Objectives

- Software Development
  - Various models
- Testing
  - Overview of goals and approaches

Rest of the Semester

- Shift from learning Java, specifically, to learning how to develop software (abstractly) with Java as our implementation/example
- Why Java?
  - Popular language
  - Many frameworks and tools for Java
  - Java's structure allows for strict adherence to design techniques
- Just a start on Java
  - You'll need to continue learning more Java on your own

SOFTWARE DEVELOPMENT

Programming is not Software Engineering

> "It's Programming if 'clever' is a compliment.
> It's Software Engineering if 'clever' is an accusation."
> -- Titus Winters

- This course is software development…
  - We're moving from programming towards software engineering
  - One metric: how long you think before you code
- Titus Winters: formerly at Google, now at Adobe

https://twitter.com/tituswinters/status/1143595692113481728

No Silver Bullet:
Essence and Accidents of Software Engineering

"Of all the monsters that fill the nightmares of our folklore, none terrify more than werewolves, because they transform unexpectedly from the familiar into horrors. For these, one seeks bullets of silver that can magically lay them to rest.

"The familiar software project, at least as seen by the nontechnical manager, has something of this character; it is usually innocent and straightforward, but is capable of becoming a monster of missed schedules, blown budgets, and flawed products. So we hear desperate cries for a silver bullet—something to make software costs drop as rapidly as computer hardware costs do.

"But, as we look to the horizon of a decade hence, we see no silver bullet. **There is no single development, in either technology or in management technique, that by itself promises even one order-of-magnitude improvement in productivity, in reliability, in simplicity**. In this article, I shall try to show why, by examining both the nature of the software problem and the properties of the bullets proposed."

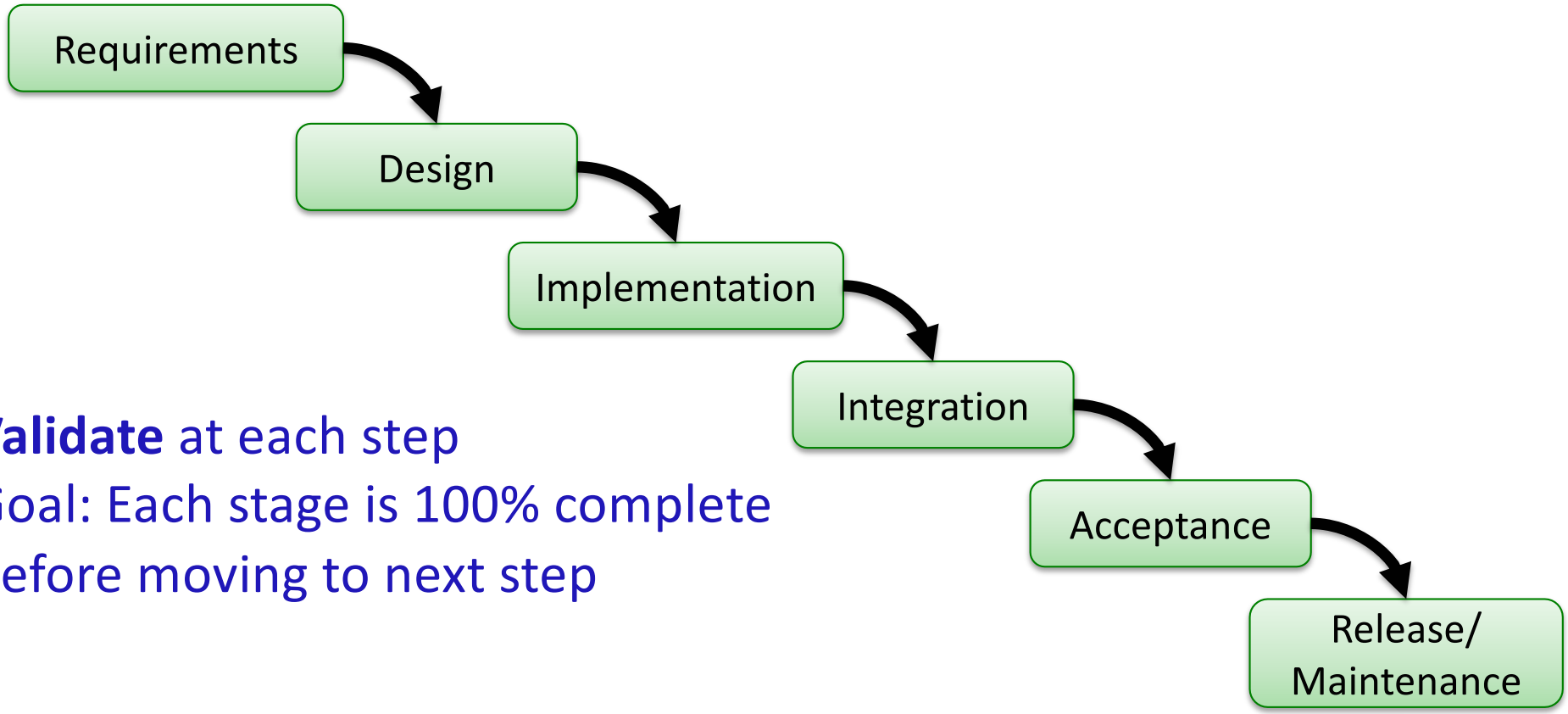
by Frederick P. Brooks, Jr., 1986

Software Engineering

- Software Engineering is a relatively new field
  - Still learning best practices

Takeaway: We will employ lots of techniques that help make software development process more efficient without sacrificing software quality

