# How to fall in love with automated tests!😍

Andrew Poole

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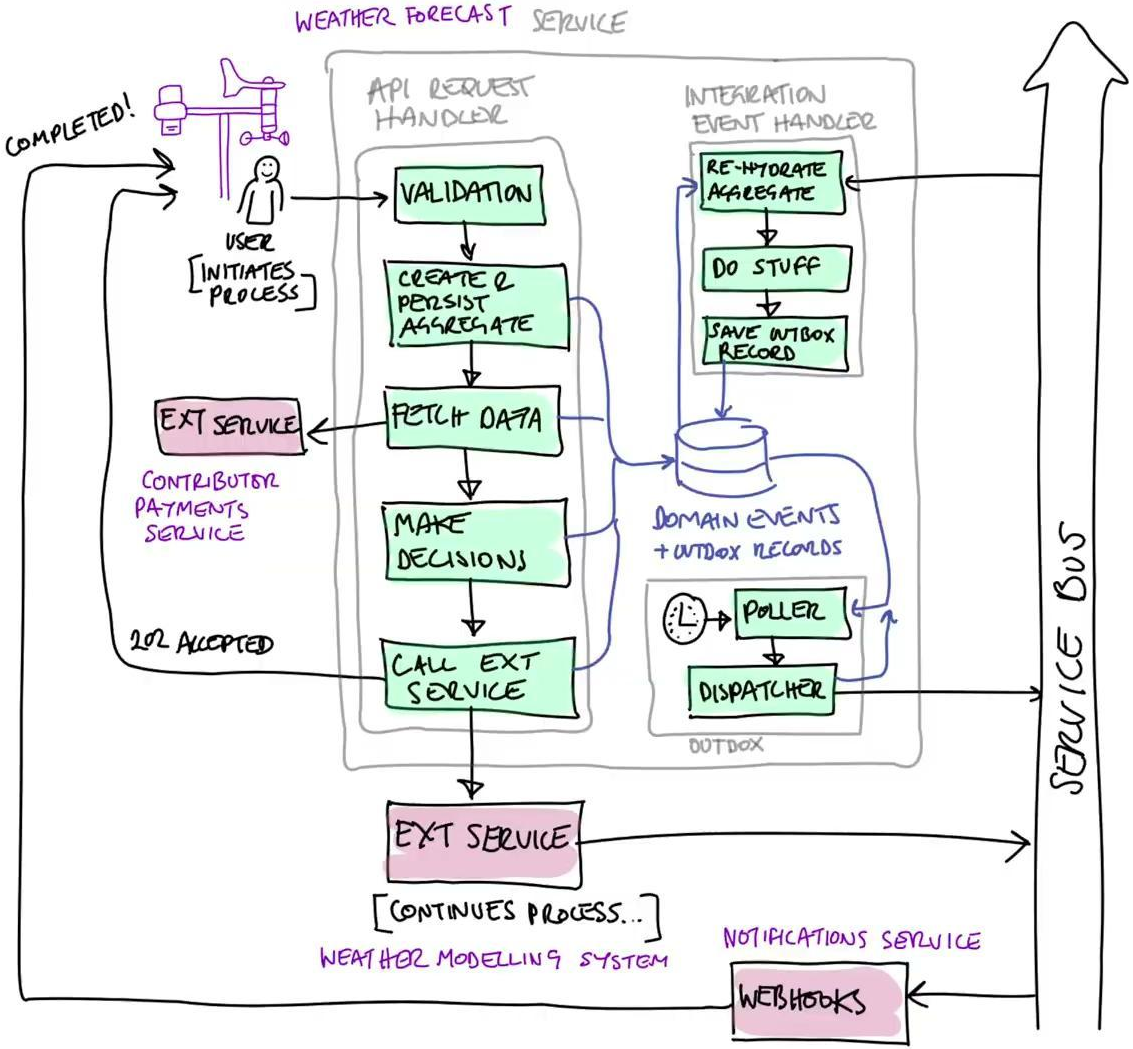
# EndToEnd Component Tests

