Module 14

”LINQ to Objects”

TEKNOLOGISK
INSTITUT

Agenda

- **Introducing LINQ**
- LINQ Query Keywords
- LINQ Query Operator Methods
- Lab 14
- Extra: LINQ to Entities
- Extra: LINQ to XML
- Discussion and Review

Motivation for LINQ

- LINQ = Language INtegrated Query

- Several distinct motivations for LINQ
  - Uniform programming model for any kind of data
  - A better tool for embedding SQL queries into type-safe code
  - Another data abstraction layer
  - …

- All of these descriptions to some extent hold true

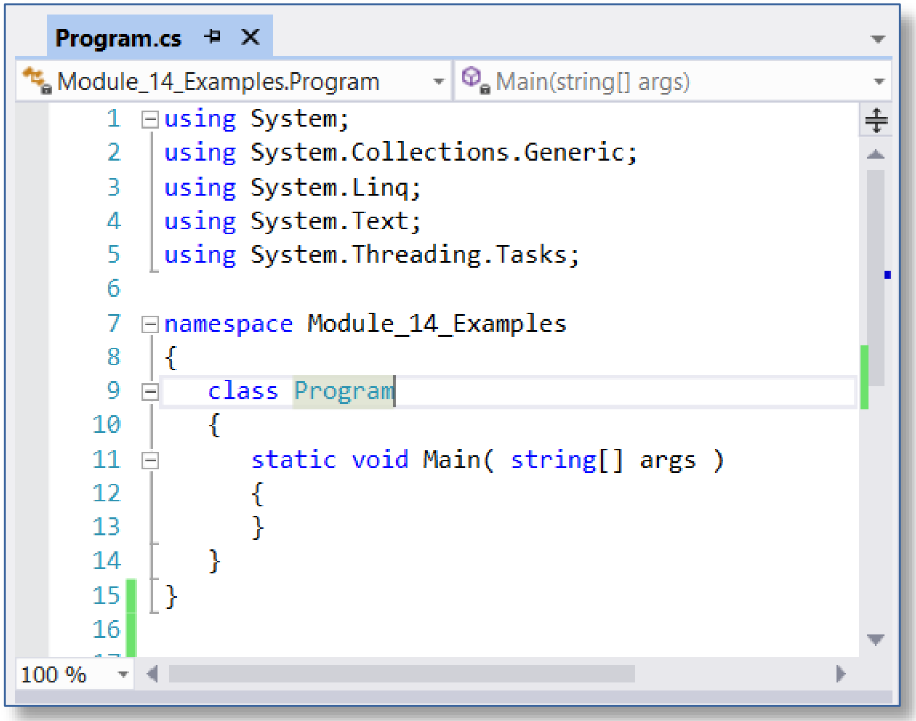
LINQ Components

- LINQ to Objects
- LINQ to XML
- LINQ to Entities
- Parallel LINQ
- …

- Later we will see a little bit of
  - LINQ to Entities
  - LINQ to XML

Starting LINQ to Objects

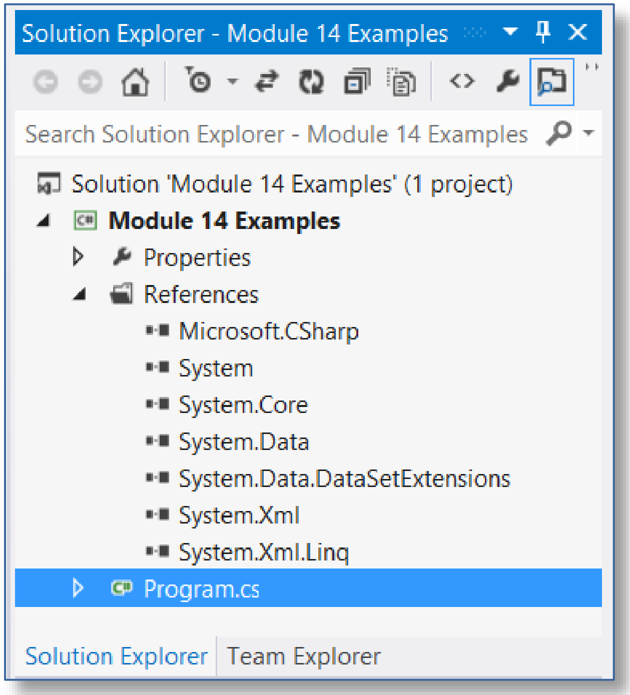
- Main LINQ features live in **`System.Core.dll`** in the **`System.Linq`** namespace



```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace Module_14_Examples
{
    class Program
    {
        static void Main( string[] args )
        {
        }
    }
}

