CS/ENGRD 2110
SPRING 2017

Lecture 4: The class hierarchy; static components
http://cs.cornell.edu/courses/cs2110

Announcements

- We're pleased with how many people are already working on **A1**, as evidenced by Piazza activity
  - Please be sure to look at **Piazza note @6** every day for frequently asked questions and answers.
  - Also search existing questions!
  - **Groups:** Forming a group of two? Do it **well before** you submit – at least one day before. **Both members must act:** one invites, the other accepts. Thereafter, only ***one*** member has to submit the files.
  - **Reminder:** groups must complete the assignment working together.
- Reminder: **before** this week's section, watch the tutorial videos on exception handling:
  - www.cs.cornell.edu/courses/cs2110/2017sp/online/exceptions/EX1.html

A1: Checking Correctness of Assertions

- See Piazza note @129 (also linked from A1 FAQ)
- The description there will make sense after you've learned about exceptions in recitation.

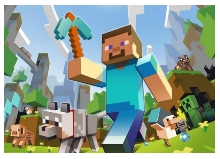
```
try {
    //<code with assertion that should fail>
    fail("");
} catch (AssertionError e) {
    if (e.getMessage() != null) {
        fail();
    }
}
```

References to text and JavaSummary.pptx

- Class Object, superest class of them all.
  Text: C.23 slide 30
- Function toString() C.24 slide 31-33
- Overriding a method C15–C16 slide 31-32
- Static components (methods and fields) B.27 slide 21, 45
- Java application: a program with a class that declares a method with this signature:
  public static void main(String[])

Homework

1. Read the text, about applications: Appendix A.1–A.3
2. Read the text, about the if-statement: A.38–A.40
3. Visit course website, click on Resources and then on Code Style Guidelines. Study
   2. Format Conventions
   4.5 About then-part and else-part of if-statement



Where am I? Big ideas so far.

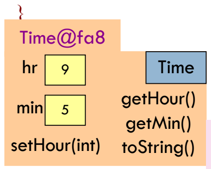
- Java variables have *types* (L1)
  - A type is a set of values and operations on them
    (int: +, -, *, /, %, etc.)
- *Classes* define new types (L2)
  - *Methods* are the operations on objects of that class.
  - *Fields* allow objects to store data (L3)
- Software Engineering Principle:
  - Give user access to *functionality*, not the *implementation details*

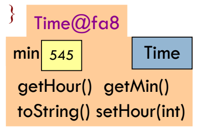
Example: Method specs should not mention fields

```
public class Time {
  private int hr;   //in 0..23
  private int min; //in 0..59
  /** return hour of day*/
  public int getHour() {
     return h;
  }
```

Decide to change implemen -tation

```
public class Time {
    // min, in 0..23*60+59
    private int min;
  /** return hour of day*/
  public int getHour() {
       return min / 60;
  }
```





Specs of methods stay the same.
Implementations, including fields, change!

A bit about testing

Test case: Set of input values, together with the expected output.

Develop test cases for a method from its specification --- even before you write the method's body.

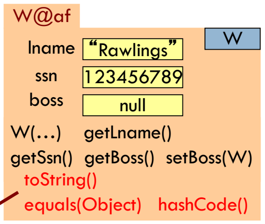
```
/** return the number of vowels in word w.
Precondition: w contains at least one letter and nothing but letters */
public int numberOfVowels(String w) {
   …
}
```

Developing test cases first, in "critique" mode, can prevent wasted work and errors

How many vowels in each of these words?
creek
syzygy
yellow

Class W (for Worker)

```
/** Constructor: worker with last name n,  SSN s, boss b (null if none).
     Prec:  n not null,  s in 0..999999999 with no leading zeros.*/
public W(String n, int s, W b)
/** = worker's last name */
public String getLname()
/** = last 4 SSN digits */
public String getSsn()
/** = worker's boss (null if none) */
public W getBoss()
/** Set boss to b */
public void setBoss(W b)
```



Contains other methods!