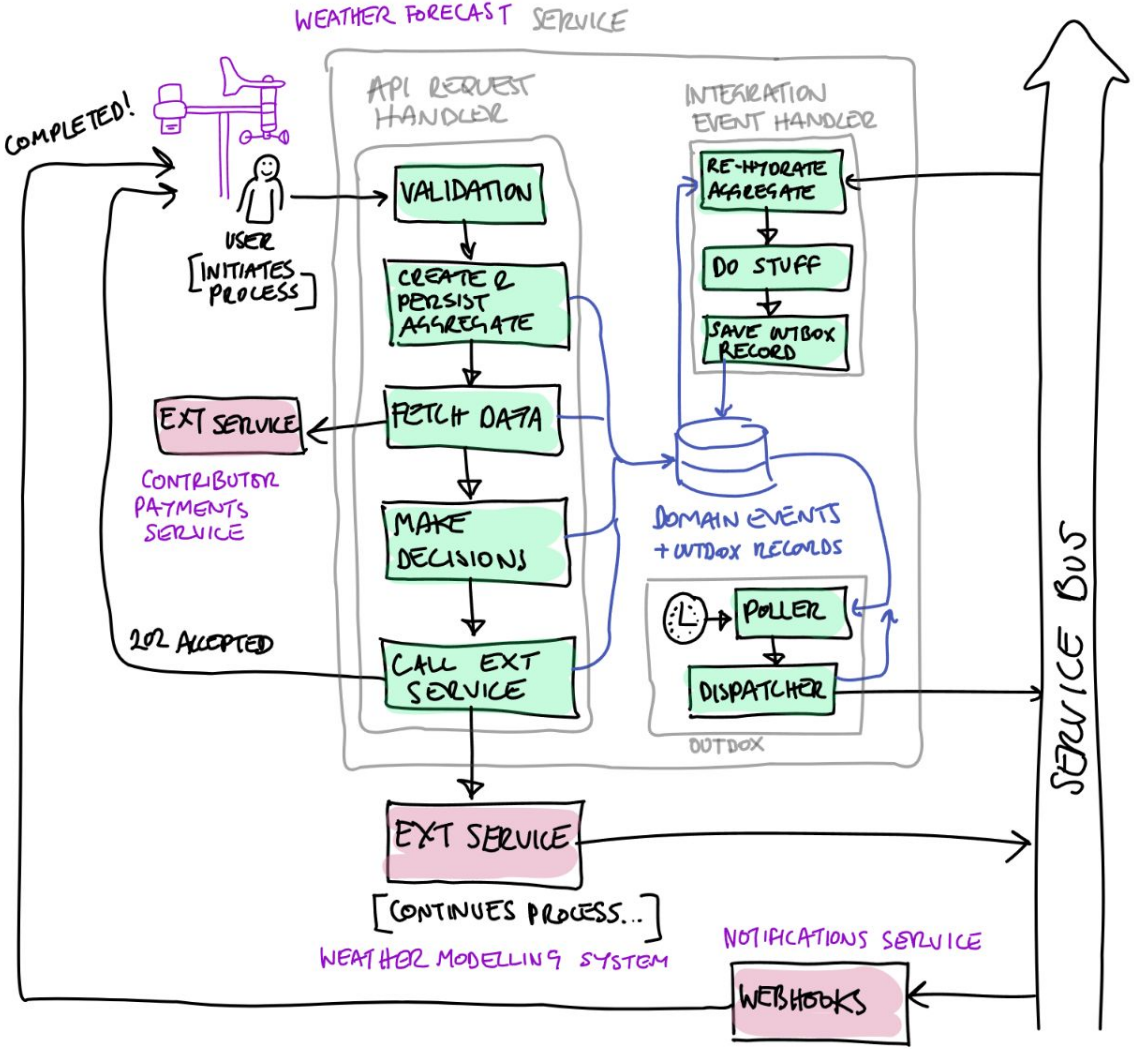
How to get the maximum mileage from a minimal number of tests🚀

