C# Expression Trees in the Real World

In C# and .NET

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Have you ever...

- Query a database with a LINQ expression?

```
from product in db.Products
where product.Price < 2.55
select new {
     product.Name,
     product.Price
}
```

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Have you ever…

- Render a field in an ASP.NET Core app like this?

```
@Html.EditorFor(e => e.FirstName)
```

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Have you ever…

- Select one or more members from an object?

```
ForMember(x => x.Name)
```

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If you've ever done any of those

- Then you've used expression trees

```
ForMember(x => x.Name)
```

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So what are expression trees anyways?

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Let’s talk lambdas first

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Lambda expressions

```
Func<string, string> toUpper = str => str.ToUpper();

var result = toUpper("spencer");
```

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Lambda expressions

```
Func<string, string> toUpper = str => str.ToUpper();

var result = toUpper("spencer");          //SPENCER
```

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Lambda expressions

```
Expression<Func<string, string>> toUpper = str => str.ToUpper();

var result = toUpper("spencer");
```

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Lambda expressions

```
Expression<Func<string, string>> toUpper = str => str.ToUpper();

var result = toUpper("spencer");     //does not compile
```

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What the heck?

```
Expression<Func<string, string>> toUpper = str => str.ToUpper();

var result = toUpper("spencer");
```

```
Func<string, string> toUpper = str => str.ToUpper();

var result = toUpper("spencer");
```

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Key difference

- Lambdas do the thing

- Expressions describe the lambda that does the thing

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Homoiconicity

```
Expression<Func<string, string>> toUpper = str => str.ToUpper();

var result = toUpper("spencer");
```

```
Func<string, string> toUpper = str => str.ToUpper();

var result = toUpper("spencer");
```

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So what can we do with expressions?

- **Read them**
- Create them
- Use them

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Lambda expressions

```
Expression<Func<string, string>> toUpper = str => str.ToUpper();
```

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```
str => str.ToUpper()
```

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```
str => str.ToUpper()
```

str

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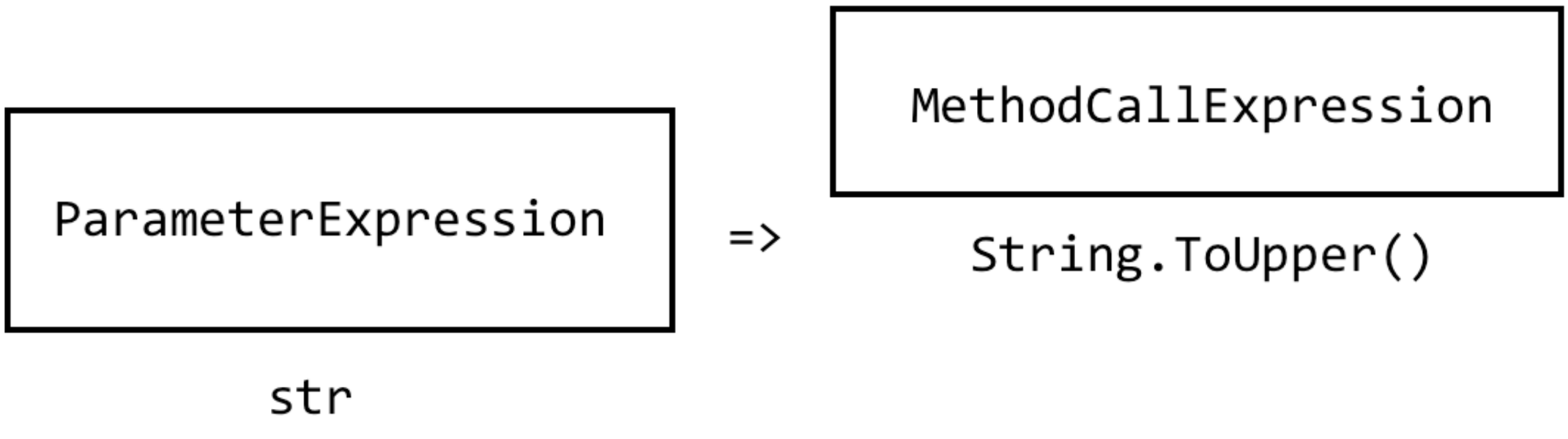
```
str => str.ToUpper()
```



