Level up your devex! 😍

Unit Test Complex E2E Flows + Integration Integration Testing with Aspire & OTEL

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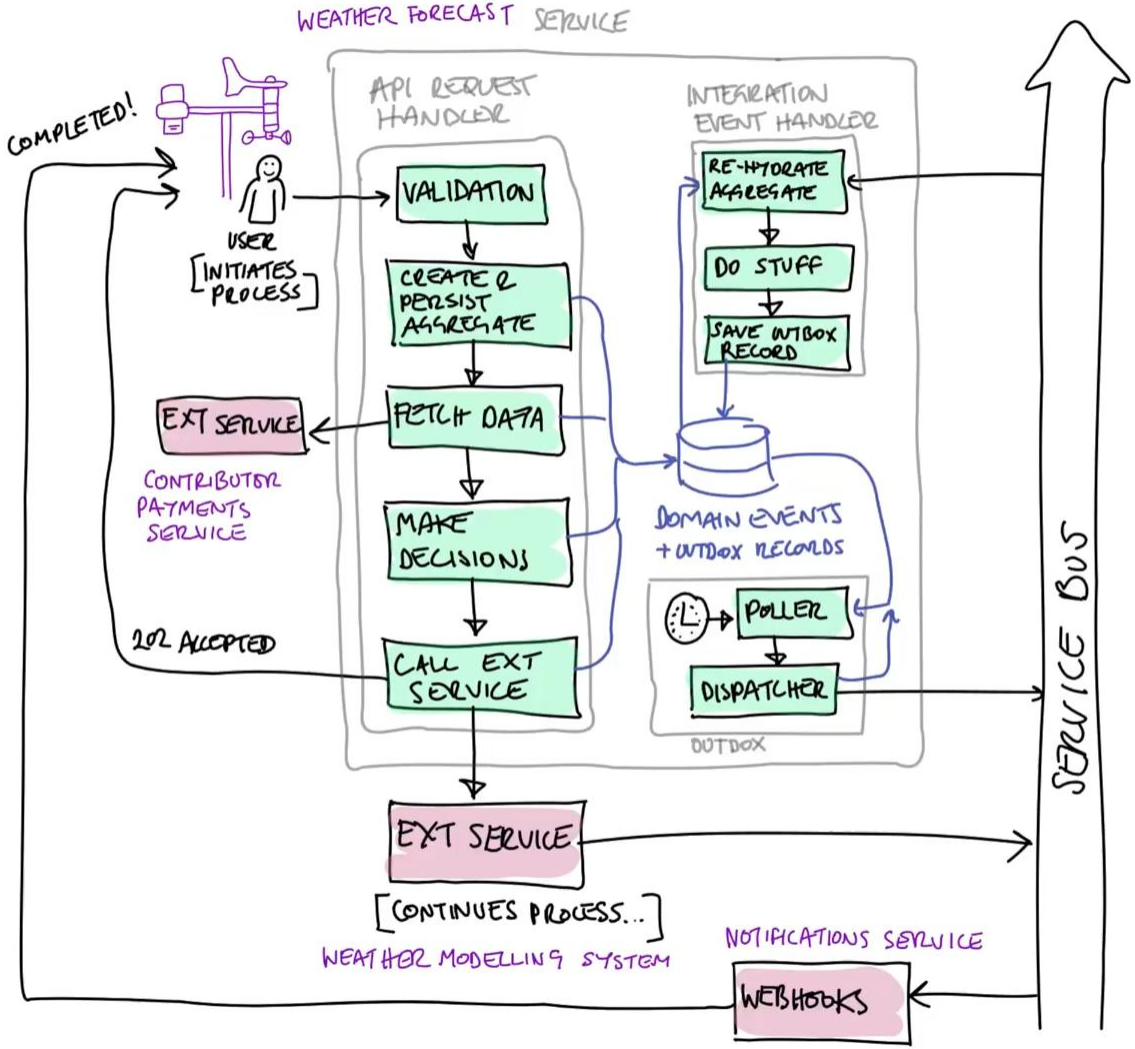
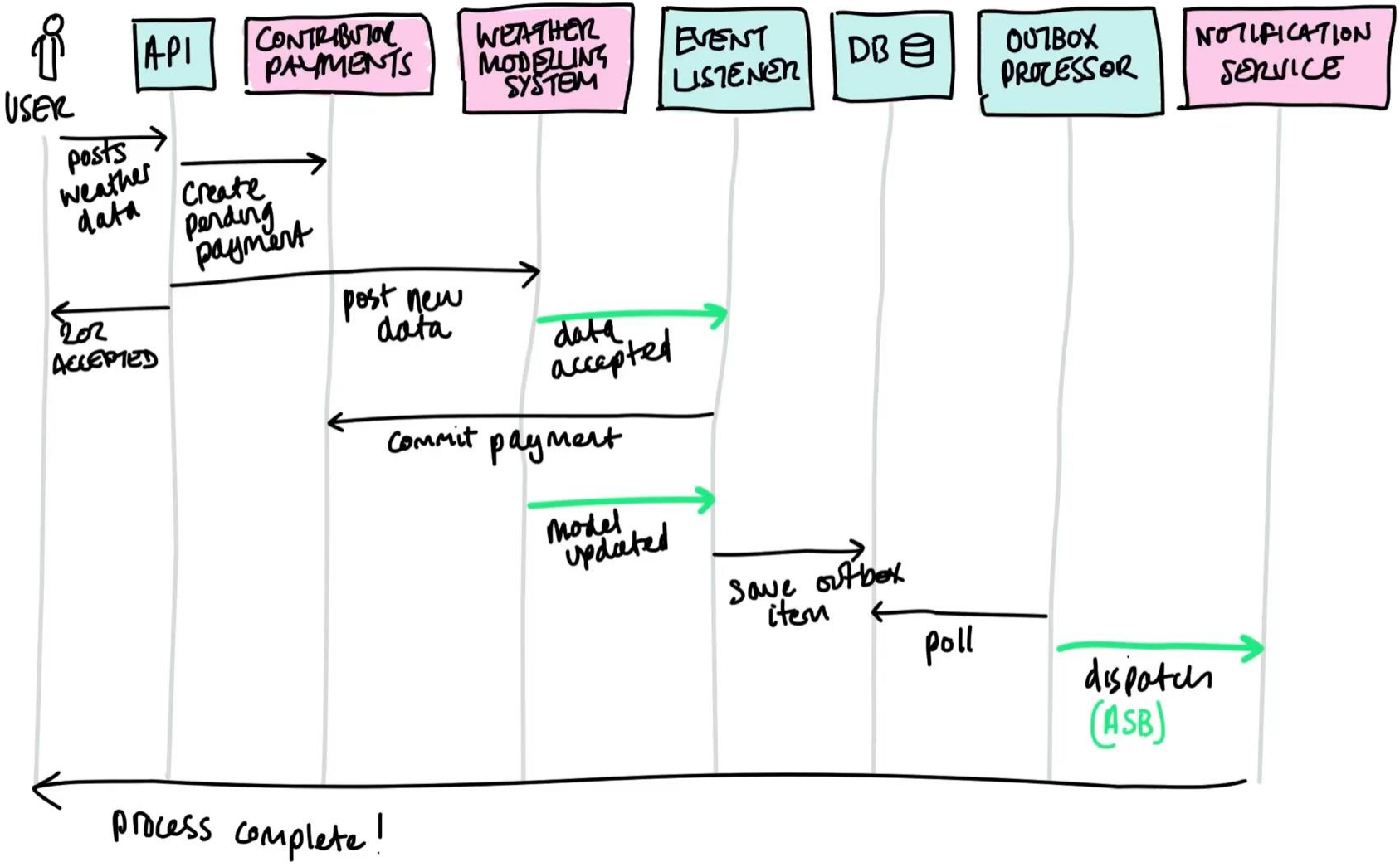
github.com/andrewjpoole/event-sourced-but-flow-driven-example

