CS 5154: Software Testing

Introduction

Instructor: Owolabi Legunsen

Fall 2021

On the state of software quality

The New York Times

Airline Blames Bad Software in San Francisco Crash

GOOGLE SELF-DRIVING CAR CAUSED FREEWAY CRASH AFTER ENGINEER MODIFIED ITS SOFTWARE

BY JASON MURDOCK ON 10/17/18 AT 11:34 AM

Newsweek

~9% of 2017 US GDP

Report: Software failure caused $1.7 trillion in financial losses in 2017

TechRepublic.

Software testing company Tricentis found that retail and consumer technology were the areas most affected, while software failures in public service and healthcare were down from the previous year.

By Scott Matteson | January 26, 2018, 7:54 AM PST

Hard Questions Raised When A Software 'Glitch' Takes Down An Airliner

Forbes

Why learn software testing?

- Testing is usually the last line of defense against bugs
- Testing is widely used by developers for finding bugs
- **It will be your job to test software!**

What this course is about

- Systematic, organized approaches to testing

- You will learn
  - how to design and write high quality tests
  - cutting-edge testing techniques and tools
  - how to apply techniques and tools to (real) code

Prerequisites

- You will likely struggle if you didn't satisfy the prereqs

- We will use knowledge from
  - Discrete math
  - Java
  - Version control with Git, GitHub
  - Prog. languages, software engineering, or compilers
  - …

CS 5154: theory meets practice

- We'll use some basic theory to answer practical questions
  - What inputs should we choose?
  - Have we tested software sufficiently?
  - How good are our tests?
  - …

What this course is *not* about

- How to develop software for clients
- Basic software engineering knowledge and skills
- A tutorial on Company X's latest testing tools

Some praise for this course

I work with a large enterprise software company. One of my main projects is to write tests. By applying the concepts that I learned in this class, I was able to write a strong test suite which received high-praise from my manager and team. This class had a direct effect on my efficacy in writing that test suite. So, I want to thank you for teaching me these concepts and always mentioning the practical applications of the concepts.

Meet the course staff

- **Instructor:** Owolabi Legunsen
  - Office Hours: Tue and Thu 3:30–4:30pm, Gates 310

- **TAs**
  - Ayaka Yorihiro,
    - OH: Mon 3-4pm, Rhodes 405 (9/6 only)
    - OH: Fri 10:30-11:30am, Rhodes 406 (after 9/6)
  - Sandipan Nath, OH: Sun 6-7pm, Rhodes 400

Course webpage

- https://www.cs.cornell.edu/courses/cs5154/2021fa
  - Announcements
  - Syllabus
  - All lecture materials
  - Handy links
  - Where to get help @ Cornell

Course Communication

- Course Email: cs5154-staff@cornell.edu
  - Send all questions, comments, complaints, etc.
  - You will get a response within 24 hours
  - Plan ahead!

- We will make announcements on Canvas/CMS

Your grade will be based on…

Homework assignments	**35%**
Announced in-class quizzes	**10%**
Readings	**10%**
In-class labs	**5%**
Prelim	**20%**
Final Exam	**20%**

Working in a team

- Software engineering (including testing) is a team sport
- Team sizes: ~3
- Form your own teams

Questions on course logistics?

?

Now it's your turn

- Form groups of three to four
- Introduce yourselves
- Discuss: **If testing is so widely used, why are there still so many software failures?**

What did your group discuss?