```


Solution Explorer - Module 14 Examples
Search Solution Explorer - Module 14 Examples
Solution Explorer
Team Explorer

```
Solution 'Module 14 Examples' (1 project)
  Module 14 Examples
    Properties
    References
      Microsoft.CSharp
      System
      System.Core
      System.Data
      System.Data.DataSetExtensions
      System.Xml
      System.Xml.Linq
    Program.cs
```

A First Example

- Find all games with more that 18 characters in the title

```
string[] wiiGames = {
   "Super Mario Galaxy",
   "FIFA 09",
   "Guitar Hero III",
   "Wii Sports",
   "Wii Fit",
   "Legend of Zelda: Twilight Princess"
};

IEnumerable<string> query = from g in wiiGames
                            where g.Length >= 18
                            select g;
```

```
foreach( string s in query )
{
   Console.WriteLine( s );
}
```

Implicitly Typed Variables

- Query results can be of a multitude of types

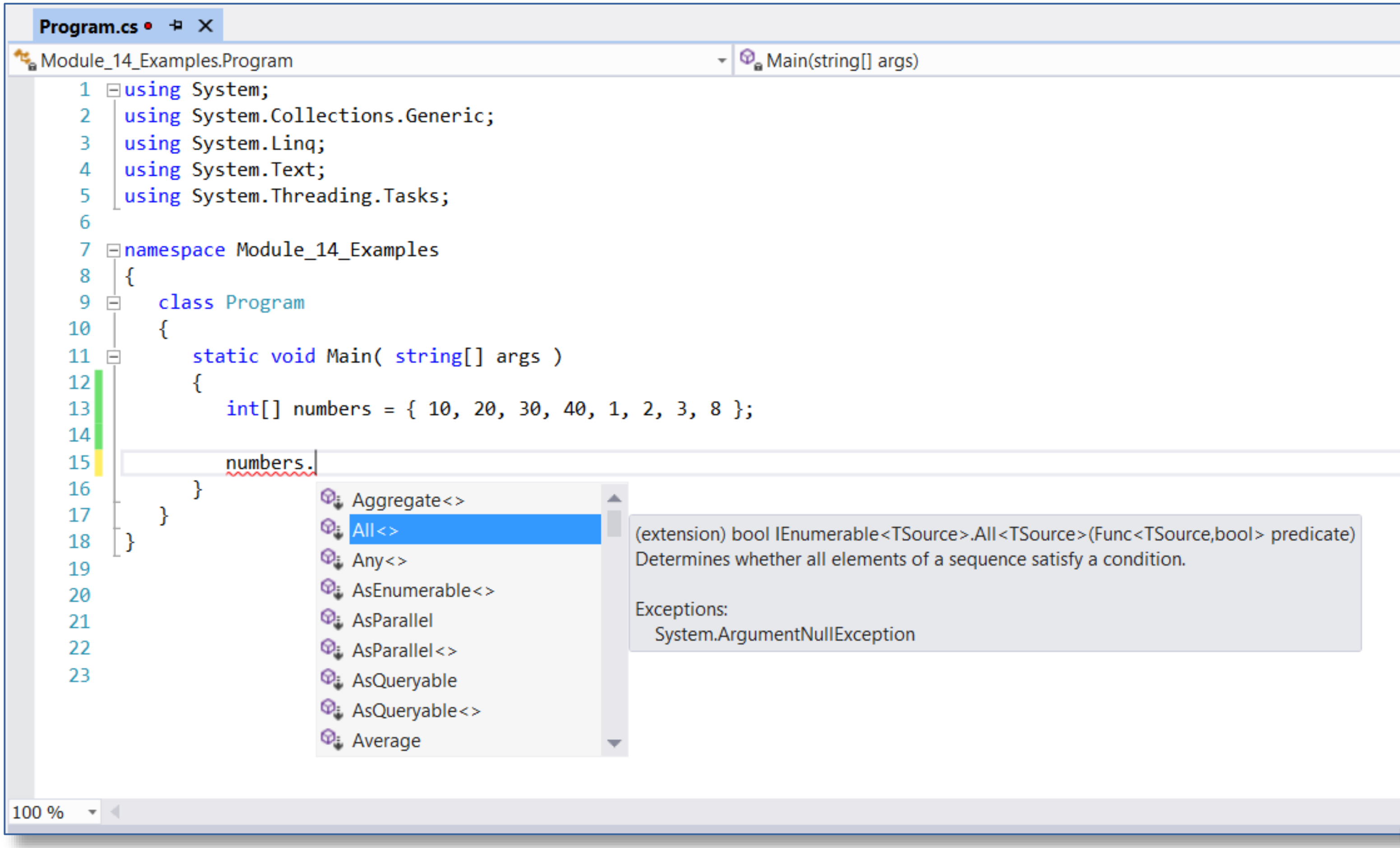
```
int[] numbers = {10, 20, 30, 40, 1, 2, 3, 8};
IEnumerable<int> query = from i in numbers
                         where i < 10 select i;
foreach( int i in query )
{
   Console.WriteLine( i );
}
```

