

CS 4530 Software Engineering

Module 14: Continuous Development Processes

Jonathan Bell, Adeel Bhutta, Mitch Wand
Khoury College of Computer Sciences
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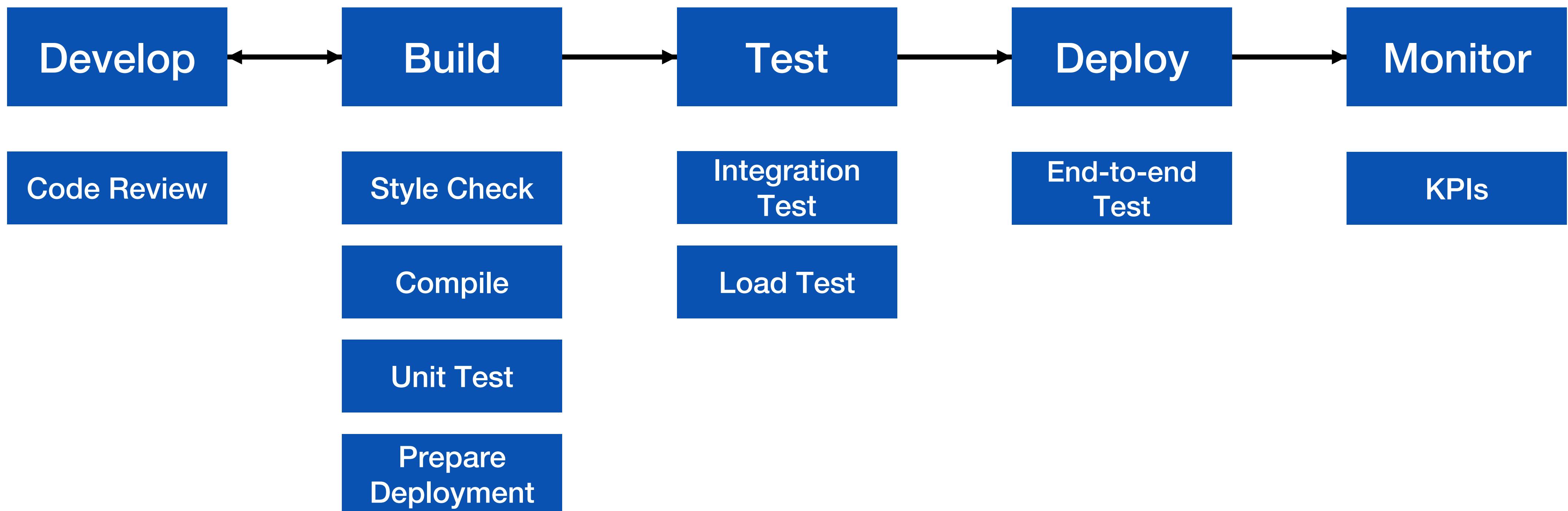
Learning Objectives for this Lesson

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

- Describe how continuous integration helps to catch errors sooner in the software lifecycle
- Describe the benefits of a culture of code review
- Describe strategies for performing quality-assurance on software as and after it is delivered

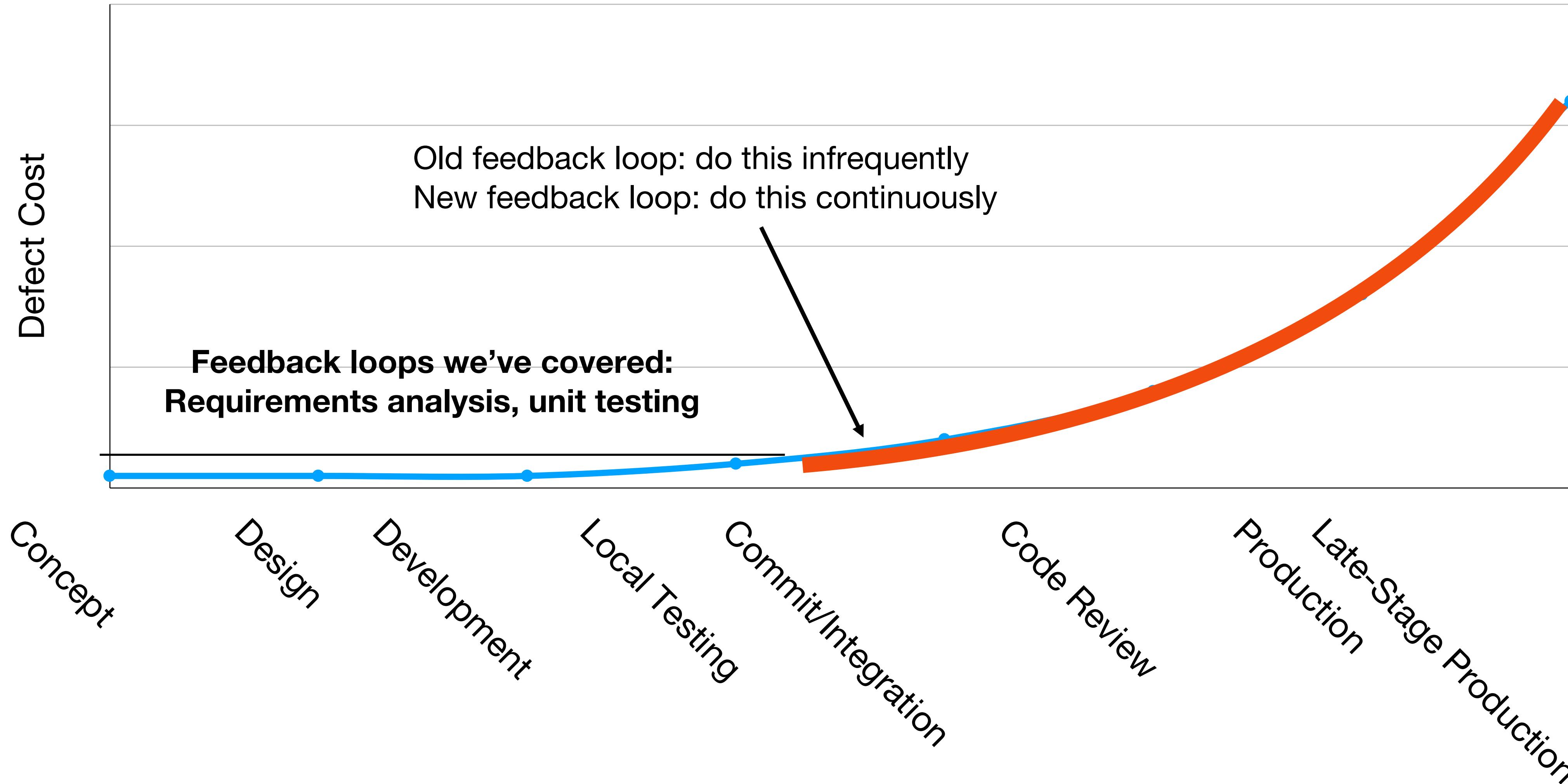
Continuous Development

Improving quality & velocity with frequent, fast feedback loops



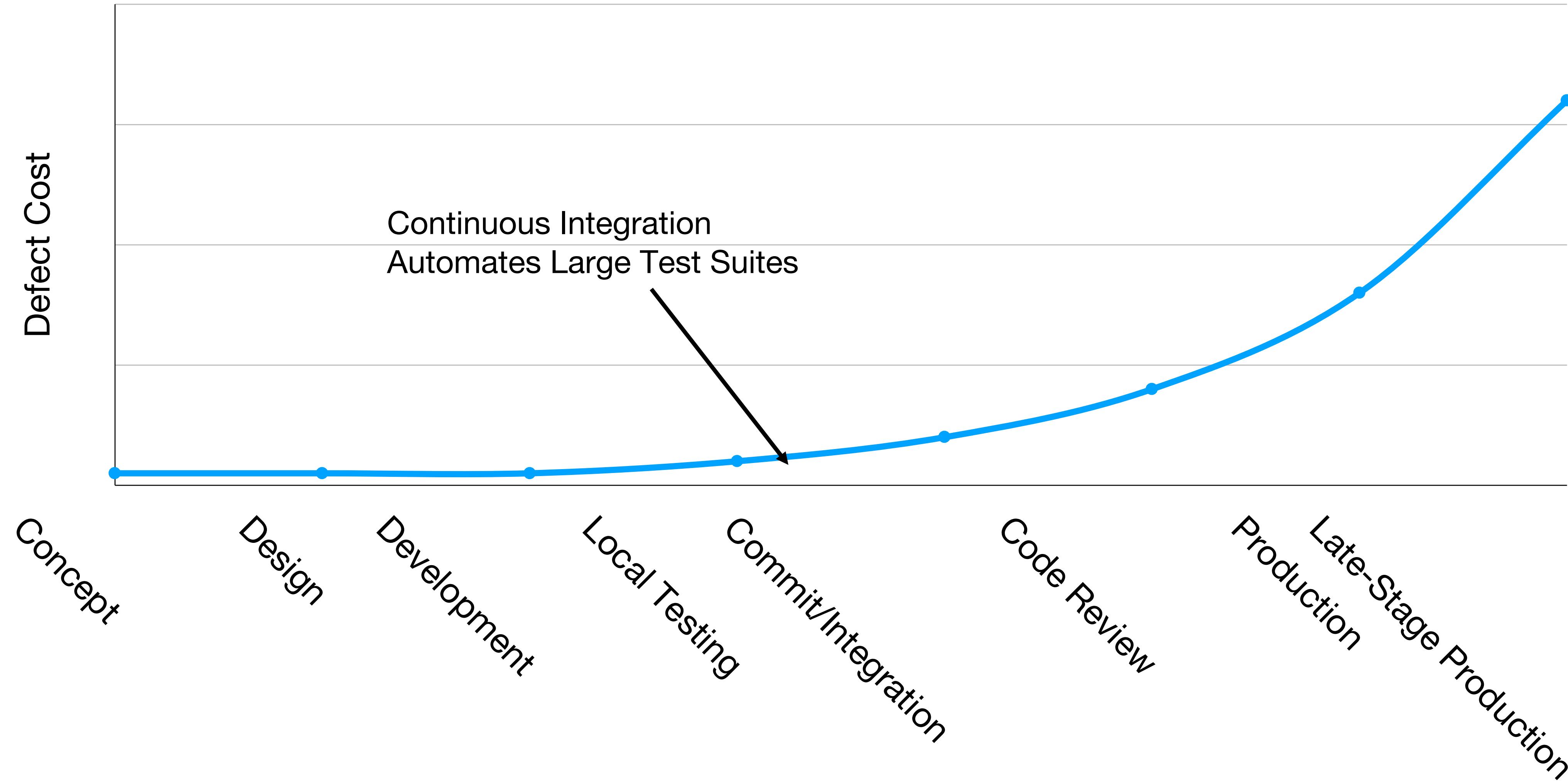
Agile Values Fast Quality Feedback Loops