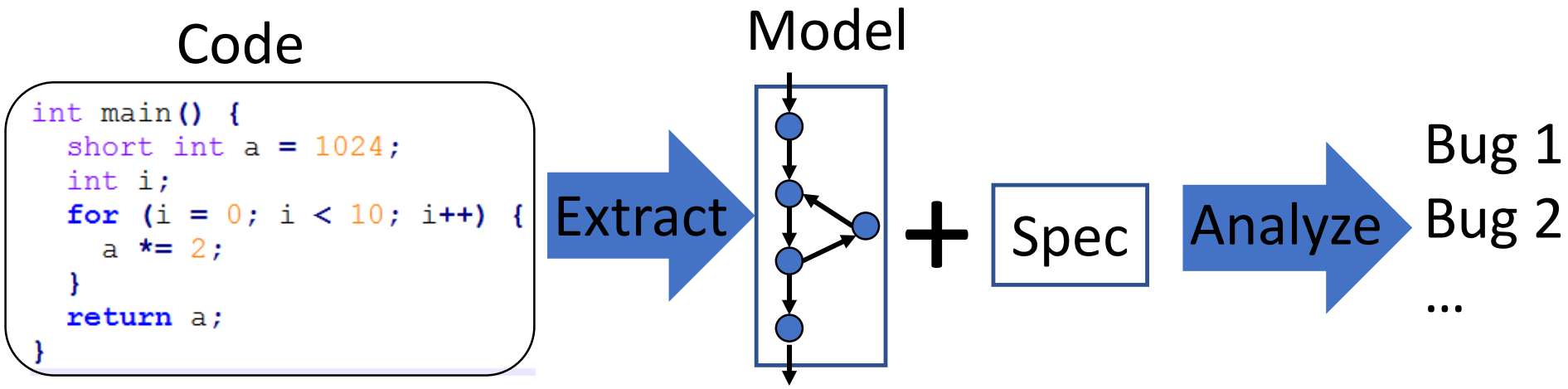
What did your group discuss? (2)

A view of software testing

Pros	Cons
Easier for most developers	Can miss bugs
Scales well in practice	Oracle generation is hard
Uses developer insights	High maintenance costs

