Review: A Puzzle

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   Choices
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   b. B.f
   c. Some kind of error

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3. If we made f static?
4. If we overrode g in B?
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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 `B.f`, 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 `B.f`; selection of `f` still depends on dynamic type of `this`. Same for overriding `g` in `B`.

3. If `f` were static, would print `A.f` 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 a compile-time error
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

/** 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);
}

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

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));
}

Sample output:
>= 0.00 | 10
>= 10.25 | 80
>= 20.50 | 120
>= 30.75 | 50
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:

```java
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 int size() { return _size; }

    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 \(k\)\(^{th}\) 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.