CSC301

Code Craftsmanship - Writing maintainable code

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About Patrick:

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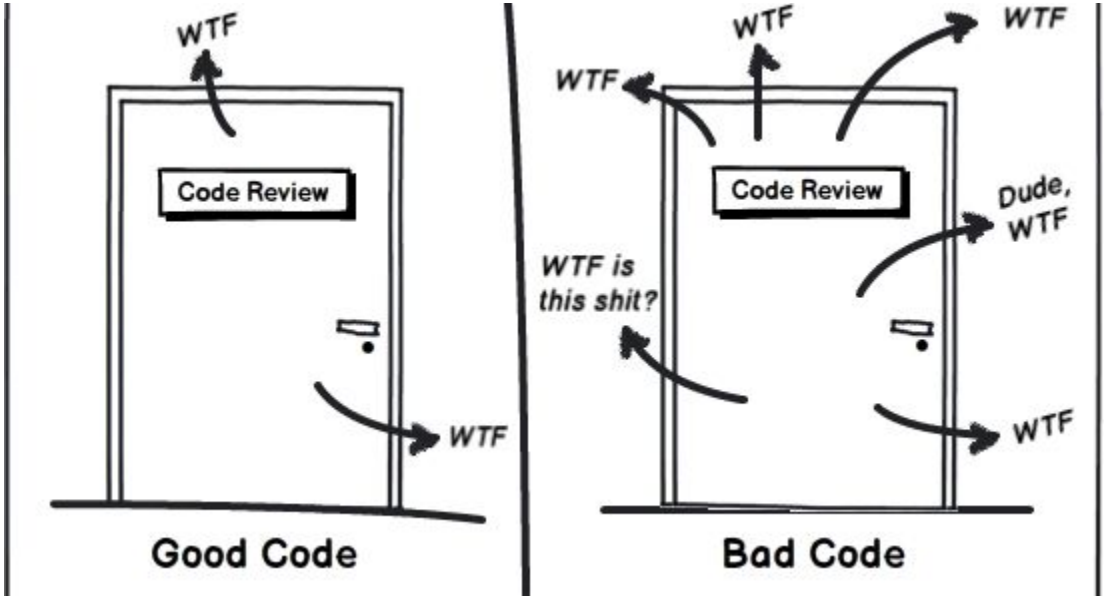
  - Class of 2007
- PEY at Red Hat
- Currently Director of Engineering at Flipp
- Previously ~9 years at BlackBerry

Initial Topics:

- Feature Journey at Flipp
- Staying current in Tech
- Hiring Process
- Development Processes

Code Quality

- Clean Code



Code Quality

- What do we mean by *high quality* code?
- Correct and efficient (that's the obvious part), but also
  - Easy to read & understand
    - By OTHER people
  - Easy to test
  - Easy to deploy
  - Easy to extend & maintain

Code Quality

- Producing code ≠ Maintaining code
- Why is maintenance important?
  - Produce once, maintain forever (or for a while)
  - Code constantly needs to change
    - Without errors
    - Without negative effect on existing users
    - E.g.: Scaling up

Code Quality

- Low-quality code has a price:
  - Low productivity slows down business growth
  - Degrades customer experience (i.e., bugs and regressions)
  - Hard for the company to attract talent
    - Which leads to even lower-quality code
- Problem: Measuring quality is hard
  - *Quality* is an abstract concept
  - It is hard to quantify

Code Quality

- Craftsmanship
  - Attention to details
  - Continuous refactoring
  - Commitment to quality & consistency
  - Experience
- Tools
  - Automate as much as possible
- Communication
  - Peer review

Code Quality

- Different people have different notions of what counts as high quality code.
  - Don’t scream at someone for their messy code
  - Don’t get insulted when someone criticizes your code

- But everyone should follow the **Boy Scout rule**
  - *“Leave the campground cleaner than you found it”*

Let’s start with a few simple *“dos and don’ts”* …

Basic “Rules”

- Be consistent
  - Follow the same style and conventions that are already in the codebase
- Be predictable
  - Follow industry standards
  - Don’t surprise other developers
  - Write code where it belongs (proper class names)
- Avoid duplication
  - If you see duplicate code, try to refactor it
  - If you can’t, at least don’t add to the mess

