Microservice Architecture with ASP.NET Core

Agenda

- Introduction to .NET Core
- .NET 8.0 SDK
- Modern C# and What's New
- ASP.NET Core Application Architecture
- Models
- Controllers
- Request Routing
- Web APIs
- Data Validation
- Error Handling

Microservice Architecture with ASP.NET Core

Agenda

- Logging
- Microservice Architecture
- Designing Microservices
- Integration Patterns
- Scale and Resilience
- Containerization
- Security

Microservice Architecture with ASP.NET Core

Introduction

- Evolution of the .NET Platform
- .NET SDKs and Runtimes
- Visual Studio and Visual Studio Code

2002	.NET 1.0, C# 1.0, Visual Studio .NET
2003	.NET 1.1, Visual Studio 2003
2004	Mono 1.0
2005	.NET 2.0, C# 2.0, Visual Studio 2005 *Generics, Nullable Value Types*
2006	.NET 3.0, Mono 1.2 *WPF, WCF, WF*
2007	.NET 3.5, C# 3.0, Visual Studio 2008 *LINQ, Anonymous Types, Lambda Expressions, Extension Methods, Implicit Typing*
2008	Entity Framework 1.0
2009	ASP.NET MVC 1.0
2010	.NET 4.0, C# 4.0, ASP.NET MVC 2, Visual Studio 2010 *Named / Optional Arguments, Dynamic Binding*
2012	.NET 4.5, C# 5.0, Mono 3.0, ASP.NET MVC 4, Visual Studio 2012 *Asynchronous Members (async / await)*
2013	.NET 4.5.1, ASP.NET MVC 5, Visual Studio 2013 *SignalR 1.0*

2015 .NET 4.6, C# 6.0, Mono 4.0, Visual Studio 2015, Visual Studio Code 1.0
Expression Bodied Members, Null Propagator, String Interpolation

2016 Xamarin Acquisition, .NET Core 1.0, .NET Standard 1.0
Entity Framework Core 1.0

2017 .NET 4.7, .NET Core 2.0, C# 7.0, Visual Studio 2017
ASP.NET Razor Pages, Out Variables, Tuples, Ref Locals and Returns

2018 GitHub Acquisition, .NET Standard 2.0
Blazor Server

2019 .NET 4.8, .NET Core 3.0, C# 8.0, Visual Studio 2019
gRPC, Default Interface Methods, Using Declarations, Nullable Reference Types

2020 .NET 5, C# 9.0
Blazor WebAssembly, Records, Init Only Setters, Top-Level Statements

2021 .NET 6, C# 10.0, Visual Studio 2022
.NET MAUI

2022 .NET 7, C# 11.0
Standard-Term Support (STS) release primarily focused on performance

2023 .NET 8, C# 12
Collection Expressions, ref readonly Parameters, Blazor Render Modes

Introduction

Evolution of the .NET Platform

- In 2016, Microsoft introduced a new variant of .NET called .NET Core
- Many components were completely rewritten
- Fully supported on Windows, macOS, and Linux
- Included a subset of the functionality provided by .NET Framework
  - Focused on web-based workloads (web UIs and services)
- Merged MVC and Web API into the core framework

Introduction

Evolution of the .NET Platform

- The version of .NET Core after 3.1 became the "main line" for .NET and was labeled .NET 5.0
- The ASP.NET framework in .NET still includes the name "Core" to avoid confusion with previous versions of ASP.NET MVC

Introduction

Evolution of the .NET Platform

- The entire .NET platform is made available as open-source
- Community contributions are encouraged via pull requests
  - Thoroughly reviewed and tightly controlled by Microsoft

`github.com/dotnet`

Introduction

.NET SDKs and Runtimes

- .NET Runtime
  - Different version for each platform
  - Provides assembly loading, garbage collection, JIT compilation of IL code, and other runtime services
  - Includes the dotnet tool for launching applications
- ASP.NET Core Runtime
  - Includes additional packages for running ASP.NET Core applications
  - Reduces the number of packages that you need to deploy with your application

Introduction

.NET SDKs and Runtimes

- .NET SDK
  - Includes the .NET runtime for the platform
  - Additional command-line tools for compiling, testing, and publishing applications
  - Contains everything needed to develop .NET applications (with the help of a text editor)

Introduction

.NET SDKs and Runtimes

- Each version of .NET has a lifecycle status
  - Standard Term Support (STS) – Includes the latest features with a support period of 18 months
  - Long Term Support (LTS) – Has an extended support period of three years
  - Preview – Not supported for production use
  - Out of support – No longer supported

`dotnet.microsoft.com/download`

Introduction

Visual Studio and Visual Studio Code

- Visual Studio is available for Windows and macOS
  - Full-featured IDE
- Visual Studio Code is available for Windows, macOS, and Linux
  - Includes IntelliSense and debugging features
  - Thousands of extensions are available for additional functionality

`visualstudio.microsoft.com`

Introduction

Visual Studio and Visual Studio Code

- JetBrains also offers an IDE for .NET development called Rider
- Available for Windows, macOS, and Linux
- Includes advanced capabilities in the areas of refactoring, unit testing, and low-level debugging

`www.jetbrains.com/rider`

Microservice Architecture with ASP.NET Core

.NET SDK

- Installation
- Version Management
- Command-Line Interface (CLI)

.NET SDK

Installation

- The .NET SDK is distributed using each supported platform's native install mechanism
- Requires administrative privileges to install
- A list of installed SDK versions is available by using the .NET Command Line Interface (CLI)

```
dotnet --list-sdks
```

- A complete list of all installed runtimes and SDKs (as well as the default version) is also available

```
dotnet --info
```

.NET SDK

Version Management

- By default, CLI commands use the newest installed version of the SDK
  - This behavior can be overridden with a global.json file

```
{
  "sdk": {
    "version": "6.0.14"
  }
}
```

  - Will be in effect for that directory and all sub-directories

.NET SDK

Version Management

- Use of global.json files can allow developers to experiment with newer versions of the SDK while ensuring consistency for specific projects
- Include a global.json file in a source control repository to ensure every member of the team is using the same version of the SDK
  - Will generate an error if the specified SDK version is not present on the system

.NET SDK

Version Management

- While the SDK version (tooling) is specified using a global.json file, the runtime version is specified within the project file

```
<PropertyGroup>
  <TargetFramework>net8.0</TargetFramework>
</PropertyGroup>
```

.NET SDK

Version Management

- When an application is launched, it will automatically use the newest available runtime with the same major and minor version number
  - For example, if version 8.0 is specified, the application will automatically use the 8.0.3 runtime but will not automatically use version 8.1 of the runtime
- Allows for system administrators to apply security patches and runtime bug fixes without the need to recompile and re-deploy the application
- Behavior can be overridden by specifying a RollForward policy value

.NET SDK

Version Management

- The target framework for a project can be an older version than the version of the SDK that you are using
  - For example, you can use version 8 of the SDK to build an application that targets the .NET 6 runtime

```
<PropertyGroup>
  <TargetFramework>net6.0</TargetFramework>
</PropertyGroup>
```

- Recommended approach – Use the newest version of the tools possible and choose a runtime target based on your deployment environment

.NET SDK

Command-Line Interface (CLI)

- Many higher-level tools and IDEs use the CLI "under-the-covers"
- CLI commands consist of the driver (“dotnet”), followed by a “verb” and then possibly some arguments and options

.NET SDK

Command-Line Interface (CLI)

- dotnet new
  - Create a new project from an available template
- dotnet restore
  - Restore the dependencies for a project (download missing NuGet packages)
- dotnet build
  - Build a project and all its dependencies
- dotnet run
  - Run an application from its source code (performs a build if necessary)

.NET SDK

Command-Line Interface (CLI)

- dotnet test
  - Execute unit tests for a project
- dotnet publish
  - Pack an application and its dependencies into a folder for deployment
- And many more…

Lab

.NET SDK

- Create and run a .NET 8 console application using the CLI
- Create and run an ASP.NET Core application using the CLI

