Singleton

Lecture 29

Preventing Instantiation

- Default (zero-argument) constructor
  - Provided *only* if there is no explicit constructor
- Declare a single explicit *private* constructor
  - Result: No other class can instantiate
  - Note: including constructor prevents construction!
  - Document the private constructor
- Side effect: Class can not be extended
  - Subclass must call parent's constructor
  - So, parent's constructor must be visible
- Use: Utility classes
  - Collection of static members
  - See java.lang.Math, java.util.Arrays
  - Beware: easily abused to write procedural code

Example: Non-instantiability

```
//Non-instantiable utility class
public class UtilityClass {

  //Suppress default constructor
  private UtilityClass() {
    //Constructor never invoked
  }

  . . . //other parts of class
}
```

Singleton Pattern

- A singleton is a class that is instantiated exactly once
  - eg Window manager, file system
- Basic recipe
  - Private constructor
  - (One) instance reference in private field
  - Static factory method
- Optimization: Lazy initialization
  - Instantiate only if requested

Example Singleton

```
//Singleton with static factory
public class Manager {
  private static final Manager INSTANCE =
                                  new Manager();

  //suppress default constructor
  private Manager() {
    . . .
  }

  public static Manager getInstance() {
    return INSTANCE;
  }

  . . . //other parts of class
}
```

Example Lazy Singleton

```
//Singleton with static factory and lazy init
public class Manager {
  private static Manager INSTANCE; //default is null

  //suppress default constructor
  private Manager() {
    . . .
  }

  public synchronized static Manager getInstance() {
    if (INSTANCE == null) {
      INSTANCE = new Manager();
    }
    return INSTANCE;
  }

  . . . //other parts of class
}
```

Many Subtle Problems

- Multiple threads
  - Static factory must be synchronized
- Multiple classloaders
  - Each classloader has a different instance
- Serialization
  - Saving singleton to disk then re-reading results in new instance

Potpourri: Memory Leaks and Random

Memory Management

- Java (generally) manages memory for you
- Every call to "new" creates a new instance
  - Memory allocated to hold instance
- When is this memory released?
  - Answer: when there are no references to this instance
  - eg End of scope

```
void someMethod() {
  someClass x = new someClass();
  . . .
} //x goes out of scope
```

  - (Beware of aliases of course)

Example "Memory Leak"


```
public class Stack {
  private Object[] elements;
  private int size = 0;

  public Stack (int initialCapacity) {
    elements = new Object[initialCapacity];
  }

  public void push (Object e) {
    ensureCapacity();
    elements[size++] = e;
  }

  public Object pop () {
    if (size == 0)
      throw new EmptyStackException();
    return elements[--size];
  }
```

Example Continued


```
//class Stack continued...

  private void ensureCapacity() {
    if (elements.length == size) {
      Object[] oldElements = elements;
      elements = new Object[2*elements.length + 1];
      System.arraycopy(oldElements, 0,
                       elements, 0, size);
    }
  }
}
```

Example Repaired


```
public Object pop() {
  if (size == 0)
    throw new EmptyStackException();
  Object result = elements[--size];
  elements[size] = null;
  return result;
}
```

Memory Leak: Problem and Solution

- Problem: Keeping obsolete references
  - Stack has array of reference that will *never* be dereferenced
- Solution: explicitly null-out reference

```
someReference = null;
```

- But, do *not* do this needlessly
  - Clumsy and complicates code
- When is it needed?
  - Classes that manage their own memory
  - Classes that keep caches
    - WeakHashMap discards entries when key no longer accessible

Know The Libraries: Random

- Generating uniform random [0..bound)

```
import java.util.Random;
Random rnd = new Random(); //time seed
int x = rnd.nextInt(bound);
```

- Do *not* scale using 0-argument version

```
int x = Math.abs(rnd.nextInt()) % bound;
```

  - Problems
    - No abs for Integer.MIN_VALUE
    - Short repetition period for bounds small power of 2
    - Uneven distribution for some bounds

To Ponder


```
static Random rnd = new Random();

static int random(int n) {
  return Math.abs(rnd.nextInt()) % n;
}

public static void main(String args[]) {
  int b = 2 * (Integer.MAX_VALUE / 3);
  int low = 0;
  for (int i=0; i < 1000000; i++)
    if (random(b) < b/2)
      low++;

  System.out.println(low);  //prints ~666,666
}
```

Summary

- Singleton
  - Instantiated at most once
  - Private constructor ensures no default constructor
  - Static factory returns existing reference
  - Lazy initialization defers instantiation
- Memory Leaks
  - Problem: indefinitely retaining obsolete reference
  - Solution: explicit null-out (only when necessary!)
- Random
  - Use 1-argument (bounded) nextInt method