Comments

- “Reader’s notes” (or annotations) for your code
  - Communicate extra info with other developers working on the code
  - Example: When borrowing code from *StackOverflow* (or other websites), include a link in order to provide more context
- Avoid comments that are
  - Wrong
  - Obsolete
  - Redundant or
  - Poorly written

Comments

- Avoid commented out code
  - Other developers will not remove it, and it makes the code messy and hard to read
  - Use version control for backup
- Why “bad comments” are bad?
  - At best, they are just noise
  - In the worst case, they are misleading
  - *Update your comments as your code changes*

Coding Style

```
if (condition == true){
 // Do something ...
}
```

```
if (condition){
 // Do something ...
}
```

Coding Style

```
if (someCondition){
 return true;
} else {
 return false;
}
```

```
return someCondition;
```

Coding Style, Flag Variables

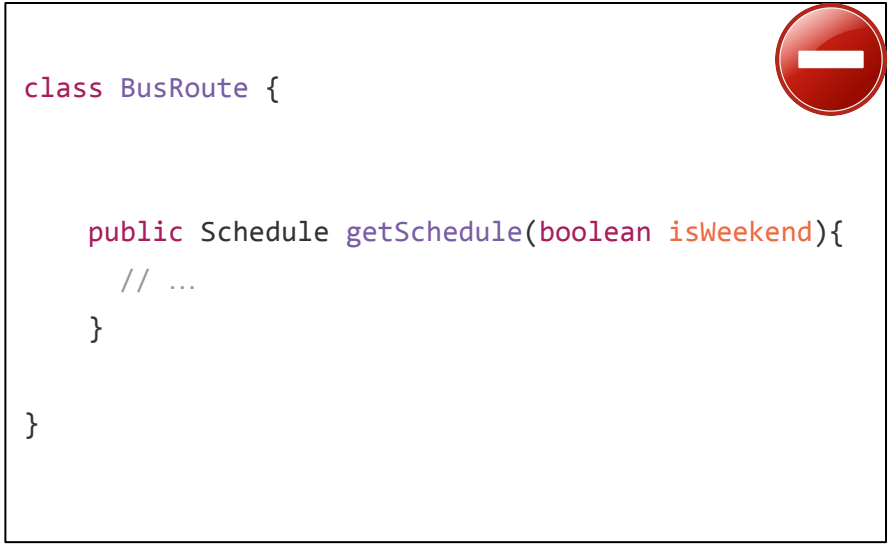
```
boolean done = false;
while(! done){
     // Do stuff ...

     if(finishedDoingStuff){
          done = true;
     }
}
```

Almost always, one can define an explicit stopping condition for the while-loop, and

- Result in clearer code
- Avoid unnecessary flag variable

Coding Style, Flag Arguments

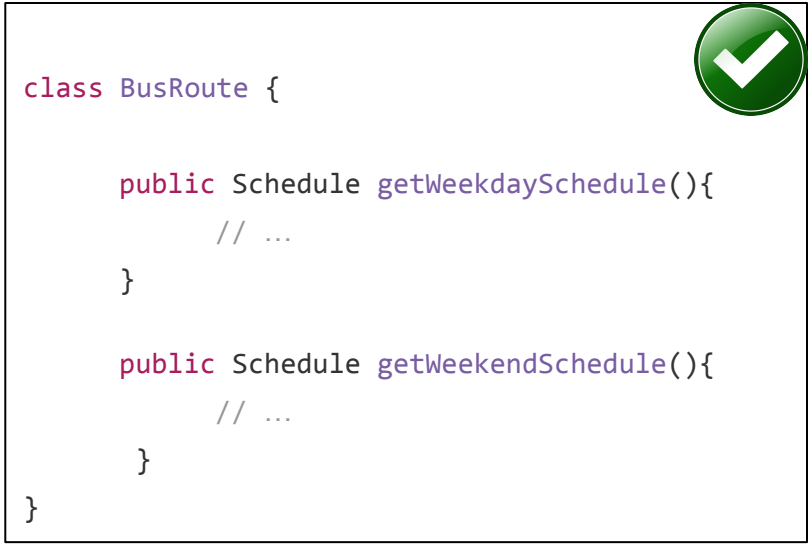


```
class BusRoute {


    public Schedule getSchedule(boolean isWeekend){
      // ...
    }

}
```

VS.



```
class BusRoute {

      public Schedule getWeekdaySchedule(){
            // ...
      }

      public Schedule getWeekendSchedule(){
            // ...
       }
}
```

* Think of the code written by users of the `BusRoute` class

Coding Style, Returning Status Code

```
public boolean doSomething(){
      // ...

      if(somethingGoesWrong){
            return false;
      }

      // ...
      return true;
}
```

vs.

```
public void doSomething(){
  // ...

  if(somethingGoesWrong){
    throw new RuntimeException("Something went wrong");
  }

  // ...
}
```

* What if the caller forgets to check the returned status code?