Microservice Architecture with ASP.NET Core

Modern C# and What's New

- Introduction
- Global Using Directives
- File-Scoped Namespace Declarations
- Top-Level Statements
- Nullable Reference Types
- Init Only Setters
- Record Types
- Deferred Execution

Modern C# and What's New

Introduction

- C# 9 introduced with .NET 5
- C# 10 introduced with .NET 6
- C# 11 introduced with .NET 7
- C# 12 introduced with .NET 8

Modern C# and What's New

Global Using Directives

- C# 10 introduced global using directive support
- If the global keyword is present, the using directive will be in effect for every file in the project

```
global using EComm.Core;
```

- Can be in any file but a good practice is to have a separate cs file for all the project’s global using directives

Modern C# and What's New

Global Using Directives

- Starting with .NET 6, global using directives for common system namespaces can be included implicitly via a project setting

```
<ImplicitUsings>enable</ImplicitUsings>
```

- This setting is included in new projects by default
- For an ASP.NET project, there are a total of 16 namespaces that will be implicitly referenced

Modern C# and What's New

File-Scoped Namespace Declarations

- Typically, code within a namespace is defined within curly braces

```
namespace Acme.Models
{
  ...
}
```

- C# now allows for a namespace declaration to specify that all the code within a file belongs to a specific namespace

```
namespace Acme.Models;

...
```

Modern C# and What's New

Top-Level Statements

- A .NET application requires an entry point function named Main defined within a static class

```
class Program {
  static void Main(string[] args) {
    Console.WriteLine("Hello, World!");
  }
}
```

- The C# compiler (10 and later) can recognize executable code that is outside of a class as the code for the entry point and generate the necessary function and static class for you

```
Console.WriteLine("Hello, World!");
```

Modern C# and What's New

Top-Level Statements

- ASP.NET project templates combine the implicit using feature with top-level statements to minimize the amount of code required in Program.cs

```
var builder = WebApplication.CreateBuilder(args);
var app = builder.Build();

app.MapGet("/", () => "Hello World!");

app.Run();
```

Modern C# and What's New

Nullable Reference Types

- By default, value types in .NET cannot be set to null
  - A variable can be defined as a nullable value type so that it can store a null value

```
int? num = null;
```

- Reference types can store null and default to null if not provided with an initial value

```
Product p;  // p is null
```

Modern C# and What's New

Nullable Reference Types

- The most common exception encountered during .NET development is the NullReferenceException
  - Occurs when attempting to access the member of an object that is null
- Safety can be significantly improved by using types that cannot be null unless explicitly identified to allow it

Modern C# and What's New

Nullable Reference Types

- C# 8 introduced the idea of nullable reference types
  - Like values types, reference types are not allowed to be null unless the variable is defined as nullable
- Because of the impact on existing code, this feature was not enabled by default
- Could be enabled via the Nullable annotation in the project file

```
<Nullable>enable</Nullable>
```

- Starting with .NET 6, nullable reference types are enabled by default

Modern C# and What's New

Nullable Reference Types

- If enabled, compiler warnings will be generated when…
  - Setting a non-nullable reference type to null
  - Defining a reference type that does not initialize all non-nullable reference type members as part of construction
  - Dereferencing a possible null reference without checking for null (or using the null-forgiving operator)

```
string fn = person!.FirstName;
```

Modern C# and What's New

Nullable Reference Types

- It is a good idea to enable nullable reference types for new projects
- Refactoring an existing application to use nullable reference types could require a significant amount of effort

Modern C# and What's New

Init Only Setters

- It is very convenient to initialize the properties of an object by using object initialization syntax

```
var product = new Product { Name = "Bread", Price = 2.50 }
```

- However, in the past, this was only possible by defining the properties as writable

Modern C# and What's New

Init Only Setters

- It is now possible to define properties with init only setters
- Properties can be set as part of object initialization but become read-only after that

```
public class Product
{
  public string Name { get; init; }
  public double Price { get; init; }
}
```

Modern C# and What's New

Record Types

- Every type in .NET is either a value type or a reference type
  - Struct is a value type
  - Class is a reference type
- Values types are recommended to be defined as immutable and are copied on assignment
  - Use value semantics for equality
  - Supports additional safety and optimizations especially for concurrent programming with shared data

Modern C# and What's New

Record Types

- The record type introduced in C# 9 allows you to easily define an immutable reference type that supports value semantics for equality

```
public record Person
{
    public string LastName { get; }
    public string FirstName { get; }

    public Person(string first, string last) =>
       (FirstName, LastName) = (first, last);
}
```

Modern C# and What's New

Record Types

- None of the properties of a record can be modified once it's created
- Records do support inheritance
- It is easy to create a new record from an existing one via the with keyword

```
var person = new Person("Joe", "Smith");

Person brother = person with { FirstName = "Bill" };
```

Modern C# and What's New

Record Types

- Record types can be a very good fit for things like ViewModels and Data Transfer Objects (DTOs)

Modern C# and What's New

Deferred Execution

- When using LINQ methods in C#, it is important to be aware of deferred execution

Microservice Architecture with ASP.NET Core

ASP.NET Core Application Architecture

- Introduction
- NuGet Packages
- Application Startup
- Hosting Environments
- Middleware and the Request Pipeline
- Services and Dependency Injection

ASP.NET Core Application Architecture

Introduction

- Single stack for Web UI and Web APIs
- Modular architecture distributed as NuGet packages
- Flexible, environment-based configuration
- Built-in dependency injection support
- Support for using an MVC-based architecture or a more page-focused architecture by using Razor Pages
- Blazor allows for the implementation of client-side functionality using .NET code

ASP.NET Core Application Architecture

NuGet Packages

- NuGet is a package manager for .NET
  - `www.nuget.org`
- All the libraries that make up .NET (and many 3rd-party libraries) are distributed as NuGet packages
- NuGet package dependencies are stored in the project file

```
<PackageReference Include="Microsoft.EntityFrameworkCore" Version="8.0.3" />
```

ASP.NET Core Application Architecture

NuGet Packages

- The dotnet restore command will fetch any referenced NuGet packages that are not available locally
- Uses nuget.org as the package source by default
- Additional or alternative package sources (remote or local) can be specified by using a nuget.config file

ASP.NET Core Application Architecture

NuGet Metapackages

- Metapackages are a NuGet convention for describing a set of packages that are meaningful together
- Every .NET Core project implicitly references the Microsoft.NETCore.App package
  - ASP.NET Core projects also reference the Microsoft.AspNetCore.App package
- These two metapackages are included as part of the runtime package store
  - Available anywhere the runtime is installed

ASP.NET Core Application Architecture

Application Startup

- When an ASP.NET Core application is launched, the first code executed is the application's Main method
  - Generated by the compiler if using top-level statements
- Code in the Main method is used to…
  - Create a WebApplication object
  - Configure application services
  - Configure the request processing pipeline
  - Run the application

ASP.NET Core Application Architecture

Application Startup

- WebApplication's CreateBuilder method is typically used to create the WebApplicationBuilder object
- When the WebApplicationBuilder is created, it loads configuration information from…
  - appsettings.json and appsettings.{Environment}.json
  - User secrets (when running in Development environment)
  - Environment variables and command-line arguments

ASP.NET Core Application Architecture

Application Startup

- After the WebApplicationBuilder has been initialized, application services can be added
- WebApplicationBuilder's Build method is used to construct the WebApplication object and initialize the dependency injection system
- The WebApplication object is used to configure the request processing pipeline

ASP.NET Core Application Architecture

Application Startup

- A collection of framework services are automatically registered with the dependency injection system
  - IHostApplicationLifetime
    - Used to handle post-startup and graceful shutdown tasks
  - IHostEnvironment / IWebHostEnvironment
    - Has many useful properties (ex. EnvironmentName)
  - ILoggerFactory
  - IServer
  - And many others…

ASP.NET Core Application Architecture

Application Startup

- The environment for local machine development can be set in the launchSettings.json file
  - Overrides values set in the system environment
  - Only used on the local development machine
  - Is not deployed
  - Can contain multiple profiles

