CS 4530
Fundamentals of Software Engineering
Lesson 11: Refactoring, Code Smells and Technical Debt

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Learning Goals

By the end of this lesson, you should be able to…

- Describe different kinds of “Refactoring”: restructuring of code to improve structure.
- Review some common code “smells” (anti-patterns).
- Identify the “technical debt” metaphor; Indicate when and where technical debt is appropriate to accrue versus retire.

Refactoring

- **refactoring** is the process of applying transformations (refactorings) to a program, with the goal of improving its design
- goals:
  - keep program readable, understandable, and maintainable
  - by eliminating small problems soon, you can avoid big trouble later
- characteristics:
  - **behavior-preserving**: make sure the program works after each step
  - **small steps**

History of Refactoring

- refactoring is something good programmers have always done
  - Opdyke's PhD thesis (1990): refactoring tools for Smalltalk
  - popularized by various agile development methodologies

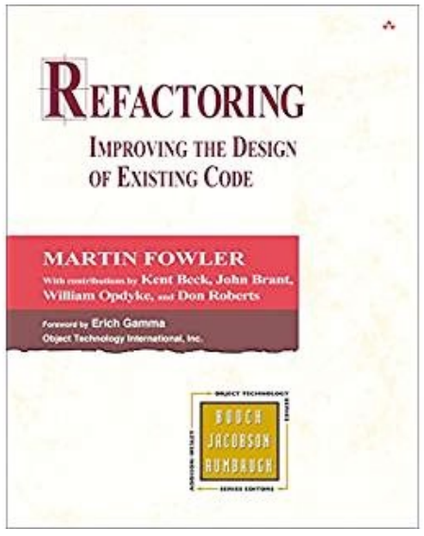
- especially popular in the context of object-oriented languages
  - OO features are well-suited to make designs flexible & reusable
  - but refactoring is not specific to OO

Refactoring

Martin Fowler

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

Fowler's book



- presents a **catalogue of refactorings**, similar to the catalogue of design patterns in the GoF book
  - catalogues "bad smells" - indications that refactoring may be needed
  - explains when and how to apply refactorings

- many of Fowler's refactorings are the inverse of another refactoring
  - often there is not a unique "best" solution
  - discussion of the tradeoffs

Why Refactor?

- requirements have changed, and a different design is needed
- design needs to be more flexible (so new features can be added)
  - design patterns are often a target for refactoring
- address sloppiness by programmers

Example Refactoring

Consolidating duplicate conditional fragments

Original Code

```
if (isSpecialDeal()) {
    total = price * 0.95;
    send()
} else {
    total = price * 0.98;
    send()
}
```

Refactored Code

```
if (isSpecialDeal()) {
    total = price * 0.95;
} else {
    total = price * 0.98;
}
send()
```

Observations

- **small incremental steps** that preserve program behavior
- most steps are so simple that they can be **automated**
  - automation limited in complex cases
- refactoring does not always proceed “in a straight line”
  - sometimes, undo a step you did earlier…
  - …when you have insights for a better design

When to refactor?

Refactoring is incremental redesign

- Acknowledge that it will be difficult to get design right the first time
- When adding new functionality, fixing a bug, doing code review, or any time
- Refactoring evolves design in increments
- Refactoring reduces technical debt
- What do you refactor?

Code Smells

A complete list (links to book!)

Mysterious Name
Duplicated Code
Long Function
Long Parameter List
Global Data
Mutable Data
Divergent Change
Shotgun Surgery
Feature Envy
Data Clumps
Primitive Obsession
Repeated Switches
Loops
Lazy Element
Speculative Generality
Temporary Field
Message Chains
Middle Man
Insider Trading
Large Class
Alternative Classes with Different Interfaces
Data Class
Refused Bequest