Class Object: the superest class of them all

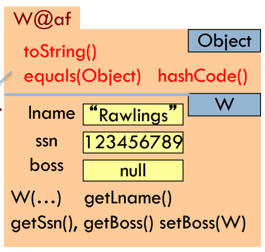
Java: Every class that does not extend another extends class Object. That is,

public class W {…}

is equivalent to

public class W **extends** Object {…}

We draw object like this



We often omit this partition to reduce clutter; we know that it is always there.

A note on design

- Don't use **extends** just to get access to hidden members!
- The inheritance hierarchy should reflect **modeling semantics**, not implementation shortcuts
- A should extend B if and only if **A "is a" B**
  - An elephant is an animal, so Elephant **extends** Animal
  - A car is a vehicle, so Car **extends** Vehicle
  - An instance of any class is an object, so AnyClass **extends** java.lang.Object

A note on design

- Don't use **extends** just to get access to hidden members!
- The inheritance hierarchy should reflect **modeling semantics**, not implementation shortcuts
- Which of the following seem like reasonable designs?
  - A. Triangle extends Shape { … }
  - B. PHDTester extends PHD { … }
  - C. BankAccount extends CheckingAccount { … }

A note on design

- Which of the following seem like reasonable designs?
  - A. Triangle extends Shape { … }
    - A. Yes! A triangle is a kind of shape.
  - ~~B. PHDTester extends PHD { … }~~
    - A. No! A PHDTester "tests a" PHD, but itself is not a PHD.
  - ~~C. BankAccount extends CheckingAccount { … }~~
    - A. No! A checking account is a kind of bank account; we likely would prefer:

      CheckingAccount extends BankAccount { … }

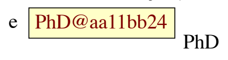
toString() gives us the "name" of the object.

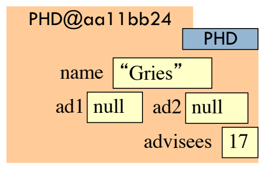
The name of the object below is

PHD@aa11bb24

It contains a pointer to the object –i.e. its address in memory and you can call it a pointer if you wish – I prefer to call it a reference.

Variable e, declared as
PHD e;
contains not the object but the name of the object (or a reference to the object).





Method toString

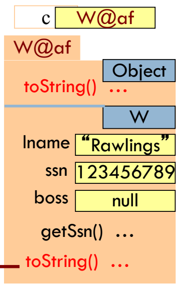
toString() in Object returns the name of the object: W@af

Java Convention: Define toString() in any class to return a representation of an object, giving info about the values in its fields.

New definitions of toString() **override** the definition in Object.toString()

In appropriate places, the expression c automatically does c.toString()

c.toString() calls this method

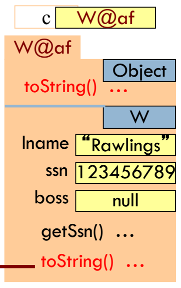


Method toString

toString() in Object returns the name of the object: W@af

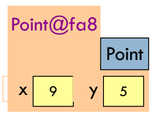
```
public class W {
  …
  /** Return a representation of this object */
  public String toString() {
    return "Worker " + lname
           + " has SSN ???-??-" + getSsn()
           + (boss == null
                     ? ""
                     : " and boss " + boss.lname);
  }
```

c.toString() calls this method



Another example of toString()

```
/** An instance represents a point (x, y) in the plane */
public class Point {
    private int x;  // x-coordinate
    private int y;  // y-coordinate
    …
    /** = repr. of this point in form "(x, y)" */
    public String toString() {
        return "(" + x + "," + y + ")";
    }
}
```



(9, 5)

Function toString should give the values in the fields in a format that makes sense for the class.

What about `this`

- **`this`** keyword: **this** evaluates to the name of the object in which it occurs
- Makes it possible for an object to access its own name (or pointer)
- Example: Referencing a shadowed class field

```
public class Point {
    public int x = 0;
    public int y = 0;

    //constructor
    public Point(int x, int y) {
        x = x;
        y = y;
    }
}
```

Inside-out rule shows that field x is inaccessible!

```
public class Point {
    public int x = 0;
    public int y = 0;

    //constructor
    public Point(int x, int y) {
        this.x = x;
        this.y = y;
    }
}
```

Class Hierarchy Quiz

1. How many levels deep is JFrame in the class hierarchy?
   - (Object is JFrame's super-super-…-superclass. How many supers are there?)
2. In which class is JFrame's getHeight() method defined?
   - (hint: it's not JFrame!)

