CS61B Lecture #10: OOP Mechanisms and Class Design

Review: A Puzzle

```
class A {                              class B extends A {
  void f() {                             void f() {
      System.out.println("A.f");             System.out.println("B.f");
  }                                      }
  void g() { f(); /* or this.f()  */ }
}                                      }
```

```
class C {
    static void main(String[] args) {
        B aB = new B();
        h(aB);
    }

    static void h(A x) { x.g(); }
}
```

1. What is printed?   **Choices**
2. If we made g static?   a. A.f
3. If we made f static?   b. B.f
4. If we overrode g in B?   c. Some kind of error
5. If f not defined in A?

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class B extends A {
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  }
}
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class C {
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    static void main(String[] args) {
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    }

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legal here
```java
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1. What is printed?   **Choices**
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3. If we made `f` static?   b. `B.f`
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  }                                      }
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}                                      }
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                            B aB = new B();
                            h(aB);
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  void g() { f(); /* or this.f()  */ }
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```java
class B extends A {
    static void f() {
        System.out.println("B.f");
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```java
class C {
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  void g() { f(); /* or this.f()  */ }   void g() { f(); }
}                                      }
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Review: A Puzzle

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}                                              }
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b. B.f

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Review: A Puzzle

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class A {

  void g() { f(); /* or this.f()  */ }
}
```

```
class B extends A {
  void f() {
    System.out.println("B.f");
  }


}
```

```
class C {
    static void main(String[] args) {
        B aB = new B();
        h(aB);
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    static void h(A x) { x.g(); }
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Review: A Puzzle

```java
class A {

  void g() { f(); /* or this.f()  */ }
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class B extends A {
  void f() {
     System.out.println("B.f");
  }


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class C {
    static void main(String[] args) {
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1. What is printed?
2. If we made g static?
3. If we made f static?
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5. If f not defined in A?

Choices

a. A.f
b. B.f
c. Some kind of error

Answer to Puzzle

1. Executing `java C` prints _____, because

   A. `C.main` calls `h` and passes it `aB`, whose dynamic type is `B`.

   B. `h` calls `x.g()`. Since `g` is inherited by `B`, we execute the code for `g` in class `A`.

   C. `g` calls `this.f()`. Now `this` contains the value of `h`'s argument, whose dynamic type is `B`. Therefore, we execute the definition of `f` that is in `B`.

   D. In calls to `f`, in other words, static type is ignored in figuring out what method to call.

2. If `g` were static, we see _____; selection of `f` still depends on dynamic type of `this`. Same for overriding `g` in `B`.

3. If `f` were static, would print _____ because then selection of `f` would depend on static type of `this`, which is `A`.

4. If `f` were not defined in `A`, we'd see _____

Answer to Puzzle

1. Executing `java C` prints <u>B.f</u>, because

   A. `C.main` calls `h` and passes it `aB`, whose dynamic type is `B`.

   B. `h` calls `x.g()`. Since `g` is inherited by `B`, we execute the code for `g` in class `A`.

   C. `g` calls `this.f()`. Now `this` contains the value of `h`'s argument, whose dynamic type is `B`. Therefore, we execute the definition of `f` that is in `B`.

   D. In calls to `f`, in other words, static type is ignored in figuring out what method to call.

2. If `g` were static, we see <u>B.f</u>; selection of `f` still depends on dynamic type of `this`. Same for overriding `g` in `B`.

3. If `f` were static, would print <u>A.f</u> because then selection of `f` would depend on static type of `this`, which is `A`.

4. If `f` were not defined in `A`, we'd see <u>a compile-time error</u>

Example: Designing a Class

Problem: Want a class that represents histograms, like this one:


```
0.0-0.2    0.2-0.4    0.4-0.6    0.6-0.8    0.8-1.0
```
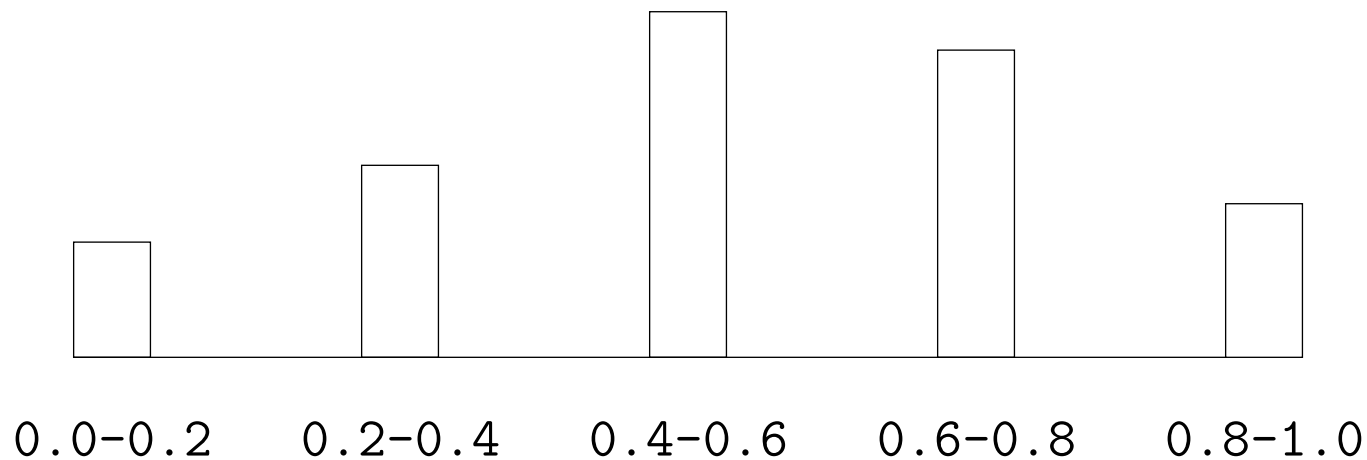
Analysis: What do we need from it? At least:

