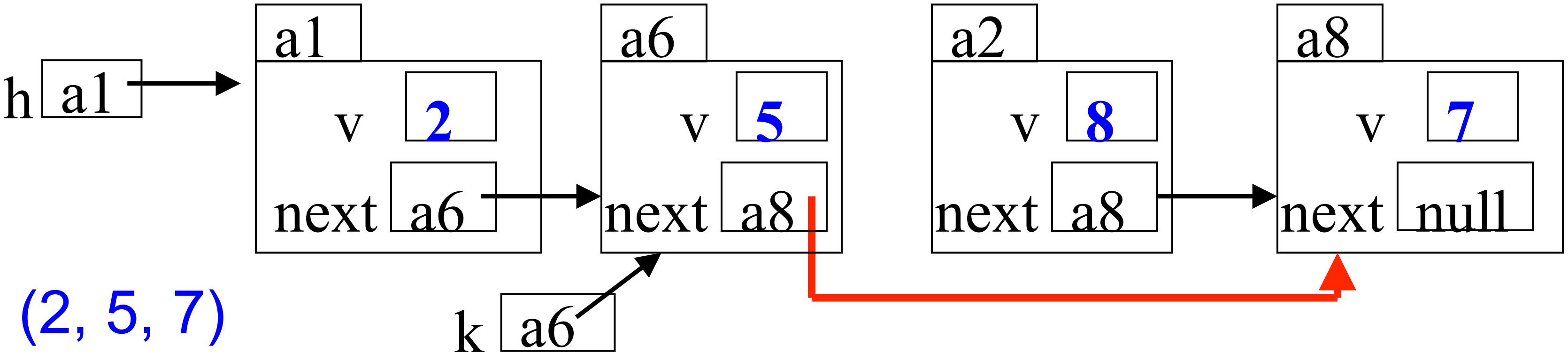


(8, 2, 5, 7)

Easy to remove a node if you have its predecessor!



(2, 5, 8, 7)



(2, 5, 7)

Recursion

Sum the digits in a non-negative integer

```
/** return sum of digits in n.
  * Precondition:  n >= 0 */
 public static int sum(int n) {
     if (n < 10) return n;

     // { n has at least two digits }
     // return first digit + sum of rest
     return sum(n/10)  +  n%10 ;
 }
```

sum calls itself!

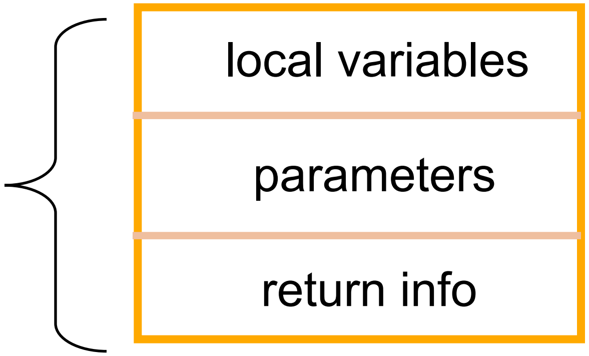
E.g. sum(7) = 7

E.g. sum(8703) = sum(870) + 3;

Stack Frame

A “frame” contains information about a method call:

At runtime, Java maintains a stack that contains frames for all method calls that are being executed but have not completed.



local variables

parameters

return info

Method call: push a frame for call on stack, assign argument values to parameters, execute method body. Use the frame for the call to reference local variables, parameters.

End of method call: pop its frame from the stack; if it is a function, leave the return value on top of stack.

(some) things to know for the prelim

- Can you list the steps in evaluating a new-expression? Can you do them yourself on a piece of paper?
- Can you list the steps in executing a method call? Can you do them yourself on a piece of paper?
- Do you understand exception handling? E.g. What happens after a catch block has been executed?
- Can you write a recursive method or understand a given one?
- Abstract class and interfaces
- ArrayList, interface Comparable
- Loops invariants