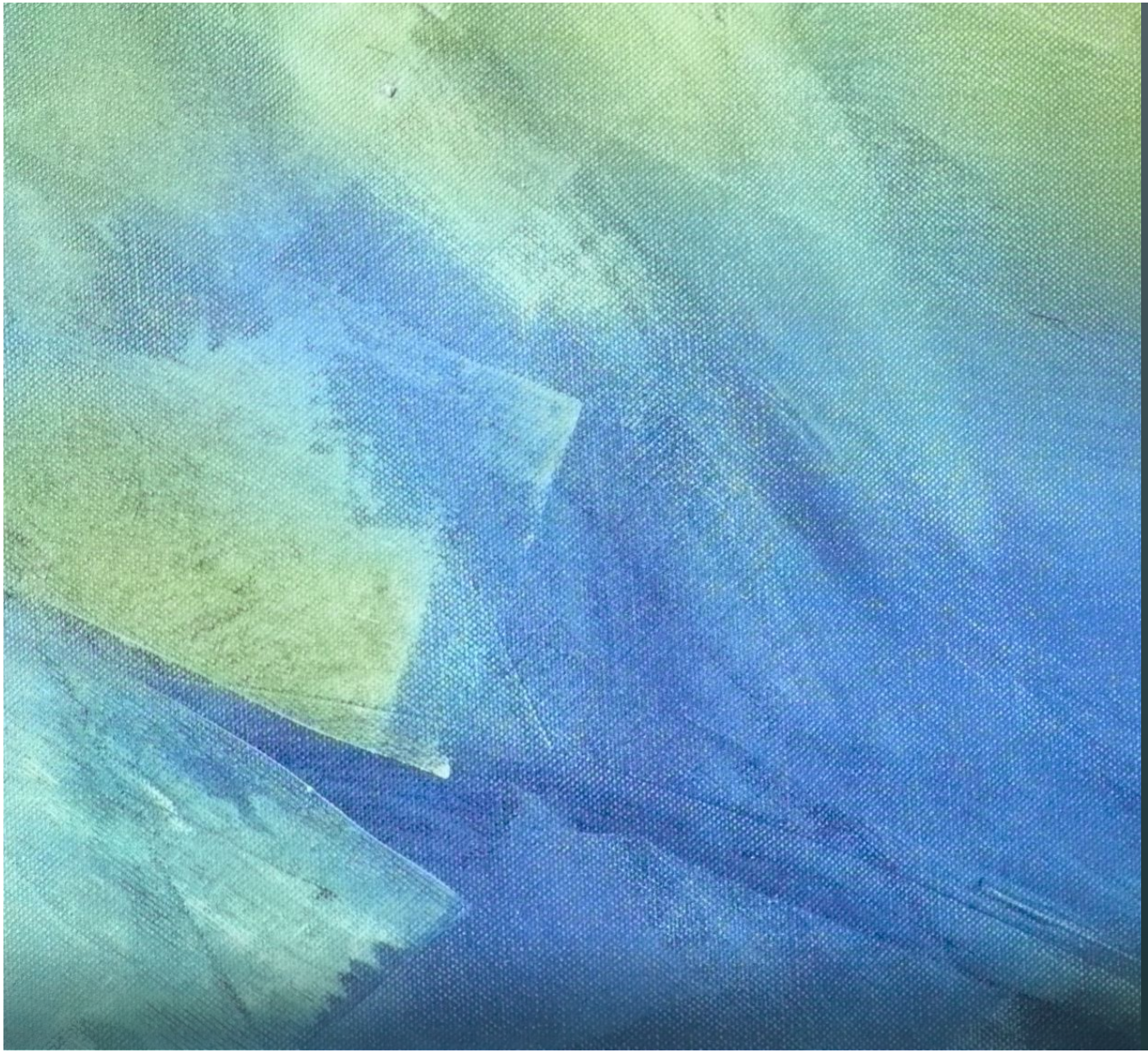


Testing Microservices Part 1

Wiwat Vatanawood

Duangdao Wichadakul

Nuengwong Tuaycharoen

Pittipol Kantavat

The Chapter covers

- Effective testing strategies for microservices
- Using mocks and stubs to test a software element in isolation
- Using the test pyramid to determine where to focus testing efforts
- Unit testing the classes inside a service

Agenda

- Overview of testing microservice
- Testing strategies for microservice architectures
- The challenge of testing microservices
- The deployment pipeline
- Writing unit tests for a service

An Overview of Testing Microservice

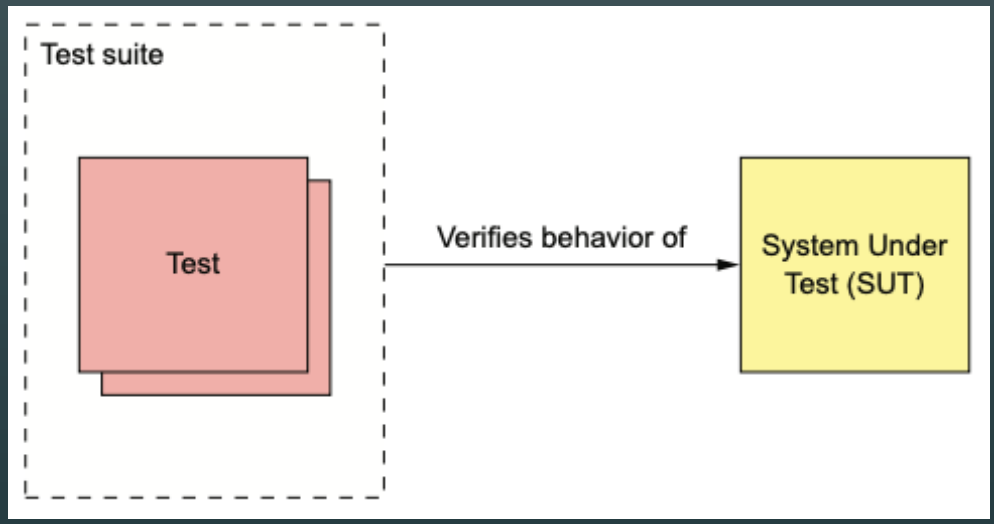
- Testing is primarily an activity that happens after development.
- Why we need automated testing?
  - Manual testing is extremely inefficient — You should never ask a human to do what a machine can do better.
  - Manual testing is done far too late in the delivery process — A much better approach is for developers to write automated tests as part of development.
- Your development workflow should be:
  edit code → run tests (ideally with a single keystroke) → repeat

Agenda

- Overview of testing microservice
- Testing strategies for microservice architectures
- The challenge of testing microservices
- The deployment pipeline
- Writing unit tests for a service

Testing strategies for microservice architectures

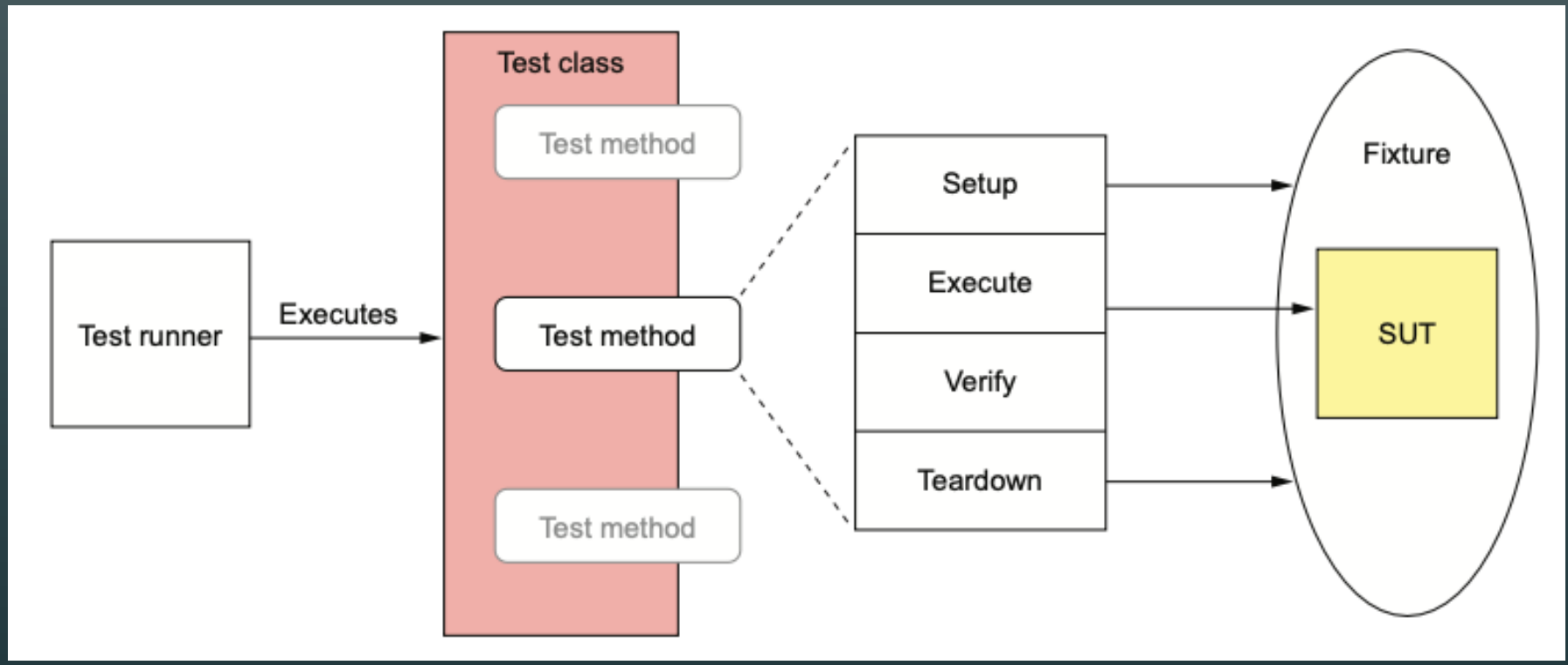
- The goal of a test is to verify the behavior of the System Under Test (SUT)
- An SUT might be as small as a class or as large as an entire application.
- A collection of related tests are called a "Test Suite".



Writing Automated Tests (1)

- An automated test typically consists of four phases:
  1. Setup — Initialize the test fixture, which consists of the SUT and its dependencies, to the desired initial state.
  2. Exercise — Invoke the SUT—for example, invoke a method on the class under test.
  3. Verify — Make assertions about the invocation's outcome and the state of the SUT.
  4. Teardown — Clean up the test fixture, if necessary. Many tests omit this phase, but some types of database test will, for example, roll back a transaction initiated by the setup phase.