Let’s start with a scenario…

github.com/andrewjpoole/event-sourced-but-flow-driven-example


WEATHER FORECAST SERVICE
API REQUEST HANDLER
INTEGRATION EVENT HANDLER
COMPLETED!
USER
[INITIATES PROCESS]
VALIDATION
CREATE & PERSIST AGGREGATE
FETCH DATA
EXT SERVICE
CONTRIBUTOR PAYMENTS SERVICE
MAKE DECISIONS
202 ACCEPTED
CALL EXT SERVICE
EXT SERVICE
[CONTINUES PROCESS...]
WEATHER MODELLING SYSTEM
RE-HYDRATE AGGREGATE
DO STUFF
SAVE OUTBOX RECORD
DOMAIN EVENTS + OUTBOX RECORDS
POLLER
DISPATCHER
OUTBOX
SERVICE BUS
NOTIFICATIONS SERVICE
WEBHOOKS


USER
API
CONTRIBUTION PAYMENTS
WEATHER MODELLING SYSTEM
EVENT LISTENER
DB
OUTBOX PROCESSOR
NOTIFICATION SERVICE
posts weather data
create pending payment
post new data
202 ACCEPTED
data accepted
commit payment
model updated
save outbox item
poll
dispatch (ASB)
process complete!

There are lots of ways to test a piece of software

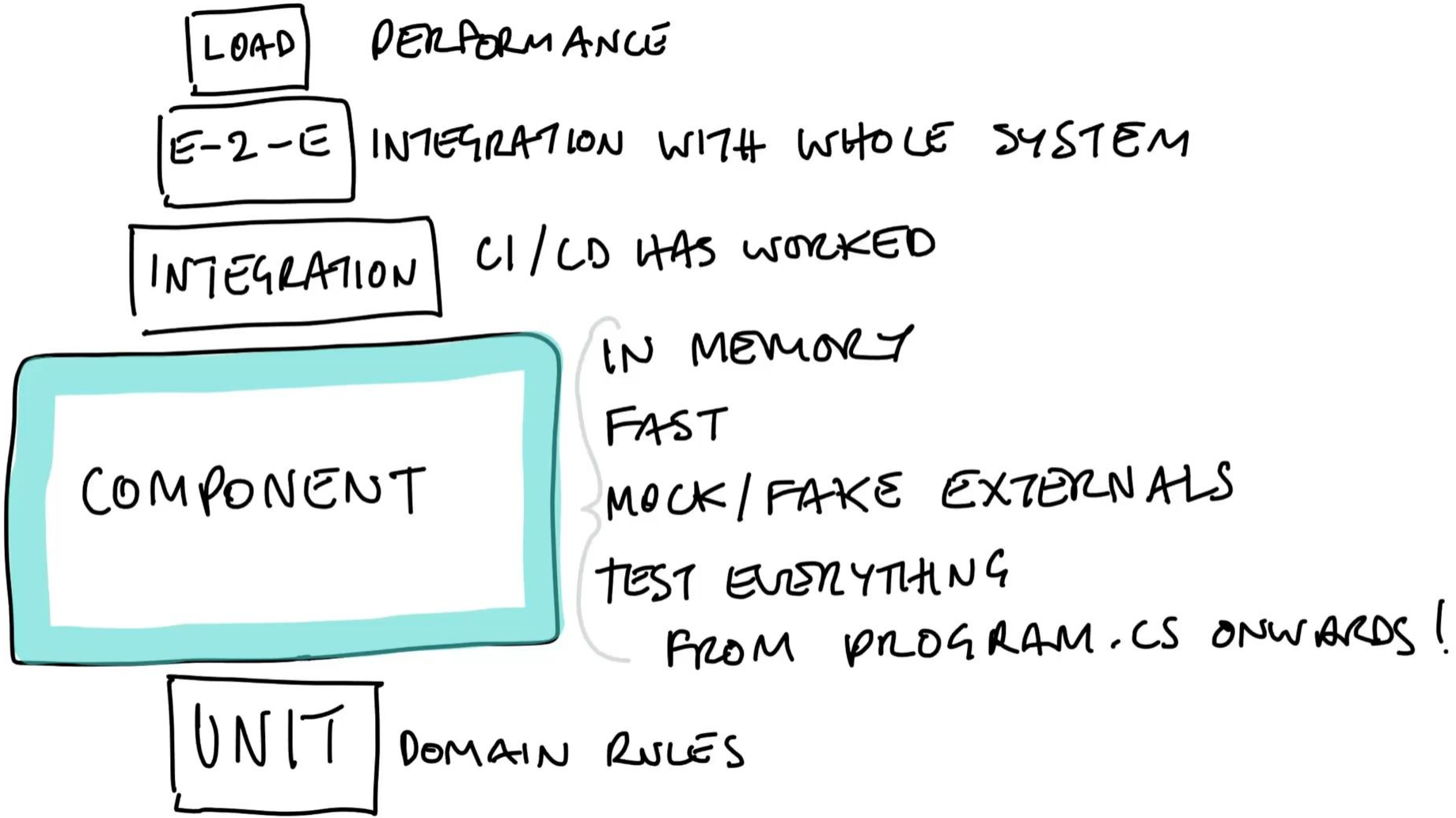
Every org|team|project|dev has a way

EndToEnd Component Tests

How to get the maximum mileage from a minimal number of tests🚀

What?