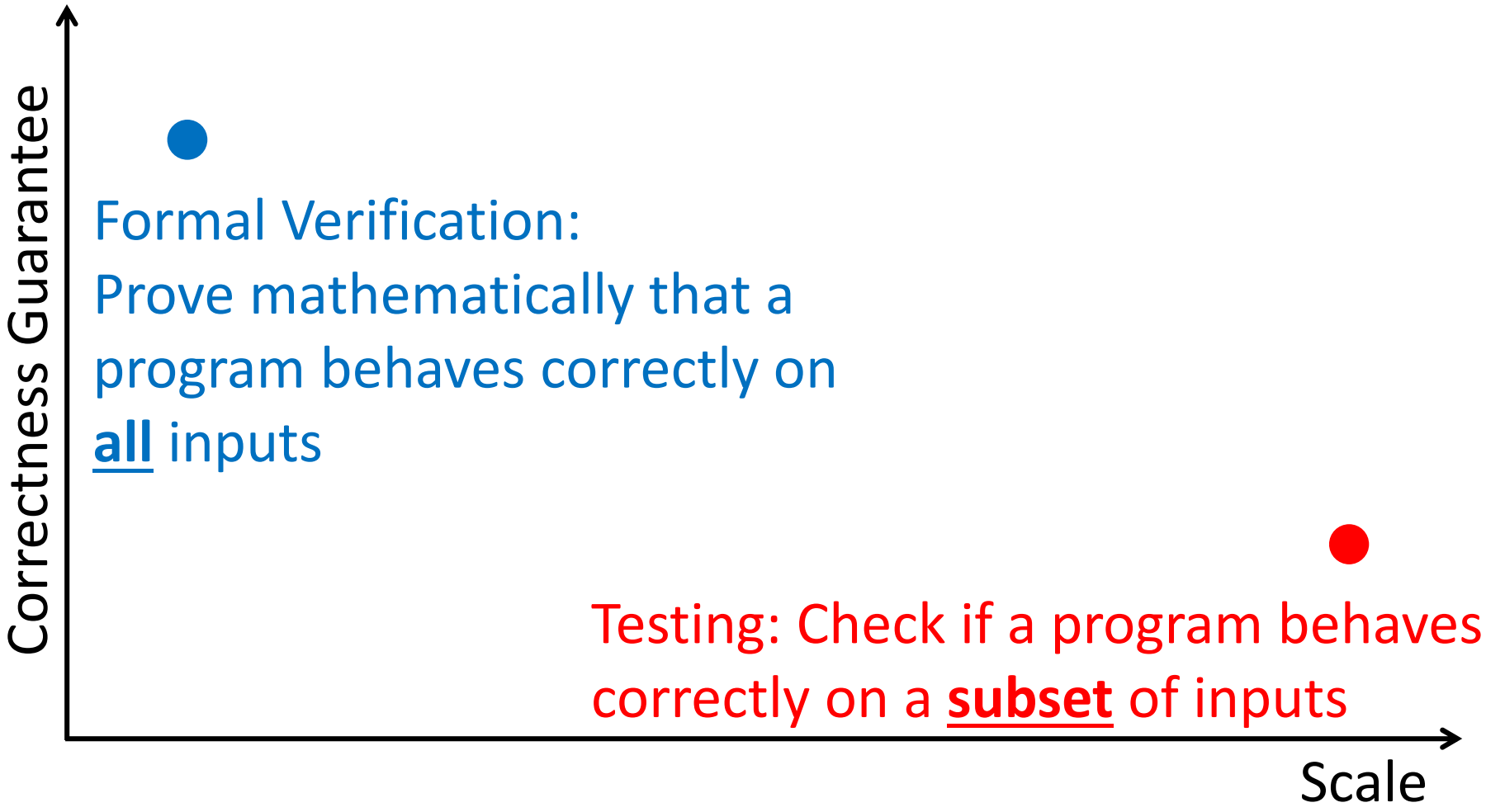
An alternative to software testing

- Formal (static) verification, e.g., model checking

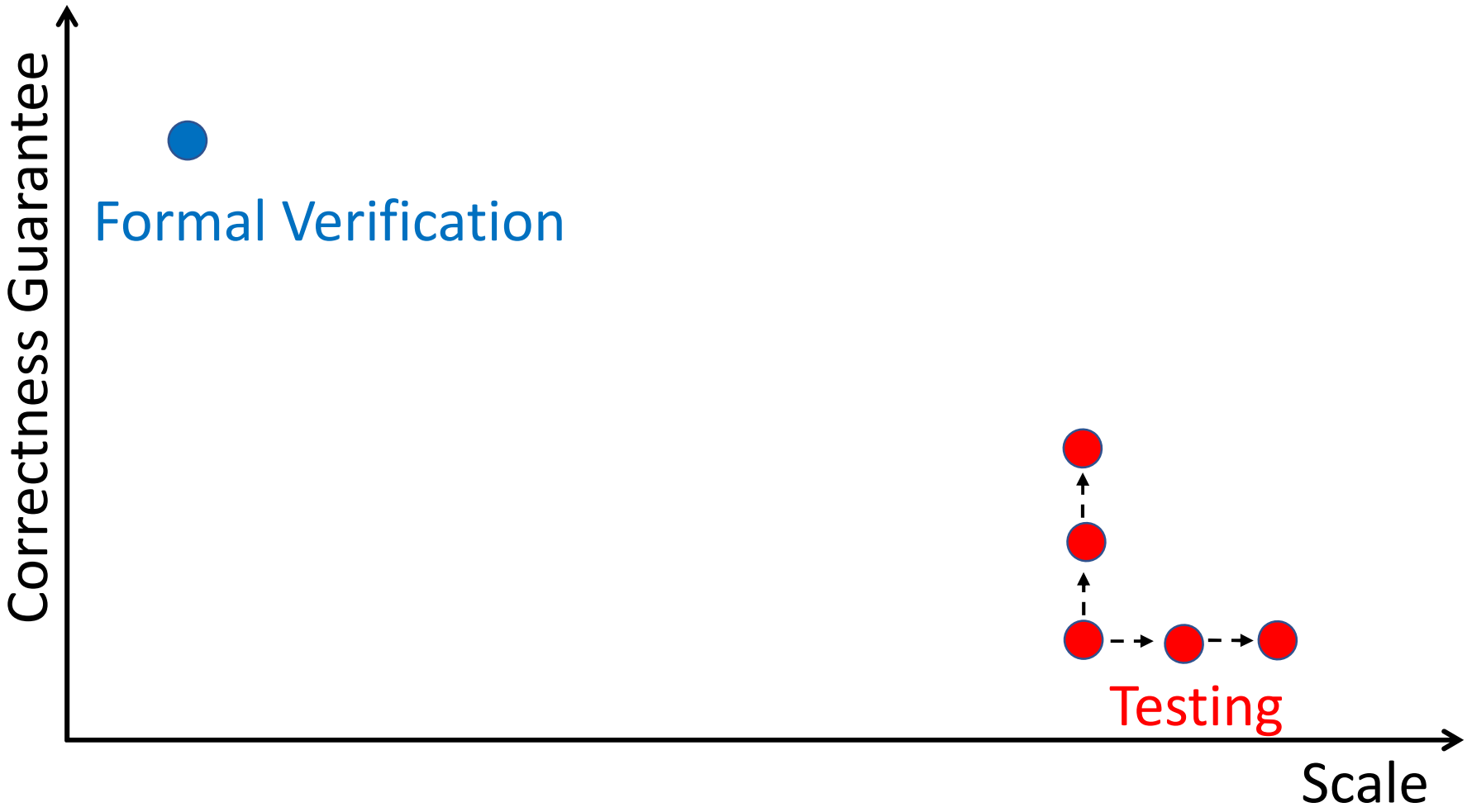


Pros	Cons
Finds more bugs than testing	Errors in modeling
Uses math and logic	False positives
Mature and well studied	Does not scale

One reason testing is widely used



The essence of this course



How to improve the guarantees that testing provides?

How to make testing scale even better?