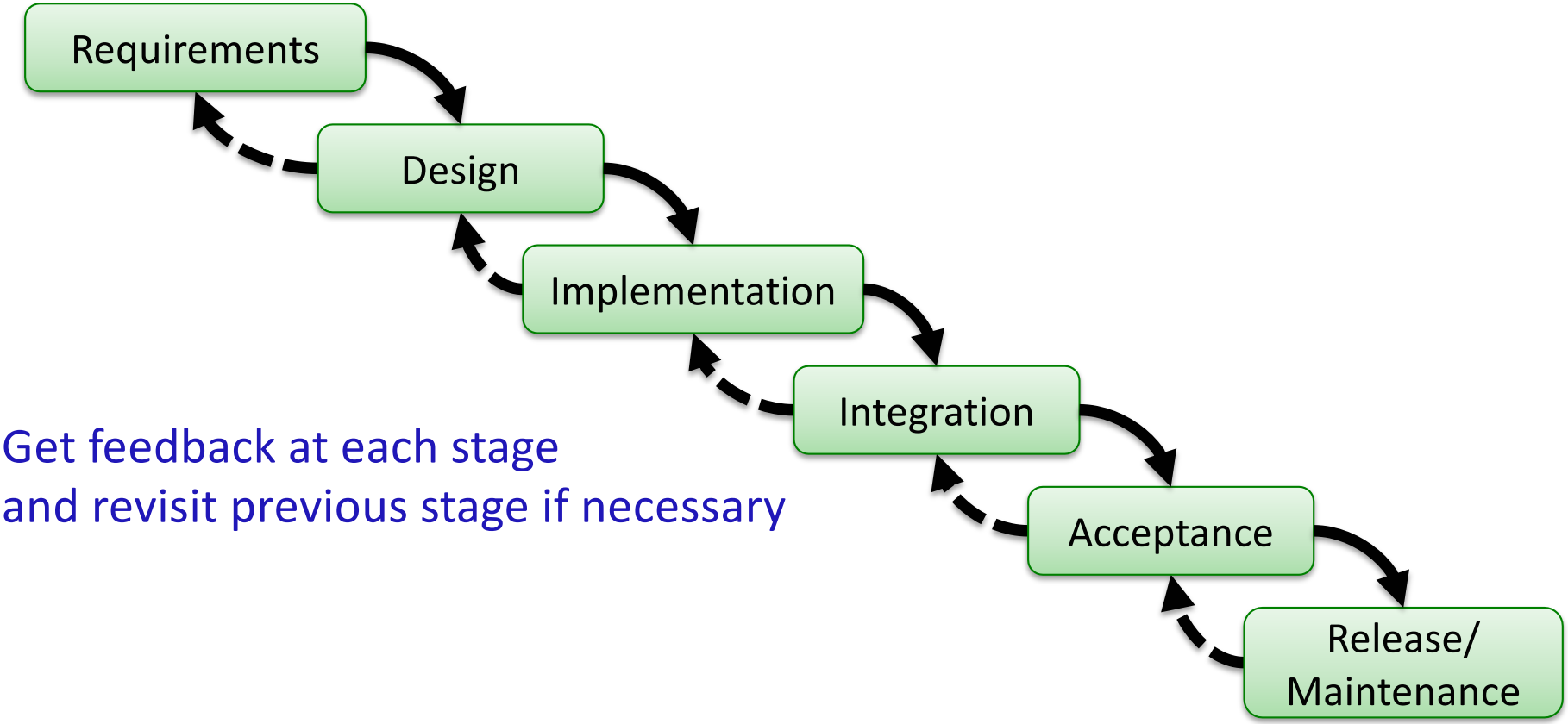
Traditional Software Engineering Process: Waterfall Model



Validate at each step

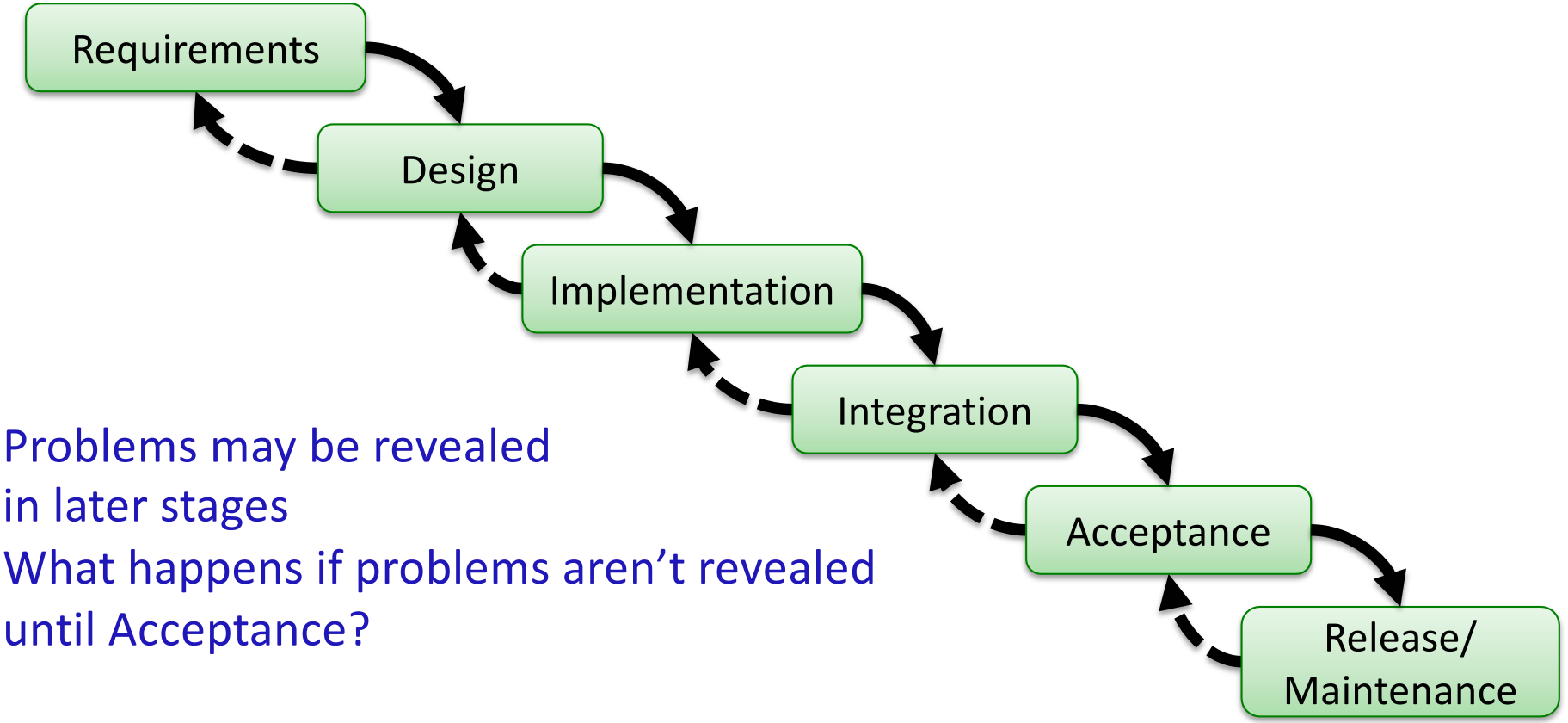
Goal: Each stage is 100% complete before moving to next step

