COMP 303 Winter 2024

Introduction to Software Design

Jin L.C. Guo

Why are we here?

Design Patterns: Ele… 1994

Domain-driven design Eric J. Evan…

Code Complete Steve McCo…

Head First Design Patte… 2004

Refactoring 1999

Clean Architecture:… Robert Cecil…

Agile Principles, P… 2002

Code: The Hidden Lang… 1999

A Philosophy of Software … John Ouster…

Building Microservice… Sam Newma…

The Algorithm Design Manual Steven Skie…

Designing Data-Intensi… Martin Klepp…

Pattern-oriented Soft… 1995

Refactoring to Patterns Joshua Keri…

Beautiful Code 2007

Site Reliability Engineering:… 2016

Software Systems Arc… 2005

Applying UML and patterns Craig Larma…

Don't Make Me Think Steve Krug, …

Head First Object-Orien… Brett McLau…

Design patterns expl… Alan Shallo…

The Design of Design Fred Brooks,…

… …

Why are we here?

The Verge

GitHub and OpenAI launch an AI Copilot tool that generates its own code

GitHub and OpenAI have launched a technical preview of a new AI tool called Copilot, which lives inside the Visual Studio Code editor and...

Jun 29, 2021

TechTalks

What OpenAI and GitHub's "AI pair programmer" means for the software industry

OpenAI has once again made the headlines, this time with Copilot, an AI-powered programming tool jointly built with GitHub.

Jul 5, 2021

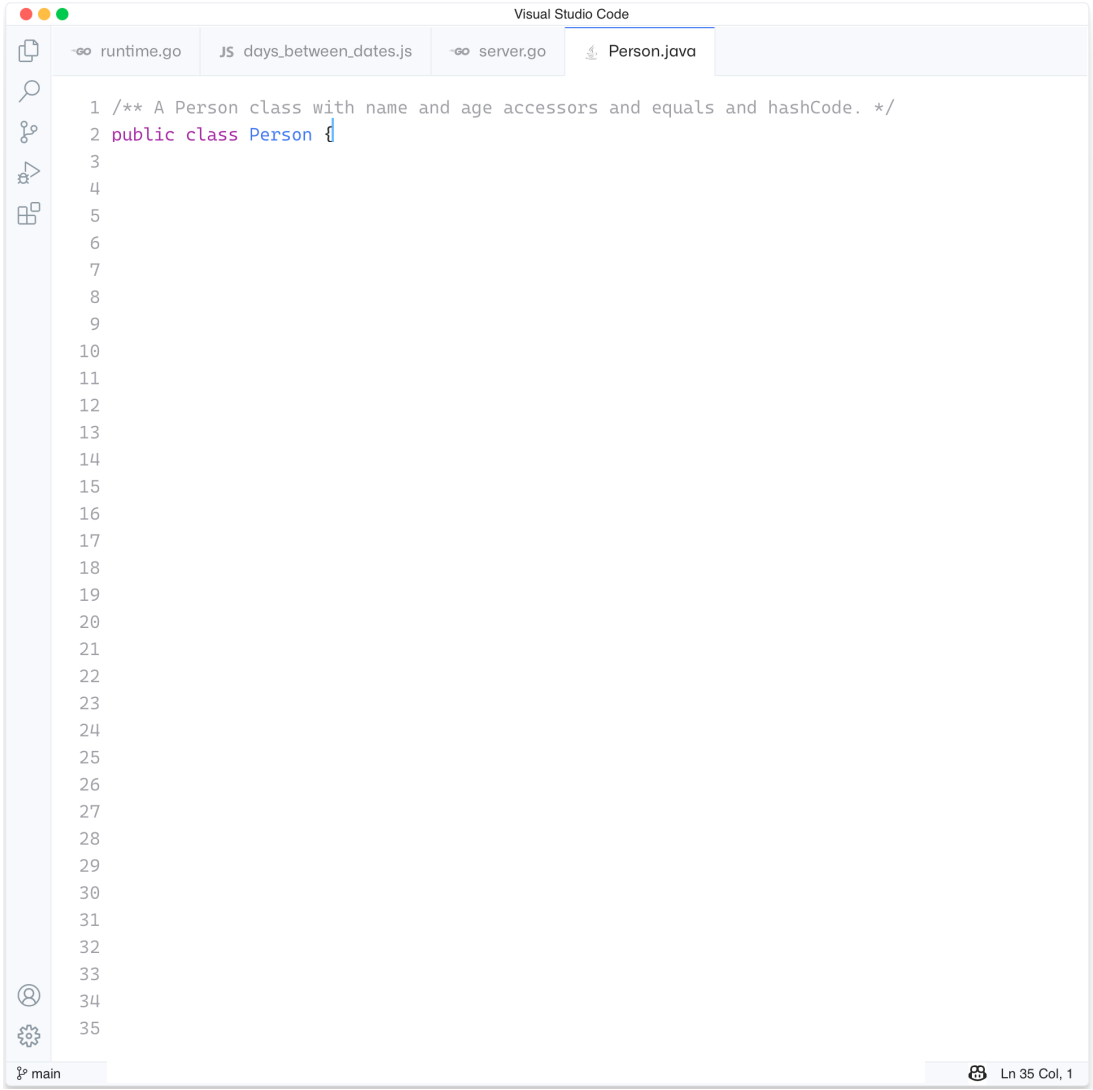
Viewpoint

The End of Programming

The end of classical computer science is coming, and most of us are dinosaurs waiting for the meteor to hit.

I CAME OF AGE in the 1980s, programming personal computers such as the Commodore VIC-20 and Apple][e at home. Going on to study computer science (CS) in college and ultimately getting a Ph.D. at Berkeley, the bulk of my professional training was rooted in what I will call "classical" CS: programming, algorithms, data structures, systems, programming languages. In Classical Computer Science, the ultimate goal is to reduce an idea to a program written by a human—source code in a language like Java or C++ or Python. Every idea in Classical CS—no matter how complex sophisticated, from a database join mind-bogglingly ob- protocol—can be

https://m-cacm.acm.org/magazines/2023/1/267976-the-end-of-programming/fulltext



https://copilot.github.com

https://youtu.be/SGUCcjHTmGY

Why are we here?