# Integration Tests

how *not* to hate them!❤️

Let’s start with a scenario…


WEATHER FORECAST SERVICE
COMPLETED!
USER
[INITIATES PROCESS]
API REQUEST HANDLER
VALIDATION
CREATE & PERSIST AGGREGATE
FETCH DATA
MAKE DECISIONS
CALL EXT SERVICE
EXT SERVICE
CONTRIBUTOR PAYMENTS SERVICE
202 ACCEPTED
INTEGRATION EVENT HANDLER
RE-HYDRATE AGGREGATE
DO STUFF
SAVE OUTBOX RECORD
DOMAIN EVENTS + OUTBOX RECORDS
POLLER
DISPATCHER
OUTBOX
SERVICE BUS
EXT SERVICE
[CONTINUES PROCESS...]
WEATHER MODELLING SYSTEM
NOTIFICATIONS SERVICE
WEBHOOKS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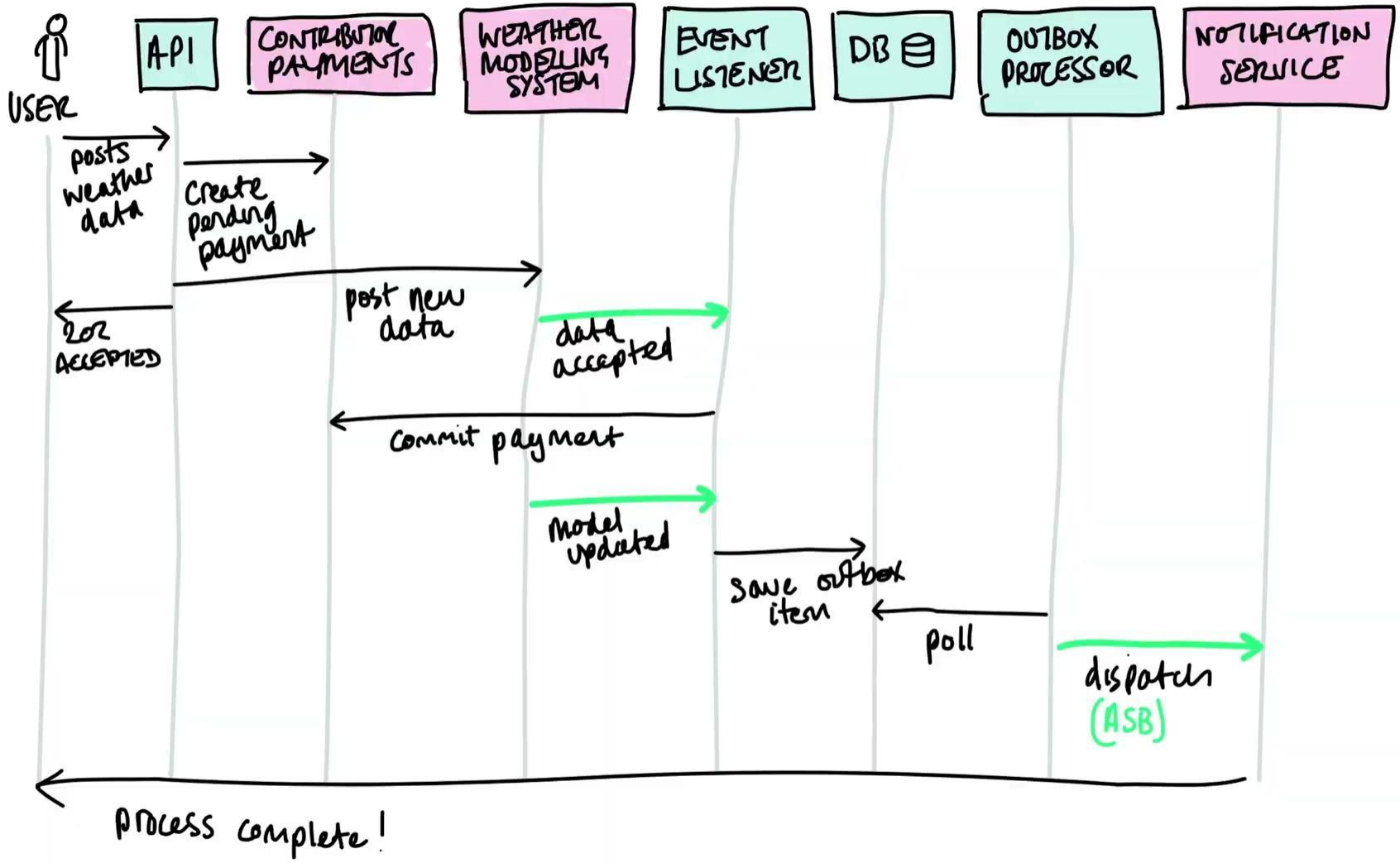