Feedback in Waterfall Model



- Get feedback at each stage and revisit previous stage if necessary

Feedback in Waterfall Model

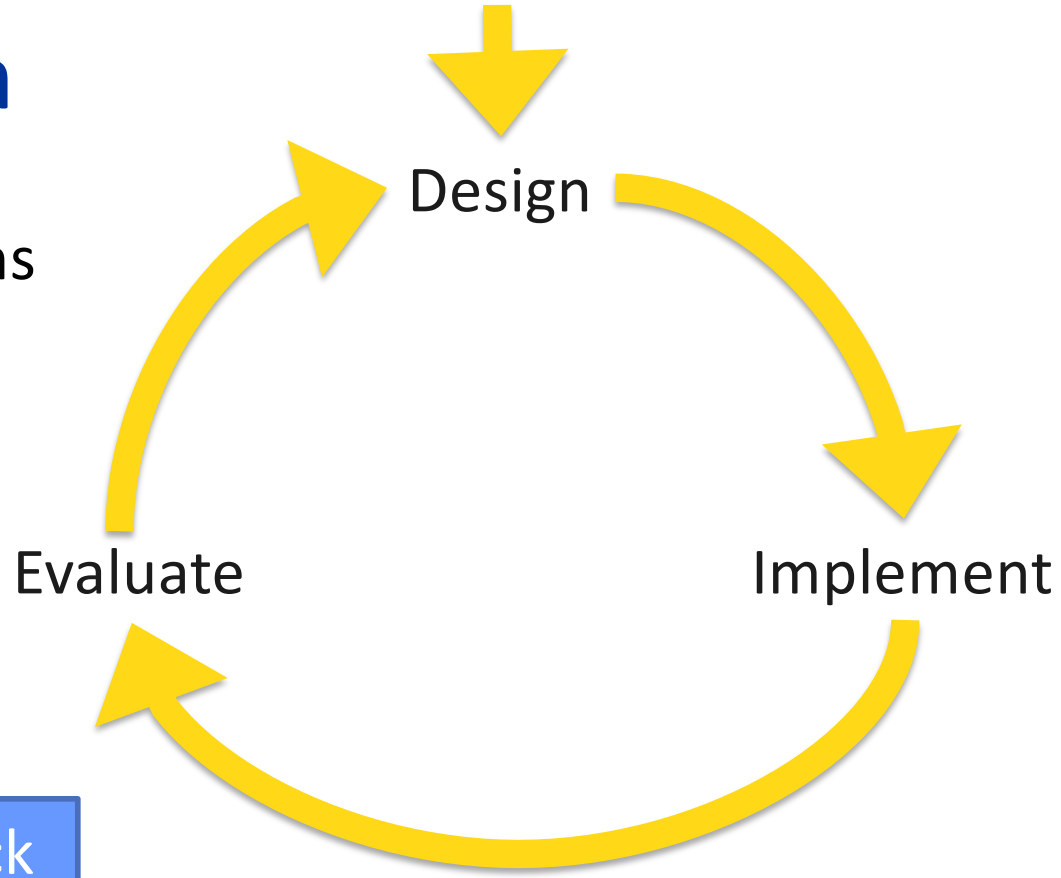


- Problems may be revealed in later stages
- What happens if problems aren't revealed until Acceptance?

Iterative Design

Various implementations

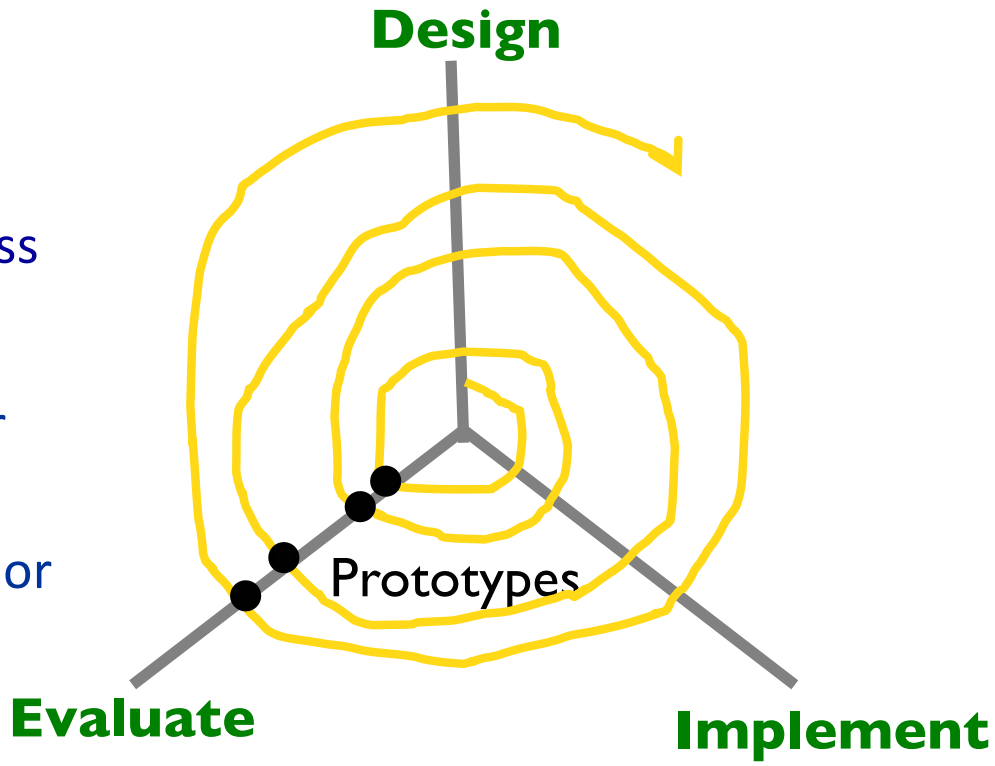
Get feedback/requirements
from users/clients