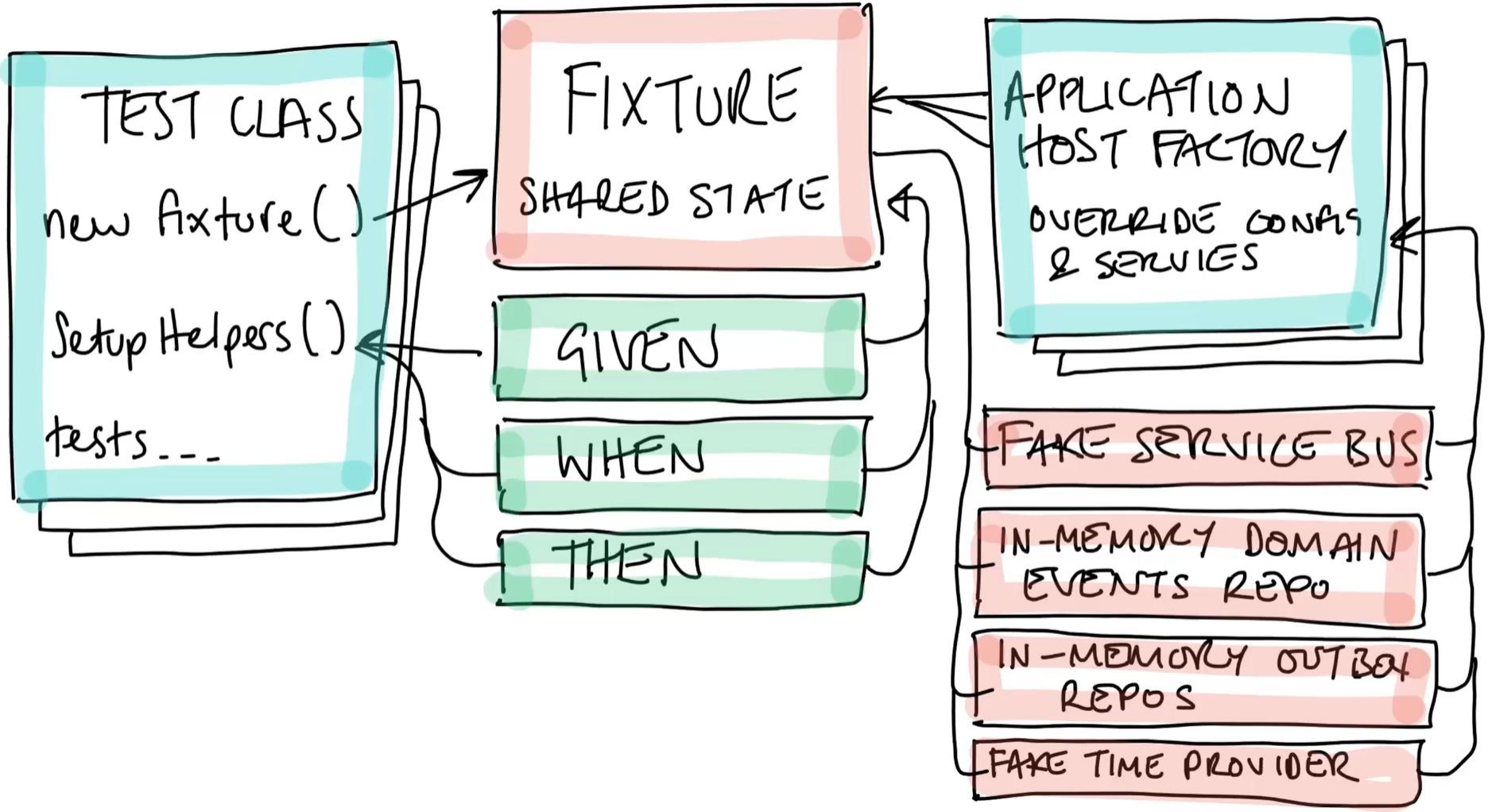
- Unit is as large as possible
  - multiple executables!
- Test as much of the surface area as possible
- Test behaviour *not* impl


LOAD
PERFORMANCE
E-2-E
INTEGRATION WITH WHOLE SYSTEM
INTEGRATION
CI/CD HAS WORKED
COMPONENT
IN MEMORY
FAST
MOCK/FAKE EXTERNALS
TEST EVERYTHING
FROM PROGRAM.CS ONWARDS!
UNIT
DOMAIN RULES

Why?

- Black box, refactor away!
- writing tests is not fun, building a test framework *can* be fun!
- Maximises reuse
- Probably less code overall
- Almost as good as running locally😊

How? Anatomy of an e2e component test


TEST CLASS
new Fixture()
SetupHelpers()
tests...
FIXTURE
SHARED STATE
GIVEN
WHEN
THEN
APPLICATION HOST FACTORY
OVERRIDE CONFIG & SERVICES
FAKE SERVICE BUS
IN-MEMORY DOMAIN EVENTS REPO
IN-MEMORY OUTBOX REPOS
FAKE TIME PROVIDER

How? #1 Make a nice framework

Given, When & Then or Arrange, Act & Assert etc

```
[Fact]
0 references
public void Return_a_WeatherReport_given_valid_region_and_date()
{
    var (given, when, then) = testFixture.SetupHelpers();

    given.WeHaveAWeatherReportRequest("bristol", DateTime.Now, out var apiRequest)
        .And.TheServersAreStarted();

    when.WeSendTheMessageToTheApi(apiRequest, out var response);

    then.TheResponseCodeShouldBe(response, HttpStatusCode.OK)
        .And.TheBodyShouldNotBeEmpty<WeatherReportResponse>(response,
            x => x.Summary.Should().NotBeEmpty());
}
```

How? #2 Single test fixture

```
public ComponentTestFixture()
{
    ApiFactory = new(this) { SetSharedEventRepository = () ⇒ EventRepositoryInMemory };
    EventListenerFactory = new(this)
    {
        SetSharedEventRepository = () ⇒ EventRepositoryInMemory,
        SetSharedOutboxRepositories = () ⇒ OutboxRepositoryInMemory
    };
    OutboxApplicationFactory = new(this) { SetSharedOutboxRepositories = () ⇒ OutboxRepositoryInMemory };
    NotificationServiceFactory = new(this);

    FakeServiceBus = new FakeServiceBus(
        string entityName ⇒ EntityNames.GetTypeNameFromEntityName(entityName),
        Type type ⇒ EntityNames.GetEntityNameFromTypeName(type));

    FakeServiceBus.AddSenderFor<UserNotificationEvent>();
    FakeServiceBus.AddProcessorFor<ModelingDataAcceptedIntegrationEvent>();
    FakeServiceBus.AddProcessorFor<ModelingDataRejectedIntegrationEvent>();
    FakeServiceBus.AddProcessorFor<ModelUpdatedIntegrationEvent>();
    FakeServiceBus.AddProcessorFor<UserNotificationEvent>();

    FakeServiceBus.MessagesSentToSendersWillBeReceivedOnCorrespondingProcessors();

    FakeTimeProvider = new FakeTimeProvider();
```

