Announcements

- Lab 1 due by Wednesday 8pm.
- Try to have a functional Stars repl/cli this weekend.
- Lab 2 is on HTML. Then you can work on UI and details.
Effective CS32

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/course/cs0320/www/lectures/

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Help on getting help

- Never say “I tried to do X, but it doesn’t work.”
- Report *exactly* how it didn’t work. For example:
  - It didn’t compile.
  - It compiled and ran, but threw an exception.
  - It ran, but I got a different answer than I expected.

- In all cases, describe exactly what you did, and include details of the most pertinent error. The compile error, the exception message and stacktrace, or the results.

- Prefer cut-n-paste to screenshot.
- But *read* them first!
- Report on things you tried to fix it. That prevents fruitless speculation.

A clear problem report is halfway to a solution. (And easier to search for, from other students.)
This lecture may be review, or it may not.

It is not intended to be about Java, *per se*.

But you should speak up if I show *anything* you don’t understand.

Today we’ll look at some simple rules for method, class, and package design.

“Effective Java” by Joshua Bloch goes into all of this and more.
- I don’t require a textbook, but you could certainly treat this as one.
  It’s great.
- 3rd edition just came out. I’m inordinately excited.
Effective Java has 90 guidelines

Here’s a top 10 list we’ll discuss today

1. Check parameters for validity
2. Make defensive copies when needed.
3. Minimize the accessibility of classes and methods.
4. Don’t use raw types
5. Prefer lists to arrays
6. Return empty collections or arrays, not nulls.
7. Minimize the scope of local variables.
8. Know and use the libraries.
9. Always override toString()
10. Adhere to generally accepted naming conventions
There’s plenty of depth to the advice

Here’s a preview of 10 more, I’ll be pushing throughout the term.

1. Consider static factory methods instead of constructors.
2. Consider a builder
3. Avoid strings where other types are more appropriate
4. Minimize mutability
5. Favor composition over inheritance.
6. Prefer interfaces to abstract classes.
7. Favor generic types
8. Consistently use the Override annotation
9. Refer to objects by their interfaces
10. Prefer try-with-resources to...
Recall Hailstone.java

```java
public class Hailstone {
    public static void main(String[] argv) {
        int n = 3;
        while (n != 1) {
            System.out.println(n);
            if (n % 2 == 0) {
                n = n / 2;
            } else {
                n = 3 * n + 1;
            }
        }
        System.out.println(n);
        return;
    }
}
```

Five easy changes

- ETU - move core code into its own method
- ETU - add specifications
- RFC - take arguments
- RFC - move I/O “up” the call stack, return sequence
- SFB - prefer List over arrays
- SFB – (less easy) use exceptions for overflow

What if a Hailstone sequence might reasonably be many thousands long?
A “Classy” Hailstone

```java
public class Hailstone2 {
    private int state;

    public Hailstone2(int start) {
        state = start;
    }

    public static int next(int n) {
        return (n % 2 == 0) ? n/2 : 3*n+1;
    }

    public int increment() {
        return state = next(state);
    }

    public int size() {
        return state;
    }

    public static void main(String[] argv) {
        Hailstone2 stone = new Hailstone2(3);
        do {
            System.out.println(stone.size());
            stone.increment();
        } while (stone.size() != 1);
    }
}
```

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Class Design

- Principles to consider
  - Simplicity
    - Ease of use.
    - Ease of understanding. (Principle of Least Astonishment)
    - Ease of coding.
  - Abstraction
    - Hide as much as possible.
    - Yet retain flexibility.
    - Common interfaces to disparate functionality (multiple implementations)
  - Correctness
    - Prevent misuse (e.g. don’t set a negative age).
    - Think ahead about testing. You can even “test ahead.”

- Design Methodology
  - Consider alternatives. Mutable? Inheritance? Primitives?
  - Evaluate possibilities. Try using them (write tests first).
Package Design

- Similar choices
- But at a higher-level.
- And focusing more on visibility than implementation.
- Fewer public classes and interfaces means easier understanding.
- Don’t write “public class Something” out of habit.
Case study: A geography library

- You need to represent a location on the Earth.
- You’ll care about distances between them.
- Finding nearby locations.
- Some notion of “inside” an area.

Discuss ideas.
More concrete: A LatLng and a BoundingBox

- We’ll create two classes.
  - We’ve already made our first choice.
  - We don’t want to pass latitude and longitude as primitives.
  - Ick: Geo.distance(double lat1, double lng1, double lat2, double lng2);

- A location on the Earth — LatLng
- An square(ish) area — BoundingBox

Think about how you would like to represent them.

Think about how you would like client code to use them.
  - Consider construction from simpler things.
  - Consider useful “questions”.
  - Consider creation from “algebra” on types.
  - Consider (if you allow) mutation.
More concrete: A (too) simple implementation

```java
class LatLng {
    double lat;
    double lng;
}
```

- That’s probably as few keywords as you could possibly use...
- But what have we ended up with?
- Which callers can declare (and construct) LatLng objects?

