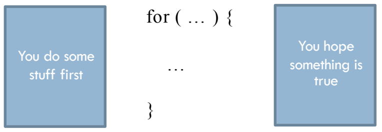
CS/ENGRD 2110
FALL2017

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

Announcements

- A0, HW1 due tonight
- Next week's recitation: loop invariants

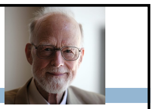

You do some stuff first

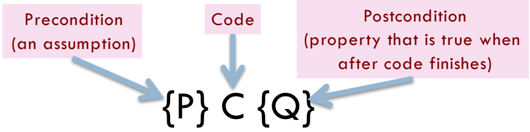
```
for ( … ) {
    …
}
```

You hope something is true

How do you know that your code is correct?

Hoare Triples




Precondition (an assumption)

Code

Postcondition (property that is true when after code finishes)

{P} C {Q}

$\{x = 5\}\ x = x + 1\ \{x \geq 5\}$

~~$\{x = 5\}\ x = x - 1\ \{x \geq 5\}$~~

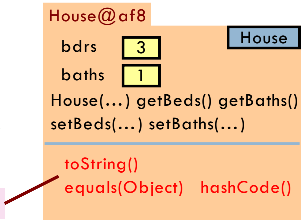
There are videos to watch before recitation. Watch them before your recitation.

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 contain data (L3)

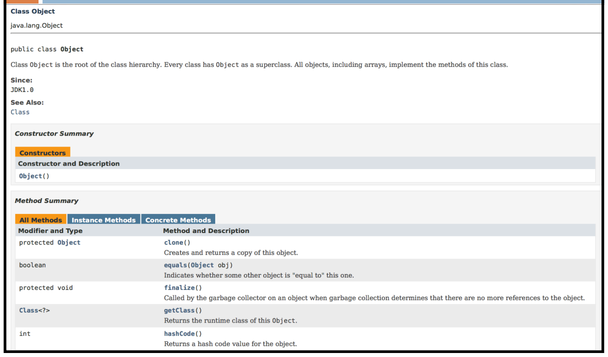
Class House

```
public class House {
    private int bdrs;    // number of bedrooms, >= 0.
    private int baths; // number of bathrooms, in 1..5

    /** Constructor: number of bedrooms b1, number of bathrooms b2
     *    Prec: b1 >= 0, 0 < b2 <= 5 */
    public House(int b1, int b2);

    /** Return number of bedrooms */
    public int getBeds() {
        return bdrs;
    }
    /** Return number of bathrooms */
    public int getBaths() {
        return baths;
    }
}
```



Contains other methods!

Class Object



Class Object

java.lang.Object

`public class Object`

Class `Object` is the root of the class hierarchy. Every class has `Object` as a superclass. All objects, including arrays, implement the methods of this class.

Since:
JDK1.0

See Also:
Class

Constructor Summary

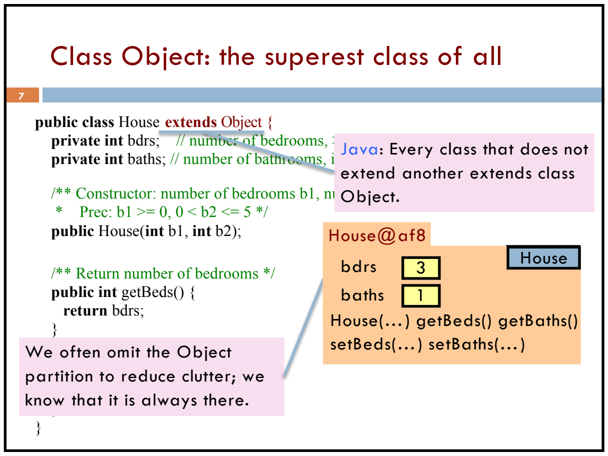
Constructors

Constructor and Description
`Object()`

Method Summary

All Methods | Instance Methods | Concrete Methods

Modifier and Type	Method and Description
`protected Object`	`clone()` Creates and returns a copy of this object.
`boolean`	`equals(Object obj)` Indicates whether some other object is "equal to" this one.
`protected void`	`finalize()` Called by the garbage collector on an object when garbage collection determines that there are no more references to the object.
`Class<?>`	`getClass()` Returns the runtime class of this `Object`.
`int`	`hashCode()` Returns a hash code value for the object.