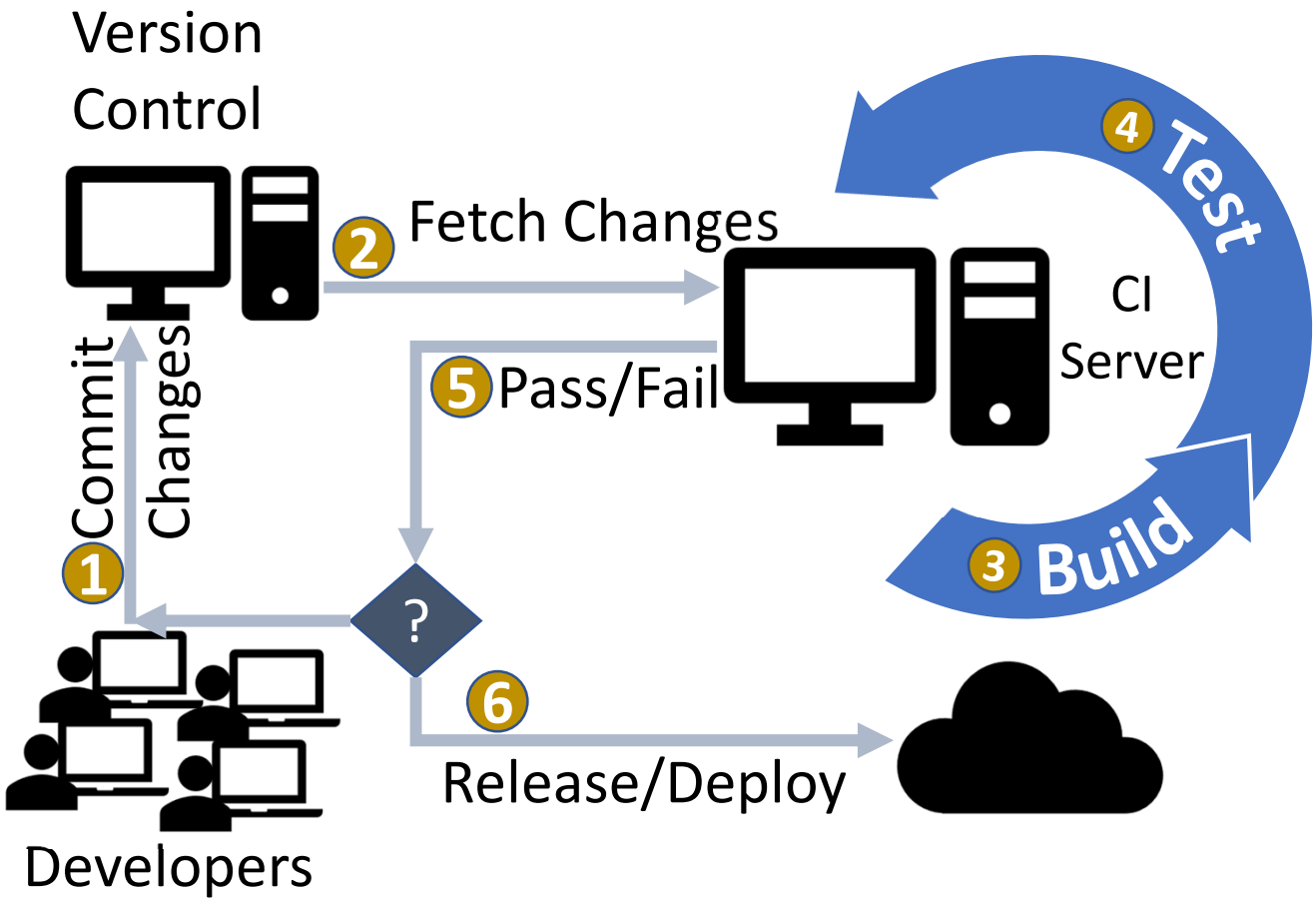
CS5154 is organized into six themes

1. How to automate the execution of tests?
2. How to design and write high-quality tests?
3. How to measure the quality of tests?
4. How to automate the generation of tests?
5. How to reduce the costs of running existing tests?
6. How to deal with bugs that tests reveal?

Theme 1: test automation

- The xUnit paradigm and the JUnit framework
- Parameterized Unit Tests
- The Maven build system
- Continuous Integration (??)

Automation Continuous Integration (CI)



Theme 2: test design

- Goal: systematically derive tests that increase the chance to reveal bugs

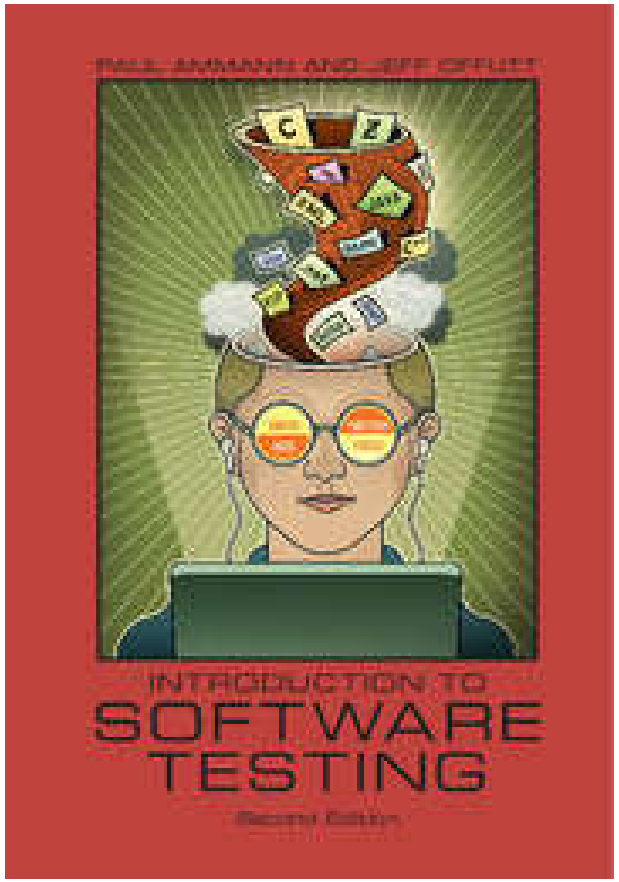
- We will use only four models of software
  - Input space
  - Graph structure
  - Logic conditions
  - Syntax

Theme 3: checking test quality

- Question: How do you test your tests?
- We'll learn about mutation testing

Required Text for Themes 1 – 3

- Readings will be assigned from book
  - Starting next week
- Copies on reserve @ Uris library
- Copies available via the Bookstore