- Specify buckets and limits.

- Accumulate counts of values.

- Retrieve counts of values.

- Retrieve numbers of buckets and other initial parameters.

Specification Seen by Clients

- The *clients* of a module (class, program, etc.) are the programs or methods that *use* that module's exported definitions.

- In Java, intention is that exported definitions are designated **public**.

- Clients are intended to rely on *specifications,* (aka APIs) not code.

- *Syntactic specification:* method and constructor headers—syntax needed to use.

- *Semantic specification:* what they do. No formal notation, so use comments.

  - Semantic specification is a *contract.*

  - Conditions client must satisfy (*preconditions*, marked "Pre:" in examples below).

  - Promised results (*postconditions*).

  - Design these to be *all the client needs!*

  - Exceptions communicate errors, specifically failure to meet pre-conditions.

Histogram Specification and Use

```java
/** A histogram of floating-point values */
public interface Histogram {
  /** The number of buckets in THIS. */
  int size();

  /** Lower bound of bucket #K. Pre: 0<=K<size(). */
  double low(int k);

  /** # of values in bucket #K. Pre: 0<=K<size(). */
  int count(int k);

  /** Add VAL to the histogram. */
  void add(double val);
}
```

Sample output:

```
>=  0.00 |   10
>= 10.25 |   80
>= 20.50 |  120
>= 30.75 |   50
```

```java
void fillHistogram(Histogram H,
                   Scanner in)
{
    while (in.hasNextDouble())
      H.add(in.nextDouble());

}
```

```java
void printHistogram(Histogram H) {
    for (int i = 0; i < H.size(); i += 1)
       System.out.printf
          (">=%5.2f | %4d%n",
             H.low(i), H.count(i));
}
```

An Implementation

```java
public class FixedHistogram implements Histogram {
  private double _low, _high; /* From constructor*/
  private int[] _count; /* Value counts */

  /** A new histogram with SIZE buckets of values >= LOW and < HIGH. */
  public FixedHistogram(int size, double low, double high)
  {
    if (low >= high || size <= 0) throw new IllegalArgumentException();
    _low = low; _high = high;
    _count = new int[size];
  }

  public int size() { return _count.length; }
  public double low(int k) { return _low + k*(_high-_low)/_count.length; }

  public int count(int k) { return _count[k]; }

  public void add(double val) {
    if (val >= _low && val < _high)
      count[(int) ((val-_low)/(_high-_low) * _count.length)] += 1;
  }
}
```

Let's Make a Tiny Change

Don't require *a priori* **bounds:**

```
class FlexHistogram implements Histogram {
  /** A new histogram with SIZE buckets. */
  public FlexHistogram(int size) {
     ?
  }
  // What needs to change?
}
```

- How would you do this? Profoundly changes implementation.

- But *clients* (like `printHistogram` and `fillHistogram`) still work with no changes.

- Illustrates the power of *separation of concerns*.

Implementing the Tiny Change

- Pointless to pre-allocate the _count array.

- Don't know bounds, so must save arguments to add.

- Then recompute _count array "lazily" when _count(···) called.

- Invalidate _count array whenever histogram changes.

```java
class FlexHistogram implements Histogram {
    private ArrayList<Double> _values = new ArrayList<>();
    int _size;
    private int[] _count;

    public FlexHistogram(int size) { _size = size; _count = null;  }

    public void add(double x) { _count = null; _values.add(x); }

    public int count(int k) {
        if (_count == null) { compute _count from _values here.  }
        return _count[k];
    }
}
```

Advantages of Procedural Interface over Visible Fields

By using public method for `count` instead of making the array `_count` visible, the "tiny change" is transparent to clients:

- If client had to write `myHist._count[k]`, it would mean

    "The number of items currently in the kth bucket of histogram `myHist` (which, by the way, is stored in an array called `_count` in `myHist` that always holds the up-to-date count)."

- Parenthetical comment *worse than useless* to the client.

- If `_count` array had been visible, after "tiny change," *every use* of `count` in client program would have to change.

- So using a method for the public `count` method decreases what client *has to* know, and (therefore) has to change.