Midterm #1 Answers

CMSC 433
Programming Language Technologies and Paradigms
Fall 2006

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1. (24 pt, Short answer)

   (a) What is the information hiding principle?
   Answer: Identify design decisions that are likely to change and isolate each one in a module.

   (b) Why use information hiding?
   Answer: Ease of change.

   (c) Say you have a class whose data members are all private. Is this enough to ensure that the design decision hidden in this module remains hidden? If it is, explain why; if not, write a few lines of Java showing how information hiding can still be violated.
   Answer: No.

```
/* Hides the decision of where data is stored: file, database, web... */
class DataStore {
private File dataFile ;
public void writeObject(Object o) {...}
// Reveals that this DataStore is actually using a file
public File getFile() { return dataFile ; }
public void setFile(File dataFile) { this.dataFile = dataFile ; }
}
```

   (d) Say you have some base classes that are likely to change and want to avoid the fragile base class problem. What are two alternatives to inheritance that you can use? (One word each)
   Answer: Interfaces and composition

   (e) What is the principle of low coupling and how does it facilitate ease of change?
   Answer: Each module should interact with as few other modules as possible. This facilitates change by minimizing the the number of client modules that have to change when a module is changed.

   (f) Good or bad pair programming practice? Discuss. While the driver is implementing a class, the navigator is writing down test cases for the class.
   Answer: Bad: The driver and navigator should always be working on the same task as a pair.

2. (19 pts) List the line numbers of all violations of the Law of Demeter in the following code.

```
 1  public class MainFrame extends JFrame
 2  {
 3    private static final String appName    = "MainFrame" ;
 4    private static final String appVer    = "0.6" ;
 5    private Color        bgColor    = Color.black ;
 6    private boolean        fullScreen  = false ;
 7    private Dimension      screenSize ;
 8
 9    /* Make a new Frame with an ImageCollage as the content pane */
10    MainFrame(ImageCollage collage)
11    {
12      // Set the initial window size, title, background color, close on exit
13      setTitle(appName) ;
14      setDefaultCloseOperation(EXIT_ON_CLOSE) ;
15      setBackground(bgColor) ;
16      Toolkit toolkit = Toolkit.getDefaultToolkit() ;
17      screenSize = toolkit.getScreenSize() ;        // Get (primary) screen resolution
18      setSize(screenSize) ;
19      toolkit.setDynamicLayout(true) ;          // Tell Swing to update the window as it is being resized
20      Image icon = toolkit.getImage("icon.gif") ;
21      setIconImage(icon) ;
22      collage.setCanvasSize(screenSize) ;
23      collage.setBackgroundColor(bgColor) ;
24      collage.clearCanvas() ;
25      setContentPane(collage) ;
26      boolean fullScreen = GraphicsEnvironment.getLocalGraphicsEnvironment()
27                              .getDefaultScreenDevice().isFullScreenSupported() ;
28      Debug.d("Screen size " + (int) screenSize.getWidth() + "x" + (int) screenSize.getHeight()
29        + ", full screen " + (fullScreen ? "" : "not ") + "supported.") ;
30    }
31   }
```