- Innocently-looking modifications might change underlying type
- Make all query variables implicitly typed…!

```
int[] numbers = {10, 20, 30, 40, 1, 2, 3, 8};
var query = from i in numbers where i < 10 select i;
foreach( var i in query )
{
   Console.WriteLine( i );
}
```

`Enumerable` Extension Methods

- The **`System.Linq.Enumerable`** class provides a lot of extension methods



```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace Module_14_Examples
{
    class Program
    {
        static void Main( string[] args )
        {
            int[] numbers = { 10, 20, 30, 40, 1, 2, 3, 8 };

            numbers.
        }
    }
}
```

(extension) bool IEnumerable<TSource>.All<TSource>(Func<TSource,bool> predicate)
Determines whether all elements of a sequence satisfy a condition.

Exceptions:
  System.ArgumentNullException

Deferred Execution

- Query expressions are not evaluated until they're enumerated!
- This is called *Deferred Execution*

```
int[] numbers = { 10, 20, 30, 40, 0, 1, 2, 3, 8 };
var query = from i in numbers where i < 10 select 87 / i;

foreach( var i in query )
{
   Console.WriteLine( i );
}
```

- You can force evaluation through the Visual Studio debugger
  - Use the Results View of the query variable

Immediate Execution

- You can force evaluation by using conversion extension methods

```
int[] numbers = { 10, 20, 30, 40, 0, 1, 2, 3, 8 };
var query = from i in numbers where i < 10 select i;

int[] intNumbers = query.ToArray();
List<int> listNumbers = query.ToList();
```

- There are other such extension methods, e.g.
  - `ToDictionary<T,K>`

LINQ and Generic Collections

- LINQ can query data in various members of `System.Collections.Generic`

```
Stack<int> stack = new Stack<int>( new int[]{ 42, 87, 112, 255 } );
var query = from i in stack where i < 100 select i;
```

```
List<Car> cars = new List<Car>() {
   new Car{ PetName="Henry", Color="Silver", Speed=100, Make="VW" },
   new Car{ PetName="Daisy", Color="Tan", Speed=90, Make="BMW" },
   new Car{ PetName="Mary", Color="Black", Speed=55, Make="VW" },
   new Car{ PetName="Clunker", Color="Rust", Speed=5, Make="Yugo" },
   new Car{ PetName="Melvin", Color="White", Speed=43, Make="Ford" }
};

var query = from c in cars
            where c.Speed > 90 && c.Make == "BMW"
            select c;
```