- Which can access (and modify) the members? (lat and lng)
class LatLng {
    double lat;
    double lng;
}

That’s probably as few keywords as you could possibly use...

But what have we ended up with?

Which callers can declare (and construct) LatLng objects?
  ▶ Any other class in the same package.
  ▶ In this case, it’s the “default” package.
  ▶ You should never do that.

Which can access (and modify) the members? (lat and lng)
More concrete: A (too) simple implementation

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class LatLng {
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- That’s probably as few keywords as you could possibly use...
- But what have we ended up with?
- Which callers can declare (and construct) LatLng objects?
  - Any other class in the same package.
  - In this case, it’s the “default” package.
  - You should never do that.
- Which can access (and modify) the members? (lat and lng)
  - Any code that can get one, can modify it.
  - Even outside package!
  - Earth.getNorth Pole().lat = 45;
Consider visibility of classes and fields

```java
package edu.brown.cs.jj.geo;
public class LatLng {
    private double lat;
    private double lng;
}
```

- Always work in a named package. Think about reuse.
- Many of your classes will be public, not not all!
- Why are the members private?
- So what else do we need?
First, a constructor

```java
package edu.brown.cs.jj.geo;

public class LatLng {
    public LatLng(double lat, double lng) {
        this.lat = lat;
        this.lng = lng;
    }

    private double lat;
    private double lng;
}
```

- Eschew default constructors
- But this constructor is not safe.
- (this should be rare. Just constructors and setters.)
First, a constructor

```java
package edu.brown.cs.jj.geo;

public class LatLng {

  public LatLng(double lat, double lng) {
    this.lat = lat;
    this.lng = lng;
  }

  private double lat;
  private double lng;
}
```

- Eschew default constructors
- But this constructor is not safe. `new LatLng(91, 192);`
- `(this should be rare. Just constructors and setters.)`
We use “private” for a reason, not ritual.

```java
public LatLng(double lat, double lng) {
    this.lat = checkLatitude(lat);
    this.lng = checkLongitude(lng);
}

private static double checkLatitude(double lat) {
    if (lat < -90.0 || lat > 90.0)
        throw new IllegalArgumentException(lat + " is out of range");
    return lat;
}
```

- LatLng makes no sense with lat or lng out of range.
- Don’t allow it.
- Use reasonable builtin Exception types when possible.
- Methods can and should be private, too.

What does static mean on these check method? How could it be useful?
Use public methods to export an “interface”

```java
import java.lang.Math;

public static double EARTH_RADIUS_M = 6.371e6;

public double distance(LatLng other) {
    if (equals(other))
        return 0.0;

    double a1 = Math.toRadians(lat);
    double b1 = Math.toRadians(lng);

    return EARTH_RADIUS_M * acos(c);
}

Avoid wildcard imports. Don’t import java.lang.*
```
Define toString()

```java
@Override
public String toString () {
    return String.format("(%1.3f,%1.3f)", lat, lng);
}
```

- Debugging and logging becomes much easier.
- String.format reads a lot nicer than a bunch of +’s.

What is @Override?
Define equals()

```java
@override
public boolean equals(Object o) {
    if (o == this) return true;
    if (!(o instanceof LatLong)) return false;

    LatLong x = (LatLong) o;
    return (x.lat == lat && x.lng == lng);
}
```

- Without it, `new LatLong(1,1).equals(new LatLong(1,1))` is false.
- Why take an `Object` instead of a `LatLong`?
- `@Override` saves you if you forget.
- What happens if `o` is `null`?
- There are deep questions about equality... (that's a pun)
Define hashCode()

```java
import java.util.Objects;

@Override
public int hashCode() {
    return Objects.hash(lat, lng);
}
```

- Without it using LatLng as a key in a HashMap is badly broken.
- Even with it, take care to think about mutation.
- Use the Objects class to make this less tedious. (Note the “s”)
- Goal: few collisions.
- Required: a.hashCode() == b.hashCode() if a.equals(b);
Often (but not always!) member data should be available

- Do callers need access to the individual latitude or longitude?
- If so, how should we give it to them?
  - public double lat;
Often (but not always!) member data should be available

- Do callers need access to the individual latitude or longitude?
- If so, how should we give it to them?
  - public double lat;
  - public double lat() { return lat; }

Be aware of fields that are themselves mutable! Don't expose an array even if it's final. final lat must be assigned once, in a constructor. Our coding style requires private. Your future team probably does too.
 Often (but not always!) member data should be available

- Do callers need access to the individual latitude or longitude?
- If so, how should we give it to them?
  - public double lat;
  - public double lat() { return lat; }
  - public double getLat() { return lat; }

**public final double lat;**

final means lat can't be reassigned, even by LatLong.

It is one of the few ways that public can still be "safe."

Beware of fields that are themselves mutable! Don't expose an array even if it's final.