"GitHub Copilot is powered by Codex, the new AI system created by OpenAI. GitHub Copilot understands significantly more context than most code assistants. So, whether it's in a docstring, comment, function name, or the code itself, GitHub Copilot uses the context you've provided and synthesizes code to match. Together with OpenAI, we're designing GitHub Copilot to get smarter at producing safe and effective code as developers use it."

Guest

Don’t quit your day job: Generative AI and the end of programming

Mike Loukides, O'Reilly Media

@mikeloukides

August 6, 2023 10:10 AM

Image Credit: VentureBeat made with Midjourney

https://venturebeat.com/ai/dont-quit-your-day-job-generative-ai-and-the-end-of-programming/

Programmers needed: AI lacks design skills

That “rest of the job” (particularly the “user’s needs” part) is something our industry has never been particularly good at. Design — of the software itself, the user interfaces and the data representation — is certainly not going away and isn’t something the current generation of AI is very good at.

We’ve come a long way, but I don’t know anyone who hasn’t had to rescue code that was best described as a “seething mass of bits.” Testing and debugging — well, if you’ve played with ChatGPT much, you know that testing and debugging won’t disappear. AIs generate incorrect code, and that’s not going to end soon.

Security auditing will only become more important, not less; it’s very hard for a programmer to understand the security implications of code they didn’t write. Spending more time on these things — and leaving the details of pushing out lines of code to an AI — will surely improve the quality of the products we deliver.

https://venturebeat.com/ai/dont-quit-your-day-job-generative-ai-and-the-end-of-programming/

“We explore Copilot’s performance on three distinct code generation axes—examining how it performs given diversity of weaknesses, diversity of prompts, and diversity of domains. In total, we produce 89 different scenarios for Copilot to complete, producing 1,689 programs. Of these, we found approximately 40% to be vulnerable.”

H. Pearce, B. Ahmad, B. Tan, B. Dolan-Gavitt and R. Karri, "Asleep at the Keyboard? Assessing the Security of GitHub Copilot’s Code Contributions," 2022 IEEE Symposium on Security and Privacy (SP), 2022, pp. 754-768, doi: 10.1109/SP46214.2022.9833571.

Activity - Software Design is about?

INTRODUCE YOURSELF TO THE STUDENT WHO SIT NEXT TO YOU AND TELL THEM WHY YOU ARE HERE.

PICK AN OBJECT YOU HAVE USED SINCE THIS MORNING THAT YOU CONSIDERED AS AN EXAMPLE OF GOOD DESIGN. EXPLAIN WHY.

WRITE DOWN FIVE ACTIVITIES RELATED TO SOFTWARE DESIGN THAT MIGHT HELP TO ACHIEVE HIGH QUALITY SOFTWARE.

Good design is

Inclusive

Intuitive

Stress-free

sustainable

A problem-solver

Blends into the environment

……

Software Design is about?

Managing COMPLEXITY

Image source: https://sourcemaking.com/files/sm/images/spagett.jpg

Software Design is about?

Complexity leads to

change amplification,

cognitive load, and

unknown unknown

Software Design is about?