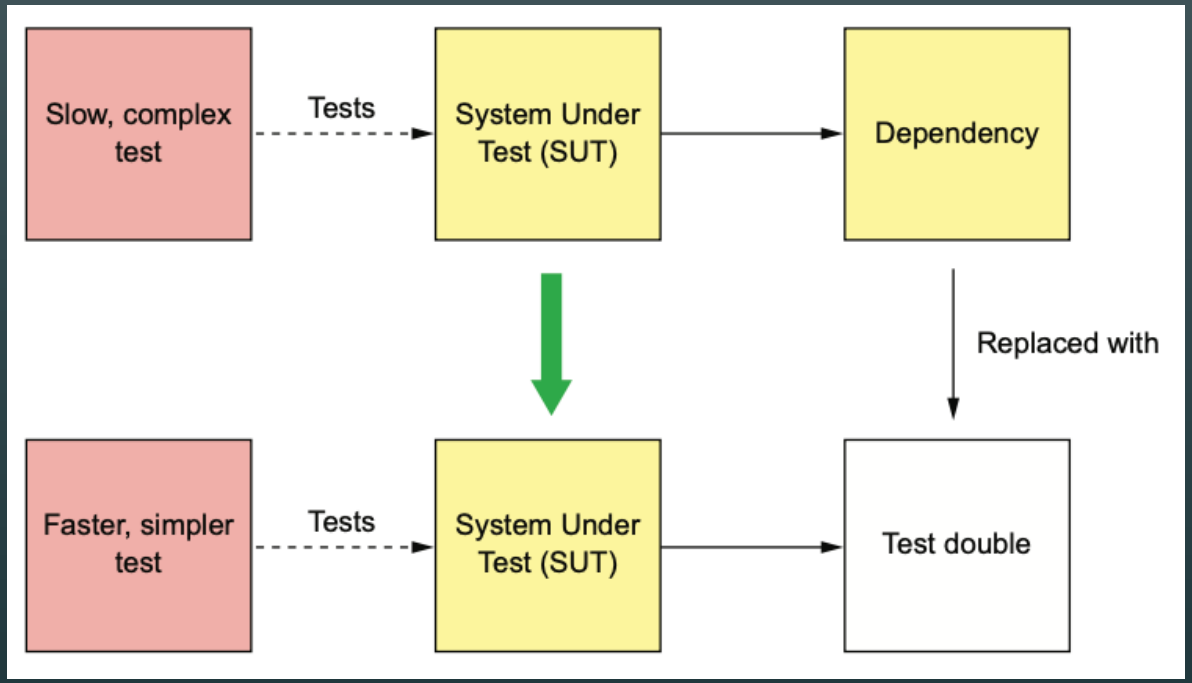
Writing Automated Tests (2)



- A test consists of four phases: setup, execute, verify, and teardown.

Testing Using Mocks and Stub (1)

- An SUT often has dependencies.
- The solution is to replace the SUT's dependencies with Test doubles.
- Replacing a dependency with a test double enables the SUT to be tested in isolation; The test is simpler and faster.



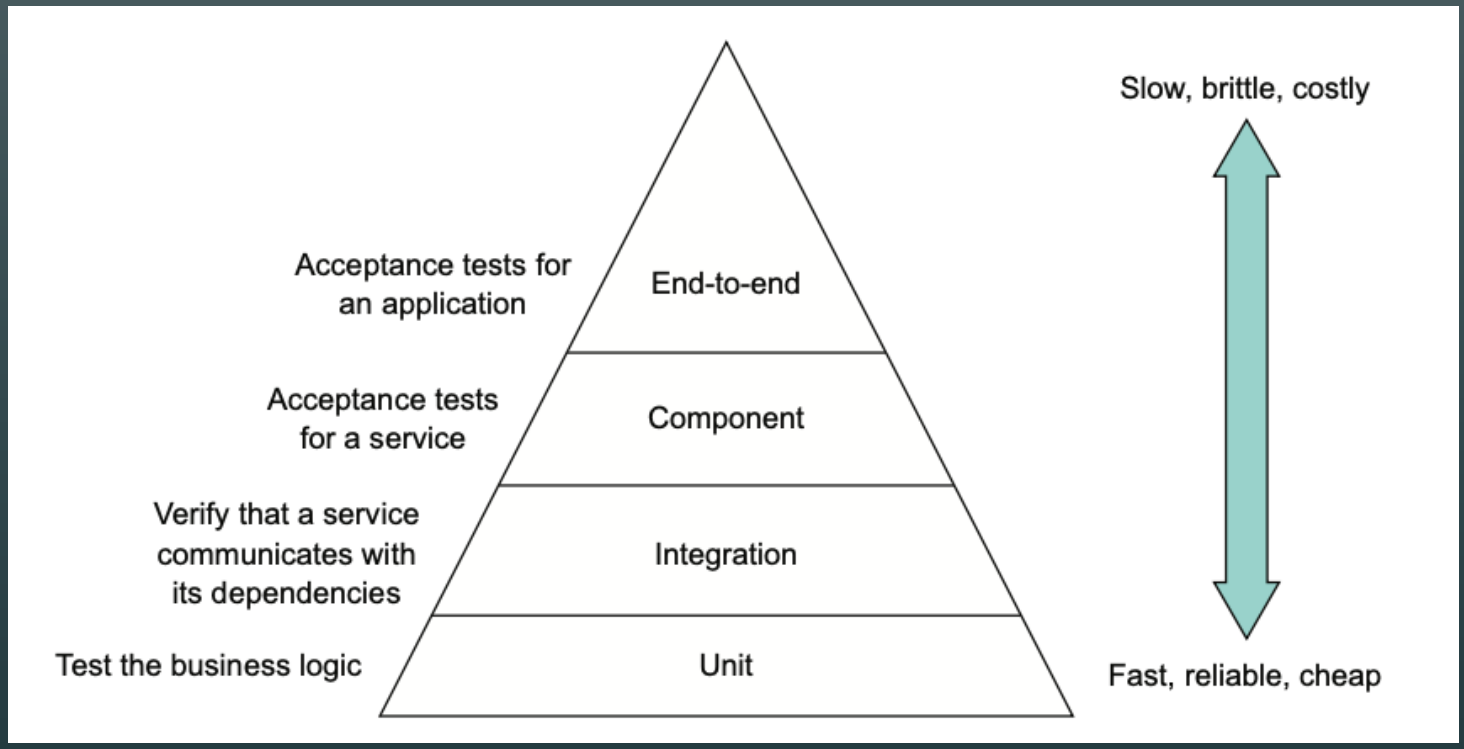
Testing Using Mocks and Stub (2)

- There are two types of test doubles: **stubs** and **mocks**.
  - The terms stubs and mocks are often used interchangeably, although they have slightly different behavior.
- A **stub** is a test double that returns values to the SUT.
- A **mock** is a test double that a test uses to verify that the SUT correctly invokes a dependency. Also, a mock is often a stub.

The Different Type of Tests

- We focus on automated tests that verify the functional aspects of the application or service (Functional Requirements - FR).
- There are four different types of tests:
  1. Unit tests — Test a small part of a service, such as a class.
  2. Integration tests — Verify that a service can interact with infrastructure services such as databases and other application services.
  3. Component tests — Acceptance tests for an individual service.
  4. End-to-end tests — Acceptance tests for the entire application.

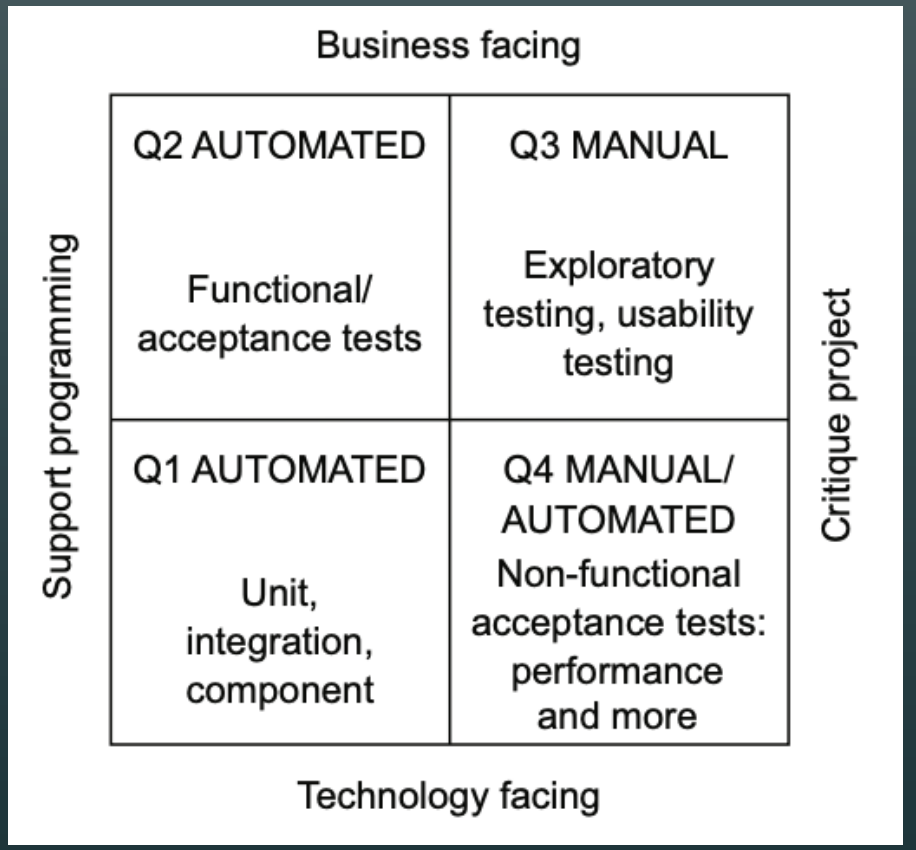
Test Pyramid



- The test pyramid describes the relative proportions of each type of test.
- As you move up the pyramid, you should write fewer and fewer tests.

Brian Marick's test quadrant

- The test quadrant categorizes tests along two dimensions.
- The first dimension is whether a test is business facing or technology facing.
- The second is whether the purpose of the test is to support programming or critique the application.

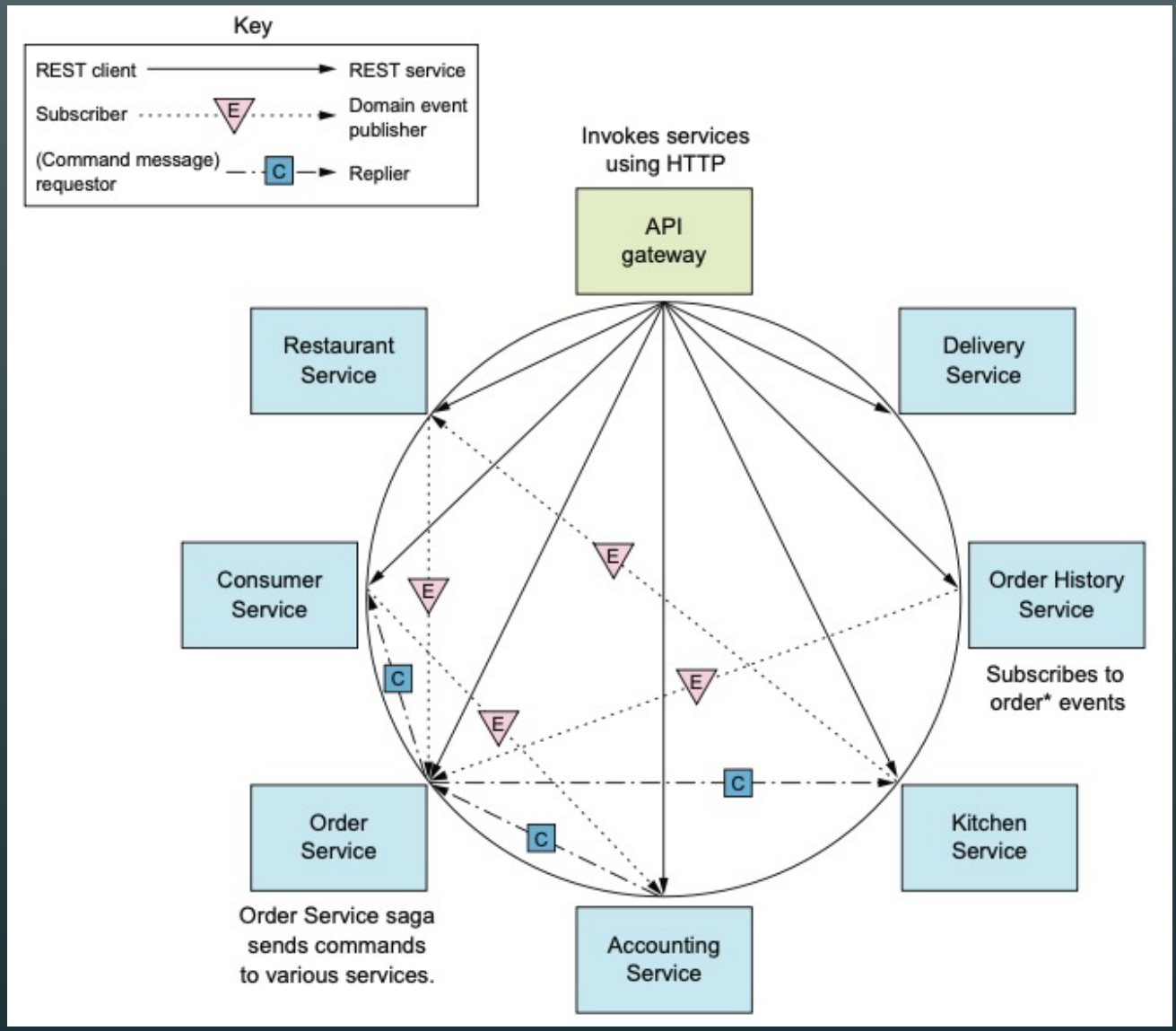


Agenda

- Overview of testing microservice
- Testing strategies for microservice architectures
- The challenge of testing microservices
- The deployment pipeline
- Writing unit tests for a service

