IT's TINKOFF

DevBrothers

LINQ Expressions: искусство запрашивать данные

Денис Цветцих | Тинькофф

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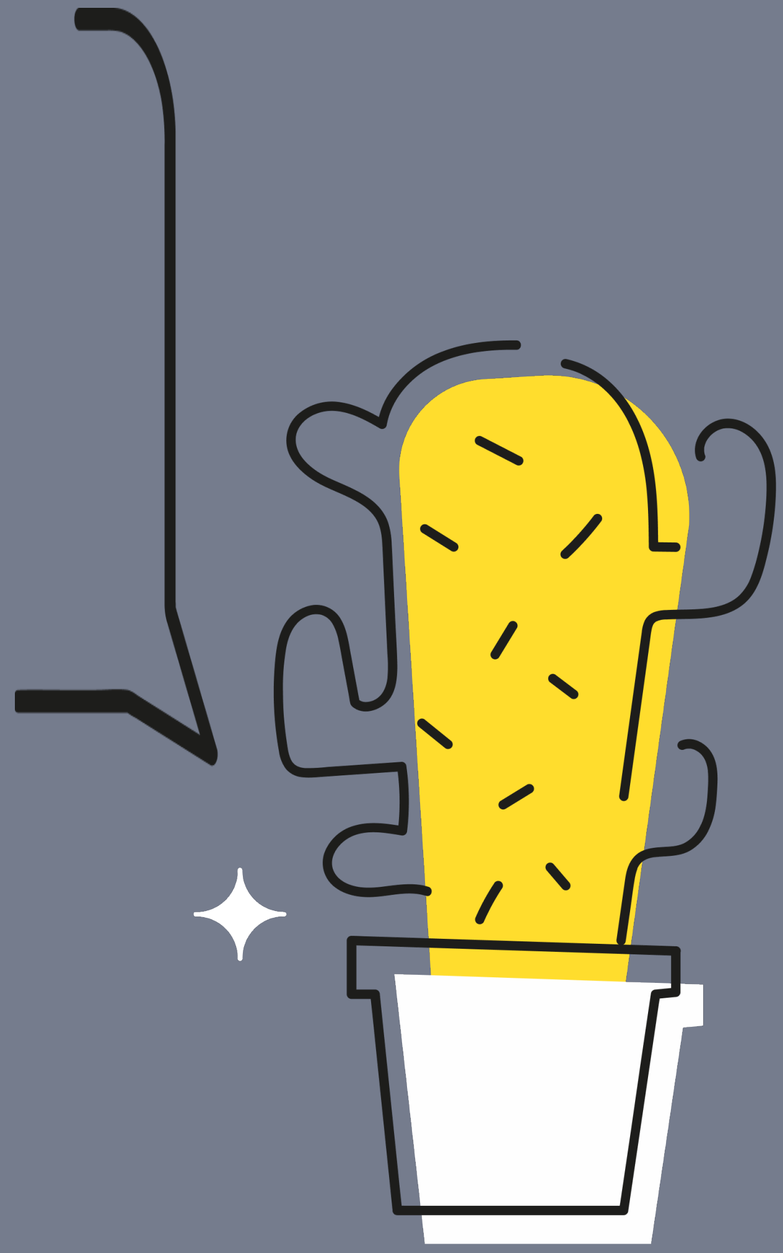
Тинькофф, DevBrothers

cRud

- 80% запросов - чтение
- Запросы **частично** дублируются
- А еще запросы меняются при изменении требований
- И много рутины для формирования запросов
- GraphQL, OData, Json Api – не серебряная пуля

О чем поговорим

- Что такое спецификация
- Современная реализация спецификации
- Фильтрация вложенных коллекций
- Как упростить рутину генерации запросов



Интернет-магазин

```
public class Product
{
    public int Id { get; set; }
    public string Name { get; set; }
    public decimal Price { get; set; }

    public bool IsSaleEnabled { get; set; }
}
```

Список товаров

```
var products = dbContext.Products
    .Where(x => x.IsSaleEnabled)
    .ToList();
```

Учитываем склад

```
public class Product
{
    public int Id { get; set; }
    public string Name { get; set; }
    public decimal Price { get; set; }

    public bool IsSaleEnabled { get; set; }
    public int StockCount { get; set; }
}
```

Список товаров с учетом склада

```
var products = dbContext.Products
    .Where(x => x.IsSaleEnabled && x.StockCount > 0)
    .ToList();
```

Инкапсулируем

```
public class Product
{
    public int Id { get; set; }
    public string Name { get; set; }
    public decimal Price { get; set; }

    public bool IsSaleEnabled { get; set; }
    public int StockCount { get; set; }

    public bool IsAvailable => IsSaveEnabled && StockCount > 0;
}
```

Extension method

```
public static class Queries
{
    public static IQueryable<Product> Available(this IQueryable<Product> query)
        => query.Where(x => x.IsSaleEnabled && x.StockCount > 0);
}

var products = dbContext.Products
    .Available()
    .ToList();
```

Группируем по И

```
var products = dbContext.Products
    .Available()
    .HasDiscount()
    .ToList();
```

Спецификация

Представляет бизнес-правила в виде цепочки объектов, связанных бизнес-логикой

01

Инкапсуляция правил

02

Комбинация правил

Спецификация

```
public interface ISpecification
{
    bool IsSatisfiedBy(object candidate);
}


Func<T, bool>
```

Делегат не работает

```
public static class Queries
{
    public static bool IsAvailable(Product product)
        => product.IsSaleEnabled && product.StockCount > 0;
}

var products = dbContext.Products
    .Where(x => Queries.IsAvailable(x))
    .ToList();
```

Фильтр в памяти – не вариант

```
var products = dbContext.Products
    .AsEnumerable()
    .Where(x => Queries.IsAvailable(x))
    .ToList();
```

Спецификация как выражение

Func<T, bool> - IEnumerable

Expression<Func<T, bool>> - IQueryable

Func<T, bool> ⇨ Expression<Func<T, bool>> ?