“Refactoring: Improving the Design of Existing Code,” Martin Fowler, 1992

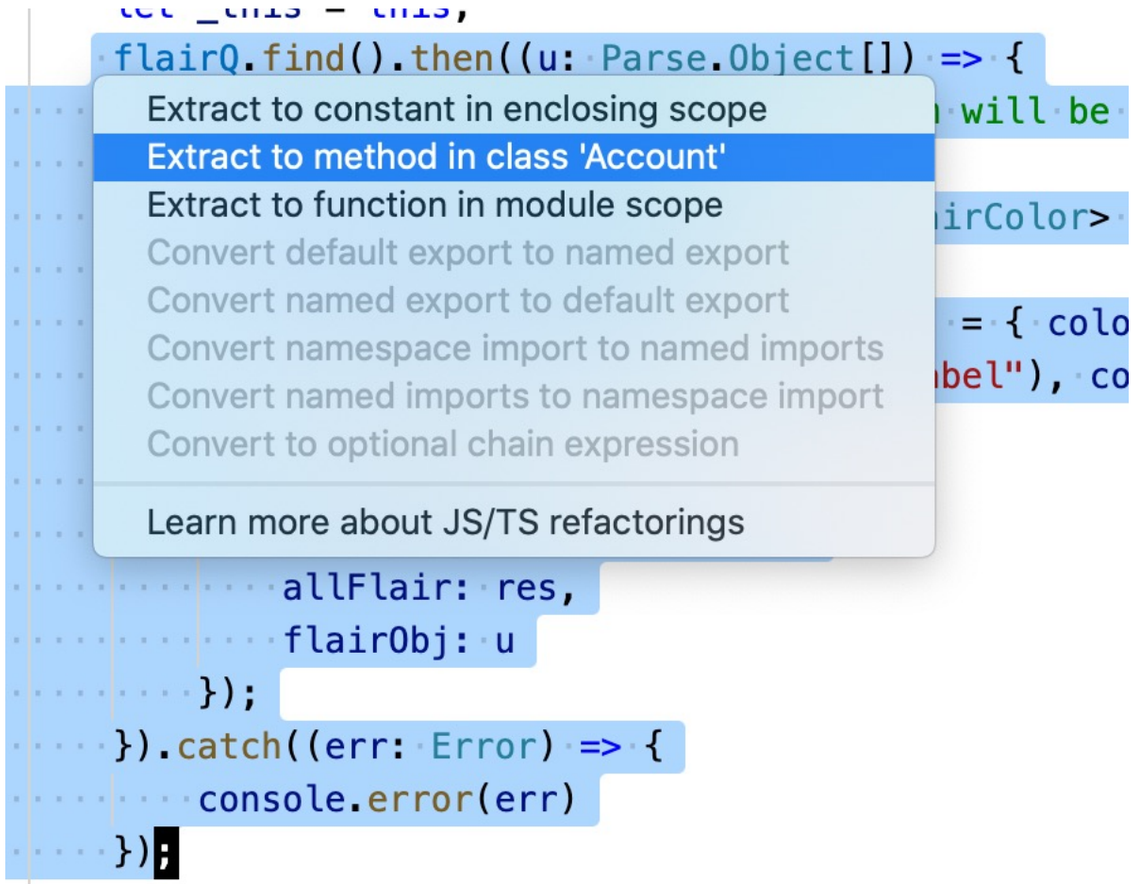
“Local” Refactorings

Rename	rename variables, fields methods, classes, packages provide better intuition for the renamed element’s purpose
Extract Method	extract statements into a new method enables reuse; avoid cut-and-paste programming improve readability
Inline Method	replace a method call with the method’s body often useful as intermediate step
Extract Local	introduce a new local variable for a designated expression
Inline Local	replace a local variable with the expression that defines its value
Change Method Signature	reorder a method’s parameters
Encapsulate Field	introduce getter/setter methods
Convert Local Variable to Field	convert local variable to field sometimes useful to enable application of Extract Method

Type-Related Refactorings

Generalize Declared Type	replace the type of a declaration with a more general type
Extract Interface	create a new interface, and update declarations to use it where possible
Pull Up Members	move methods and fields to a superclass
Infer Generic Type Arguments	infer type arguments for “raw” uses of generic types

Automated Refactorings in VSC



Refactoring Risks

- Developer time is valuable: is this the best use of time *today*?
- Despite best intentions, may not be safe
- Potential for version control conflicts