The challenge of testing microservices

- The figure show some Some of the interprocess communication in the FTGO application.
- Each arrow points from a consumer service to a producer service

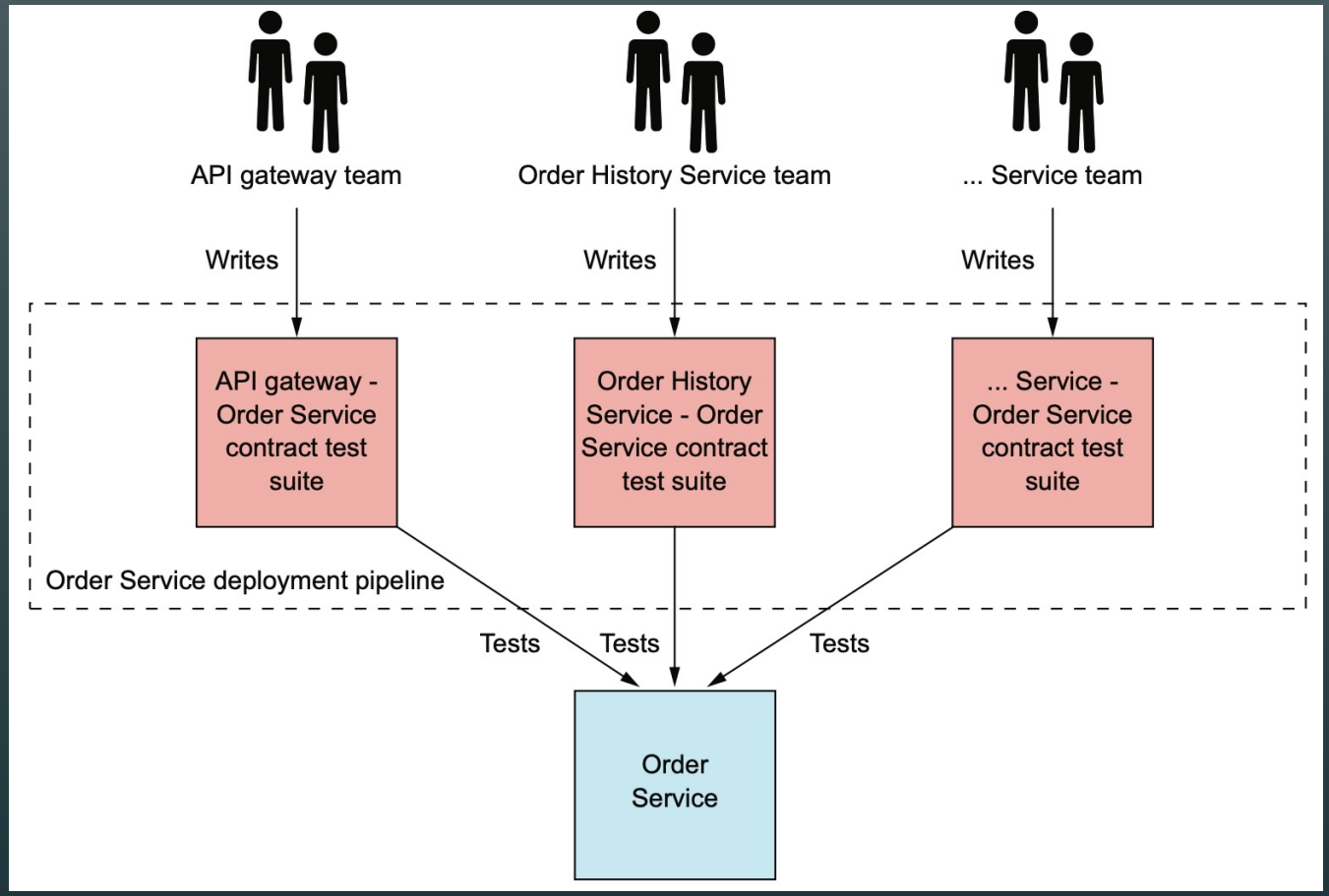


Consumer-Driven Contract Testing (1)

- A consumer contract test focuses on verifying that the "shape" of a provider's API meets the consumer's expectations.
- For a REST endpoint, a contract test verifies that the provider implements an endpoint (for the consumer) that
  - Has the expected HTTP method and path
  - Accepts the expected headers, if any
  - Accepts a request body, if any
  - Returns a response with the expected status code, headers, and body

Order Service's API testing

- Each team that develops a service that consumes Order Service's API contributes a contract test suite.
- The test suite verifies that the API matches the consumer's expectations.
- This test suite, along with those contributed by other teams, is run by Order Service's deployment pipeline.

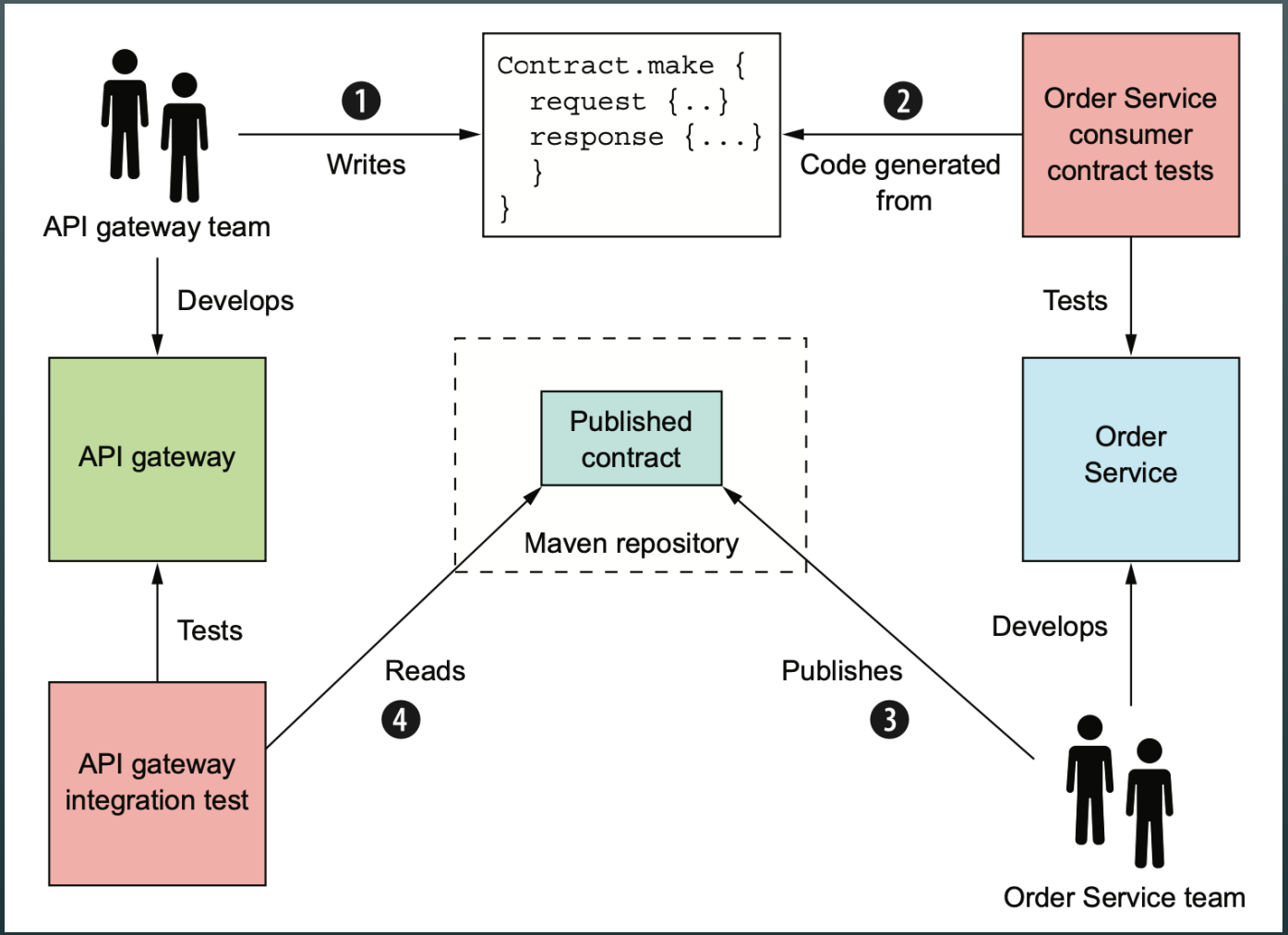


Consumer-Driven Contract Testing (2)

- The interaction between a consumer and provider is defined by a set of examples, known as contracts.
  - Each contract consists of example messages that are exchanged during one interaction.
- Even though the focus of consumer-driven contract testing is to test a provider, contracts are also used to verify that the consumer conforms to the contract.
  - Testing both sides of interaction ensures that the consumer and provider agree on the API

Ex. Testing Service Using Spring Cloud Contract

1. The API Gateway team writes the contracts.
2. The Order Service team uses those contracts to test Order Service and publishes them to a repository.
3. The API Gateway team uses the published contracts to test API Gateway.

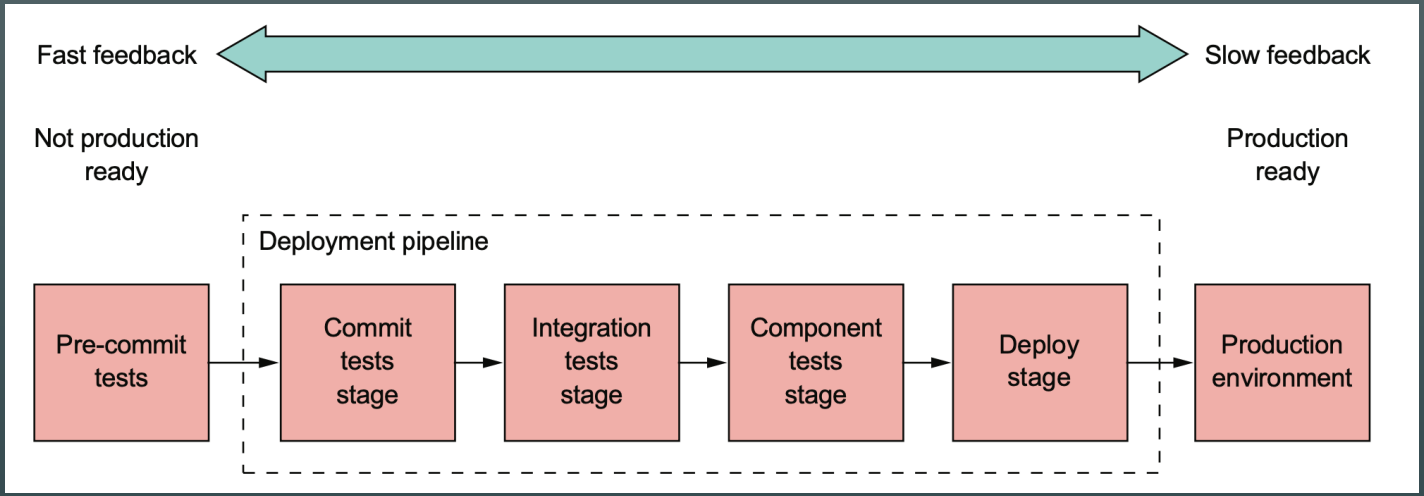


Agenda

- Overview of testing microservice
- Testing strategies for microservice architectures
- The challenge of testing microservices
- The deployment pipeline
- Writing unit tests for a service

The deployment pipeline

- Every service has a deployment pipeline.
- Continuous Delivery (CD) describes a deployment pipeline as the automated process of getting code from the developer's desktop into production.
  - Ideally, it's fully automated, but it might contain manual steps.
- A deployment pipeline is often implemented using a Continuous Integration (CI) server, such as **Jenkins**.