LINQ and Nongeneric Collections

- Nongeneric collections lack the **`IEnumerable<T>`** infrastructure for querying
- This can be provided using the **`OfType<T>`** extension method

```
ArrayList cars = new ArrayList() {
   new Car{ PetName="Henry", Color="Silver", Speed=100, Make="BMW" },
   new Car{ PetName="Daisy", Color="Tan", Speed=90, Make="BMW" },
   new Car{ PetName="Mary", Color="Black", Speed=55, Make="VW" },
   new Car{ PetName="Clunker", Color="Rust", Speed=5, Make="Yugo" },
   new Car{ PetName="Melvin", Color="White", Speed=43, Make="Ford" }
};

IEnumerable<Car> enumerableCars = cars.OfType<Car>();
var query = from c in enumerableCars
            where c.Speed > 90 && c.Make == "BMW"
            select c;
```

LINQ and Custom Collections

- LINQ queries can be performed directly on any **`IEnumerable<T>`** type
  - Even your own types!

```
class Garage : IEnumerable<Car>
{
   ...
}
```

```
Garage g = new Garage();
var query = from c in garage
            where c.PetName.StartsWith( "F" )
            select c;

foreach (var c in query)
{
    Console.WriteLine( c.PetName );
}
```

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The **from** Clause

- Range variables and data source are specified in the **from** clause

```
Stack<int> stack = new Stack<int>( new int[]{ 42, 87, 112, 255} );
var query = from i in stack where i < 10 select i;
```

- It can define the type of the range variable as well

```
ArrayList cars = new ArrayList {
   new Car{ PetName="Henry", Color="Silver", Speed=100, Make="BMW" },
   ...
};
var query = from Car c in cars
            where c.Speed > 90 && c.Make == "BMW"
            select c;
```

- Can in fact have multiple **from** clauses…

The **where** Clause

- Filtering conditions are specified by a boolean expression in a **where** clause

```
List<Car> cars = new List<Car> {
   new Car{ PetName="Henry", Color="Silver", Speed=100, Make="BMW" },
   ...
};
var query = from c in cars
            where c.Speed > 90 && c.Make == "BMW"
            select c;
```

```
var query = from c in cars
            where c.Speed > 90
            where SomePredicate( c )
            select c;
```

- Can have multiple **where** clauses also

The **select** Clause

- Projections of results are done through the **select** clause

```
List<Car> cars = new List<Car> {
   new Car{ PetName="Henry", Color="Silver", Speed=100, Make="BMW" },
   ...
};
var query = from c in cars
            where c.Speed > 90 && c.Make == "BMW"
            select c.Make;
```

```
var query = from c in cars
            where c.Speed > 90 && c.Make == "BMW"
            select new { c.Make, c.Color };
```

- Projections can create new (anonymous) data types

The **orderby** Clause

- Results can be sorted using the **orderby** clause

```
List<Car> cars = new List<Car> {
   new Car{ PetName="Henry", Color="Silver", Speed=100, Make="BMW" },
   ...
};
var query = from c in cars
            where c.Speed >= 55
            orderby c.PetName
            select c;
```

- The order can be **ascending** (the default) or **descending**

```
var query = from c in cars
            where c.Speed >= 55
            orderby c.PetName descending, c.Color
            select c;
```

Query Operators Resolution

- These query operators are keywords with syntax highlighting and IntelliSense
- But they are resolved as extension methods in the **`Enumerable`** class

```
var query = from g in wiiGames
            where g.Length >= 18
            orderby g.Length, g
            select g.ToUpper();
```

```
var query = wiiGames.Where( g => g.Length >= 18 )
                    .OrderBy( g => g.Length )
                    .ThenBy( g => g )
                    .Select( g => g.ToUpper() );
```

- You can use either syntax or use delegates instead of anonymous methods etc.