Goals: Frequent feedback
→Identify problems early
→Higher quality product

Spiral Model

- Idea: smaller prototypes to test/fix/throw away
  - Finding problems early costs less
- In general…
  - Break functionality into smaller pieces
  - Implement most depended-on or highest-priority features first



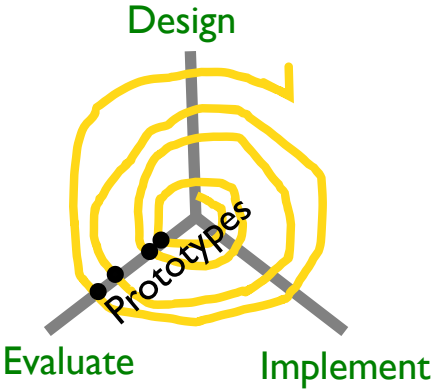
Radial dimension: cost

[Boehm 86]

Prototypes, In Brief

- Sample of application
  - Often: Demonstrate one part/purpose
  - Focus on one thing, not the whole thing
- Purpose/Dimensions
  - Functionality
  - Interaction
  - Implementation
- Fidelity
  - Low: omits details
  - High: very similar to finished product

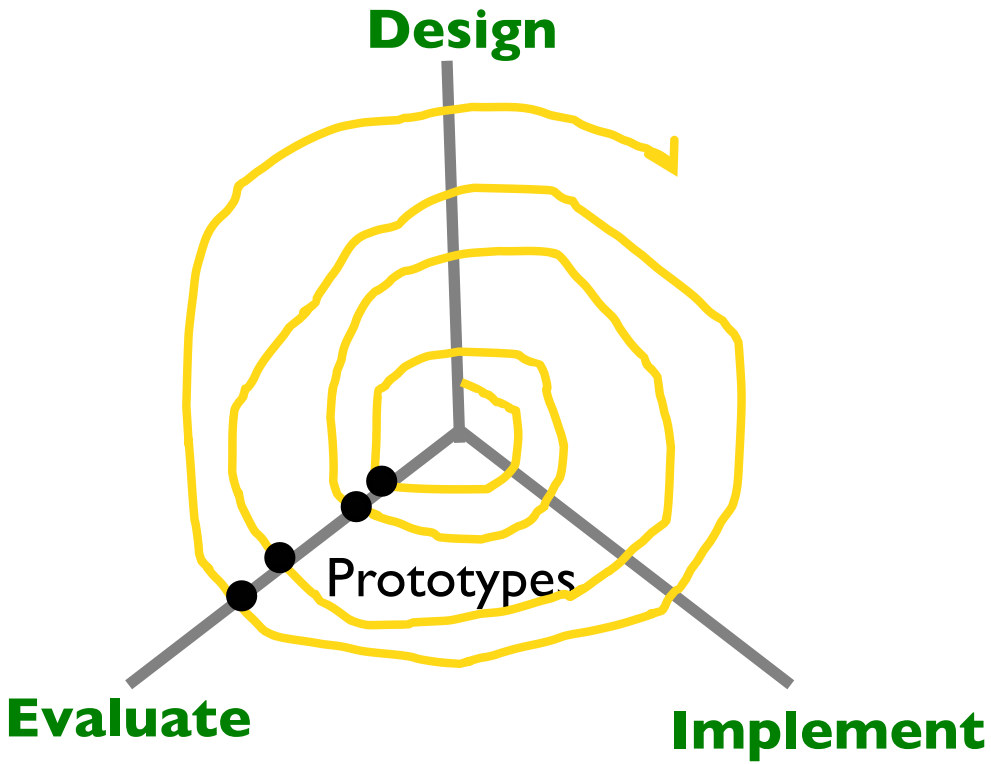
Spiral Model/Iterative Design Model Benefits



- Builds in getting feedback from client
  - Demo prototypes or working versions of [parts of] application
  - Clients' requirements may change
  - Clients' requirements may be ambiguous or were misinterpreted
- Makes project development more ***agile***
  - Goal: find problems early
  - Easier to throw away cheaper early prototypes
  - Adjust/adapt to changes

Spiral Model: Breaking Down Further

- Project's development process: Spiral Model
- What does this look like day to day?
  - Agile development is a common implementation



Radial dimension: cost

[Boehm 86]