1. Pre-commit tests stage — Runs the unit tests. This is executed by the developer before committing their changes.
2. Commit tests stage — Compiles the service, runs the unit tests, and performs static code analysis.
3. Integration tests stage — Runs the integration tests.
4. Component tests stage — Runs the component tests for the service.
5. Deploy stage — Deploys the service into production.

Agenda

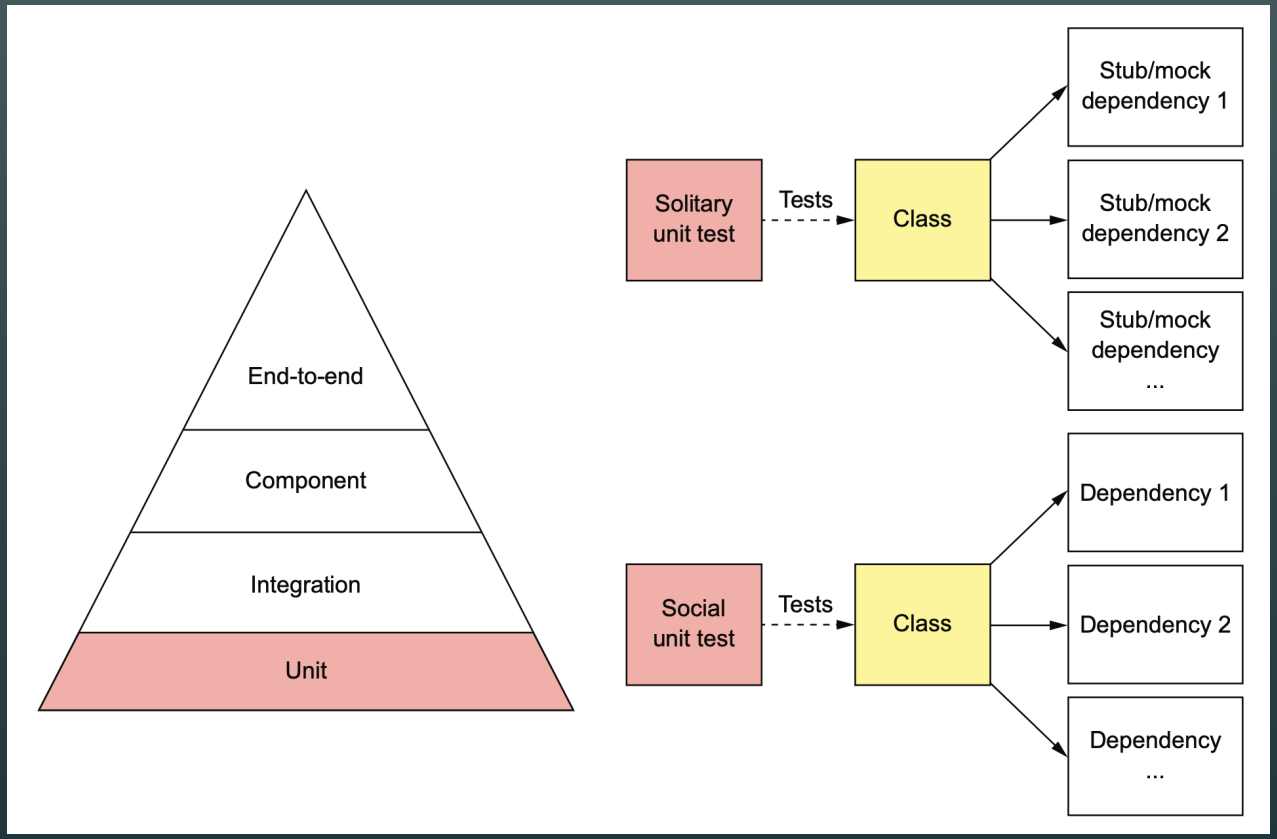
- Overview of testing microservice
- Testing strategies for microservice architectures
- The challenge of testing microservices
- The deployment pipeline
- Writing unit tests for a service

Writing Unit Tests for a Service (1)

- Unit tests are the lowest level of the test pyramid.
- They're technology-facing tests that support development.
- A unit test verifies that a unit, which is a very small part of a service, works correctly.
- A unit is typically a class, so the goal of unit testing is to verify that it behaves as expected.

Writing Unit Tests for a Service (2)

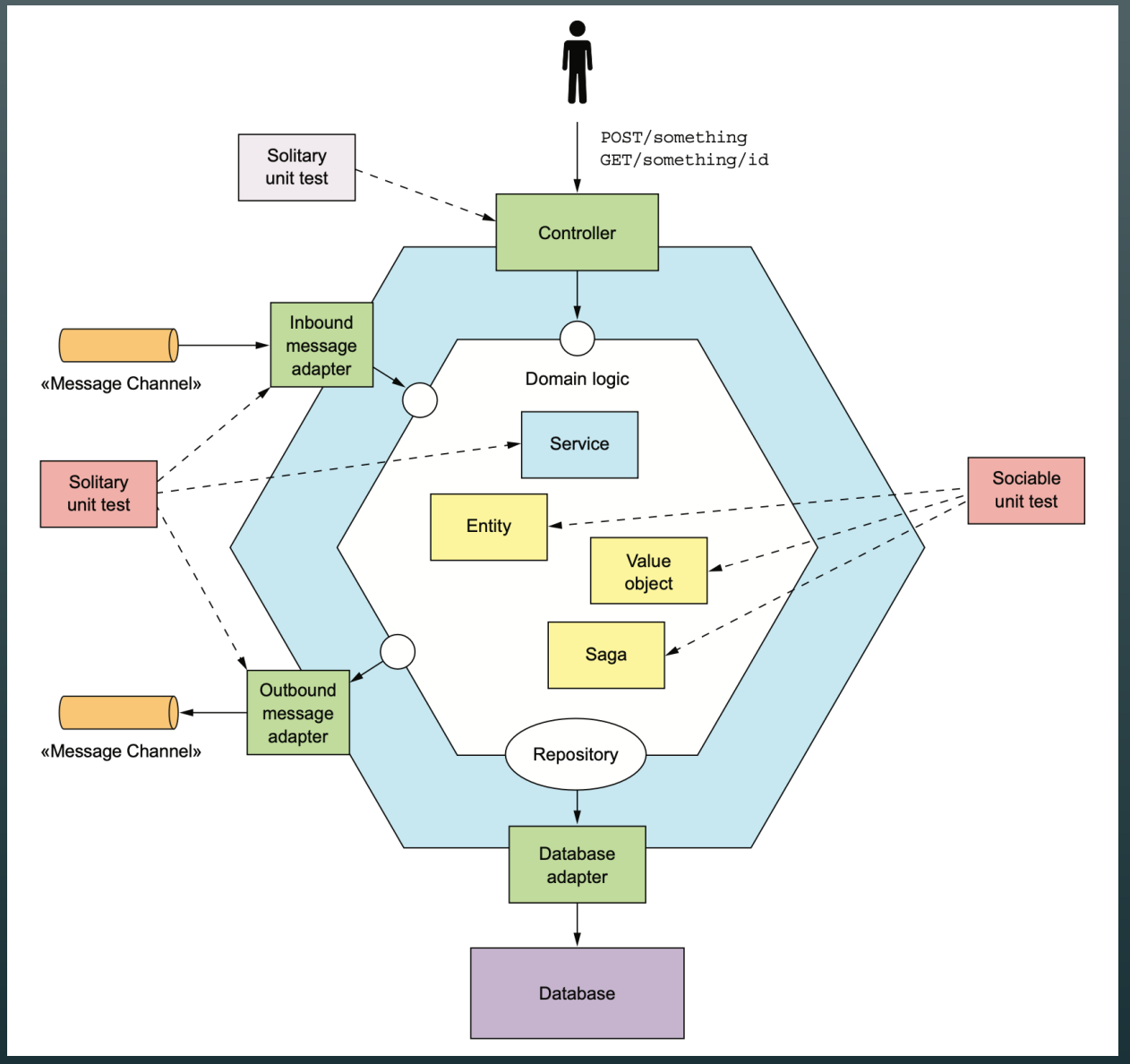
- There are two types of unit tests*
  - Solitary unit test — Tests a class in isolation using mock objects for the class's dependencies
  - Sociable unit test — Tests a class and its dependencies



*https://martinfowler.com/bliki/UnitTest.html

Writing Unit Tests for a Service (3)

- The responsibilities of the class and its role determine which type of test to use.
  - Controller and service classes are often tested using solitary unit tests.
  - Domain objects, such as entities and value objects, are typically tested using sociable unit tests.

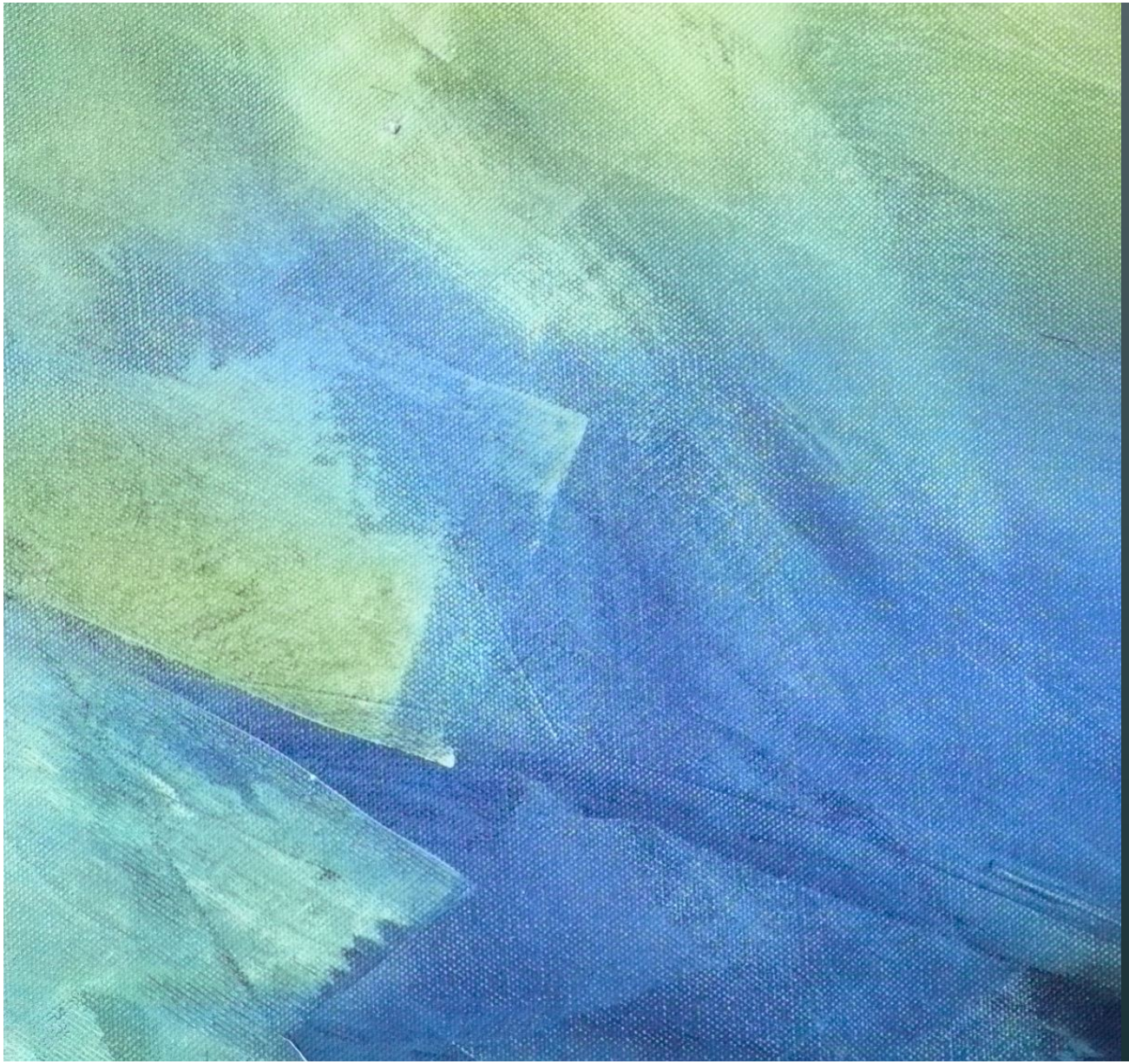


Writing Unit Tests for a Service (4)

