

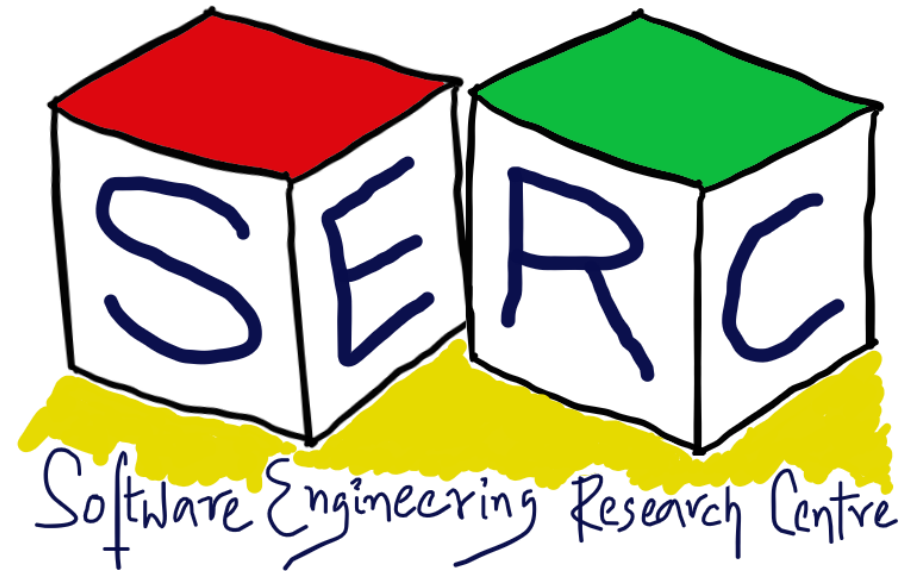
# Refactoring: An Introduction

CS6.401 Software Engineering

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# Acknowledgements

The materials used in this presentation have been gathered/adapted/generate from various sources as well as based on my own experiences and knowledge

-- Karthik Vaidhyanathan


## Sources:

1. Refactoring, Improving the design of existing code, Martin Fowler et al., 2000
2. Refactoring for Software design Smells, Girish Suryanarayana et al.
3. [martinfowler.com](http://martinfowler.com)
4. Few articles by Ipek Ozkaya and Robert Nord, SEI, CMU

*As an E-type system evolves, its complexity increases unless work is done to maintain or reduce it*

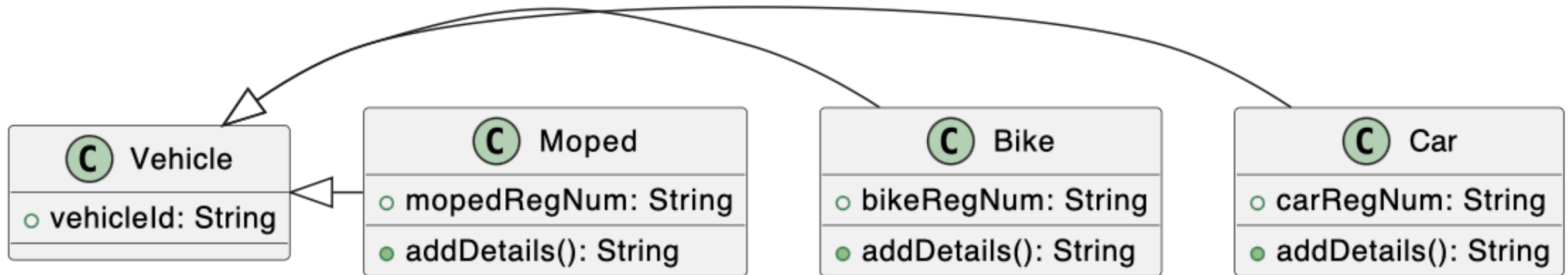
-- Lehmans' Law of Increasing Complexity

# Few Examples to Begin with..

 Payment
<ul style="list-style-type: none"><li>❑ isUPI: boolean</li><li>❑ isInternetBanking: boolean</li><li>❑ paymentId: String</li><li>○ userId: String</li><li>...</li></ul>
<ul style="list-style-type: none"><li>■ processUPIPayment(): String</li><li>■ processInternetBanking(): String</li></ul>

Do you see some issues here?

# Few Examples to Begin with..



What about this?



Ever heard about Technical  
Debt?

# What is Debt?



## debt

/dɛt/

*noun*

a sum of money that is owed or due.  
"I paid off my debts"