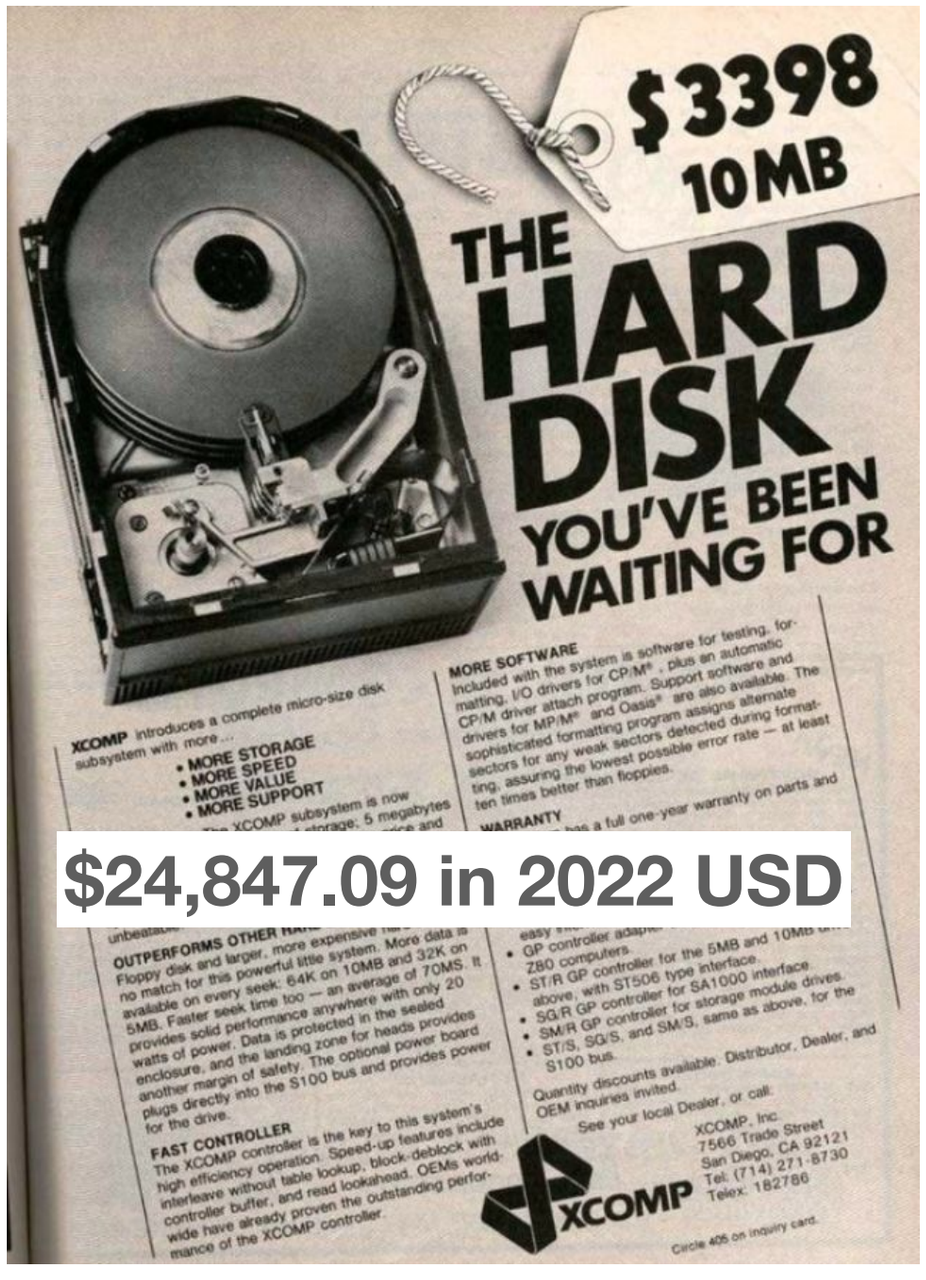
Technical Debt is Sum of Internal Problems in Project Codebase

- Internal because they don't show as user-visible failures.
- Examples:
- Code Smells;
- Missing tests;
- Missing documentation;
- Dependency on old versions of third-party systems;
- Inefficient and/or non-scalable algorithms.

Not just code!

Technical Debt Can Accrue On Purpose

How many digits does it take to store a year?



$24,847.09 in 2022 USD

> "I just never imagined anyone would be using these systems 10 years later, let alone 20."