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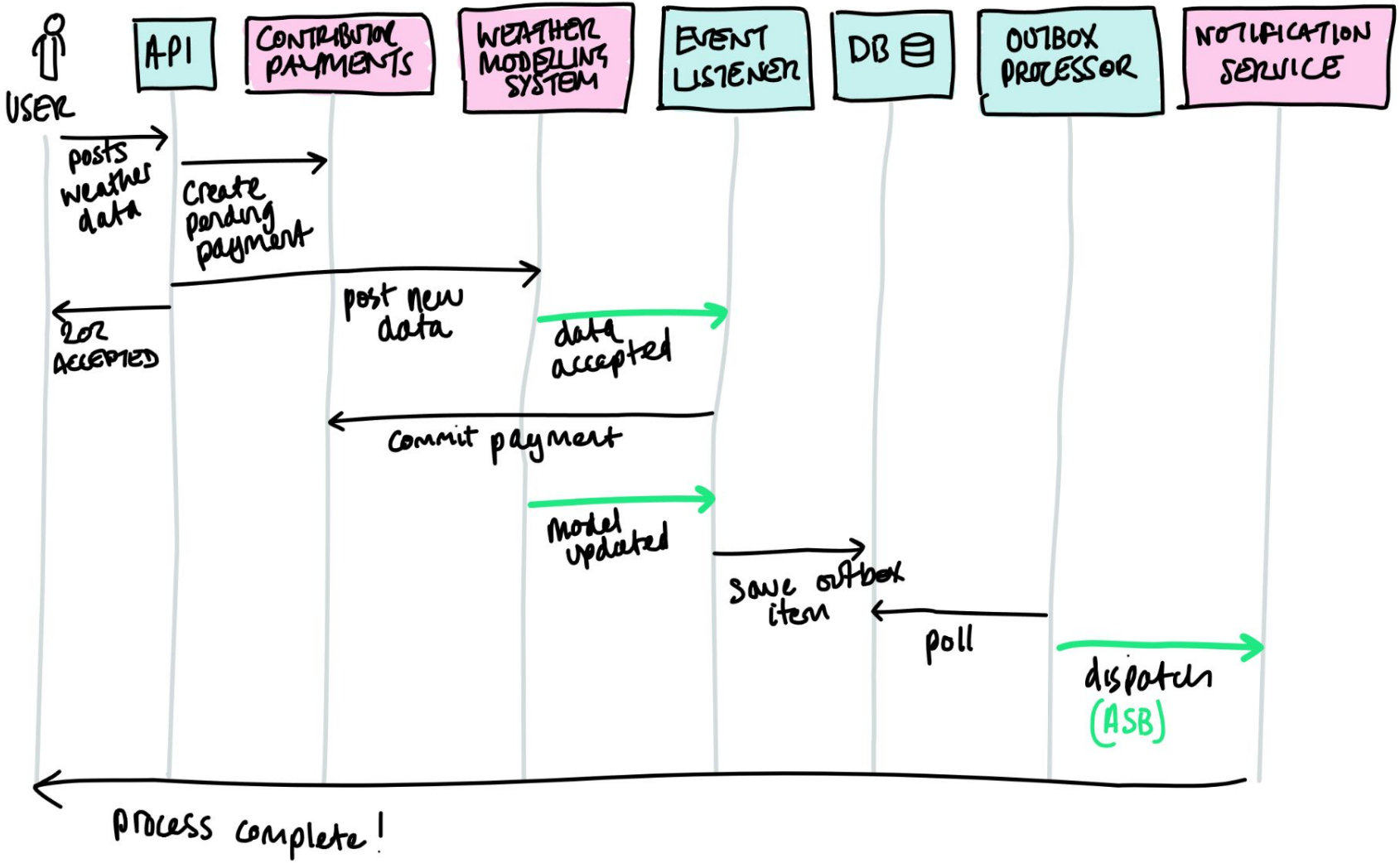
NOTIFICATION SERVICE
posts weather data
create pending payment
post new data
202 ACCEPTED
data accepted
commit payment
model updated
save outbox item
poll
dispatch (ASB)
process complete!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data accepted
commit payment
model updated
save outbox item
poll
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!
- Consolidation (one project for multiple components)
- Test as much of the surface area as possible
- Test behaviour *not* impl

