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CS/ENGRD 2110
FALL 2016

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

Announcements

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- 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 @54** every day for frequently asked questions and answers
  - **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.
- **A2:** Practice with strings
  - We will give you our test cases soon!

References to text and JavaSummary.pptx

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- A bit about testing and test cases
- 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

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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

A bit about testing

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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) {
    …
}
```

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

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

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Class W (for Worker)

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```
/** 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!

W@af

	W
lname	"Obama"
ssn	123456789
boss	null

W(…) getLname()
getSsn() getBoss() setBoss(W)
toString()
equals(Object) hashCode()

Class Object: the superest class of them all

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

public class W {…}
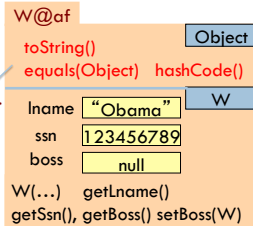
is equivalent to

public class W **extends** Object {…}

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

We draw object like this

W@af

toString()		Object
equals(Object)	hashCode()	
		W
lname	"Obama"	
ssn	123456789	
boss	null	

W(…)   getLname()
getSsn(), getBoss() setBoss(W)

A note on design

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- ☐ Don't use **extends** just to get access to hidden members!
- ☐ A should extend B if and only if **A "is a" B**
  - ▫ A PhDTester is *not* a PhD Student!
  - ▫ 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
- ☐ The inheritance hierarchy should reflect **modeling semantics**, not implementation shortcuts

---

What is "the name of" the object?

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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. But it contains more than that.

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

e   PhD@aa11bb24   PhD

PhD@aa11bb24

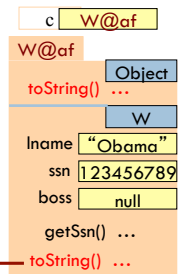| | | PhD |
name	"Mumsie"	
ad1	null	ad2	null
	advisees	1

Method toString

10
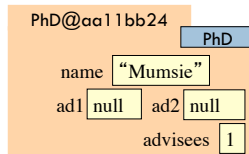
toString() in Object returns the name of the object: W@af

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

c   W@af

W@af

toString() …		Object
		W
lname	"Obama"	
ssn	123456789	
boss	null	
getSsn() …		
toString() …		

Method toString

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

public class W {

…

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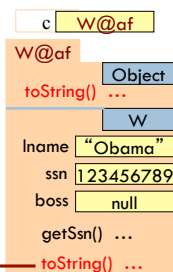 **return** "Worker " + lname
    + " has SSN ???-??-" + getSsn()
    + (boss == **null**
        ? ""
        : " and boss " + boss.lname);
}

}

c.toString() calls this method

c   W@af

W@af

toString() …		Object
		W
lname	"Obama"	
ssn	123456789	
boss	null	
getSsn() …		
toString() …		

Another example of toString()

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/** 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 + ")";
  }
}

Point@fa8

| | | Point |
| x | 9 | y | 5 |

(9, 5)

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

What about **this**

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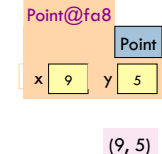
- **this** keyword: **this** evaluates to the name of the object in which it occurs
- Makes it possible for an object to access its own name (or pointer)
- Example: Referencing a shadowed class field

```
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;
    }
}
```
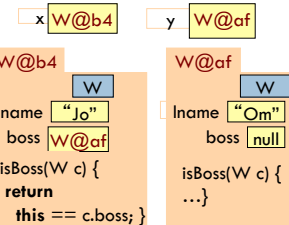
Intro to static components

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

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

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

x W@b4   y W@af

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

W@b4
| W |
lname "Jo"
boss W@af
isBoss(W c) {
return
this == c.boss; }

W@af
| W |
lname "Om"
boss null
isBoss(W c) {
…}

Intro to static components

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```
/** = "b is c's boss".
    Pre: b and c are not null. */
public boolean isBoss(W b, W c) {
    return b == c.getBoss();
}
```
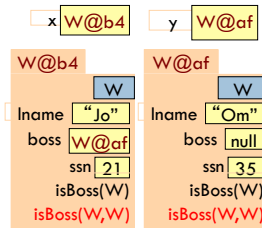
Body doesn't refer to any field or method in the object. Why put method in object?

x W@b4   y W@af

W@b4
| W |
lname "Jo"
boss W@af
ssn 21
isBoss(W)
isBoss(W,W)

W@af
| W |
lname "Om"
boss null
ssn 35
isBoss(W)
isBoss(W,W)

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

Intro to static components

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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();
}
```

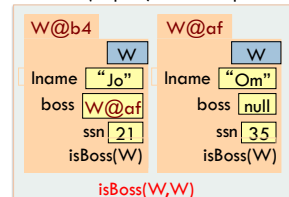~~x.isBoss(x, y)~~
~~y.isBoss(x, y)~~

Preferred:
W.isBoss(x, y)

x W@b4   y W@af

Box for W (objects, static components)

W@b4
| W |
lname "Jo"
boss W@af
ssn 21
isBoss(W)

W@af
| W |
lname "Om"
boss null
ssn 35
isBoss(W)

isBoss(W,W)

Good example of static methods

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- java.lang.Math

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

Java application

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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

Use of static variables: Maintain info about created objects

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```
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.

W@bd   W@12

W
Iname "Ob"

W
Iname "Bid"

numObs 2
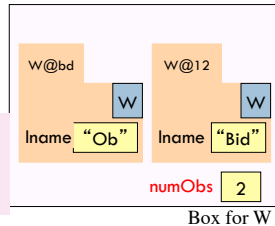
Box for W

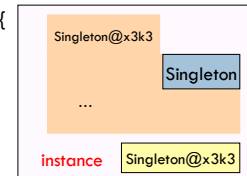### Uses of static variables: Implement the Singleton pattern

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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
}
```

Singleton@x3k3

Singleton
…

instance   Singleton@x3k3

Box for Singleton

Class java.awt.Color uses static variables

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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 = …;
…
```