Variable Names

- Use *“good”* variable names
- That is, follow some sensible guidelines

Bad	Good	Notes
`List<Double> lst`	`List<Double> marks`	Names should be meaningful
`int weight`	`int weightInGrams`	Names should be precise
`Set<Employee> employeeList`	`Set<Employee> employeeSet`	Names shouldn’t be misleading
`Timestamp tsMod`	`Timestamp modificationTime`	Names should be pronounceable
`String doc`	`String documentName`	Names should be explicit

Variable Names

- Anti-pattern: One-letter names
  - They have no meaning
  - They are not easily searchable (imagine searching for **a** to refactor it)
  - Especially bad: lower-case L and upper-case O (visually similar to the digits 1 and 0)
- But there are exceptions...
  - Local variables with a small scope
  - E.g.: The variable **i** is the loop index
  - Length of variable name ~ Size of the variable's scope

Variable Names, Example

```
public Iterator<ITweet> iterator(InputStream data, Set<String> hashTags) throws IOException {
      Iterator<ITweet> streamiter = iterator(data);
      Predicate<ITweet> hashpred = h -> h.getHashTags().containsAll(hashTags);
      TweetFilteringIterator<ITweet> filteriter = new TweetFilteringIterator<ITweet>(streamiter, hashpred);
      return filteriter;
}
```

Versus

```
public Iterator<ITweet> iterator(InputStream data, Set<String> hashTags) throws IOException {
      Iterator<ITweet>  tweets = iterator(data);
      Predicate<ITweet> filter = tweet -> tweet.getHashTags().containsAll(hashTags);
      return new TweetFilteringIterator<ITweet>(tweets, filter);
}
```

Example, Cont'd

Or

```
public Iterator<ITweet> iterator(InputStream data, Set<String> hashTags) throws IOException {
      return new TweetFilteringIterator<ITweet>(iterator(data),
            tweet -> tweet.getHashTags().containsAll(hashTags));
}
```

Declaring Variables

Don’t use a concrete type, use an interface!

```
ArrayList<String> words;
```

vs.

```
List<String> words;
```

Declaring Variables

Especially important when declaring method arguments:

```
public int count(ArrayList<String> words);
```

VS.

```
public int count(List<String> words);
```

Functions

- Functions/methods should do one thing
  - And one thing only!
  - All statements at the same level of abstraction

    E.g.: A function that mentions *Tweets* and *Bytes* almost certainly does more than one thing
- Keep functions small!
  - Different people have different definitions of small
  - Should definitely fit on a laptop screen
  - Use helper functions

Functions

- Use descriptive names
  - For functions **and** their arguments
- Avoid deeply nested blocks
- Avoid functions with too many arguments
  - Easier for the caller to get things wrong
  - Harder to test
  - We will cover this more when discussing the telescoping constructor

Throw Early & Avoid nested blocks

```
if(everythingIsOk){

      // The body the function ...

} else {
      throw new RuntimeException("Oops");
}
```

VS.

```
if(somethingIsWrong){
      throw new RuntimeException("Oops");
}

// The body the function ...
```

Functions

- Use standard terminology
  - E.g.: kill(), and not whack()
- Avoid slang
  - E.g.: abort() versus ScrewItImGoingHome()
- Be consistent
  - E.g.: Don’t use at the same time `fetch`, `retrieve` and `get`

Past Example

```
public List<ITweet> load(InputStream data) throws IOException{
	int i;
	char c;
	String str = "";
	tweets = new ArrayList<ITweet>();

	while((i = data.read()) != -1){
		c = (char) i;
		if (c == '\n'){
			tryToAddTweet(str);
			str = "";
			continue;
		}
		str += c;
	}
	tryToAddTweet(str);

	return tweets;
}
```