Caveat: **only opinions**!

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

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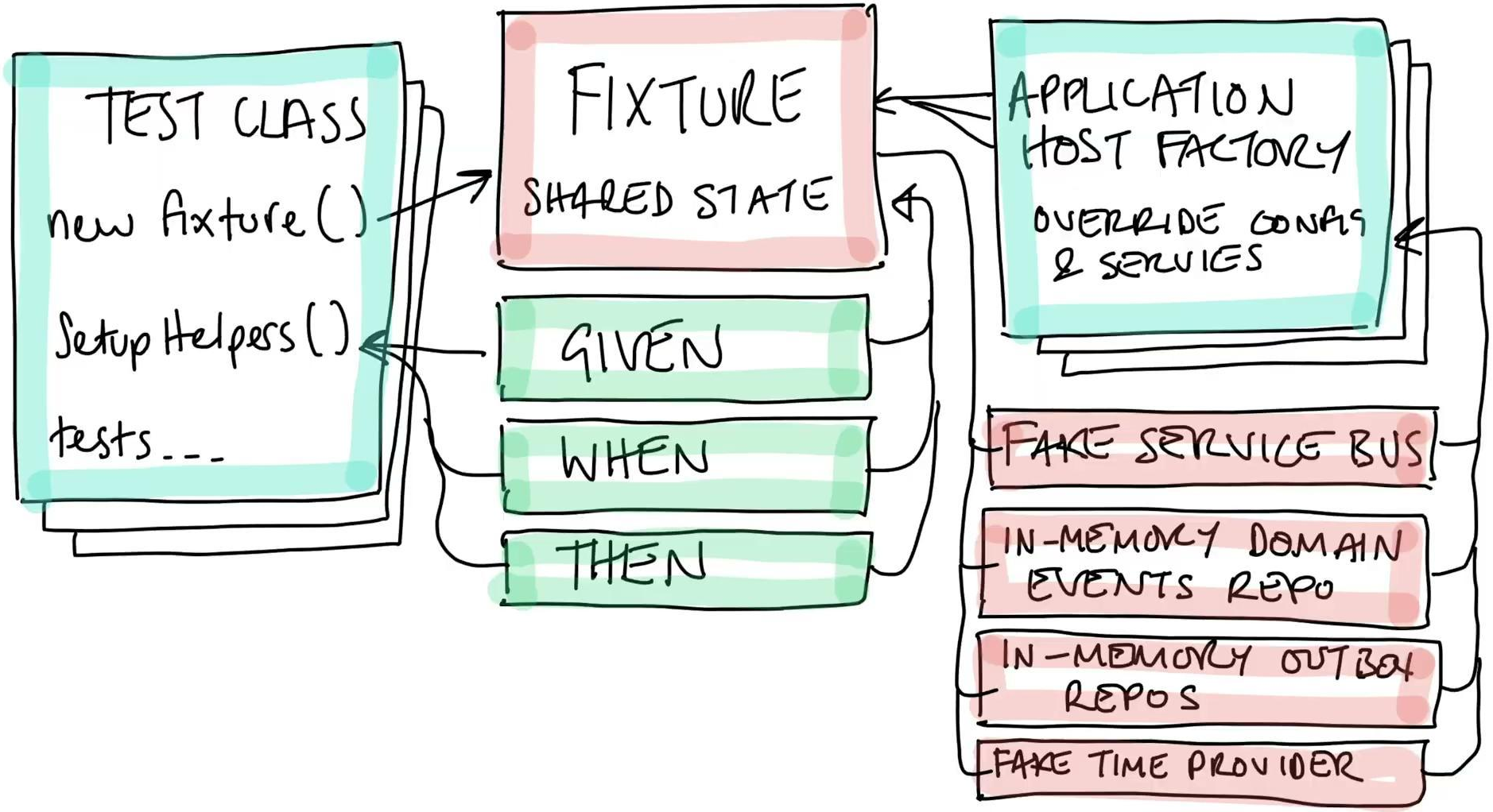
UNIT — DOMAIN RULES