How? #3 Create test host factory for each executable app

Microsoft.AspNetCore.Mvc.Testing

```
public class OutboxApplicationFactory(ComponentTestFixture fixture) : WebApplicationFactory<Outbox.Program>
{
    1 reference
    public HttpClient? HttpClient;
    1 reference
    public readonly Mock<ILogger> MockLogger = new();
    3 references
    public Func<OutboxRepositoryInMemory>? SetSharedOutboxRepositories = null;

    0 references
    protected override IHost CreateHost(IHostBuilder builder)
    {
        Environment.SetEnvironmentVariable(variable: "ConnectionStrings__WeatherAppDb", value: "dummyConnectionString");
        Environment.SetEnvironmentVariable(
            variable: $"{nameof(OutboxProcessorOptions)}__{nameof(OutboxProcessorOptions.IntervalBetweenBatchesInSeconds)}",
            value: "1");

        builder
            .ConfigureServices(IServiceCollection services ⇒
            {
                services.AddMockLogger(MockLogger);
                services.AddSingleton<TimeProvider>(fixture.FakeTimeProvider);
                fixture.FakeServiceBus.WireUpSendersAndProcessors(services);
```

How? #4 Testable service bus processor 😎

Azure.Messaging.ServiceBus package includes the ServiceBusModelFactory…

```
public class TestableServiceBusProcessor(string entityName) : ServiceBusProcessor
{
    6 references
    public List<TestableMessageEventArgs> MessageDeliveryAttempts =  List<TestableMessageEventArgs>[];

    public override Task StartProcessingAsync(CancellationToken cancellationToken = default)
        => Task.CompletedTask;

    public async Task PresentMessage<T>(T message, int deliveryCount = 1,
    {
        var args = CreateMessageArgs(message, deliveryCount, applicationP
        MessageDeliveryAttempts.Add((TestableMessageEventArgs)args);
        await base.OnProcessMessageAsync(args);
    }
```

```
public override Task DeadLetterMessageAsync(Service
    string? deadLetterErrorDescription = null, Canc
{
    WasDeadLettered = true;
    DeadLetterReason = deadLetterReason;
    return Task.CompletedTask;
}
```

```
var message = ServiceBusModelFactory
    .ServiceBusReceivedMessage(
        body: BinaryData.FromString(payloadJson),
        correlationId: correlationId,
        properties: applicationProperties,
        deliveryCount: deliveryCount);

return new TestableMessageEventArgs(message);
```

How? #5 Mock service bus sender🚌

ServiceBusSender can be Mocked using your favourite mocking framework

```
public Then AMessageWasSent(Mock<ServiceBusSender> senderMock, Func<ServiceBusMessage, bool> match, int times = 1)
{
    senderMock.Verify(ServiceBusSender x ⇒ x.SendMessageAsync(
        It.Is<ServiceBusMessage>(ServiceBusMessage m ⇒ match(m)),
        It.IsAny<CancellationToken>()), Times.Exactly(times));
```

If one service sends a message to another, use Callback() or equivalent

```
public void MessagesSentToSendersWillBeReceivedOnCorrespondingProcessors()
{
    foreach (var mockSender in mockSenders)
    {
        if (processors.ContainsKey(mockSender.Key) == false)
            break;

        mockSender.Value.Setup(ServiceBusSender x ⇒ x.SendMessageAsync(It.IsAny<ServiceBusMessage>(), It.IsAr
            .Callback<ServiceBusMessage, CancellationToken>((ServiceBusMessage sbm, CancellationToken ctx) ⇒
            {
                var message = JsonSerializer.Deserialize(sbm.Body, mockSender.Key) ?? throw new Exception(mes

                var props = (Dictionary<string, object>?)sbm.ApplicationProperties;

                var processor = GetProcessorFor(mockSender.Key);
                processor.PresentMessage(message, applicationProperties: props).GetAwaiter().GetResult();
            });
```

How? #7 Database Connections

- Replace db connection in IoC container with Mock/Fake backed by in-memory collections
- SqlLite or EFCore in-memory database*
- Or use a real database with something like CSharpSqlTests

Bending time 🕰️

TimeProvider

FakeTimeProvider

```
FakeTimeProvider = new FakeTimeProvider();
FakeTimeProvider.SetUtcNow(TimeProvider.System.GetUtcNow());
FakeTimeProvider.AutoAdvanceAmount = TimeSpan.FromMilliseconds(100);
```

```
services.AddSingleton<TimeProvider>(fixture.FakeTimeProvider);
```

```
await Task.Delay(TimeSpan.FromSeconds(options.IntervalBetweenBatchesInSeconds),
    timeProvider, cancellationToken);
```

```
// Advance the time so the outbox processor wakes up to check for messages...
fixture.FakeTimeProvider.Advance(TimeSpan.FromMilliseconds(numberOfMsToAdvance));
// So cool!😁
```

Demo 🥳

[enable breakpoints!]

