**Naked Functions**

**Application Developer Manual**

**[under construction]**

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# Introduction

## What is Naked Functions?

Naked Functions is a framework for developing enterprise-scale business applications for the .NET platform, using Microsoft’s Entity Framework Core to manage persistence on a relational database.

Naked Functions is different from most other .NET application development frameworks in two major respects:

1. All your application domain code, typically written in C#, follows a *pure* ‘functional programming’ patterns.
2. You do not need to write any user interface code at all: Naked Functions comes with a generic user interface that makes all the data and functionality of your application available to the user automatically. It is possible to customise this generic UI, which is written in TypeScript using the Angular framework and following standard Angular patterns, to any extent that you wish – however, you might be surprised by the effectiveness of the generic UI without any customisation at all.

Expanding on the first of these points, Functional programming (FP) means building programs from pure, side-effect free functions. While there are programming languages purpose-designed to support FP – such as Haskell, or F# – it is also possible to adopt a pure FP approach in ‘mixed-paradigm’ programming langages such as C#. The benefits of FP include:

* Testability. Because the result returned by a pure function depends only upon the arguments passed into it, and because the function generates no side-effects, automated tests are easier to write and more effective.
* Provability. If functions A and B are pure, side-effect free functions, and both A and B are correct, then any combination of A and B is also correct. This is not true when combining functions and methods that do not adopt this pure approach.
* Parallelism. Functionality written using the pure FP approach is much easier to parallelise for performance and scaleability.

However, there is a fundamental conundrum in FP, elegantly articulated by Simon Peyton Jones, one of the leading lights in the world of FP:

*‘The whole point of running a program is to have some side effect’ ­*  – whether this means writing to the database, sending an email, or even just displaying data on a screen.

The solution to this conundrum – expressed in non-technical terms – is that any real system will include both pure functions, which transform data, and ‘dirty’ functions that handle the input-output. Dirty functions may invoke pure functions, but not vice versa: if a pure function were to call a dirty function, then it becomes a dirty function itself. The traditional objective is to keep the dirty functions to an absolute minimum, but this is easier said than done. This is one of the reasons why, while FP is now widely adopted in the world of mathematical and scientific programming, it has made very little impact on traditional enterprise business applications, where there is typically far more code devoted to input/output than to pure computation.

Naked Functions addresses this challenge in a unique way: you *only* write pure functions, because all of the input/output (i.e. all of the interaction with the user, and the database) is handled by the framework, invisible to the application programmer. And, critically, your application functionality *never* makes calls into Naked Functions framework; it is the framework that makes calls into your application functions. The best way to understand how this is even possible is to look at a simple example.

## Starting from the Naked Functions Template solution

The Naked Functions Template provides a very simple application example than might be considered as a start point for building a full-scale enterprise application: it contains only a single record type – Student.

But don’t be fooled into thinking that Naked Functions is intended for the kind of simple applications you could have built using Microsoft Access! Naked Functions is designed specifically for building large-scale, highly-complex enterprise applications that may involve literally thousands of record types and millions of instances (corresponding to rows in the database), and with tens of thousands of functions defining business logic. It has been developed by the same team that designed the proven Naked Objects framework which has been in continuouos development for more than 20 years, and which has been deployed at very large scale. Naked Functions has some similarities to Naked Objects. The two frameworks share a common core and a common client, but adopt radically different application programming approaches: the former adopting pure object-oriented programming, and the latter adopting pure functional programming.

You can find the template solutions here:

<https://github.com/NakedObjectsGroup/NakedObjectsFramework/tree/master/Template>

You will need to download two separate solutions from within this directory:

* The Naked Functions solution (note that there is also a Naked Objects Server within the same main directory – but we won’t be using this here).
* The SPA Client (SPA = ‘Single Page Application’)

To use these template solutions you will need Visual Studio 2019 or later, set up to work (initially) with the SQL Server LocalDb, which is a common start-point for prototyping applications using Entity Framework Core (you can switch to full SQL Server, or another compatible database at a later point).