Philippe Kruchten, Robert Nord, Ipek Ozkaya:
"Managing Technical Debt: Reducing Friction in Software Development"

Technical Debt is Sum of Internal Problems in Project Codebase

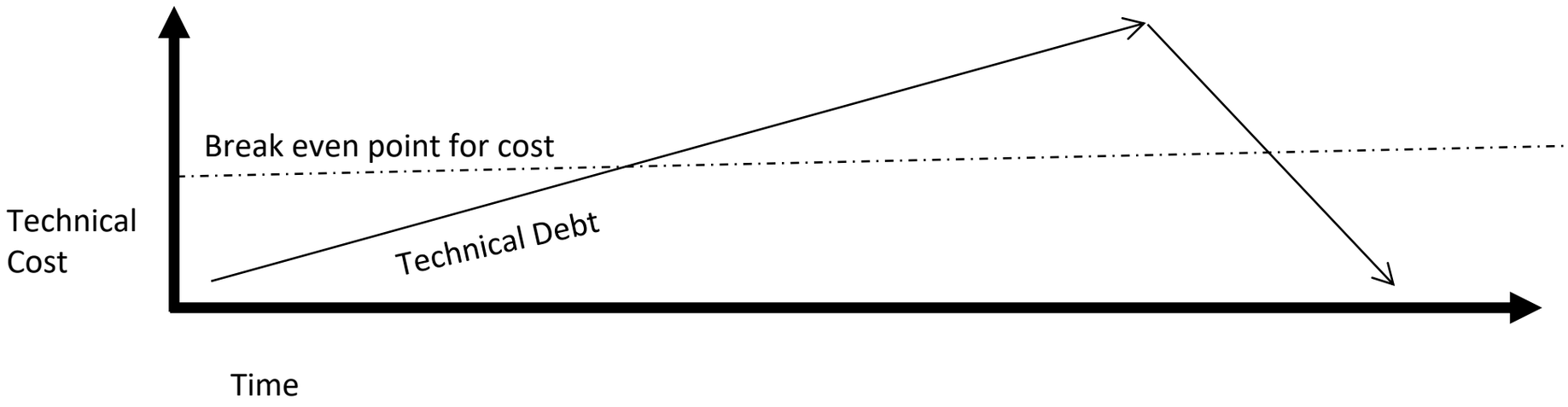
Example of Debt

- Code Smells;
- Missing tests;
- Missing documentation;
- Dependency on old versions of third-party systems;
- Inefficient and/or non-scalable algorithms.
- Sub-optimal architecture choices

Example of Cost

- “Smelly” code is less flexible;
- Need to revert breaking change;
- Can’t figure out how to use;
- May have take over maintenance of old system;
- Lose potential customers.
- Challenges in scalability, maintainability

