# CS 2110

## Software Design Principles I

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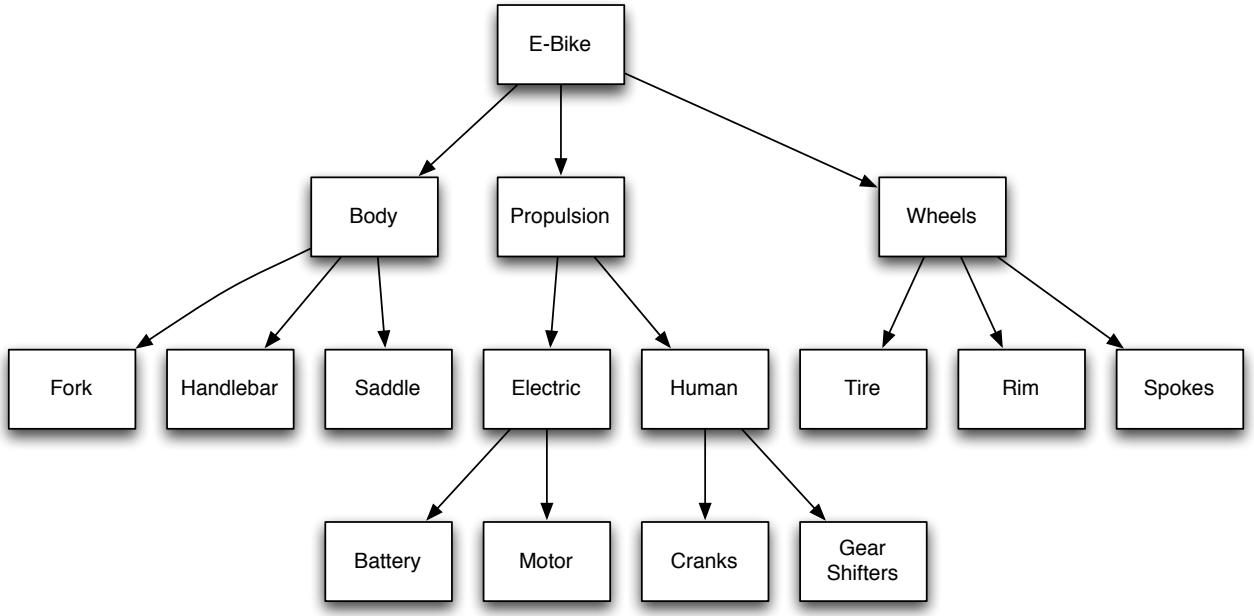
# Overview

- Today: Design Concepts & Principles
  - Top-Down, Bottom-Up Design
  - Software Process (briefly)
  - Modularity
  - Information Hiding, Encapsulation
  - Principles of Least Astonishment and "DRY"
  - Refactoring (if there's time)

- Next week: Test-Driven Development

# Top-Down Design

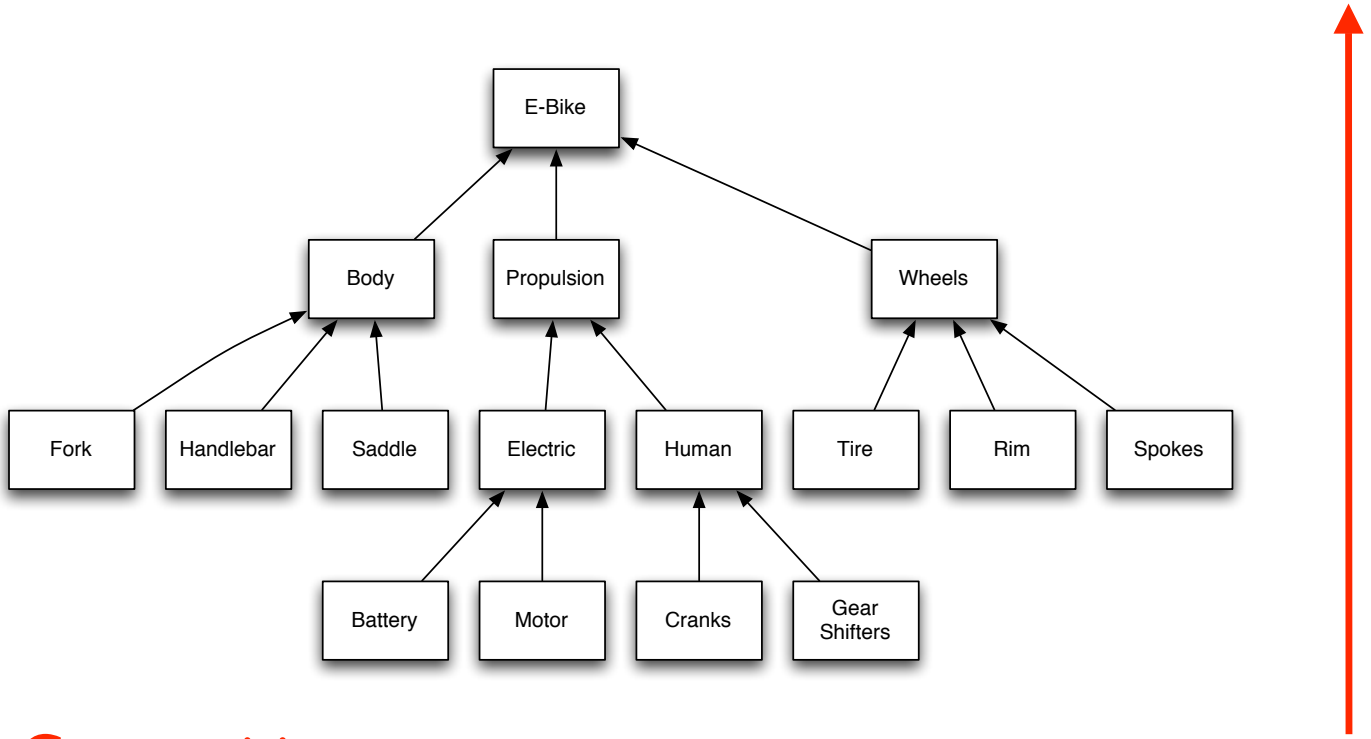
- Let's build and electric bicycle!