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Count<T>

- You can compute the number of items in the result set with **Count<T>**

```
string[] wiiGames = {
   "Super Mario Galaxy",
   "FIFA 09",
   "Guitar Hero III",
   "Wii Sports",
   "Wii Fit",
   "Legend of Zelda: Twilight Princess"
};
var query = from g in wiiGames
            where g.Length >= 18
            select g;
Console.WriteLine( "{0} games match the query", query.Count() );
```

- This forces an evaluation of the query expression!

Set Operations: **Except<T>**

- Differences between queries can be computed with **`Except<T>`**

```
string[] wiiGames = {
   "Super Mario Galaxy", ...
};
string[] xbox360Games = {
   "Halo", ...
};

var query = ( from ... where ... select ... ).Except(
   ( from ... where ... select ... );
var query2 = wiiGames.Except( xbox360Games );
```

- Do you think this will evaluate the query expression? ☺
- **`Union<T>`**, **`Intersect<T>`**, and **`Except<T>`** constitute the set operations (**`Distinct<T>`** is also helpful!)

Singleton Operations

- A single element can be retrieved from a query result
  - `First<T>`
  - `Last<T>`
  - `Single<T>`

```
var query = wiiGames.Intersect( xbox360Games );

var first = query.First();
var last = query.Last();
var theOnlyOne = query.Single();

Console.WriteLine( first );
Console.WriteLine( last );
Console.WriteLine( theOnlyOne );
```

- Each of these has an …**`OrDefault<T>`** version
  - `FirstOrDefault<T>`
  - `LastOrDefault<T>`
  - `SingleOrDefault<T>`

Partitioning Operators

- Take() and Skip()

```
string[] wiiGames = {
   "Super Mario Galaxy", ...
};
string[] xbox360Games = {
   "Halo", ...
};

var query1 = wiiGames.Union( xbox360Games ).Take( 7 );
var query2 = wiiGames.Union( xbox360Games ).Skip( 3 );
```

- There are also
  - TakeWhile()
  - SkipWhile()

Lab 14: Creating LINQ Queries

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ADO.NET Entity Framework

- The de-facto standard for disconnected data access providing
  - Entity Data Models (EDM)
  - Entity SQL
  - Object Services
- It supports
  - Writing code against a conceptual model
  - Type-safe data access
  - Robustness and indepedance across storage systems
  - Maintainability
- Tools and wizards supporting
  - Database-first design
  - Code-first design

Querying and Updating Data

- Using LINQ to Entities to query data

```
using( ShopEntities entities = new ShopEntities() )
{
   var query = from c in entities.Customers
               where c.Orders.Count > 0
               select c;
   ...
}
```

- DbContext-generated class
  - keeps tracks of updates
  - saves back to database

```
using( ShopEntities entities = ... )
{
   ...
   entities.SaveChanges();
}
```

Customizing Classes

- Never modify the auto-generated classes!!
    - Instead, augment the auto-generated <u>partial</u> classes

```
public partial class Customer
{
   public string FullName => $"{FirstName} {LastName}";

   public int Age
   {
      get { return ...; }
   }
}
```

