

CS61B Lecture #10: OOP mechanism and Class Design

Review: A Puzzle

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

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

Review: A Puzzle

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

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

Review: A Puzzle

```
class A {  
    void f() {  
        System.out.println("A.f");  
    }  
    static void g(A y) { y.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);  
    }  
}
```

```
static void h(A x) { A.g(x); } // x.g(x) also legal here  
}
```

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

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

Review: A Puzzle

```
class A {  
    void f() {  
        System.out.println("A.f");  
    }  
    static void g(A y) { y.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);  
    }  
}
```

```
    static void h(A x) { A.g(x); } // x.g(x) also legal here  
}
```

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

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

Review: A Puzzle

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

```
class B extends A {  
    static void f() {  
        System.out.println("B.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?
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

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

Review: A Puzzle

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

```
class B extends A {  
    static void f() {  
        System.out.println("B.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?
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

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

Review: A Puzzle

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

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

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

Review: A Puzzle

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

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

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

Review: A Puzzle

```
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);  
    }  
  
    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

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

Review: A Puzzle

```
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);  
    }  
  
    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

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

Answer to Puzzle

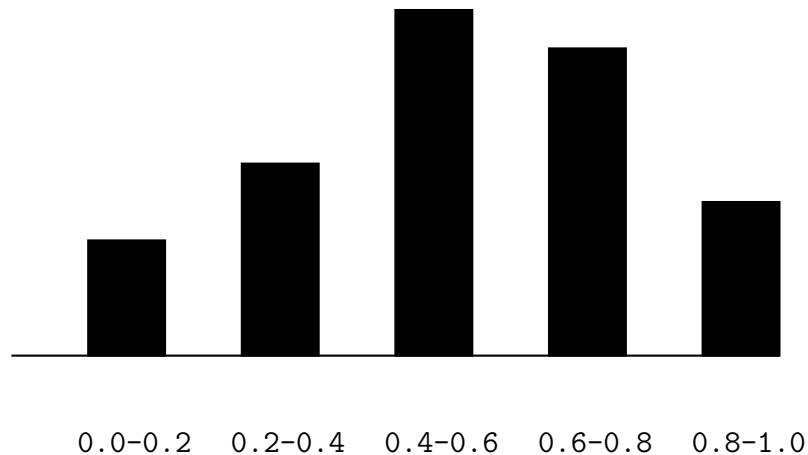
1. Executing `java C` prints _____, because
 - A. `C.main` calls `h` and passes it `aB`, whose dynamic type is `B`.
 - B. `h` calls `x.g()`. Since `g` is inherited by `B`, we execute the code for `g` in class `A`.
 - C. `g` calls `this.f()`. Now `this` contains the value of `h`'s argument, whose dynamic type is `B`. Therefore, we execute the definition of `f` that is in `B`.
 - D. `h` 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:



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);
}
```

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]`, would mean
“The number of items currently in the k^{th} bucket of histogram `myHist` (and by the way, there is an array called `count` in `myHist` that always holds the up-to-date count).”
- Parenthetical comment *useless* to the client.
- But 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` decreases what client has to know, and (therefore) has to change.