CS61B Lecture #10: OOP mechanism and Class Design

Review: A Puzzle

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

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

  static void h(A x) { x.g(); }
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1. What is printed?
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3. If we made f static?
4. If we overrode g in B?
5. If f not defined in A?

Choices

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

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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 <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.

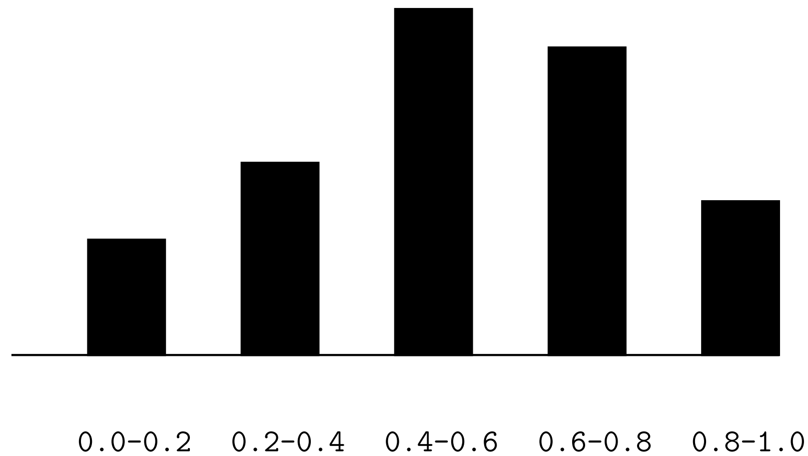
2. If `g` were static, we see <u>`B.f`</u>; selection of `f` still depends on dynamic type of `this`. Same for overriding `g` in `B`.

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:



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 preconditions.

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);
}
```

Sample output:

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

```
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));
}
```

An Implementation

```
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();
    this.low = low; this.high = high;
    this.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.

```
class FlexHistogram implements Histogram {
   private ArrayList<Double> values = new ArrayList<>();
   int size;
   private int[] count;

   public FlexHistogram(int size) { this.size = size; this.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 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.