CSE 331
Software Design & Implementation

Hal Perkins

Fall 2016

Lecture 1 – Introduction & Overview

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

Welcome!

We have 10 weeks to move well beyond novice *programmer*:

- Larger programs
  - Small programs are easy: “code it up”
  - Complexity changes everything: “design an artifact”
  - Analogy: using hammers and saws vs. making cabinets (but not yet building houses)
- Principled, systematic software: What does “it’s right” mean? How do we know “it’s right”? What are best practices for “getting it right”?
- Effective use of languages and tools: Java, IDEs, debuggers, JUnit, JavaDoc, git, …
  - Principles are ultimately more important than details
    - You will forever learn details of new tools/versions

Concise to-do list

Before next class:

1. Familiarize yourself with website & post a followup to the welcome message

   http://courses.cs.washington.edu/courses/cse331/16au/

2. Read syllabus and academic-integrity policy

   (know this stuff – do we need a quiz?)

3. Fill in online form after class if still trying to add
   - Instructions supplied at end of class
   - Go to any section tomorrow if not registered yet

4. Do Homework 0 (see web calendar), due by 10 am Friday! & no late days this time
   - (Can submit using dropbox even if not registered)

Who: Course staff

- Lecturer:
  - Hal Perkins: Faculty since last century, CSE331 veteran
- TAs:
  - Chris Chen
  - Mike Han
  - Chandra Nandi
  - Erin Peach
  - Matthew Yang
  - Lucy Zhu
- Office hours: M-F, 4-5, starts tomorrow. Where? CSE 021 or lab?

Get to know us!

- Make sure this *feels like* a 30-person class with 105 students
- We're here to help you succeed

Acknowledgments

- Course designed/created/evolved/edited by others
  - Michael D. Ernst
  - Dan Grossman
  - David Notkin
  - (me)
  - Zach Tatlock
  - Kevin Zatloukal
  - A couple dozen amazing TAs

- Hoping my own perspective offers benefits

- [Because you are unlikely to care, I won't carefully attribute authorship of course materials]

Staying in touch

- Message Board
  - Join in! Use for most discussions; staff will read/contribute
    (Do this today: post a reply to the Welcome message)
  - Help each other out and stay in touch outside of class

- Course staff: **`cse331-staff@cs.washington.edu`**
  - For things that don't make sense to post on message board

- Course email list: **`cse331a_au16@u.washington.edu`**
  - Students and staff already subscribed (your UW email address)
  - You must get announcements sent there
  - Fairly low traffic

Lecture and section

- Both required

- All materials posted, but they are visual aids
  - Arrive punctually and pay attention (& take notes!)
  - If doing so doesn't save you time, one of us is messing up (!)

- Section will often be more tools and homework-details focused
  - Especially next week: preparing for projects
  - Section AC room changed at the beginning of this week – be sure to go to the right one!

- Other posted handouts related to class material

Homeworks

- Biggest misconception about CSE331 (?)

  "Homework was programming projects that seemed disconnected from lecture"

  – If you think so, you are making them harder!
    - Reconsider
    - Seek out the connections by thinking-before-typing
    - Approaching them as CSE143 homework won't work well
    - Don't keep cutting with a dull blade

- First couple assignments are "more on paper", followed by software development that is increasingly substantial

- Four (**4**) late days for the quarter: save for emergencies

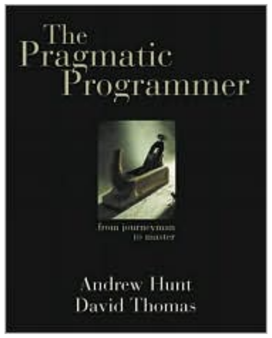
  – **Max 2** per homework, save them for later

Resources – Books

Required:

- *Pragmatic Programmer*, Hunt & Thomas
- *Effective Java* 2nd ed, Bloch

Serious programmers
should study these



Decent "Java book" is a wise thing to have

- *Core Java* Vol I, Horstmann

And must learn to use the Java API Docs

Readings (and quizzes)

- These are “real” books about software, approachable in 331
  - Occasionally slight reach: accept the challenge
- Overlap only partial with lectures
- Want to make sure you “do it”
  - Reading and thinking about software design is essential
    - Books may seem expensive given your budget, but very cheap as a time-constrained professional
  - Will have some simple online reading quizzes
    - In a few batches; no late days
  - Material is fair-game for exams

Books? In the 21st century?

- Why not just use Google, Stack Overflow, Reddit, Quora, …?
- Web-search good for:
  - Quick reference (What is the name of the function that does …? What are its parameters?)
  - Links to a good reference
- (can be) Bad for
  - Why does it work this way?
  - What is the intended use?
  - How does my issue fit into the bigger picture?
- Beware:
  - Random code blobs cut-and-paste into your code (why does it work? what does it do?)
  - "This inscrutable incantation solved my problem on an unknown version for no known reason"

Exams

- Midterm: middle of the quarter – will post exact date shortly
- Final: Monday, December 12, **8:30**-10:20 (sorry – most definitely not our preference)
- All the concepts, different format than homework
  - Will post old exams from various quarters later

Academic Integrity

- Read the course policy carefully
  - Clearly explains how you can and cannot get/provide help on homework and projects

- Always explain any unconventional action

- I have promoted and enforced academic integrity since I first started teaching (many years ago)
  - Great trust with little sympathy for violations
  - Honest work is the most important feature of a university (or engineering or business or life). Anything less disrespects your colleagues (including me) and yourself.