Coping with imperfect world --

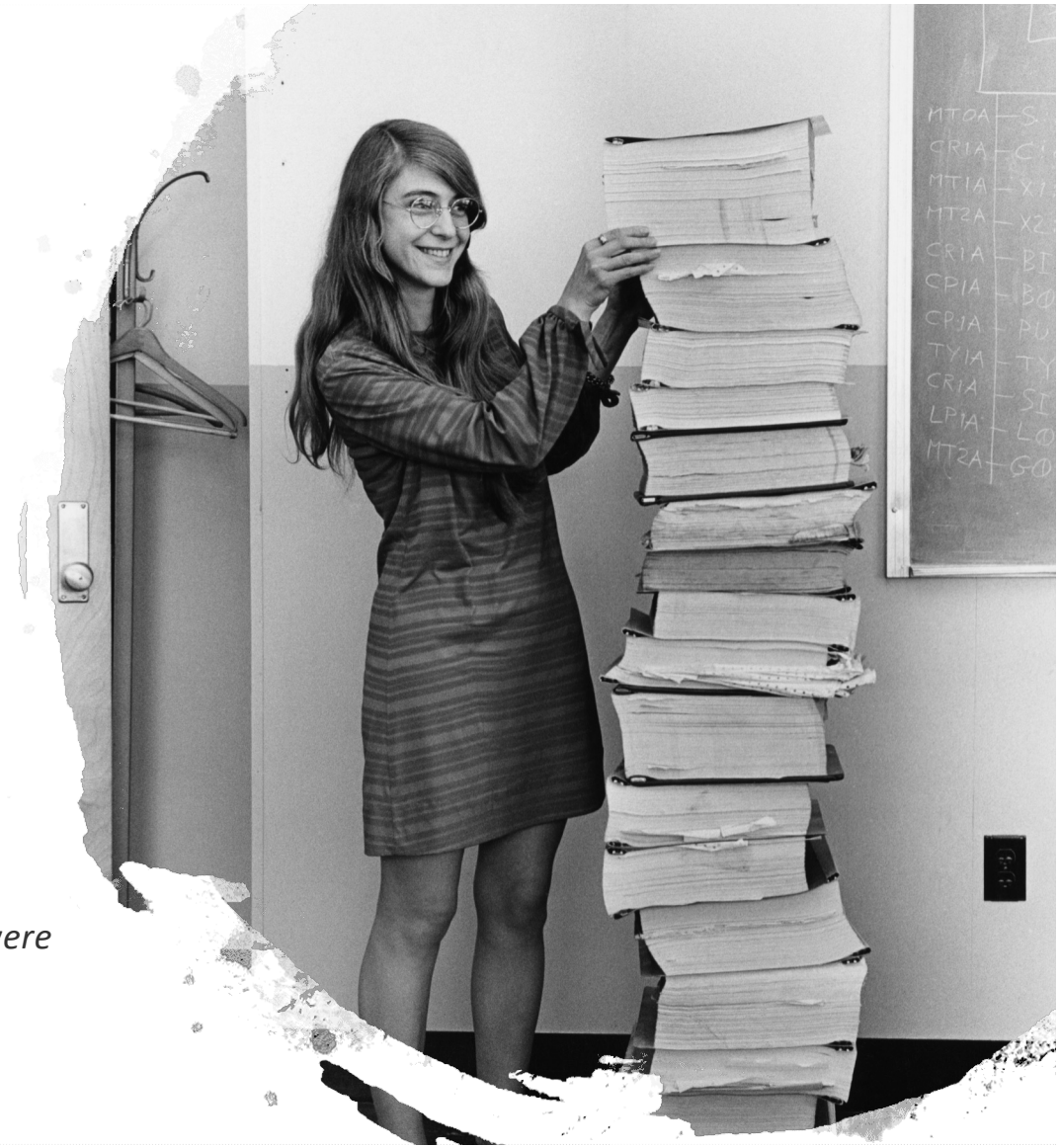
the potential defects from

Client

Developer/User

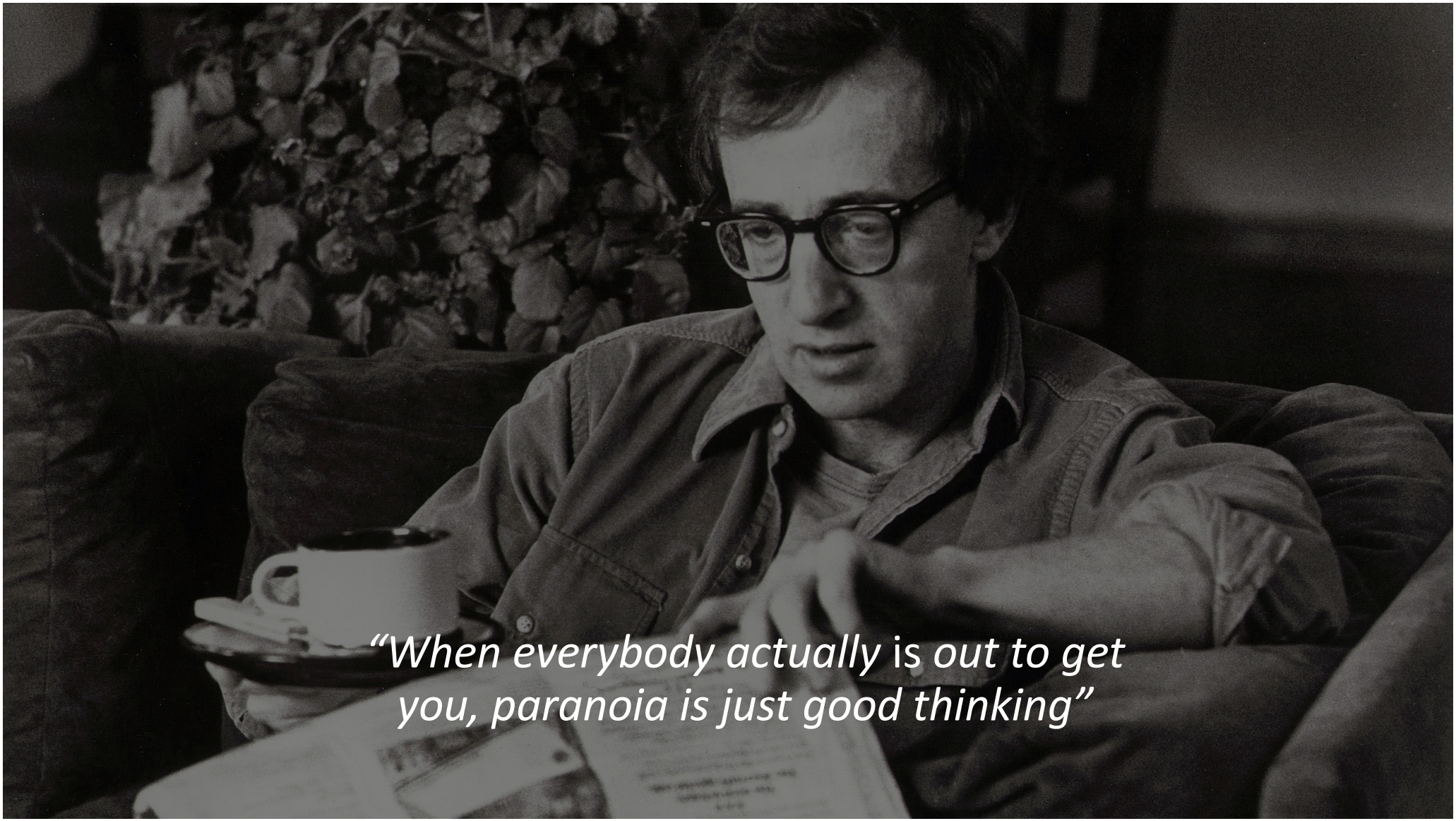
Environment

Software



NASA: "Astronauts would not make any mistakes. They were trained to be perfect."

Plenary Session by Margaret Hamilton @ ICSE 2018
https://youtu.be/ZbVOF0Uk5lU


“When everybody actually is out to get
you, paranoia is just good thinking”

Software Design is about?

Communication with

Computers

PEOPLE

"... the ratio of time spent reading versus writing is well over 10 to 1" – Robert C. Martin

Definition of Software Design

(As a process) the construction of abstractions of data and computation and the organization of these abstraction into a working software application.

- Abstractions – variables, classes, objects, etc.
- Organization – modularized in a flexible and maintainable manner
- Working – correctly functioning (specification, testing)

How to approach software design?