- Entities, such as Order, are objects with persistent identity → sociable unit tests.
- Value objects, such as Money, are objects that are collections of values → sociable unit tests.
- Sagas, such as CreateOrderSaga, maintain data consistency across services → sociable unit tests.
- Domain services, such as OrderService, are classes that implement business logic that doesn't belong in entities or value objects → solitary unit tests.
- Controllers, such as OrderController, which handle HTTP requests → solitary unit tests.
- Inbound and outbound messaging gateways → solitary unit tests.

Summary

- Automated testing is the key foundation of rapid, safe delivery of software
- The purpose of a test is to verify the behavior of the system under test (SUT).
- A good way to simplify and speed up a test is to use test doubles.
- Use the test pyramid to determine where to focus your testing efforts for your services.



Testing Microservices Part 2

Wiwat Vatanawood

Duangdao Wichadakul

Nuengwong Tuaycharoen

Pittipol Kantavat

The Chapter covers

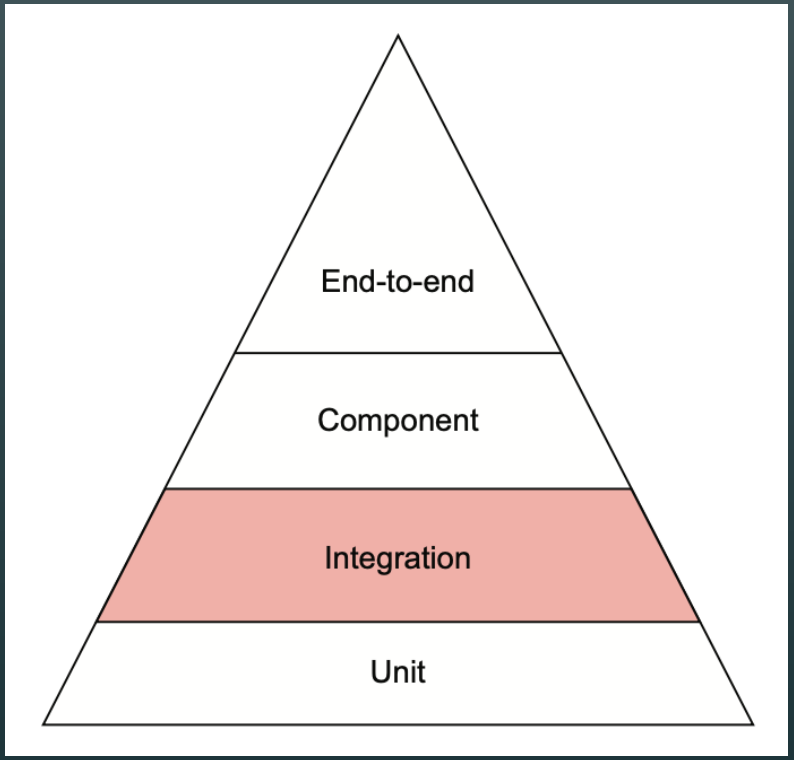
- Techniques for testing services in isolation
- Using consumer-driven contract testing to write tests that quickly yet reliably verify interservice communication
- When and how to do end-to-end testing of applications

Agenda

- Writing integration tests
- Developing component tests
- Writing end-to-end tests

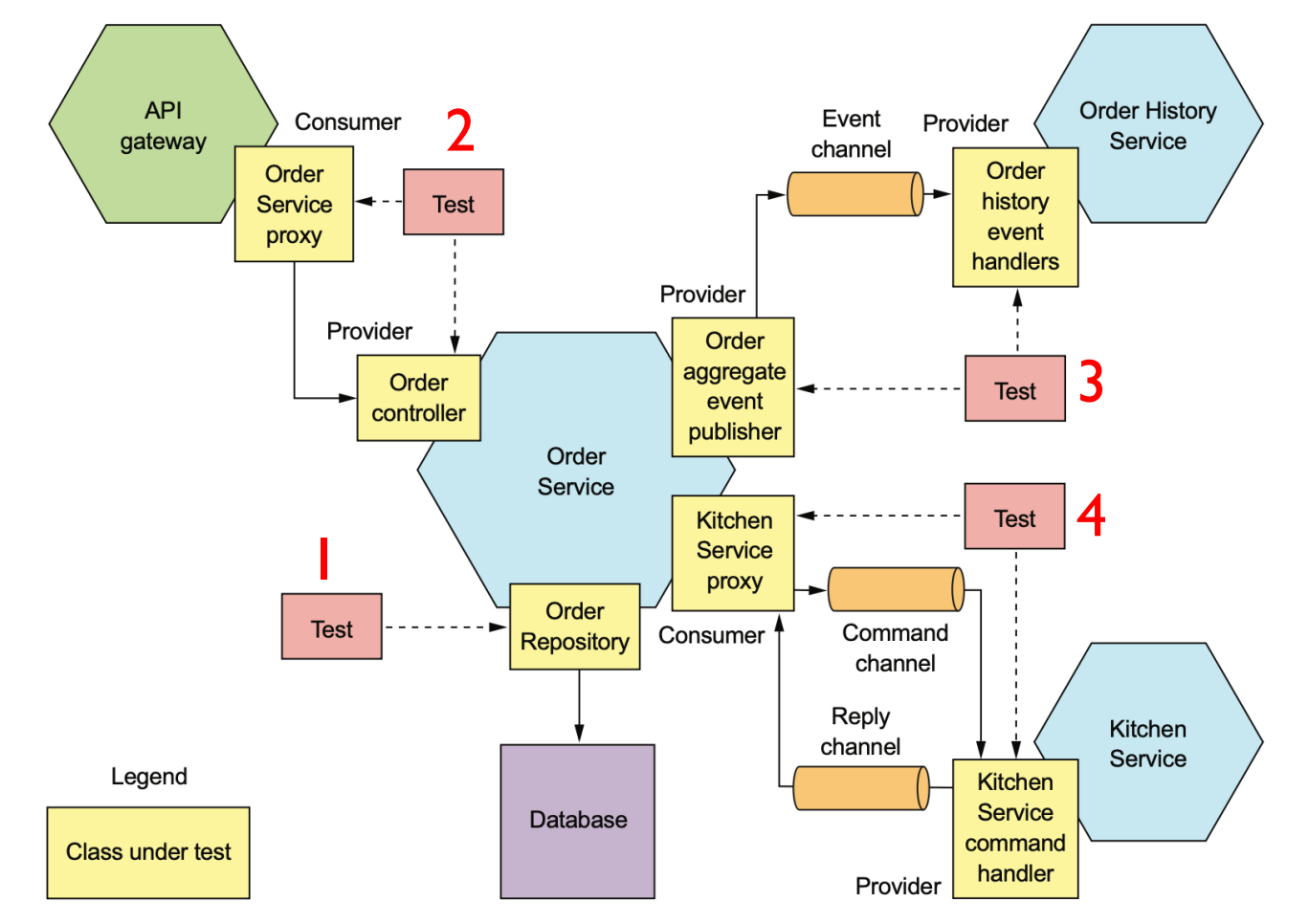
Writing Integration Tests

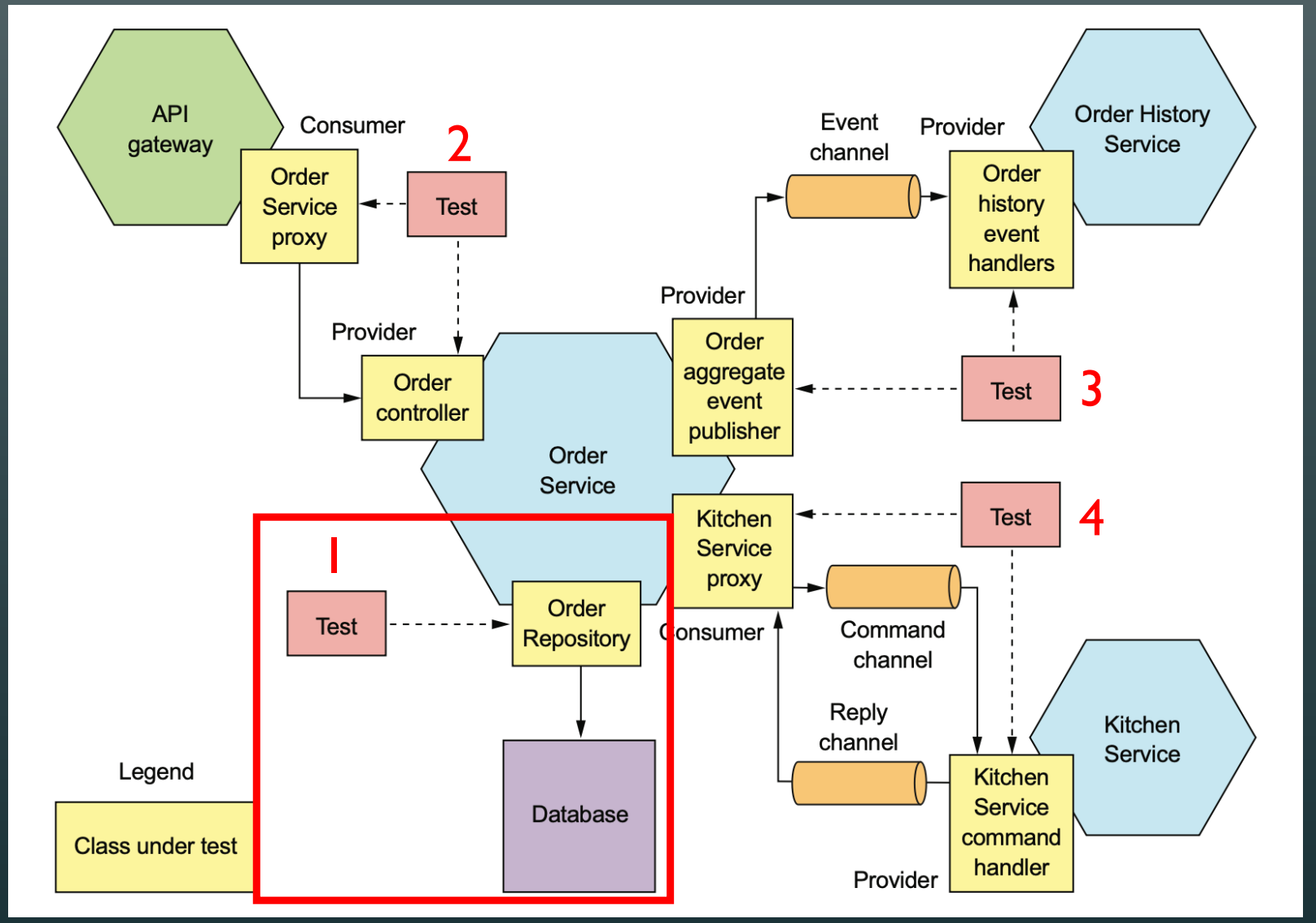
- Integration tests are the layer above unit tests.
- They verify that a service can communicate with its dependencies, which includes infrastructure services, such as the database, and application services.