Pros and Cons⚖️

✔️Test entire e2e flows in addition to individual phases

✔️The more reusable the code, the more care/love is justified

✔️Detect config and IoC registration issues

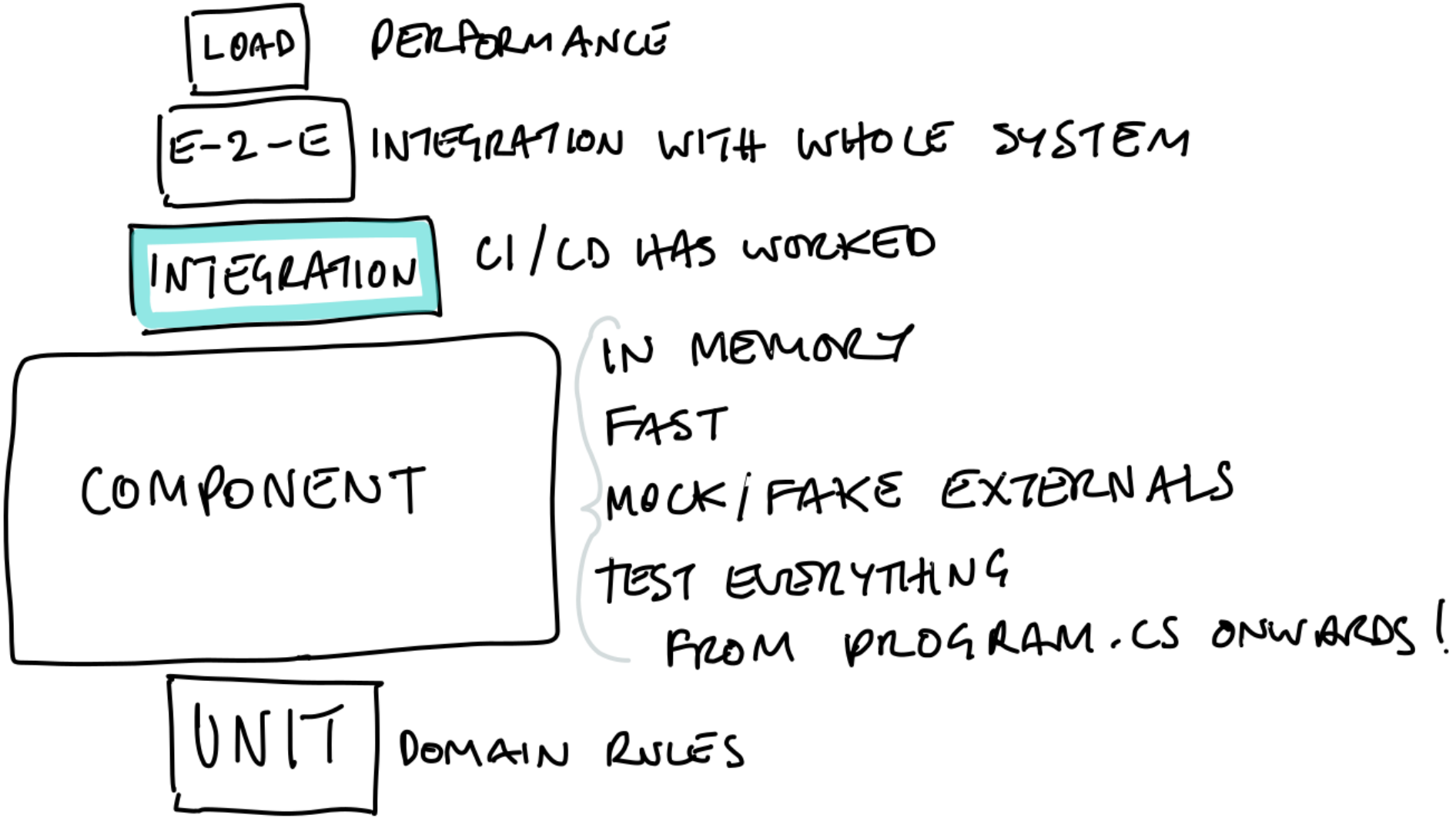
❌TDD is possible but is harder and especially at the start

❌Still need to run locally to prove integrations/mocked behaviours match real dependencies etc

Using .Net Aspire

For next level devex & easy integration tests asserting against OTEL trace data ❤️‍🔥

A mini journey, starting from a hatred of integration tests…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The problem with integration tests…

They tend to be the last task on a story…😔

change → CI → release → tests, loop is *way* too long🤭

They expose how difficult it is to run things locally😬

The problem with local dev ex…

Heavily dependant on Compute platform 😟

Too many options! 😵

Large differences between local and real running in an environment 😖

Specific issues 🤯

Config, _so_ many options

Azure Service Bus topics, subscriptions, queues etc

ManagedIdentity from within containers

Auth

#IF DEBUG 😳

VS ≠ AKS | ACA | anything else!