**Similar:**

bill

account

tally



# Technical Debt

## Technical Debt



Customer's view



Developer's view

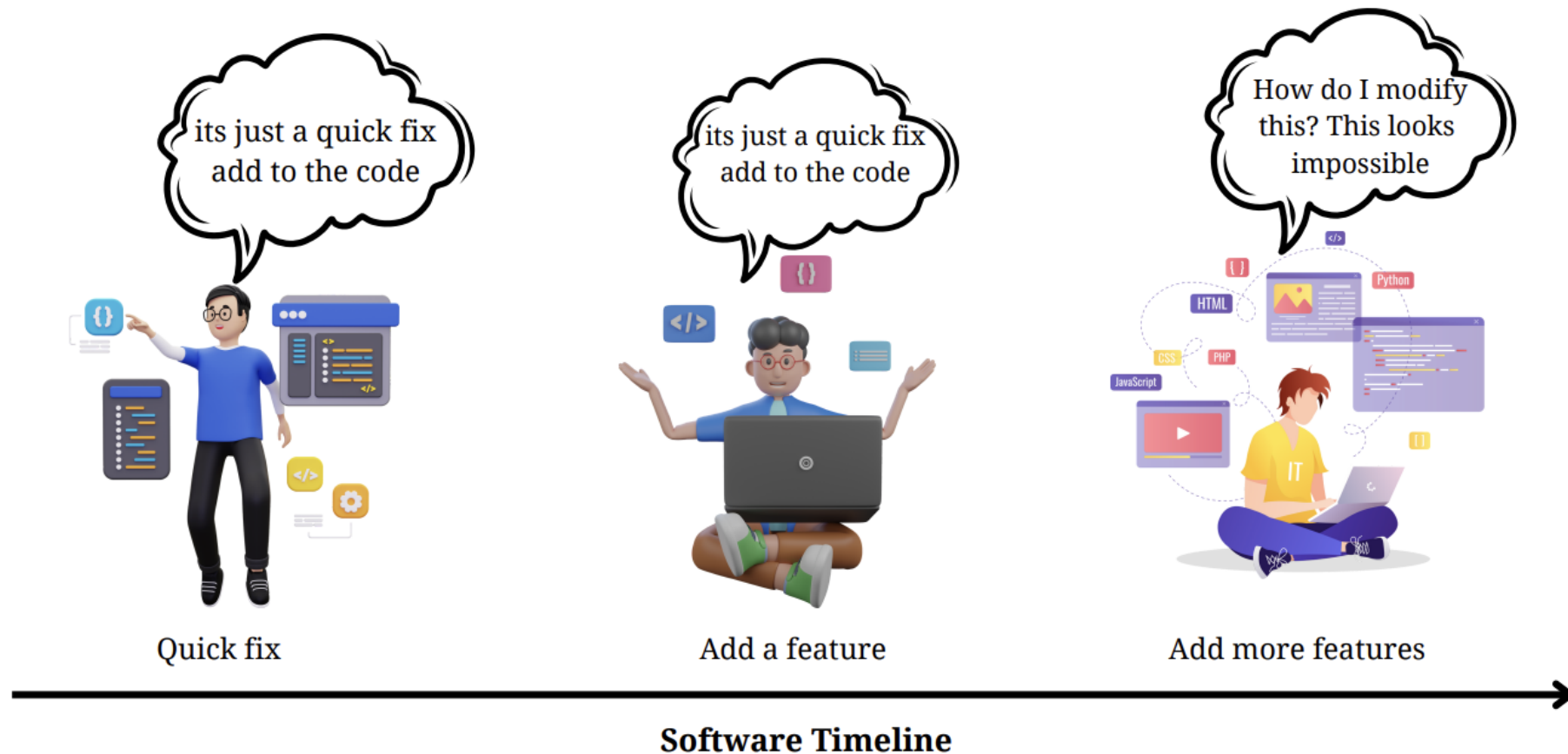




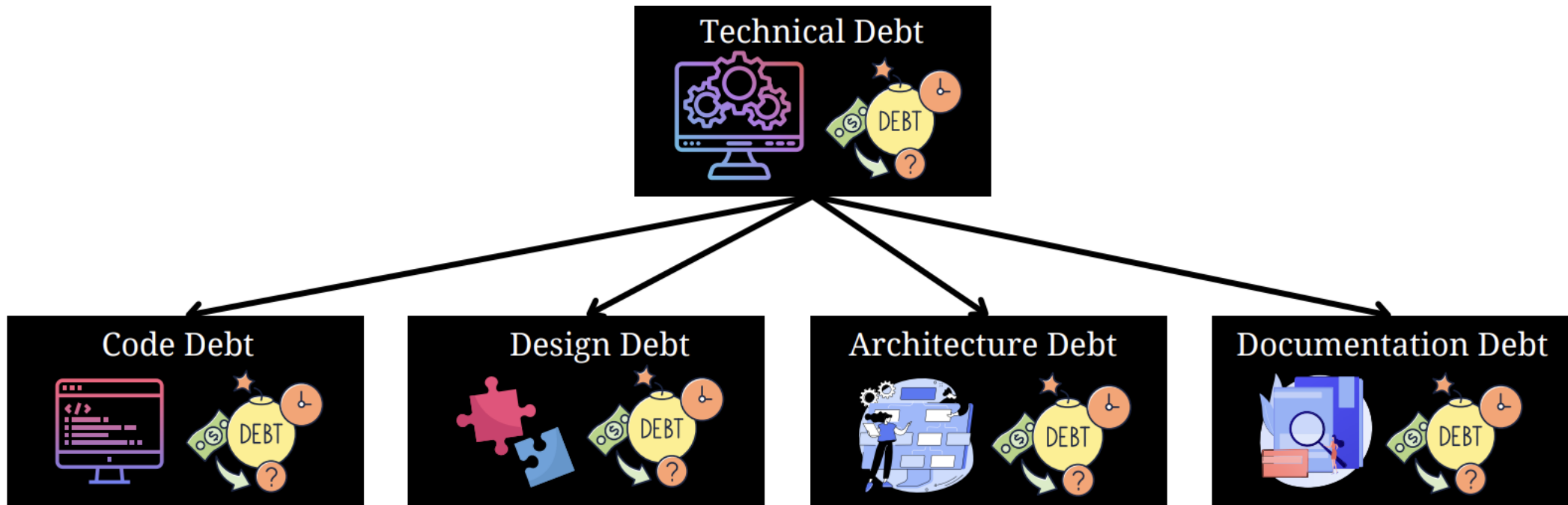
# Technical Debt - Definition

Technical debt is the **debt that accrues** when you knowingly or unknowingly make **wrong or non-optimal design decisions**