Open the Template.Server.Sln in Visual Studio and run it. If your Visual Studio is set up correctly, then after a short delay – during which Entity Framework Core is creating and populating the initial version of the database – you should see a browser open on http://localhost:5000/ (we recommend using Chrome as the default) showing a page of JSON something like this:



If your browser does not have a JSON viewer installed, the result might be unformatted and harder to read, but this is not important: *you do not need to read or navigate this view, and it it is never seen by a real user in a deployed application .* This is just a direct view of the RESTful API that is generated by the Naked Functions framework based on the application model.

Now, *in a separate instance of Visual Studio*, open and run the Template.Client.Sln, which should launch another browser instance, this time on http://localhost:5001/, showing the Home screen of the generic SPA client. Once the client and server have connected – there might be a short delay here – the Home screen will display a ‘main menu’ called Students, providing actions for retrieving existing records and creating new ones.

Click on the Students menu (a real application will usually have multiple such menus side by side), then the All Students action, and from the returned list (of just three students) click on the first one, to view the very simple record for student Alie Algol:

Graphical user interface

Description automatically generated with medium confidence

There’s not much to explore here, yet, but try the following. Use the ‘back’ icon at the bottom of the screen (you may use the browser’s back button, here, but it is safer to user the icon) to return to the list of students. This time *right-click* on a Student and see what difference that makes. Then explore the other generic icons at the bottom of the screen.

Note that the student record has an Actions button, but this is greyed out because we don’t yet have any actions (functions) that may applied to a specific student, for example to update the record or generate an instance of another type of record related to this one (a TestScore, for example). The Reload button is like a safe version of ‘refresh’ but it is useful only when you might have multipler users updating the same data.

Let’s now explore the structure of this tiny application.

The server solution comprises two projects.

The Template.Model project holds all the application code. Importantly, it does *not* depend upon the Naked Functions framework. It does have a reference to the NakedFunctions.ProgrammingModel NuGet package, but this largely consists of attributes, plus a few interfaces. (In a more substantial application, the application model might be spread across multiple model projects.)

This model defines the Student type. For further information see Defining domain types.

The actions rendered on the Students menu are defned as pure functions, here:

[Named("Students")]

public static class Student\_MenuFunctions

{

public static (Student, IContext) CreateNewStudent(string fullName, IContext context)

{

var s = new Student { FullName = fullName };

return (s, context.WithNew(s));

}

public static IQueryable<Student> AllStudents(IContext context) =>

context.Instances<Student>();

public static IQueryable<Student> FindStudentByName(string name, IContext context) =>

context.Instances<Student>().Where(c => c.FullName.ToUpper().Contains(name.ToUpper()));

public static Student FindStudentById(int id, IContext context) =>

context.Instances<Student>().FirstOrDefault(c => c.Id == id);

}

Notes:

* All functions recognised by Naked Functions are static, and should be defined on static classes.
* By default actions seen by the user are formatted versions of the names of the functions, and the menu name is a formatted version of the name of the static class. Either may optionally be overridden using the Named attribute.
* The retrieval functions return either a single instance (e.g. FindStudentById) or some collection of a specified record type. If the type is specified as an IQueryable<T> (e.g. AllStudents), and the database has many matching records, then the results will be presented to the user in pages, automatically.
* All these menu functions take a parameter of type IContext. When the user invokes the action, Naked Functions will automatically pass in an implementation of IContext. This provides access to instances of any specified record type, to which LINQ may be applied. As you might guess, the context is acting as a wrapper onto the DbContext class, but it has other capabilities.
* If a function takes other parameters besides the IContext, then invoking it via the UI will display a dialog, providing fields for each parameter (except the IContext).
* The CreateNewStudent function returns a tuple. The first item in the tuple (a Student) will be displayed to the user. The second item (an IContext) alerts NakedFunctions that there are new and/or updated records that must be written to the database. The IContext itself is deliberately *immutable*, but the WithNew method will return a new copy of the original context, containing the newly created instance. Importantly, *the* CreateNewStudent *function does not update the database*. Rather, once the CreateNewStudent function has completed, NakedFunctions will handle the persistence of any new or updated objects to the database. The CreateNewStudent function is *pure* (it depends only on arguments passed in as parameters) and *side-effect free* – it returns new instances but does not mutate any existing instances or other aspects of the system.

