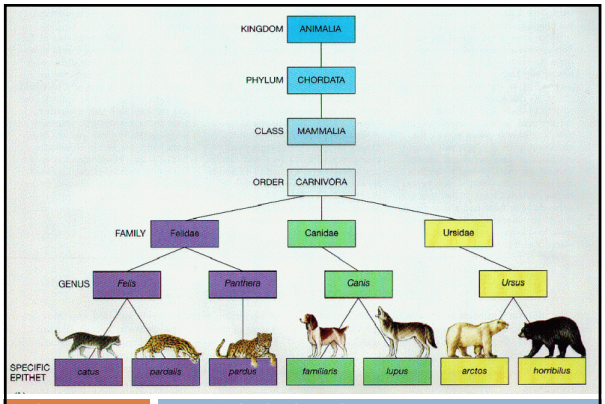

CS/ENGRD 2110 FALL 2018

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

Announcements

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- A1 Due Friday
- A2 Out Today

Where am I? Big ideas so far.

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- Java variables have *types* (L1)
  - A type is a set of values and operations on them (**int**: +, –, *, /, %, etc.)
- *Classes* define new types (L2) and define the contents of each object of the class.
  - *Methods* are the operations on objects of that class.
  - *Fields* allow objects to contain data (L3)

Class House

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

  /** Constructor:  bed is number of bedrooms,
    *                bath is number of bathrooms
    *   Prec:  bed >= 0, 0 < bath <= 5 */
  public House(int bed, int bath) {
      nBed= bed; nBath= bath;
  }
  /** Return no. of bedrooms */
  public int getNumBed() {
      return nBed;
  }
  ...
```

Contains other methods!

House@af8

House

nBed 3

nBath 1

House(…) getNumBed()
getNumBath() setNumBed(…)
setNumBath(…)
toString()
equals(Object) hashCode()

Class Object

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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

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```
public class House extends Object {
  private int nBed;   // number of bedrooms, >= 0.
  private int nBath; // number of bathrooms, in 1..5

  /** Constructor:  bed is number of bedrooms,
    *                bath is number of bathrooms
    *   Prec:  bed >= 0, 0 < bath <= 5 */
  public House(int bed, int bath) {
      nBed= bed; nBath= bath;
  }
  /** Return no. of bedrooms */
  public int getNumBed() {
      return nBed;
  }
  ...
}
```

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

House@af8

House

nBed 3

nBath 1

House(…) getNumBed()
getNumBath() setNumBed(…)

Class Object: the superest class of all

7

```
public class House extends Object {
  private int nBed;   // number of bedrooms, >= 0.
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  /** Constructor: bed is number of bedrooms,
   *               bath is number of bathrooms
   *  Prec: bed >= 0, 0 < bath <= 5 */
  public House(int bed, int bath) {
      nBed= bed; nBath= bath;
  }
  /** Return no. of bedrooms */
```

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

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

House@af8

House

nBed 3

nBath 1

House(…) getNumBed() getNumBath() setNumBed(…)

Class Object: the superest class of all

8

```
public class House extends Object {
  private int nBed;   // number of bedrooms, >= 0.
  private int nBath; // number of bathrooms, in 1..5

  /** Constructor: bed is number of bedrooms,
   *               bath is number of bathrooms
   *  Prec: bed >= 0, 0 < bath <= 5 */
  public House(int bed, int bath) {
      nBed= bed; nBath= bath;
  }
  /** Return no. of bedrooms */
```

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

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

House@af8

Object

toString() equals(Object) hashCode()

House

nBed 3

nBath 1

House(…) getNumBed() getNumBath() setNumBed(…)

Classes can extend other classes

We saw this in L2!

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```
/** 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 3 partitions:
for Object components,
for JFrame components,
for C components

C@6667f34e

Object

equals() toString() …

JFrame

hide() show()
setTitle(String) getTitle()
getWidth() getHeight() …
getX() getY() setLocation(int, int)

C

Classes can extend other classes

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- You also saw this in the tutorial for this week's recitation
- There are subclasses of Exception for different types of exceptions

NFE@2

Object

Throwable

Exception

NumberFormatException

Accessing superclass things

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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

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

  /** Constructor:   */
  public House(int nBed, int nBath) {
      nBed= nBed;
      nBath= nBath; // has no effect!
  }
}
```

Inside-out rule shows that field nBed is inaccessible! ☹

```
this.nBed= nBed;
this.nBath= nBath;
```

this avoids overshadowed field names

- **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

A Subclass Example

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```
public class House {
  private int nBed;   // num bedrooms, >= 0
  private int nBath; // num bathrooms, in 1..5

  /** Constructor:  bed is number of  bedrooms
    *    bath is number of bathrooms
    *    Prec:  bed >= 0, 0 < bath <= 5 */
  public House(int bed, int bath) {
        nBed= bed; nBath= bath;
  }
  public int getNumBed() {
        return nBed;
  }
  ...
```

```
public class Apt extends House {
 private int floor;
 private Apt downstairsApt;

 public Apt(int floor, Apt downstairs) {
      this. floor= floor;
      downstairsApt= downstairs;
  }
}
```

Overriding methods

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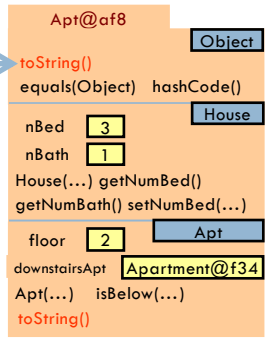
Object defines a method toString() that returns the name of the object Apt@af8

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

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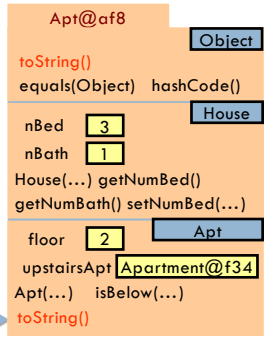
```
public class Apt{
  …
  /** Return a representation of an
      Apartment*/
  @Override
  public String toString() {
     return "" +
       (getNumBed() +  getNumBath()) +
       " room  apartment on " +
       floor + "th floor";

  }
}
```

a.toString() calls this method



When should you make a subclass?

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- 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?

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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?

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- 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

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- 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.*

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

An Example

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```
/** returns true if this object is below Apt a".
    Pre: a is not null. */
public Boolean isBelow(Apt a){
    return this == a.downstairsApt;
}

/** returns true if Apt b is below Apt a
    Pre: b and c are not null. */
public static boolean isBelow(Apt b, Apt a){
    return b == a.downstairsApt;
}
```

Referencing a static method

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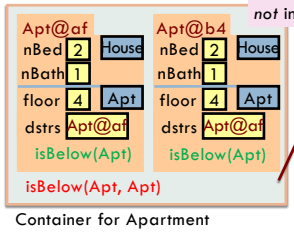
static: there is only one copy of the method. It is *not* in each object



Container for Apartment
contains: objects, static components

```
{   a= new Apt(...);
    b= new Apt(...);
    if (a.isBelow(b)) ...
    if (Apt.isBelow(a, b)) ...
}
```

Good example of static methods

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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

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- 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

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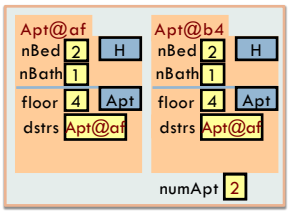
```
public class Apt extends House {
  public static int numApt; // number of Apartments created
  /** Constructor:  */
  public Apt(...) {
    ...
    numApt= numApt + 1;
  }
}
```



To have numApt 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.numApt

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= …;
…
```

Uses of static variables: Implement the singleton pattern

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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
}
```