Faster feedback = lower cost to fix bugs



Continuous Integration

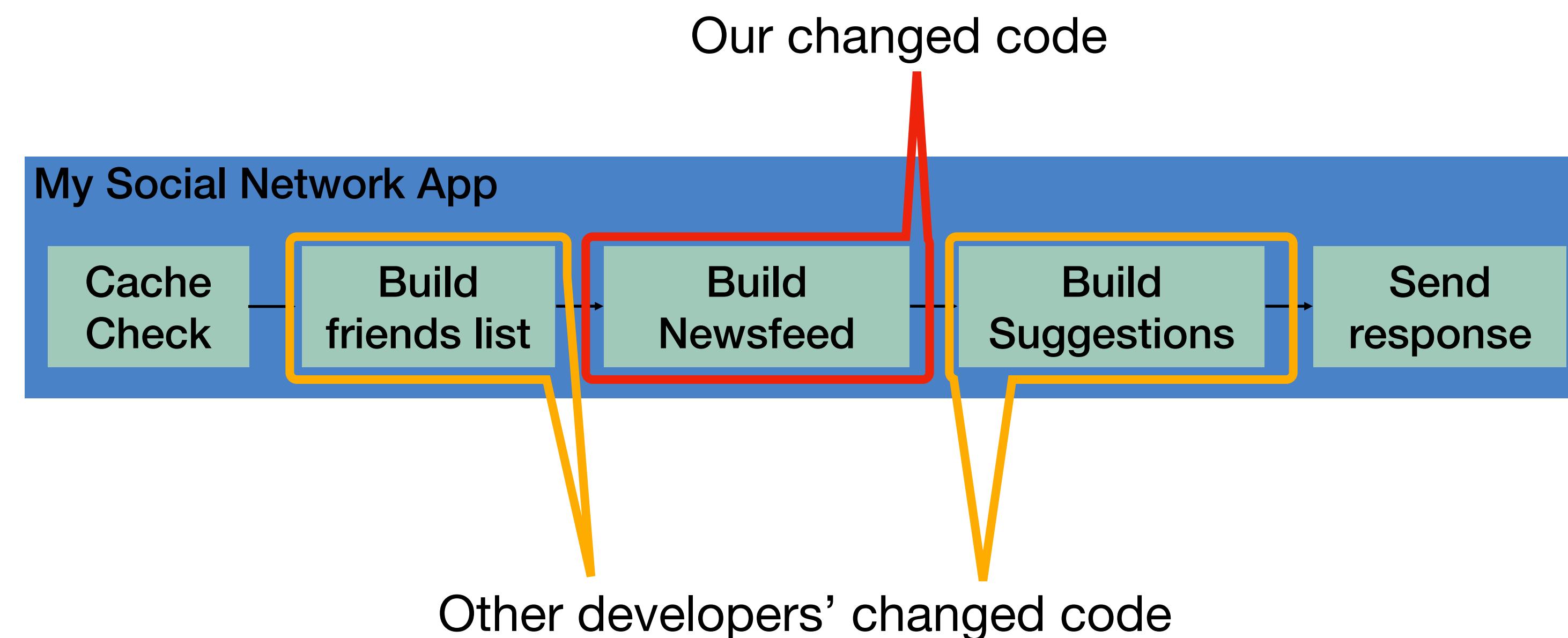
Fast feedback on integration errors



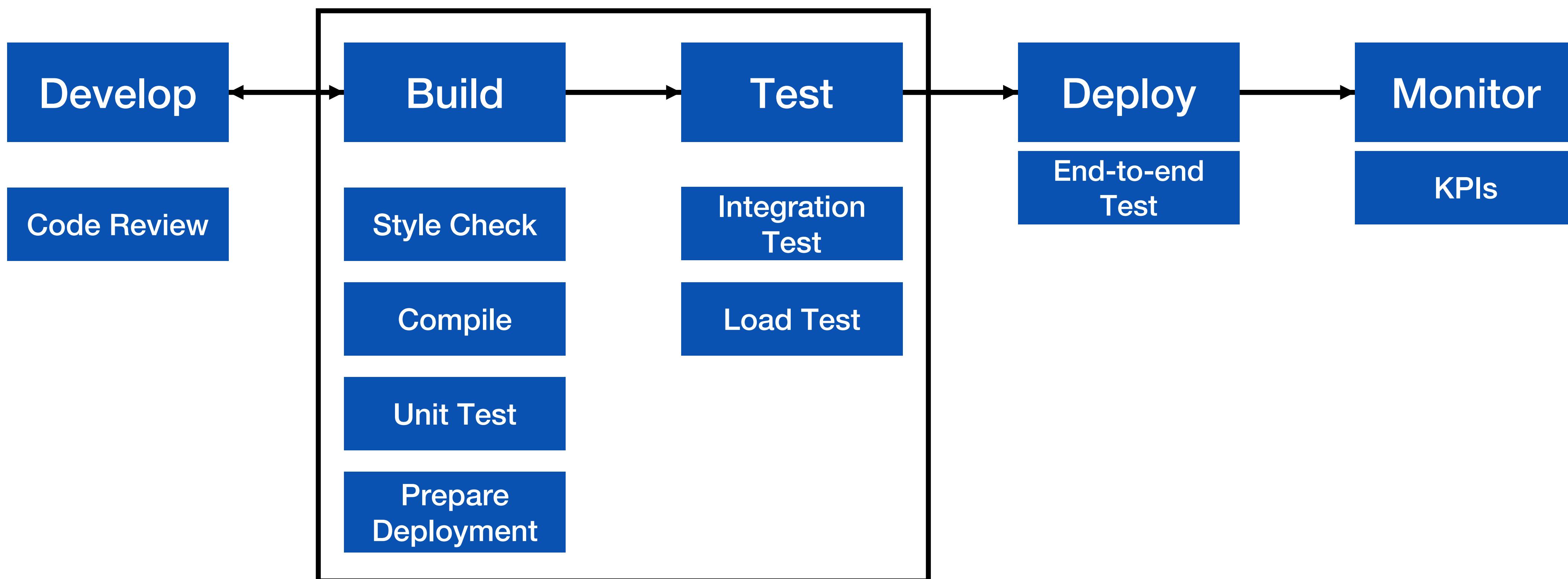
Continuous Integration

Motivation

- Our systems involve many components, some of which might even be in different version control repositories
- How does a developer get feedback on their (local) change?



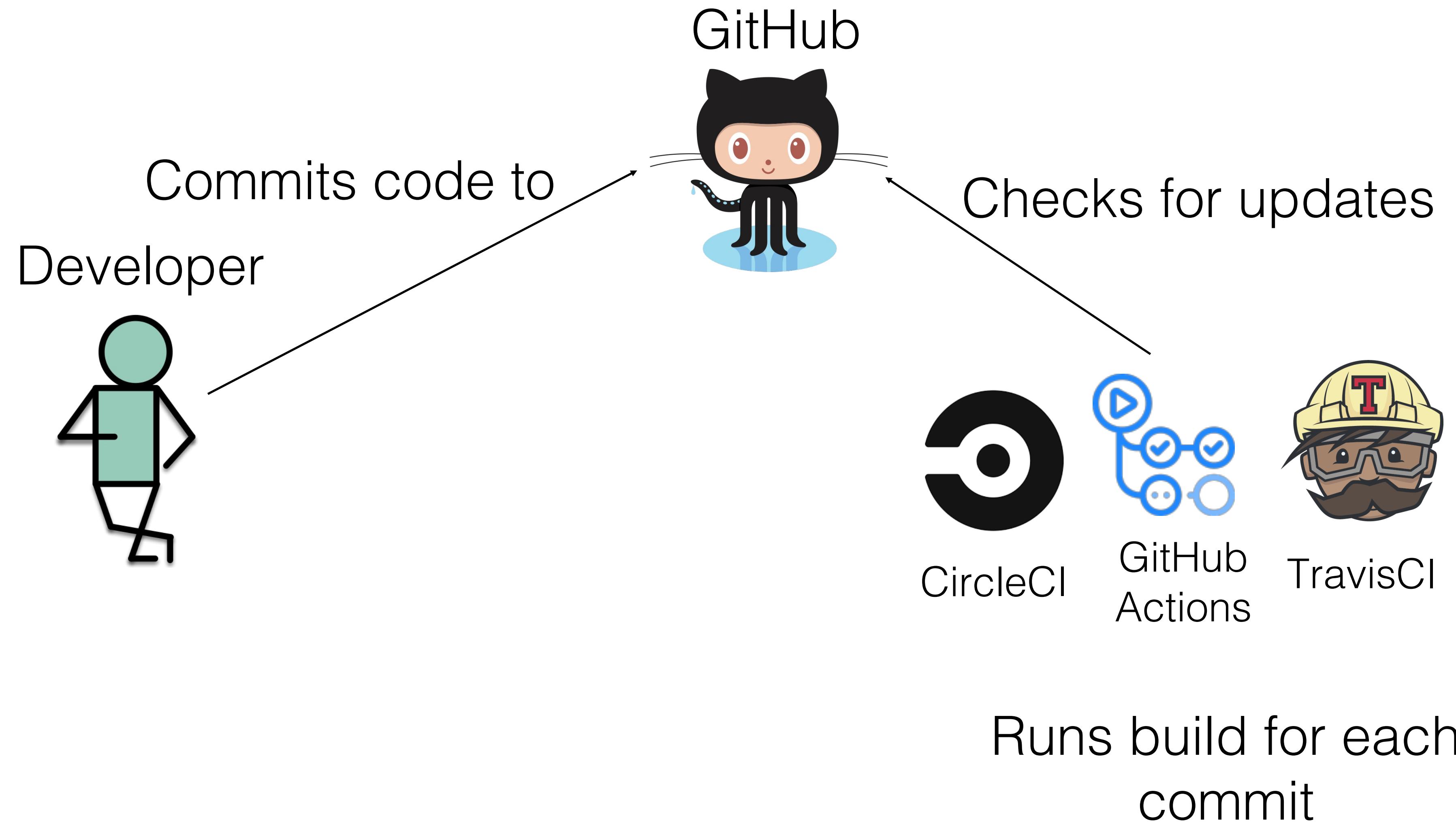
Continuous Integration is a Software Pipeline



Automate this centrally, provide a central record of results

Continuous Integration in Practice

Small scale, with a service like CircleCI, GitHub Actions or TravisCI



Example CI Pipeline

Open source project: PrestoDB

prestodb / presto build passing

Current Branches Build History Pull Requests More options

Pull Request #15372 Fix extracting logic in dynamic filtering when

When integrating with filter pushdown, we extract dynamic filter

-o Commit cde9e65 ↗
↳ #15372: Fix extracting logic in dynamic filtering when integrated with
↳ Branch master ↗

Ke

Build jobs View config

X # 52304.1	AMD64	Trusty	Java	MAVEN_CHECKS=true	10 min 51 sec
✓ # 52304.2	AMD64	Trusty	Java	WEBUI_CHECKS=true	58 sec
✓ # 52304.3	AMD64	Trusty	Java	TEST_SPECIFIC_MODULES=presto-tests	6 min 7 sec
✓ # 52304.4	AMD64	Trusty	Java	TEST_SPECIFIC_MODULES=presto-tests	24 min 50 sec
✓ # 52304.5	AMD64	Trusty	Java	TEST_SPECIFIC_MODULES=presto-tests	7 min 45 sec
✓ # 52304.6	AMD64	Trusty	Java	TEST_SPECIFIC_MODULES=presto-tests	8 min 4 sec

<https://travis-ci.com/github/prestodb/presto>

Example CI Pipeline - TravisCI

At a glance, see history of build

prestodb / presto  build passing

Current Branches Build History Pull Requests More options 

Branch	Description	Status	Build ID	Duration	Time Ago
✓ master	This patch bumps Alluxio dependency to 2.3.0-2	passed	#52300	10 hrs 49 min 31 sec	2 days ago
! master	Handle query level timeouts in Presto on Spark	errored	#52287	11 hrs 6 min 44 sec	2 days ago
! master	Fix flaky test for TestTempStorageSingleStreamSp	errored	#52284	11 hrs 50 min 37 sec	2 days ago
✓ master	Check requirements under try-catch	passed	#52283	11 hrs 3 min 20 sec	2 days ago
✓ master	Update TestHiveExternalWorkersQueries to create	passed	#52282	10 hrs 55 min 37 sec	2 days ago
✓ master	Introduce large dictionary mode in SliceDictionary	passed	#52277	10 hrs 43 min 30 sec	2 days ago

<https://travis-ci.com/github/prestodb/presto>

CI In Practice: Individual Project Autograder

test.yml (CI workflow file)

```
name: 'Build and Test the Grader'
on: # rebuild any PRs and main branch changes
  pull_request:
  push:
    branches:
      - main
      - 'releases/*'
jobs:
  build:
    runs-on: self-hosted
    steps:
      - uses: actions/checkout@v2
      - uses: actions/setup-node@v2
        with:
          node-version: '16'
      - run: |
        npm install
  test:
    runs-on: self-hosted
    strategy:
      matrix:
        submission: [a, b, c, ts-ignore, linting-error, non-green-tests, empty]
    steps:
      - uses: actions/checkout@v2
      - uses: actions/setup-node@v2
        with:
          node-version: '16'
      - uses: ./
        with:
          submission-directory: solutions/${{ matrix.submission }}
```

GitHub Actions Results

test.yml

on: push

build

30s

Matrix: test

test (a)

3m 6s

test (b)

3m 3s

test (c)

2m 58s

test (ts-ignore)

5s

test (linting-error)

31s

test (non-green-tests)

35s

test (empty)

4s

Attributes of Effective CI Processes

- Do not allow builds to remain broken for a long time
- CI should run for every change
- CI should be *fast*, providing feedback within minutes or hours
- CI should not completely replace pre-commit testing

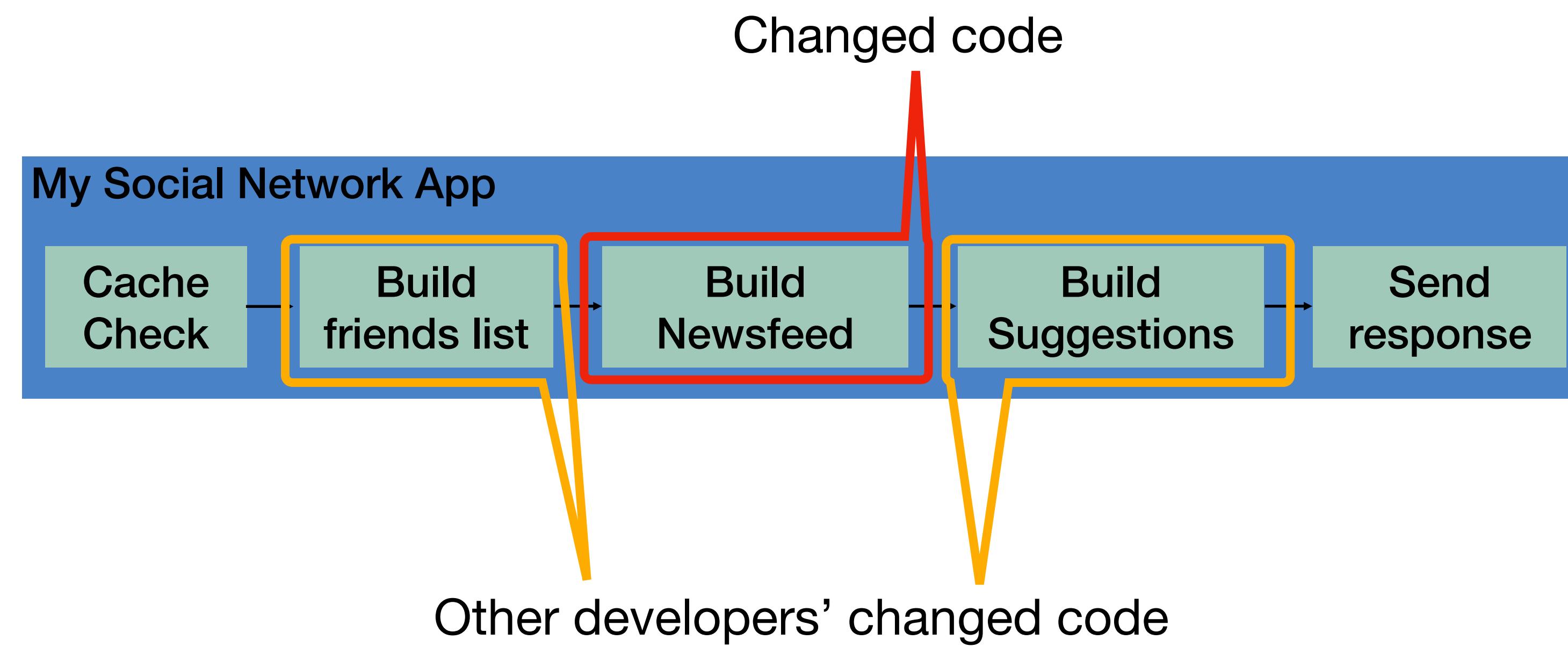
A screenshot of a CI build status page. At the top, a green checkmark icon and the text "Output the full test name" are displayed. Below this, a summary states "All checks have passed" and "9 successful checks". A list of five successful checks is shown, each with a green checkmark icon, a GitHub logo, and a link labeled "Details". The checks are: "Build and Test the Grader / build (push)", "Check dist/ / check-dist (push)", "Build and Test the Grader / test (reference) (push)", "Build and Test the Grader / test (b) (push)", and "Build and Test the Grader / test (ts-ignore) (push)".