Writing Integration Tests (cont.)

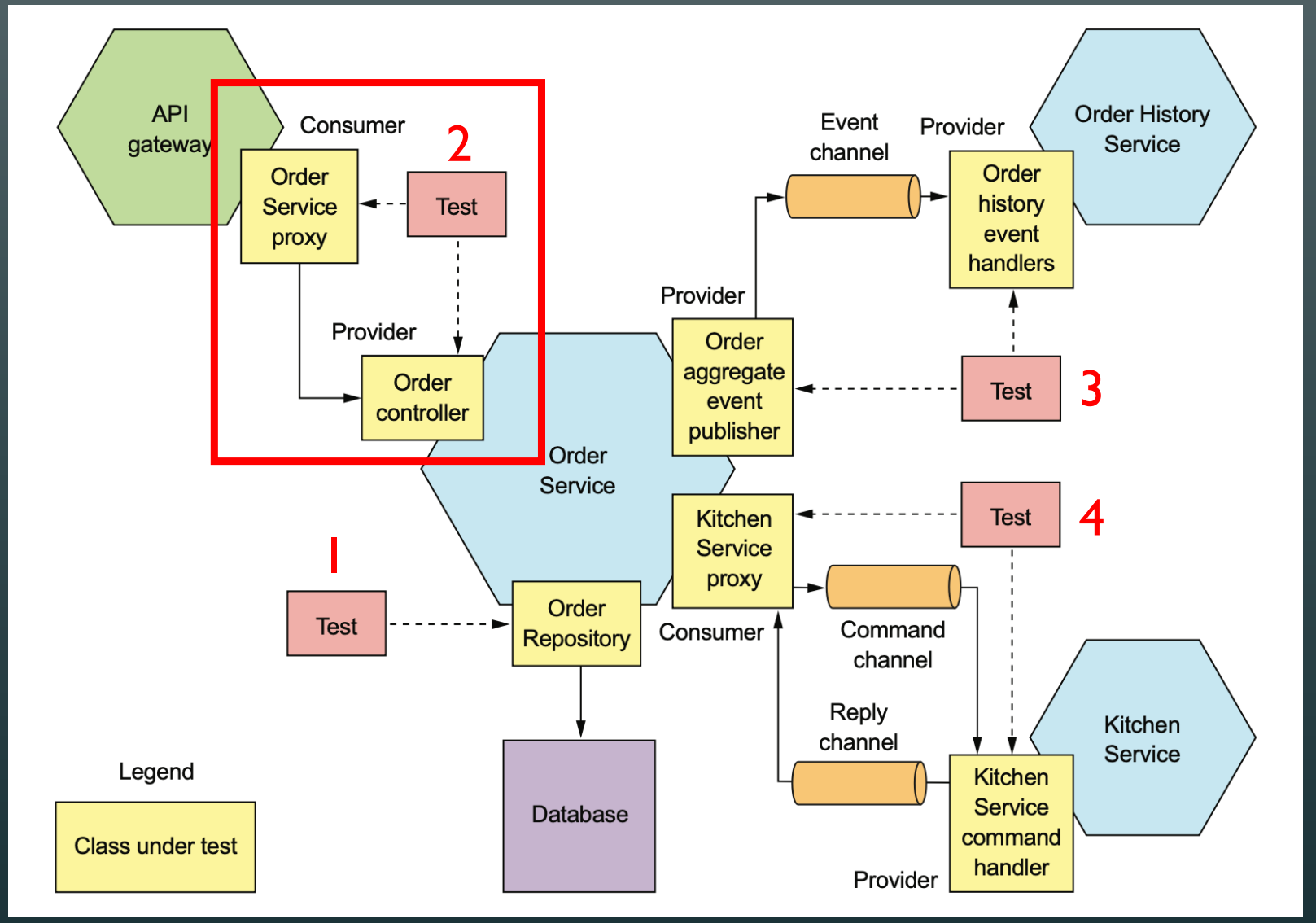
- Integration tests must verify that a service can communicate with its clients and dependencies.
- But rather than testing whole services, the strategy is to test the individual adapter classes that implement the communication



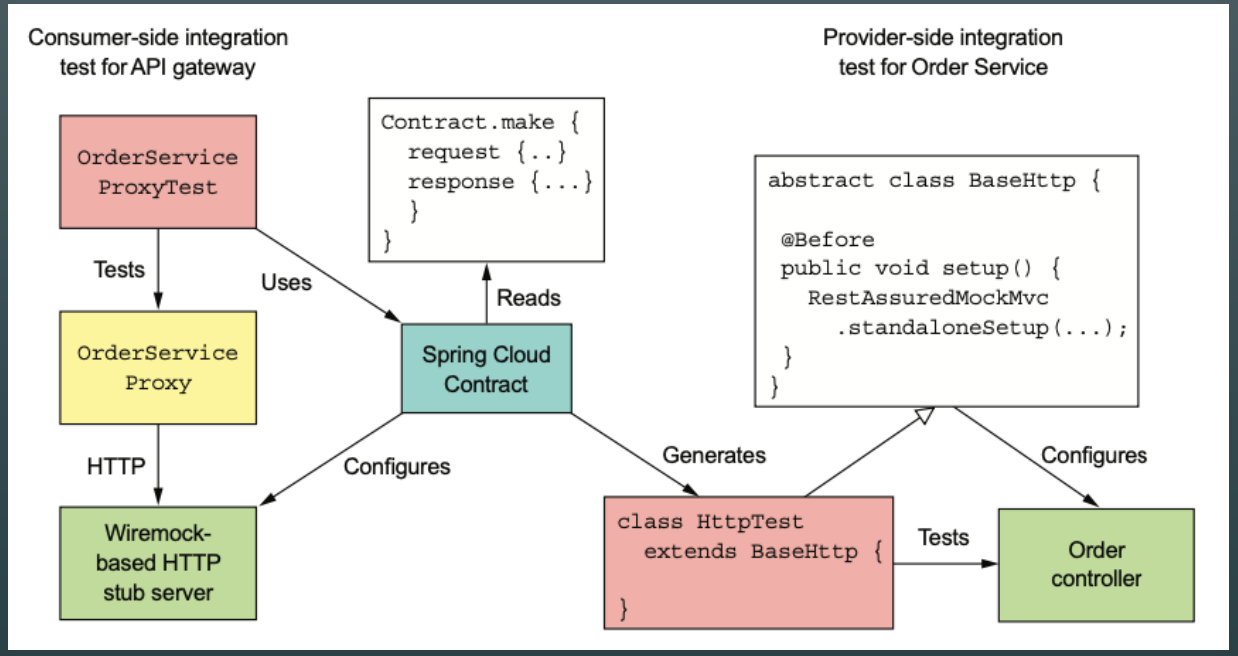

API gateway
Consumer
Order Service proxy
2
Test
Event channel
Provider
Order History Service
Order history event handlers
Provider
Order controller
Provider
Order aggregate event publisher
Test
3
Order Service
Kitchen Service proxy
Test
4
1
Test
Order Repository
Consumer
Command channel
Reply channel
Kitchen Service
Database
Legend
Class under test
Kitchen Service command handler
Provider

1. Persistence Integration tests

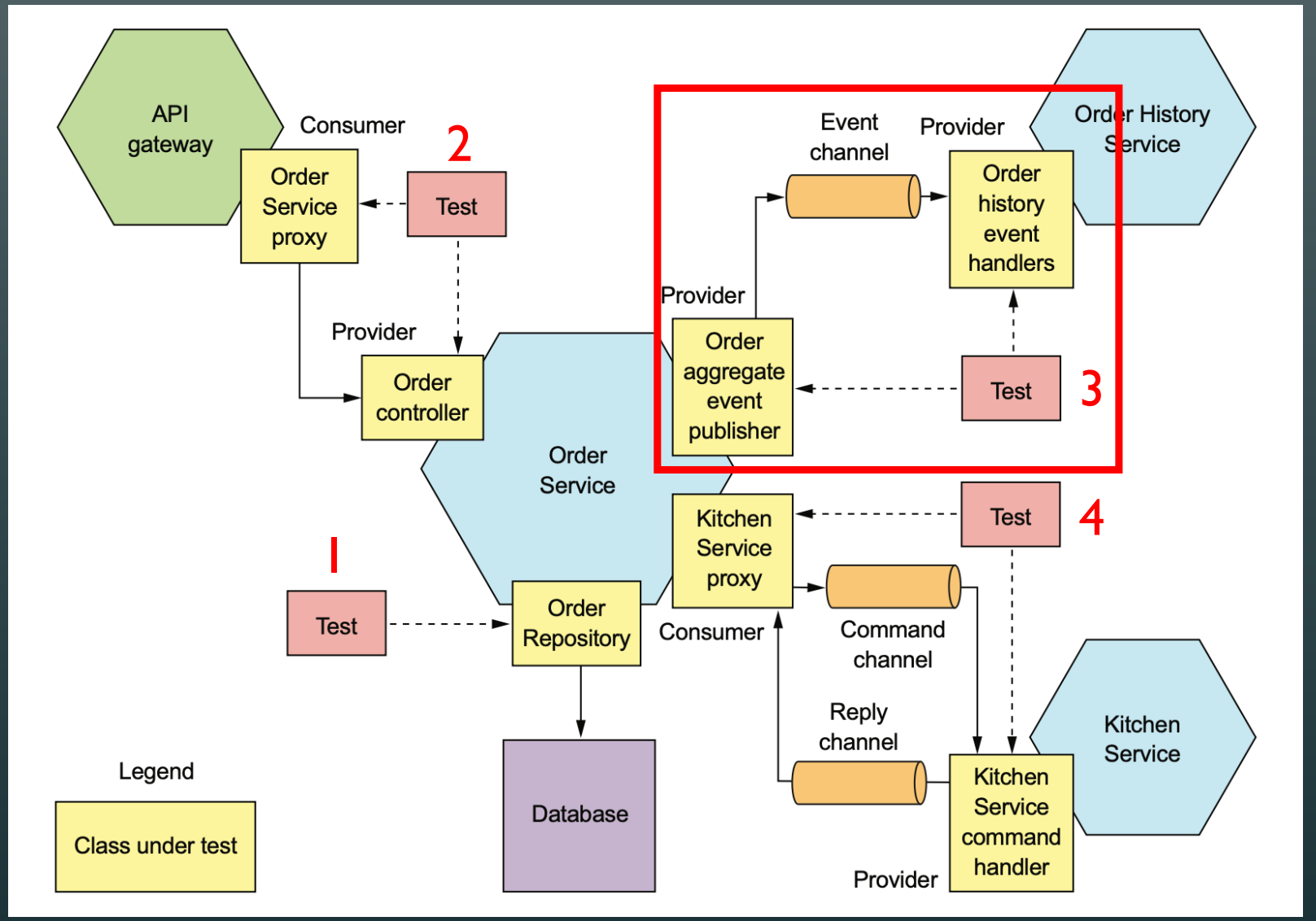
- Verifying that a service's database access logic works as expected.
- Each phase of a persistence integration test behaves as follows:
  - Setup — Set up the database by creating the database schema and initializing it to a known state. It might also begin a database transaction.
  - Execute — Perform a database operation.
  - Verify — Make assertions about the state of the database and objects retrieved from the database.
  - Teardown — An optional phase that might undo the changes made to the database.
    - for example, rolling back the transaction that was started by the setup phase.