ASP.NET Core Application Architecture

Application Startup

- By default, clients can use HTTP/2 when selected during the TLS handshake; otherwise, HTTP/1.1 is used
- Additional configuration options are described in the documentation

ASP.NET Core Application Architecture

Hosting Environments

- EnvironmentName property can be set to any value
- Framework-defined values include:
  - Development
  - Staging
  - Production (default if none specified)
- Typically set using the ASPNETCORE_ENVIRONMENT environment variable
- Can also be configured via launchSettings.json

ASP.NET Core Application Architecture

Middleware

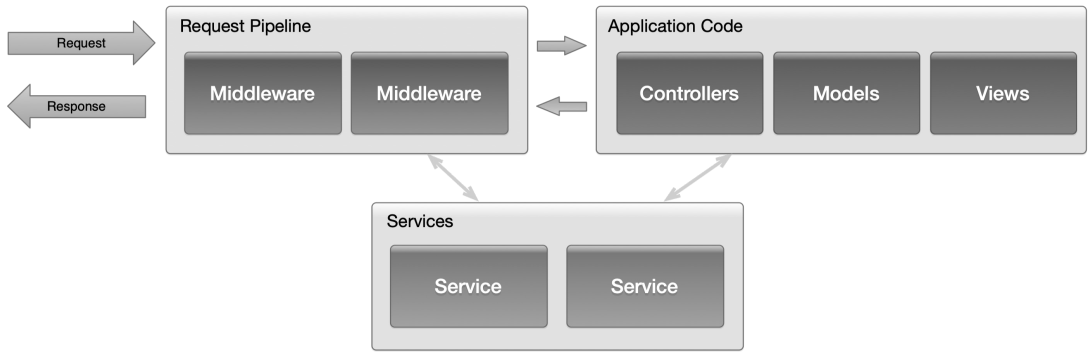
- ASP.NET uses a modular request processing pipeline
- The pipeline is composed of middleware components
- Each middleware component is responsible for invoking the next component in the pipeline or short-circuiting the chain
- Examples of middleware include…
  - Request routing
  - Handling of static files
  - Authentication
  - Response caching
  - Error handling

ASP.NET Core Application Architecture

Services

- ASP.NET Core also includes the concept of services
- Services are components that are available throughout an application via dependency injection
- An example of a service would be a component that accesses a database or sends an email message

ASP.NET Core Application Architecture



ASP.NET Core Application Architecture

Pipeline

- The last piece of middleware in the pipeline is typically the routing middleware
- Routes the incoming request to a controller
- Instead of using controllers, the new minimal API framework in .NET can be used

Microservice Architecture with ASP.NET Core

Models

- Introduction
- Persistence Ignorance
- Object-Relational Mapping
- Asynchronous Data Access

Models

Introduction

- Models represent "real world" objects the user is interacting with
- Entities are the objects used during Object-Relational Mapping and provide a way to obtain and persist model data
- The term Data Transfer Object (DTO) is often used to describe an object that carries data between different processes or subsystems
  - A single DTO may contain multiple different entities, exclude some entity properties, or use different property names
  - In a Web API application, the object that get serialized into JSON is often a DTO

Models

Persistence Ignorance

- The model data typically comes from an external source (database, web service, file, etc.)
- For better maintainability and testability, it is a best practice to use a data access component to encapsulate the details about where the model data comes from
- In ASP.NET, data access should be performed by a service made available via dependency injection
  - Makes it easy to test components independently with hard-coded data (no database)

Models

Object-Relational Mapping

- If a data access component communicates with a relational database, a necessary task will be to convert between relational data and C# objects
- This can be done manually by with ADO.NET, or several frameworks exist that can help with this task
  - Entity Framework Core
  - Dapper (3rd-party micro-ORM)
  - AutoMapper (mapping one object to another)

Models

Asynchronous Data Access

- When performing IO-bound operations (database access, web service calls, etc.), it is a best practice to perform that work asynchronously
- Allows for the efficient use of thread resources
  - Thread pool threads can be used to handle other incoming requests while the IO-bound operation is in progress
  - Improves the scalability of a web application

```
public async Task<IEnumerable<Product>> GetAllProducts()
{
  return await _repository.GetProductsAsync();
}
```

Microservice Architecture with ASP.NET Core

Application Configuration

- Middleware
- Services
- Configuration Providers and Sources
- Configuration API
- Options Pattern

Application Configuration

Middleware

- A middleware component typically adds an extension method to IApplicationBuilder for adding it to the pipeline
  - By convention, these methods start with the prefix "Use"

```
app.UseHttpsRedirection();
app.UseAuthorization();
```

- The order in which middleware is added to the pipeline can be important
  - Determines the order of execution
  - As an example, it would be very important for authentication middleware to execute before some caching middleware that could return a cached response

Application Configuration

Services

- Services are components that are available throughout an application via dependency injection
- The lifetime of a service can be…
  - Singleton (one instance per application)
  - Scoped (one instance per web request)
  - Transient (new instance each time component requested)
- An example of a service would be a component that accesses a database or sends an email message

Application Configuration

Services

- Services are typically added via extension methods available on IServiceCollection

```
builder.Services.AddDbContext<ApplicationDbContext>(...);
builder.Services.AddScoped<IEmailSender, MyEmailSender>();
builder.Services.AddScoped<ISmsSender, MySmsSender>();
```

- Most methods include the service lifetime as part of the method name (e.g., AddScoped)
- The AddDbContext method is a custom method specifically for adding an Entity Framework DbContext type as a service

Application Configuration

Services

- Services are available throughout the application via dependency injection
- A common practice is to follow the Explicit Dependencies Principle
  - Controllers include all required services as constructor parameters
  - System will provide an instance or throw an exception if the type cannot be resolved via the DI system

```
public class ProductController : ControllerBase
{
  public ProductController(IEmailSender emailSender) {
    ...
  }
}
```

Application Configuration

Configuration Providers and Sources

- Before ASP.NET Core, application settings were typically stored in an application's web.config file
- ASP.NET Core introduced a completely new configuration infrastructure
  - Based on key-value pairs gathered by a collection of configuration providers that read from a variety of different configuration sources

Application Configuration

Configuration Providers and Sources

- Available configuration sources include:
  - Files (INI, JSON, and XML)
  - System environment variables
  - Command-line arguments
  - In-memory .NET objects
  - Azure Key Vault
  - Custom sources

Application Configuration

Configuration Providers and Sources

- The default WebApplicationBuilder adds providers to read settings (in the order shown) from:
  - appsettings.json
  - appsettings.{Environment}.json
  - User secrets
  - System environment variables
  - Command-line arguments
- Values read later override ones read earlier

Application Configuration

Configuration API

- The configuration API provides the ability to read from the constructed collection of name-value pairs
- An object of type IConfiguration is available to be used via dependency injection

```
public class HomeController : ControllerBase
{
  public HomeController(IConfiguration configuration)
  {
    _emailServer = configuration["EmailServer"];
  }
}
```

Application Configuration

Configuration API

- Hierarchical data is read as a single key with components separated by a colon

```
{
  "Email": {
    "Server": "gmail.com",
    "Username": "admin"
  }
}
```

```
public class HomeController
{
  public HomeController(IConfiguration configuration)
  {
    _emailServer = configuration["Email:Server"];
  }
}
```

Application Configuration

Options Pattern

- The options pattern can be used to provide configuration information to other components within your application as strongly-typed objects via dependency injection

```
public class EmailOptions
{
  public string Server { get; set; }
  public string Username { get; set; }
}
```

```
builder.Services.Configure<EmailOptions>(Configuration.GetSection("Email"));
```

```
public HomeController(IOptions<EmailOptions> emailOptions)
{
  _emailOptions = emailOptions;
}
```

Microservice Architecture with ASP.NET Core

Controllers

- Responsibilities
- Requirements and Conventions
- Dependencies
- Action Results
- Model Binding

Controllers

Responsibilities

- The action executed for a particular endpoint is typically a method of a controller
- A controller may need to retrieve or make modifications to model data
- The controller also determines the appropriate type of response to return
    - HTML, JSON, XML, redirection, error, etc.