A screenshot of a GitHub pull request interface. The title of the pull request is "Tools: extract_features.py: correct define name for AP_RPM_ENABLED". Below the title, it shows "peterbarker committed 5 days ago" with a red 'X' icon. The commit message is "AP_Mission: prevent use of uninitialised stack data". It has 2 comments, indicated by a "2" next to a comment icon. The next commit is "AP_HAL_ChibiOS: disable DMA on I2C on bdshot boards to free up DMA ch...", authored by "andyp1per" and committed by "tridge" 6 days ago, with a red 'X' icon. The fourth commit is "SITL: Fixed rounding lat/Ing issue when running JSBSim SITL", authored and committed by "ShivKhanna" 6 days ago, with a red 'X' icon. The fifth commit is "AP_HAL_ChibiOS: define skyviper short board names", authored and committed by "yuri-rage" 6 days ago, with a red 'X' icon.

How do we apply continuous integration?

Testing the right things at the right time

- Do we integrate changes immediately, or do a pre-commit test?
- Which tests do we run when we integrate?
- How do we compose the system under test at each point?

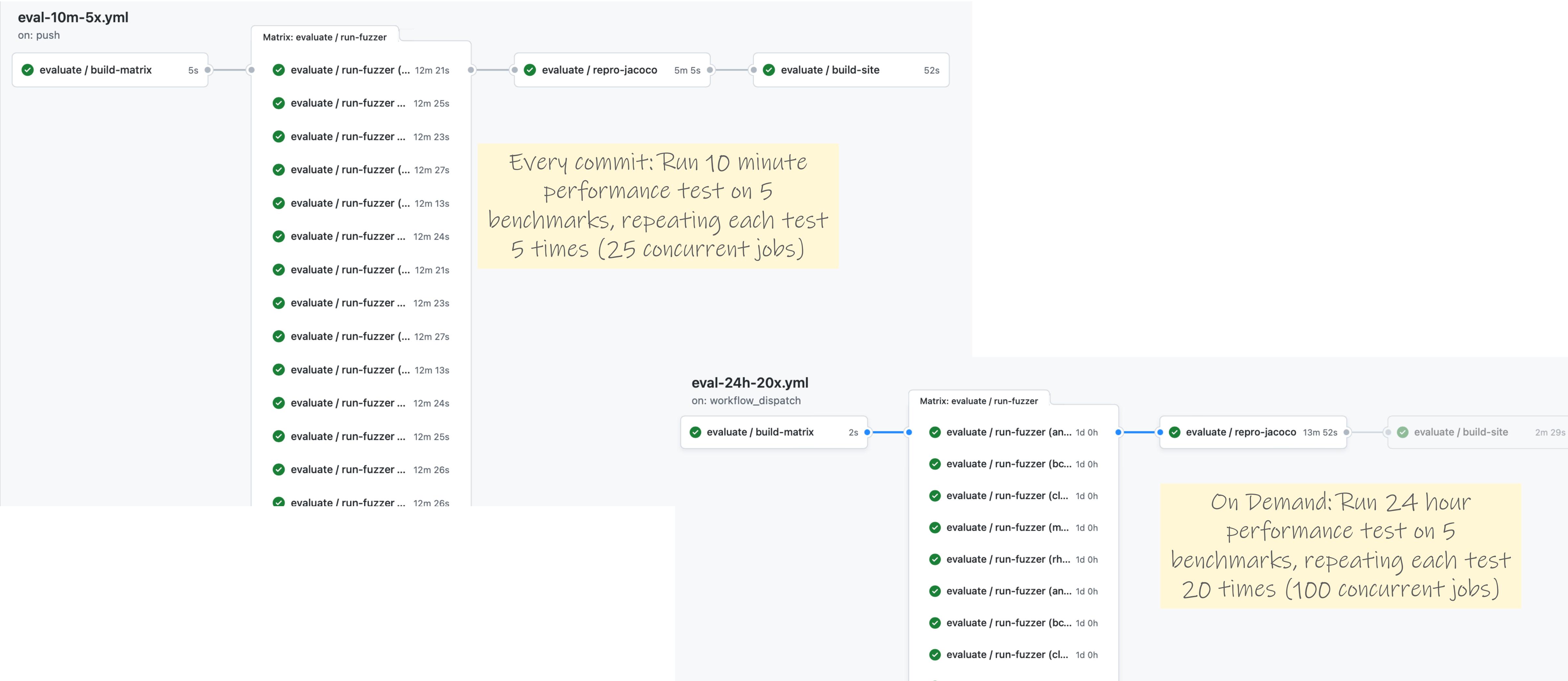


Use Scalable Cloud Resources for CI

Example: Developing a Fuzzer

- “Fuzzers” are automated testing systems that aim to automatically generate inputs to programs that cover code and reveal bugs
- Fuzzers are non-deterministic: to evaluate with confidence, need repeated, long-running trials
- Evaluating fuzzers is time consuming, determining which changes impact performance is confusing
- How to run experiments in the cloud?

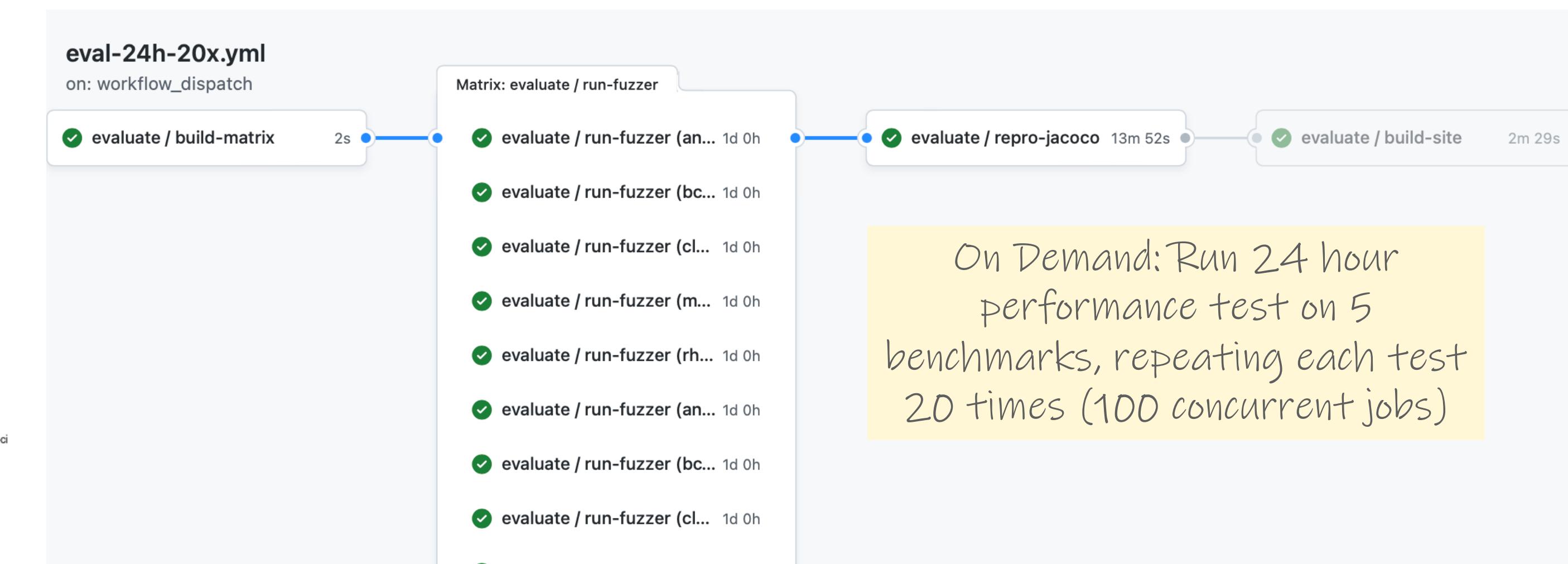
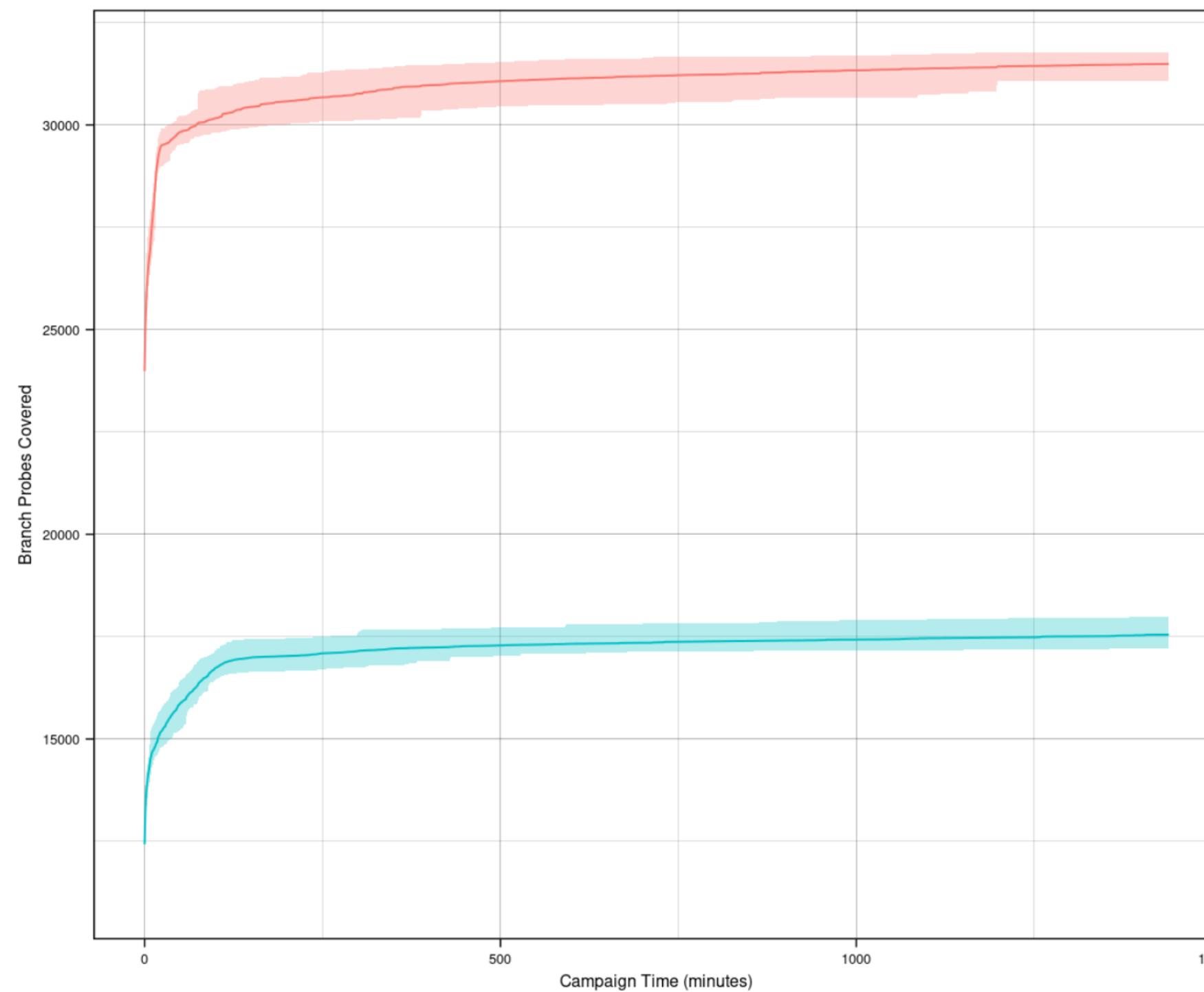
CI Pipelines Automate Performance Testing



CI Pipelines Automate Performance Testing

closure

Branch Probes Over Time



[Download this graph as PDF](#)

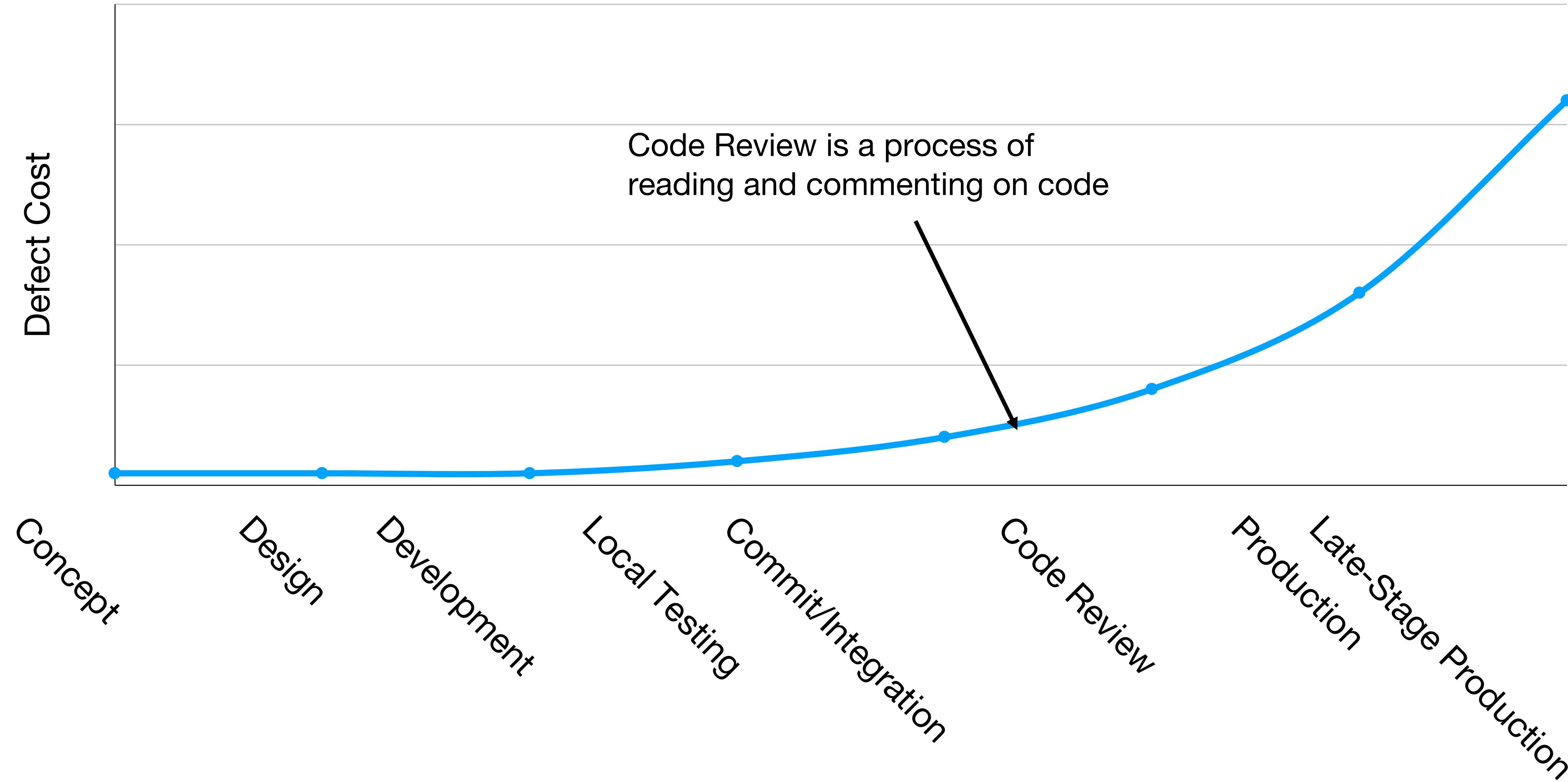
Continuous Integration in Practice

Large scale example: Google TAP

- >50,000 unique changes per-day, > 4 billion test cases per-day
- Pre-submit optimization: run fast tests for each individual change (before code review). If fast tests pass, allow the merge to continue
- Then: run all affected tests; “build cop” monitors and acts immediately to roll-back or fix
- Build cop monitors integration test runs
- Average wait time to submit a change: 11 minutes