Expression первичен, делегат вторичен

```
Func<Product, bool> delegate = expression.Compile();
```

CompileFast: 10-40 раз быстрее

```
Func<Product, bool> delegate = expression.CompileFast();
```

https://github.com/dadhi/FastExpressionCompiler

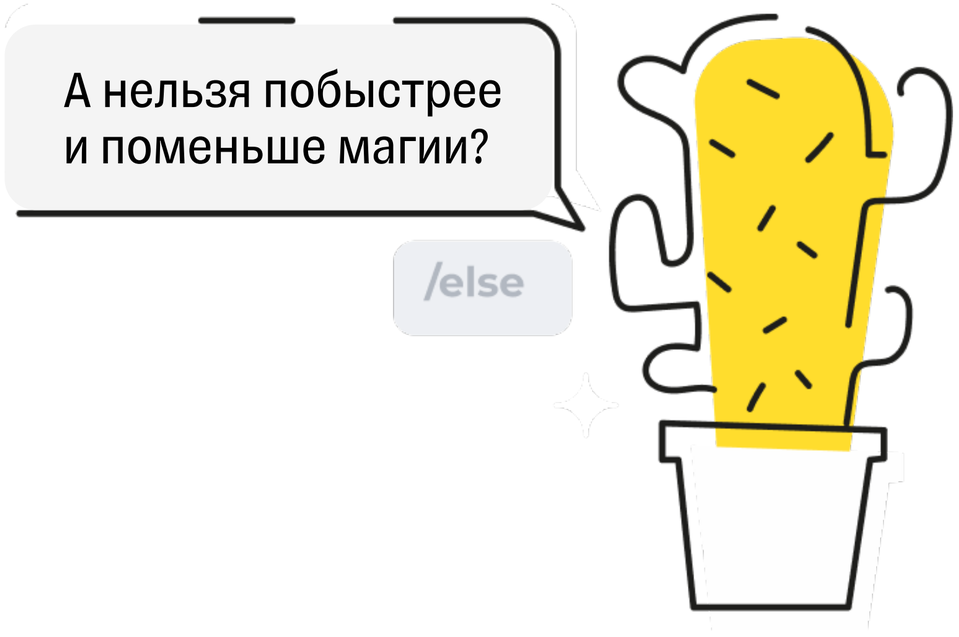
Delegate Decompiler (0.32)

```
public class Product
{
    public int Id { get; set; }
    public string Name { get; set; }
    public decimal Price { get; set; }

    public bool IsSaleEnabled { get; set; }
    public int StockCount { get; set; }

    [Computed]
    public bool IsAvailable => IsSaleEnabled && StockCount > 0;
}
```

https://github.com/hazzik/DelegateDecompiler

Декоратор Queryable

```
var products = dbContext.Products
    .Where(x => x.IsAvailable)
    .Decompile()
    .ToList();
```



Linq Spec

```
public abstract class Specification<T>
{
    public abstract Expression<Func<T, bool>> ToExpression();

    public static implicit operator Expression<Func<T, bool>>(Specification<T> spec)
        => spec?.ToExpression() ?? throw new ArgumentNullException(nameof(spec));
}
```

https://github.com/navozenko/LinqSpecs

Спецификация –> LinqExpression

```
public class IsProductAvailableSpecification : Specification<Product>
{
    public override Expression<Func<Product, bool>> ToExpression()
        => x => x.IsSaleEnabled && x.StockCount > 0;
}

public class Product
{
    public static readonly Specification<Product> IsAvailable
        = new IsProductAvailableSpecification();
}

var products = dbContext.Products
    .Where(Product.IsAvailable)
    .ToList();
```

AdHocSpecification без отдельного класа

```
public class Product
{
    public static readonly Specification<Product> HasDiscount =
        new AdHocSpecification<Product>(x => x.IsDiscount && x.Price > 100);
}

var products = dbContext.Products
    .Where(Product.IsAvailable || Product.HasDiscount)
    .ToList();
```

Объединение Expression

```
Expression<Func<Product, bool>> saleEnabled = x => x.IsSaleEnabled;

Expression<Func<Product, bool>> onStock     = y => y.StockCount > 0;
```

parameter — body

```
var isAvailableBody = Expression.And(saleEnabled.Body, onStock.Body);
// x.IsSaleEnabled And y.StockCount > 0
var isAvailable = Expression.Lambda<Func<Product, bool>>(isAvailableBody, parameter);
```

System.InvalidOperationException: 'The LINQ expression 'x' could not be translated

Подмена параметра

```
public class ReplaceVisitor : ExpressionVisitor
{
    private readonly Expression _from, _to;
    public ReplaceVisitor(ParameterExpression from, ParameterExpression to)
    {
        _from = from;
        _to = to;
    }

    protected override Expression VisitParameter(ParameterExpression node)
    {
        return node == _from ? _to : base.Visit(node);
    }
}
```

Делаем один параметр

```
var saleParam = saleEnabled.Parameters.Single(); // x
var stockParam = onStock.Parameters.Single(); // y

var replace = new ReplaceVisitor(saleParam, stockParam);
var fixedSaleEnabled = replace.Visit(saleEnabled.Body)!; // x.IsSaleEnabled -> y.IsSaleEnabled

var isAvailableBody = Expression.And(fixedSaleEnabled, onStock.Body);
// y.IsSaleEnabled && y.StockCount > 0

var isAvailable = Expression.Lambda<Func<Product, bool>>(isAvailableBody, stockParam);
// y => y.IsSaleEnabled && y.StockCount > 0
```

