CSE 331
Software Design & Implementation

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Lecture 1 – Introduction

(Based on slides by Mike Ernst, Dan Grossman, and many others)

Motivation

What is the goal of CSE 331?

How to build harder-to-build software

- Move from CSE 143 problems toward what you'll see in upper-level courses and in industry

Specifically, how to write code of

- Higher **quality**
- Increased **complexity**

We will discuss *tools* and *techniques* to help with this and the *concepts* and *ideas* behind them

- There are *timeless principles* to both
- Widely used across the industry

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

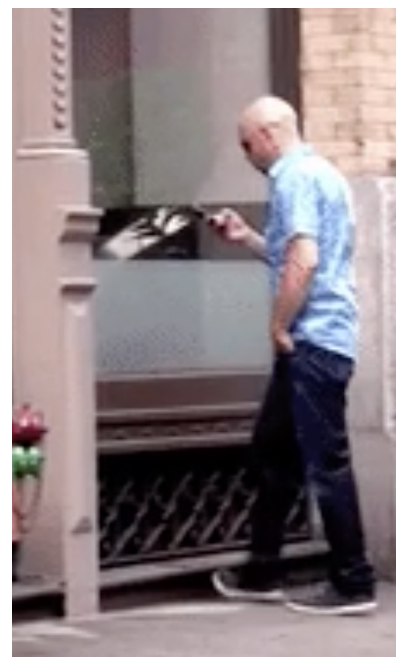
3. Easy to **understand**
   – Needed for 1 & 2 above

How do we ensure correctness...

... when **people** are involved?

People have been known to

- walk into windows
- drive away with a coffee cup on the roof
- drive away still tied to gas pump
- lecture wearing one brown shoe and one black shoe



What is increased complexity?

Analogy to building physical objects:

- 100 well-tested LOC = a nice cabinet
- 2,500 LOC = a room with furniture
- 2,500,000 LOC = 1000 rooms ≈

North Carolina class WW2 battleship

≈

the entire British Naval fleet in WW2

Actually, software is more complex…

- Every bit of code is unique, individually designed
  - US built 10 identical Essex carriers

  - Software equivalent would be one carrier 10 times as large:

- Defects can be even more destructive
  - A defect in one room can sink the ship
  - But a defective OS could sink the *whole fleet*

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% of errors are between modules [Seaman, '08]
- Communication costs dominate schedules [Brooks, '75]
- Small probability cases become high probability cases
  - Corner cases are more important with more users

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

People Do Build Great Software

Full scope of the challenge:

- software is built by people, who make mistakes all the time
- surprisingly difficult to get even a small program to work
- needed to write hundreds of millions of lines of code
- each line gets harder to write as the program scale

Despite those challenges, we have lots of software that works

- hundreds of millions of lines of working programs
- products rarely fail because the software is too buggy

How do we do it?

How do we ensure correctness...

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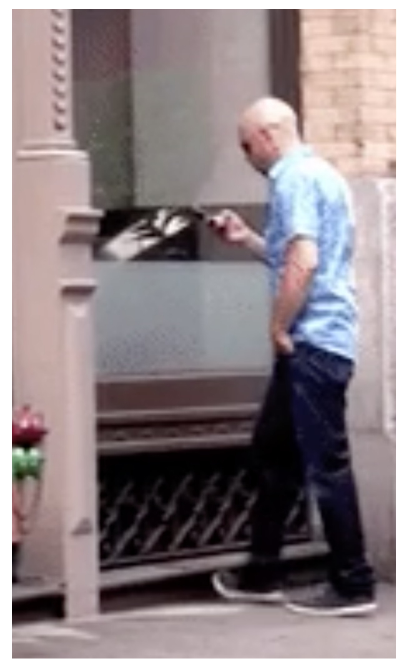

Key insights:

- Can't stop people from making mistakes
- Can stop mistakes from getting to users

How do we ensure correctness?

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

1. **Tools**
   – Type checkers, test runners, etc.
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%

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

What is high quality code?

In summary, we want our code to be:

1. Correct
2. Easy to change
3. Easy to understand
4. Easy to scale (modular)

These qualities also allow for increased complexity

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, IntelliJ, 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
- listeners & callbacks

Understandability

- specifications, ADTs
- Adv. Java: exceptions
- subtypes

Modularity

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