Questions?

Anything I forgot about course mechanics before we discuss, you know, software?

Goals

- CSE 331 will teach you to how to write correct programs
- What does it mean for a program to be correct?
  - Specifications
- What are ways to achieve correctness?
  - Principled design and development
  - Abstraction and modularity
  - Documentation
- What are ways to verify correctness?
  - Testing
  - Reasoning and verification

Main topic: Managing complexity

- Abstraction and specification
  - Procedural, data, and control flow abstractions
  - Why they are useful and how to use them
- Writing, understanding, and reasoning about code
  - Will use Java, but the issues apply in all languages
  - Some focus on object-oriented programming
- Program design and documentation
  - What makes a design good or bad (example: modularity)
  - Design processes and tools
- Pragmatic considerations
  - Testing
  - Debugging and defensive programming
  - [more in CSE403: Managing software projects]

The goal of system building

- To create a correctly functioning artifact
- All other matters are secondary
  - Many of them are ***essential*** to producing a correct system
- We insist that you learn to create correct systems
  - This is hard (but fun and rewarding!)

Related skill: *communication*

- Can you convince yourself and others something is correct via precise, coherent explanations?

Why is building good software hard?

- Large software systems are enormously complex
  - Millions of “moving parts”
- People expect software to be malleable
  - After all, it’s “only software”
- We are always trying to do new things with software
  - Relevant experience often missing

- Software engineering is about:
  - Managing complexity
  - Managing change
  - Coping with potential defects
    - Customers, developers, environment, software

Orders of magnitude

"We understand walls in terms of bricks, bricks in terms of crystals, crystals in terms of molecules etc. As a result the number of levels that can be distinguished meaningfully in a hierarchical system is kind of proportional to the logarithm of the ratio between the largest and the smallest grain, and therefore, unless this ratio is very large, we cannot expect many levels.

In computer programming our basic building block has an associated time grain of less than a microsecond, but our program may take hours of computation time. I do not know of any other technology covering a ratio of 10^{10} or more: the computer, by virtue of its fantastic speed, seems to be the first to provide us with an environment where highly hierarchical artifacts are both possible and necessary."

-- Dijkstra

Programming is hard

- It is surprisingly difficult to specify, design, implement, test, debug, and maintain even a simple program
- CSE331 will challenge you
- If you are having trouble, *think* before you act
  - Then, look for help
- We strive to create assignments that are reasonable if you apply the techniques taught in class…

  … but likely hard to do in a brute-force manner

  … and almost certainly impossible to finish if you put them off until a few days before they're due

Prerequisites

- Knowing Java is a prerequisite
  - We assume you have mastered CSE142 and CSE143

Examples:

- Sharing:
  - Distinction between **`==`** and **`equals()`**
  - Aliasing: multiple references to the same object
- Object-oriented dispatch:
  - Inheritance and overriding
  - Objects/values have a run-time type
- Subtyping
  - Expressions have a compile-time type
  - Subtyping via **`extends`** (classes) and **`implements`** (interfaces)

You have homework!

- Homework 0, due online by 10 am Friday (no late days)
  - Write (don't run!) an algorithm to rearrange (swap) the elements in an array
  - in O(*n*) time (and preferably in a single pass)
  - And argue (prove) in concise, convincing English that your solution is correct!

- Purpose:
  - Great practice
  - Surprisingly difficult
  - So we can build up to reasoning about large designs, not just 5-10 line programs

CSE331 is hard! (but very rewarding)

- You will learn a lot!
- Be prepared to work and to think
- The staff will help you learn
  - And will be working hard, too

- So let’s get going…
  - Before we create masterpieces we need to hone our ability to reason very precisely about code…

A Problem

“Complete this method such that it returns the index of the max of the first **`n`** elements of the array **`arr`**.”

```
int index_of_max(int[] arr, int n) {
    ...
}
```

A Problem

"Complete this method such that it returns the index of the max of the first **`n`** elements of the array **`arr`**."

```
int index_of_max(int[] arr, int n) {
    ...
}
```

What questions do you have about the *specification*?

Given a (better) specification, is there exactly 1 *implementation*?

Moral

- You can all write the code

- More interesting in CSE331:
  - What if n is 0?
  - What if n is less than 0?
  - What if n is greater than array length
  - What if there are “ties”?
  - Ways to indicate errors: exceptions, return value, …
  - Weaker versus stronger specifications?
  - Hard to write English specifications (n vs. n-1)

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