Cost to Fix a Defect Over Time

Rough estimate



Code Review should be a Formal Process

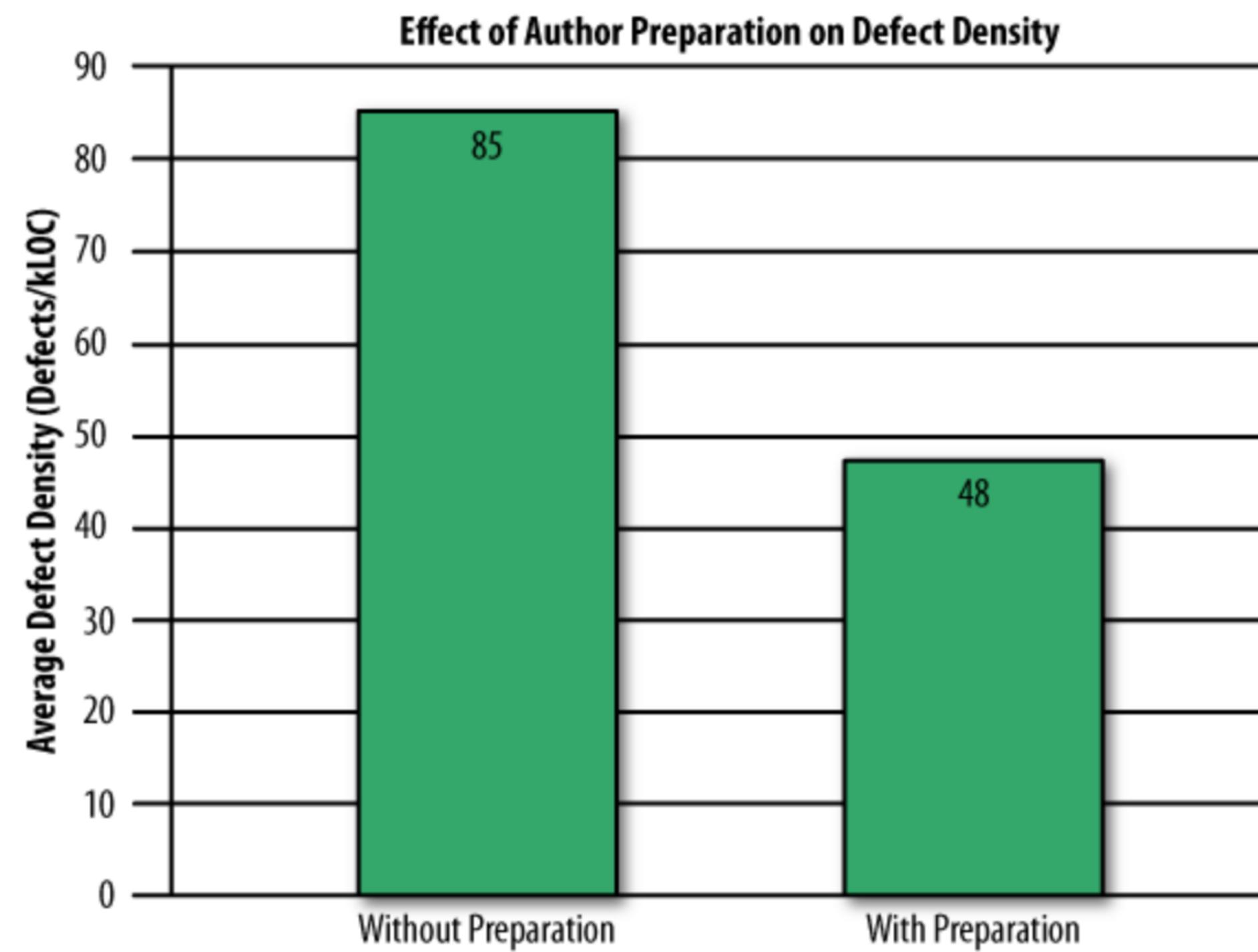
- A code review is the process in which the author of some code is asked to explain it to their peers:
 - What purpose the code has;
 - How the code accomplishes this purpose;
 - How the author is confident of this information,
 - E.g., show results of running tests (CI results)
- A code review often concerns a code *change* (“diff”)

Why should we perform code review?

- Code review increases breadth of knowledge of code:
 - Other people "know" the code;
 - Easier to handle someone cycling off project.
- Verbalizing decisions improves their quality:
 - The process of writing an explanation encourages critical thinking.
- Code reviews improve quality of code base:
 - Knowing code will be reviewed pushes developers to make code more presentable and understandable.

Self-Review Less Effective than Peer Review

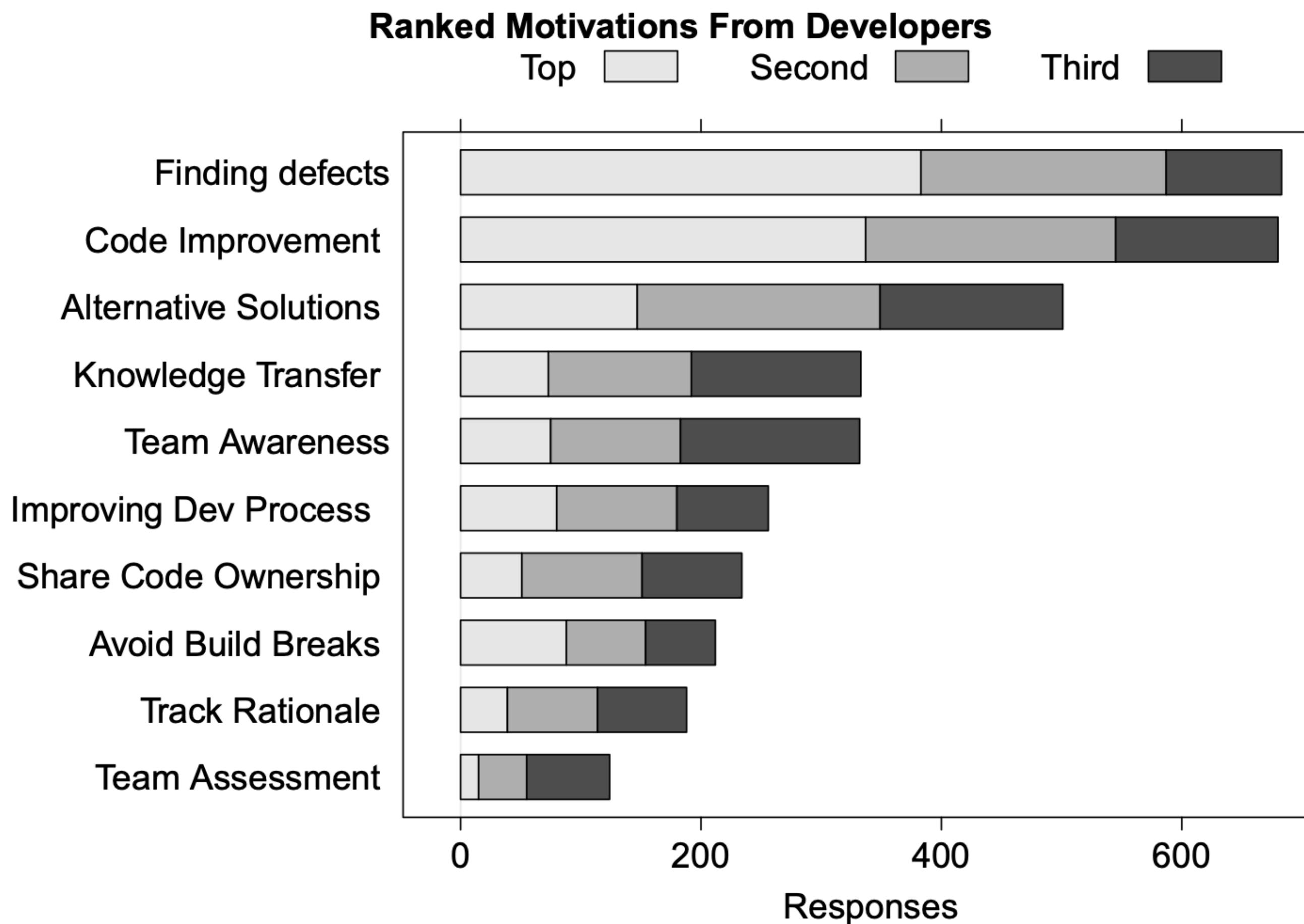
Study of 300 reviews at Cisco in 2006



Even if developers pre-review their code, many defects still found in peer review

“Best Kept Secrets of Peer Code Review”, Jason Cohen, SmartBear Software, 2006

Code Reviews Have Many Benefits (Microsoft)



“Expectations, Outcomes, and Challenges of Modern Code Review”, Bacchelli & Bird, ICSE 2013

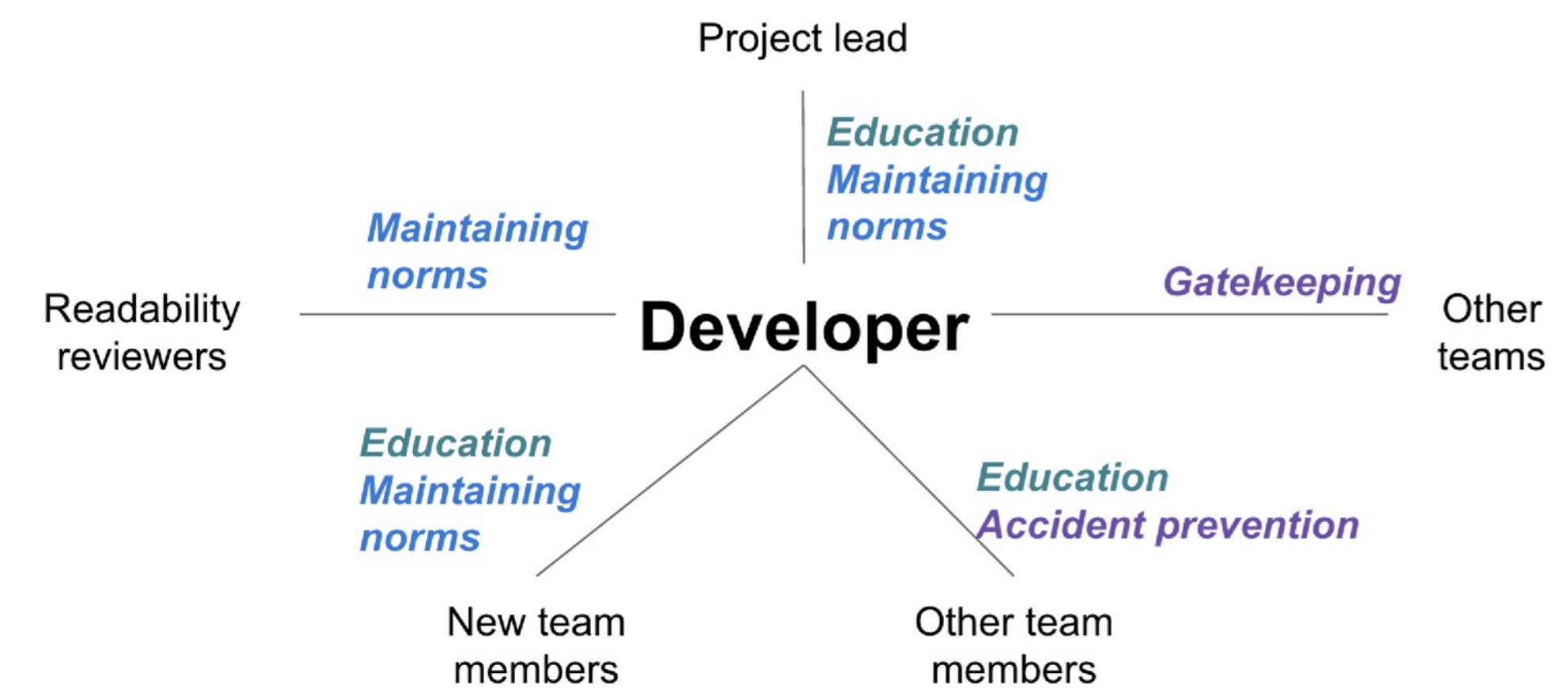
Code Reviews Descend from Traditional Code Inspection

- Formal process of reading through code as a group;
- Applied to all project documents;
- A 3-5 person team reads the code aloud and explains what is being done;
- Each person has a specific role (moderator, reviewer, reader, scribe, observer, author)
- Usually a 60 minute meeting;
- Less efficient (defects/cost) than modern review processes.
- Very waterfall.
- Traceable, measurable

Many Stakeholders can Benefit from Code Review

Reviewers might be...

- An owner of the code being changed or added to
- Someone to verify that the code meets standards.
- Someone to ensure documentation is consistent.
- Other people:
 - Interested in this code base;
 - Experts in the code base.



Code Review: How

- At Google, reviewers get access to changes, explanation and all relevant test results: review is asynchronous.
- Elsewhere reviews can be in person:
 - More heavyweight, cannot be as common.
- Review must be professional and impersonal:
 - No one is being “attacked” (or, no one *should* be).
 - Don’t rehash design arguments (defer to author).
 - All suggestions and criticisms must be addressed:
 - At least in the negative.

