CS1007: Object Oriented Design and Programming in Java

Lecture #18
Mar 28

Shlomo Hershkop
shlomo@cs.columbia.edu

Announcement

- Homework released
  - Start early
  - Test often
- Goal:
  - Waste time playing othello ☺
  - Learn to work with objects
  - Learn to use AI
  - Learn to implement graphics (java framework)

Homework hints

- Start early
- Work with your UML sketches
- Don't be afraid of updating/changes

- Focus:

Graphical displays

- If you are working on your local machine no need for this

- If you want to work on cunix you need to run a local xserver to display graphics on your end

1. Putty needs x tunneling turned on
2. Download and run xwin32 on your machine

Outline

- Hashing ..plenty of details
- Copying (again)
- Working with unknown objects ..reflection
- Generic Objects inner working

- Reading for today: 7.3-7.8
- For next time 7.8 - end

Quick question

- Given a set of dictionary word

- How would you build a spell checker ?

- Take a second to describe some pseudo code

- How fast does this run?

HashTable

- what is happening in the background of the following code:

```
ht.put("Sh553","Shlomo Hershkop");


if(ht.containsKey("sh553")){
  String info = ht.get("sh553");
}
```

- What is the difference between `contains` and `containsKey`??

Now we can begin to ask

- What is happening in our black box?
- What algorithm is being used?
- Is it the best/fastest or can we improve this.

Side issue

- When is it worth actually trying to improve your code?

Rule of improvement

- Informally:
- When we are trying to improve something, we can only improve it by the percentage of improved code contribution
- Example: if the improvement if used 10% of the time, say we improved by double the speed, it will only have a fractional effect on the whole system

Amdahl's Law

- Formally
- P = proportion which we are improving
- S = speedup
- Improvement = $$\frac{1}{(1-P)+\frac{P}{S}}$$
- So if you make 10% of your program 10 times faster….

- Rule 2: generally speaking 90% of the work is being done by 10% of the code
- What does that tell us?

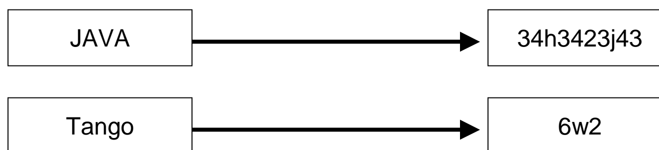
Hashing Components

- At the end of today's class you should be confident enough to know what these all mean….

- Hash function
- Hash table
- Collision
- Load

Hash function

- This is an algorithm for taking inputs and producing fixed value outputs



- Used on many different areas
  - Security
  - Error checking
  - Cryptography
  - Today's class

Hashing

- hashCode method used in HashMap, HashSet is the standard java hashing algorithm
- Computes some (hopefully unique) int from each object
- Rule: if two hashes are different then the input differs in some way

One way hashes

- Given some input we can compute Hash(input)
- Almost impossible to find:
  Hash(x) == Hash(y)
- Given the results of the Hash can’t compute the input, but given the input, can verify the hash

Example: MD5

- Message digest algorithm
- MD5("The quick brown fox jumps over the lazy **d**og") =
  - 9e107d9d372bb6826bd81d3542a419d6
- MD5("The quick brown fox jumps over the lazy **c**og") =
  - 1055d3e698d289f2af8663725127bd4b
- MD5(“”)
  - d41d8cd98f00b204e9800998ecf8427e

Algorithm

- Example: hash code of String

```
int h = 0;
for (int i = 0; i < s.length(); i++)
  { h = 31 * h + s.charAt(i);
  }
```