Agile Development

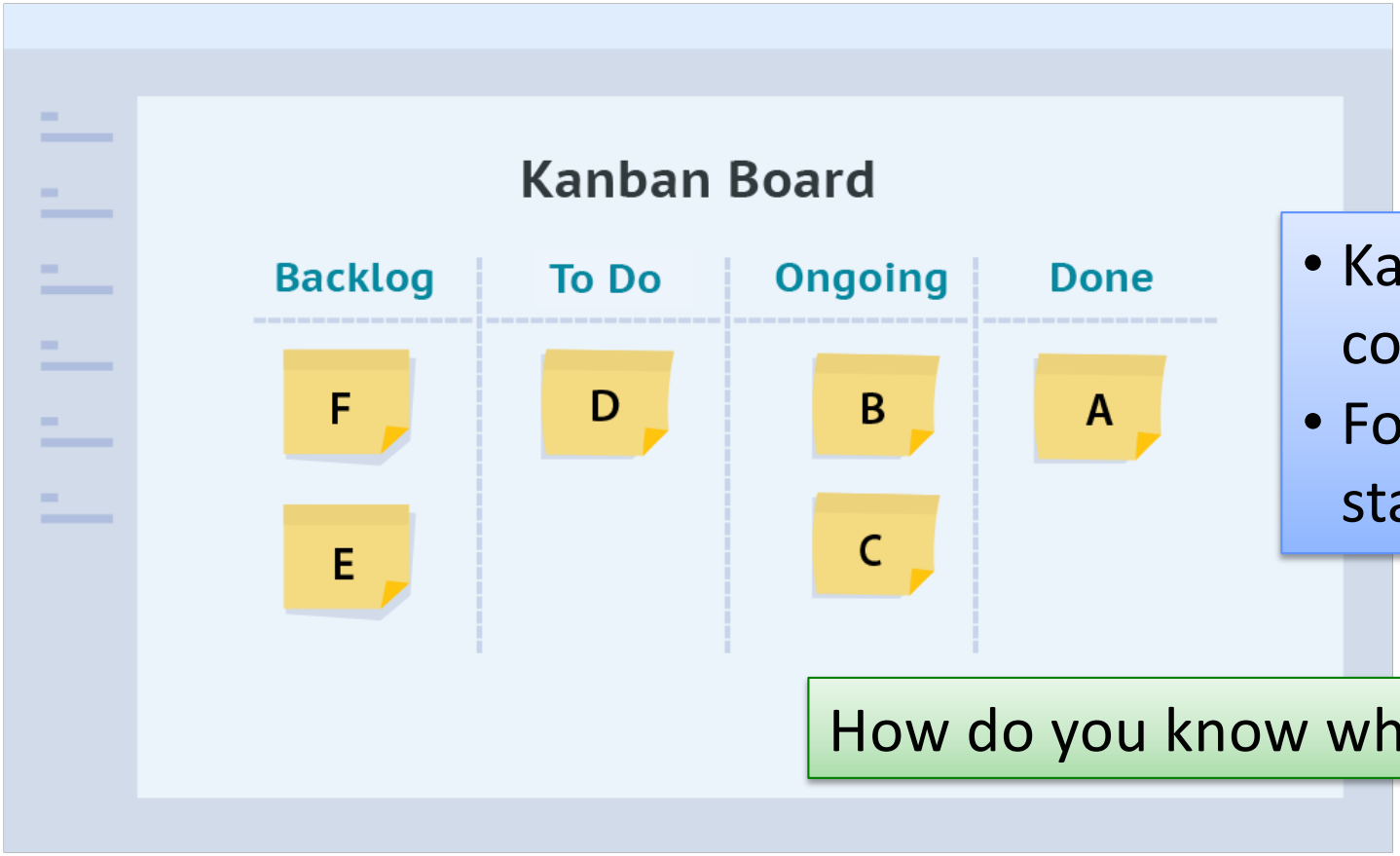
- Iterative approach to project management and software development
  - Work in small, launchable increments
  - Frequent review of requirements, plans, results
- Goals:
  - Respond to change quickly
  - Deliver application faster
  - Fewer conflicts about requirements
- Lots of variations – often company- or team-specific

Agile Development Framework: Scrum

- Product owner creates prioritized wish list: *a product backlog*
- Team works in a *sprint*, usually 2-4 weeks
  - During planning, team picks a subset of wish list, *a sprint backlog*, and decides how to implement those pieces
  - Daily Scrum: team meets daily to assess its progress
    - ScrumMaster keeps the team focused on its goal
  - At end of sprint, work should be potentially shippable:
    - ready to hand to a customer, put on a store shelf, or show to a stakeholder
  - The sprint ends with a sprint review and retrospective
- Repeat sprint

`https://www.scrumalliance.org/why-scrum`

Tools to Help: Kanban Board

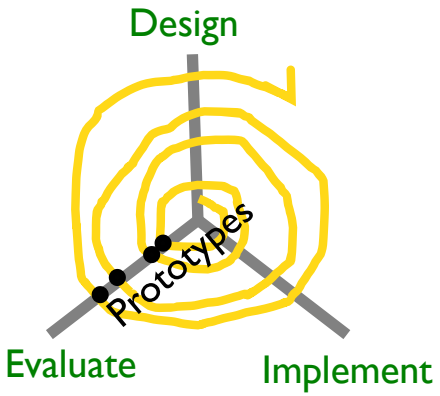


- Kanban is continuous, fluid.
- Focus on short start to finish time

How do you know when you're done?