Controllers

Responsibilities

- Controller methods that are reachable via the routing system are referred to as controller actions
- Any public method of a controller can be an action if a valid route to that action exists

Controllers

Requirements and Conventions

- For a class to act as a controller, it must…
  - Be defined as public
  - Have a name that ends with Controller or inherit from a class with a name that ends with Controller
- Common conventions (not requirements) are...
  - Place all controllers in a root-level folder named Controllers
  - Inherit from a system class called Controller (or its subclass ControllerBase for an API)
    - Provides many helpful properties and methods

Controllers

Dependencies

- It is a recommended best practice for controllers to follow the Explicit Dependencies Principle
- Specify required dependencies via constructor parameters that can be supplied via dependency injection

```
public class HomeController : Controller
{
  private IEmailSender _emailSender;

  public HomeController(IEmailSender es) {
    _emailSender = es;
  }
}
```

Controllers

Action Results

- ActionResult<T> enables returning a type derived from ActionResult or a specific type
- Framework uses the ExecuteResultAsync when creating the HTTP response

```
public ActionResult<Product> GetProduct(int id)
{
  var product = _repository.GetProduct(id);
  if (product == null) return NotFound();
  return product;
}
```

- Writing directly to the response should be avoided
  - Adds a dependency to the HTTP context
  - Make things like unit testing more difficult

Controllers

Action Results

- The base class Controller provides helper methods to generate various types of results
  - View `return View(customer);`
  - Serialized object `return Json(customer);`
  - HTTP status code `return NotFound();`
  - Raw content `return Content("Hello");`
  - Contents of a file `return File(bytes);`
  - Several forms of redirection
    - Redirect, RedirectToRoute, RedirectToAction, …
  - And more...

Controllers

Asynchronous Controller Actions

- It is common for a controller action to invoke an asynchronous method to perform an IO-bound operation
  - Database access, web service call, etc.
- The action should be marked as async with a return type of Task<T> and await used with the asynchronous method

```
public async Task<IEnumerable<Product>> Index()
{
  var products = await _repository.GetAllProducts();
  return products;
}
```

Controllers

Asynchronous Controller Actions

- Making an action asynchronous does not change the experience for the client
  - No response is sent until the entire action is complete
- Can improve application scalability by allowing the thread pool thread to handle other incoming requests while waiting for the IO-bound operation to complete
- It is also possible to accept a CancellationToken that can be used to handle the cancellation of a long-running request

```
public async Task<IEnumerable<Product>> Index(CancellationToken token)
{
  var products = await _repository.GetAllProducts(token);
  return products;
}
```

Controllers

Model Binding

- When an action is invoked, the model binding system attempts to populate the parameters of the action with values in the request
  - Body values
  - Route value
  - Query strings
- Items above are listed in priority order (i.e., body values will take precedence over other values)

Controllers

Model Binding

- If an action accepts an object parameter, the model binding system will create an instance of that type and attempt to populate its public properties with values from the request
- If validation errors occur during the model binding process, the IsValid property of the ModelState property will return false

```
public ActionResult Edit(ProductViewModel vm)
{
  if (ModelState.IsValid) { ... }
  ...
}
```

Controllers

Model Binding

- It is important to ensure the model binding system does not alter values that you do not intend to be modified
  - Can lead to a security vulnerability known as over-posting
- Attributes can be used to define properties that should not participate in model binding

```
[BindNever]
public int EmployeeId { get; set; }
```

- Alternatively, use a DTO that only includes properties that are intended to participate in model binding

Microservice Architecture with ASP.NET Core

Request Routing

- RESTful Services
- Endpoint Routing
- Route Attributes
- Route Templates
- Route Constraints
- Route Template Precedence

Request Routing

RESTful Services

- When configuring request routing, you should try to maintain a RESTful API
- Clean, extension-less URLs that identify resources
- Use of the correct HTTP verbs within an API
- Avoid query string parameters except for ancillary data that is related to the presentation of the information
    - Sorting key, current page number, etc.

Request Routing

Endpoint Routing

- Routing is responsible for mapping request URIs to endpoints and dispatching incoming requests to those endpoints
- Routing can also be used to generate URLs that map to endpoints
  - Eliminates hardcoded URLs that would need to be updated when the routing configuration changes

Request Routing

Endpoint Routing

- A collection of extension methods on ApplicationBuilder are available for adding different types of endpoints
  - All start with the word "Map"
- Verb-based methods make it easy to configure simple endpoints
  - MapGet, MapPost, MapPut, MapDelete, etc.
- MapControllers will configure and add an endpoint for each controller action defined in the application

Request Routing

Route Attributes

- If using controllers, attributes can be used to define the routing information used to construct the endpoints
- The Route attribute will create an endpoint for all HTTP verbs

```
[Route("products")]
public IActionResult AllProducts() { ... }
```

- Verb-specific attributes should be used to define an endpoint for a specific HTTP verb

```
[HttpGet("products")]
public IActionResult AllProducts() { ... }
```

Request Routing

Route Attributes

- A controller-level attribute can be used to specify a prefix for all the actions of the controller

```
[Route("[controller]")]
public class ProductController : Controller
{
  [HttpGet("{id}")]
  public IActionResult GetProduct(int id) { ... }
}
```

- In the example above, a request for a product would use a URL of https://example.com/product/6

Request Routing

Route Templates

- Tokens within curly braces define route value parameters which will be bound if the route is matched
  - You can define more than one route value parameter in a route segment, but they must be separated by a literal value

```
site/{name}/{id}
```

```
{language}-{region}/library/{topic}
```

🚫
```
{language}{region}/{topic}
```

Request Routing

Route Templates

- Route value parameters can have default values
  - The default value is used if no value is present in the URL for the parameter

```
products/{sort=price}
```

- Route value parameters may also be marked as optional
  - When bound to an action parameter, the value will be null (reference type) or zero (value type)

```
product/{id?}
```

Request Routing

Route Templates

- The catch-all parameter (identified using an asterisk) allows for a route to match a URL with an arbitrary number of parameters

```
query/{category}/{*path}
```

```
http://localhost/query/people/hr/managers
```

```
public IActionResult Query(string category, string path)
{
  // category = "people"
  // path = "hr/managers"
}
```

Request Routing

Route Constraints

- A route value parameter can include an inline constraint
- URLs that do not match the constraint are not considered a match
- Multiple constraints can be specified for one parameter

```
products/{id:int}
```

```
products/{id:range(100, 999)}
```

```
employees/{ssn:regex(d{3}-d{2}-d{4})}
```

```
products/{id:int:range(100, 999)}
```

Request Routing

Route Constraints (Partial List)

Constraint	Example Route	Example Match
int	{id:int}	123
bool	{active:bool}	true
datetime	{dob:datetime}	2016-01-01
guid	{id:guid}	7342570B-44E7-471C-A267-947DD2A35BF9
minlength(value)	{username:minlength(5)}	steve
length(min, max)	{filename:length(4, 16)}	Somefile.txt
min(value)	{age:min(18)}	19
max(value)	{age:max(120)}	91
range(min, max)	{age:range(18, 120)}	91
alpha	{name:alpha}	Steve
regex(expression)	{ssn:regex(d{3}-d{2}-d{4})}	123-45-6789

Request Routing

Route Constraints

- Route constraints should be used to help determine the route that should be used but should not be used for the validation of input values
- If a matching route is not found, the response from the server will be a 404 (resource not found)
- Invalid input should typically result in a different response (e.g., 400 with an appropriate error message)

Request Routing

Route Template Precedence

- Each route template is assigned a value by the system based on how specific it is
- Literal segments are considered more specific than parameter segments

`/hello/customer` `/hello/{name}`

- A parameter segment with a constraint is considered more specific than one without a constraint
- The Order property of an endpoint can be used to override the default precedence behavior
- If a request matches multiple endpoints with the same precedence, an AmbiguousMatchException is thrown at runtime

Microservice Architecture with ASP.NET Core

Web APIs

- API Controllers
- OpenAPI / Swagger
- Testing APIs
- Retrieval Operations
- Model Binding
- Update, Create, and Delete Operations
- Cross-Origin Request Sharing (CORS)