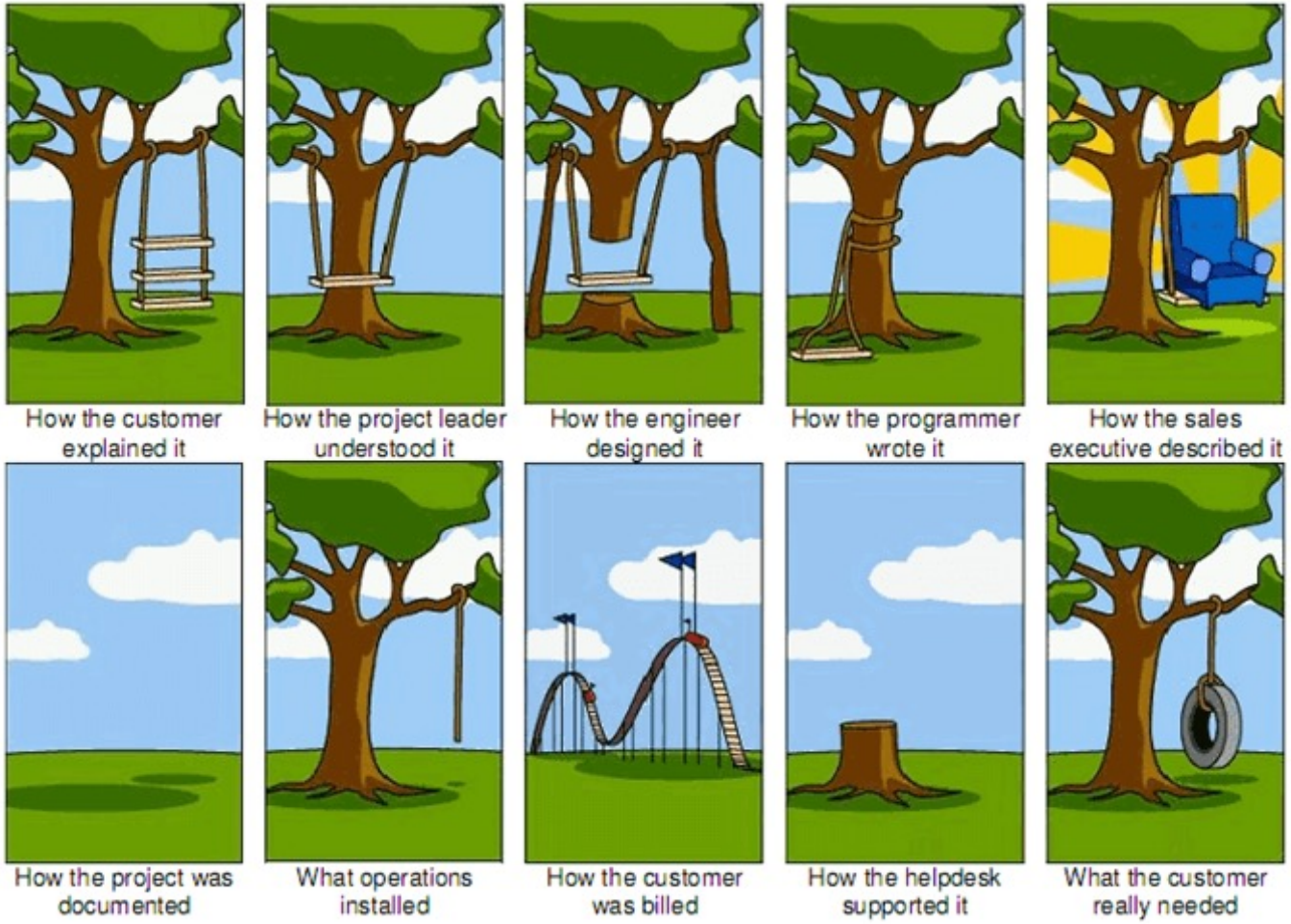


Image Source: http://tamingdata.com/wp-content/uploads/2010/07/tree-swing-project-management-large.png

Design in Software Engineering

- **NATO Software Engineering Conferences** (1968 and 1969)

> The major cause of the ***software crisis*** is that the machines have become several orders of magnitude more powerful! To put it quite bluntly: as long as there were no machines, programming was no problem at all; when we had a few weak computers, programming became a mild problem, and now we have gigantic computers, programming has become an equally gigantic problem.
>
> — *Edsger Dijkstra, The Humble Programmer (EWD340), Communications of the ACM. 1972*

Design in Software Engineering

- **NATO Software Engineering Conferences** (1968 and 1969)

Key questions:

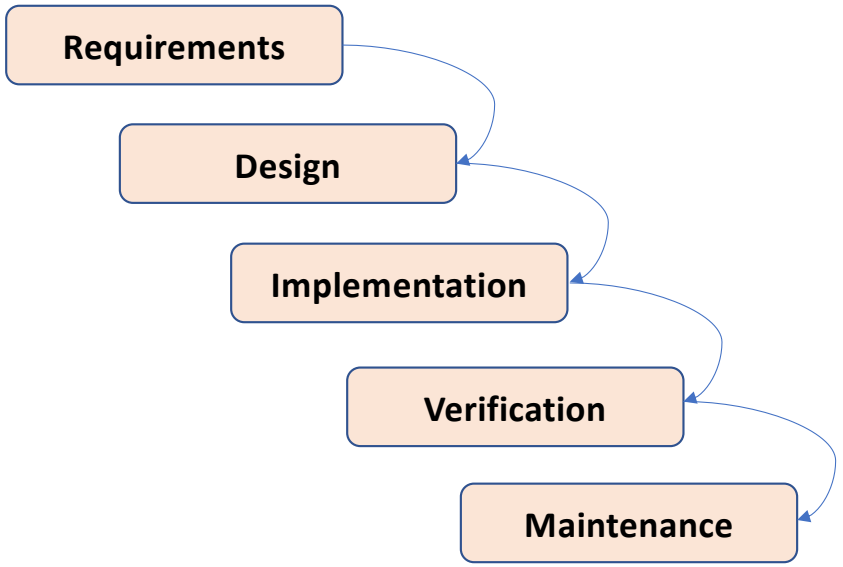
How to keep code maintainable?