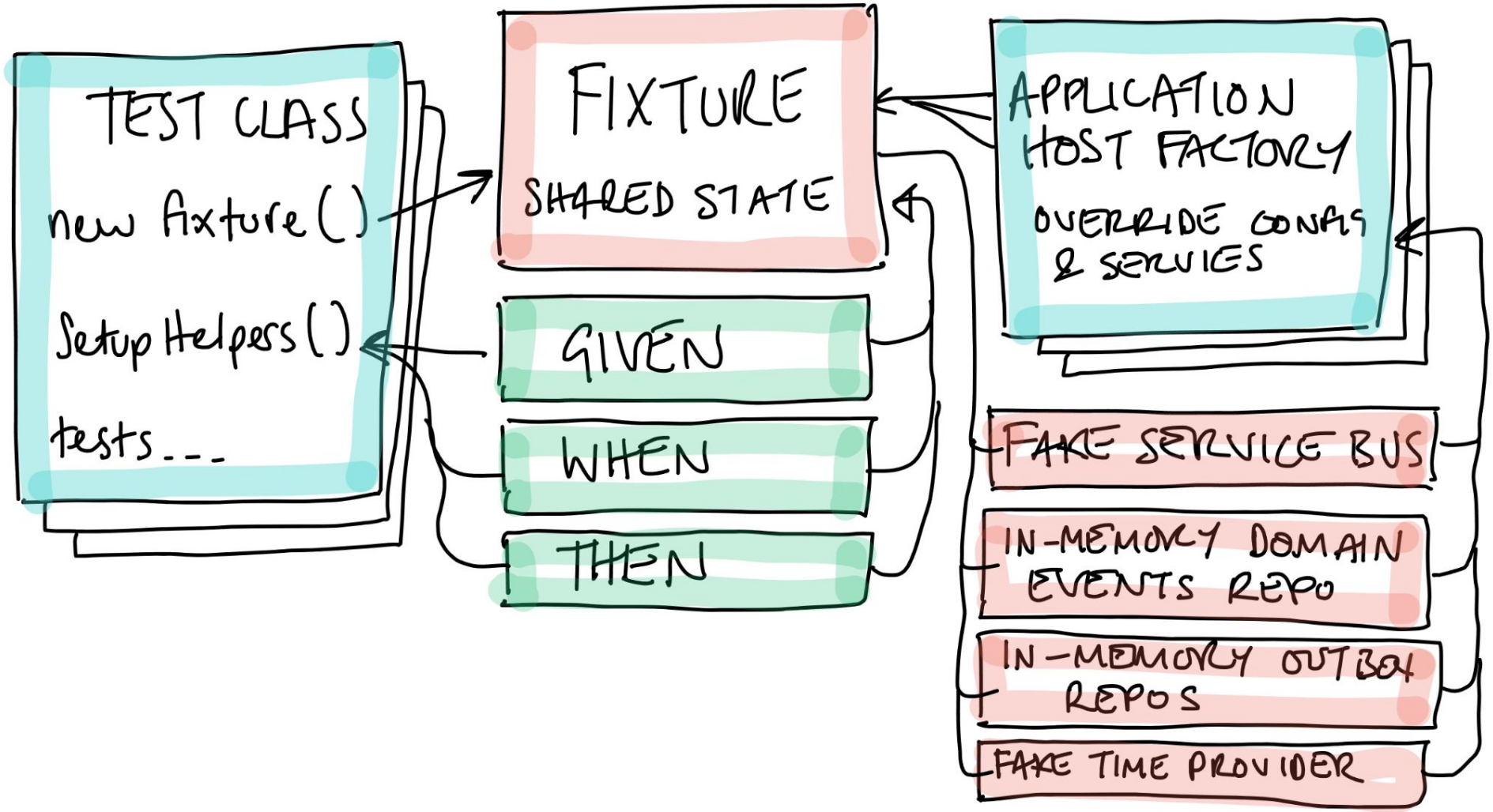
# Why?

- blackbox, refactor away!
- writing tests is not fun, building a test framework *can* be fun!
- Almost as good as running locally😊

# Show me!

```
[Test]
0 references
public void e2e_flow_notifications_sent_when_ModelingDataAccepted()
{
    var (given, when, then) = testFixture.SetupHelpers();

    var testLocation = $"testLocation{Guid.NewGuid()}"[..20];
    var testReference = $"testReference{Guid.NewGuid()}"[..5];

    given.WeHaveSomeCollectedWeatherData(out var weatherData)
        .And.TheContributorPaymentsServicePendingEndpointWillReturn(HttpStatusCode.Accepted)
        .And.TheModelingServiceSubmitEndpointWillReturn(HttpStatusCode.Accepted)
        .And.TheServersAreStarted();

    when.InPhase(newPhase: "1 (initial API request)")
        .And.WeWrapTheCollectedWeatherDataInAnHttpRequestMessage(weatherData, testLocation, testReference, out var httpRequest)
        .And.WeSendTheMessageToTheApi(httpRequest, out var response);

    then.And.TheModelingServiceSubmitEndpointShouldHaveBeenCalled(times: 1)
        .And.TheEventShouldHaveBeenPersisted<SubmittedToModeling>()
        .And.TheResponseCodeShouldBe(response, HttpStatusCode.OK)
        .And.TheBodyShouldNotBeEmpty<WeatherDataCollectionResponse>(response, out var responseBody);

    when.InPhase(newPhase: "2 (1st ASB message back from modeling service)")
        .AMessageAppears(message: new ModelingDataAcceptedIntegrationEvent(responseBody.RequestId));

    then.TheEventShouldHaveBeenPersisted<ModelingDataAccepted>();

    when.InPhase(newPhase: "3 (2nd ASB message back from modeling service)")
        .AMessageAppears(message: new ModelUpdatedIntegrationEvent(responseBody.RequestId));

    then.TheEventShouldHaveBeenPersisted<ModelUpdated>()
        .And.AnOutboxRecordWasInserted();

    then.InPhase(newPhase: "4 (Notification Service handles event dispached by outbox)")
        .AfterSomeTimeHasPassed(numberOfMsToAdvance: 2_000, numberOfMsToWait: 1_000)
        .And.TheMessageWasHandled<ModelUpdatedIntegrationEvent>()
        .And.TheNotificationServiceNotifiedTheUser(testLocation, testReference);
}
```