Web APIs

API Controllers

- ASP.NET Core includes a class named ControllerBase
  - Includes many properties and methods for handling HTTP requests
- The Controller class inherits from ControllerBase and adds support for views
- If creating a controller that does not have any views, you should inherit directly from ControllerBase

Web APIs

API Controllers

- An API controller should be decorated with the ApiController attribute

```
[ApiController]
public class ProductApiController : ControllerBase
```

  - Automatic HTTP 400 responses for validation failures
  - Problem details for error status codes

Web APIs

OpenAPI / Swagger

- OpenAPI is a specification for describing REST APIs
- Swagger is a collection of tools that work with OpenAPI
  - SwaggerDocument objects expose data about the API in JSON format (openapi.json)
  - Swagger UI is a dynamically generated web-based UI that can be used to view and test API methods

Web APIs

OpenAPI / Swagger

- By default, the API project templates include a reference to Swashbuckle.AspNetCore
- SwaggerDocument generation is handled by a service

```
services.AddSwaggerGen();
```

- Document availability and Swagger UI is configured via middleware components

```
app.UseSwagger();
app.UseSwaggerUI();
```

Web APIs

OpenAPI / Swagger

- The ProducesResponseType attribute should be used when defining Web API actions

```
[HttpPost]
[ProducesResponseType(StatusCodes.Status201Created)]
[ProducesResponseType(StatusCodes.Status400BadRequest)]
public ActionResult<Product> Create(Product product)
```

- Used by tools like Swagger to generate more descriptive documentation

Web APIs

OpenAPI / Swagger

- Actions (or entire controllers) can be omitted from the Swagger document generation process by using the ApiExplorerSettings attribute

```
[ApiExplorerSettings(IgnoreApi = true)]
public class ErrorController : Controller
```

Web APIs

Testing APIs

- API endpoints that are exposed via GET are easy to test using a web browser
- For other verbs, it can be helpful to have a tool that can be used to craft custom HTTP requests
  - Postman application is very popular (getpostman.com)
  - Many other options are available

Web APIs

Testing APIs

- Microsoft introduced a new tool called the HTTP REPL

```
dotnet tool install -g Microsoft.dotnet-httprepl
```

- Command-line tool for making HTTP requests
- Supports most of the HTTP verbs
- Can use Swagger documents to discover the endpoints

```
> https://localhot:5001/~ ls

Products   [get|post]
Customers  [get|post]
```

docs.microsoft.com/en-us/aspnet/core/web-api/http-repl

Web APIs

Retrieval Operations

- In a Web API, retrieval operations are performed with an HTTP GET request
- If successful, the response should use an HTTP 200 status code

Web APIs

Retrieval Operations

- There are several options available for altering the format of the JSON returned
  - Attributes
  - Custom formatter
  - Data projection

```
[JsonPropertyName("price")]
public double UnitPrice { get; set; }
```

```
public async Task<ActionResult> GetProduct(int id)
{
  var product = await _repository.GetProduct(id, true);
  if (product == null) return NotFound();
  var retVal = new {
    Id = product.Id, Name = product.ProductName,
    Price = product.UnitPrice,
    Supplier = product.Supplier.CompanyName
  };
  return Ok(retVal);
}
```

Web APIs

Create Operations

- In a Web API, create operations are performed with an HTTP POST request
- If successful, the response should use an HTTP 201 (created) status code with a Location header set to the URI of the newly created resource
- The CreatedAtAction and CreatedAtRoute methods can be used to generate a correctly formatted response

```
return CreatedAtAction("GetProduct", new { id = product.Id }, product);
```

Web APIs

Delete Operations

- In a Web API, delete operations are performed with an HTTP DELETE request
- If successful, the response should use an HTTP 204 (no content) status code

```
return new NoContentResult();
```

Web APIs

Update Operations

- In a Web API, update operations are performed with…
  - HTTP PUT – Replaces an existing resource
  - HTTP PATCH – Modifies part of an existing resource
- If successful, the response should be HTTP 204 (no content)

```
public async Task<ActionResult> PutProduct(int id, Product product)
{
  if (id != product.Id) return BadRequest();

  var existingProduct = await _repository.GetProduct(id);
  if (existingProduct == null) return NotFound();

  await _repository.SaveProduct(product);
  return NoContent();
}
```

Web APIs

Cross-Origin Resource Sharing (CORS)

- Browser security prevents a web page from making Ajax requests to another domain
- CORS is a W3C standard that allows a server to relax this policy
- A server can explicitly allow some cross-origin requests
- CORS is configured in ASP.NET Core via a service and middleware

```
builder.Services.AddCors(options => {
    options.AddPolicy("MyCorsPolicy",
        policy => {
            policy.WithOrigins("https://myapp.com");
        });
});
```

```
app.UseCors("MyCorsPolicy");
```

Microservice Architecture with ASP.NET Core

Data Validation

- Introduction
- Data Annotations
- Model Binding
- IValidatableObject

Data Validation

Introduction

- Whenever any data from the client is being used to perform an action, it is important to have data validation in place
  - Don't skip validation for hidden form fields, HTTP header values, cookies, etc. (all are easy to modify)
- Client-side validation provides a good user experience and improved application scalability (less trips to the server)
- Server-side validation must also be provided
  - Client-side validation is easy to circumvent or may not be supported on the client

Data Validation

Data Annotations

- A variety of data annotations can be added to the model (or view model) that is sent to a view
- Data annotations are used during model binding to perform server-side validation

```
public class ProductEditViewModel
{
  [Required]
  public string ProductName { get; set; }
```

Data Validation

Data Annotations

Attribute	Purpose
[Required]	Property value is required (cannot allow nulls)
[StringLength]	Specifies a maximum length for a string property
[Range]	Property value must fall within the given range
[RegularExpression]	Property value must match the specified expression
[Compare]	Property value must match the value of another property
[EmailAddress]	Property value must match the format of an email address
[Phone]	Property value must match the format of a phone number
[Url]	Property value must match the format of a URL
[CreditCard]	Property value must match the format of a credit card number

Data Validation

Model Binding

- If a value is considered to be invalid, an error is added to ModelState and ModelState.IsValid will return false
- ModelState is also used by the helpers in the view when returning a view after a server-side validation error

Data Validation

IValidatableObject

- For custom server-side validation, you can implement the IValidatableObject interface for the type being populated by the model binder
- Any errors returned are automatically added to ModelState by the model binder

```
public IEnumerable<ValidationResult> Validate(ValidationContext
                                              validationContext)
{
  var retVal = new List<ValidationResult>();
  if (BirthDate > HireDate) {
    retVal.Add(new ValidationResult("Employee cannot be
                                    hired before they were born"));
  }
  return retVal;
}
```

Microservice Architecture with ASP.NET Core

Error Handling

- Best Practices
- HTTP Error Status Codes

Error Handling

Best Practices

- Handle errors as best you can when they occur
- Record the error information and/or send a notification
- Provide the user with an appropriate response
  - Do not reveal information that a malicious user could potentially use against you (e.g., database schema information)
  - Give the user some options (e.g., link to visit the home page in the case of a 404)
  - Use static content whenever possible to avoid an error page that itself produces an error

Error Handling

HTTP Error Status Codes

- The HTTP protocol defines a range of status codes that signify an error
  - 4xx = client error (not found, bad request)
  - 5xx = server error
- It is a best practice to define an appropriate customized response that will be returned to the client in these cases

Microservice Architecture with ASP.NET Core

Logging

- Introduction
- Configuration
- ILogger
- Serilog and Seq

Logging

Introduction

- Just as important as error handling is the ability to record information about events that occur
- Logging of error information is essential for tracking down an issue that occurs in production
- It is sometimes helpful to record information about events that are not errors
  - Performance metrics
  - Authentication audit logs

Logging

Introduction

- ASP.NET Core has a logging API that works with a variety of logging providers
- Built-in providers allow you to log to the console and the Visual Studio Debug window
- Other 3rd-party logging frameworks can be used to provide many other logging options
  - Serilog
  - NLog
  - Log4Net
  - Loggr
  - elmah.io