How to satisfy extensive and changing requirements?

How to work on code as a team?

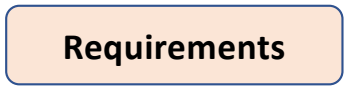
Design in Software Engineering

Software development process



Design in Software Engineering

Software development process



Elicit *Analyze* *Document*

Quality Attribute: **Maintainability, Portability, Reliability, Scalability, Flexibility, Auditability, Documentation, Performance, Security, Usability, …**

Image Source: https://www.outsystems.com/blog/truth-about-non-functional-requirements.html

Design in Software Engineering

Software development process

Conceptual Design

Technical Design

*Recognize the **components**, **connections**, and **responsibility** of the software product.*

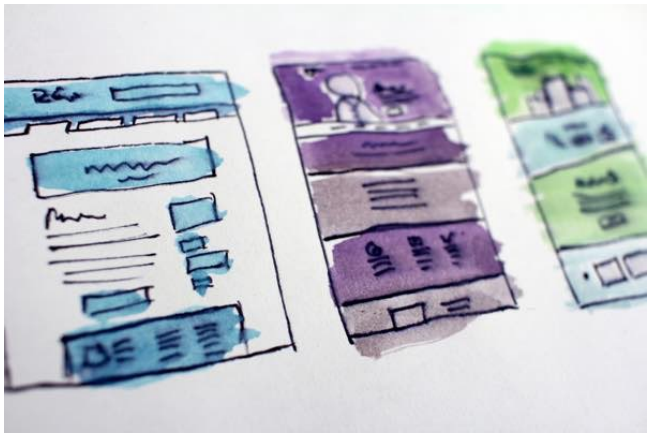


Image source: http://maryshaw.net/wp-content/uploads/ui-design-course.jpg

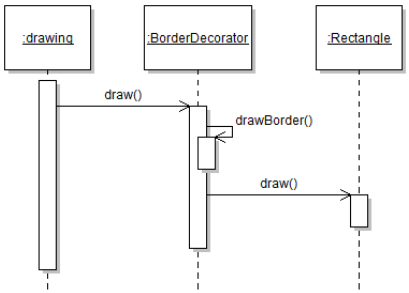
Design in Software Engineering

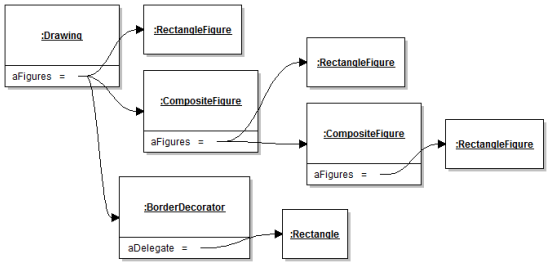
Software development process

Conceptual Design

Technical Design

describe how the responsibilities are met.