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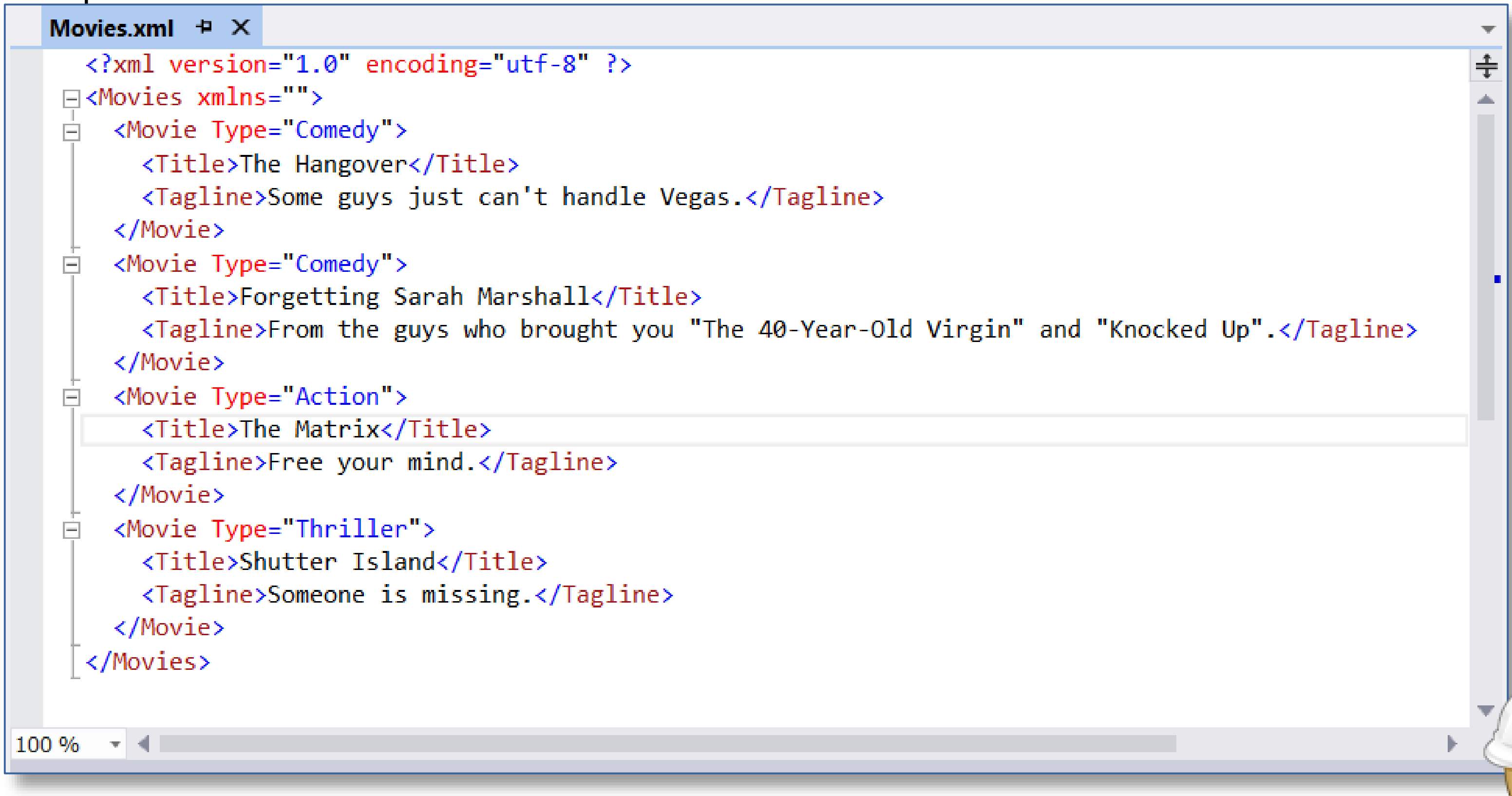
Extra: LINQ to XML Example