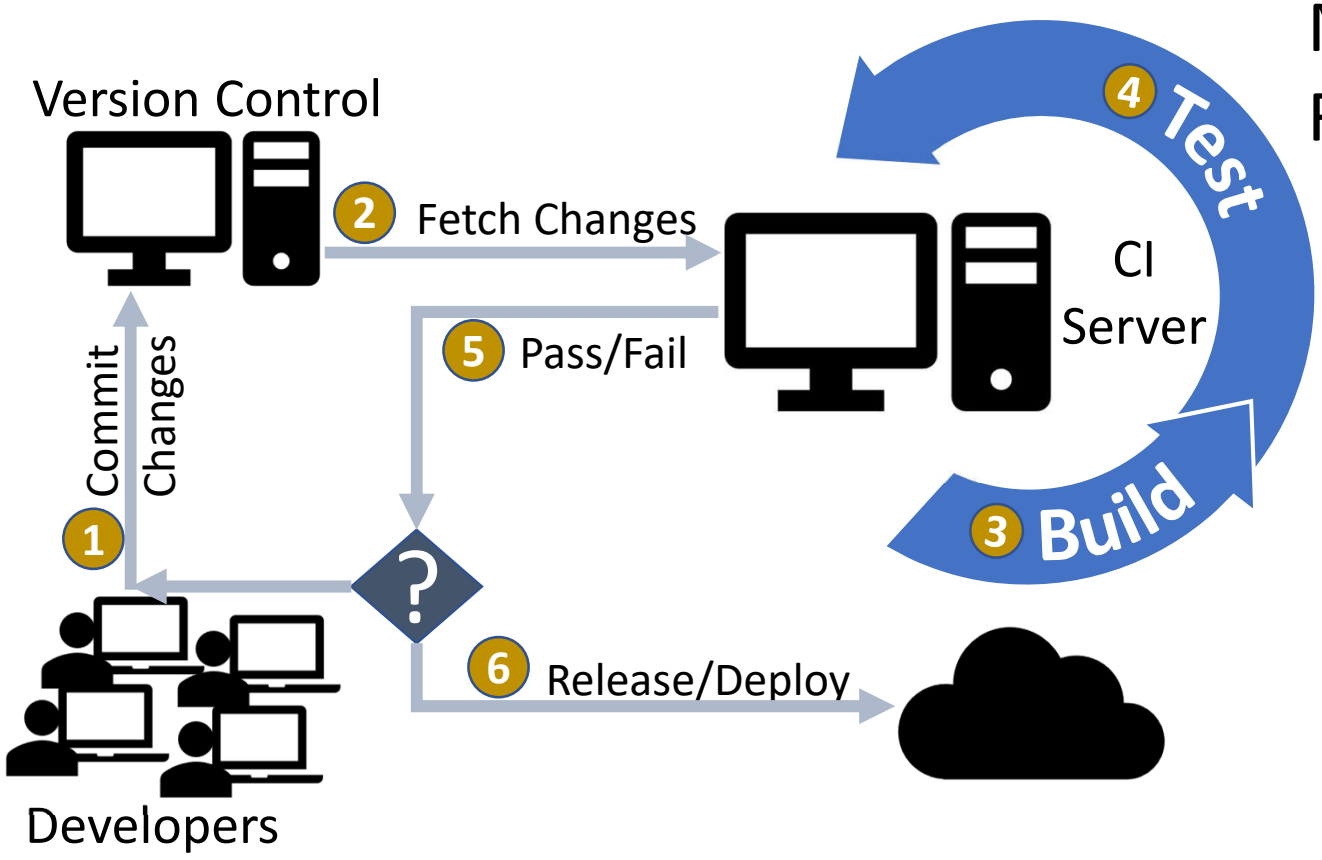


Theme 4: automatic test generation

- Problem: writing tests is very expensive
  - 75% of development effort at Microsoft (??)
  - “customers pay for features, not tests” ☹
- Goal: learn about automated test generation