Code Review: Example on Pull Request

...re-api/src/main/java/org/apache/maven/surefire/booter/CommandReader.java Hide resolved

```
case BYE_ACK:  
    //After SHUTDOWN no more commands can come. Hence, do NOT go back to blocking in IO  
    callListeners( command );  
    return;  
default:  
    callListeners( command );
```

Tibor17 on Nov 12, 2019 Contributor ...
The listeners are called here. But we can put IF condition:
IF BYE_ACK -> return at the end of the default case.

Tibor17 on Nov 12, 2019 Contributor ...
Instead of calling the return we can make softer exit with CommandReader.this.state.set(TERMINATED).

eolivelli on Dec 17, 2019 Contributor ...
Yes, I came to this same conclusion, change the state to TERMINATED.

jon-bell on Dec 19, 2019 Author Contributor ...
Changed.

Reply...

Unresolve conversation jon-bell marked this conversation as resolved.

Code Review: Sample Check-List

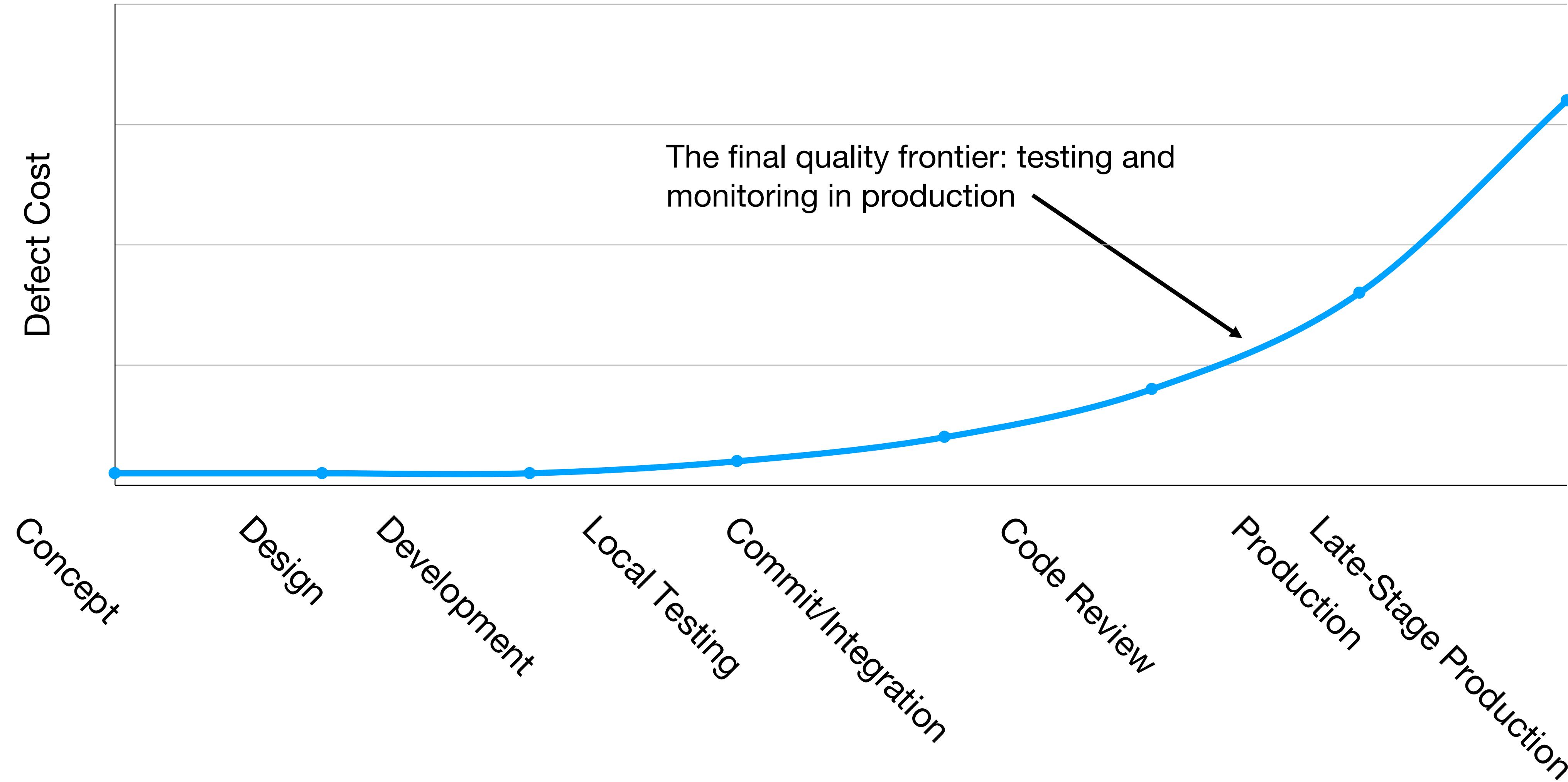
- Am I able to understand the code easily?
- Does the code follow our style guidelines?
- Is the same code duplicated more than once?
- Is this file (or change) too big?
- Does this code meet our non-functional requirements?
- Is this code maintainable?
- Does this code have unintended side-effects?

Code Reviews and Programmer's Ego

- Code review means someone's looking over your work
- You might have some attachment to it
- Criticisms: sometimes hard not to take personally
- Acknowledge a criticism and move on
- Acknowledgment doesn't imply that the author agrees with the content of the criticism
- Remember: The review is not about *you*, the goal is to improve code

Cost to Fix a Defect Over Time

Rough estimate



Case Study of a Failed Deployment: Knight Capital

Knightmare: A DevOps Cautionary Tale

• D7 • DevOps • April 17, 2014 • 6 Minutes

I was speaking at a conference last year on the topics of DevOps, Configuration as Code, and Continuous Delivery and used the following story to demonstrate the importance making deployments fully automated and repeatable as part of a DevOps/Continuous Delivery initiative. Since that conference I have been asked by several people to share the story through my blog. This story is true – this really happened. This is my telling of the story based on what I have read (I was not involved in this).

This is the story of how a company with nearly \$400 million in assets went bankrupt in minutes because of a failed deployment.



"In the week before go-live, a Knight engineer manually deployed the new RLP code in SMARS to its eight servers. However, the engineer made a mistake and did not copy the new code to one of the servers. Knight did not have a second engineer review the deployment, and neither was there an automated system to alert anyone to the discrepancy. "

Deployment Philosophy: Instagram

“Faster is safer”



“If stuff blows up it affects a very small percentage of people”



Instagram cofounder and CTO Mike Krieger

Continuous Delivery

“Faster is safer”: Key values of continuous delivery

- Release frequently, in small batches
- Maintain key performance indicators to evaluate the impact of updates
- Phase roll-outs
- Evaluate business impact of new features

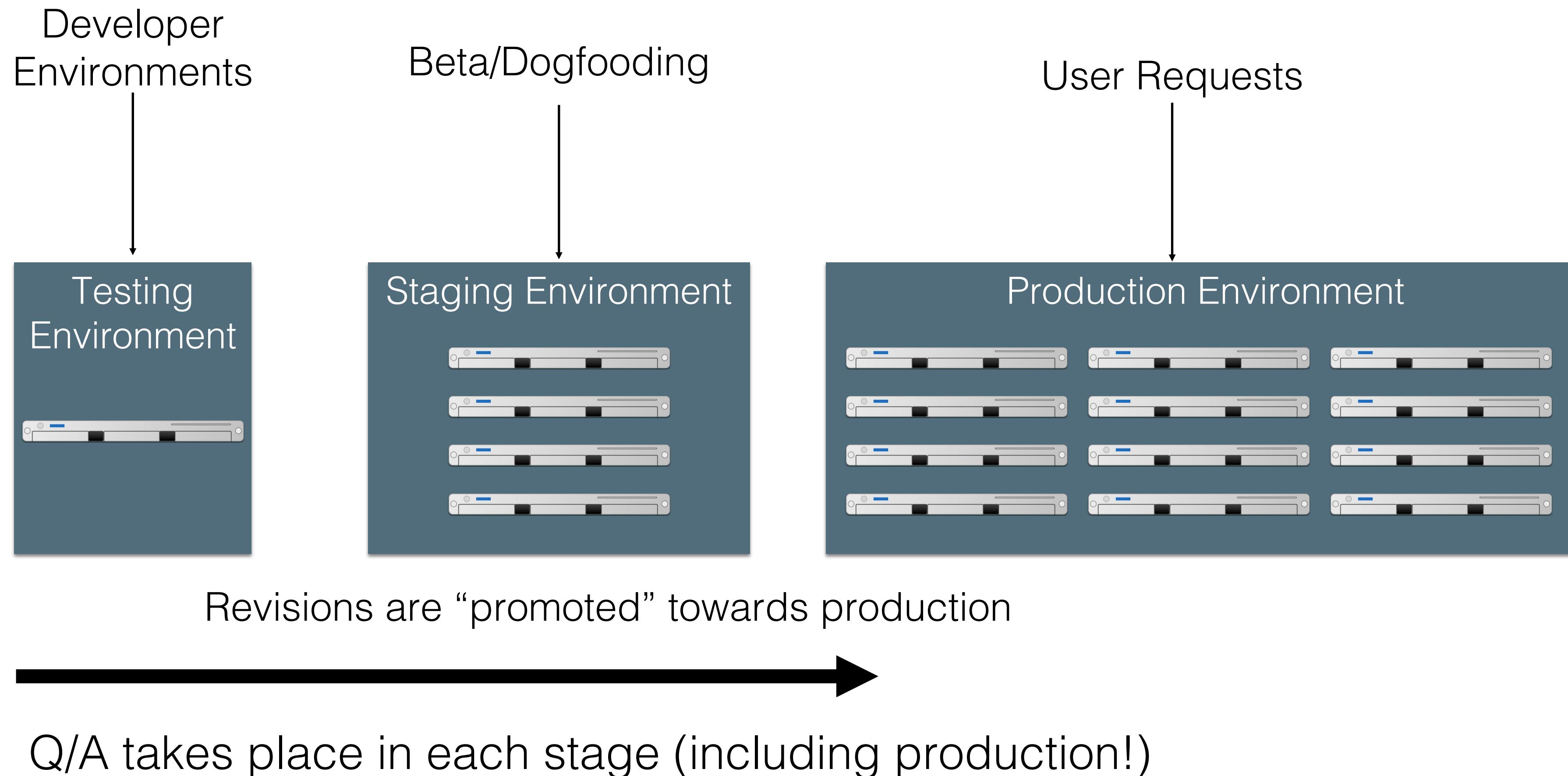
Staging Environments

Enabling Continuous Delivery

- As software gets more complex with more dependencies, it's impossible to simulate the whole thing when testing
- Idea: Deploy to a complete production-like environment, but don't have everyone use it
 - Examples:
 - “Eat your own dogfood”
 - Beta/Alpha testers
 - Lower risk if a problem occurs in staging than in production

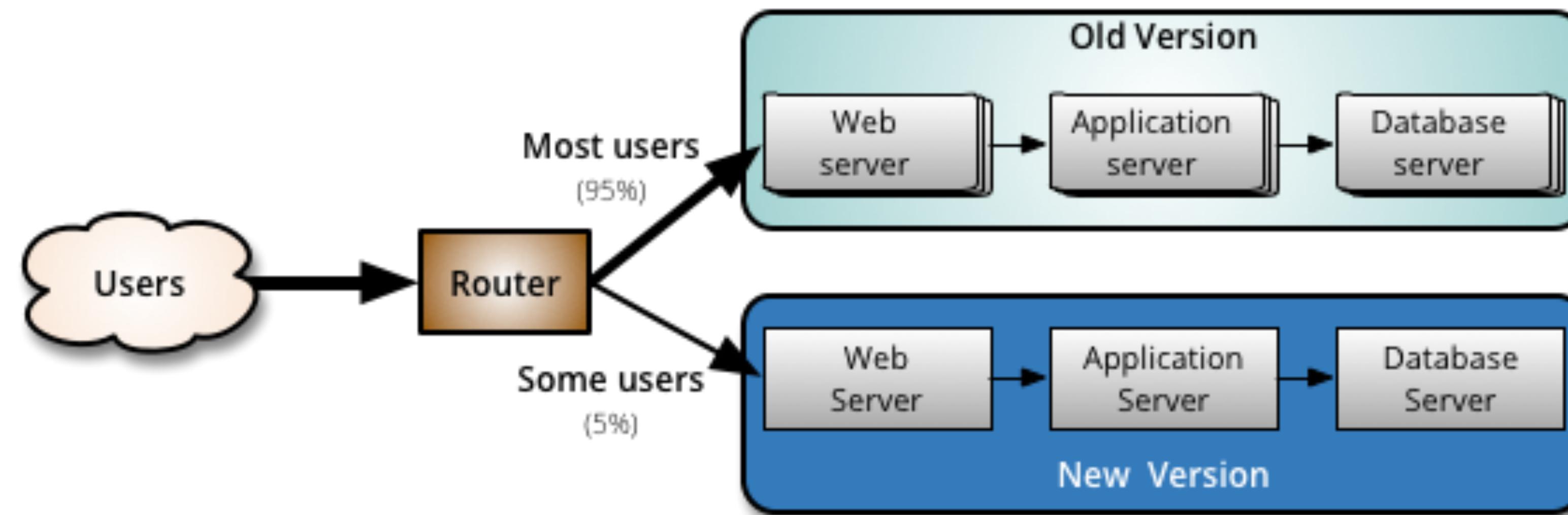
Test-Stage-Production

Continuous Delivery in Action



A/B Deployments with Canaries

Mitigating risk in continuous delivery

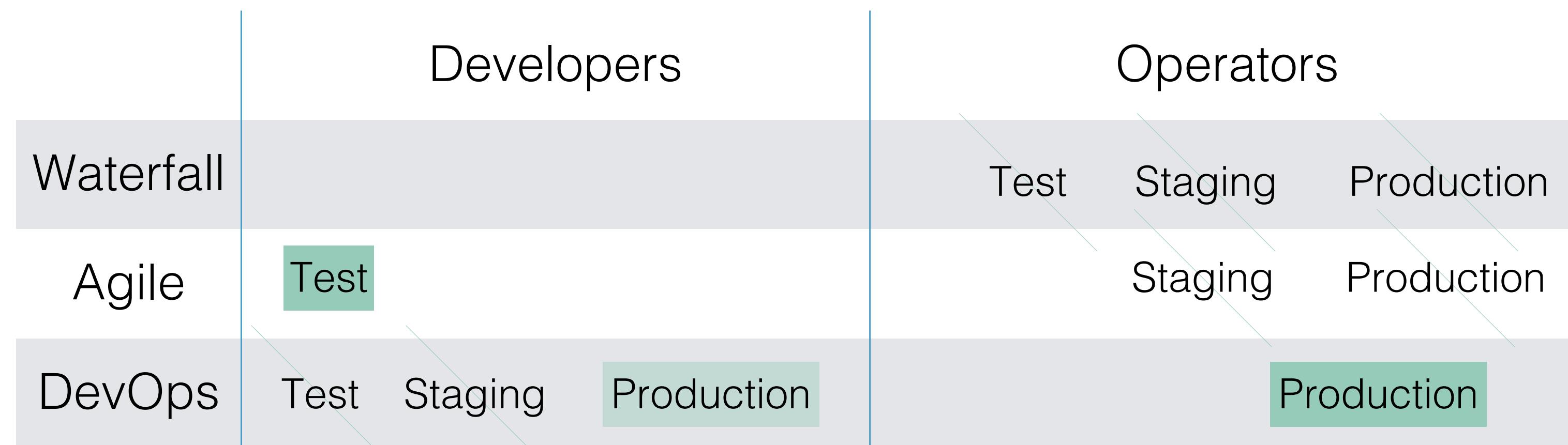


Monitor both:
But minimize impact of problems in new version

Operations Responsibility

DevOps in a slide

- Once we **deploy**, someone has to monitor software, make sure it's running OK, no bugs, etc
- Assume 3 environments:
 - Test, Staging, Production
 - Whose job is it?