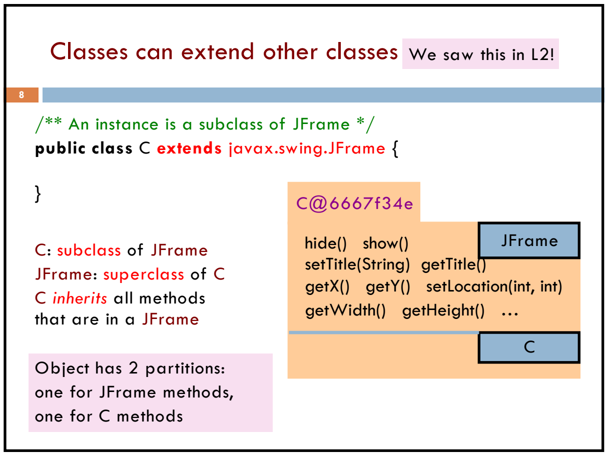
Class Object: the superest class of all

7

```
public class House extends Object {
   private int bdrs;    // number of bedrooms, >
   private int baths; // number of bathrooms, i

   /** Constructor: number of bedrooms b1, nu
    *    Prec: b1 >= 0, 0 < b2 <= 5 */
   public House(int b1, int b2);

   /** Return number of bedrooms */
   public int getBeds() {
     return bdrs;
   }
}
```

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

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



Classes can extend other classes

We saw this in L2!

8

```
/** An instance is a subclass of JFrame */
public class C extends javax.swing.JFrame {

}
```

C: subclass of JFrame
JFrame: superclass of C
C *inherits* all methods that are in a JFrame

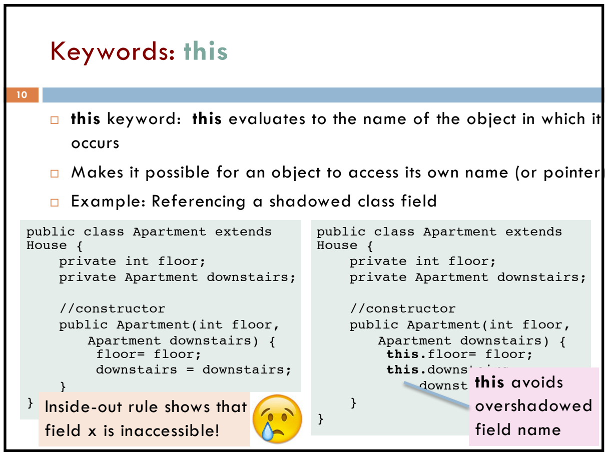
Object has 2 partitions: one for JFrame methods, one for C methods

C@6667f34e
JFrame
hide() show()
setTitle(String) getTitle()
getX() getY() setLocation(int, int)
getWidth() getHeight() …
C

Accessing superclass things

9

- Subclasses are different classes
  - Public fields and methods can be accessed
  - Private fields and methods cannot be accessed
  - Protected fields can be access by subclasses



Keywords: this

10

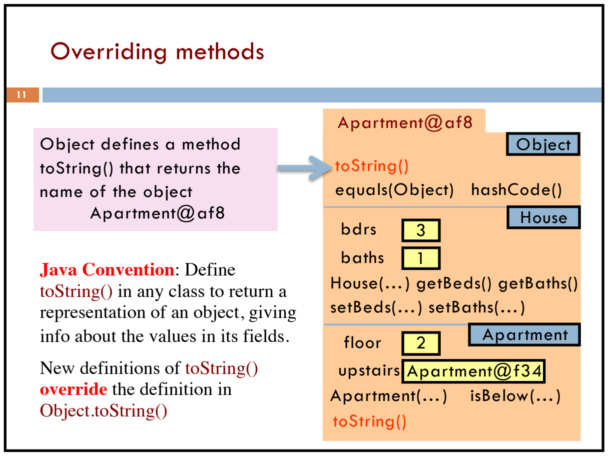
- **this** keyword: **this** evaluates to the name of the object in which it occurs
- Makes it possible for an object to access its own name (or pointer
- Example: Referencing a shadowed class field

```
public class Apartment extends
House {
    private int floor;
    private Apartment downstairs;

    //constructor
    public Apartment(int floor,
        Apartment downstairs) {
         floor= floor;
         downstairs = downstairs;
    }
}
```