Azure API Management

Windows vs Linux

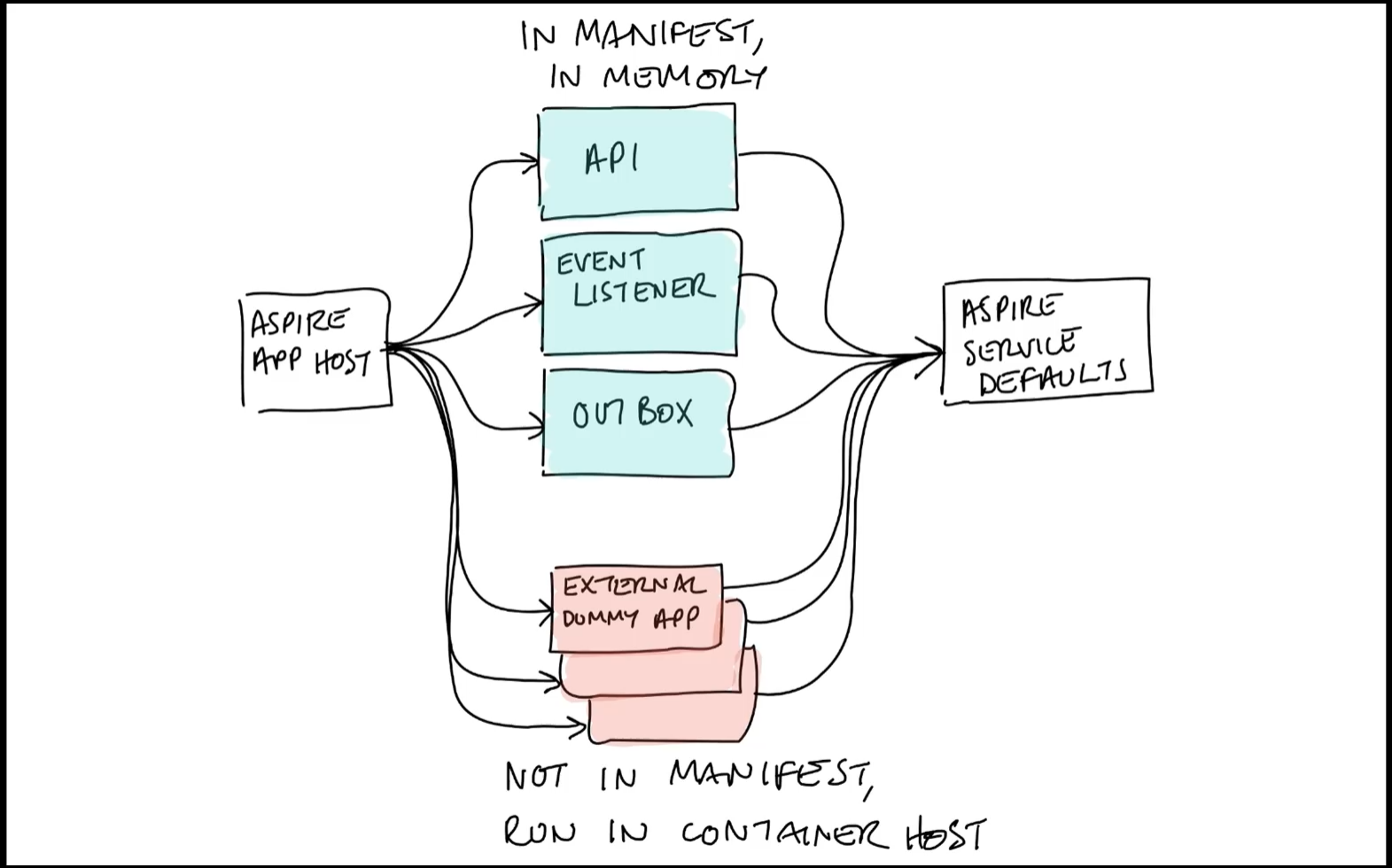
In an ideal world…

We would:

- Clone a repo
- Run non-integration tests, all pass *first time*
- Run local deploy script/command?
- Run integration tests, all pass *first time*
- From there on, hit [F5] and everything runs nicely😁

Aspire🚀 exceptional local devex!

- ✔️ Dashboard!
- ✔️ OTLP!
- ✔️ Easy to add to an existing app
- ✔️ Define everything in one file
- ✔️ Supports testing!


IN MANIFEST,
IN MEMORY
API
EVENT LISTENER
OUTBOX
ASPIRE APP HOST
ASPIRE SERVICE DEFAULTS
EXTERNAL DUMMY APP
NOT IN MANIFEST,
RUN IN CONTAINER HOST

Aspire Demo 🚀

[disable breakpoints!]

Adding missing trace data

✔️Lots of operations traced out-of-the-box

🔧Trace across air-gaps (i.e. outbox)

🔧Trace significant events

[back to vscode…]

Back to integration tests…

- ✔️ Aspire has a test framework!
- ✔️ All resources are run
- ✔️ Obtain a client and wait until ready
- ✔️ Passing test from the project template

[back to vscode…]

Better solution for assertions?