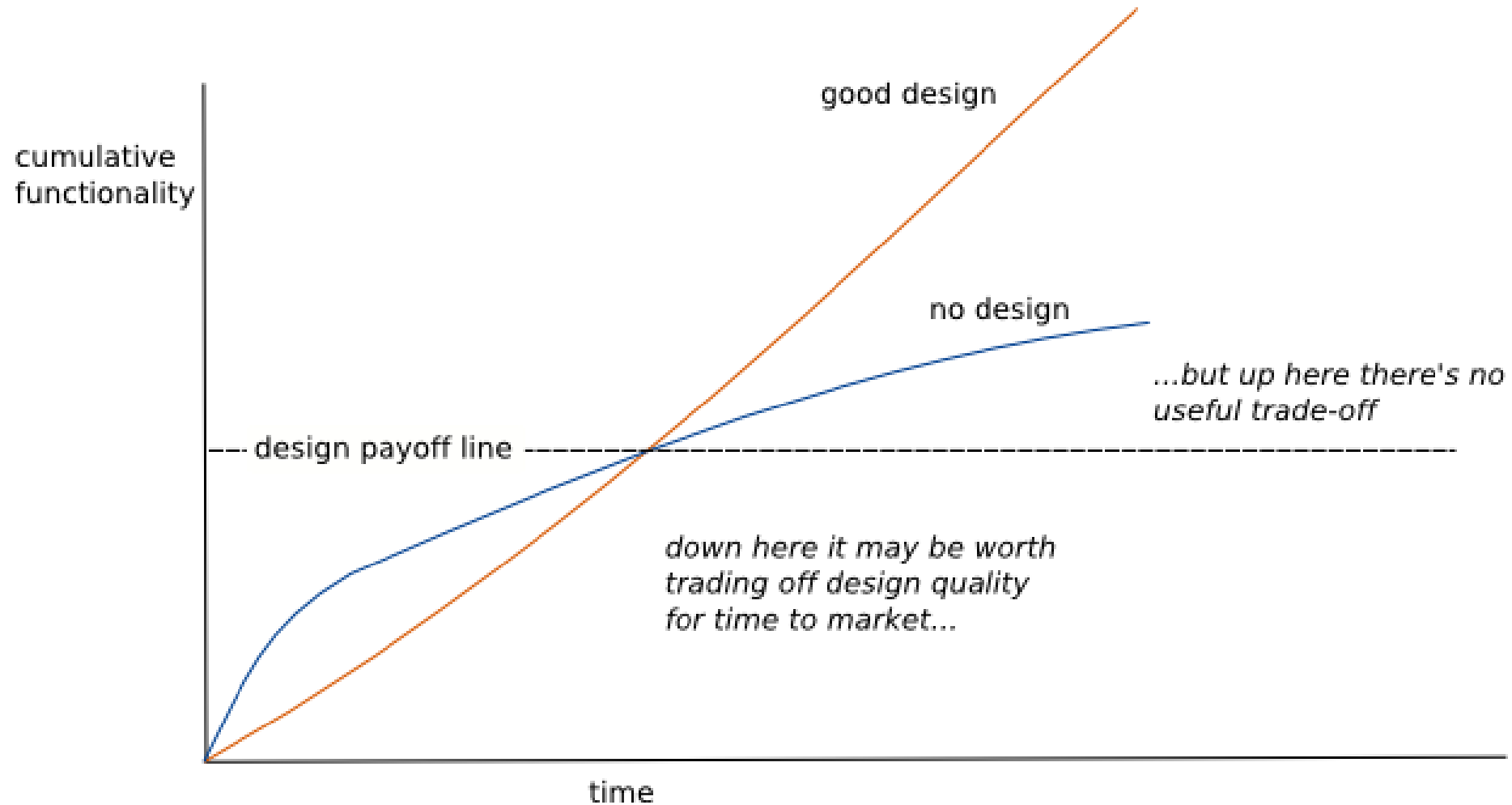
Metaphor coined by *Ward Cunningham*, 1992



# Types of Technical Debt



# Design Stamina Hypothesis



# Impact of Technical Debt

*“One large North American bank learned that its more than 1,000 systems and applications together generated over \$2 billion in tech-debt costs” - McKinsey*

- Interest is very much compounding in nature – changes has to be done on already existing debt
- Cost of Change becomes extremely high!
- Affects morale of development team
- Huge impact on progress of the business – product and feature delays
- Often considered as the digital dark matter!

# Impact of Technical Debt – An Example Scenario

*A successful company in the maritime equipment industry successfully evolved its products for 16 years, in the process amassing 3 million lines of code. Over these 16 years, the company launched many different products, all under warranty or maintenance contracts; new technologies evolved; staff turned over; and new competitors entered the industry.*

*The company's products were hard to evolve. Small changes or additions led to large amounts of work in regression testing with the existing products, and much of the testing had to be done manually, over several days per release. Small changes often broke the code, for reasons unsuspected by the new members of the development team, because many of the design and program choices were not documented.*

What were some things they could have done right?

# Impact of Technical Debt – Another Case

## Southwest Airlines: ‘Shameful’ Technical Debt Bites Back



BY: **RICHI JENNINGS** ON JANUARY 5, 2023 — 0 COMMENTS

Welcome to *The Long View*—where we peruse the news of the week and strip it to the essentials. Let’s work out **what really matters**.

### 20 Years of Neglect Led to ‘Meltdown’

Last month’s débâcle of canceled flights was caused by decades of technical debt. That’s the analysis of Columbia University professor **Zeynep Tufekci**.

#### **Analysis: SWA needs a cloud burst**

Although there were several contributing factors, a lack of scalability in a critical crew scheduling system led to days of near-total paralysis: In many cases, the staff were in the right place to fly and crew the planes, but the *SkySolver* system had no way of knowing that. Making things worse, manual fallbacks collapsed under the **weight of the workload**.

The answer:... **employee scheduling software that debuted around the same time as the Xbox 360 and PlayStation 3.**  
... Southwest pilots have reportedly begged company executives to update the “antiquated” systems since at least 2015.

Eventually someone has to pay for the debt!!

# Reasons for Technical Debt

*Everyone in the decision making could be blamed – Architects, developers, managers.. but that doesn't end there. There are many other reasons..*

- **Schedule pressure** – Copy paste programming
  - Its not always about getting the syntax right and making something work
- **Lack of skilled designers** – Poor applications of design principles
  - Lack of awareness about best practices
  - Leading in the wrong direction
- **Lack of awareness of key indicators and checks** - Design issues
  - Periodic review of design and making changes can go a long way!!



# Lot of research being done!

## TechDebt 2025

Sun 27 - Mon 28 April 2025 Ottawa, Ontario, Canada

### Hidden Technical Debt in Machine Learning Systems

**D. Sculley, Gary Holt, Daniel Golovin, Eugene Davydov, Todd Phillips**  
{dsculley, gholt, dgg, edavydov, toddphillips}@google.com  
Google, Inc.