Inside-out rule shows that field x is inaccessible!

```
public class Apartment extends
House {
    private int floor;
    private Apartment downstairs;

    //constructor
    public Apartment(int floor,
        Apartment downstairs) {
         this.floor= floor;
         this.downst
             downst
    }
}
```

this avoids overshadowed field name



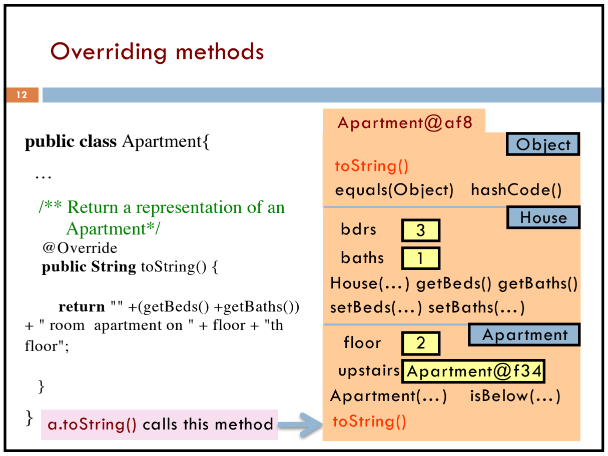
Overriding methods

11

Object defines a method toString() that returns the name of the object Apartment@af8

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()



Overriding methods

12

```
public class Apartment{
  …
   /** Return a representation of an
      Apartment*/
   @Override
   public String toString() {

      return "" +(getBeds() +getBaths())
+ " room apartment on " + floor + "th
floor";

   }
}
```

a.toString() calls this method

When should you make a subclass?

13

- 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
- Don't use **extends** just to get access to protected fields!

When should you make a subclass?

14

- Which of the following seem like reasonable designs?
  - A. Triangle extends Shape { … }
  - B. PHDTester extends PHD { … }
  - C. BankAccount extends CheckingAccount { … }

When should you make a subclass?

15

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

    CheckingAccount extends BankAccount { … }

Static Methods

16

- Most methods are instance methods: every instance of the class has a copy of the method
- There is only one copy of a static method. *There is not a copy in each object.*

You should make a method static if the body does not refer to any field or method in the object.

An Example

17

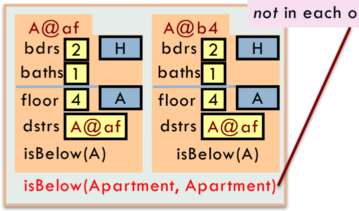
```
/** = "this object is below".
    Pre: a is not null. */
public boolean
isBelow(Apartment a){
    return this == a.downstairs;
}
```

```
/** = "a is below b".
    Pre: b and c are not null. */
public static boolean
isBelow(Apartment b, Apartment a){
    return b == a.downstairs;
}
```

Referencing a static method

18

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



Container for Apartment
contains: objects, static components

```
public static void main(String[] args) {
    Apartment.isBelow(a, b);
}
```

Good example of static methods

19

- java.lang.Math

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

- Or find it by googling

  Java 8 Math

Static Fields

20

- There is only one copy of a static method. *There is not a copy in each object.*
- There is only one copy of a static field. *There is not a copy in each object.*

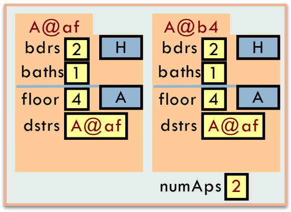
What are static fields good for?

Use of static variables: Maintain info about created objects

21

```
public class Apartment extends House {
  public static int numAps; // number of Apartments created
  /** Constructor:   */
  public Apartment(…) {
    …
    numAps=  numAps + 1;
  }
}
```

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



numAps stored in the Container for Apartment
To access: Apartment.numAps

Class java.awt.Color uses static variables

22

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:

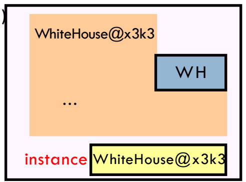
```
public static final Color black = …;
public static final Color blue = …;
public static final Color cyan = new Color(0, 255, 255);
public static final Color darkGray = …;
public static final Color gray = …;
public static final Color green = …;
…
```

Uses of static variables: Implement the singleton pattern

23

Only one WhiteHouse can ever exist.

```
public class WhiteHouse extends House{
  private static final WhiteHouse instance= new WhiteHouse();

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

  public static WhiteHouse getInstance() {
    return instance;
  }

  // ... methods
}
```



Box for WhiteHouse