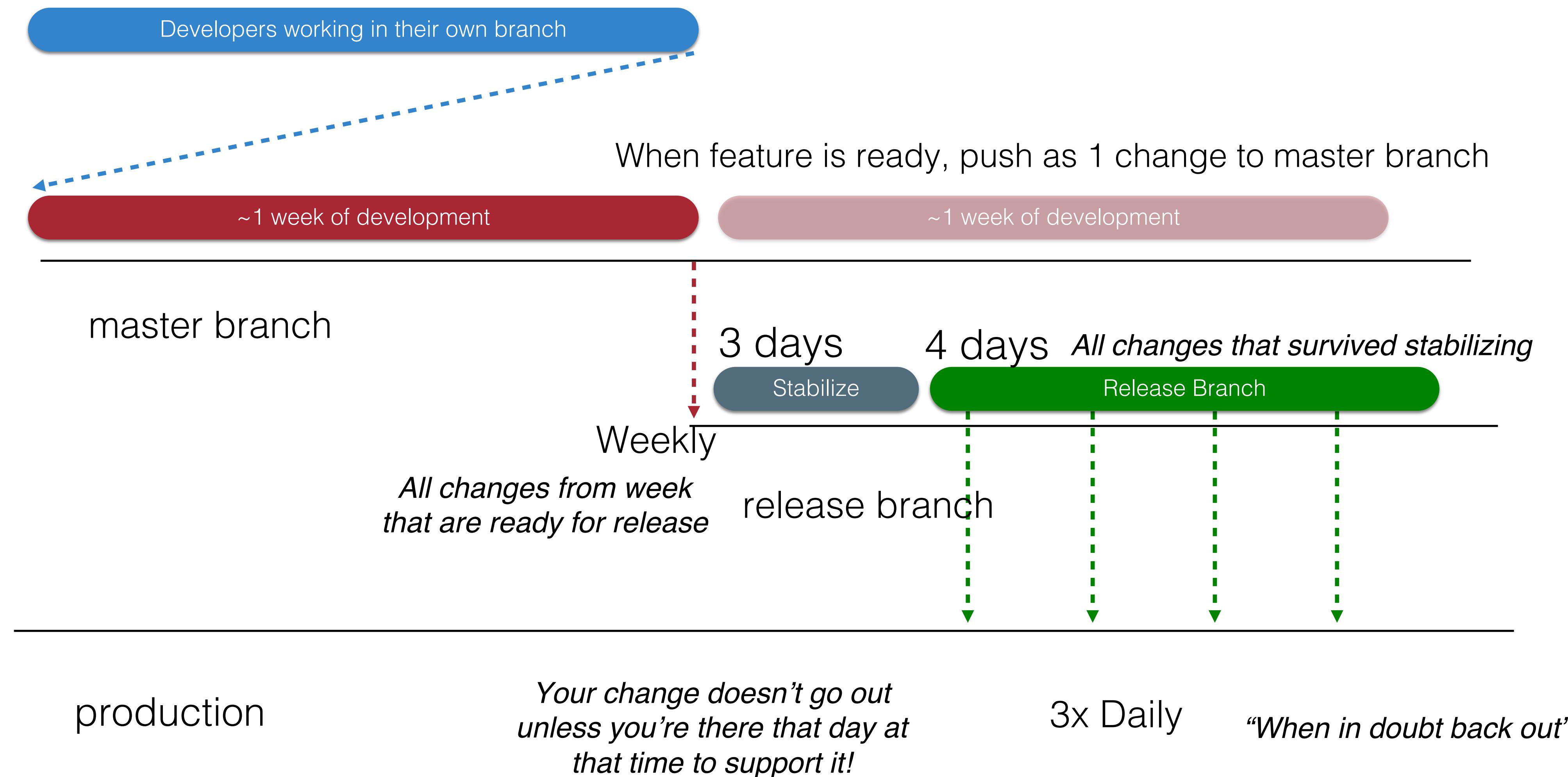
Release Pipelines

How quickly is my change deployed?

- Even if you are deploying every day, you still have some latency
- A new feature I develop today won't be released today
- But, a new feature I develop today can begin the **release pipeline** today (minimizes risk)
- **Release Engineer**: gatekeeper who decides when something is ready to go out, oversees the actual deployment process

Deployment Example: Facebook.com

Pre-2016



Deployment Example: Facebook.com

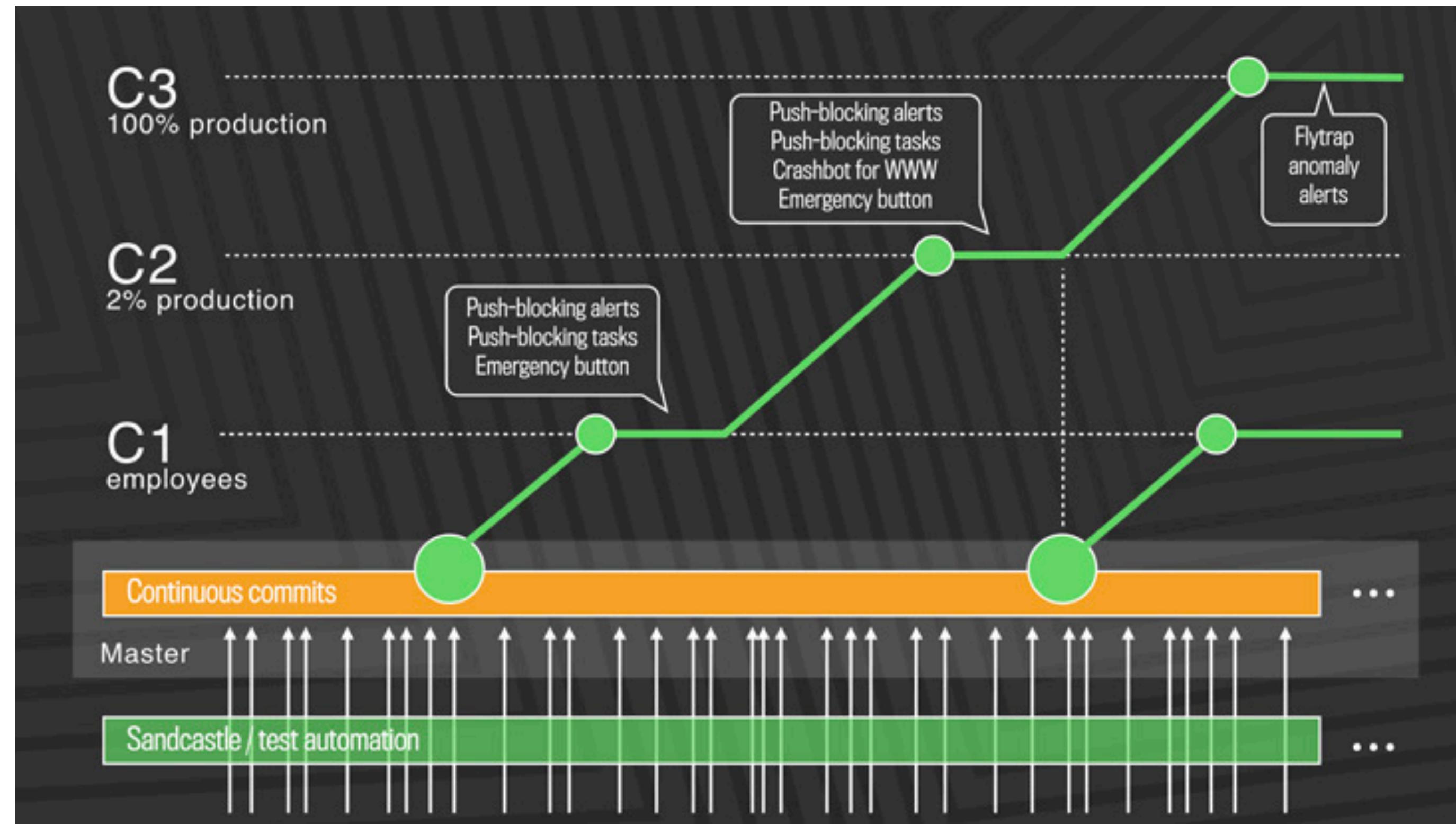
Chuck Rossi, Director Software Infrastructure & Release Engineering @ Facebook



“Our main goal was to make sure that the new system made people’s experience better — or at the very least, didn’t make it worse. After almost exactly a year of planning and development, over the course of three days in April 2017 we enabled 100 percent of our production web servers to run code deployed directly from master.”