https://www.digite.com/kanban/what-is-kanban/

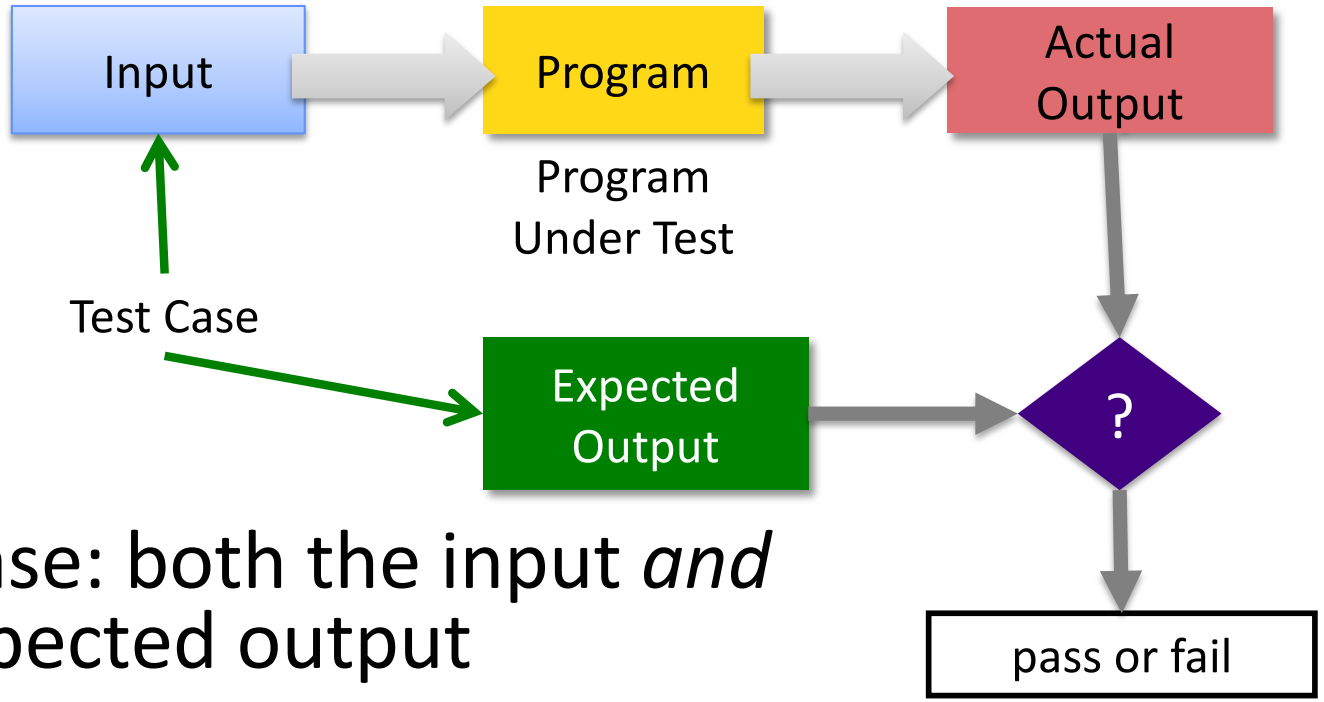
Implementation Step



- Implementation includes developing and testing
- How do you know when you're done developing/testing?
  - Helpful to have a systematic way to know that you're done ✅

SOFTWARE TESTING PROCESS

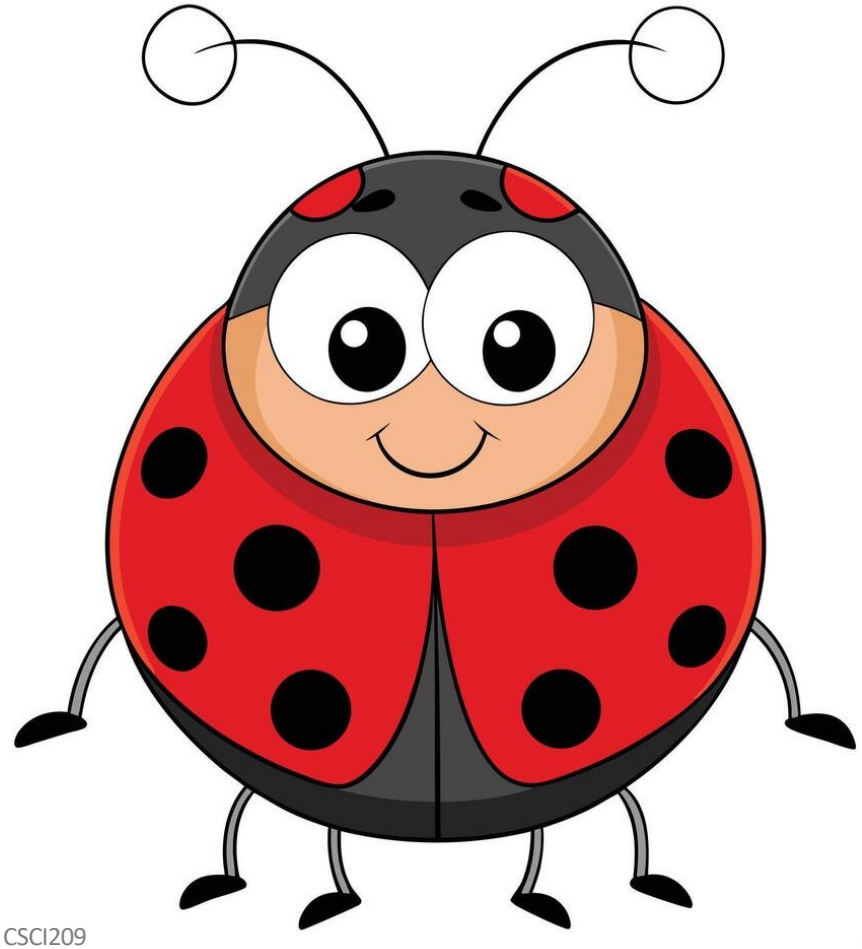
Review: Software Testing Process



- Test case: both the input *and* the expected output
- Test Suite: set of test cases

Type 1 Bugs: Compile-Time

- Syntax errors
  - Missing semicolon, parentheses
- Compiler notifies of error
- Cheap, easy to fix