Logging

ILogger

- Any component that wants to use logging can request an ILogger<T> as a dependency

```
public class ProductController : Controller
{
  public ProductController(IRepository repository,
    ILogger<ProductController> logger) { }
}
```

Logging

ILogger

- ILogger defines a set of extension methods for different verbosity levels
  - Trace (most detailed)
  - Debug
  - Information
  - Warning
  - Error
  - Critical

```
_logger.LogInformation("About to save department {0}", id);
```

Logging

ILogger

- The highest verbosity level written to the log is typically set in appsettings

```
"Logging": {
  "LogLevel": {
    "Default": "Debug",
    "System": "Information",
    "Microsoft": "Information"
  }
}
```

Logging

Serilog

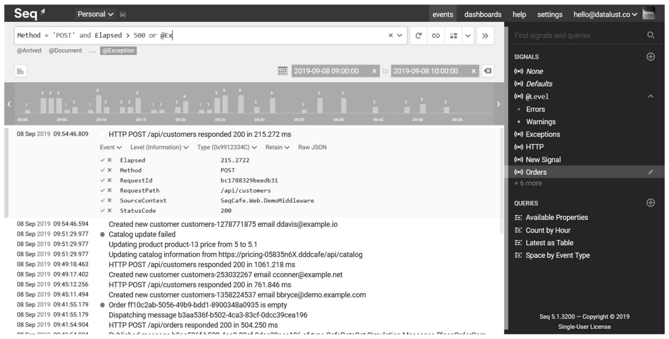
- Serilog has become a popular choice for ASP.NET Core
  - Wide variety of destinations and formats
  - Can record structured event data

github.com/serilog/serilog-aspnetcore

Logging

Seq

- In many ASP.NET Core applications, the log data needs to be off-host and centralized (e.g., load-balanced environment)
- Seq is an open-source server that can accept logs via HTTP
  - Integrates with .NET Core, Java, Node.js, Python, Ruby, Go, Docker, and more



```
Method = 'POST' and Elapsed > 500 or @Ex
```

2019-09-08 09:00:00 to 2019-09-08 10:00:00

```
08 Sep 2019  09:54:46.809    HTTP POST /api/customers responded 200 in 215.272 ms
                             Event   Level (Information)   Type (0x9912334C)   Retain   Raw JSON
                             Elapsed          215.2722
                             Method           POST
                             RequestId        bc1788329beedb31
                             RequestPath      /api/customers
                             SourceContext    SeqCafe.Web.DemoMiddleware
                             StatusCode       200
08 Sep 2019  09:54:46.594    Created new customer customers-1278771875 email ddavis@example.io
08 Sep 2019  09:51:29.977  ● Catalog update failed
08 Sep 2019  09:51:29.977    Updating product product-13 price from 5 to 5.1
08 Sep 2019  09:51:29.977    Updating catalog information from https://pricing-05835n6X.dddcafe/api/catalog
08 Sep 2019  09:49:18.463    HTTP POST /api/customers responded 200 in 1061.218 ms
08 Sep 2019  09:49:17.402    Created new customer customers-253032267 email cconner@example.net
08 Sep 2019  09:45:12.256    HTTP POST /api/customers responded 200 in 761.846 ms
08 Sep 2019  09:45:11.494    Created new customer customers-1358224537 email bbryce@demo.example.com
08 Sep 2019  09:41:55.179  ● Order ff10c2ab-5056-49b9-bdd1-8900348a0935 is empty
08 Sep 2019  09:41:55.179    Dispatching message b3aa536f-b502-4ca3-83cf-0dcc39cea196
08 Sep 2019  09:41:54.904    HTTP POST /api/orders responded 200 in 504.250 ms
```

Logging

Maintainability

- One important note is that the logging framework(s) you choose should not change how you write to the log (ILogger)
  - The only code that changes is in Program.cs

Microservice Architecture with ASP.NET Core

Microservice Architecture

- Introduction
- The Monolith
- Service Oriented Architecture
- Microservice Defined
- Service Boundaries
- Key Principals

Microservice Architecture

Introduction

- Building distributed systems is difficult
- Microservices can optimize for one kind of problem while making other parts of your system more complex
- A monolithic application on a single server will be simpler in many ways

Microservice Architecture

The Monolith

- Single process
- Single code base
- Shared database

Microservice Architecture

The Monolith

- A modular monolith can help with maintainability
- Well defined interfaces
- Unit tests

Microservice Architecture

The Monolith

- Where a modular monolith struggles is with scalability
- When the load on an application increases, the load tends to not be distributed evenly
- Scaling a monolith to handle more load can be difficult and wasteful
- Deployment coupling makes the system fragile
- Monoliths also make it difficult to scale a team of developers beyond a certain point

Microservice Architecture

Service Oriented Architecture

- Introduced as an architecture style in 1998
- First step toward breaking a monolith down into smaller pieces

Microservice Architecture

Service Oriented Architecture

- One service tends to be aligned with an entire business domain
  - Payment service, order service, inventory service, etc.
- All data exposed via service interfaces
- All communication via service calls over the network
- Presence of a network introduces additional complexity and failure points

Microservice Architecture

Service Oriented Architecture

- Presence of a network introduces additional complexity, latency, and failure points

Microservice Architecture

Microservices Defined

- An independently deployable unit that performs one job extremely well
- Interacts with other services via a clearly defined interface
- Done correctly, microservices can provide flexibility, scalability, and resilience
- Ideally, microservices should be able to evolve independently
  - Avoid breaking backward compatibility of interfaces

Microservice Architecture

Microservice Boundaries

- Defining microservice boundaries is a critical step in the design process
- Two tools are primarily used to help find boundaries
  - Domain Driven Design
  - Event Storming

Microservice Architecture

Event Storming

- Should involve technical and non-technical stakeholders
- Start with a list of all events that could occur
- For each…
  - Who triggered this event?
  - What command is given?
  - What action was taken?
  - What system is this part of?

Microservice Architecture

Key Principals

- Service Independence
  - Independently deployable and scalable
  - Can be developed and maintained by separate teams
- Decentralized Data
  - Each microservice should maintain and be in complete control of its own data store
  - Ensures loose coupling and autonomy

Microservice Architecture

Key Principals

- API Based Communication
  - Involves committing to a contract
  - Commonly REST APIs via HTTP
  - Can also use other mechanisms like gRPC or a message queue
- Resilience and Fault Tolerance
  - Microservices should be designed to handle failures gracefully

Microservice Architecture

Key Principals

- Scalability
  - Additional resources can be added to a single microservice
- Autonomous Teams
  - Enables faster development and innovation
  - Reduces blocking

Microservice Architecture with ASP.NET Core

Designing Microservices

- Coupling and Cohesion
- Sharing Data
- Synchronous Communication
- Asynchronous Communication
- Backward Compatibility
- Cross-Cutting Concerns
- Service Discovery

Designing Microservices

Coupling and Cohesion

- Coupling is the degree of interdependence between modules in your system
- Cohesion is the degree in which elements inside a module belong together
  - “Things that change together, live together”

Designing Microservices

Coupling and Cohesion

- A service boundary determines…
  - How your services interact
  - What they share
  - What they don't share
- If a change to one service requires changes to other services, you may have a distributed monolith

Designing Microservices

Sharing Data

- Each service owns its own data
- No services have direct access to the data of another
- Therefore, accessing shared data is typically the biggest area where coupling comes from

Designing Microservices

Sharing Data

- Information hiding is the principle of hiding as much data as possible behind a microservices boundary
- Data Transfer Objects (DTOs) are useful for providing an abstraction layer over the underlying data store
  - Allows the data schema to vary independently from the API

Designing Microservices

Synchronous Communication

- The most common form of communication between microservices is synchronous communication
  - For example, an HTTP request / response
- Immediate feedback for operation completion / failure
- Introduces runtime coupling
  - Service needs to know how to communicate with the external service
- Latency of external service adds to latency of the calling service
- Increases the chance of a cascading failure