VS.

```
public List<ITweet> load(InputStream data) throws IOException{
	List<ITweet> tweets = new ArrayList<ITweet>();

	List<String> lines = readNonEmptyLines(data);
	for(String line : lines){
		tweets.add(lineToTweet(line));
	}

	return tweets;
}
```

Example

```
// NOTE: This is a Predicate<Set<String>>
(hashTagsSet) -> {
            Set<String> set = (Set<String>) hashTagsSet;
            if (set.isEmpty()){
                  return false;
            }
            Iterator iter = hashtags.iterator();
            boolean contain = true;
            while (iter.hasNext()){
                  if (!set.contains(iter.next())){
                        contain = false;
                        break;
                  }
            }
            return contain;
}
```

- Can you guess what this lambda does?
- Can you describe it in English?

If we’re already talking about functions, let’s see factory methods…

Static Factory Methods

- Simple design pattern - “Wrap” constructors in a static method with a meaningful name.
- Might help developers using your class:
  - Make their code easier to read
  - Save them from making “silly” mistakes
- E.g.:
  - `new Complex(2.7)` vs. `Complex.fromRealNumber(2.7)`
  - `3DPoint.fromCartesian(9.0, 2.1, 0)`

Static Factory Methods, Example

```
public class Location {

  public static Location fromLonLat(double longitude, double latitude){
        return new Location(longitude, latitude);
  }

  public static Location fromAddress(Address address){
        return new Location(address);
  }

  public static Location fromNameOfaPlace(String name){
        return new Location(name);
  }

  // Private constructors force others to use factory methods
  private Location(double longitude, double latitude) { /* ... */ }
  private Location(Address address){ /* ... */ }
  private Location(String name){ /* ... */ }
}
```

Makes the caller's code easier to read:

// Which is first? Longitude or latitude?
`new Location(14.241,9.021)`

vs

`Location.fromLonLat(14.241,9.021)`

And reduces the chance of developers getting it wrong.

Let’s talk about the relation (and/or correlation) between code quality and software design...

Code & Design

- Good code makes the design clearer
  - Precise & meaningful names
  - Interfaces and classes correspond to cohesive domain concepts
    - Distinguish between abstract and concrete concepts
- Good design makes it easier to code
  - Each component is responsible for one thing
  - Allows you to focus on one thing at a time when reading/writing code

Example

```
public class TweetFilteringIterator implements Iterator<ITweet>{
  Iterator<ITweet> iterator;
  Predicate<Set> condition;

  public TweetFilteringIterator(Iterator<ITweet> iter, Predicate<Set> cond){
     iterator = iter;
     condition = cond;
  }
  // ...
```

Can you spot the problem?

Example, Cont’d

- Let’s describe the code in English …
  - A tweet-filtering iterator is an iterator of tweets
  - We construct it using two arguments:
    - An iterator of tweets
    - A filtering condition
- Why does the filter take a set of strings?
- What about other filtering criteria?
  - E.g.: username, posting time, length of text, etc.

Artificial Coupling

- As a general rule, we want to reduce the dependencies between the various components of our software
- Artificial coupling means:
  - A has a dependency on B
  - Although A doesn't really need B
- Let's see an example...

Artificial Coupling

```
interface Vehicle {
 TransportType getTransportType();
 // ...
}

class Car implements Vehicle {
 public static enum TransportType {LAND, SEA, AIR};
 // ...
}

class Boat implements Vehicle {  /* ... */ }

class Airplane implements Vehicle {  /* ... */ }
```

The `TransportType` enum is fairly general - Every class that implement `Vehicle` uses it

We mistakenly defined the enum in a fairly specific class, `Car`.

As a result, every class that implements `Vehicle` will depend on the `Car`.

Artificial Coupling

- Why is artificial coupling bad?
  - Changes to a specific class require recompilation of general classes
    - E.g.: Changes to `Car` will require us to recompile every `Vehicle` implementation.
  - General classes cannot be compiled without the specific class

Cohesion

- An abstract concept
  - *“The act or state of sticking together tightly”*, according to Merriam-Webster dictionary
  - *“The degree to which the elements of a module belong together”*, according to Yourdon & Constantine
- Idea: An object in memory corresponds to a single (conceptual) object in the domain

Cohesion

- Let’s try to be concrete:
  - The *more (instance) variables* a method needs, the *more cohesive* the *method is to the class*.
  - A class is *maximally cohesive* if each instance variable is used by each method.
  - We are not after *maximal cohesion*, but we definitely want *high cohesion*

Cohesion

- As a general rule, classes should be small
  - Also means small number of instance variables
- Sometimes classes with many instance variables represent multiple concepts
  - Look at which methods use which variables
  - “Clusters of variables” can indicate how to separate into smaller, more cohesive classes.