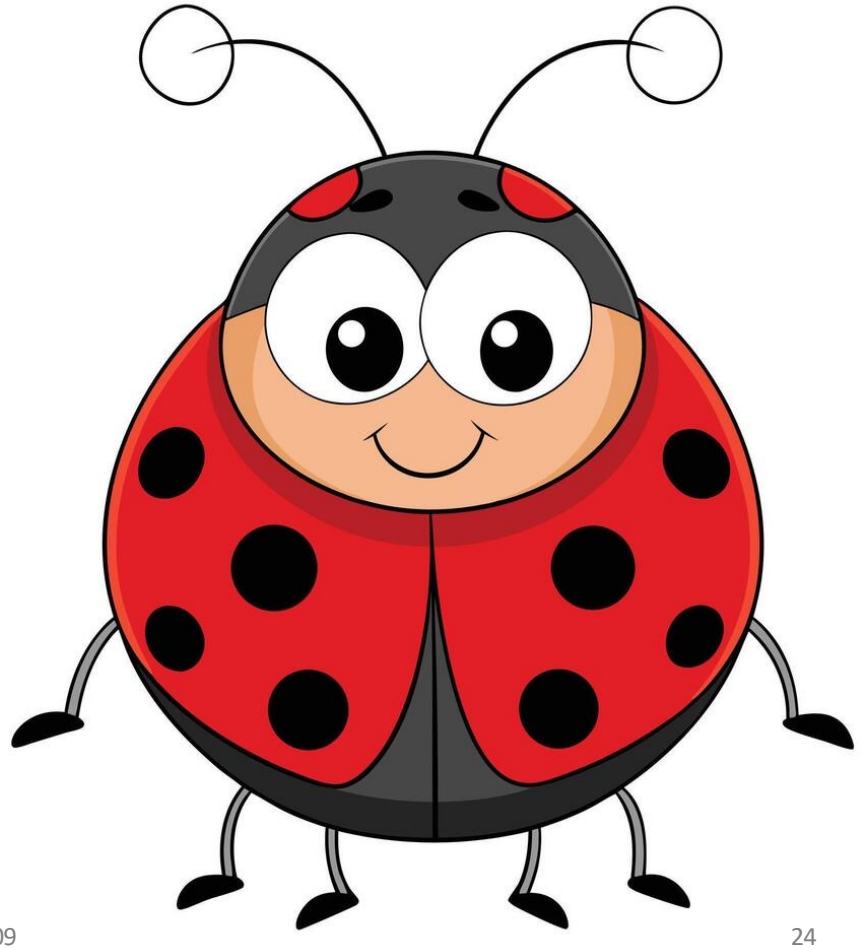
Type 2 Bugs: Run-Time

- Usually logic errors
- Expensive to locate, fix

A mother wolf spider (not a bug) with her 100 babies that was in my flowers.

Aside: Objections to "Bug" Terminology

- "Bug"
  - Sounds like it's just an annoyance
    - Can simply swat away
  - Minimizes potential problems
  - Hides programmer's responsibility
- Alternative terms
  - **Defect**
  - **Fault**



Tenor of Conversation

How do we detect bugs and fix them before the user sees them?

- NOT: how do we *never* write bugs?
  - We're human!
  - I mean, don't *try* to write bugs/be sloppy…
  - There's a balance.

Discussion: Your Testing Process

- How do you test?
- Categorize what you test/look for
- Are you a good tester? Why or why not?
  - What do you do well?
  - What do you need to get better at?

Common Bad Development Approaches

- Run the code. Did it do what you expect? <shrug/>
- Identify bug. Fix the bug on the test case that revealed the error. Don't test the other cases.
  - Similar: made a change to code (famous last words: "it shouldn't affect anything") and don't retest
- Tests don't help you identify the problem
  - A good set of tests will help you narrow the scope of the problem
- Random (only) testing

Microsoft  Testing

- Beyond their internal testing …
  - 5 million people beta tested
  - 60+ years of performance testing
  - 1 Billion+ Office 2007 sessions
- Still, users found correctness, stability, robustness, and security bugs

OSS Fuzz Project

- Continuous Fuzzing for Open Source Software
  - Fuzzing is a testing technique
- "Google has found thousands of security vulnerabilities and stability bugs by deploying guided in-process fuzzing of Chrome components"
- Also found 40K+ bugs in 600+ projects

https://github.com/google/oss-fuzz

Conclusion: Software Testing is Hard!

- Need to use a lot of different approaches
  - Different approaches catch different defects

Types of Testing
(Non-Exhaustive)

- Black-box testing
- White-box testing
- Non-functional testing
- Acceptance testing

Ideas about or definitions of any of these?
What is the approach? Or, what problems are they trying to reveal?

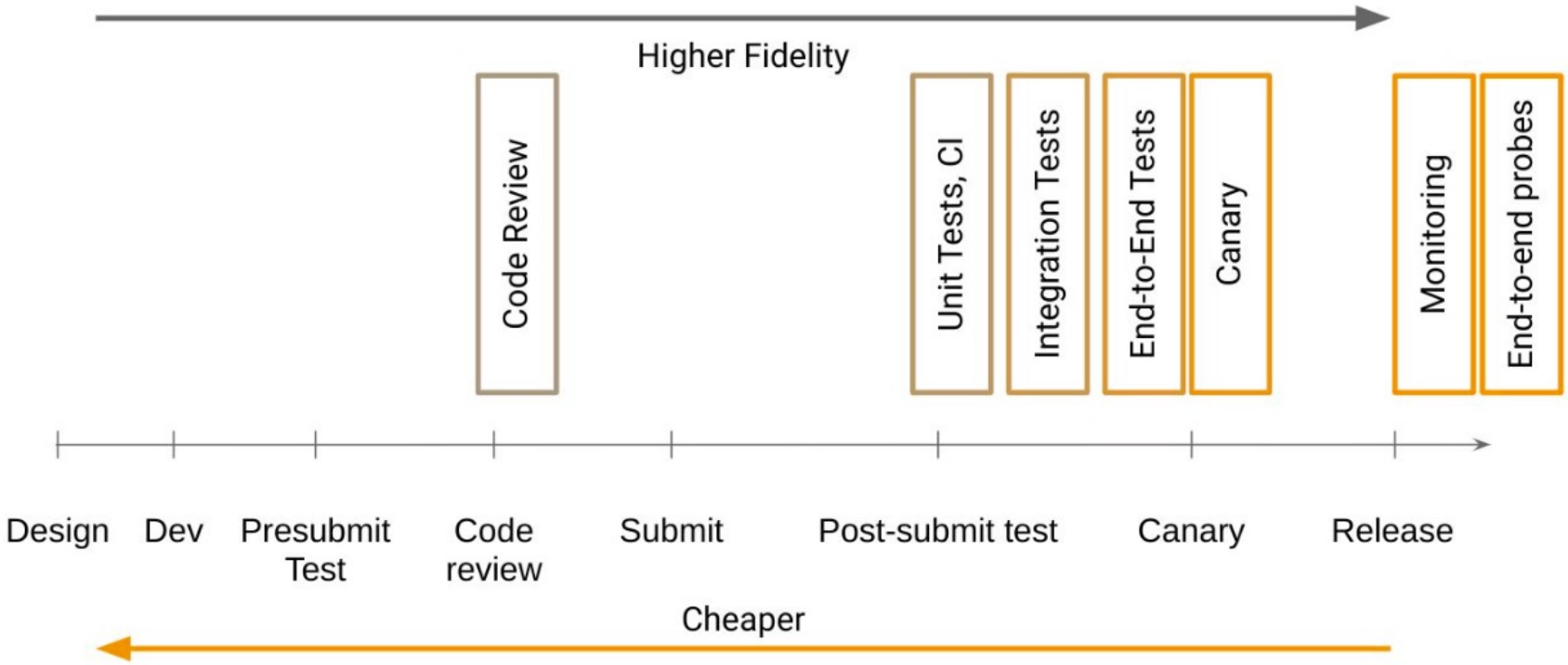
Types of Testing
(Non-Exhaustive)