**Dietmar Ebner, Vinay Chaudhary, Michael Young, Jean-François Crespo, Dan Dennison**  
{ebner, vchaudhary, mwyong, jfcrespo, dennison}@google.com  
Google, Inc.

#### Abstract

Machine learning offers a fantastically powerful toolkit for building useful complex prediction systems quickly. This paper argues it is dangerous to think of these quick wins as coming for free. Using the software engineering framework of *technical debt*, we find it is common to incur massive ongoing maintenance costs in real-world ML systems. We explore several ML-specific risk factors to account for in system design. These include boundary erosion, entanglement, hidden feedback loops, undeclared consumers, data dependencies, configuration issues, changes in the external world, and a variety of system-level anti-patterns.



### ICSE 2025 47th International Conference on Software Engineering

Sun 27 April - Sat 3 May 2025  
Ottawa, Ontario, Canada



### 40th International Conference on Software Maintenance and Evolution

Flagstaff, AZ, USA  
Oct 6 - Oct 11, 2024



# Opportunities for Startup!



Platform ▾

Customers

Partners ▾

Resources ▾



Request a Demo

## Technical Debt Management

Win the Battle! Tackle technical debt with Ardoq

Get Started With Ardoq



# Lot of space!!



Company

Services

Platforms

Industries

Insights

Careers

Contact



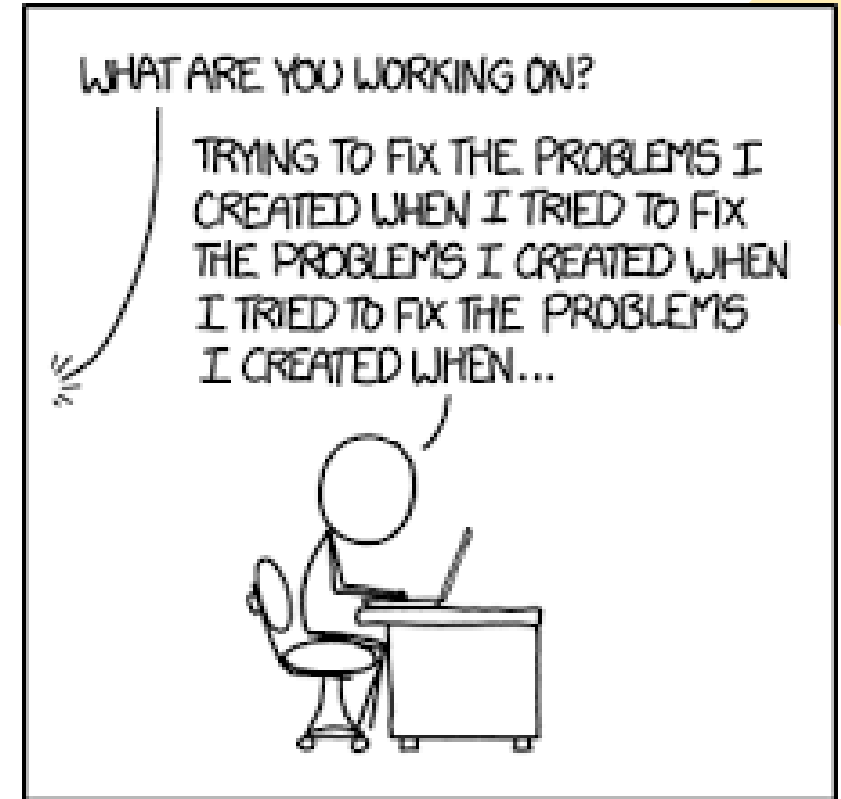
## Technical Debt Management

We help identify, manage and mitigate technical/code debt.



# Managing Technical Debt

- **Increase awareness about tech debt**
  - Being aware is the best start
  - Create goals keeping this in mind
- **Detect and repay tech debt systematically**
  - Identify instances of debt (huge impact)
  - Create systematic plan on recovery
- **Prevent accumulation of tech debt**
  - Once under control, prevent further accumulation
  - Perform regular monitoring
- Companies should allocate some budget for tech debt



# Key Major Questions

1. Why do even good developers write bad software?
2. How do we fix our software?
3. How to know if the software is “bad” even when its working fine?



# Refactoring!

*“Any fool can write code that a computer can understand.  
Good Programmers write code that humans can  
understand”*