Cohesion, example

The `Student` class contains many instance variables

Try to think of which (hypothetical) methods might use which variables

On the next slide, we will make this class more cohesive...

```
class Student {
 static enum Session {FALL, WINTER, SUMMER};

 String                  studentId;
 String                  firstName;
 String                  lastName;
 LocalDate               birthDate;
 List<ProgramOfStudy>    programs;
 List<Course>            courses;
 Map<Course,CourseMark>  course2mark;
 Map<Course,Integer>     course2year;
 Map<Course,Session>     course2session;
 BigDecimal              accountBalance;
 List<Scholarship>       scholarships;
 boolean                 eligibleForOSAP;
 // ...
}
```

Cohesion, example

Instead of one big class, use 3 smaller, more-cohesive classes

```
class Student {
 String    studentId;
 String    firstName;
 String    lastName;
 LocalDate birthDate;
 StudentEnrollment
             enrollment;
 StudentAccount account;
 // ...
}
```

```
class StudentEnrollment {
 static enum Session {FALL, WINTER,
  SUMMER };

 List<ProgramOfStudy>    programs;
 List<Course>            courses;
 Map<Course,CourseMark> course2mark;
 Map<Course,Integer>     course2year;
 Map<Course,Session>     course2session;
 // ...
}
```

```
class StudentAccount {
 BigDecimal         balance;
 List<Scholarship> scholarships;
 boolean            eligibleForOSAP;
 // ...
}
```

Cohesion

- Cohesive classes have a **single responsibility**
- Therefore, they are easy to describe:
  - Student - Contains all the information related to a single student
  - StudentEnrollment - Enrollment records of a single student
  - StudentAccount - Financial records of a single student

Cohesion

- Why is cohesion desirable?
- Smaller classes that are
  - Easier to understand
  - Easier to test
  - Easier to maintain
- Better articulation of the domain model
  - Each class represents a simpler concept

Know your interfaces

- Do not make false assumptions about interfaces that you use
- E.g.: Iterators, maps and sets do **not** guarantee ordering
  - If your code depends on the order in which you get the items of the set/map/iterator, then you have a bug hiding in your code
  - We've seen it in some of of the previous A3 solutions (assuming that the first GridCell you get from an iterator will be the south-west corner)
  - We've seen it in open-source libraries (that broke when a new version of Java, with a different Map/Set implementations, came out and tests started to fail)

In order to keep code quality high, developers can/should use (and develop) tools...

Code Quality Tools

- Lint
- Detect *suspicious* part of the code
  - Usually, using static analysis
  - Can detect things like:
    - Unused variables & dead code
    - Constant conditions
    - Statements with no effect
    - etc.
- Extremely common in interpreted languages

Code Quality Tools

- Style checkers
  - Ensure code follows specific styling rules, such as
    - Lines short enough to fit on the screen (e.g., 80 character per line)
    - Indentation rules
    - Where to put curly braces
    - etc.
  - Enforce consistency
- Can be integrated into your workflow
  - E.g.: Travis runs style checker on each commit/PR

Code Quality Tools

- Try searching for “code quality tools”
  - You will find many tools
  - For many languages
  - Solving different problems
- What’s the point?
  - Code quality is a big deal!
  - Otherwise, people wouldn’t bother writing tools

And, finally, a very effective way to improve code quality is with peer review

Peer Review

- Code review is a very common practice
  - Professional review, not personal!
  - Experienced developers can help beginners
    - Maintain code quality & consistency
  - More eyes on the code ⇒ Better chance of detecting problems
  - Code review experience can help in interviews
- Relates to “Agile values” like open communication and transparency

Summary

- Code quality is important!
  - Especially for large teams and/or projects
  - For example, it is really important to Google (C++), Java
- We've only scratched the surface
  - Many books about software craftsmanship
    - Clean Code
- The main lesson to take home is:
  - Take pride in your work and develop your craft