Deployment Example: Facebook.com

Post-2016: Truly continuous releases from master branch



<https://engineering.fb.com/2017/08/31/web/rapid-release-at-massive-scale/>

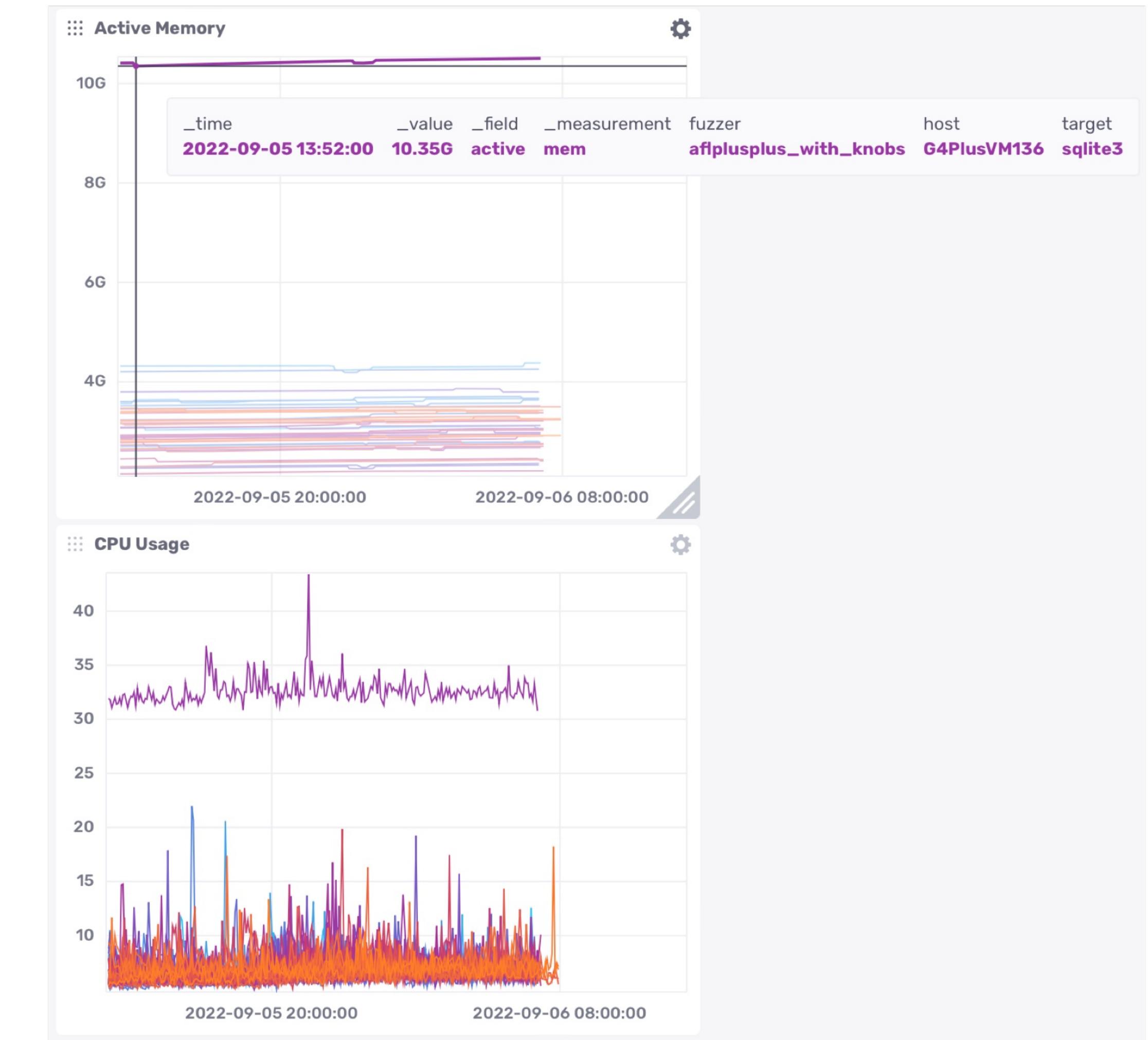
Monitoring

The last step in continuous deployment: track metrics

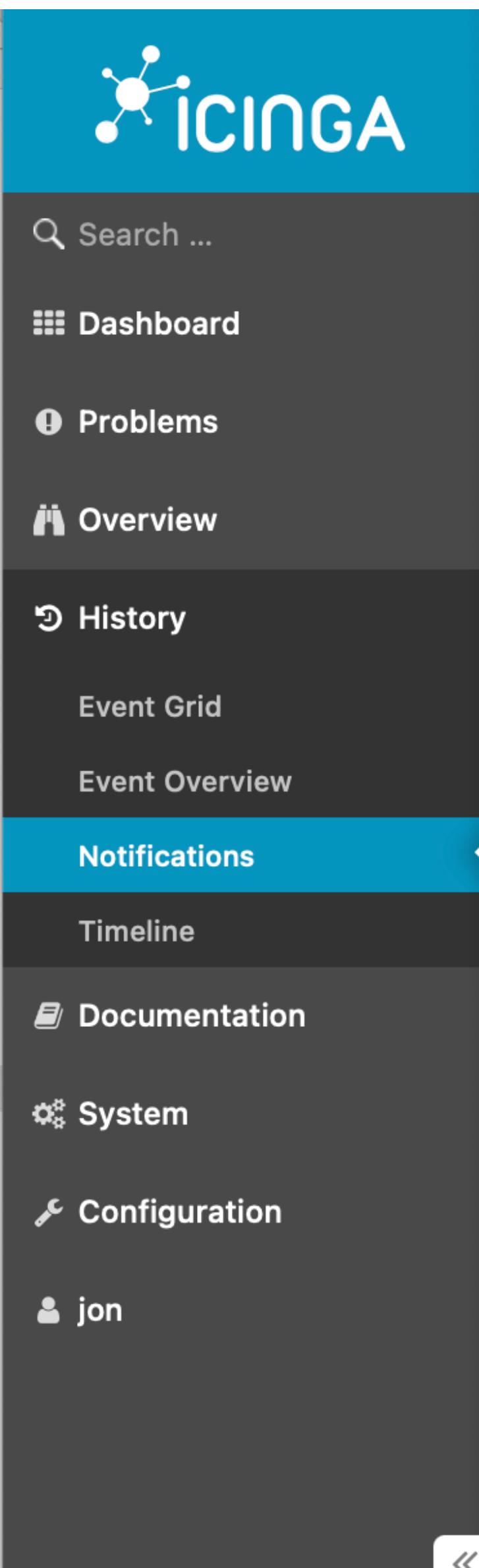
- Hardware
 - Voltages, temperatures, fan speeds, component health
- OS
 - Memory usage, swap usage, disk space, CPU load
- Middleware
 - Memory, thread/db connection pools, connections, response time
- Applications
 - Business transactions, conversion rate, status of 3rd party components

Monitoring Services Aggregate System Status

Monitoring Dashboards Help Gather Insights



Monitoring Services Take Automated Actions



The sidebar contains the Icinga logo at the top, followed by a search bar and a list of navigation links:

- Dashboard
- Problems
- Overview
- History
- Event Grid
- Event Overview
- Notifications** (selected)
- Timeline
- Documentation
- System
- Configuration
- jon

Notifications

Notifications Sort by Notification Start

Time	Service	State	Details	Recipient
2022-02-18 08:49:05	Slurm Nodes on nagios	OK	OK - 0 nodes unreachable, 332 reachable	Sent to jon
2022-02-18 08:49:05	Slurm Nodes on nagios	OK	OK - 0 nodes unreachable, 332 reachable	Sent to icingaadmin
2022-02-18 08:45:05	Slurm Nodes on nagios	WARNING	WARNING - 7 nodes unreachable, 326 reachable	Sent to jon
2022-02-18 08:45:05	Slurm Nodes on nagios	WARNING	WARNING - 7 nodes unreachable, 326 reachable	Sent to icingaadmin
2022-02-18 08:42:05	Slurm Nodes on nagios	CRITICAL	CRITICAL - 65 nodes unreachable, 161 reachable	Sent to icingaadmin
2022-02-18 08:42:05	Slurm Nodes on nagios	CRITICAL	CRITICAL - 65 nodes unreachable, 161 reachable	Sent to jon
2022-02-18 08:40:05	Slurm Nodes on nagios	WARNING	WARNING - 12 nodes unreachable, 205 reachable	Sent to icingaadmin
2022-02-18 08:40:05	Slurm Nodes on nagios	WARNING	WARNING - 12 nodes unreachable, 205 reachable	Sent to jon
2022-02-18 08:34:07	Slurm Nodes on nagios	CRITICAL	CRITICAL - 204 nodes unreachable, 145 reachable	Sent to icingaadmin

Notification

Current Service State

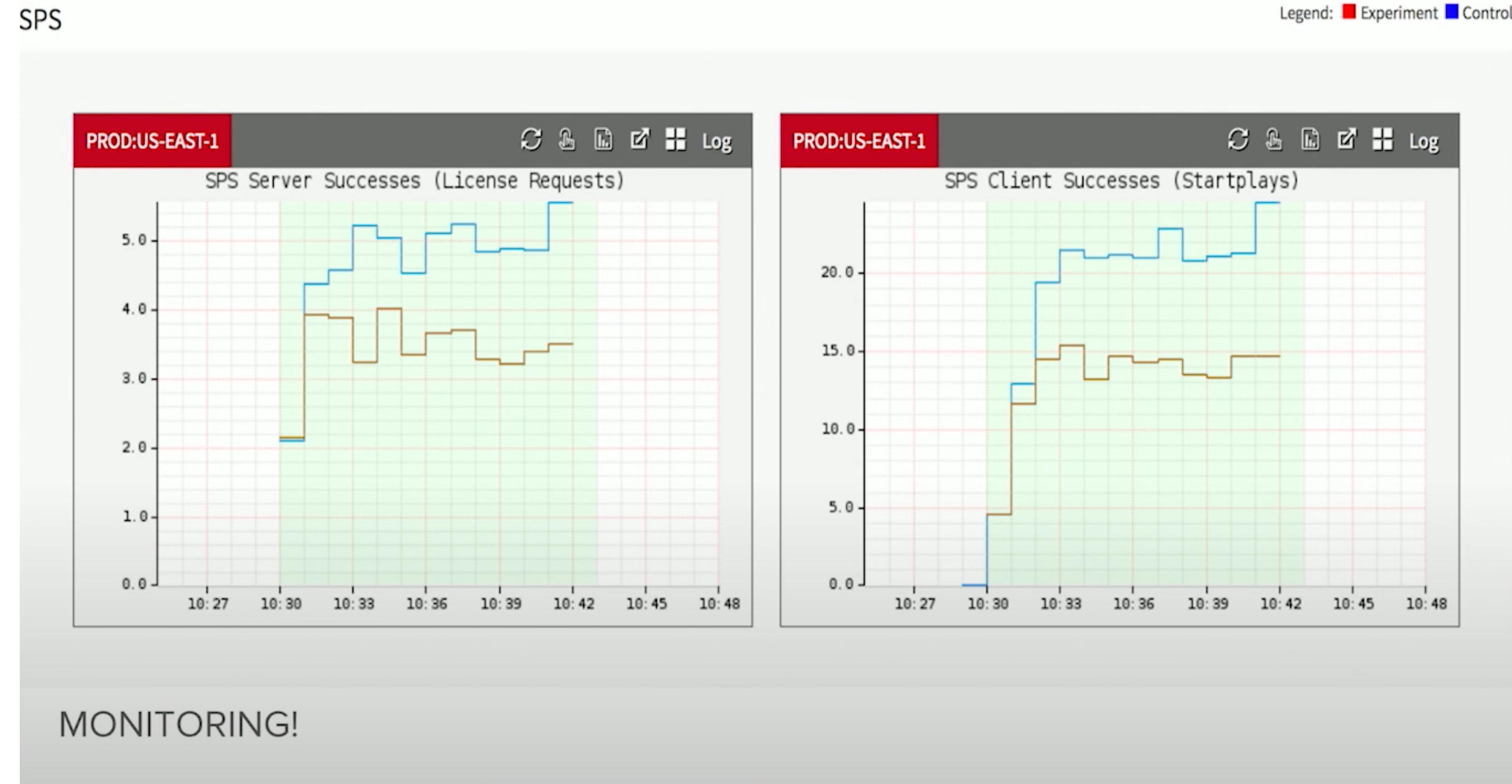
UP since 2021-11	nagios ::1 127.0.0.1
OK for 1m 52s	Service: Slurm Nodes

Event Details

Type	Notification
Start time	2022-02-18 08:42:05
End time	2022-02-18 08:42:05
Reason	Normal notification
State	CRITICAL
Escalated	No
Contacts notified	2
Output	CRITICAL - 65 nodes unreachable, 161 reachable

Monitoring Services Take Automated Actions

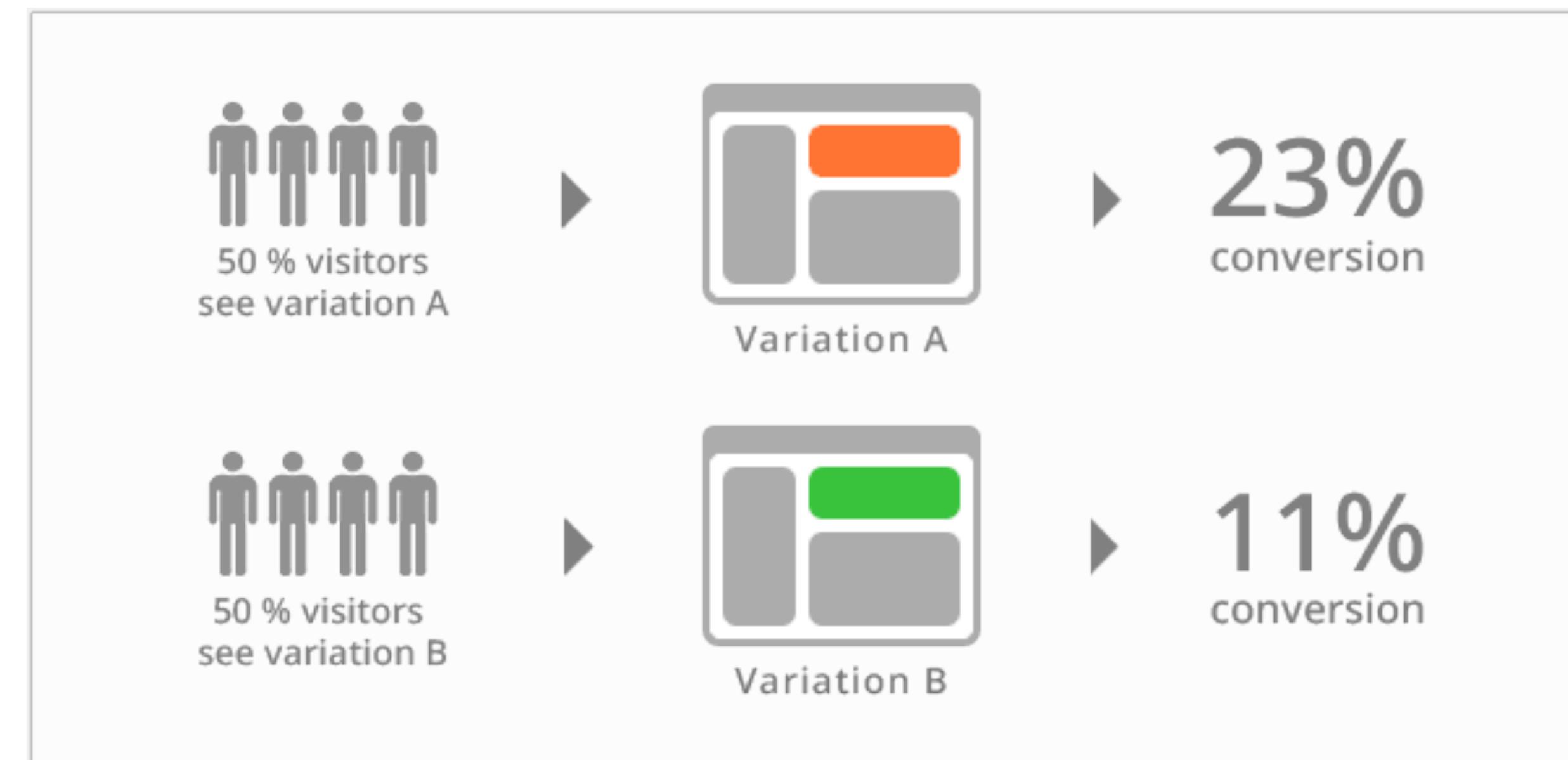
Automatically detecting irregular behavior at Netflix



Usability Testing in Continuous Development

A/B Testing

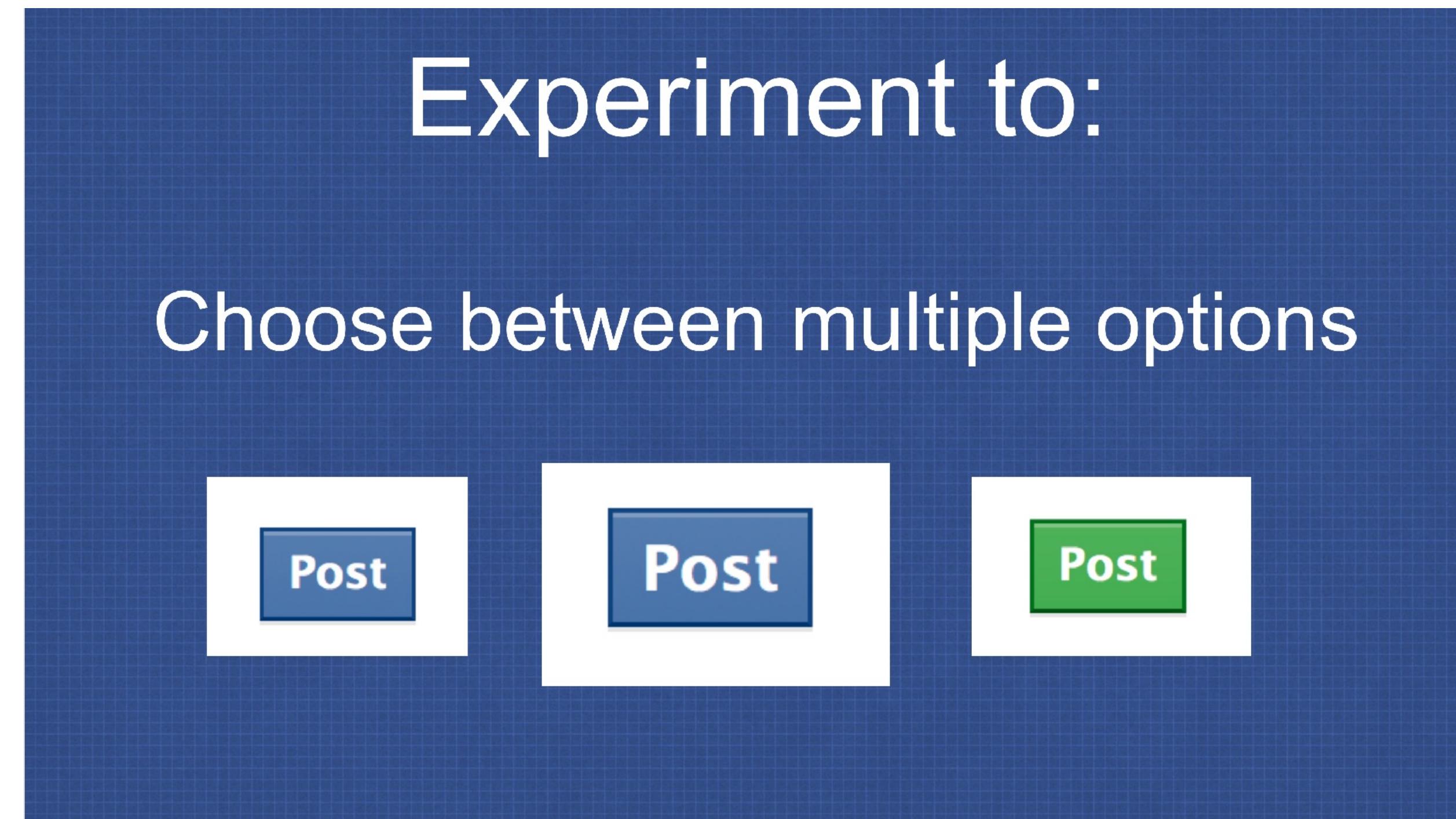
- Ways to test new features for usability, popularity, performance without a focus group
- Show 50% of your site visitors version A, 50% version B, collect metrics on each, decide which is better