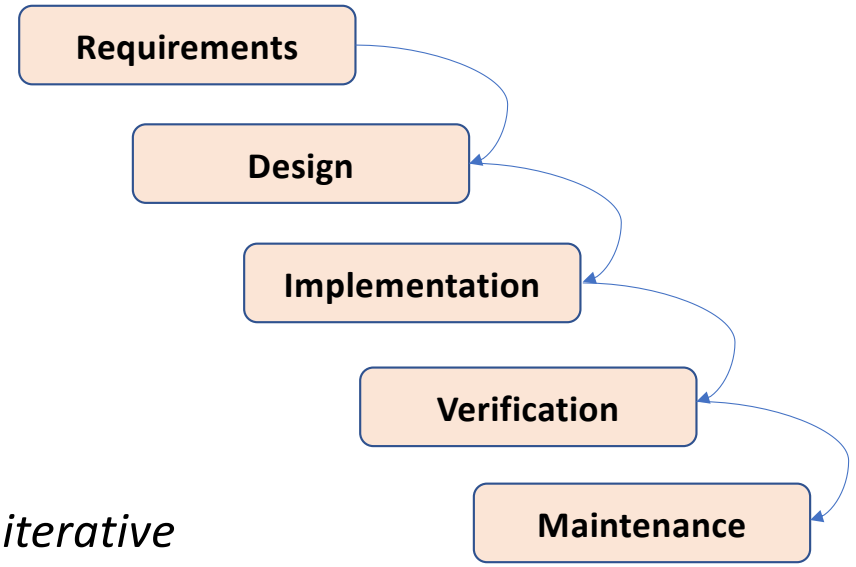


Design in Software Engineering

Software development process

Waterfall

Agile

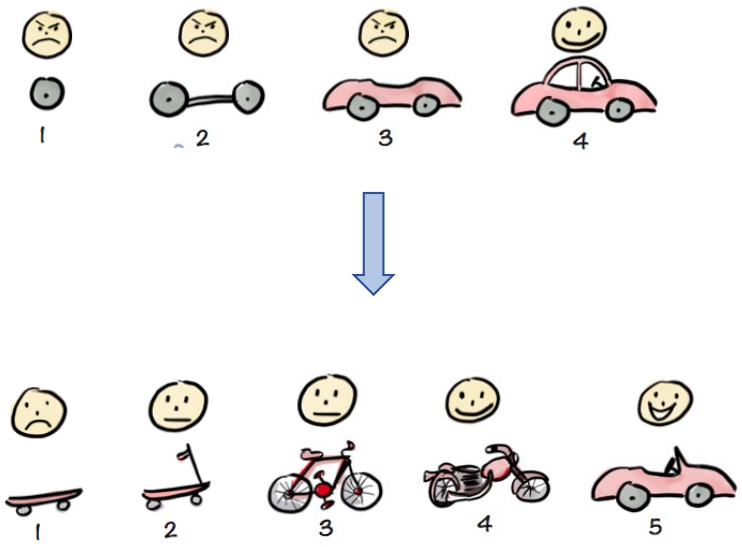


Emphasize incremental and iterative development and delivery

Agile Practices

Waterfall

Agile



Emphasize incremental and iterative development and delivery

Image source: https://blog.crisp.se/2016/01/25/henrikkniberg/making-sense-of-mvp

Agile Practices

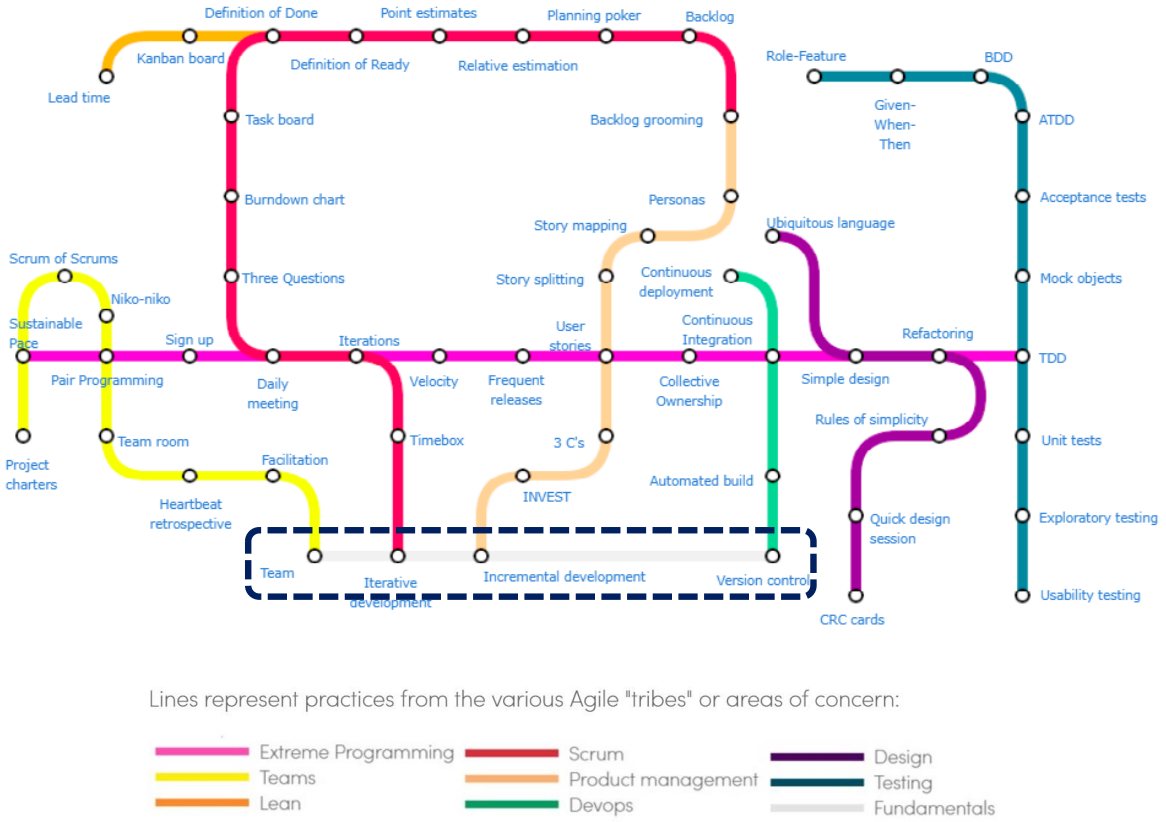
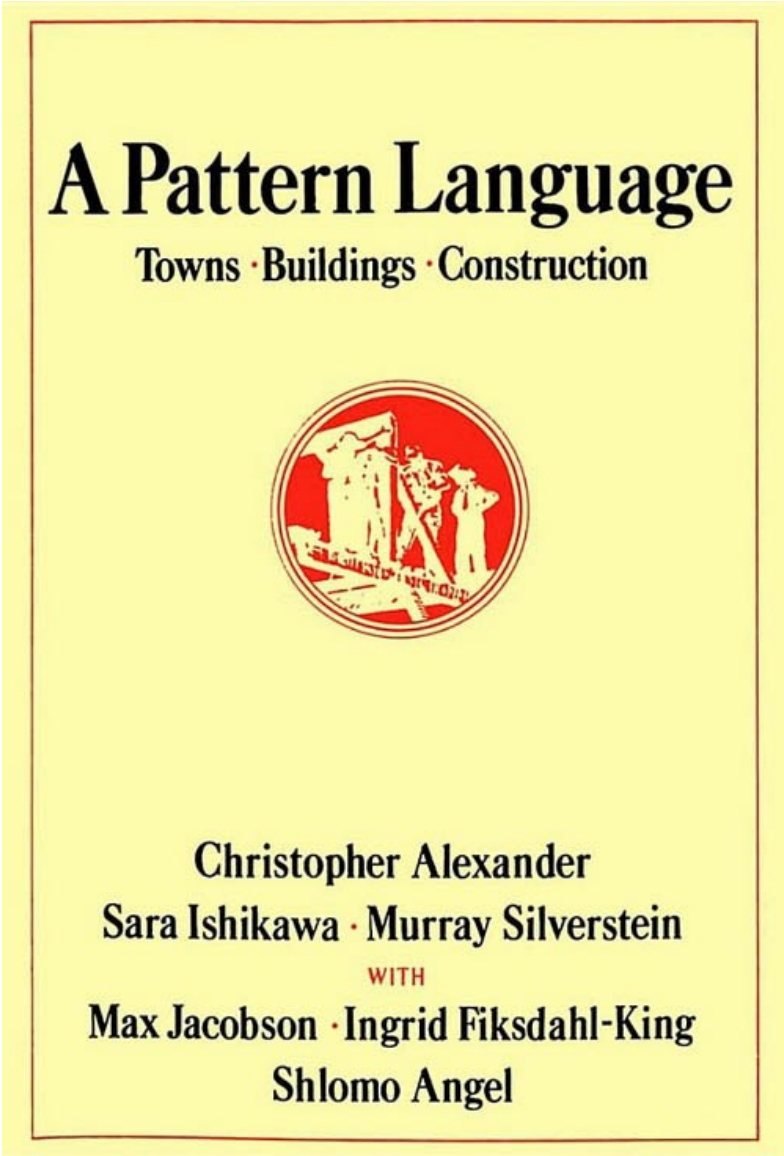