API gateway
Consumer
Order Service proxy
2
Test
Provider
Order controller
Order Service
1
Test
Order Repository
Database
Event channel
Provider
Order History Service
Order history event handlers
Provider
Order aggregate event publisher
Test
3
Kitchen Service proxy
Test
4
Consumer
Command channel
Reply channel
Kitchen Service
Kitchen Service command handler
Provider
Legend
Class under test

2. Integration testing REST-based request/response style interactions

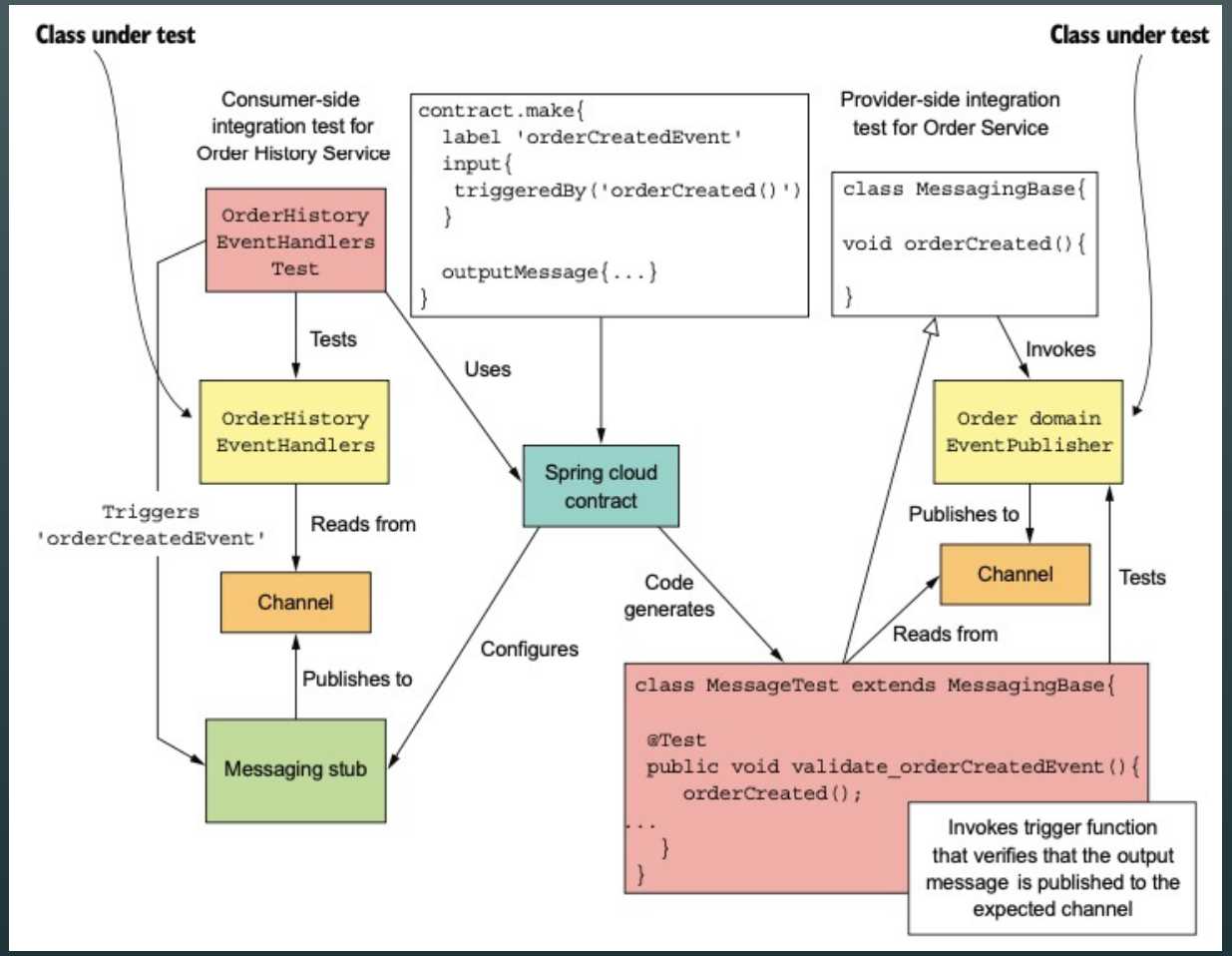


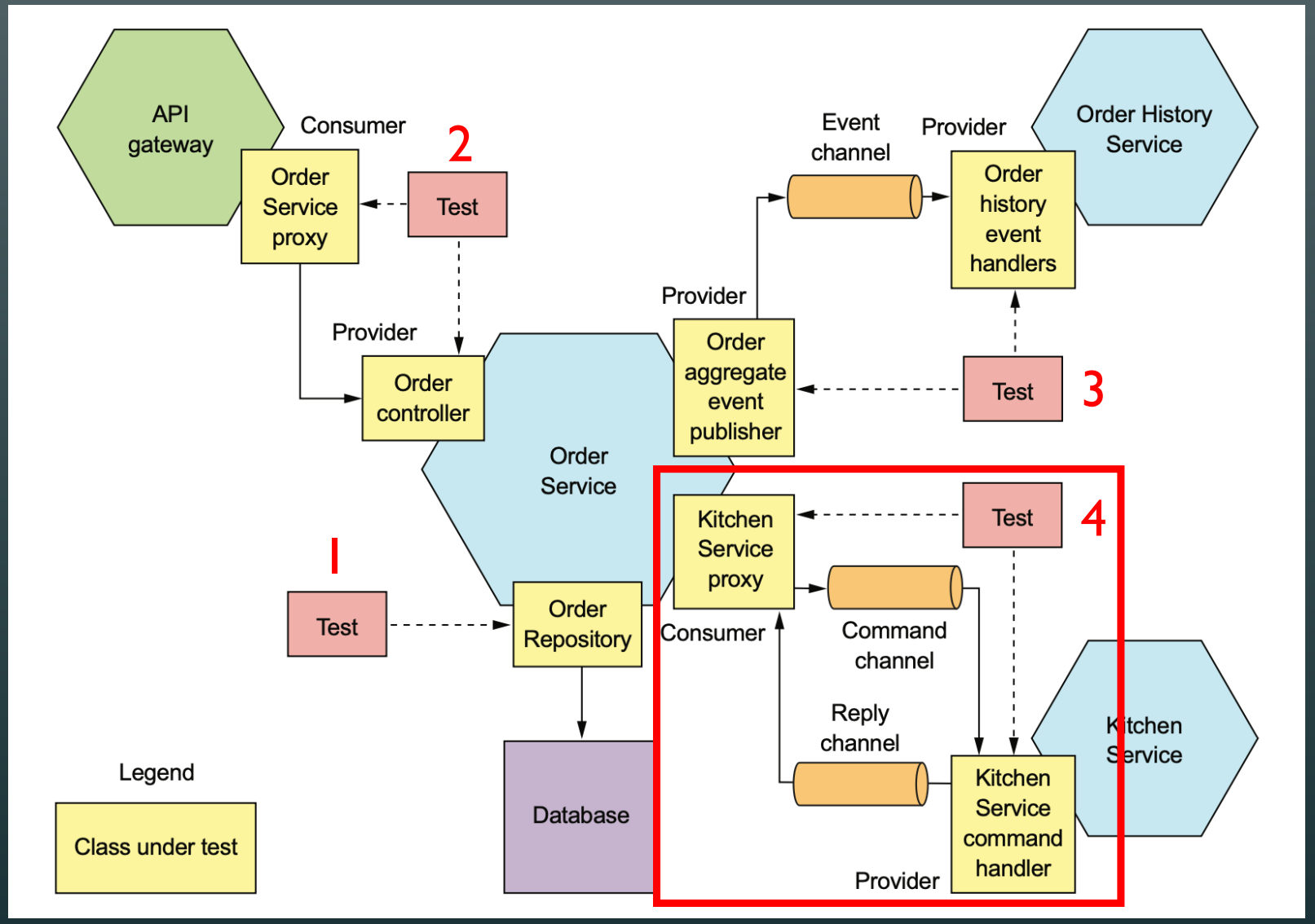
- The contracts are used to verify that the adapter classes on both sides.
- The consumer-side tests verify that OrderServiceProxy invokes Order Service correctly.
- The provider-side tests verify that OrderController implements the REST API endpoints correctly.


API gateway
Consumer
Order Service proxy
2
Test
Provider
Order controller
Order Service
Event channel
Provider
Order History Service
Order history event handlers
Provider
Order aggregate event publisher
Test
3
Test
4
Kitchen Service proxy
1
Test
Order Repository
Consumer
Command channel
Reply channel
Kitchen Service
Kitchen Service command handler
Provider
Database
Legend
Class under test

3. Integration testing publish/subscribe-style interactions

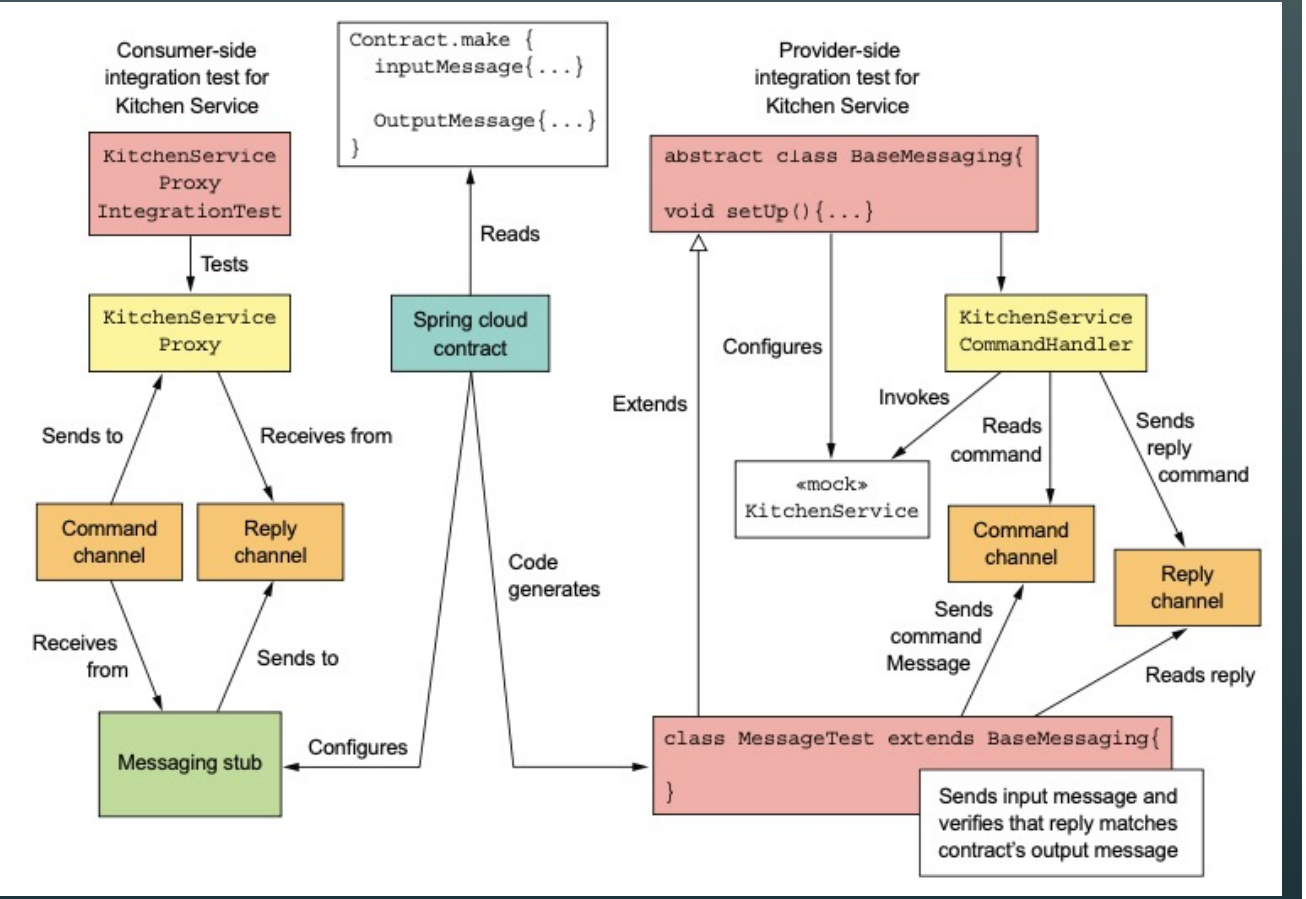
- The contracts are used to test both sides of the publish/subscribe interaction.
- The provider-side tests verify that OrderDomainEventPublisher publishes events that confirm to the contract.
- The consumer-side tests verify that OrderHistoryEventHandlers consume the example events from the contract.




