

advanced mvvm using contoso cookbook

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Introduction

Modern desktop and mobile applications demand clean, maintainable codebases that can evolve quickly as business requirements change. The Model–View–ViewModel (MVVM) architectural pattern has become the go to solution for developers working with technologies such as WPF, Xamarin.Forms, and .NET MAUI. While the fundamentals of MVVM are well documented, truly advanced implementations require a deeper understanding of patterns, best practices, and real world recipes that can be applied to complex scenarios.

In this article we dive into **advanced MVVM using the Contoso Cookbook**, a curated set of patterns, code snippets, and architectural guidelines that help teams move beyond the basics. We'll explore how to structure projects for testability, how to harness dependency injection, how to manage state across multiple views, and how to incorporate modern tooling such as source generators and reactive extensions. Whether you're a seasoned MVVM practitioner or a developer looking to elevate your application architecture, this guide will provide actionable insights and concrete examples.

Why Advanced MVVM Matters

At its core, MVVM separates concerns: the *Model* holds data, the *View* renders UI, and the *ViewModel* acts as the glue that binds them together. This separation brings many benefits—testability, reusability, and a cleaner codebase. However, as applications grow, the naive implementation of MVVM can become brittle:

- Large ViewModels that try to manage too many responsibilities.
- Hard to test code due to tight coupling between services and UI components.
- Inconsistent data binding patterns that lead to subtle bugs.
- Performance bottlenecks when handling large data sets or complex UI interactions.

The Contoso Cookbook addresses these pain points by offering a library of proven solutions—think of it as a recipe book for seasoned developers. Each “recipe” tackles a specific challenge, providing clear guidance on design decisions, code structure, and best practices.

Project Structure for Advanced MVVM

Before we jump into code, let's establish a project structure that scales. The Contoso Cookbook recommends a multi layered architecture that separates concerns while keeping dependencies minimal.

Solution Overview

1. Core – Contains domain entities, interfaces, and business logic.
2. Infrastructure – Implements persistence, networking, and platform specific services.
3. Presentation – Houses Views, ViewModels, and UI specific helpers.
4. App – The entry point, responsible for configuring services and navigation.

By keeping the Core layer free of UI dependencies, we make it trivially testable. The Infrastructure layer can be swapped for mocks or stubs during unit tests, and the Presentation layer can be composed of lightweight ViewModels that expose only the data needed by the View.

Using Dependency Injection

Dependency injection (DI) is the backbone of advanced MVVM. It decouples ViewModels from concrete implementations of services, enabling easier testing and maintenance. In .NET, the Microsoft.Extensions.DependencyInjection package is a common choice. Below is a simplified registration snippet:

```
public static void ConfigureServices(IServiceCollection services)
{
    // Core services
    services.AddTransient();
    services.AddTransient();

    // Infrastructure services
    services.AddHttpClient();
    services.AddSingleton();

    // ViewModels
    services.AddTransient();
    services.AddTransient();

    // Navigation
    services.AddSingleton();
}
```

Notice how each ViewModel is registered as Transient, ensuring a fresh instance per navigation. This pattern aligns with the Contoso Cookbook's recommendation to keep ViewModels stateless where possible.

Building Robust ViewModels

Advanced MVVM places a strong emphasis on ViewModel design. A well-crafted ViewModel not only exposes data but also encapsulates behavior, state, and validation logic.

Commanding with Reactive Extensions

Commands are the primary way Views invoke actions on ViewModels. While ICommand is straightforward, combining it with Reactive Extensions (Rx) unlocks powerful features such as debouncing, throttling, and composition. Here's a concise example using ReactiveUI:

```
public class SearchViewModel : ReactiveObject
{
    private readonly IUserRepository _userRepo;
    private readonly ObservableAsPropertyHelper<IList<User>>, _searchResults;

    public SearchViewModel(IUserRepository userRepo)
    {
        _userRepo = userRepo;
    }
}
```

```

var searchTextChanged = this
    .WhenAnyValue(x => x.SearchText)
    .Throttle(TimeSpan.FromMilliseconds(300))
    .DistinctUntilChanged()
    .SelectMany(SearchUsers);

_searchResults = searchTextChanged
    .ToProperty(this, x => x.SearchResults);

SearchCommand = ReactiveCommand.CreateFromTask(SearchAsync);
}

public string SearchText { get; set; }

public IList<User> SearchResults => _searchResults.Value;

public ReactiveCommand<Unit, Unit> SearchCommand { get; }

private async Task SearchAsync()
{
    // Implementation omitted for brevity
}

private IObservable<IList<User>> SearchUsers(string query)
    => _userRepo.SearchAsync(query).ToObservable();
}

```

This pattern ensures that the UI remains responsive even when the user types quickly. The Contoso Cookbook suggests wrapping such reactive logic in a base ViewModel to promote reuse.