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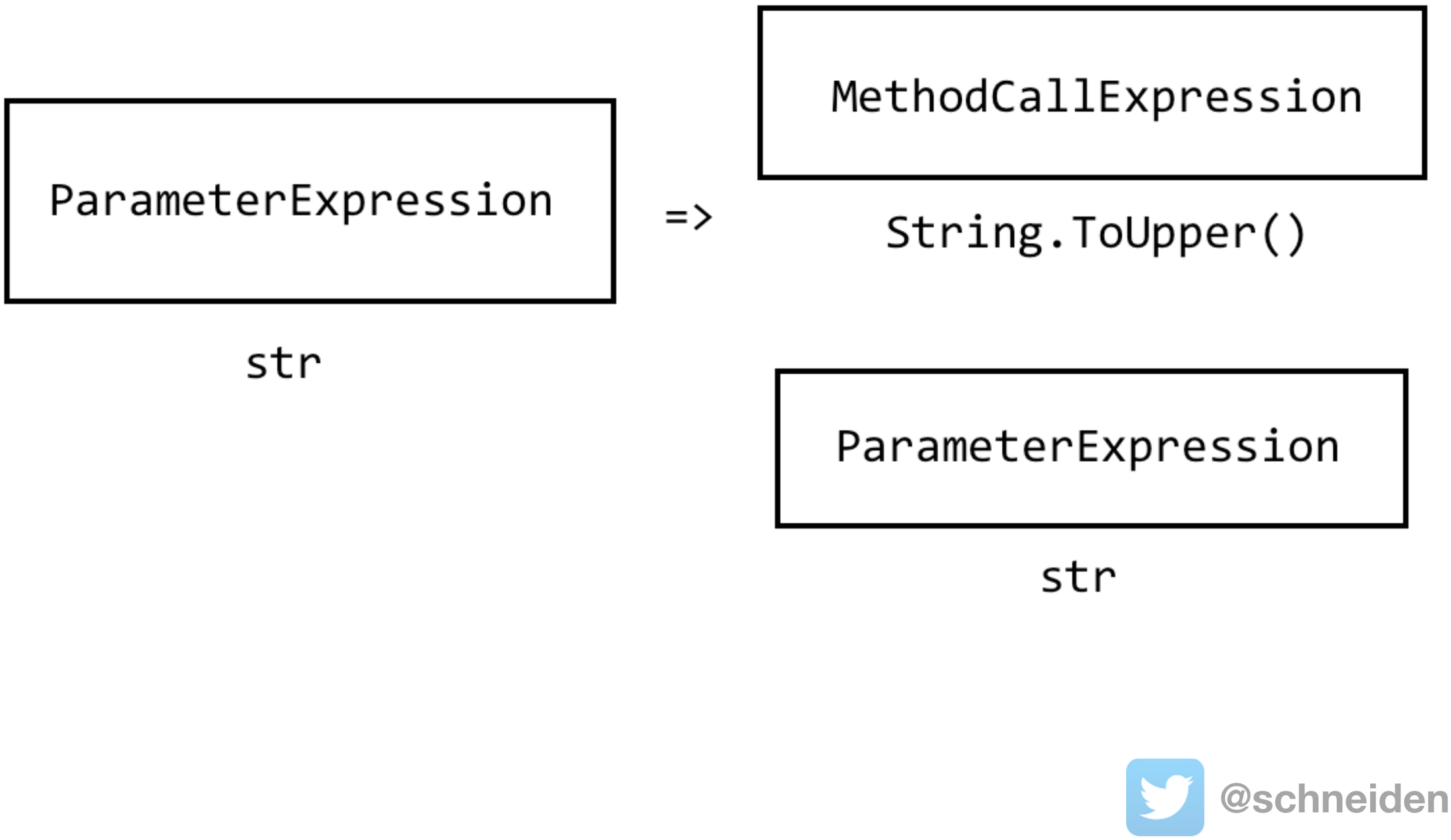
```
str => str.ToUpper()
```



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So what can we do with expressions?