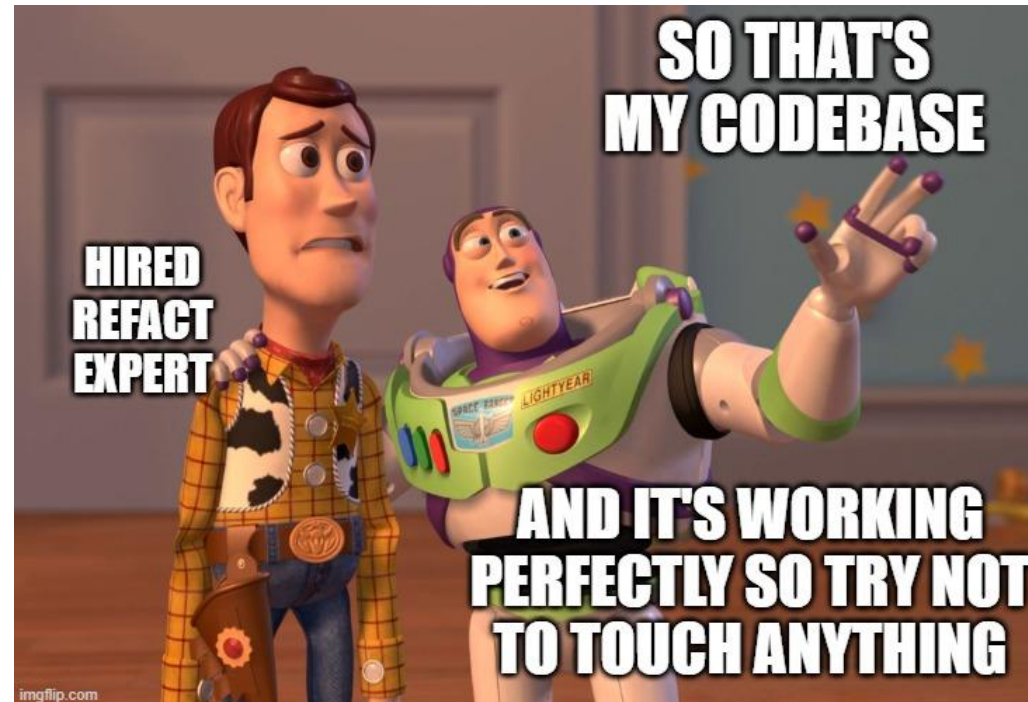


Martin Fowler  
Thoughtworks

# What is Refactoring?

*It is a change made to the internal structure of software to make it easier to understand and cheaper to modify without changing its observable behaviour*

-- Martin Fowler



# What is Refactoring?

- Refactoring is not always a clean up of code!
- Goal is to make software easier to understand and modify
- Think of performance optimization
- Refactoring does not or should not change behavior – No change to external user [Changing hats]
- Not always same as:
  - Adding features
  - Debugging code
  - Rewriting code

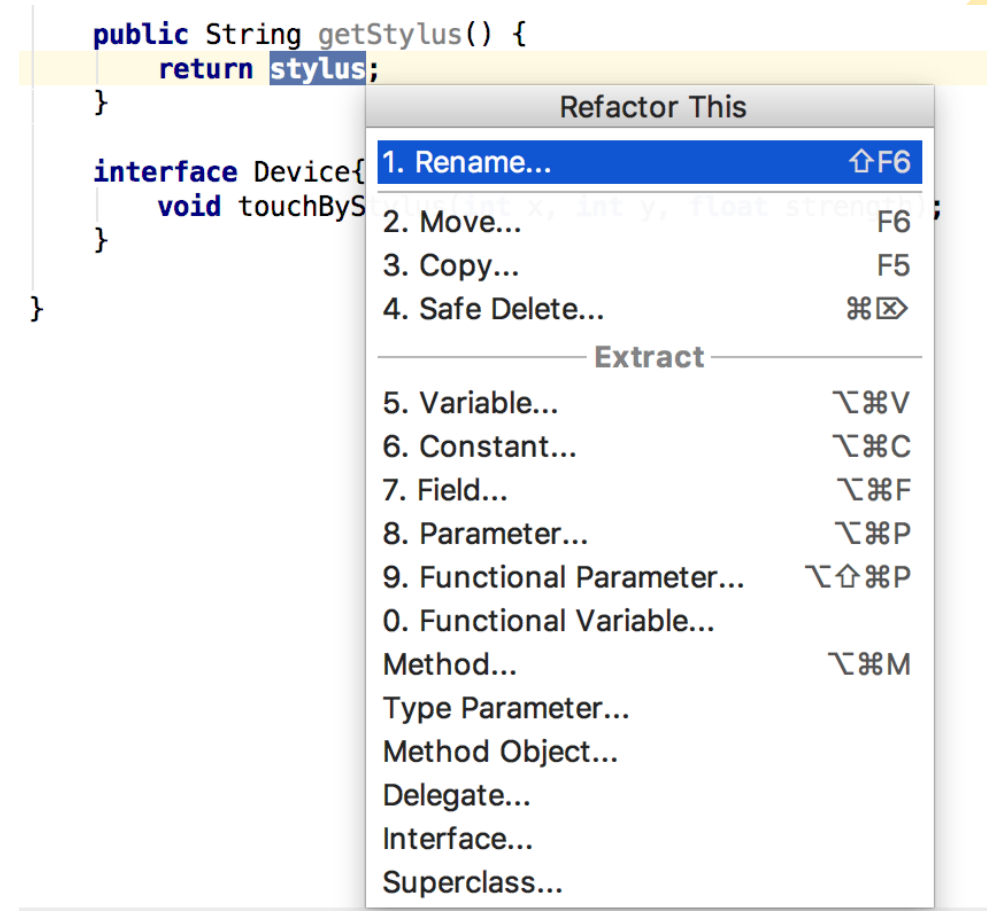
# When to Refactor?

- Follow the rule of three
  - First time, just get it done
  - Second time to do something similar, duplicate
  - Third time, just refactor
- Refactor when you add a function (feature)
  - When adding new feature, make it more effective and efficient
- Refactor when you fix a bug
  - Bug by themselves can be good indicators – Are they becoming more common?
- Refactor when you do code reviews
  - Create review groups for code reviews, new perspective may lead to refactoring



# Some Common Refactoring – Low Level refactoring

- IDEs provide a lot of support
- Variable/method/class renaming
- Extraction of duplicate code snippets
- Change in method signature
- Method or constant extraction
- Warnings about unused variables, parameter uses/declarations
- Auto-completion support and minimal documentation support



# High-level refactoring - Challenges

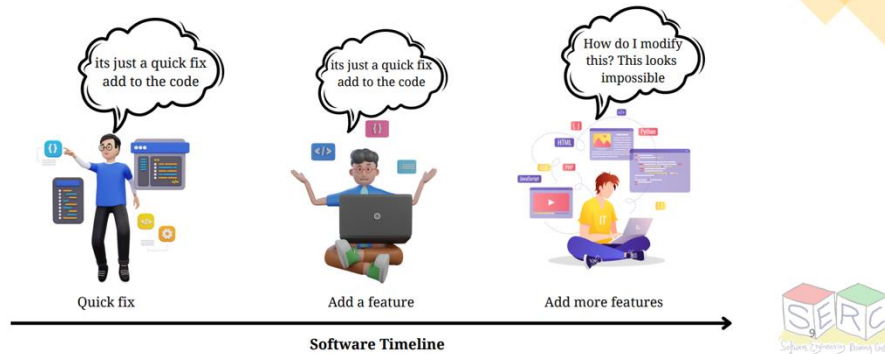
- Much more complex – has dependency on use case, context
- Risk of introducing bugs – Changes in design can introduce new issues
- Testing can become difficult – New test cases needs to be added, overall Behavior may change [ideally not!]
- Communication of changes – Changes can be more abstract and harder to explain
- Measuring the impact – Changes can be harder to quantify