API gateway
Consumer
Order Service proxy
2
Test
Event channel
Provider
Order History Service
Order history event handlers
Provider
Order controller
Order Service
Provider
Order aggregate event publisher
Test
3
1
Test
Order Repository
Kitchen Service proxy
Test
4
Consumer
Command channel
Reply channel
Kitchen Service
Database
Kitchen Service command handler
Provider
Legend
Class under test

4. Integration tests for asynchronous request/response interactions

- The contracts are used to test the adaptor classes.
- The provider-side tests verify that KitchenServiceCommandHandler handles commands and sends back replies.
- The consumer-side tests verify KitchenServiceProxy sends commands that conform to the contract, and that it handles the example replies from the contract.

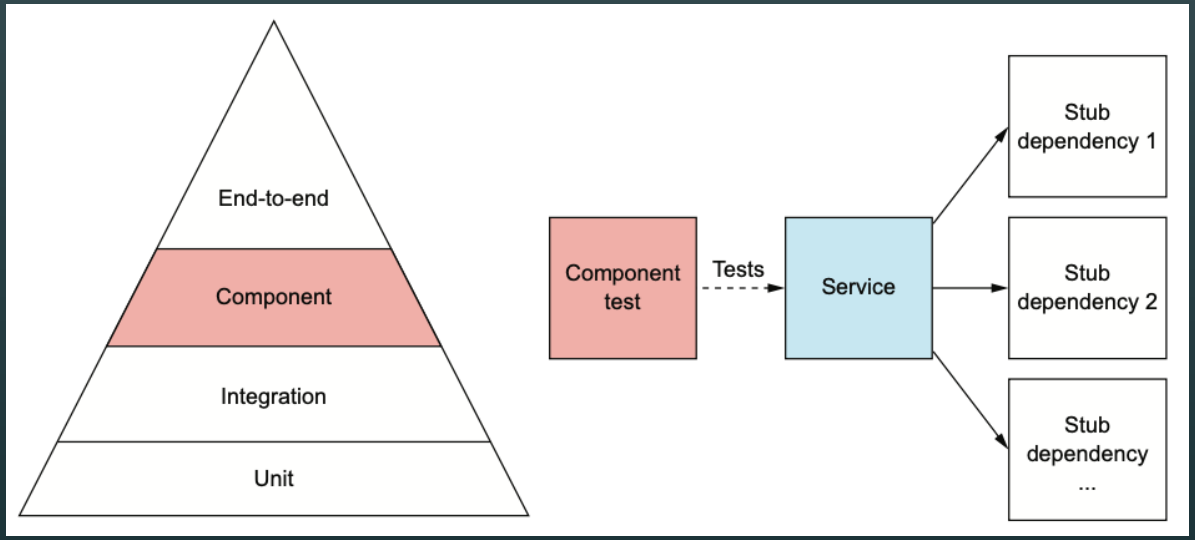


Agenda

- Writing integration tests
- Developing component tests
- Writing end-to-end tests

Developing Component Tests

- We now want to verify that Order Service works as expected.
- In other words, we want to write the service's acceptance tests, which treat it as a black box and verify its behavior through its API.
- Component testing verifies the behavior of a service in isolation.
- It replaces a service's dependencies with stubs that simulate their behavior.



Defining Acceptance Tests

- Acceptance tests are business-facing tests for a software component.
- They describe the desired externally visible behavior from the perspective of the component's clients rather than in terms of the internal implementation.
- These tests are derived from user stories or use cases.
  - For example, one of the key stories for Order Service is the Place Order story:

```
As a consumer of the Order Service
I should be able to place an order
```

Defining Acceptance Tests (cont.)

- We can expand this story into scenarios such as the following:

```
Given a valid consumer
Given using a valid credit card
Given the restaurant is accepting orders
When I place an order for Chicken Vindaloo at Ajanta
Then the order should be APPROVED
And an OrderAuthorized event should be published
```

- Each scenario defines an acceptance test.
  - The givens correspond to the test's setup phase.
  - The when maps to the execute phase.
  - The then and the and to the verification phase.

Writing acceptance tests using Gherkin

- Gherkin is a DSL for writing executable specifications.
- When using Gherkin, you define your acceptance tests using English-like scenarios.
- You then execute the specifications using Cucumber, a test automation framework for Gherkin.
- Gherkin and Cucumber eliminate the need to manually translate scenarios into runnable code.

Example of Using Gherkin specification

Listing 10.11 The Gherkin definition of the `Place Order` feature and some of its scenarios

```
Feature: Place Order

  As a consumer of the Order Service
  I should be able to place an order

  Scenario: Order authorized
    Given a valid consumer
    Given using a valid credit card
    Given the restaurant is accepting orders
    When I place an order for Chicken Vindaloo at Ajanta
    Then the order should be APPROVED
    And an OrderAuthorized event should be published

  Scenario: Order rejected due to expired credit card
    Given a valid consumer
    Given using an expired credit card
    Given the restaurant is accepting orders
    When I place an order for Chicken Vindaloo at Ajanta
    Then the order should be REJECTED
    And an OrderRejected event should be published

...
```

Executing Gherkin Specifications Using Cucumber

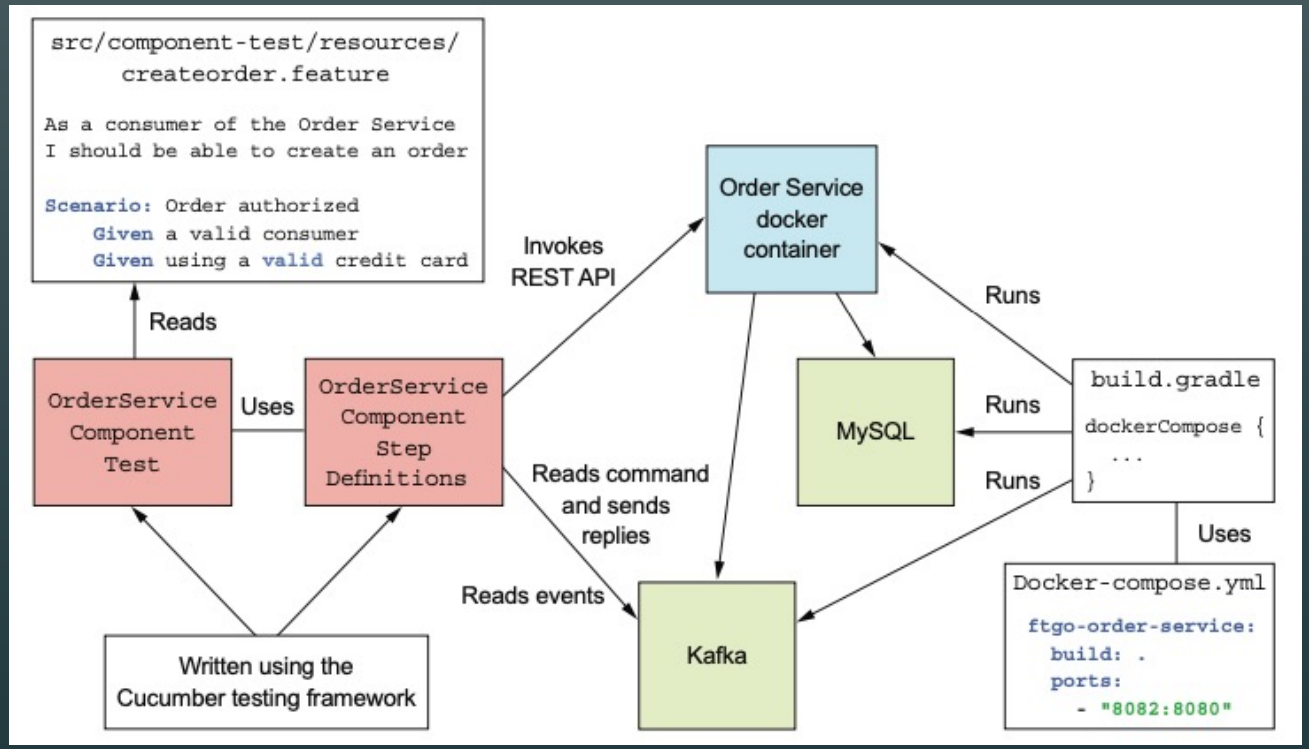
- "@Given"
  — The setup phase
- "@When"
  — The execute phase
- "@Then" and "@And"
  — The verification phase

Listing 10.12 The Java step definitions class makes the Gherkin scenarios executable.

```
public class StepDefinitions ...  {

  ...

  @Given("A valid consumer")
  public void useConsumer() { ... }

  @Given("using a(.?) (.*) credit card")
  public void useCreditCard(String ignore, String creditCard) { ... }

  @When("I place an order for Chicken Vindaloo at Ajanta")
  public void placeOrder() { ... }

  @Then("the order should be (.*)")
  public void theOrderShouldBe(String desiredOrderState) { ... }

  @And("an (.*) event should be published")
  public void verifyEventPublished(String expectedEventClass)  { ... }

}
```

Writing component tests for the FTGO Order Service

- The component tests for Order Service use the Cucumber testing framework to execute tests scenarios written using Gherkin acceptance testing DSL.
- The tests use Docker to run Order Service along with its infrastructure services, such as Apache Kafka and MySQL.



Agenda

- Writing integration tests
- Developing component tests
- Writing end-to-end tests

Writing End-to-end Tests

- End-to-end tests are business-facing tests.
- You can write the end-to-end tests using Gherkin and execute them using Cucumber.
- The main difference is that rather than a single **"Then"**, this test has multiple actions.

Example of Writing End-to-end Tests

Listing 10.17 A Gherkin-based specification of a user journey

```
Feature: Place Revise and Cancel

  As a consumer of the Order Service
  I should be able to place, revise, and cancel an order

  Scenario: Order created, revised, and cancelled
    Given a valid consumer
    Given using a valid credit card
    Given the restaurant is accepting orders
    When I place an order for Chicken Vindaloo at Ajanta
     Then the order should be APPROVED
    Then the order total should be 16.33
    And when I revise the order by adding 2 vegetable samosas
     Then the order total should be 20.97
    And when I cancel the order
    Then the order should be CANCELLED
```

Create Order.

Revise Order.

Cancel Order.

Running End-to-end Tests

- End-to-end tests must run the entire application, including any required infrastructure services.
- The implementation of the end-to-end test is quite similar to the implementation of the component tests.
- These tests are written using Gherkin and executed using Cucumber.

Summary (1)

- Use contracts to drive the testing of interactions between services.
- Write tests that verify that the adapters of both services conform to the contracts.
- Write component tests to verify the behavior of a service via its API.
- You should simplify and speed up component tests by testing a service in isolation, using stubs for its dependencies.

Summary (2)

- Write user journey tests to minimize the number of end-to-end tests, which are slow, brittle, and time consuming.
- A user journey test simulates a user's journey through the application and verifies high-level behavior of a relatively large slice of the application's functionality.