✔️ Forensic timeline of everything that's happened

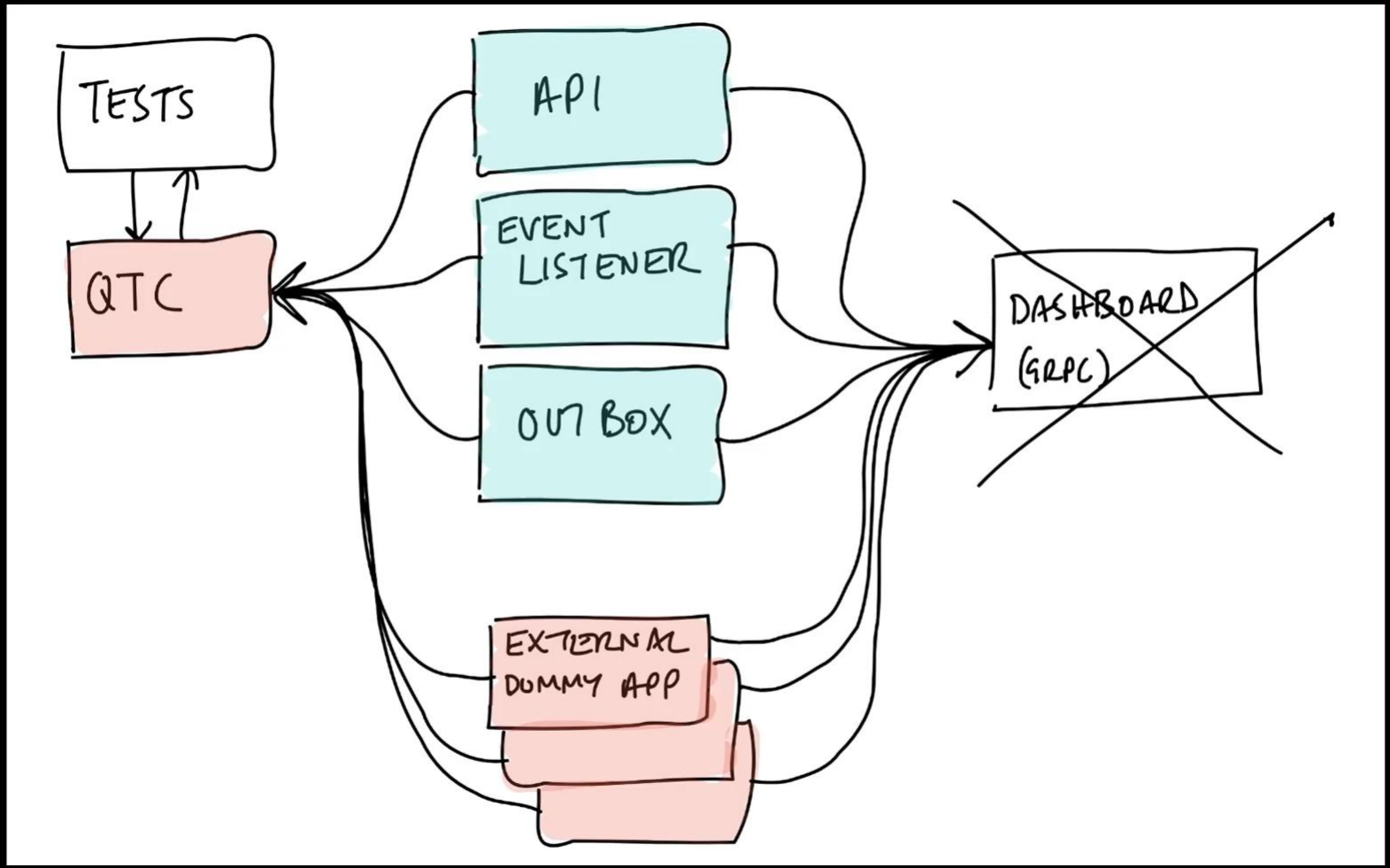
✔️ Single place to query

❌ Dashboard is not run during tests

🔧 Need something out-of-process

💡 Aspire is extensible: QueryableTraceCollector

hosting package + client package


TESTS
QTC
API
EVENT LISTENER
OUT BOX
EXTERNAL DUMMY APP
DASHBOARD (GRPC)

Aspire Demo 🚀

[disable breakpoints!]

Pros and Cons ⚖️

- ✔️ Massive shift-left
- ✔️ Easy to realistically run the service locally
- ✔️ Easy to write and run integration tests locally
- ✔️ Observability Driven Development?
- ✖️ May have to create Dummy/Mocked external services

Next stage in this journey…

- How does the opinionated nature of Aspire fit into enterprise CI/CD pipeline and existing environments?🤔
- Do we still need those e2e component tests?🥳
- Could we also assert against trace data in component tests?💡

Any Questions?

Github repo: everything I showed + lots more cool stuff ⇒

github.com/andrewjpoole/event-sourced-but-flow-driven-example

Including a PDF of these slides😊

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