Answer: 17, 19, 20, 26/27

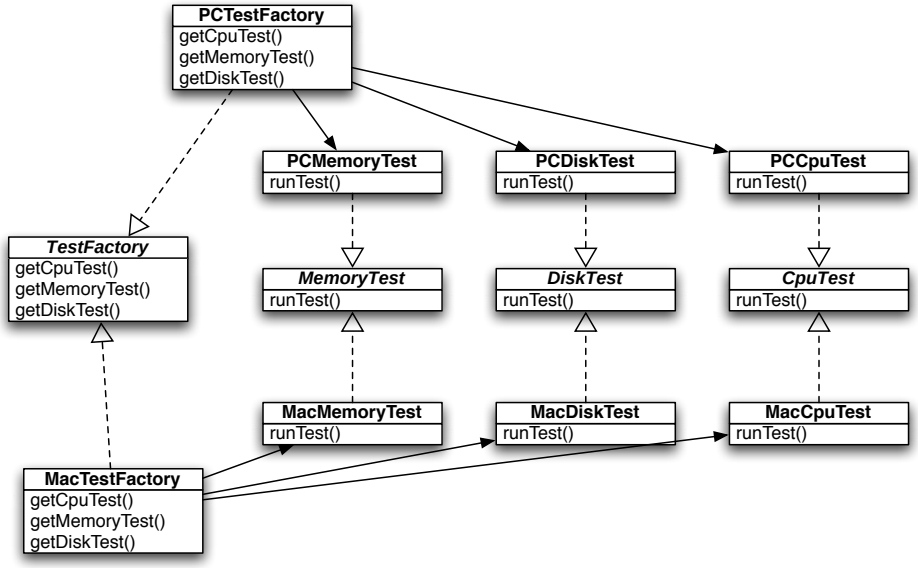
3. (19 pt) Design pattern

(a) You are writing a diagnostic utility to test the various components of a computer system to ensure that they will work with your big, expensive enterprise application. You want to write one class for each computer component you diagnose: CPUTest, MemoryTest, and DiskTest. However, your utility needs to be cross-platform, and each class contains some platform-specific code. So for each type of test, you will have several implementations, one for each platform: PCMemoryTest, MacMemoryTest, LinuxMemoryTest, etc. You'd like your diagnostic utility to create and use the right test classes for the platform its running on, without having to change a lot of code each time you add a new platform. You recall that there is a design pattern to solve this problem. What design pattern would you use?

Answer: Abstract Factory Pattern

(b) Draw a UML class diagram showing the relationships among participants in your design pattern. Include the three types of tests above, for two platforms: PC and Mac.

Answer:



4. (19 pt) Visitor / Double dispatch

(a) You have an interface A, implemented by classes B and C and an interface X, implemented by classes Y and Z.

Define a method Test.doubleDispatch

```
class Test {
        static void doubleDispatch(A a, X x) { ... }
        }
```

Use the visitor or double dispatch design pattern to use dynamic dispatch so that a method chosen to be executed based on the runtime type of `a` and `x`. In other words, there should be one method that is selected if `a` is a `B` and `x` is a `Y`, another method selected if `a` is a `B` and `x` is a `Z`, and so on. You may not use `instanceof` or any conditional expressions; instead, use the visitor pattern or double dispatch to achieve this. You may add any methods you need to add to the interfaces and classes. Label the methods that select for each combination of runtime types (e.g., label one method as the `BY` method). Use space on the following page if needed.

Answer:

```
interface A {
  void accept(X x);
  ...
  }
class B implements A {
  public void accept(X x) { x.visit(this); }
  ...
  }
class C implements A {
  public void accept(X x) { x.visit(this); }
  ...
  }
interface X {
  void visit(B b);
  void visit(C c);
  ...
  }
class Y implements X {
  void visit(B b) { /* BY method */ };
  void visit(C c) { /* CY method */ };
  ...
  }
class Z implements X {
  void visit(B b) { /* BZ method */ };
  void visit(C c) { /* CZ method */ };
  ...
  }

class C implements A {
  void accept(X x) { x.visit(this); }
  ...
  }
class Test {
        static void doubleDispatch(A a, X x) { a.accept(x); }
        }
```

(b) Given the implementation you chose, what would be easier: adding an additional class that implemented `A`, or an additional class that implemented `X` (in either case, the code would now

need to select one of six different methods, depending upon the runtime type of `a` and `x`).

Answer: Adding another class implementing X would be easier, no existing classes would need to be touched.

5. (19 pts) Iterator pattern

The `3n+1` problem is a simple but open problem in computer science. [1] Given the following method, a sample call to threeNPlusOne(22) will print the sequence 22 11 34 17 52 26 13 40 20 10 5 16 8 4 2 1.

```
void threeNPlusOne(int n) {
   while (true) {
     System.out.println(n);
     if (n == 1) return;
     if (n%2 == 0) n = n/2;
     else n = 3*n+1;
   }
}
```

Your job is to define a method:

```
Iterator<Integer> threeNPlusOneIterator(int n) {...}
```

that returns an iterator over integer values.

Answer:

```
static Iterator<Integer> threeNPlusOneIterator(final int n) {
  return new Iterator<Integer>() {
    int nextValue = n;
    boolean done = false;

    public boolean hasNext() {
      return !done;
    }

    public Integer next() {
      int result = nextValue;
      if (nextValue == 1) done = true;
      else if (nextValue % 2 == 0) nextValue /= 2;
      else nextValue = 3 * nextValue + 1;
      return result;
    }

    public void remove() {
      throw new UnsupportedOperationException("Remove not supported");
    }
  };

}
```

[1] It is believed that this sequence will terminate for any positive integer n, but that conjecture is unproven (fame if not fortune to the first person who proves it). It is known to terminate for all positive integer values that can be represented with a `int`. To win the fame, you need to prove that it terminates for all positive integer values.