- Read them
- **Create them**
- Use them

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Lambda expressions

```
Expression<Func<string, string>> toUpper = str => str.ToUpper();
```

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Lambda expressions

```
Expression<Func<string, string>> toUpper = str => str.ToUpper();
```

Useful, but mainly for libraries to use them

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Expression API

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ParameterExpression

- Represents a parameter to a function

```
Expression.Parameter(typeof(string));
Expression.Parameter(typeof(string), "myStr"); //with a name
```

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ConstantExpression

- Represents a declared value (e.g. 1, “str”, etc)

```
Expression.Constant("spencer");
```

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MethodCallExpression

- Represents a call to a method

```
var prm = Expression.Parameter(typeof(string));
var toUpper = typeof(string).GetMethod("ToUpper", Type.EmptyTypes);

Expression.Call(prm, toUpper);
```

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Let’s build this guy!

```
Expression<Func<string, string>> toUpper = str => str.ToUpper();
```

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str => str.ToUpper()

```
var prm = Expression.Parameter(typeof(string), "str");
var toUpper = typeof(string).GetMethod("ToUpper", Type.EmptyTypes);

var body = Expression.Call(prm, toUpper);

var lambda = Expression.Lambda(body, prm);
```

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So what can we do with expressions?

- Read them
- Create them
- **Use them**

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Your favorite libraries

- Entity Framework/EF Core

- AutoMapper

Entity Framework

- Translates LINQ expressions to SQL

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Entity Framework

```
var products = db.Products
.Where(p => p.Name == "eggs")
.OrderByDescending(p => p.Price);
```

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Entity Framework

```
var products = db.Products
    .Where(p => p.Name == "eggs")
    .OrderByDescending(p => p.Price);
```

```
SELECT * FROM Products
WHERE Name = 'eggs'
ORDER BY Price DESC
```

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Entity Framework

```
var products = db.Products
    .Where(p => p.Name == "eggs")
    .OrderByDescending(p => p.Price);
```

?

```
SELECT * FROM Products
WHERE Name = 'eggs'
ORDER BY Price DESC
```

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Entity Framework

```
var products = db.Products
.Where(p => p.Name == "eggs")
.OrderByDescending(p => p.Price);
```

db.Products is an IQueryable

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Enumerable

```
Enumerable<T>.Where(Func<T, bool> predicate)
```

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Queryable

```
Queryable<T>.Where(Expression<Func<T, bool>> predicate)
```

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Queryable

```
Queryable<T>.Where(Expression<Func<T, bool>> predicate)
```

This one can be interpreted at runtime!

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ExpressionVisitor

Used to read and operate on expressions

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Entity Framework

```
var products = db.Products
.Where(p => p.Name == "eggs")
.OrderByDescending(p => p.Price);
```

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Entity Framework

```
.Where(p => p.Name == "eggs")
```

```
WHERE Name = 'eggs'
```

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Entity Framework

```
.Where(p => p.Name == "eggs")
```

This is what is known as a binary expression

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BinaryExpression

Represents an operation with a left side, right side, and an operator

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BinaryExpression

Property	What is it?
Left	Expression
Right	Expression
NodeType	Equal, NotEqual, etc.

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ExpressionVisitor

Reads each part of the expression and does *something*
based on what it’s reading

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p.Name == "Eggs"

Part of function	SQL
p.Name	Name
==	=
"eggs"	eggs'

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Entity Framework

```
var products = db.Products
    .Where(p => p.Name == "eggs")
    .OrderByDescending(p => p.Price);
```

ExpressionVisitor

```
SELECT * FROM Products
WHERE Name = 'eggs'
ORDER BY Price DESC
```