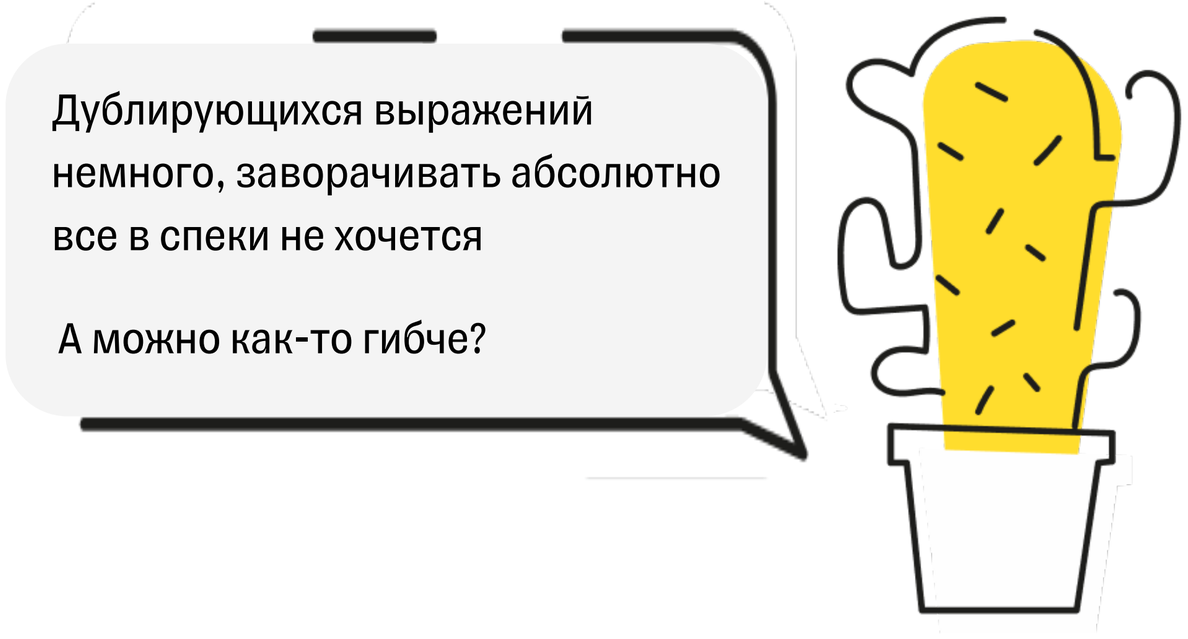
PredicateBuilder (LINQKit)

```
Expression<Func<Product, bool>> saleEnabled = x => x.IsSaleEnabled;

Expression<Func<Product, bool>> onStock     = y => y.StockCount > 0;

var combined = saleEnabled.And(onStock); //Or, Not
```

https://github.com/scottksmith95/LINQKit

Спецификация не дружит с выражением

```
var products = dbContext.Products
    .Where(x => Product.IsAvailable || x.Price > 0) // Compilation error
    .ToList();
```



NeinLinq

```
public static class Ext
{
    [InjectLambda]
    public static bool IsAvailable(this Product product)
        => throw new NotImplementedException();

    public static Expression<Func<Product, bool>> IsAvailable()
        => p => p.IsSaleEnabled && p.StockCount > 0;
}
```

https://github.com/axelheer/nein-linq

Снова декоратор Queryable

```
var products = dbContext.Products
    .ToInjectable()
    .Where(x => x.IsAvailable() && x.Price > 0)
    .ToList();
```

Не только агрегаты, но и значения

```
public static class Ext
{
    [InjectLambda]
    public static bool IsPositive(this decimal value)
        => value > 0;

    public static Expression<Func<decimal, bool>> IsPositive()
        => (p) => p > 0;
}

var products = dbContext.Products
    .Where(x => x.IsAvailable() && x.Price.IsPositive())
    .ToList();
```

Настройка декоратора

```
services.AddDbContext<AppDbContext>(options =>
        options.UseSqlOrTheLike("...")
            .WithLambdaInjection());

var products = dbContext.Products
    .ToInjectable()
    .Where(x => x.IsAvailable() && x.Price > 0)
    .ToList();
```

Projectable

```
services.AddDbContext<AppDbContext>(options => options
        .UseSqlServer("").UseProjectables());
```

https://github.com/koenbeuk/EntityFrameworkCore.Projectables

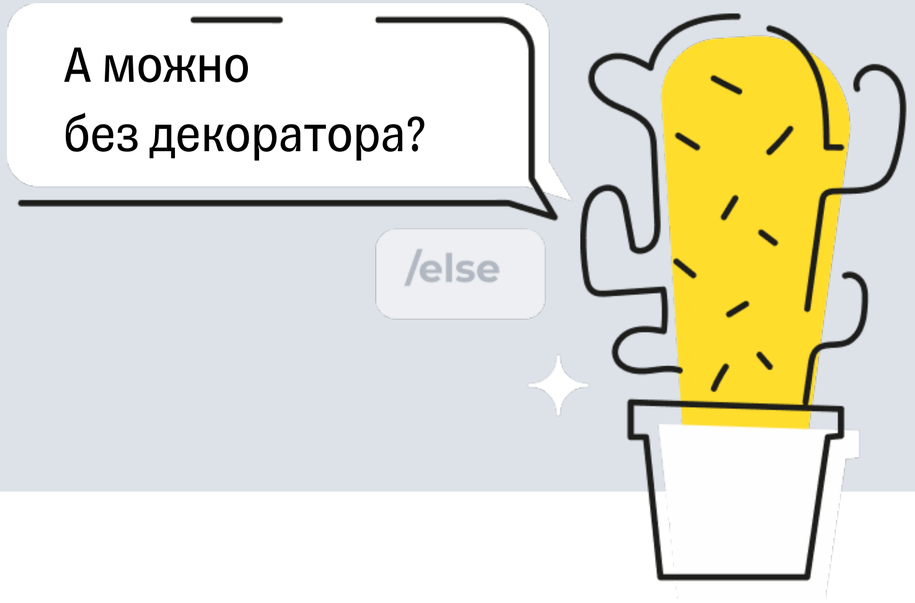
Свойство

```
public class Product
{
    [Projectable]
    public bool IsAvailable => IsSaleEnabled && StockCount > 0;
}

var products = dbContext.Products
    .Where(x => x.IsAvailable)
    .ToList();
```