Image source: https://www.agilealliance.org/agile101/subway-map-to-agile-practices/

Storing and Sharing Design knowledge

- Interval -- Human head
- External
  - Source code, including identifier, comments
  - Design documents, including diagrams, blog post
  - Discussion platforms and version control system
  - Design Patterns: name, problem, solution, consequences



Storing and Sharing Design knowledge

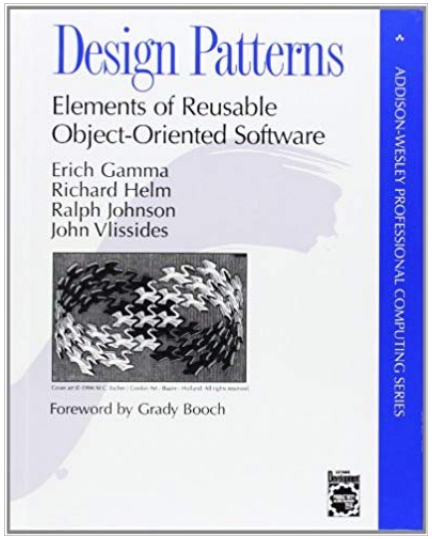
- *"The elements of this language are entities called patterns. Each pattern describes a problem that occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice."* — Christopher Alexander

- How to achieve greater beauty and livability (Wholeness) – within the built environment


1 Levels of Scale
2 Strong Centers
3 Boundaries
4 Alternating Repetition
5 Positive Space
6 Good Shape
7 Local Symmetries
8 Deep Interlock
9 Contrast
10 Graded Variation
11 Roughness
12 Echoes
13 The Void
14 Inner Calm
15 Not-Separateness

Storing and Sharing Design knowledge

- Design pattern
  - Name
  - Problem
  - Solution template
  - Consequences

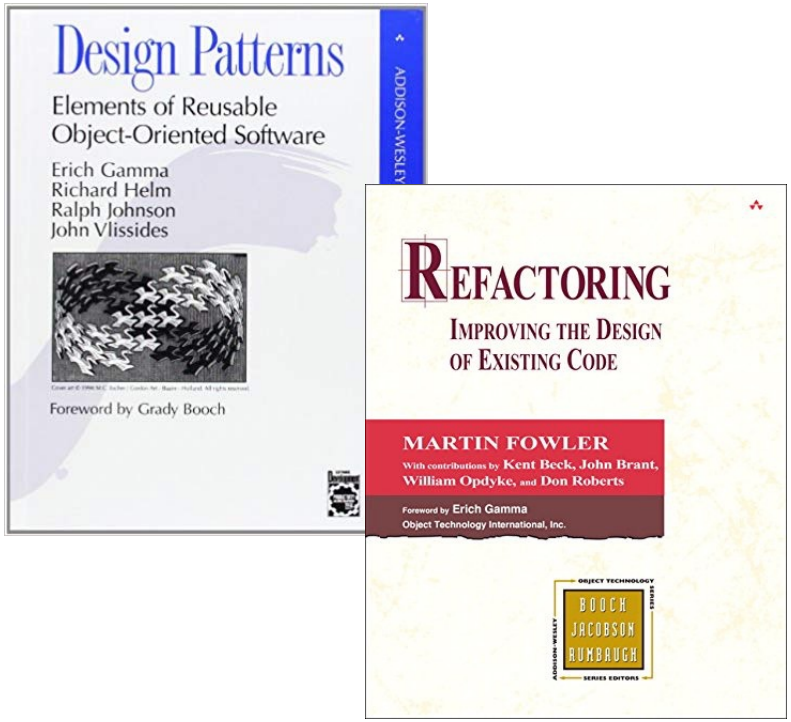


Storing and Sharing Design knowledge

- Design pattern
  - Name
  - Problem
  - Solution template
  - Consequences

- Code smell or Antipatterns
  - God classes
  - Primitive Obsession

  ……



This course is about?

Effectively *Use*

- **Programming language mechanisms**: typing, enumerated types, scopes, access modifiers, assertions, Java interfaces, interface implementation, null references, final variables, optional types, nested classes, closures, unit testing frameworks, JUnit, metaprogramming, annotations, aggregation, delegation, cloning, inheritance, subtyping, downcasting, object initialization, super calls, overriding, overloading, abstract classes, abstract methods, final classes, final methods, application framework, event loop, graphical user interface (GUI).

This course is about?

Properly *Explain* and *Apply*

- **Design Concepts and Principles**: Encapsulation, information hiding, abstraction, immutability, interface, reference sharing, escaping references, polymorphism, loose coupling, reusability, extensibility, separation of concerns, interface segregation, concrete and abstract object states, object life cycle, object identity, object equality, object uniqueness, state space minimization, unit testing, regression testing, quality attributes of unit tests, test suites, test coverage, divide and conquer, law of Demeter, code reuse, extensibility, Liskov substitution principle, inversion of control, model–view–controller (MVC) decomposition, callback method.

This course is about?

Effectively *Adopt*

- **Design Techniques**: class definition, object diagrams, immutable wrappers, reference copying, copy constructors, design by contract, decoupling behavior from implementation, interface-based behavior specification, class diagrams, function objects, iterators, state diagrams, test suite organization, use of test fixtures, testing with stubs, testing private structures, use of test coverage metrics, testing exceptional conditions, sequence diagrams, combining design patterns, inheritance-base reuse, class hierarchy design, adapter inheritance, event handling, GUI design, behavior composition, functions as data sources, interface segregation with first-class functions, pipelining, map–reduce.

This course is about?