- Refine the design at each step
- Decomposition / "Divide and Conquer"

# Bottom-Up Design

- Just the opposite: start with parts




- Composition
- Build-It-Yourself (e.g. IKEA furniture)

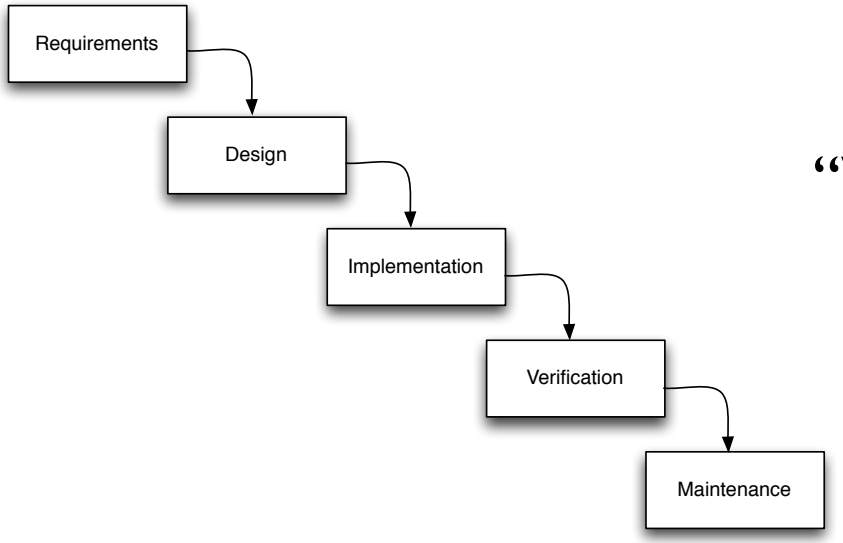
# Top-Down vs. Bottom-Up

- Two ways to think about a problem
  - It's sometimes good to alternate
  - Not the only ways to go about it

- With Top-Down it's harder to test early because parts needed may not have been designed yet
- With Bottom-Up, you may end up needing things different from how you built them

# Software Process

- How do you go about developing software?

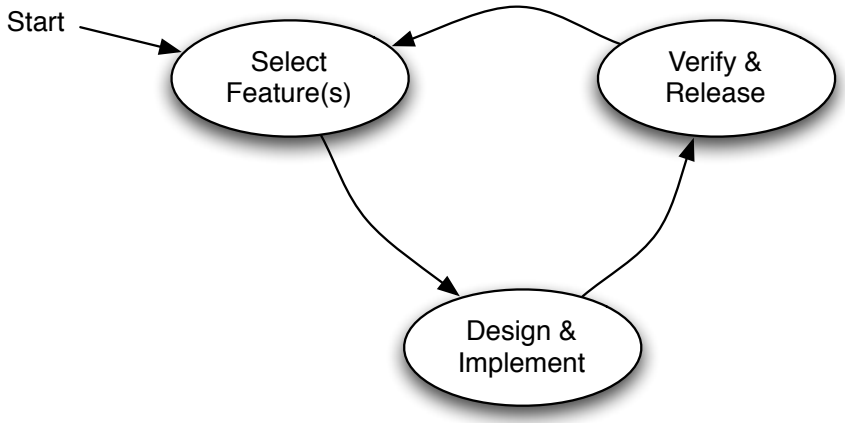



"Waterfall"

- Are the requirements fixed and well understood?
  Most software problems are not like that
- Not enough customer feedback

# Incremental & Iterative

- Deliver parts in several small cycles




- "Don't build for the future, for it is unknown"
- Software development is more like gardening than architecture

# Modularity

- Module: component of a system with a well-defined interface. Examples:
  - Tires in a car
  - Tuner in a TV
  - Screen Savers
  - ...
  - And in Java??