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```
[Project1].[downtimeId] AS [downtimeId],
CASE WHEN ([Extent12].[downtimeStart] > @p__linq__7) THEN [Extent13].[downtimeStart] ELSE @p__linq__8 END AS [C1],
CASE WHEN ([Extent14].[equipmentID] IS NULL) THEN 0 ELSE [Extent15].[equipmentID] END AS [C2],
CASE WHEN ([Extent16].[equipmentID] IS NULL) THEN N''Unit Overhead'' ELSE [Extent18].[equipmentCode] END AS [C3],
CASE WHEN ( CAST( [Project1].[downtimeEquipmentStart] AS datetime2) > @p__linq__9) THEN  CAST( [Project1].[downtimeEquipmentStart] AS
datetime2) ELSE @p__linq__10 END AS [C4],
CASE WHEN ( CAST( [Project1].[downtimeEquipmentEnd] AS datetime2) < @p__linq__11) THEN  CAST( [Project1].[downtimeEquipmentEnd] AS
datetime2) ELSE @p__linq__12 END AS [C5],
CASE WHEN ([Extent19].[standardHourRate] IS NULL) THEN cast(0 as decimal(18)) ELSE [Extent20].[standardHourRate] END AS [C6],
CASE WHEN ([Extent21].[equipmentID] IS NULL) THEN 0 ELSE [Filter2].[reportingSequence] END AS [C7]
FROM                    (SELECT
    @p__linq__0 AS [p__linq__0],
    [Extent1].[downtimeId] AS [downtimeId],
    [Extent1].[equipmentID] AS [equipmentID],
    [Extent1].[downtimeEquipmentStart] AS [downtimeEquipmentStart],
    [Extent1].[downtimeEquipmentEnd] AS [downtimeEquipmentEnd]
    FROM [dbo].[DowntimeEquipment] AS [Extent1] ) AS [Project1]
OUTER APPLY  (SELECT [Extent2].[reportingSequence] AS [reportingSequence]
    FROM   [dbo].[ProcessUnitEquipment] AS [Extent2]
    INNER JOIN [dbo].[Downtime] AS [Extent3] ON [Extent3].[equipmentID] = [Extent2].[equipmentID]
    LEFT OUTER JOIN  (SELECT
        [Extent4].[downtimeId] AS [downtimeId]
        FROM [dbo].[Downtime] AS [Extent4]
        WHERE [Project1].[downtimeId] = [Extent4].[downtimeId] ) AS [Project2] ON 1 = 1
    WHERE ([Project1].[downtimeId] = [Extent3].[downtimeId]) AND ([Extent2].[processUnitID] = @p__linq__0) AND (@p__linq__0 IS NOT NULL) )
AS [Filter2]
LEFT OUTER JOIN [dbo].[Downtime] AS [Extent5] ON [Project1].[downtimeId] = [Extent5].[downtimeId]
LEFT OUTER JOIN [dbo].[Downtime] AS [Extent6] ON [Project1].[downtimeId] = [Extent6].[downtimeId]
LEFT OUTER JOIN [dbo].[Downtime] AS [Extent7] ON [Project1].[downtimeId] = [Extent7].[downtimeId]
LEFT OUTER JOIN [dbo].[Downtime] AS [Extent8] ON [Project1].[downtimeId] = [Extent8].[downtimeId]
LEFT OUTER JOIN [dbo].[Downtime] AS [Extent9] ON [Project1].[downtimeId] = [Extent9].[downtimeId]
LEFT OUTER JOIN [dbo].[Downtime] AS [Extent10] ON [Project1].[downtimeId] = [Extent10].[downtimeId]
LEFT OUTER JOIN [dbo].[DownTimeType] AS [Extent11] ON [Extent10].[downTimeTypeId] = [Extent11].[downTimeTypeId]
LEFT OUTER JOIN [dbo].[Downtime] AS [Extent12] ON [Project1].[downtimeId] = [Extent12].[downtimeId]
LEFT OUTER JOIN [dbo].[Downtime] AS [Extent13] ON [Project1].[downtimeId] = [Extent13].[downtimeId]
LEFT OUTER JOIN [dbo].[Downtime] AS [Extent14] ON [Project1].[downtimeId] = [Extent14].[downtimeId]
LEFT OUTER JOIN [dbo].[Downtime] AS [Extent15] ON [Project1].[downtimeId] = [Extent15].[downtimeId]
LEFT OUTER JOIN [dbo].[Downtime] AS [Extent16] ON [Project1].[downtimeId] = [Extent16].[downtimeId]
LEFT OUTER JOIN [dbo].[Downtime] AS [Extent17] ON [Project1].[downtimeId] = [Extent17].[downtimeId]
LEFT OUTER JOIN [dbo].[Equipment] AS [Extent18] ON [Extent17].[equipmentID] = [Extent18].[equipmentID]
LEFT OUTER JOIN [dbo].[Equipment] AS [Extent19] ON [Project1].[equipmentID] = [Extent19].[equipmentID]
LEFT OUTER JOIN [dbo].[Equipment] AS [Extent20] ON [Project1].[equipmentID] = [Extent20].[equipmentID]
LEFT OUTER JOIN [dbo].[Downtime] AS [Extent21] ON [Project1].[downtimeId] = [Extent21].[downtimeId]
```

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ExpressionVisitor

Used to read and operate on expressions

…or even modify them… kind of

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```
public class ToUpperVisitor : ExpressionVisitor
{
    public override Expression Visit(Expression node)
    {
        if (node.NodeType == ExpressionType.Parameter)
        {
            return base.Visit(node);
        }

        if (node.Type == typeof(string))
        {
            var toUpper = typeof(string).GetMethod("ToUpper", Type.EmptyTypes);
            var methodCallExpression = Expression.Call(node, toUpper);
            return methodCallExpression;
        }
        return base.Visit(node);
    }
}
```