- Black-box testing
  - Test *functionality* (e.g., the calculator)
  - No knowledge of the code
  - Examples of testing: boundary values
- White-box testing
  - Have access to code
  - **Goal**: execute *all* code
- Non-functional testing
  - Performance testing
  - Usability testing (HCI)
  - Security testing
  - Internationalization, localization
- Acceptance testing
  - Customer tests to decide if they accept the product

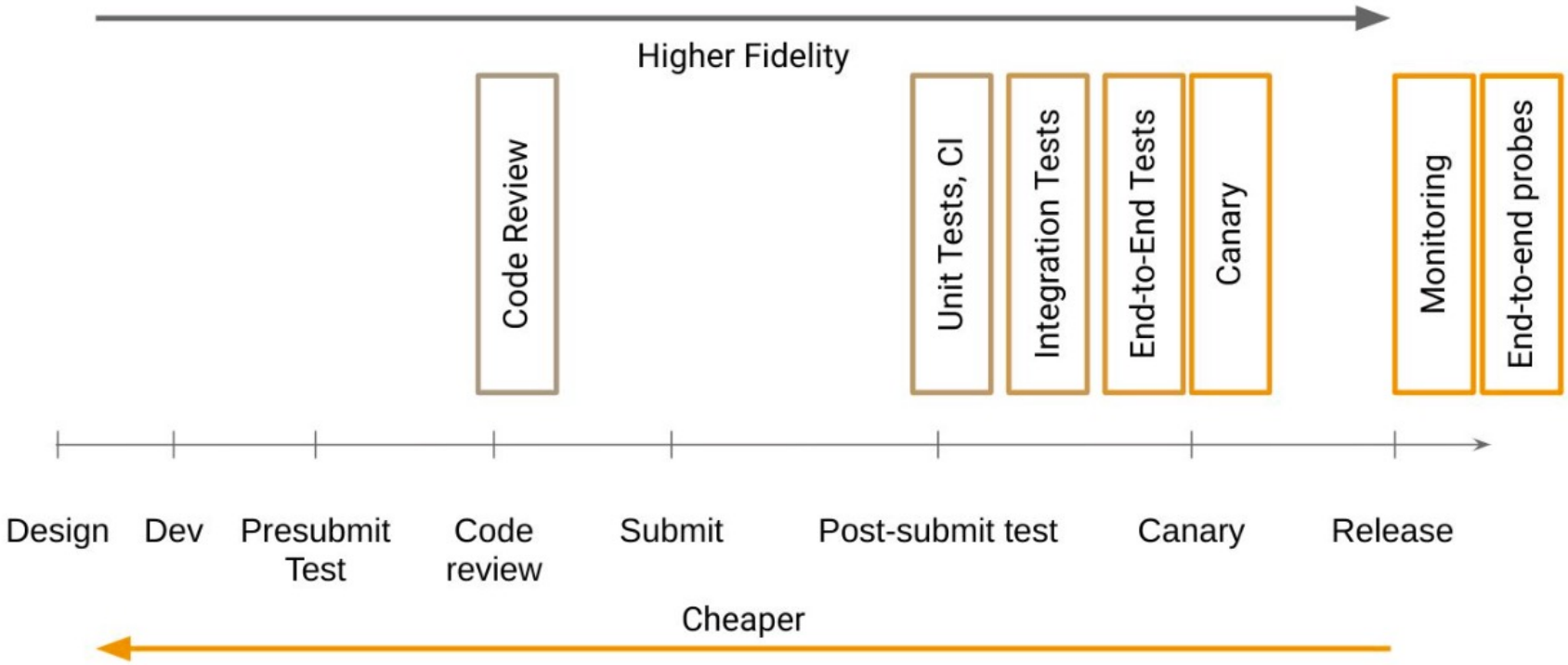
Levels of Testing

- Unit
  - Tests minimal software component, in isolation
  - For us, Class-level testing
  - Web: Web pages (Http Request)
- Integration
  - Tests interfaces & interaction of classes
- System
  - Tests that completely integrated system meets requirements
- System Integration
  - Test system works with other systems, e.g., third-party systems

Software Development Process



Software Development Process



Shift Left's Goal: Catch defects earlier

A Bad Role Model

http://imgur.com/HBSbn

Software Testing Issues

- How should you test? How often?
  - Code may change frequently
  - Code may depend on others' code
  - A lot of code to validate
- How do you know that an output is correct?
  - Complex output
  - Human judgment?
- What caused a code failure?

➥ Need a *systematic*, *automated*, *repeatable* approach

Some Approaches to Testing Methods

- Typical case
  - Test typical values of input/parameters
- Boundary conditions
  - Test at boundaries of input/parameters
  - Many faults live “in corners”
- Parameter validation
  - Verify that parameter and object bounds are documented and checked
  - Example: pre-condition that parameter isn’t null

➥ All black-box testing approaches

Looking Ahead

- Assignment 4 is due on Monday