CS61B Lecture #10: OOP Mechanisms and Class Design

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Review: A Puzzle

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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}

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

1. What is printed?
2. If we made g static?
3. If we made f static?
4. If we overrode g in B?
5. If f not defined in A?

Choices

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b. B.f
c. Some kind of error
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    } // x.g(x) also legal here
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2. If we made `g` static?

3. If we made `f` static?

4. If we overrode `g` in `B`?

5. If `f` not defined in `A`?
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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 _____
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:

![Histogram Example](image)

**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.
/** 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));
}
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.