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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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 Create test host factory for each executable app

Microsoft.AspNetCore.Mvc.Testing package

```
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.MockServiceBus.WireUpSendersAndProcessors(services);
```

# How? #3 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);

    MockServiceBus = new MockServiceBus(
        string entityName => EntityNames.GetTypeNameFromEntityName(entityName),
        Type type => EntityNames.GetEntityNameFromTypeName(type));

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

    MockServiceBus.MessagesSentToSendersWillBeReceivedOnCorrespondingProcessors();

    FakeTimeProvider = new FakeTimeProvider();
    FakeTimeProvider.SetUtcNow(TimeProvider.System.GetUtcNow());
```

# How? #4 Testable service bus processor😎

Azure.Messaging.ServiceBus has a few test hooks included…

```
public class TestableServiceBusProcessor<T> : ServiceBusProcessor where T : class
{
    public List<TestableProcessMessageEventArgs> MessageDeliveryAttempts = [];
```

```
public override Task StartProcessingAsync(CancellationToke
{
    return Task.CompletedTask;
}
```

```
public async Task SendMessage(T request, int deliveryCount = 1)
{
    var args = CreateMessageArgs(request, deliveryCount);
    MessageDeliveryAttempts.Add((TestableProcessMessageEventArgs)args);
    await base.OnProcessMessageAsync(args);
}
```

```
public static ProcessMessageEventArgs CreateMessageArgs(T payload, int deliveryCount = 1)
{
    var payloadJson = JsonSerializer.Serialize(payload, GlobalJsonSerialiserSettings.Defa

    var correlationId = Guid.NewGuid().ToString();
    var applicationProperties = new Dictionary<string, object>
    {
        {"origin", "ComponentTests"}
    };

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

    var args = new TestableProcessMessageEventArgs(message);

    return args;
}
```

```
public class TestableProcessMessageEventArgs(ServiceBusReceivedMessage message)
    : ProcessMessageEventArgs(message, null, CancellationToken.None)
{
    public bool WasCompleted;
    public bool WasDeadLettered;
    public bool WasAbandoned;
    public DateTime Created = DateTime.UtcNow;
    public string DeadLetterReason = string.Empty;

    0 references
    public override Task CompleteMessageAsync(ServiceBusReceivedMessage message,
        CancellationToken cancellationToken = new())
    {
        WasCompleted = true;
        return Task.CompletedTask;
    }
```

# 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(x => x.SendMessageAsync(It.Is<ServiceBusMessage>(m => match(m)), It.IsAny<CancellationToken>()), Times.Exactly(times));

    return this;
}
```

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.IsAny<Cancellat
            .Callback<ServiceBusMessage, CancellationToken>((ServiceBusMessage sbm, CancellationToken ctx) =>
            {
                var message = JsonSerializer.Deserialize(sbm.Body, mockSender.Key) ??
                              throw new Exception(message: "unable to deserialise service bus message body");