Extension метод

```
public static class Ext
{
    [Projectable]
    public static bool IsAvailable(this Product p)
        => p.IsSaleEnabled && p.StockCount > 0;
}

var products = dbContext.Products
    .Where(x => x.IsAvailable())
    .ToList();
```

Projectable



01

Source Generator для LINQ

02

Декоратор для замены выражения

EF Core 7: IQueryExpressionInterceptor

```
public class SpecificationInterceptor : IQueryExpressionInterceptor
{
    public Expression QueryCompilationStarting(Expression queryExpression, QueryExpressionEventData eventData)
        => new SpecificationVisitor().Visit(queryExpression);

    private class SpecificationVisitor : ExpressionVisitor
    {
        protected override Expression VisitMethodCall(MethodCallExpression? methodCallExpression)
        {
            var methodInfo = methodCallExpression!.Method;
            if (methodInfo.Name != nameof(Ext.IsAvailable))
                return base.VisitMethodCall(methodCallExpression);

            var argument = methodCallExpression.Arguments.First();
            return Expression.Property(argument, nameof(Product.IsSaleEnabled));
        }
    }
}
```

https://devblogs.microsoft.com/dotnet/announcing-ef7-preview7-entity-framework/

linq2db

Все в одном

https://github.com/linq2db/linq2db

LINQ to DB is type-safe SQL

Нет ChangeTracking

Документация не очень

Спецификация – Extension method

```
[ExpressionMethod("IsAvailable")]
public static bool IsAvailable(this Product p)
    => p.IsSaleEnabled && p.StockCount > 0;

public static Expression<Func<Product, bool>> IsAvailable()
    => (p) => p.IsSaleEnabled && p.StockCount > 0;

var res = db.Product.Where(x => x.IsAvailable())
    .ToList();
```

http://blog.linq2db.com/2016/06/how-to-teach-linq-to-db-convert-custom.html

Спецификация – свойство класса

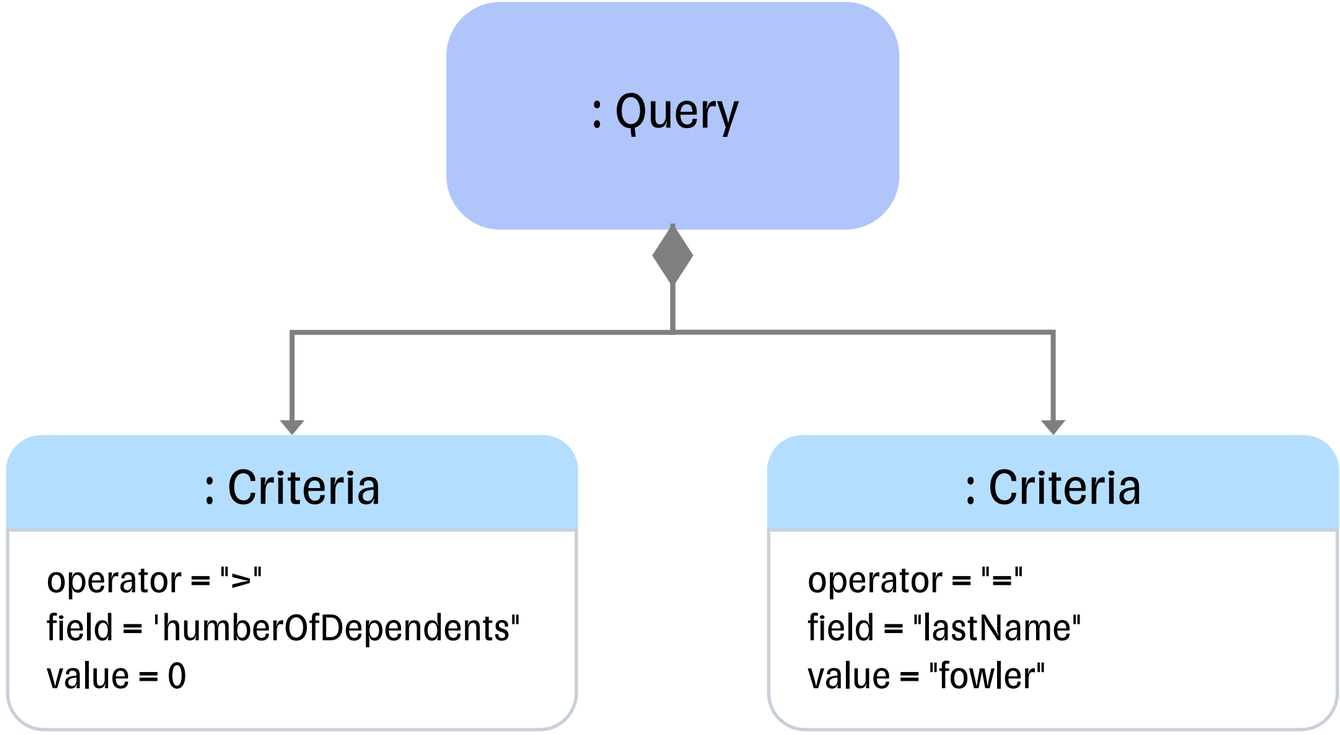
```
public class Product
{
    [ExpressionMethod("IsAvailableExpr")]
    public bool IsAvailable => IsSaleEnabled && StockCount > 0;

    private static Expression<Func<Product, bool>> IsAvailableExpr()
        => (p) => p.IsSaleEnabled && p.StockCount > 0;
}

var res = db.Product.Where(x => x.IsAvailable)
    .ToList();
```

eShopOnWeb - Ardalis.Specification

```
public interface ISpecification<T>
{
    bool IsSatisfiedBy(T entity);

    IEnumerable<WhereExpressionInfo<T>> WhereExpressions   { get; }
    IEnumerable<OrderExpressionInfo<T>> OrderExpressions   { get; }
    IEnumerable<IncludeExpressionInfo>  IncludeExpressions { get; }

    int? Take { get; }
    int? Skip { get; }

    bool CacheEnabled { get; }
    string? CacheKey { get; }

    bool AsNoTracking { get; }
    bool AsSplitQuery { get; }
    bool AsNoTrackingWithIdentityResolution { get; }
    bool IgnoreQueryFilters { get; }
}
```

https://github.com/ardalis/Specification

Query Object



https://www.martinfowler.com/eaaCatalog/queryObject.html

Ardalis.Specification.EntityFrameworkCore

```
public sealed class ProductIsAvailableSpecification : Specification<Product>
{
    public ProductIsAvailableSpecification()
    {
        Query.Where(x => x.IsSaleEnabled && x.StockCount > 0);
    }
}

var products = dbContext.Products
    .WithSpecification(new ProductIsAvailableSpecification())
    .ToList();
```