The ExampleDbContext follows the standard pattern for any application written to work with Microsoft Entity Framework Core. It is best to define a DbSet for each persisted type e.g.:

public DbSet<Student> Students { get; set; }

Another option, useful during early stage prototyping is to define ‘seed data’, thus:

protected override void OnModelCreating(ModelBuilder modelBuilder)

{

modelBuilder.Entity<Student>().HasData(new Student { Id = 1, FullName = "Alie Algol" });

modelBuilder.Entity<Student>().HasData(new Student { Id = 2, FullName = "Forrest Fortran" });

modelBuilder.Entity<Student>().HasData(new Student { Id = 3, FullName = "James Java" });

}

The Template.Server project, which is the start-up project, runs the Naked Functions framework and generates the RESTful API based on the ‘model’ project(s) that it references. In the early stages of prototyping, there is no need to make any changes to the server project when you add or update types or functions to the model. (When your application becomes ready for deployment, then you will need to configure various capabilities in the server project).

The Startup class in the server project, which follows standard Microsoft patterns, sets up the NakedFunctions. It also needs to be told various things about the model:

* A list of application domain types (records)
* A list of all functions that need to be accessed via the UI (main menu functions and functions that will be rendered as actions on a given domain type).
* A separate list of the static types that define the main menus.
* A function that, whenever called, will create an instance of the DbContext for use by Entity Framework Core.

All of this information may be specified manually, but the Template solution uses a more convenient approach, whereby all four responsibilities are delegated to functions defined on ModelConfig::

public void ConfigureServices(IServiceCollection services)

{

...

services.AddNakedFramework(frameworkOptions =>

{

frameworkOptions.MainMenus = MenuHelper.GenerateMenus(ModelConfig.MainMenus());

frameworkOptions.AddEFCorePersistor(peristorOptions => { peristorOptions.ContextCreators = new[] { ModelConfig.EFCoreDbContextCreator }; });

frameworkOptions.AddNakedFunctions(appOptions =>

{

appOptions.FunctionalTypes = ModelConfig.Types();

appOptions.Functions = ModelConfig.Functions();

});

frameworkOptions.AddRestfulObjects(\_ => { });

});

ModelConfig is defined and maintaned in the model project.

public static class ModelConfig

{

public static Type[] Types() =>

DomainClasses.Where(t => t.Namespace == "Template.Model.Types" && t.IsStaticClass()).ToArray();

public static Type[] Functions() =>

DomainClasses.Where(t => t.Namespace == "Template.Model.Functions" && t.IsStaticClass()).ToArray();

public static Type[] MainMenus() =>

Functions().Where(t => t.FullName.Contains("MenuFunctions")).ToArray();

public static Func<IConfiguration, DbContext> EFCoreDbContextCreator =>

c => {

var db = new ExampleDbContext(c.GetConnectionString("ExampleCS"));

db.Create();

return db;

};  
 ...

}

Note that the first three functions make use of reflection (via helper methods DomainClasses and Functions) to create the lists automatically based on various optional naming conventions.

#### Server solution

Sets up the system using standard Microsoft patterns

Specifies where to find what is needed from the domain model programs.

Link to system service configuration section

### Client solution

The only things you *need* to do.

Things you *may* do, but with the *caveats* that you shouldn’t unless you need to. And you can keep the two teams very separate.

You would then, however, need to have skills in using Angular. For this reason separate manual for configuring and customising the Naked Objects Client.