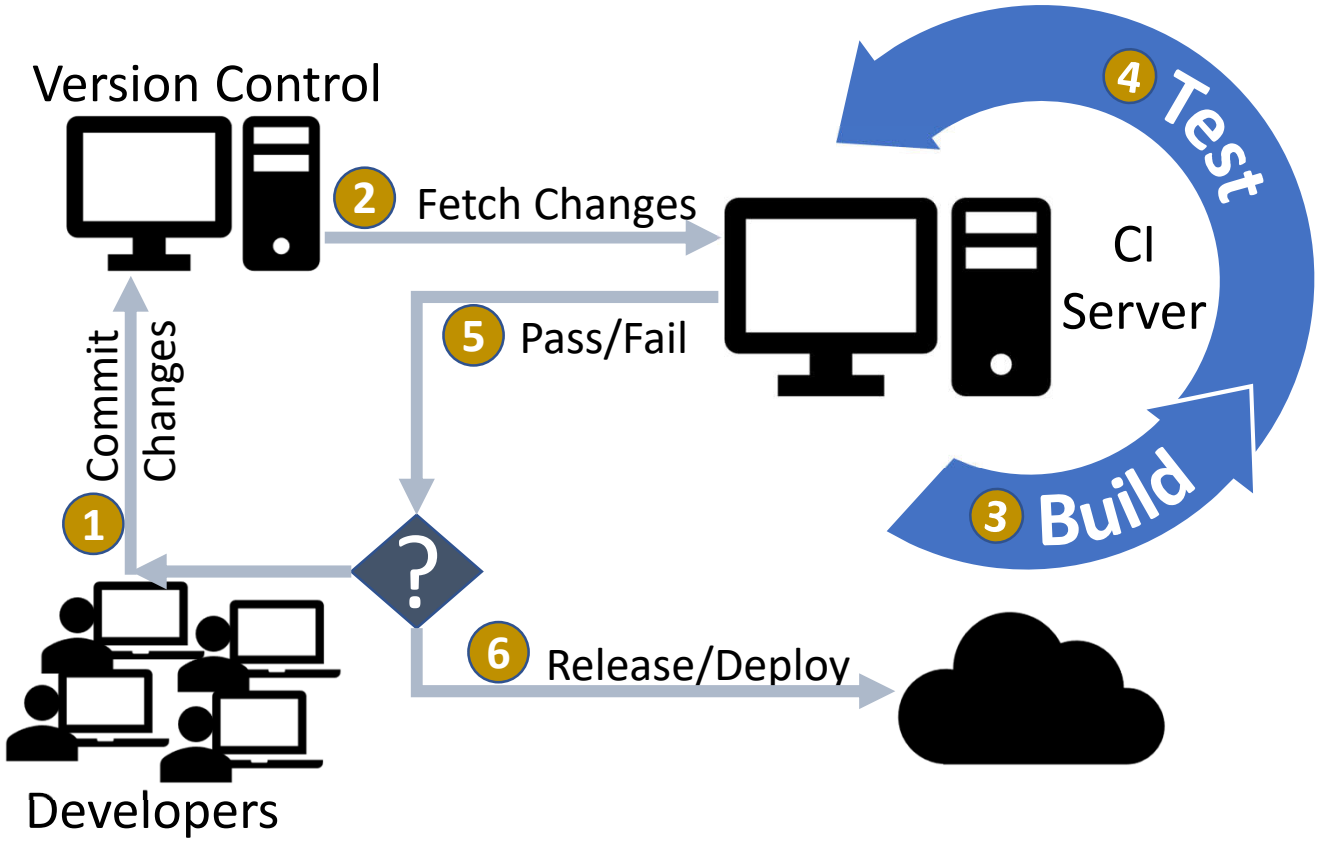
Quiz: How many CI cycles per day?

At companies like Microsoft, Facebook, Google?



By individual developers?

Tests are re-run very frequently



Cycles per day:

- Facebook: 60K*
- Google: 17K
- HERE: 100K
- Microsoft: 30K
- Single OSS: up to 80

Releases per day

- Etsy: 50

* Android only; Facebook: https://bit.ly/2CAPvN9 ; Google: https://bit.ly/2SYY4rR ; HERE: https://oreil.ly/2T0EyeK ; Microsoft: https://bit.ly/2HgjUpw ; Etsy: https://bit.ly/2IiSOJP ;

Re-running tests is very costly

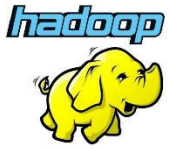
↑ no. of changes per day * ↑ no. of tests

⇒ quadratic increase in test execution time

- 75+ million tests run per day
- 20+ revisions per minute

*http://google-engtools.blogspot.com/2011/06testing-at-speed-and-scale-of-google.html

Re-running tests is very costly (2)

	test execution time	number of tests
	~5min	1667
	~10min	641534
	~45min	1296
	~45min	361
	~45min	631
	~4h	4975
	~17h	8663

Run many times each day

Did you deal with long-running tests?

- Q: what's the longest your tests took to run?

- Q: what do you do while waiting for long-running tests?

Theme 5: regression testing

- Problem: Re-running tests after every code change is expensive

- Goal: learn cutting-edge techniques and tools for making regression testing more efficient and effective

Theme 6: dealing with bugs

- Context: your tests revealed a bug. Now what?

- If time permits, we'll learn about

  - Debugging

  - Bug Advocacy

Questions on course content?

?

A review of today's class

- Learning outcomes, course content, and logistics
- High-level introduction to Software Testing
- Comparison of testing with another QA approach
- Whirlwind tour of how this course is organized

Next class…

- Testing Foundations