QueryObject нельзя комбинировать

```
queryObject.Take = 20 && 30;

queryObject.OrderBy = "FirstName DESC" || "Date ASC";
```

QueryObject vs Specification

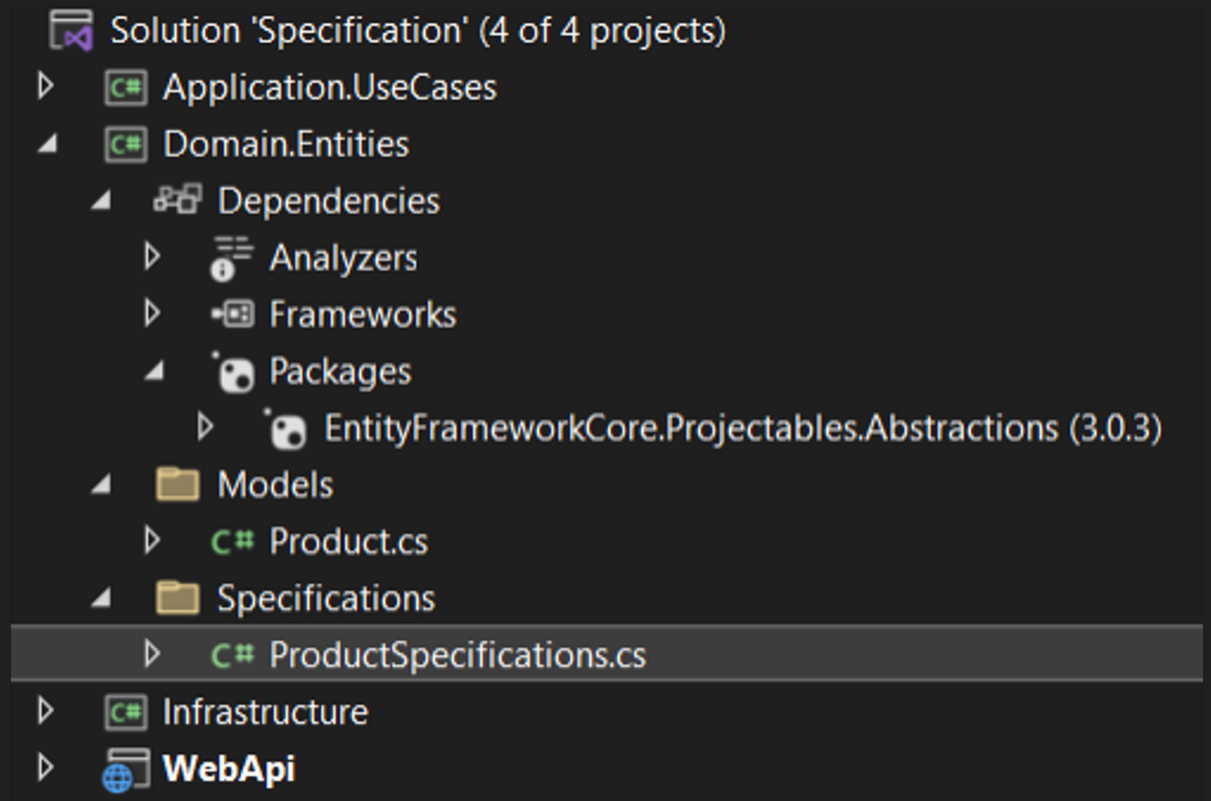
```
var products = dbContext.Products
    .WithQueryObject(new QueryObject())
    .ToList();

var products = dbContext.Products
    .WithSpecification(new Specification())
    .OrderBy(x => x.Name)
    .Skip(pageNumber * pageSize).Take(pageSize)
    .ToList();
```

Dynamic Linq

```
Expression<Func<Product, bool>> saleEnabled = x => x.IsSaleEnabled;
Expression<Func<Product, bool>> onStock = x => x.StockCount > 0;

var products = dbContext.Products
    .Where("@0(it) and @1(it)", saleEnabled, onStock)
    .ToList();
```

https://github.com/zzzprojects/System.Linq.Dynamic.Core

Спецификации в Domain.Entities



Фильтрация по вложенным коллекциям

В категории много товаров

```
public class Product
{
    public int CategoryId { get; set; }
    public Category Category { get; set; }
}

public class Category
{
    public int Id { get; set; }

    public string Name { get; set; }

    public List<Product> Products { get; set; }
}
```

Фильтрация вложенных коллекций

```
var categories = dbContext.Categories
    .Where(x => x.Products.Any(p => p.IsSaleEnabled && p.StockCount > 0))
    .ToList();
```

LINQ-спецификация не подходит

```
Expression<Func<Product, bool>> specification =
            x => x.IsSaleEnabled && x.StockCount > 0;

var categories = dbContext.Categories
    .Where(x => x.Products.Any(specification)) // compilation error
    .ToList();
```