Designing Microservices

Asynchronous Communication

- Allows a service to make a non-blocking call to another service
- Reducing runtime coupling
  - In a message-based architecture, the schema of a message is a dependency and an alternative form of runtime coupling
- Can add significant complexity
  - Operation status, completion, and timeouts
  - Eventual consistency

Designing Microservices

Eventual Consistency

- With asynchronous communication…
  - You cannot guarantee the state of another microservice
  - You need to handle failures differently
- Most microservice architectures end up including a mix of synchronous and asynchronous communication
- As a general best practice, start with asynchronous options and use synchronous communication when necessary

Designing Microservices

Backward Compatibility

- It is not possible to eliminate all forms of runtime coupling
- When changing an interface or message schema, always strive for maintaining backward compatibility
- You can offer alternate versions of a service

```
/api/v1/orders

/api/v2/orders
```

```
{
  "messageVersion": "v2",
  "messageType": "orderCreated"
  ...
}
```

- Should be used with care and with a process to eventually remove older versions

Designing Microservices

Cross-Cutting Concerns

- Code sharing among microservices should be minimized
- Resist the urge to apply the DRY principle to microservices for domain logic
- Common libraries should only be used for generic cross-cutting concerns (e.g., logging)
  - Multiple microservices running different versions of the shared library should not present an issue

Designing Microservices

Service Discovery

- Less of a problem for asynchronous communication
  - One central message bus or queue
- For synchronous communication, service A needs a way to know how to communicate with service B
- DNS provides a simple form of service discovery
- An API Gateway maps external requests onto internal services
  - Can terminate things like HTTPS and authentication

Microservice Architecture with ASP.NET Core

Integration Patterns

- Introduction
- Shared Data
- Request / Response
- Publish / Subscribe
- Point to Point
- Distributed Transactions
- API First Design

Integration Patterns

Introduction

- "It's not the boxes you need to worry about in microservices, it's the lines"
- You can facilitate the integration of microservices by using enterprise integration patterns

Integration Patterns

Shared Data

- A shared data integration involves an agreed upon data transfer format and a shared storage location
- Form of asynchronous integration
- Useful for integration between disparate legacy systems but other options should be considered first

Integration Patterns

Request / Response

- Most common integration pattern in distributed systems
- Includes RPC, REST, and GraphQL
- RPC based services provide better performance at the cost of interoperability and tighter coupling
- GraphQL is a query language and an API runtime that allows clients to request specific data from servers
  - Allows clients to specify the structure of the data returned

Integration Patterns

Publish / Subscribe

- Messaging pattern that decouples publishers and subscribers
  - Some coupling does still exist at the message schema level
- A single message type could have multiple publishers and multiple subscribers
- AWS SNS is an example
- Observability, sequencing, and durability can present challenges

Integration Patterns

Point to Point

- Asynchronous form of communication but is one-to-one
- Can be durable and enforce sequencing
- AWS SQS is an example

Integration Patterns

Distributed Transactions

- Most developers are familiar with performing multiple database operations in the context of a single transaction
- With multiple microservice in control of their own data, this practice becomes more challenging
- One solution is to use a two-phase commit
  - Can introduce blocking and limit scalability

Integration Patterns

Distributed Transactions

- Another approach is the Saga pattern
- Saga is a collection of individual tasks
- State of the Saga often managed by a separate microservice
- Compensation (rollback) logic handled by the microservices responsible for each individual task

Integration Patterns

API First Design

- When starting a new integration project, agree on the API first
  - Could include message schemas
- Different teams can develop based on the agreed upon contract
- Start with a short period of synchronous collaboration followed by independent development processes

Microservice Architecture with ASP.NET Core

Scale and Resilience

- Introduction
- Timeouts and Retries
- Circuit Breakers
- Bulkheads
- Idempotency
- Vertical vs. Horizontal Scaling
- Caching
- Chaos Engineering

Scale and Resilience

Introduction

- Resilience
  - Robustness – Ability to accommodate expected failures
  - Rebound – How quickly a system can recover from a failure
  - Graceful extensibility – Ability to react to things that aren't expected
  - Sustained adaptability – Ability to modify a system in response to new types of failures that are discovered

Scale and Resilience

Introduction

- How much failure is acceptable?
- Can your system still operate in a degraded state?
- How will failures be detected and responded to?

Scale and Resilience

Timeouts and Retries

- Base your timeouts and retries on your expected response times and latency
- Consider implementing an exponential backoff and possibly jitter

Scale and Resilience

Circuit Breakers

- Ensures a system can handle failures and maintain functionality in the presence of disruptions
  - Helps to prevent a cascading failure
- When a failure condition is detected, a circuit breaker can prevent additional calls to the failed component
- When a circuit breaker is "open", calling components can choose a different path or use cached data

Scale and Resilience

Bulkheads

- In a microservice architecture, a bulkhead another technique for preventing an issue from cascading through a system
- One common implementation is to place a request queue in front of a commonly used service
  - Can absorb an abnormal load
  - Can be monitored to trigger the deployment of additional resources

Scale and Resilience

Idempotency

- Means that performing the same action multiple times will have the same result as performing it just once
- Supports many of the other resiliency mechanisms
- Can be implemented with unique message IDs
    - Adding a time component can reduce overhead

Scale and Resilience

Vertical vs. Horizontal Scaling

- Vertical scaling involves adding more resources to an instance (vCPUs, RAM, etc.)
- Horizontal scaling involves adding more instances
    - More flexible and resilient but adds complexity

Scale and Resilience

Caching

- Can provide improved performance and resilience
- Useful when the resources used to retrieve the data from the cache are less than going directly to the source
- Useful for read heavy workloads and to support patterns such as circuit breaker
- System needs to be able to tolerate stale data

"There are only two hard things in Computer Science: cache invalidation and naming things" – Phil Karlton

Scale and Resilience

Chaos Engineering

- Proactively address potential failures by intentionally injecting controlled chaos
- Useful for testing both technical failure mechanisms as well as human response
- Netflix "chaos monkey" is an extreme example

Microservice Architecture with ASP.NET Core

Containerization

- dotnet publish
- Docker
- Orchestration
- Kubernetes

Containerization

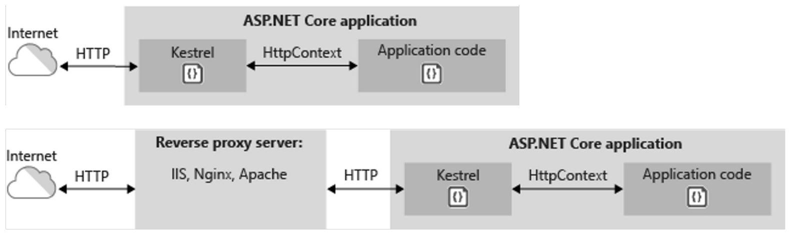
dotnet publish

- The dotnet publish command compiles an app and copies the files required for deployment into a publish folder
  - Used by Visual Studio's [Build > Publish] wizard
- When preforming a publish, the app can be…
  - Framework-dependent
    - Does not include the .NET runtime – correct version must already be present on the deployment machine
  - Self-contained
    - Does include the .NET runtime
    - Must choose the target architecture at publish time

Containerization

Kestrel

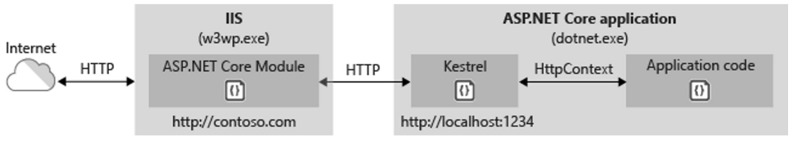
- The Kestrel web server is supported on all platforms where .NET is supported
- You can use Kestrel by itself or with a reverse proxy server