- Hash code of "eat" is 100184
- Hash code of "tea" is 114704

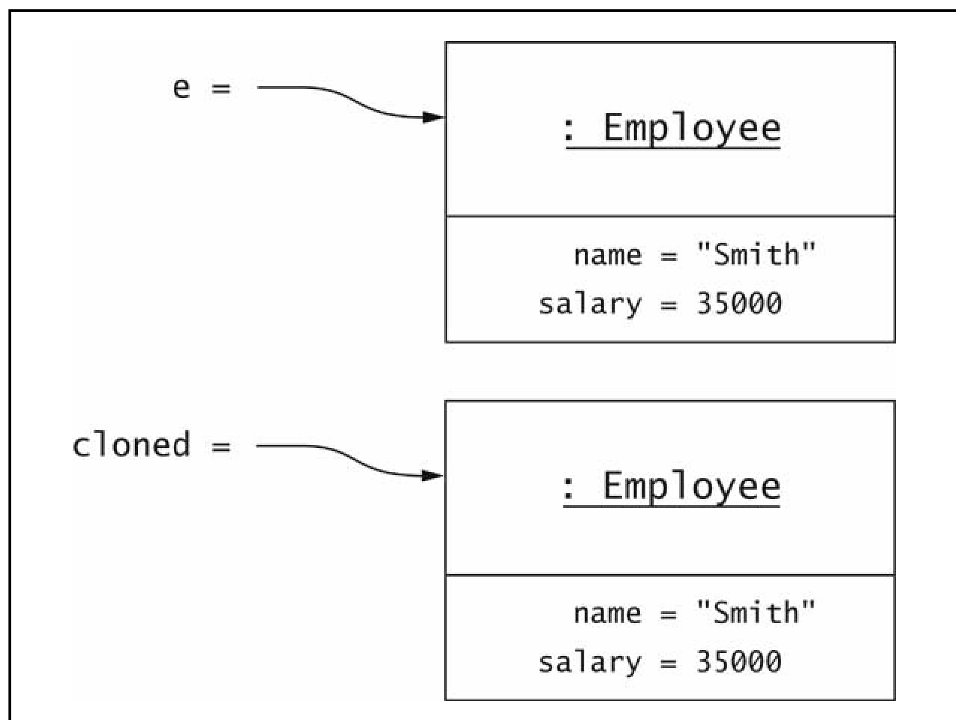
Hashing

- Whatever returned be compatible with equals:
- if x.equals(y), then has to x.hashCode() == y.hashCode()
- Object.hashCode hashes memory address
- NOT compatible with redefined equals
- Remedy: Hash all fields and combine codes:

```
public class Employee
{
   public int hashCode()
   {
      return name.hashCode()
         + new Double(salary).hashCode();
   }
   ...
}
```

Shallow vs. Deep Copy

- Assignment (copy = e) makes shallow copy
- Clone should be defined to make deep copy
- Employee cloned = (Employee)e.clone();



Cloning

- Object.clone makes new object and copies all fields
- Cloning is subtle
- Object.clone is protected
- Subclass must redefine clone to be public

```
public class Employee
{
   public Object clone()
   {
      return super.clone(); // not complete
   }
   ...
}
```

Cloneable Interface

- Object.clone is nervous about cloning
- Will only clone objects that implement Cloneable interface

```
public interface Cloneable
{
}
```

- Interface has no methods!
- Tagging interface--used in test

if x implements Cloneable

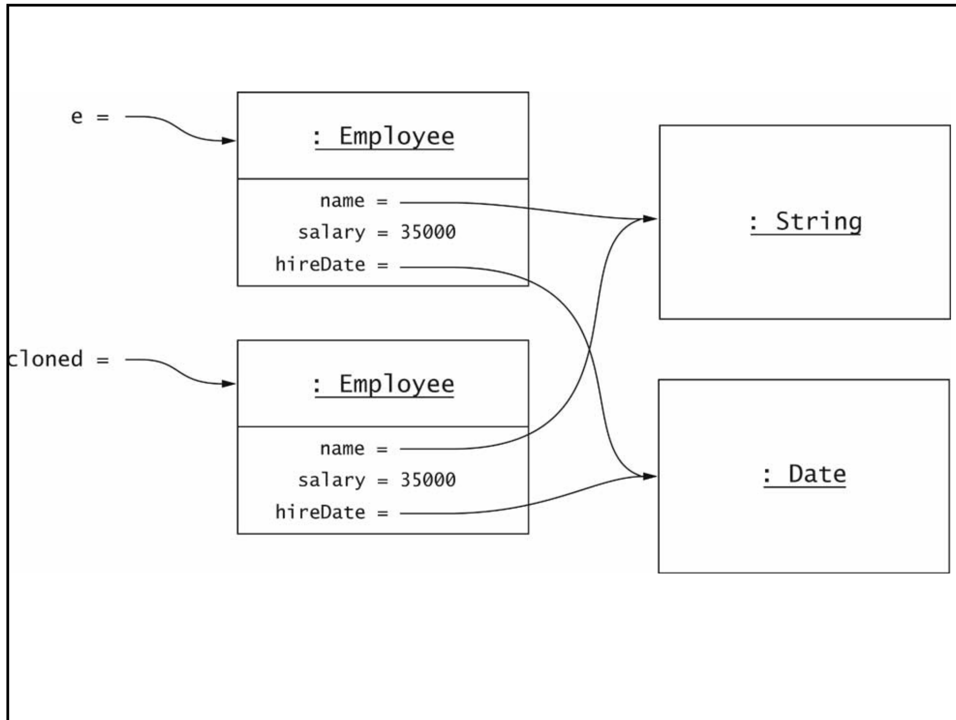
- Object.clone throws CloneNotSupportedException
- A checked exception!