Interest on Technical Debt Accrues over Time



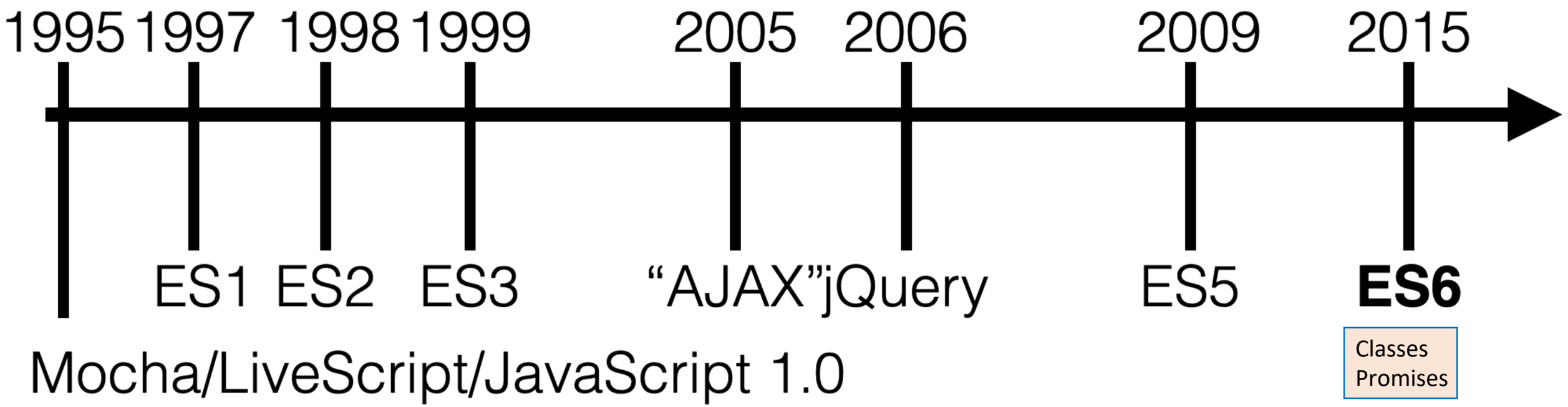
Good Reasons to Go Into Technical Debt

- Prototyping:
  - If code will be discarded, or drastically rewritten, don't waste time perfecting it.
- Getting a product out the door:
  - Time is often crucial in a competitive environment.
- Fixing a critical failure:
  - People are waiting.
- Maybe a simple algorithm is good enough:
  - "Premature optimization is the root of all evil"
    - Tony Hoare, Donald Knuth

Architectural Technical Debt is Most Expensive

- Total cost of ownership generally higher than implementation-level issues; harder to get out of choices of:
  - Language
  - Middleware frameworks
  - Deployment pipeline
- Consider: What are the quality attributes that our software needs to ultimately satisfy, and how do these architectural decisions reflect those attributes?

Evolving Languages bring Technical Debt



PLUS:
2016: ES7 (Array.includes)
2017: ES8 (Async/Await)
2018: ES9 (rest/spread operator, async iterators)

https://www.fastcompany.com/3028778/why-facebook-invented-a-new-php-derived-language-called-hack