Intro to static components

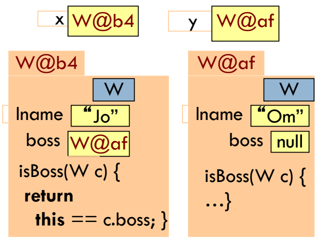
```
/** = "this object is c' s boss".
    Pre: c is not null. */
public boolean isBoss(W c) {
    return this == c.boss;
}
```

Spec: return the value of that true-false sentence. True if this object is c's boss, false otherwise

keyword **this** evaluates to the name of the object in which it appears

x.isBoss(y) is **false**

y.isBoss(x) is **true**

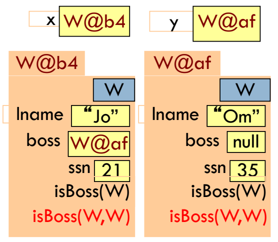


Intro to static components

```
/** = "b is c' s boss".
    Pre: b and c are not null. */
public boolean isBoss(W b, W c) {
    return b == c.getBoss();
}
```

Body doesn't refer to any field or method in the object. Why put method in object?

```
/** = "this object is c' s boss".
    Pre: c is not null. */
public boolean isBoss(W c) {
    return this == c.boss;
}
```



Intro to static components

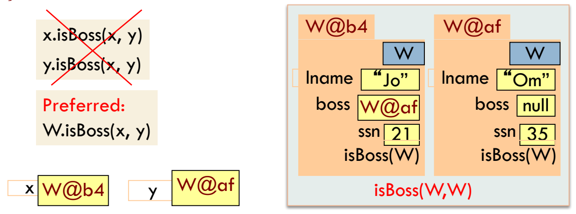
static: there is only one copy of the method. It is *not* in each object

```
/** = "b is c' s boss".
    Pre: b and c are not null. */
public static boolean isBoss(W b, W c) {
    return b == c.getBoss();
}
```

~~x.isBoss(x, y)~~
~~y.isBoss(x, y)~~

Preferred:
W.isBoss(x, y)

Box for W (objects, static components)



Good example of static methods

- java.lang.Math

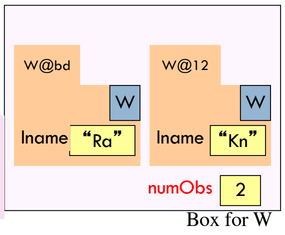
http://docs.oracle.com/javase/8/docs/api/java/lang/Math.html

- Or find it by googling
  java.lang.Math 8

Use of static variables: Maintain info about created objects

```
public class W {
  private static int numObs; // number of W objects created
  /** Constructor:  */
  public W(…) {
    …
    numObs= numObs + 1;
  }
}
```

To have numObs contain the number of objects of class W that have been created, simply increment it in constructors.



Class java.awt.Color uses static variables

An instance of class Color describes a color in the RGB (Red-Green-Blue) color space. The class contains about 20 static variables, each of which is (i.e. contains a pointer to) a non-changeable Color object for a given color:

```
public static final Color black = …;
public static final Color blue = …;
public static final Color cyan = new Color(0, 255, 255);
public static final Color darkGray = …;
public static final Color gray = …;
public static final Color green = …;
…
```

Java application

Java application: bunch of classes with at least one class that has this procedure:

```
public static void main(String[] args) {
      …
}
```

Type String[]: array of elements of type String. We will discuss later

Running the application effectively calls method main

Command line arguments can be entered with args

Uses of static variables: Implement the Singleton pattern

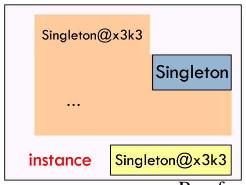
Only one Singleton can ever exist.

```
public class Singleton {
    private static final Singleton instance= new Singleton();

    private Singleton() { }  // ... constructor

    public static Singleton getInstance() {
        return instance;
    }

    // ... methods
}
```



Box for Singleton