clone

```
public class Employee
  implements Cloneable
{
   public Object clone()
   {
      try
      {
         return super.clone();
      }
      catch(CloneNotSupportedException e)
      {
         return null; // won't happen
      }
   }
   ...
}
```

default

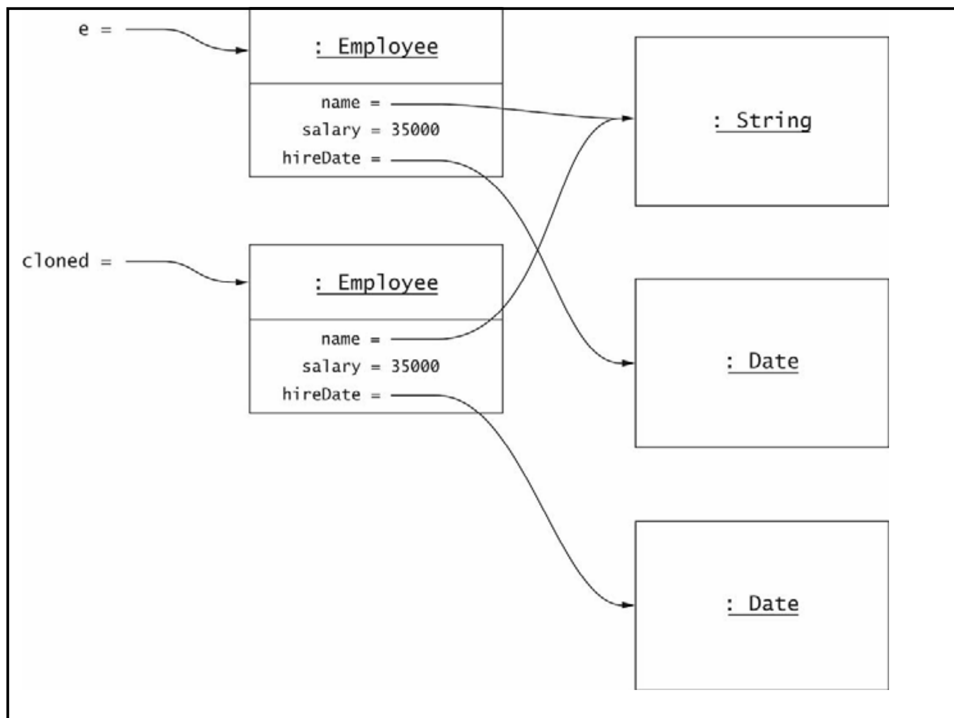
- By default the clone method is very lazy
- Shallow copy!!!
  - For immutable objects not a problem



- Why doesn't clone make a deep copy?
  - Wouldn't work for cyclic data structures
- Not a problem for immutable fields
- You must manually clone mutable fields

Deep cloning

```
public class Employee
  implements Cloneable
{
   public Object clone()
   {
      try
      {
         Employee cloned = (Employee)super.clone();
         cloned.hireDate = (Date)hiredate.clone();
         return cloned;
      }
      catch(CloneNotSupportedException e)
      {
         return null; // won't happen
      }
   }
   ...
}
```



Cloning and Inheritance

- Object.clone is paranoid
  - clone is protected
  - clone only clones Cloneable objects
  - clone throws checked exception
- You don't have that luxury
- Manager.clone must be defined if Manager adds mutable fields
- Rule of thumb: if you extend a class that defines clone, redefine clone
- Lesson to learn: Tagging interfaces are inherited. Use them only to tag properties that inherit

Objects

- So you understand…
- Object equals
- Object class objects
- Object clone

Working with the unknown

- Generally when you have Object from some class,
  - you wrote it yourself, so have doc/source
  - Using standard library, have docs
  - Unknown class, have no idea how to:
    - Instantiated
    - Construct
    - If you don't know how to use, probably not a good idea to use ☺

Reflection

- Ability of running program to find out about its objects and classes
- Class object reveals
  - superclass
  - interfaces
  - package
  - names and types of fields
  - names, parameter types, return types of methods
  - parameter types of constructors
- Great of dynamic operation

Who cares?