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```
public class ToUpperVisitor : ExpressionVisitor
{
    public override Expression Visit(Expression node)
    {
        if (node.NodeType == ExpressionType.Parameter)
        {
            return base.Visit(node);
        }

        if (node.Type == typeof(string))
        {
            var toUpper = typeof(string).GetMethod("ToUpper", Type.EmptyTypes);
            var methodCallExpression = Expression.Call(node, toUpper);
            return methodCallExpression;
        }
        return base.Visit(node);
    }
}


Expression<Func<string, string>> spencyString =
    s => s + " belongs to Spencer";

var toUpperVisitor = new ToUpperVisitor();
var expressed = toUpperVisitor.VisitAndConvert(spencyString, null);

Console.WriteLine(expressed.Compile().DynamicInvoke("the cheese"));

//output: THE CHEESE BELONGS TO SPENCER
```

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My Real World

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SQL Model Mapper

- Needed to map one entity to another
- Stored procs vs. code

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SQL Model Mapper

- SalesForce Customer -> Quickbooks Customer

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```
public class SalesForceCustomer
{
    public string CustomerName { get; set; }
    public DateTime? CreateDate { get; set; }
}
```

```
public class QuickbooksCustomer
{
    public string Name { get; set; }
    public DateTime? OpenDate { get; set; }
}
```

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```
INSERT QuickbooksCustomers (Name, OpenDate)
SELECT CustomerName, CreateDate
FROM SalesForceCustomers
```

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```
INSERT QuickbooksCustomers (Name, OpenDate)
SELECT CustomerName, CreateDate
FROM SalesForceCustomers
```

Now do this for 100’s of objects and 1,000’s of properties, and never make a mistake

```
public class SfCustomerToQbCustomer
{
    public SfCustomerToQbCustomer()
    {
        SourceField(sfc => sfc.CustomerName)
            .IsEqualTo(qbc => qbc.Name.Trim());
        SourceField(sfc => sfc.CreateDate)
            .IsEqualTo(qbc => qbc.OpenDate ?? DateTime.Now);
    }
}
```

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Tasks

- Write an expression visitor

- Handle any type of expression we want to translate

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```
qbc => qbc.Name.Trim()
```

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```
qbc => qbc.Name.Trim()
```

LTRIM(RTRIM(Name))

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```
qbc => qbc.CreateDate ?? DateTime.Now
```

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```
qbc => qbc.CreateDate ?? DateTime.Now
```

```
ISNULL(CreateDate, GETDATE())
```

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```
INSERT QuickbooksCustomers (Name, OpenDate)
SELECT LTRIM(RTRIM(CustomerName)), ISNULL(CreateDate, GETDATE())
FROM SalesForceCustomers
```

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Benefits

- Predictable

- Saved 1,000’s of hours of developer time

Order by…string?

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api/Customers?orderBy=name

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```
db.Customers.OrderBy(c => c.Name)
db.Customers.OrderBy("Name")    //doesn't exist
```

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Solution: cook an expression!