LINQKit Core

```
Expression<Func<Product, bool>> specification =
            x => x.IsSaleEnabled && x.StockCount > 0;

var categories = dbContext.Categories
    .AsExpandable()
    .Where(x => x.Products.Any(specification.Compile()))
    .ToList();
```

https://github.com/scottksmith95/LINQKit

Нет компиляции спецификации, но...

```
private Expression TryVisitExpressionFunc(MemberExpression input, FieldInfo field)
{
    var propertyInfo = input.Member as PropertyInfo;
    if (field.FieldType.GetTypeInfo().IsSubclassOf(typeof(Expression)) || propertyInfo != null && propertyInfo.F
    {
        return Visit(Expression.Lambda<Func<Expression>>(input).Compile()());
    }

    return input;
}
```

https://github.com/scottksmith95/LINQKit/blob/master/src/LinqKit.Core/ExpressionExpander.cs#L253

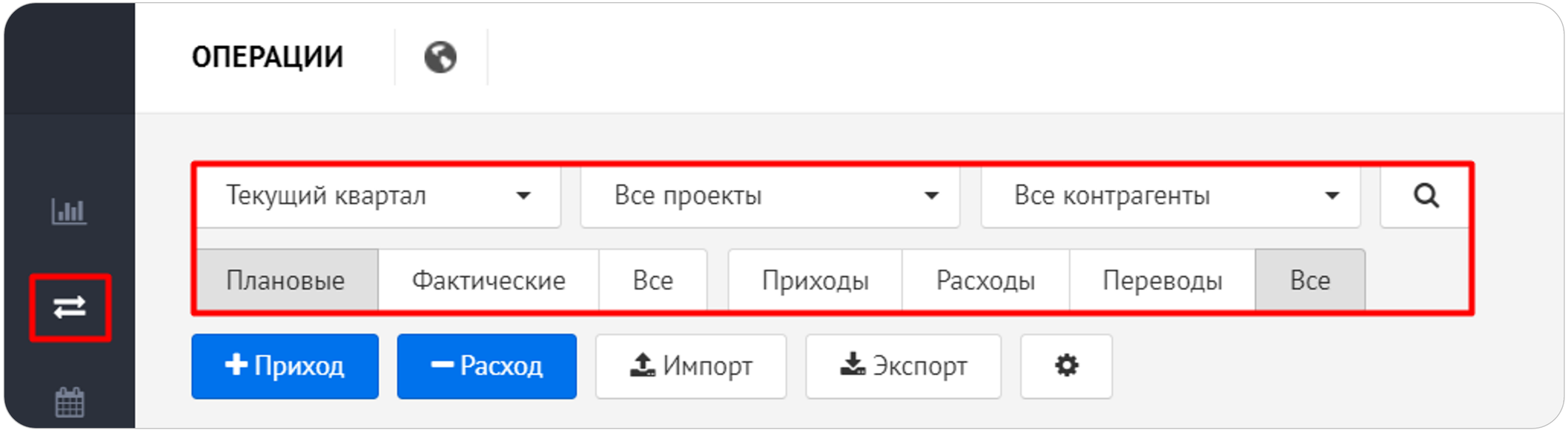
Projectable спешит на помощь

```
public class Product
{
    [Projectable]
    public bool IsAvailable => IsSaleEnabled && StockCount > 0;
}

var categories = dbContext.Categories
    .Where(x => x.Products.Any(p => p.IsAvailable))
    .ToList();
```

Extension-метод тоже работает

```
public static class Ext
{
    [Projectable]
    public static bool IsAvailable(this Product p)
        => p.IsSaleEnabled && p.StockCount > 0;
}

var categories = dbContext.Categories
    .Where(x => x.Products.Any(p => p.IsAvailable()))
    .ToList();
```

Рутина фильтрации



Рутина фильтрации

```
public class Filter
{
    public string? Name { get; set; }
    public decimal? PriceFrom { get; set; }
    public decimal? PriceTo { get; set; }
}
```

Рутина фильтрации

```
var filter = request.Filter;

IQueryable<Product> query = dbContext.Products;

if (filter.Name != null)
    query = query.Where(x => x.Name.Contains(filter.Name));
if (filter.PriceFrom != null)
    query = query.Where(x => x.Price >= filter.PriceFrom);
if (filter.PriceTo != null)
    query = query.Where(x => x.Price <= filter.PriceTo);

var products = query.ToList();
```

Sieve

```
public class Filter
{
    [Sieve(CanFilter = true, CanSort = true)]
    public string? Name { get; set; }
}


_sieveProcessor.Apply(sieveModel, products); //IQueryable
```

https://github.com/Biarity/Sieve

SieveModel

```
?sorts=     Price
&filters=   Price<100, Name@=some name,
&page=      1,
&pageSize=  10

public class SieveModel
{
    public string Filters { get; set; }

    public string Sorts { get; set; }

    public int? Page { get; set; }

    public int? PageSize { get; set; }
}
```

Autofilterer

```
public class ProductFilter : FilterBase
{
    public Range<double>? Price { get; set; }

    [ToLowerContainsComparison]
    public string? Name { get; set; }
}

var products = dbContext.Products.ApplyFilter(filter).ToList();
```

https://github.com/enisn/AutoFilterer

AutoFilter.Sql

```
public class Filter
{
    [FilterProperty(IgnoreCase = true, StringFilter = StringFilterCondition.Contains)]
    public string? Name { get; set; }

    public Range<decimal>? Price { get; set; }
}

var products = dbContext.Products.AutoFilter(filter).ToList();
```

https://github.com/denis-tsv/AutoFilter

Под капотом AutoFilter

```
public static IQueryable<TItem> AutoFilter<TItem>(this IQueryable<TItem> items, object filter)
{
    var parameter = Expression.Parameter(typeof(TItem), "x");

    var propertyExpressions = filter.GetType().GetProperties()
        .Select(x => new { Name = x.Name, Value = x.GetValue(filter) })
        .Where(x => x.Value != null)
        .Select(x =>
        {
            var property = Expression.Property(parameter, x.Name);
            Expression value = Expression.Constant(x.Value, property.Type);

            return Expression.Equal(property, value);
        })
        .ToList();

    var body = propertyExpressions.Aggregate(Expression.AndAlso);

    var result = Expression.Lambda<Func<TItem, bool>>(body, parameter);

    return items.Where(result);
}
```