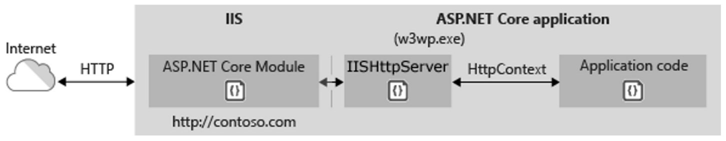
Containerization

IIS

- Out-of-process hosting



- In-process hosting



Containerization

Documentation

- There is extensive documentation for a wide variety of deployment scenarios
  - Apache httpd, Nginix, etc.

docs.microsoft.com/en-us/aspnet/core/host-and-deploy

Containerization

Docker

- Docker is an open platform that enables developers and administrators to build images, ship, and run applications in a loosely isolated environment called a container

www.docker.com

Containerization

Docker

- Developer – "Helps me to eliminate the 'works on my machine' problem"
  - Application is executed and debugged in the same container that is deployed to production
- Administrator – "Allows me to treat hardware instances less like 'pets' and more like 'cattle'"
  - Hardware resources come-and-go with minimal configuration requirements – just need the ability to run a container

Containerization

Docker

- The Docker platform uses the Docker engine to build and package apps as Docker images
- Docker images are created using files written in the Dockerfile format

Containerization

Docker

- Microsoft provides a collection of official images to act as the starting point for your own images
  - Have the .NET Core runtime pre-installed
  - Some have the .NET Core SDK installed and can be used as a build server
- Available on Docker Hub
  - hub.docker.com/_/microsoft-dotnet-sdk
  - hub.docker.com/_/microsoft-dotnet-aspnet

Containerization

Docker

- A container is a running instance of an image
- When running an ASP.NET Core application in a container, it is necessary to map the internal container port to a port on the host machine

```
docker run –d -p 80:80 ecomm/api
```

- The Microsoft images are preconfigured (via an environment variable) to run Kestrel on port 80
- Documentation has extensive information about configuring Kestrel (HTTPS, HTTP/2, host filtering, etc.)

Containerization

Docker

- Visual Studio supports building, running, and debugging containerized ASP.NET Core applications
  - Must have Docker for Windows installed
- You can enable Docker support when creating a project
- You can also add Docker support to an existing app by selecting [Add > Docker Support]

Containerization

Docker

- Docker containers can run on any machine with the Docker engine installed
- Both Amazon AWS and Microsoft Azure have extensive support for hosting containers
  - AWS EC2 Container Service and Container Registry
  - Azure Container Service and Container Registry

Containerization

Orchestration

- "Automatically provisions, deploys, scales, and manages containerized applications without worrying about the underlying infrastructure"
- Scheduling, Affinity, Health monitoring, Failover, Scaling, Networking, Service discovery, Coordinated application upgrades

Containerization

Orchestration

- Every major cloud provider offers options for container orchestration
  - AWS ECS / EKS
  - Azure AKS
- Some are custom while others are built around Kubernetes

Containerization

Kubernetes

- Open-source container orchestration tool
- Originally developed by Google
- Components include…
  - Pod – Abstraction of containers (wrapper)
  - Service – Provides communication and load balancing
  - Ingress – Routes traffic into a cluster
  - ConfigMap / Secret – External configuration
  - Volume – Data persistence
  - Deployment – Replication of pods

Containerization

Kubernetes

- Minikube can be used to run an entire cluster locally

Microservice Architecture with ASP.NET Core

Security

- Authentication
- Authorization
- Web API Authentication
- Secrets Management

Security

Authentication

- Authentication is the process of discovering the identity of an entity through an identifier and verifying the identity by validating the credentials provided by the entity
- It is common to validate the credentials once and generate a temporary unique token that is used to authorize other actions
  - The token can contain other information (claims) about the entity including group membership and privileges
  - Care must be taken to ensure the token is sent in a secure manner and the integrity of the token can be verified

Security

Authentication

- The authentication middleware is added by calling UseAuthentication in the Configure method
- If a request is not authenticated, authorization invokes a challenge using the default (or specified) authentication scheme
- Authentication challenge examples:
  - Redirection to a login page for a Web UI
  - 401 response with www-authentication: bearer header for a Web API

Security

Authorization

- The Authorize attribute can be used to authorize access to specific functionality
- Can be applied at the action or controller level
- If nothing else is specified, the attribute simply ensures the current user has been authenticated
- The AllowAnonymous attribute can be used to opt-out an action

```
[Authorize]
public class AdminController : Controller
{
  public IActionResult Dashboard() { ... }

  [AllowAnonymous]
  public IActionResult Login() { ... }
}
```

Security

Authorization

- With claims-based authorization, you can define a policy that specifies what claims must be present for a user to be authorized

```
services.AddAuthorization(options => {
  options.AddPolicy("AdminsOnly", policy =>
    policy.RequireClaim(ClaimTypes.Role, "Admin"));
});
```

- The Authorize attribute can then be used to enforce the policy

```
[Authorize(Policy="AdminsOnly")]
public IActionResult Dashboard() { ... }
```

Security

Authorization

- Programmatic authorization checks can also be performed within an action to enforce function-level access control

```
public IActionResult Delete(int id)
{
  if (User.HasClaim("SomeClaim")) {
    //
  }
}
```

```
public IActionResult Dashboard()
{
  foreach (var claim in User.Claims)
  {
    // decide what the user should see
  }
}
```

Security

Web API Authentication

- For API authentication, cookie-based authentication is typically not used, and it is not possible to directly present a UI to gather credentials
- In some scenarios, a simple form of authentication where the credentials are passed with each request is sufficient
  - HTTP Basic
  - Pre-shared key (PSK) authentication
- In a microservice architecture, an API Gateway can be used to perform authentication and proxy requests to other services

Security

Web API Authentication

- A modern flexible approach to API authentication is to use bearer token authentication
  - ASP.NET Core supports OAuth 2.0 and OpenID Connect

```
services.AddAuthentication(options => {
  options.DefaultAuthenticateScheme = AspNetCore.Authentication
    .JwtBearer.JwtBearerDefaults.AuthenticationScheme;

  options.DefaultChallengeScheme = AspNetCore.Authentication
    .JwtBearer.JwtBearerDefaults.AuthenticationScheme;
})
  .AddJwtBearer(options => {
    options.Authority = identityUrl;
    options.Audience = "EComm";
  });
```

Security

Web API Authentication

- Authority property is the address of the token-issuing authentication server
  - Used by the middleware to obtain the public key for validation of the token signature
- Audience property represents the resource the token grants access to
  - Value must match the parameter in the token

Security

Web API Authentication

- The token issuing server can be an external identity provider (Facebook, Twitter, Microsoft, etc.) or you can create your own using ASP.NET Core
- If issuing your own security tokens, it is recommended to use a third-party library to handle many of the security-related details
  - IdentityServer4
  - OpenIddict

Security

Web API Authentication

- It is also possible to create a custom authentication scheme / handler
  - Can create a subclass AuthenticationHandler and override HandleAuthenticateAsync
- When developing a custom authentication scheme, extreme care should be taken to ensure security vulnerabilities are not introduced

Security

Secrets Management

- Secrets are configuration values that are in some way sensitive
  - Connection strings
  - API keys
- It is a good practice for secrets not to be in source code or config files (things that end up in source control)
- Secrets should be made available to the production environment through a controlled means
  - Environment variables
  - Azure Key Vault
  - AWS Secrets Manager

Security

Secrets Management

- For local development, the Secret Manager tool can be used
- Secrets are stored in a JSON configuration file in a system-protected user profile folder on the local machine
- Use the init command or select Manage User Secrets in Visual Studio to enable user secrets for a project

```
dotnet user-secrets init
```

  - Adds an entry into the project file

```
<PropertyGroup>
  <TargetFramework>netcoreapp3.1</TargetFramework>
  <UserSecretsId>79a3edd0-2092-40a2-a04d-dcb46d5ca9ed</UserSecretsId>
</PropertyGroup>
```

Security

Secrets Management

- Secrets can be added via the command-line or by using the Manage User Secrets command in Visual Studio

```
dotnet user-secrets set "Movies:ServiceApiKey" "12345"
```

- CreateDefaultBuilder calls AddUserSecrets when the EnvironmentName is Development