# Summary So Far

## Technical Debt - Definition

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Metaphor coined by *Ward Cunningham*, 1992



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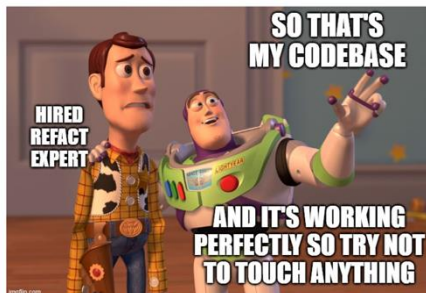
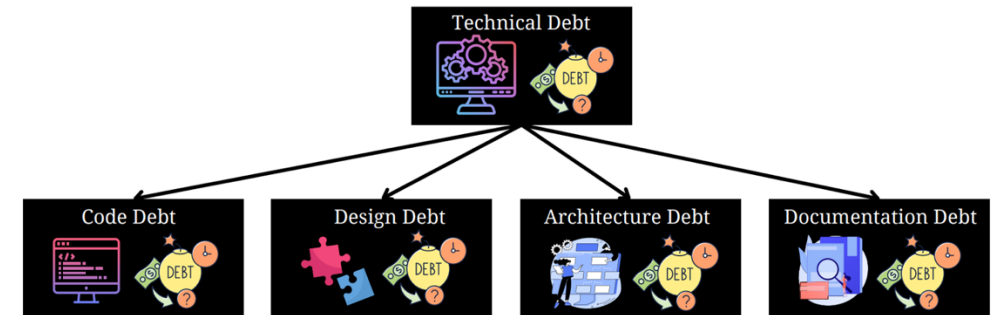


Image source: [imageflip.com](https://www.imageflip.com)

## Types of Technical Debt



## High-level refactoring - Challenges

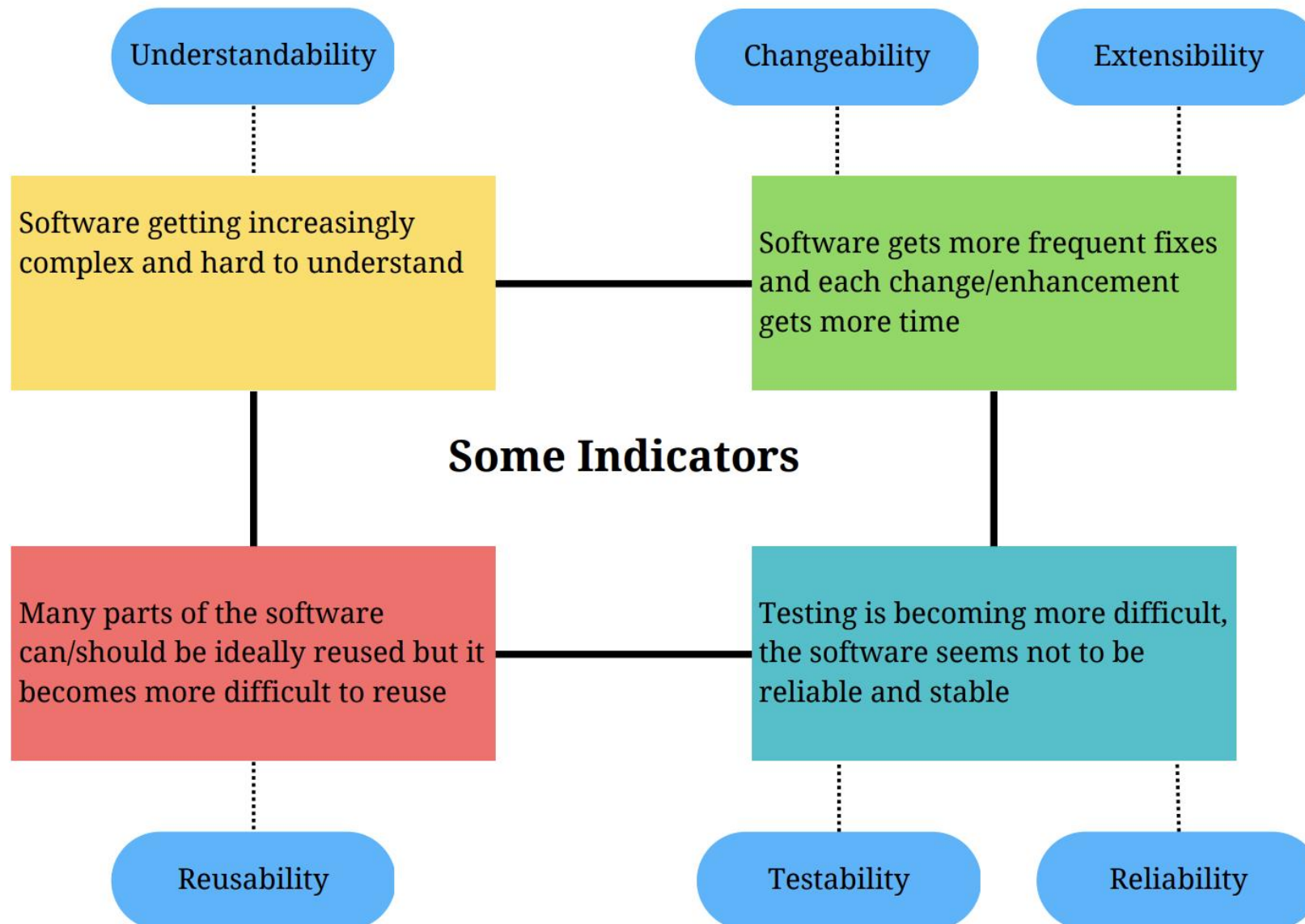
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Image source: [imageflip.com](https://www.imageflip.com)