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```
db.Customers.OrderBy(c => c.Name)
```

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Goals

- Cook our expression

- Apply it to our IQueryable

```
IQueryable<T> OrderByPropertyOrField<T>(
    this IQueryable<T> queryable,
    string propertyOrFieldName,
    bool ascending
)
```

```
IQueryable<T> OrderByPropertyOrField<T>(
    this IQueryable<T> queryable,
    string propertyOrFieldName,
    bool ascending
)
{
    var elementType = typeof (T);
    var parameter = Expression.Parameter(elementType);
    var prop = Expression.PropertyOrField(parameter, propertyOrFieldName);
    var selector = Expression.Lambda(prop, parameter);
```

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```
Queryable.OrderBy<TSource, TKey>(
    IQueryable<TSource>,
    Expression<Func<TSource, TKey>>
)
```

```
Queryable.OrderBy<TSource, TKey>(IQueryable<TSource>, Expression<Func<TSource, TKey>>)
```

```
    var selector = Expression.Lambda(prop, parameter);

    var orderByMethodName = ascending ? "OrderBy" : "OrderByDescending";
    var orderByExpression = Expression.Call(
        typeof (Queryable),     //the type whose function we want to call
    orderByMethodName,      //the name of the method
    new[] {elementType, prop.Type},    //the generic type signature
    queryable.Expression,   //parameter
    selector);              //parameter
```

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```
Queryable.OrderBy<TSource, TKey>(IQueryable<TSource>, Expression<Func<TSource, TKey>>)
```

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    selector);              //parameter
```

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```
Queryable.OrderBy<TSource, TKey>(IQueryable<TSource>, Expression<Func<TSource, TKey>>)
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Queryable.OrderBy<TSource, TKey>(IQueryable<TSource>, Expression<Func<TSource, TKey>>)
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    orderByMethodName,      //the name of the method
    new[] {elementType, prop.Type},    //the generic type signature
    queryable.Expression,   //parameter
    selector);              //parameter
```

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https://dotnetfiddle.net/5PlilF

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Rules engine?

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Define structure

```
public class Rule
{
    public string PropertyName { get; set; }
    public Operation Operation { get; set; }
    public object Value { get; set; }
}

public enum Operation
{
    GreaterThan,
    LessThan,
    Equal
}
```

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Employee search criteria

```
new Rule {
    PropertyName = "Name",
    Operation = Operation.Equal,
    Value = "gary"
},
new Rule {
    PropertyName = "HireDate",
    Operation = Operation.GreaterThan,
    Value = new DateTime(2016, 1, 1)
}
```

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Cook an expression

```
var parameter = Expression.Parameter(typeof(Employee));
BinaryExpression binaryExpression = null;

foreach (var rule in rules)
{
    var prop = Expression.Property(parameter, rule.PropertyName);
    var value = Expression.Constant(rule.Value);
    var newBinary = Expression.MakeBinary(rule.Operation, prop, value);

    binaryExpression =
        binaryExpression == null
        ? newBinary
        : Expression.MakeBinary(AndAlso, binaryExpression, newBinary);
}
```

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}
```

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Employee search criteria

```
new Rule {
    PropertyName = "Name",
    Operation = Operation.Equal,
    Value = "gary"
},
new Rule {
    PropertyName = "HireDate",
    Operation = Operation.GreaterThan,
    Value = new DateTime(2016, 1, 1)
}
```

```
e => (e.Name == "gary") && (e.HireDate > new DateTime(2016, 1, 1))
```

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https://dotnetfiddle.net/iobiuW

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Dragons

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C# compiler == magic

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```
Expression<Func<string, string, string>> combineStringsExp =
(str1, str2) => str1 + str2;
```

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```
var str1Param = Expression.Parameter(typeof(string));
var str2Param = Expression.Parameter(typeof(string));
```

```
var combineThem = Expression.MakeBinary(ExpressionType.Add, str1Param, str2Param);
```

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```
var str1Param = Expression.Parameter(typeof(string));
var str2Param = Expression.Parameter(typeof(string));
```

```
var combineThem = Expression.MakeBinary(ExpressionType.Add, str1Param, str2Param);
```

EXCEPTION: The binary operator Add is not defined for the types 'System.String' and 'System.String'

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```
Expression<Func<string, string, string>> combineStringsExp =
(str1, str2) => str1 + str2;
```

This uses string.Concat

Conversions need to be done explicitly

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How to start

- Experiment
- LINQPad
- Google
- Intellisense!

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Most importantly, EXPERIMENT!

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Thank you!

schneids.net

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