Константа вместо параметра

```
-- Как будет с константой
SELECT p."Id", p."Name" FROM "Product" p WHERE p. "Price" > 100

-- Как надо
SELECT p."Id", p."Name" FROM "Product" p WHERE p. "Price" > $1
```

Кто генерит параметры?

```
public static IQueryable<TItem> AutoFilter<TItem>(this IQueryable<TItem> items, object filter)
{
    var parameter = Expression.Parameter(typeof(TItem), "x");
    var filterExpr = Expression.Constant(filter);

    var propertyExpressions = filter.GetType().GetProperties()
        .Select(x => new { Name = x.Name, Value = x.GetValue(filter) })
        .Where(x => x.Value != null)
        .Select(x =>
        {
            var property = Expression.Property(parameter, x.Name);
            Expression value = Expression.Property(filterExpr, x.Name);

            return Expression.Equal(property, value);
        })
        .ToList();

    var body = propertyExpressions.Aggregate(Expression.AndAlso);

    var result = Expression.Lambda<Func<TItem, bool>>(body, parameter);

    return items.Where(result);
}
```

Избавляемся от констант

Sieve – OK

AutoFilter.Sql – с 2.0 (22.09.2023)

AutoFilterer – с 3.0 (27.11.2023)

Оптимизируем через компиляцию выражений

```
public static IQueryable<TItem> AutoFilter<TItem>(this IQueryable<TItem> items, object filter)
{
    var parameter = Expression.Parameter(typeof(TItem), "x");
    var filterExpr = Expression.Constant(filter);

    var propertyExpressions = filter.GetType().GetProperties()
        .Select(x => new { Name = x.Name, ValueGetter = CreateValueGetter(filter, x) })
        .Select(x => new { Name = x.Name, Value = x.ValueGetter.Invoke(filter) })
        .Where(x => x.Value != null)
        .Select(x =>
        {
            var property = Expression.Property(parameter, x.Name);
            Expression value = Expression.Property(x.ValuefilterExpr, x.Name);

            return Expression.Equal(property, value);
        })
        .ToList();

    var body = propertyExpressions.Aggregate(Expression.AndAlso);

    var result = Expression.Lambda<Func<TItem, bool>>(body, parameter);

    return items.Where(result);
}
```

Компилируем выражение в делегат

```
public static Func<Filter, object> CreateValueGetter(Filter filter, PropertyInfo x)
{
    var parameter = Expression.Parameter(typeof(Filter), "x");
    Expression body = Expression.Property(parameter, x);
    body = Expression.Convert(body, typeof(object));

    var lambda = Expression.Lambda<Func<Filter, object>>(body, parameter);
    return lambda.Compile();
}
```

Доклад про сериализацию с бенчмарками **https://youtu.be/DhzT8Abpsso**

Подмена параметра и компиляция выражения

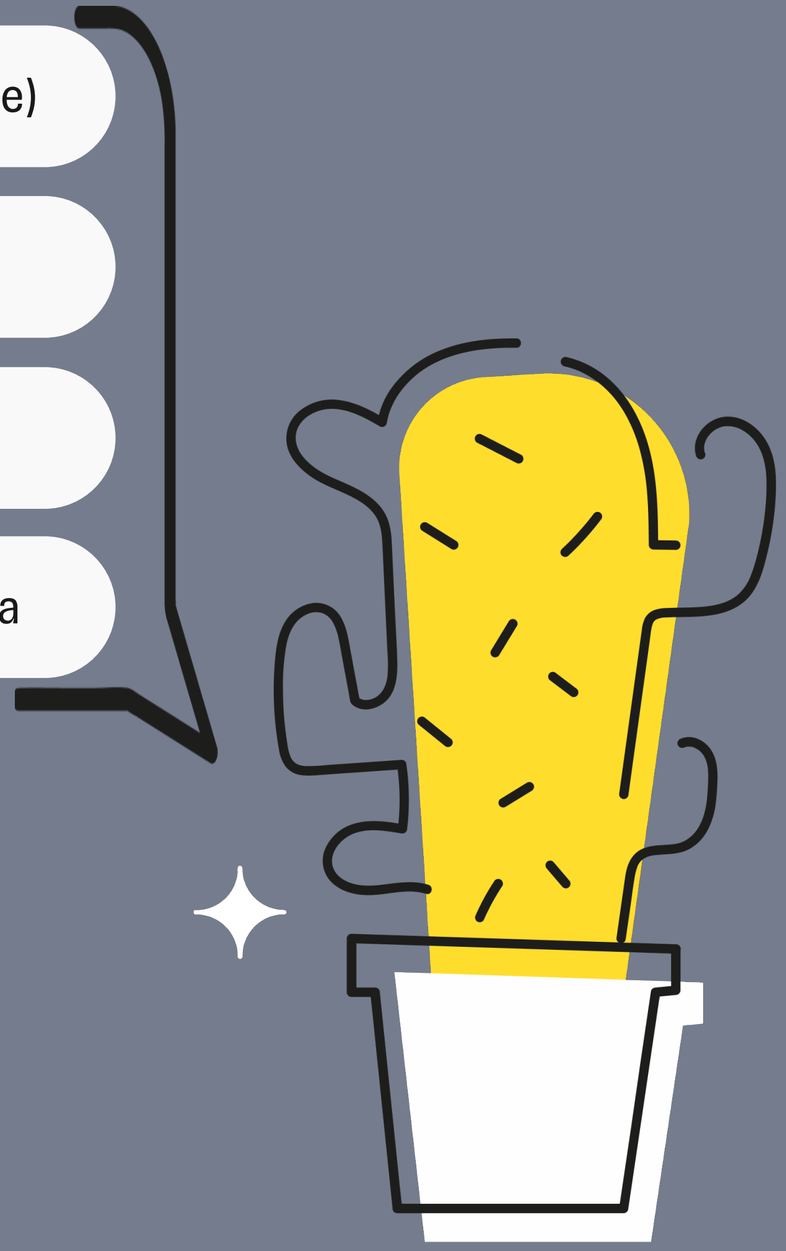
```
BenchmarkDotNet=v0.13.5, OS=Windows 10 (10.0.19044.2965/21H2/November2021Update)
AMD Ryzen 7 3700X, 1 CPU, 16 logical and 8 physical cores
.NET SDK=7.0.202
  [Host]     : .NET 7.0.4 (7.0.423.11508), X64 RyuJIT AVX2
  DefaultJob : .NET 7.0.4 (7.0.423.11508), X64 RyuJIT AVX2


|                          Method |         Mean |      Error |     StdDev |
|-------------------------------- |-------------:|-----------:|-----------:|
|                RebindParameter |     370.6 ns |    4.34 ns |    4.06 ns |
| RebindParameter_PredicateBuilder |     340.1 ns |    3.58 ns |    3.18 ns |
|                     CompileFast |   4,223.3 ns |   96.39 ns |  284.21 ns |
|                         Compile |  67,990.3 ns |  514.81 ns |  456.36 ns |
```