## Writing your own applications

Define domain types

Define domain functions

Add persistent domain types to DbContext, and specify mapping if required

Register domain types with Naked Functions, manually or reflectively

Register all domain functions with NakedFunctions, manually or reflectively

Register types that define main menu functions, Register all domain functions with NakedFunctions, manually or reflectively

# Defining domain types

An application written to work with Naked Functions will typically define many domain types, in two varieties: persisted domain types and view models (which are never persisted). Note that both varieties may be displayed on the user interface. While it is possible to have one or more view models associated with each persisted type, the recommended approach is to display persisted types directly whenever possible (this keeps the code much simpler), bearing in mind that:

* Users can right-click on any associated object in order to display its details alongside the primary object
* Authorization may be used to control which properties may be seen by which users.

ViewModels are therefore recommended only when it is necessary to construct a view built from more than persisted object.

## Persisted domain types

Persisted domain types are mapped to the database by Entity Framework Core, either relying on conventions, or by means of explicit mapping. *Typically,* each such domain type corresponds to one database table.

Persisted domain types are *immutable*. It is possible to use immutable *classes*, but – for C# 9 at least – the recommended approach is to use *records*, because these support the C# with keyword that allows making a copy of an existing instance with changes to specified properties only. (Future versions of C# may eliminate the remaining distinctions between records and immutable classes).

Persisted domain types may be marked up with any of these attributes: Bounded, DescribedAs, Named, Plural, PresentationHint, RenderEagerly (for details of the effect of each, follow the link).

Each type must override the default implantation of these two methods, using this boilerplate code:

public override int GetHashCode() => base.GetHashCode();

public virtual bool Equals(Student other) => ReferenceEquals(this, other);

Note that his requirmement is not imposed by Naked Functions but by Entity Framework Core, to support lazy loading, which is in turn required to allow the user to link directly to any associated domain instances on the UI. (This is also the reason why properties must be virtual).

Domain types may optionally override the default ToString method in order to define the title for an instance on the UI – typically based on one or more of the properties, perhaps with additional text or formatting, for example:

public override string ToString() => $"{Department} {StartDate.ToString("d")}";

### Properties

Each domain type will usually have multiple properties, each property *typically* mapping to a column of the corresponding database table.

* One property (sometimes more than one) must define a unique Id (key field), following the normal rules for Entity Framework.
* All properties should be virtual and define {get; init;} accessors.
* Properties may be of any recognised value type, or of any persisted domain type, or an ICollection<T> where T is a persisted domain type. Collection properties must be initialised in code, for example:

public virtual ICollection<EmailAddress> EmailAddresses { get; init; } = new List<EmailAddress>();

* Properties may be marked up with any of these attributes: DescribedAs, Hidden, Mask, MemberOrder, MultiLine, Named, PresentationHint, Versioned (for details of the effect of each, follow the link).
* Collection properties may additionally be marked up with these attributes: RenderEagerly, TableView,

# Defining domain functions

# System services & configuration

General introduction to configuring the

## Authentication

## Authorization

## Auditing

## Profiling

## I18N

# Attributes

### Bounded

Applied to a persisted domain type. Specifies that the type has few instances and these should be offered as drop-down choices in any action parameter of that type. For example:

[Bounded]

public record Department : IHasModifiedDate

...

public static IContext ChangeDepartmentOrShift(

this Employee e, Department department, Shift shift, IContext context)

Graphical user interface, text, application

Description automatically generated

### CreateNew

Applied to a function. Specifies that the instance returned as the first item in the tuple will be a new instance. Instead of rendering this function as a typical dialog, it will be rendered in a different way, where the fields are shown in the context of a persisted instance, but with the other fields rendered empty. For example:

[CreateNew]

public static (PurchaseOrderHeader, IContext) CreateNewPurchaseOrder(

Vendor vendor,

ShipMethod shipMethod,

IContext context)

{

var po = new PurchaseOrderHeader()

{

RevisionNumber = 0,

Status = (byte)POStatus.Pending,

VendorID = vendor.BusinessEntityID,

ShipMethodID = shipMethod.ShipMethodID,

OrderDate = context.Today(),

ModifiedDate = context.Now()