Usability Testing in Continuous Development

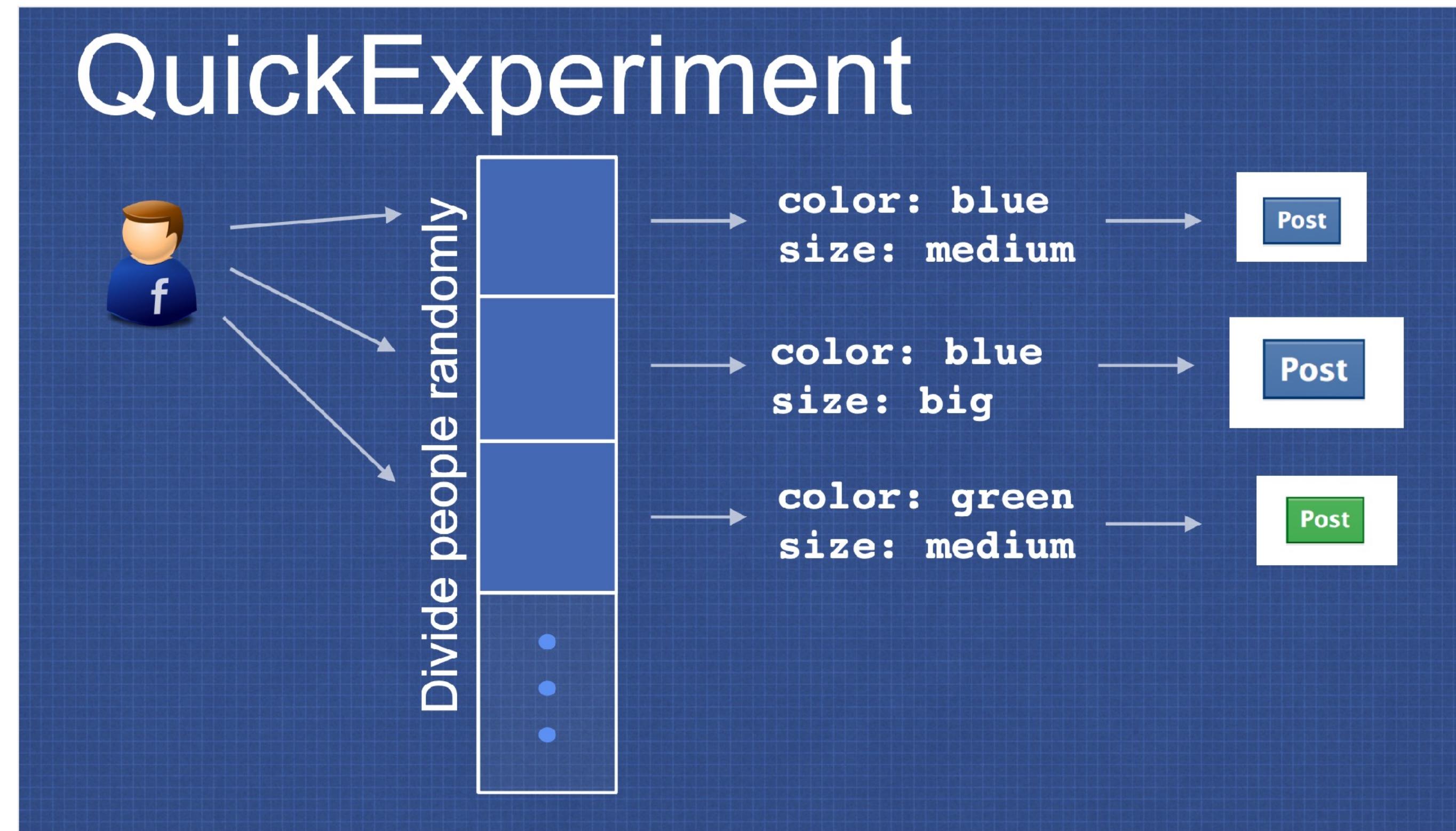
A/B Testing: PlanOut from Facebook (“N=10⁹ user study”)

- Used to test advertising strategies (and Facebook functionality)
- Segment audience and define KPIs, collect results



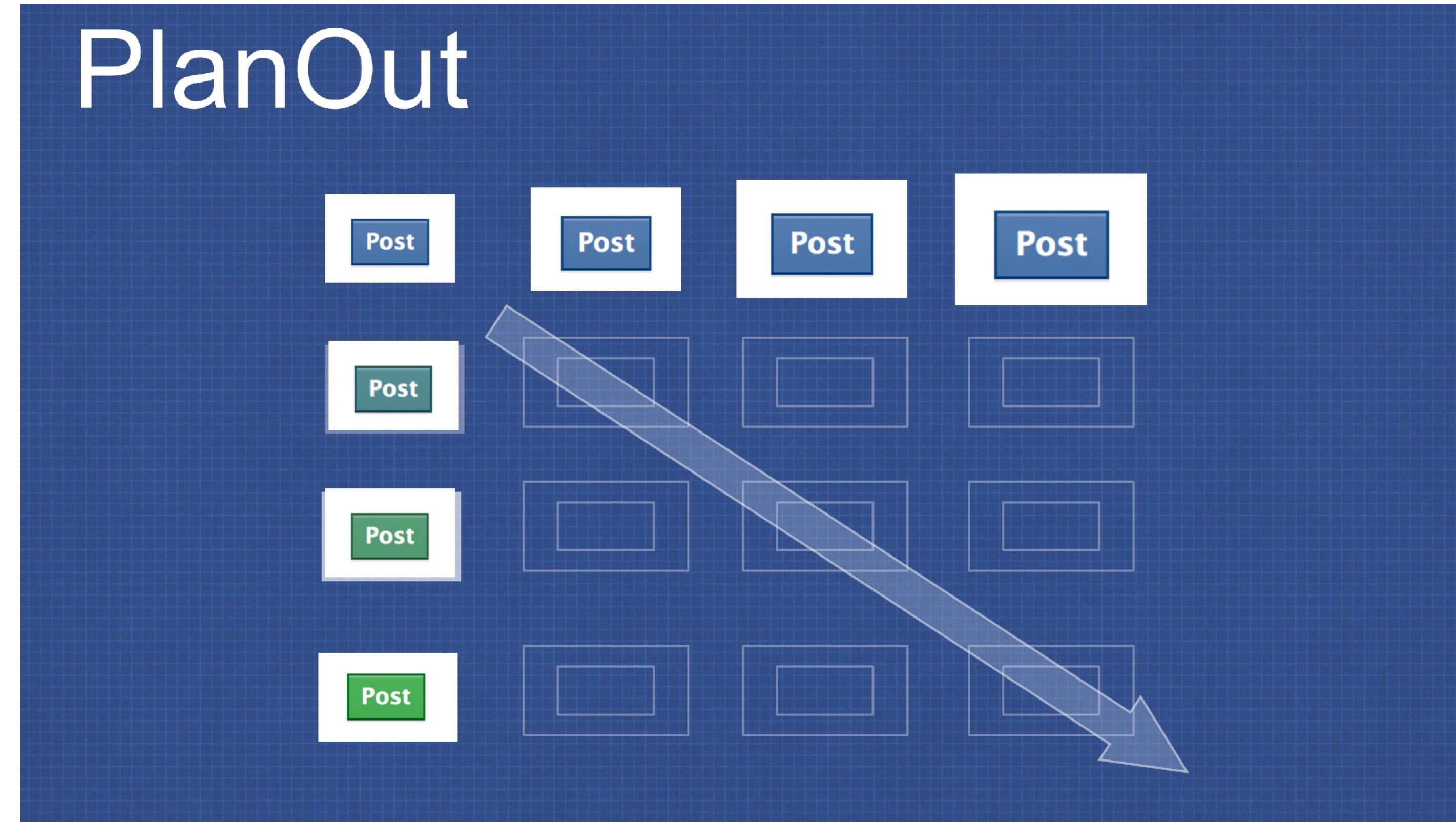
Usability Testing in Continuous Development

A/B Testing: PlanOut from Facebook (“N=10⁹ user study”)



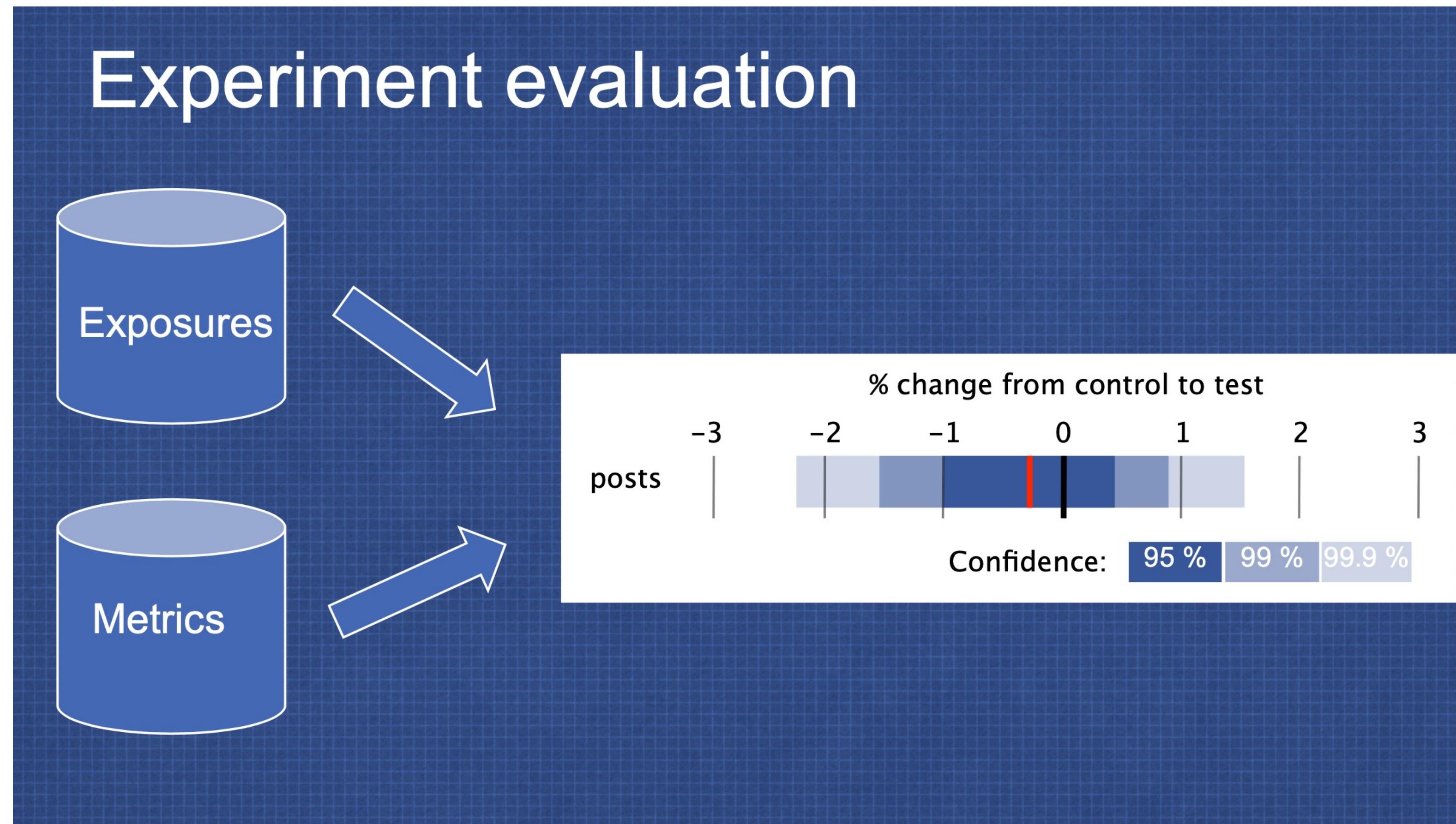
Usability Testing in Continuous Development

A/B Testing: PlanOut from Facebook (“N=10⁹ user study”)



Usability Testing in Continuous Development

A/B Testing: PlanOut from Facebook (“N=10⁹ user study”)



Beware of Metrics

McNamara Fallacy

- Measure whatever can be easily measured
- Disregard that which cannot be measured easily
- Presume that which cannot be measured easily is not important
- Presume that which cannot be measured easily does not exist



What Could Knight Capital Have Done Better?

- Use capture/replay testing instead of driving market conditions in a test
- Avoid including “test” code in production deployments
- Automate deployments
- Define and monitor risk-based KPIs
- Create checklists for responding to incidents

Learning Objectives for this Lesson

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

- Describe how continuous integration helps to catch errors sooner in the software lifecycle
- Describe the benefits of a culture of code review
- Describe strategies for performing quality-assurance on software as and after it is delivered