Автофильтр

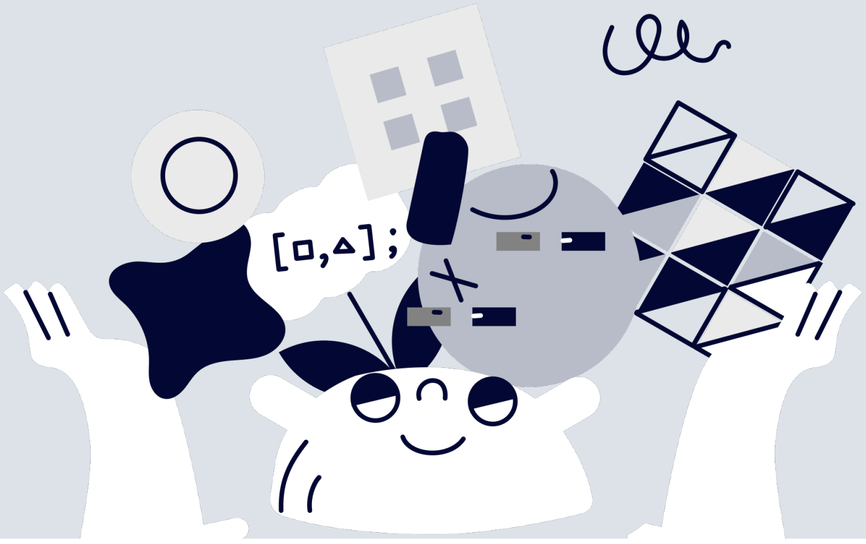
```
BenchmarkDotNet=v0.13.5, OS=Windows 10 (10.0.19044.2965/21H2/November2021Update)
AMD Ryzen 7 3700X, 1 CPU, 16 logical and 8 physical cores
.NET SDK=7.0.202
  [Host]     : .NET 7.0.4 (7.0.423.11508), X64 RyuJIT AVX2
  DefaultJob : .NET 7.0.4 (7.0.423.11508), X64 RyuJIT AVX2


|        Method |     Mean |     Error |    StdDev |
|-------------- |---------:|----------:|----------:|
|    Reflection | 2.476 us | 0.0440 us | 0.0411 us |
|     Delegates | 2.417 us | 0.0315 us | 0.0295 us |
| AutoFilterSql | 2.742 us | 0.0284 us | 0.0266 us |
|  AutoFilterer | 4.272 us | 0.0421 us | 0.0394 us |
```

О чем поговорили

- Современная спецификация: extension метод + сорсгены (Projectable)
- Подходит для фильтрации вложенных коллекций (Projectable)
- Автофильтр для автоматизации рутины фильтрации
- Компиляция Expression в делегат – доли процента от работы запроса



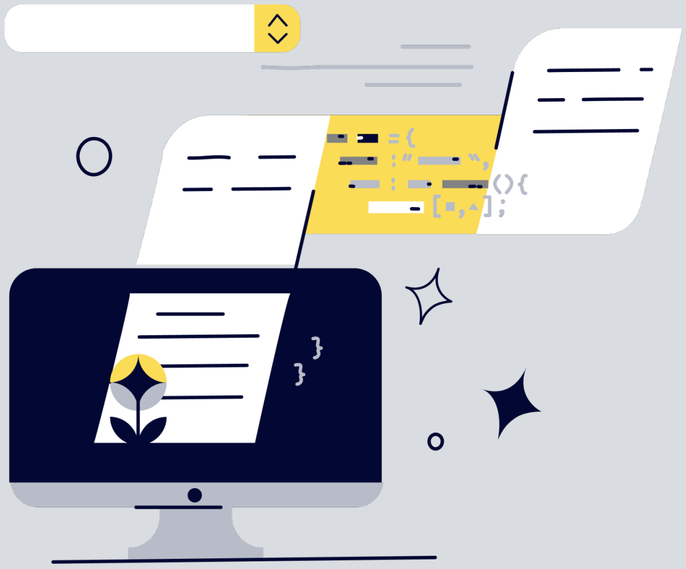
Главная мысль



LinqExpression, сорсгены, интерсепторы, компиляция в делегаты – не хайп, а полезные инструменты!

Но надо знать когда их применять ☺️

Полезные ссылки



- EF Core Extensions
  https://learn.microsoft.com/en-us/ef/core/extensions/
- EntityFramework: (анти)паттерн Repository
  https://habr.com/ru/articles/335856/
- Максим Аршинов. Деревья выражений в Enterprise разработке (2018)
  https://youtu.be/J2XzsCoJM4o

IT's TINKOFF

DevBrothers

Спасибо за внимание!

Есть вопросы?

Денис Цветцих

den.tsvettsih@yandex.ru

@den_tsvettsikh

https://github.com/denis-tsv