};

return (po, context.WithNew(po));  
}

Graphical user interface, text, application

Description automatically generated

### DefaultValue

Applied to an integer parameter on a function definition. Specifies default value for parameter. If used on a DateTime, an integer value indicates a day relative to today e.g. -1 means 'yesterday'. For example:

public static SalesOrderHeader FindOrder([DefaultValue("SO")] string orderNumber, IContext context) =>

Text

Description automatically generated

### DescribedAs

Applied to Domain Types, Functions, Parameters. Specifies a (short) descriprition, or help, to be rendered as a 'tooltip' or 'placeholder' on the UI, according to the context. For example:

[DescribedAs("... from an existing Employee")]

public static SalesPerson CreateNewSalesPerson( Employee employee) {

Graphical user interface, application, Word

Description automatically generated

### Disabled

Applied to a parameter on a function definition. Renders parameter but does not permit the user to change that value (useful for providing advisory information). For example:

public static IQueryable<Product> ListBikes(

[Disabled] ProductCategory category, ProductSubcategory subCategory, IContext context)

Note that this is only of use if a value is being provided programmatically for the disabled parameter, for example via a Default function.

Graphical user interface, text

Description automatically generated

### DisplayAsProperty

Applied to a read-only type-contributed function that returns a value, reference, or collection. Specifies that the function should be called whenever the type is displayed, and the results of calling the function rendered as a property on the type. For example:

[DisplayAsProperty]

public static ICollection<SpecialOffer> SpecialOffers(this IProduct product, IContext context)

{

int pid = product.ProductID;

return context.Instances<SpecialOfferProduct>().Where(sop => sop.ProductID == pid).Select(sop => sop.SpecialOffer).ToList();

}

A picture containing timeline

Description automatically generated

### Edit

Applied to a function intended solely to update the values of one or more properties on a single instance. The generic UI will then render this function as an edit icon next to the property (or properties) and overlay the dialog on top of the existing property rather than separately – to give the appearance of editing the property itself. For example:

[Edit]

public static IContext UpdateNationalIDNumber(this Employee e,

[MaxLength(15)] string nationalIdNumber, IContext context) =>

UpdateEmployee(e, e with { NationalIDNumber = nationalIdNumber }, context);

Graphical user interface, application

Description automatically generated Graphical user interface, application

Description automatically generated

### Hidden

Applied to a property. Specifies that a property should never be shown on the UI (irrespective of the user’s authorization).

### Mask

Applied to a value-type property. Specifies that the value should be formatted using standard Microsoft formats. For example:

[Mask("d")]

public virtual DateTime? DateOfBirth { get; init; }

Graphical user interface, text, application

Description automatically generated

### MaxLength

Applied to a string parameter. Specifies the maximum number of characters that may be entered. For example:

public static IContext UpdateNationalIDNumber(this Employee e,

[MaxLength(15)] string nationalIdNumber, IContext context) =>

UpdateEmployee(e, e with { NationalIDNumber = nationalIdNumber }, context);

Text

Description automatically generated

### MemberOrder

1. Applied to a property. Within the type, properties will be rendered in ascending order of MemberOrder value, followed by any members that have no MemberOrder specified.

2. Applied to a function. Specifies the ordering of actions within a menu. If the optional string grouping parameter is specified, this will result in the creation of an expandable/collapsable sub-menu, and the MemberOrder value will be applied within that sub-menu. For example:

[MemberOrder("Stores", 1)]

public static IQueryable<Customer> FindStoreByName(string name, IContext context)

Text

Description automatically generated

### MinLength

Applied to a string parameter. Specifies minumum accepted length. If used on the string parameter of an AutoComplete complementary function, specifies the minimum number of characters that must be typed before the auto-complete function will be engaged. For example:

public static IQueryable<PurchaseOrderHeader> OpenPurchaseOrders(this Vendor vendor, IContext context) =>