Properly *Adopt or Identify*

- **Patterns and Antipatterns:** Primitive Obsession*, Inappropriate Intimacy*, Iterator, Strategy, Switch Statement*, Speculative Generality*, Temporary Field*, Long Method*, Null Object, Flyweight, Singleton, Duplicated Code*, God Class*, Message Chain*, Composite, Decorator, Prototype, Command, Template Method, Pairwise Dependencies*, Observer, Visitor.

This course is NOT about

Reading Comprehension of LLMs' output ….

Background Knowledge

- You have taken COMP 206 and COM 250;

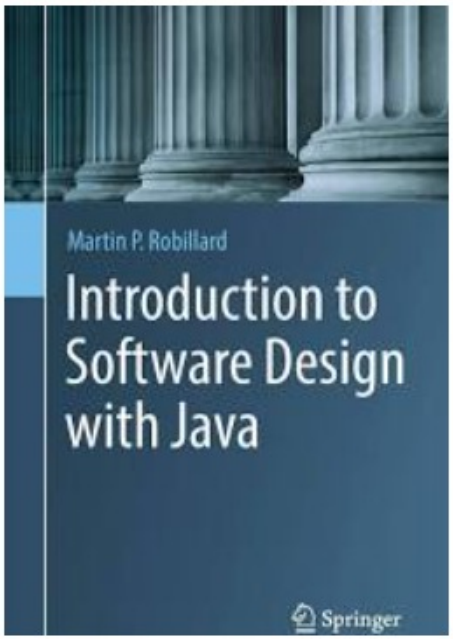
- You are able to
  - Understand and use basic data structures (such as arrays, hash tables, trees and lists);
  - Understand the basic notions of object-oriented programming (such as objects, references, self, interfaces, and subclassing);
  - Write Java programs to solve small and well-defined problems (given the specification);
  - Use a version control system to organize your work;
  - Use a debugger to trace through execution and inspect run-time values.

- Self Assessment

Textbook

- *Introduction to Software Design with Java*

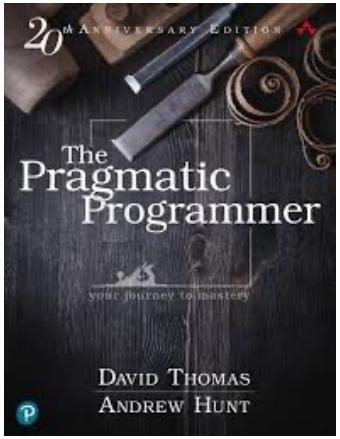
by Martin Robillard, 2nd ed. (SD)



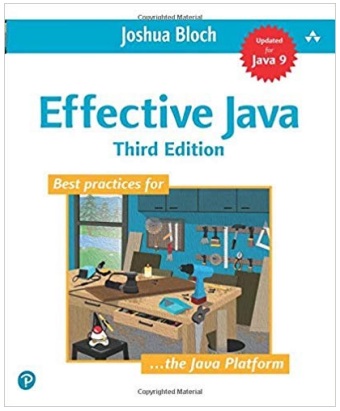
- Companion website: https://github.com/prmr/DesignBook

Other Reference Material

- *The Pragmatic Programmer* by Andrew Hunt and David Thomas, Addison-Wesley, 2019. (PP)



- *Effective Java* by Joshua Bloch, 2nd ed., Addison-Wesley, 2008; or 3rd ed. 2018. (EJ)



Assessment and Evaluation

Participation	5%
Lab tests	20%
Midterm exam	25%
Final exam	50%

TA Team

Avinash Bhat
Divya Kamath
Peiyong Liu
Bhagya Chembakottu
Shira Abramovich
Keyu Yao

Other Logistics

- QA Forum: Ed Discussion, access through MyCourses;
- Regular class attendance is required;
- Syllabus.

Schedule

Lecture	Date	Content	Reading
1	04-Jan	Introduction	SD: Chapter 1
2	09-Jan	Encapsulation - 1	SD: Chapter 2
3	11-Jan	Encapsulation - 2	EJ: Item 15-17
4	16-Jan	Types and Polymorphism - 1	SD: Chapter 3
5	18-Jan	Types and Polymorphism - 2	EJ: Item 14
6	23-Jan	No Class	
7	25-Jan	Types and Polymorphism - 3	
8	30-Jan	Object State - 1	SD: Chapter 4, EJ: Item 10, 11
9	01-Feb	Object State - 2	EJ: Item 1, 3

Schedule

Lecture	Date	Content	Reading
10	06-Feb	Design for Robustness - 1	PP: Topic 23, 24, 25
11	08-Feb	Design for Robustness - 2	EJ: Item 69 - 72
12	13-Feb	Unit Testing - 1	SD: Chapter 5
13	15-Feb	Unit Testing - 2	SD: Chapter 5
14	20-Feb	Content Review	
15	22-Feb	Composition - 1	SD: Chapter 6
16	27-Feb	Composition - 2	SD: Chapter 6
17	29-Feb	Composition - 3	SD: Chapter 6

Schedule

Lecture	Date	Content	Reading
18	12-Mar	TBD	Midterm
19	14-Mar	Inheritance - 1	SD: Chapter 7, EJ:Item 19,20
20	19-Mar	Content Review	
21	21-Mar	Inheritance - 2	SD: Chapter 7, EJ:Item 18
22	26-Mar	Inversion of Control - 1	SD: Chapter 8
23	28-Mar	Inversion of Control - 2	SD: Chapter 8
24	02-Apr	Inversion of Control - 3	SD: Chapter 8
25	04-Apr	Concurrency - 1	Java Concurrency in Practice Chapter 1,2,3
26	09-Apr	Concurrency - 2 and Wrap Up	

Ethics & Integrity

- ACM Code of Ethics and Professional Conduct

https://ethics.acm.org

- Academic Integrity

https://www.mcgill.ca/students/srr/academicrights/integrity

To-do list

- Reading:
  - ACM Code of Ethics and Professional Conduct
  - SD: Chapter 1
- Self Assessment
- Exercise M-0

Next Tuesday

Encapsulation