CSE 331
Software Design & Implementation

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Lecture 23 – Summary & Advice

(Based on slides by Mike Ernst, Dan Grossman, David Notkin, Hal Perkins, Zach Tatlock)

Announcements

- Course evaluation: https://uw.iasystem.org/survey/163511

- Final review material on the web site
  - concepts that are fair game for the final
  - questions from last 3 finals that I think are reasonable
    - (that means ignore the questions I skipped)

Review from Lecture 1

What is the goal of CSE 331?

In short: to help you become better programmers

Specifically, to teach you how to write code of

- higher **quality**
- increased **complexity**

We will discuss *tools* and *techniques* to help with these

What is high quality?

Code is high quality when it is

1. **Correct**
   – everything else is of secondary importance
2. Easy to **change**
   – most work is making changes to existing systems
3. Easy to **understand**
   – needed for 1 & 2 above

How do we ensure correctness?

Best practice: use three techniques (we'll study each)

1. **Tools**
   – e.g., type checking compiler
2. **Inspection**
   – think through your code carefully
   – have another person review your code
3. **Testing**
   – usually >50% of the work in building software

Each removes ~2/3 of bugs. Together >97%

– none of these can be left out

How do we cope with complexity?

We tackle complexity with **modularity**

- split code into pieces that can be built independently
- each must be documented so others can use it
- also helps understandability and changeability

In summary, we want our code to be:

1. correct
2. easy to change
3. easy to understand
4. modular

Scale makes everything harder

Modularity makes scale **possible** but it's still **hard**…

- Time to write N-line program grows faster than linear
  - good estimate is $O(N^{1.05})$ [Boehm, '81]
- Bugs grow like $\Theta(N \log N)$ [Jones, '12']
  - 10% are errors are btw modules [Seaman, '08]
  - corner cases are more important with more users
- Comm. costs dominate schedules [Brooks, '75]

Corollary: quality must be even higher, per line, in order to achieve overall quality in a *large* program

What we will cover in CSE 331

- Everything we cover relates to the 4 goals
- We'll use Java but the principles apply in any setting

Correctness

1. Tools
   - Git, Eclipse, JUnit, Javadoc, …
   - Java libraries: equality & hashing
   - Adv. Java: generics, assertions, …
   - debugging
2. Inspection
   - reasoning about code
   - specifications
3. Testing
   - test design
   - coverage

Changeability

- specifications
- ADTs

Understandability

- specifications
- Adv. Java: exceptions
- subtypes

Modularity

- module design & design patterns
- listeners & callbacks
- event-driven programming, MVC, GUIs

Advice

Write Less Code

- The best way to reduce bugs is to write less code.
  - more lines of code usually means more bugs

- The best way to improve your productivity is to write less code.
  - your time is valuable!
  - don’t waste it on unnecessary work

Promise as Little as Possible

- I.e., make your method specifications as **weak** as possible
- That means less work for you
  - see the previous slide!
  - don't promise to solve problems you don't actually have
- That makes your code easier to change in the future
- **Exception**: you can't have preconditions in widely used libraries
  - clients will try out your code on every input
  - whatever you do becomes the specification no matter what you say about it

Limit the Use of Abstraction

- Only introduce abstraction if it will **pay for itself**

- Abstractions usually make certain kinds of changes easier
  - e.g., interpreter vs procedural design patterns
    - one makes it easier to add operations, the other to add types
  - ADTs make it easy to change the data representation
    - the latter is common when optimizing for efficiency

- Adding abstraction is usually more work
  - see the earlier slide!
  - how likely is it you will need to change the representation?

- Adding abstraction can make the code harder to understand

Prefer Correctness to Efficiency

- We are notoriously bad at guessing what will be inefficient
  - if you guess wrong, you'll waste time optimizing
    - see the earlier slide!

- On the other hand, we can be pretty certain that users won't like it when the program crashes

- First, make it correct. Then, find out what is slow and optimize it.

- Example: copying mutable inputs and outputs
  - you can remove these copies later if it turns out to be slow

Don’t Trust Other Programmers

- Write assertions to check preconditions on code they call
  - they should read the comments carefully, but they won’t
- Avoid representation exposure so they can’t break your code.
- Copy mutable inputs and outputs
  - better yet, prefer **immutable** types
- Don’t let other programmers extend your classes
  - relationship between sub- and super-class is often *intimate*
  - either design for subclassing or make your class **`final`**
  - prefer **composition** over inheritance

Don’t Trust Yourself Either!

- The first step is recognizing you have a problem…
- You will make mistakes
  - but you can stop those mistakes (bugs) from getting to users
- Write assertions to check your assumptions
  - if you can have mistakes in your code, you can have them in your proofs of correctness as well
- Write assertions to check that your loop invariants hold.
- Write assertions to check that your representation invariants hold.

Fail Fast

- When you detect that something is wrong, just crash

- This will make debugging much easier
  - search from the failure to the bug is shorter if the failure occurs close to the bug

- This limits additional damage from the bug
  - once we know there's a mistake in our reasoning, it's hard to know what else could go wrong
  - it could be very bad…

Write Tests before the Code

- It’s easier to have the energy for good testing beforehand
  - finishing the code feels like crossing the finish line

- Thinking through the tests often makes the code easier to write
  - forces you to think through all the cases you have to handle
  - helps you realize which cases are the same

- Confirmation bias makes it hard to realize the cases you missed after you’ve written the code

- Then write more tests after
  - add tests for any special cases you missed

Test Code Should Be Obvious

- If your tests are wrong, they're not testing
- For tests, correctness matters much more than anything else
  - throw elegance and efficiency out the window
  - throw changeability out the window (most of the time)
- Any code that is not obviously correct needs its **own tests**
- It's kind of fun to write brain-dead code
  - take a break from style, efficiency, etc.

Have Fun

- Programming should be fun

- You get to…
  - create solely with the power of your imagination
  - positively affects the lives of large numbers of people