PurchaseOrder\_MenuFunctions.OpenPurchaseOrdersForVendor(vendor, context);

public static IQueryable<Vendor> AutoComplete0OpenPurchaseOrders(this Vendor vendor, [MinLength(2)] string name, IContext context) =>

PurchaseOrder\_MenuFunctions.AutoComplete0OpenPurchaseOrdersForVendor(name, context);

### MultiLine

1. Applied to a string property or parameter. Specifies that a the property/parameter should be rendered as a multi-line text field, with specified number of lines, scrollable. The Width property is unused by the current client, but is exposed on the Resftul API for custom use. For example:

[MultiLine(10)]

public virtual string Description { get; init; }

Graphical user interface, text, application

Description automatically generated

2. Applied to a function. Specifies that the user may invoke the corresponding action repeatedly - building up a table of entries. For example:

[MultiLine()]

public static IContext AddNewDetails(this PurchaseOrderHeader header,

Product prod, short qty, decimal unitPrice, IContext context) =>

Graphical user interface, text

Description automatically generated

### Named

Applied to any domain type, property, function, or parameter. Specifies that the default name rendered on the user interface (a reformatted version of the name used in the code) should be overridden. It is recommended that for simplicity the names should be the same in the code and on the display whenever possible, but the ability to override this is useful where there is a need for e.g. punctuation in the display version that cannot be used within the code name. For example:

public static (Address, IContext) CreateNewAddress(

AddressType type,

string line1,

string line2,

string city,

string postCode,

[Named("State / Province")] StateProvince sp,

IContext context)

Graphical user interface, application

Description automatically generated

### Optionally

Applied to a parameter. Specifies that the parameter is optional within a dialog. The client will not then render a '\*' in the field, nor require an entry in the field before the user may click 'OK'. For example:

public static IQueryable<Employee> FindEmployeeByName(

[Optionally] string firstName, string lastName, IContext context)



### PageSize

1. Applied to a function that returns IQueryable<T>. Overrides the default page size (of 20 instances) for the rendered results. For example:

[PageSize(10)]

public static IQueryable<Customer> FindStoreByName(string name, IContext context)

2. Applied to an AutoComplete complementary function. Specifies how many matching entries (max) will be offered to the user. For example:

public static IContext AssociateWithSpecialOffer(

this Product product, SpecialOffer offer, IContext context) =>

SpecialOffer\_Functions.AssociateWithProduct(offer, product, context);

[PageSize(10)]

public static IQueryable<SpecialOffer> AutoComplete1AssociateWithSpecialOffer(

this Product product,

[MinLength(2)] string name, IContext context) =>

context.Instances<SpecialOffer>().Where(specialOffer => specialOffer.Description.ToUpper().StartsWith(name.ToUpper()));

### Plural

Applied to a type. Where a type name needs to be rendered in plural form (for example on a collection) the type name is automatically pluralised following simple rules. Where the auto-generated plural name does not read correctly, the plural name may be specified explicitly using the Plural attribute. For example:

[Plural("Bills Of Material")]

public record BillOfMaterial : IHasModifiedDate

### PresentationHint

Applied to any type, property, function, or parameter. Allows the programmer to specify hints that can be picked up and applied by a customized user interface. The string specified in the PresentationHint, is passed through the RESTful API (as an "x-ro-nof-presentationHint":"") and in the generic client will be added as a class to the corresponding Html element. For example:

[PresentationHint("Foo")]

public record Location

Graphical user interface, text, application

Description automatically generated

### RegEx

Applied to a string parameter. Specifies that any entered string must conform to the regex pattern given. For example:

string cardType,

[RegEx("^[0-9]{16}$")][DescribedAs("No spaces")] string cardNumber,

[RegEx("^[0-9]{2}/[0-9]{2}")][DescribedAs("mm/yy")] string expires,

IContext context

)

Graphical user interface, application

Description automatically generated

Note that by also using DescribedAs, the user was prompted with the correct format on the empty field:



### RenderEagerly

(See also TableView)

1. Applied to a collection property, specifies that the collection should automatically be opened *as a list* when the instance is displayed. If the property also has a TableView attribute then the collection will automatically be opened in table view. For example:

[RenderEagerly, TableView(...)]

public virtual ICollection<ProductInventory> ProductInventory { get; init; } ...