- Most languages don't have this
- Allows a program which is handling your stuff to display and access class properties
- Useful in visual environments

Reflection

- Class getSuperclass()
- Class[] getInterfaces()
- Package getPackage()
- Field[] getDeclaredFields()
- Constructor[] getDeclaredConstructors()
- Method[] getDeclaredMethods()

Enumerating Fields

- Print the names of all static fields of the Math class:

```
Field[] fields =
  Math.class.getDeclaredFields();
for (Field f : fields)
   if (Modifier.isStatic(f.getModifiers()))
      System.out.println(f.getName());
```

Enumerating Constructors

```
for (Constructor c : cons)
{
   Class[] params = cc.getParameterTypes();
   System.out.print("Rectangle(");
   boolean first = true;
   for (Class p : params)
   {
      if (first) first = false; else
  System.out.print(", ");
      System.out.print(p.getName());
   }
   System.out.println(")");
}
```

Output

```
Rectangle()
Rectangle(java.awt.Rectangle)
Rectangle(int, int, int, int)
Rectangle(int, int)
Rectangle(java.awt.Point,
  java.awt.Dimension)
Rectangle(java.awt.Point)
Rectangle(java.awt.Dimension)
```

Getting a single method descriptor

- Supply method name
- Supply array of parameter types
- Example: Get Rectangle.contains(int, int):

```
Method m =
  Rectangle.class.getDeclaredMethod(
    "contains", int.class, int.class);
```

- Example: Get default Rectangle constructor:

```
Constructor c =
  Rectangle.class.getDeclaredConstructor();
```

- getDeclaredMethod, getDeclaredConstructor are varargs methods

Invoking a Method

- Supply implicit parameter (null for static methods)
- Supply array of explicit parameter values
- Wrap primitive types
- Unwrap primitive return value
- Example: Call System.out.println("Hello, World") the hard way.

```
Method m =
  PrintStream.class.getDeclaredMethod(
   "println", String.class);
```

m.invoke(System.out, "Hello, World!");

- invoke is a varargs method

Inspecting Objects

- Can obtain object contents at runtime
- Useful for generic debugging tools
- Need to gain access to private fields

```
Class c = obj.getClass();
Field f = c.getDeclaredField(name);
f.setAccessible(true);
```

- Throws exception if security manager disallows access
- Access field value:

```
Object value = f.get(obj);
f.set(obj, value);
```

- Use wrappers for primitive types

Inspecting Objects

- Example: Peek inside string tokenizer

Ch7/code/reflect2/FieldTester.java

- Output

```
int currentPosition=0
int newPosition=-1
int maxPosition=13
java.lang.String str=Hello, World!
java.lang.String delimiters=,
boolean retDelims=false
boolean delimsChanged=false
char maxDelimChar=,
---
int currentPosition=5
. . .
```

Inspecting Array Elements

- Use static methods of Array class
- Object value = Array.get(a, i);

Array.set(a, i, value);

- int n = Array.getLength(a);
- Construct new array:

Object a = Array.newInstance(type, length);

Generics

- We've spoken about using generics with regards to objects
- How is the code organized?

Generic Types

- A generic type has one or more type variables
- Type variables are instantiated with class or interface types
- Cannot use primitive types, e.g. no ArrayList<int>
- When defining generic classes, use type variables in definition:

```
public class ArrayList<E>
{
   public E get(int i) { . . . }
   public E set(int i, E newValue) { . . . }
   . . .
   private E[] elementData;
}
```

Quick question ?

- If S a subtype of T,
- Why is ArrayList<S> not a subtype of ArrayList<T>

- Generic method = method with type parameter(s)

```
public class Utils
{
   public static <E> void fill(ArrayList<E> a, E
  value, int count)
   {
      for (int i = 0; i < count; i++)
         a.add(value);
   }
}
```

- A generic method in an ordinary (non-generic) class
- Type parameters are inferred in call

```
ArrayList<String> ids = new ArrayList<String>();
Utils.fill(ids, "default", 10); // calls
  Utils.<String>fill
```

Generic types

- Advantages?
- Disadvantages?

Type Bounds

- Type variables can be constrained with type bounds
- Constraints can make a method more useful
- The following method is limited:

```
public static <E> void append(ArrayList<E> a,
  ArrayList<E> b, int count)
{
   for (int i = 0; i < count && i < b.size(); i++)
      a.add(b.get(i));
}
```

- Cannot append an ArrayList<Rectangle> to an ArrayList<Shape>

Type Bounds

- Overcome limitation with type bound:

```
public static <E, F extends E> void append(
   ArrayList<E> a, ArrayList<F> b, int count)
{
   for (int i = 0; i < count && i < b.size(); i++)
      a.add(b.get(i));
}
```

- extends means "subtype", i.e. extends or implements
- Can specify multiple bounds:

E extends Cloneable & Serializable

Wildcards

- Definition of append never uses type F. Can simplify with wildcard:

```
public static <E> void append(
   ArrayList<E> a, ArrayList<? extends E> b, int
  count)
{
   for (int i = 0; i < count && i < b.size(); i++)
      a.add(b.get(i));
}
```