# How to Identify Technical Debts and Refactor?

# Software Quality as an Indicator

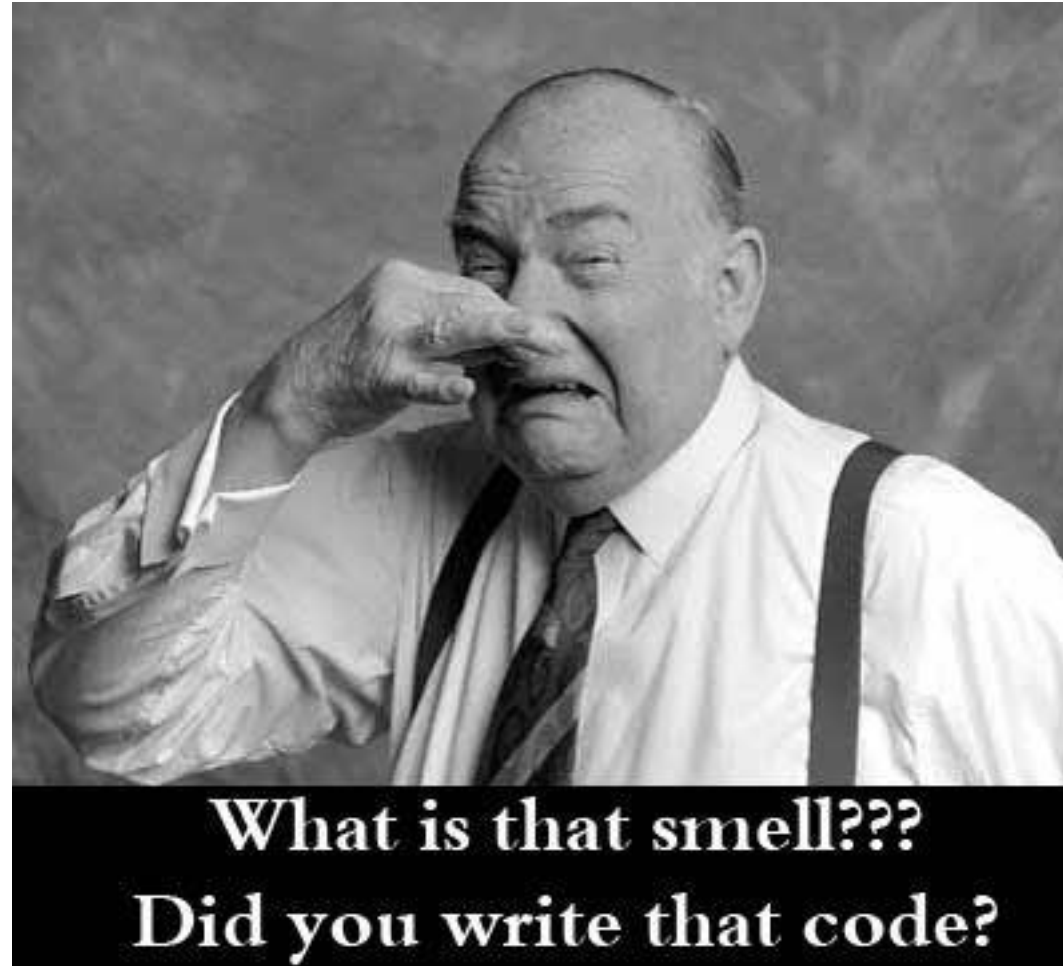


# How to Refactor?

- Identify the refactoring points
- Create a refactoring plan
- Make a backup of the existing codebase: Versioning system
- Use semi-automated approach: Some tool support is always available
- Perform the refactoring
- Test if everything works like before! – Test extensively (new bugs, broken functionalities, etc.)
- Repeat the process