2. Applied to a type, specifies that *all* collection properties on that type should automatically be opened when the instance is displayed. If any property also has a TableView attribute then that collection will automatically be opened in table view.

3. Applied to a function that returns a collection, specifies that the returned collection should be rendered in table view rather than list view. If the function also has a TableView attribute then the returned result will automatically be opened in table view.

### TableView

(See also RenderEagerly)

1. Applied to a collection property, allows the table view of the collection to be customized, showing which columns should be visible and in which order.

[TableView(false, nameof(Types.ProductInventory.Quantity), nameof(Types.ProductInventory.Location),

nameof(Types.ProductInventory.Shelf), nameof(Types.ProductInventory.Bin))]

public virtual ICollection<ProductInventory> ProductInventory { get; init; } = new List<ProductInventory>();

Chart, table, treemap chart

Description automatically generated

2. Applied to a function that returns a collection, specifies the formatting for the returned result, *when displayed as a table view.*

Notes (for both cases):

* The first (Boolean) property of the attribute specifies whether the title of the instance should also be rendered. For example.
* The names of the columns should be specified as the actual names of the properties in the type of the collection – not the names as presented on the UI (if different). The safest, and most convenient, way to ensure this is to use the C# nameof keyword as shown above.

### ValueRange

1. Applied to an integer property, specifies a minimum and maximum acceptable value. For example:

public static SpecialOffer BestSpecialOffer(

this Product p, [ValueRange(1, 999)] int quantity, IContext context) =>

1. Applied to a DateTime property, specifies the earliest and latest acceptable dates *relative to today* where negative values are before today, 0 means today, and positive values are after today. For example:

public static IContext AddProductReview(this Product p,

[DefaultValue(0), ValueRange(-30, 0)] DateTime dateOfReview,

The above code requires the date to be within the last 30 days, including today.

### Versioned

Applied to a property that is changed whenever the database row is updated. Used to test that the user's view of an object is up to date before allowing a function that returns an IContext may be invoked. For example:

[Versioned]

public virtual DateTime ModifiedDate { get; init; }

Note that this is effectively a 'long term' form of concurrency checking i.e. to test whether the user’s view is stale before any update is commenced. *Entity Framework's 'short term' form of concurrency checking, which checks for update contention during a transaction, should also be used*. The two mechanisms may use the same field, if the type is acceptable for Entity Framework Core, or use different fields for their checks. Responsibility for updating the value may be delegated to the database or implemented in code. (See also LifeCycle functions).

### ViewModel

Applied to a domain type, specifies that this is a view model, not a persisted type. For example:

[ViewModel(typeof(CustomerDashboard\_Functions))]

public record CustomerDashboard {

[Hidden]

public virtual Customer Root { get; init; }  
   
 //Other properties are derived from the Root in this example

The attribute must be given a static class that defines the two functions that specify how the string key(s) for this view model should be derived from the information within it, and how to re-create the view model instance using these keys (thereby allowing the user to navigate back and forth). These signature of these functions must follow this form:

public static string[] DeriveKeys(this VMT vm)

public static VMT CreateFromKeys(string[] keys, IContext context)

Where VMT is the view model type. For example:

public static class CustomerDashboard\_Functions {

public static string[] DeriveKeys(this CustomerDashboard cd) =>

new[] {cd.Root.CustomerID.ToString() };

public static CustomerDashboard CreateFromKeys(string[] keys, IContext context)

{

int customerId = int.Parse(keys[0]);

return new CustomerDashboard {

Root = context.Instances<Customer>().Single(c => c.CustomerID == customerId)};

}

}

Note that any view model must still be registered as a domain type.