Architectural Technical Debt: Facebook

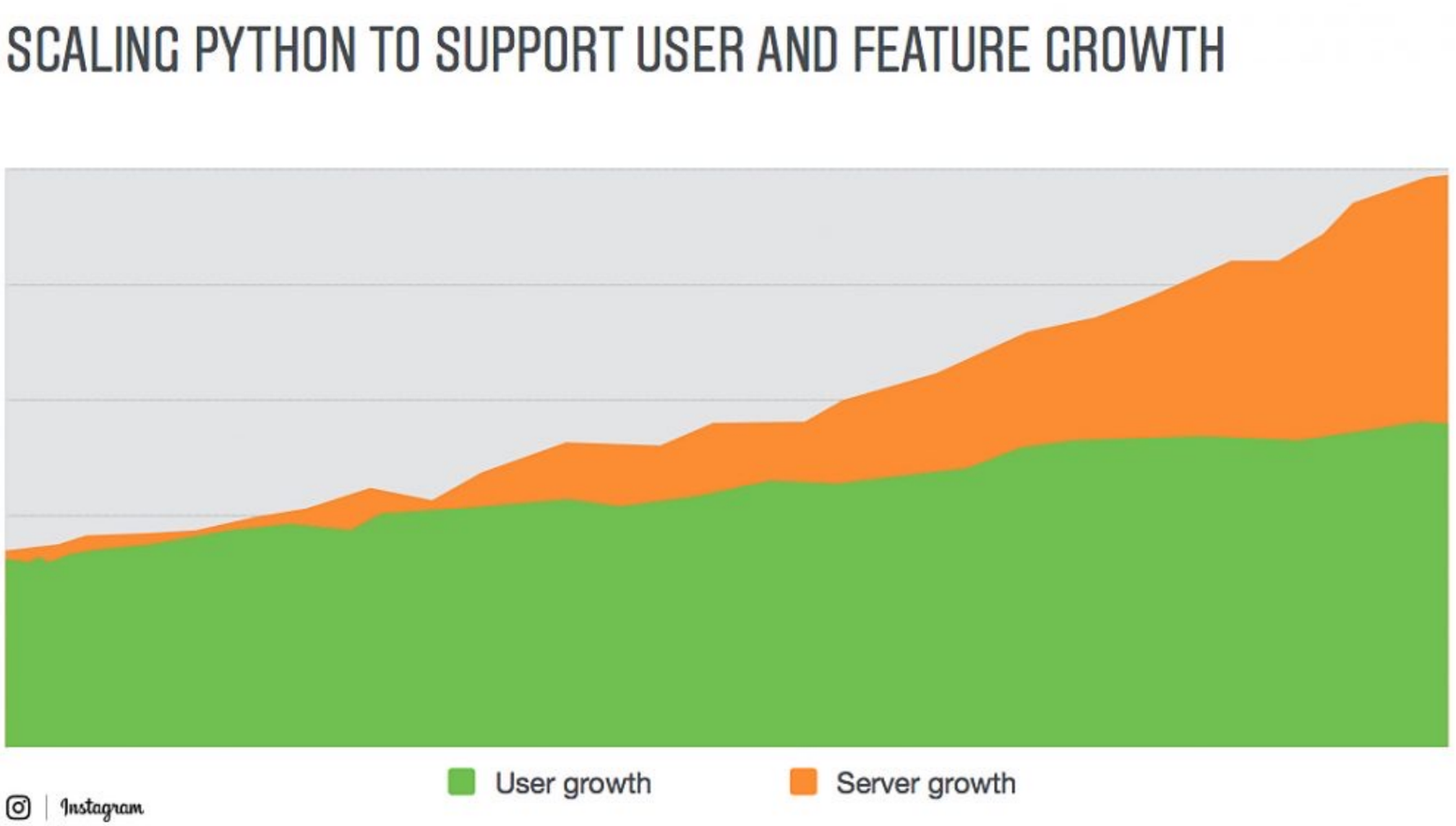
04-07-14

Why Facebook Invented A New PHP-Derived Language Called “Hack”

Instead of throwing out years of legacy code, Facebook built a new branch of the language that originally underpinned TheFacebook.com. Here’s the story behind a two-year labor of love.

https://www.fastcompany.com/3028778/why-facebook-invented-a-new-php-derived-language-called-hack

Architectural Technical Debt: Instagram

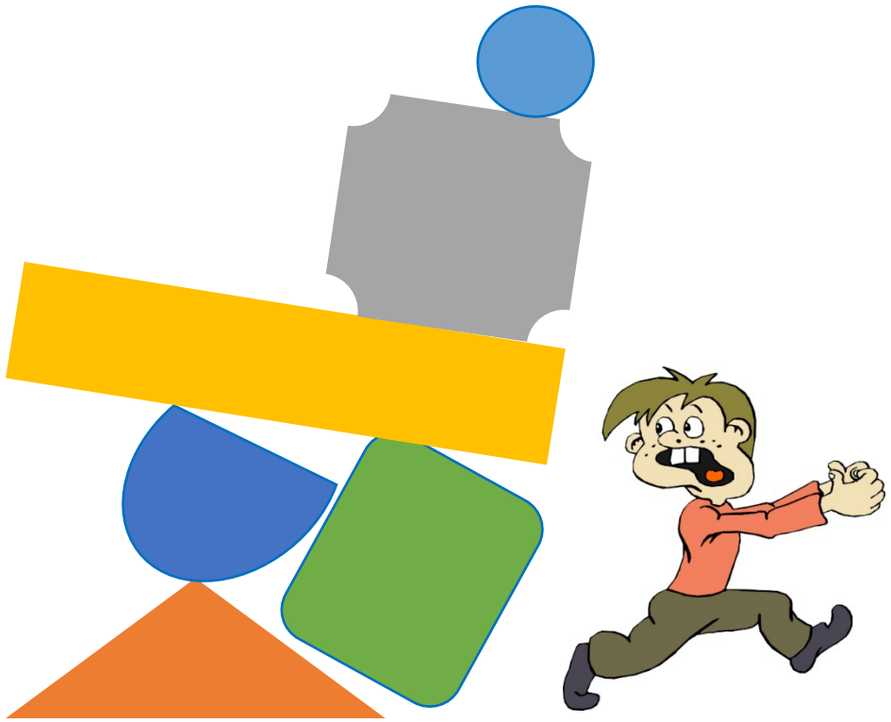


https://thenewstack.io/instagram-makes-smooth-move-python-3/

https://www.fastcompany.com/3028778/why-facebook-invented-a-new-php-derived-language-called-hack

Retire Technical Debt at Leisure

- Set aside time to pay off technical debt:
  - Google has (had?) “20%-time” for tasks such as this.
- A new initiative can take on some technical debt:
  - Refactoring at the start of a project.
- Don’t keep on putting off!
  - When a crisis hits, it’s too late;
  - Hasty fixes to unmaintainable code multiplies problems;
  - Eventually mounting technical debt can bury the team.



Review: Learning Objectives for this Lesson

- You should now be able to:
  - Describe different kinds of “Refactoring”: restructuring of code to improve structure.
  - Review some common code “smells” (anti-patterns).
  - Identify the “technical debt” metaphor; Indicate when and where technical debt is appropriate to accrue versus retire.