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

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

# How? #6 Re-wire Http clients if needed

```
public class EventListenerWebApplicationFactory : WebApplicationFactory<EventListener.Program>
{
    private readonly CustomHttpClientFactory httpClientFactory = new();

    protected override void ConfigureWebHost(IWebHostBuilder builder)
    {
        base.ConfigureWebHost(builder);
        builder.ConfigureServices(services =>
        {
            // Replace standard IHttpClientFactory impl with custom one with any added HTTP clients.
            services.AddSingleton<IHttpClientFactory>(httpClientFactory);
        });
    }

    1 reference
    public void ClearHttpClients() => httpClientFactory.HttpClients.Clear();

    1 reference
    public void AddHttpClient(string clientName, HttpClient client)
    {
        if (httpClientFactory.HttpClients.TryAdd(clientName, client) == false)
        {
            throw new InvalidOperationException($"HttpClient with name {clientName} is already added");
        }
    }
```

```
public class CustomHttpClientFactory() : IHttpClientFactory
{
    public Dictionary<string, HttpClient> HttpClients = [];

    0 references
    public HttpClient CreateClient(string name) =>
        HttpClients.GetValueOrDefault(name)
        ?? throw new InvalidOperationException($"HTTP client is not found for client with name {name}");
}
```

# How? #7 Database Connections

- Replace db connection in IoC container with Mock/Fake backed by in-memory collections
- 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😅

# Pros and Cons⚖️

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

✔️Test entire e2e flows in addition to individual phases

✔️Detect config and IoC registration issues

✖️TDD is possible but *is* definitely a bit harder and especially at the start

✖️Still need to run locally to prove integrations/mocked behaviours work as expected etc

# Integration Tests

how *not* to hate them❤️

...also sort out you local dev experience!

# Change of direction alert!⚠

# 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…

Bacs! 🤯

1) Config
- Too many options!
- Managing git changes - don’t check in secrets!

2) Service Bus topics, subscriptions, queues etc
- Sharing a team env namespace means prefixing etc
- Manual queue creation in Azure portal😒

# Differences between local and real env/pipeline

- ManagedIdentity from within containers

  #IF DEBUG 😒

- VS ≠ AKS | ACA | anything else!

  I.e. Communication with pods without Ingress etc

- No local APIM

  Different base urls per service rather than one

- Auth
- 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😁

## Closing gaps between local and env running…

- Use same tooling as release where possible?
- Use environment variables for config?
- ~~Manage via Powershell~~
- Use external services from a team/test env?
- ~~script/fixture to create ASB entities?~~

.Net Aspire ftw! 😍

# Aspire🚀 exceptional local devex!

✔️Easy to add to an existing app

✔️Define everything in one file

✔️OTLP!

✔️Dashboard!

✔️Supports testing!

🤔Deployment?

Demo needed…

# Deployment…

- infra
  - asb
    - asb.module.bicep
  - modules
    - fetch-container-image.bicep
  - abbreviations.json
  - api.tmpl.yaml
  - contributorpaymentsservice.tmpl.yaml
  - eventlistener.tmpl.yaml
  - main.bicep
  - main.parameters.json
  - notificationservice.tmpl.yaml
  - outbox.tmpl.yaml
  - queryabletracecollector.tmpl.yaml
  - resources.bicep
  - sql.tmpl.yaml
  - weathermodelingservice.tmpl.yaml
- notebooks

```
andrewsLegion  D:\git\event-sourced-but-flow-driven-example  main ≡ ?5
pwsh > azd deploy
```

| Name | Type | Location |
|---|---|---|
| acrxjgzrndt35sxi | Container registry | UK South |
| api | Container App | UK South |
| asb-xjgzrndt35sxi | Service Bus Namespace | UK South |
| cae-xjgzrndt35sxi | Container Apps Enviro... | UK South |
| contributorpaymentsservice | Container App | UK South |
| eventlistener | Container App | UK South |
| law-xjgzrndt35sxi | Log Analytics workspace | UK South |
| mi-xjgzrndt35sxi | Managed Identity | UK South |
| notificationservice | Container App | UK South |
| outbox | Container App | UK South |
| queryabletracecollector | Container App | UK South |
| sql | Container App | UK South |
| weathermodelingservice | Container App | UK South |

```
You
https://portal.azure.com/#@/resource/subscriptions/aaecc46b-3ecb-4daa-8818-aa082f1
```

# Next stage in this journey…

- How does the opinionated nature of Aspire fit into enterprise CI/CD pipeline and existing environments?
- Better solution for asserting against OTEL data?

Andrew Poole

**Constructive feedback wanted!!**

andrew.poole@flagstoneim.com | andrewjpoole@gmail.com

LinkedIn | Github | forkInTheCode.net

Github repo containing the code I showed ⇒

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

Including these slides😊

Given when then blogpost

Testing service bus blogpost

CSharpSqlTests blogpost