State Management with Immutable Models

Mutable ViewModels can become a source of bugs when multiple components try to update the same property. The Contoso Cookbook encourages the use of immutable models and functional updates. Consider a shopping cart scenario:

```

public record CartItem(Guid ProductId, string Name, decimal Price, int Quantity);

public class CartViewModel : ReactiveObject
{
    private readonly ObservableAsPropertyHelper<IReadOnlyList<CartItem>> _cart;

    public CartViewModel()
    {
        _cart = this

```

```

        .WhenAnyValue(x => x.Items)
        .ToProperty(this, x => x.Cart);
    }

    public IReadOnlyList<CartItem> Cart => _cart.Value;

    private IList<CartItem> Items { get; set; } = new List<CartItem>();

    public void AddItem(CartItem item)
    {
        Items = Items.Append(item).ToList();
        this.RaisePropertyChanged(nameof(Cart));
    }

    public void RemoveItem(Guid productId)
    {
        Items = Items.Where(i => i.ProductId != productId).ToList();
        this.RaisePropertyChanged(nameof(Cart));
    }
}

```

By treating the cart as an immutable list, we avoid accidental side effects and make the ViewModel easier to test.

Validation with Fluent Validation

Form validation can quickly become messy. The Contoso Cookbook recommends integrating FluentValidation to separate validation rules from ViewModels. A sample validator for a registration form looks like this:

```

public class RegisterUserValidator : AbstractValidator<RegisterUserViewModel>
{
    public RegisterUserValidator()
    {
        RuleFor(x => x.Email)
            .NotEmpty()
            .EmailAddress()
            .WithMessage("Enter a valid email address.");

        RuleFor(x => x.Password)
            .MinimumLength(8)
            .WithMessage("Password must be at least 8 characters long.");

        RuleFor(x => x.ConfirmPassword)
            .Equal(x => x.Password)
            .WithMessage("Passwords must match.");
    }
}

```

```
}
```

In the ViewModel, you can invoke the validator and expose error messages to the View, keeping the UI layer free of business logic.

Unit Testing ViewModels

Testing is a cornerstone of advanced MVVM. A well tested ViewModel guarantees that changes in business logic do not break the UI. The Contoso Cookbook outlines a testing workflow that leverages mocks, stubs, and the Moq library.

Mocking Dependencies

Using Moq you can create lightweight substitutes for services. Here's how you might test the LoginViewModel:

```
public class LoginViewModelTests
{
    private readonly Mock<IAuthService> _authServiceMock;
    private readonly LoginViewModel _viewModel;

    public LoginViewModelTests()
    {
        _authServiceMock = new Mock<IAuthService>();
        _viewModel = new LoginViewModel(_authServiceMock.Object);
    }

    [Fact]
    public async Task Login_WithValidCredentials_SetsIsAuthenticatedTrue()
    {
        // Arrange
        _authServiceMock
            .Setup(x => x.LoginAsync(It.IsAny<string>, It.IsAny<string>))
            .ReturnsAsync(true);

        // Act
        await _viewModel.LoginCommand.ExecuteAsync();

        // Assert
        Assert.True(_viewModel.IsAuthenticated);
    }
}
```

Notice the clear separation between the ViewModel's responsibilities and the mocked authentication service. This approach aligns with the Contoso Cookbook's emphasis on testable code.

Testing Reactive Commands

When using ReactiveUI, you can test commands by subscribing to their execution observables. The following example demonstrates how to verify that the SearchCommand triggers a repository call:

```
public class SearchViewModelTests
{
    [Fact]
    public async Task SearchCommand_Executes_SearchAsync()
    {
        var repoMock = new Mock<IUserRepository>();
        var viewModel = new SearchViewModel(repoMock.Object);

        await viewModel.SearchCommand.ExecuteAsync();

        repoMock.Verify(r => r.SearchAsync(It.IsAny<string>()), Times.Once);
    }
}
```

By asserting on the mock, we confirm that the ViewModel interacts with its dependencies correctly.

Navigation and Routing

Modern applications often require complex navigation flows. The Contoso Cookbook suggests using a dedicated navigation service that abstracts platform specifics and allows for clean navigation logic.

Navigation Service Design

A simple navigation service might look like this:

```
public interface INavigationService
{
    Task NavigateAsync<TViewModel>(object parameter = null);
    Task GoBackAsync();
}

public class NavigationService : INavigationService
{
    private readonly IServiceProvider _serviceProvider;

    public NavigationService(IServiceProvider serviceProvider)
    {
        _serviceProvider = serviceProvider;
    }

    public Task NavigateAsync<TViewModel>(object parameter = null)
    {

```

```

        var viewModel = _serviceProvider.GetRequiredService<TViewModel>();
        // Resolve the corresponding view and set its DataContext
        // Platform-specific navigation logic omitted for brevity
        return Task.CompletedTask;
    }

    public Task GoBackAsync()
    {
        // Platform-specific back navigation
        return Task.CompletedTask;
    }
}

```

By injecting the navigation service into ViewModels, we avoid hard coded navigation logic and make unit tests straightforward.

Deep Linking and Parameter Passing

For applications that need to support deep links or passing complex parameters, the navigation service can accept a dictionary or a strongly typed object. The Contoso

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