- Modules "hide information" behind their interfaces

# Information Hiding

- What "information" do modules hide?
  "Internal" design decisions.

```
class Set {
    ...

    public void add(Object o) ...

    public boolean contains(Object o) ...

    public int size() ...
}
```

- A class's interface is everything in it that is externally accessible

# Encapsulation

- By hiding code and data behind its interface, a class encapsulates its "inner workings"
- Why is that good?
  - Revising those design decisions takes changing the inner workings of the module only: helps "keep software soft"

```
class LineSegment {
   private Point2D _p1, _p2;

   ...
   public double length() {
      return _p1.distance(_p2);
   }
}
```

```
class LineSegment {
   private Point2D _p;
   private double _length;
   private double _phi;

   ...
   public double length() {
      return _length;
   }
}
```

# Encapsulation

- Why is that good? (continued)
  - There can be multiple implementations of the same thing; they all behave more or less the same way
    - That is the point of Java's `interface`

```
Iterator it = collection.iterator();

while (it.hasNext()) {
    Object next = it.next();
    doSomething(next);
}
```

# Degenerate Interfaces

- Public fields are usually a Bad Thing:

```
class Set {
    public int _count = 0;

    public void add(Object o) ...

    public boolean contains(Object o) ...

    public int size() ...
}
```

- Anybody can change them; the class has no control

# Interfaces vs. Implementations

- This says "I need this specific implementation":

```
public void doSomething(LinkedList items) ...
```

- This says "I need something with this interface" and can be used with any class that implements it:

```
public void doSomething(Iterable items) ...
```

- `Interfaces` represent higher levels of abstraction (focus on "what" and leave out the "how")

# Principle of Least Astonishment

- Have your designs work how a user would expect

  Bad:

```
public int product(int a, int b) {
   return a*b > 0 ? a*b : -a*b;
}
```

  Better:

```
public int absProduct(int a, int b) {
   return a*b > 0 ? a*b : -a*b;
}
```

- Names and other clues play a big role!

# Principle of Least Astonishment

- Unexpected side effects are a Bad Thing

```
class Integer {
   private int _value;

   ...

   public Integer times(int factor) {
      _value *= factor;
      return new Integer(_value);
   }
}

...

Integer i = new Integer(100);
Integer j = i.times(10);
```

# Duplication

- Duplication makes software less soft: when it changes, either
  - you change all instances
  - some become inconsistent
- Duplication can arise in many ways:
  - constants (repeated "magic numbers")
  - code vs. comment
  - within an object's state
  - ...

# Duplication in Comments

```
public double totalArea() {
   ...
   // now add the circle
   area += PI * pow(radius,2);
   ...
}
```

```
public double totalArea() {
   ...
   area += circleArea(radius);
   ...
}

private double circleArea(double radius) {
   return PI * pow(radius, 2);
}
```

- What is being done should be readable from code
- Comments should answer why it is being done; try to code so that you don't need them

# Duplication of State

- Duplication of state can lead to inconsistency within an object:

```
class LineSegment {
   private Point2D _p1, _p2;
   private double _length;

   ...
   public double length() {
      return _length;
   }
}
```

```
class LineSegment {
   private Point2D _p1, _p2;

   ...
   public double length() {
      return _p1.distance(_p2);
   }
}
```

- Can you see how it can become inconsistent?
- Duplication may be desirable for performance, but don't optimize too soon

# “DRY” Principle

- Don’t Repeat Yourself
- Strive to have each piece of knowledge in one place

- But don’t go crazy over it
  - DRYing up at any cost can increase dependencies between code
  - “3 strikes and you refactor” (i.e., clean up)

# Refactoring

- Refactor: to improve code's internal structure without changing its external behavior
- Most of the time we're modifying existing software
- "Improving the design after it has been written"
- Refactoring steps can be very simple:

```
public double weight(double mass) {
   return mass * 9.80665;
}
```

```
static final double GRAVITY = 9.80665;

public double weight(double mass) {
   return mass * GRAVITY;
}
```

- Other examples: renaming variables, methods, classes

# Extract Method

- A comment explaining what is being done usually indicates the need to extract a method

```
public double totalArea() {
   ...
   // now add the circle
   area += PI * pow(radius,2);
   ...
}
```

```
public double totalArea() {
   ...
   area += circleArea(radius);
   ...
}

private double circleArea(double radius) {
   return PI * pow(radius, 2);
}
```

- One of the most common refactorings

# Extract Method

- Simplifying conditionals with Extract Method

before

```
if (date.before(SUMMER_START) || date.after(SUMMER_END)) {
   charge = quantity * _winterRate + _winterServiceCharge;
}
else {
   charge = quantity * _summerRate;
}
```

after

```
if (isSummer(date)) {
   charge = summerCharge(quantity);
}
else {
   charge = winterCharge(quantity);
}
```

# Refactoring & Tests

- Eclipse supports various refactorings
- You can refactor manually
  - Automated tests are essential to ensure external behavior doesn't change
  - Don't refactor manually without tests!
- More about tests and how to drive development with tests next week