**Remember:** Refactoring is not just a one time activity!!

# Code Smells? You heard that right!



# Refactoring Points - Things starts to rot and **Smell**

*Code Smells and so does design – You heard that right!!!*

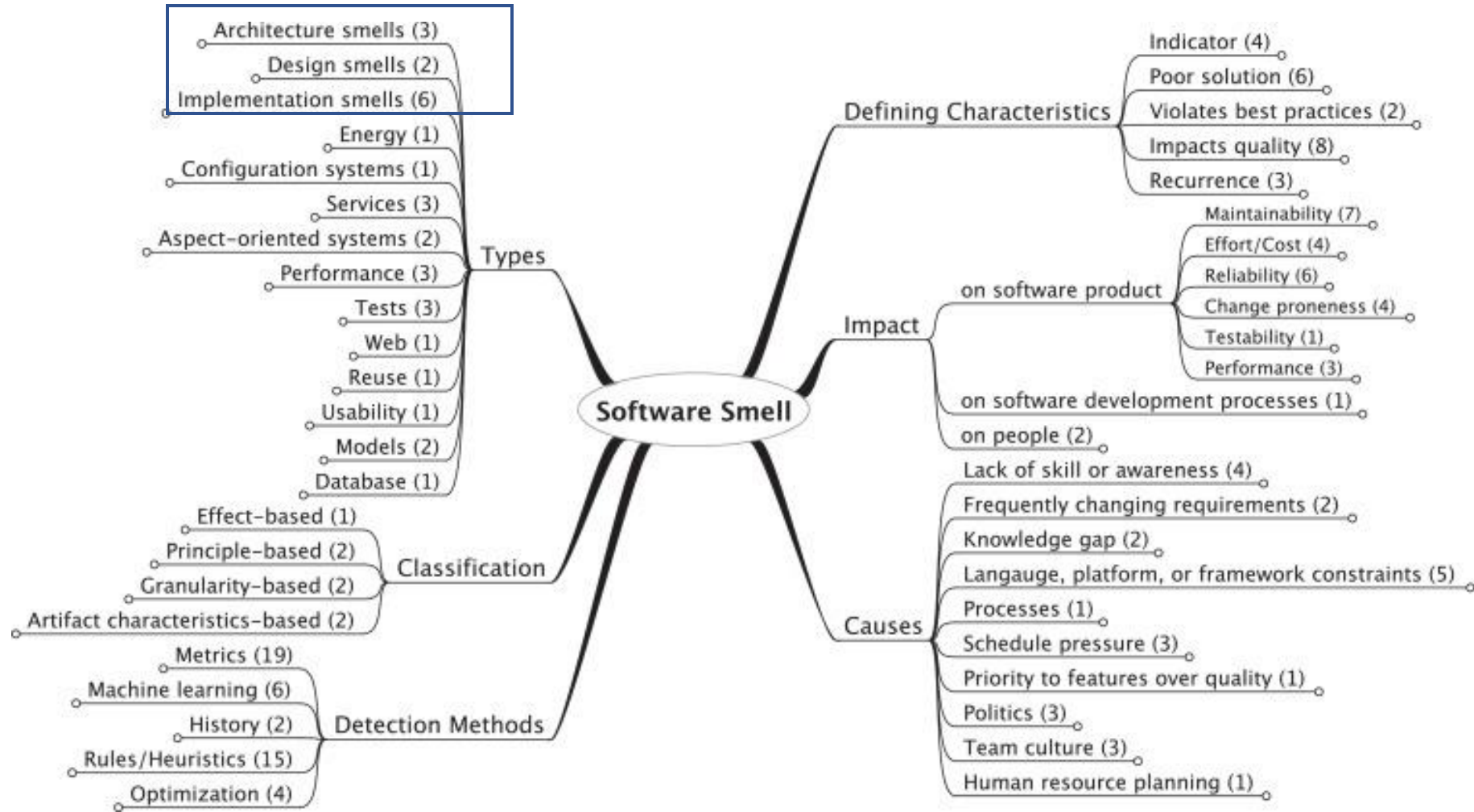
"smell", Coined by Kent Beck in 1999

Smells are certain structures in the code that **suggest** (sometimes they scream for) the **possibility of refactoring**

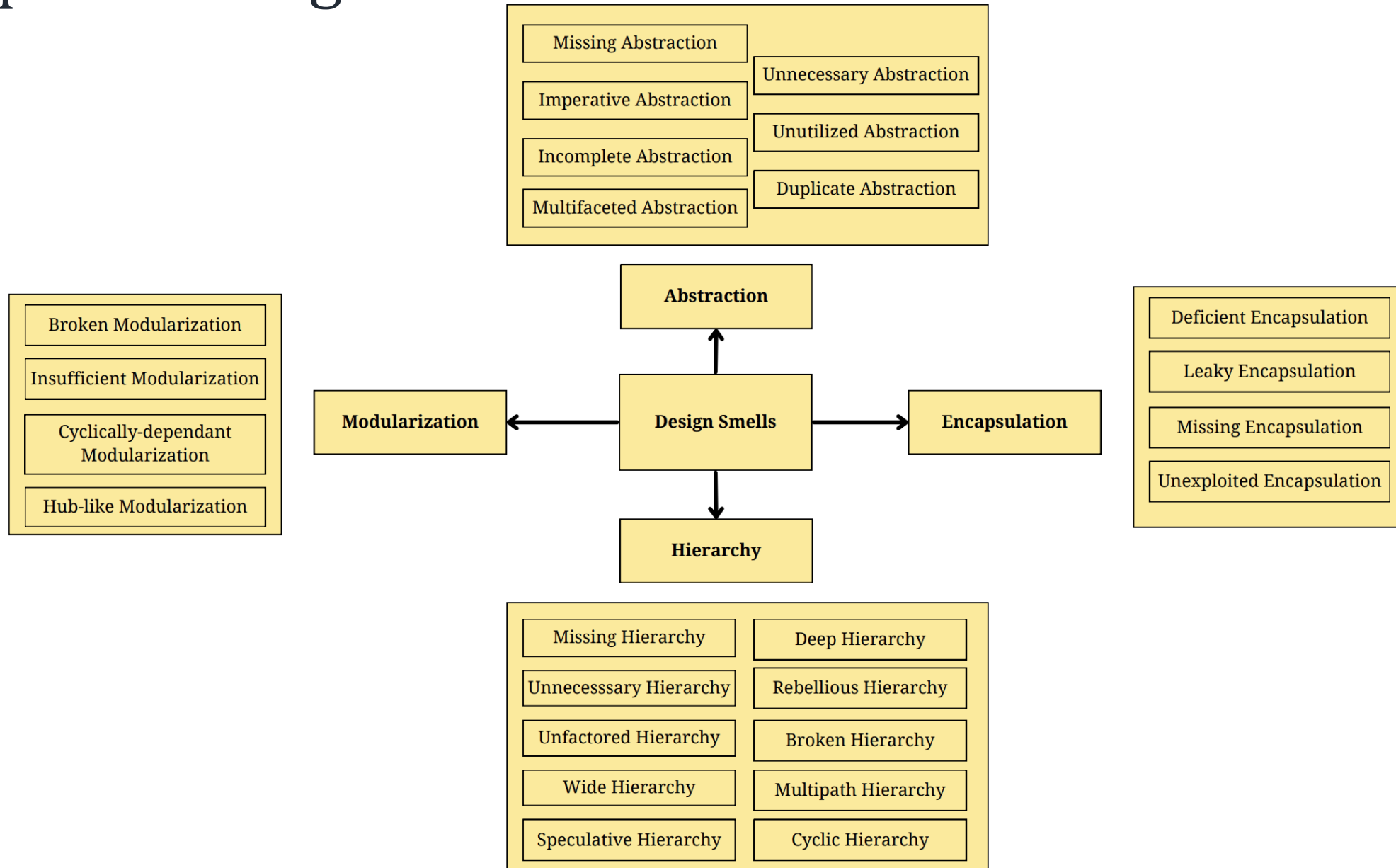
A "bad smell" describes a situation where there are hints that suggest there can be a **design problem**



# Many methods, reasons, ways to detect..



# Types of Design Smells



# Thank You



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