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Our coding style requires private. Your future team probably does too.
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- final means lat can’t be reassigned, even by LatLong.
- It is one of the few ways that public can still be “safe.”
- Beware of fields that are themselves mutable! Don’t expose an array even if it’s final.
- final lat must be assigned once, in a constructor.
- Our coding style requires private. Your future team probably does too.
Sometimes (less often!) member data should be modifiable

- Do callers need to modify the individual latitude or longitude?
- If so, how should we allow them?
  - public double lat;
Sometimes (less often!) member data should be modifiable

- Do callers need to modify the individual latitude or longitude?
- If so, how should we allow them?
  - public double lat;
  - public void setLat(double l) { lat = l; }
Sometimes (less often!) member data should be modifiable

- Do callers need to modify the individual latitude or longitude?
- If so, how should we allow them?
  - `public double lat;`
  - `public void setLat(double l) { lat = l; }`
  - `public void setLat(double l) { lat = checkLat(l); }`
Do callers need to modify the individual latitude or longitude?

If so, how should we allow them?

- public double lat;
- public void setLat(double l) { lat = l; }
- public void setLat(double l) { lat = checkLat(l); }
- public LatLong setLat(double l) {
  lat = checkLat(l);
  return this;
}
Immutability and “Value Types”

First question for a new type — does it have to be mutable?

- Prefer immutability.
- Simplifies reasoning, especially in threaded code.
- But not just there. Consider HashMap keys, shared objects...
- When to allow mutation?
  - Fundamental to the intended use: StringBuilder, Map as cache
  - Performance: Matrix library, Image manipulation
Immutability and “Value Types”

First question for a new type — does it have to be mutable?

- Prefer immutability.
- Simplifies reasoning, especially in threaded code.
- But not just there. Consider HashMap keys, shared objects...
- When to allow mutation?
  - Fundamental to the intended use: StringBuilder, Map as cache
  - Performance: Matrix library, Image manipulation
- Consider that immutable, but easily built, LatLng can be safer.

```
public LatLng withLat(double newLat) {
    return new LatLng(newLat, lng);
}
LatLong x = new LatLng(45, 100);
LatLong y = x.withLat(50);
```
public class BoundingBox {
    public BoundingBox(LatLong... points) {
        // Constructor implementation
    }
}

- Plenty of reasonable representations. “reps”
public class BoundingBox {

    public BoundingBox(LatLong... points) {

    }

    private final double[] limit = new double[4];
    private double north; private double south; ...
    private final LatLong[] corners = new LatLong[4];
    private LatLong ne; private LatLong sw;

    Plenty of reasonable representations. “reps”

    }
public class BoundingBox {
    public BoundingBox(LatLong... points) {
        . .
        .
        .
        }
    }

- Plenty of reasonable representations. “reps”
- private final double[] limit = new double[4];
- private double north; private double south; ...
- private final LatLong[] corners = new LatLong[4];
- private LatLong ne; private LatLong sw;
- Tradeoffs? Strive for clarity, avoid redundancy.
- Your choice of accessors should not depend on these decisions.
- Why would public LatLong[] getCorners() be tricky?
Consider writing repOk()

```java
private boolean repOk() {
    return limit.length == 4 && limit[N] > limit[S];
}
private boolean repOk() {
    return north > south;
}
private boolean repOk() {
    return corners.length == 4 &&
            corners[NW].lat == corners[NE].lat &&
            corners[NW].lat > corners[SE].lat ...
}
private boolean repOk() {
    return ne.lat > sw.lat;
}
```

That may also help you decide on the best representation. Add assert statements to your methods that call repOk. (Where?)
**Javadoc is source-embedded documentation**

Use `mvn site` to generate HTML from Javadoc (and other reports).

```java
public class BoundingBox {
    ...

    /**
     * Determines whether a point is located inside the BoundingBox. The point argument
     * must be non-null.
     * <p>
     * A second paragraph of explanation.
     * 
     * @param pt The point to test for membership in the BoundingBox. Being 
     * line is considered in.
     * 
     * @return true, iff pt is inside the BoundingBox. Being 
     */

    public boolean contains(LatLong pt) {
        ...
    }
}
```
Review

- Keep the Code Simple
  - Well documented
  - Hide information as much as possible.

- Continually rethink the design.
  - Especially at the early stages
  - Can you simplify the abstraction?
    - Reduce the number of methods.
    - Reduce the number of parameters.
    - Make them easier to use.
  - Can you hide any more details? Should you?
  - How might a caller screw up? Can you prevent it?

- If you don’t see tradeoffs, you’re missing them.
“Boring” details

- Coding style is important
  - Spaces
  - Comments and documentation (use language tools)
  - Make the code readable
    - Indentation, spacing, blank lines
    - Variable names
    - Consistency often matters more than anything.
    - You are communicating with *humans*
  - Consistent organization
    - Ordering of elements (imports, methods)
    - Naming conventions

- We codified some of this in our Checkstyle configuration (mvn site)
- Use Checkstyle often and configure your editor, or you will be overwhelmed.