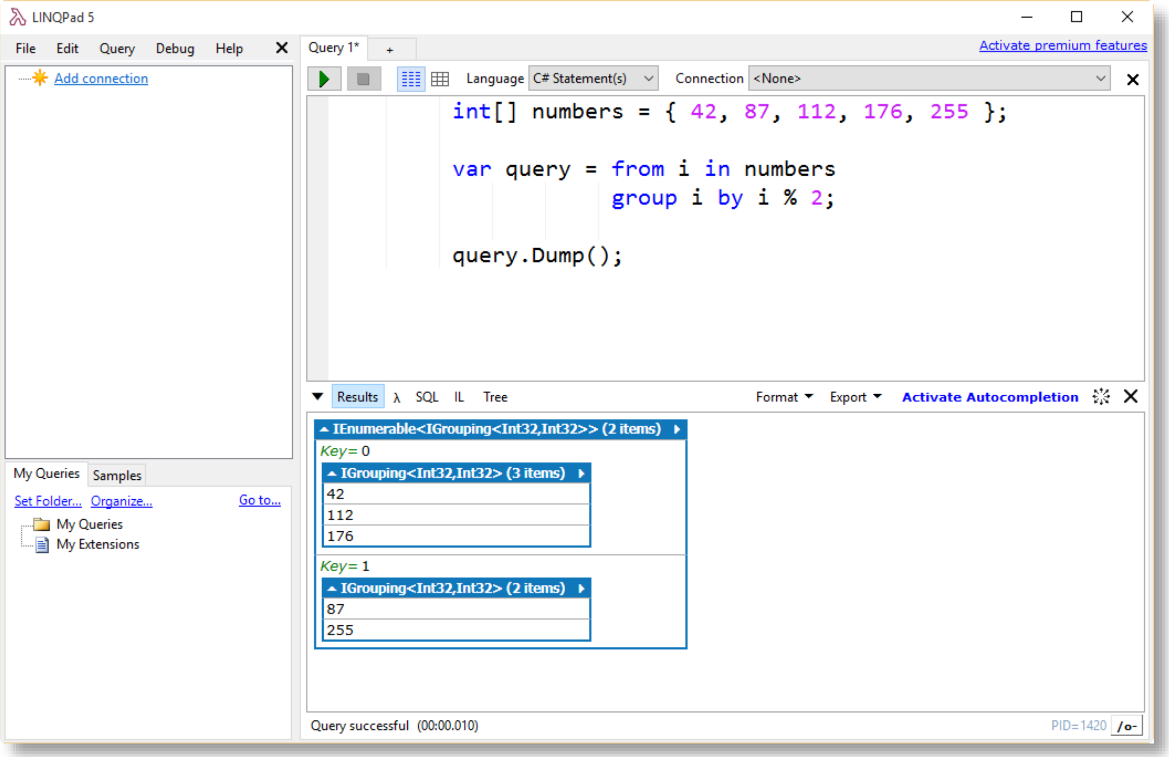
- LINQ to XML once again uses same keywords and expressions



```xml
<?xml version="1.0" encoding="utf-8" ?>
<Movies xmlns="">
  <Movie Type="Comedy">
    <Title>The Hangover</Title>
    <Tagline>Some guys just can't handle Vegas.</Tagline>
  </Movie>
  <Movie Type="Comedy">
    <Title>Forgetting Sarah Marshall</Title>
    <Tagline>From the guys who brought you "The 40-Year-Old Virgin" and "Knocked Up".</Tagline>
  </Movie>
  <Movie Type="Action">
    <Title>The Matrix</Title>
    <Tagline>Free your mind.</Tagline>
  </Movie>
  <Movie Type="Thriller">
    <Title>Shutter Island</Title>
    <Tagline>Someone is missing.</Tagline>
  </Movie>
</Movies>
```

LINQPad

- LINQPad by Joseph Albahari is indispensable!



```
int[] numbers = { 42, 87, 112, 176, 255 };

var query = from i in numbers
            group i by i % 2;

query.Dump();
```

```
IEnumerable<IGrouping<Int32,Int32>> (2 items)
Key= 0
IGrouping<Int32,Int32> (3 items)
42
112
176
Key= 1
IGrouping<Int32,Int32> (2 items)
87
255
```

Query successful (00:00.010)

PID=1420 /o-

- Get it from http://www.linqpad.net

Discussion and Review

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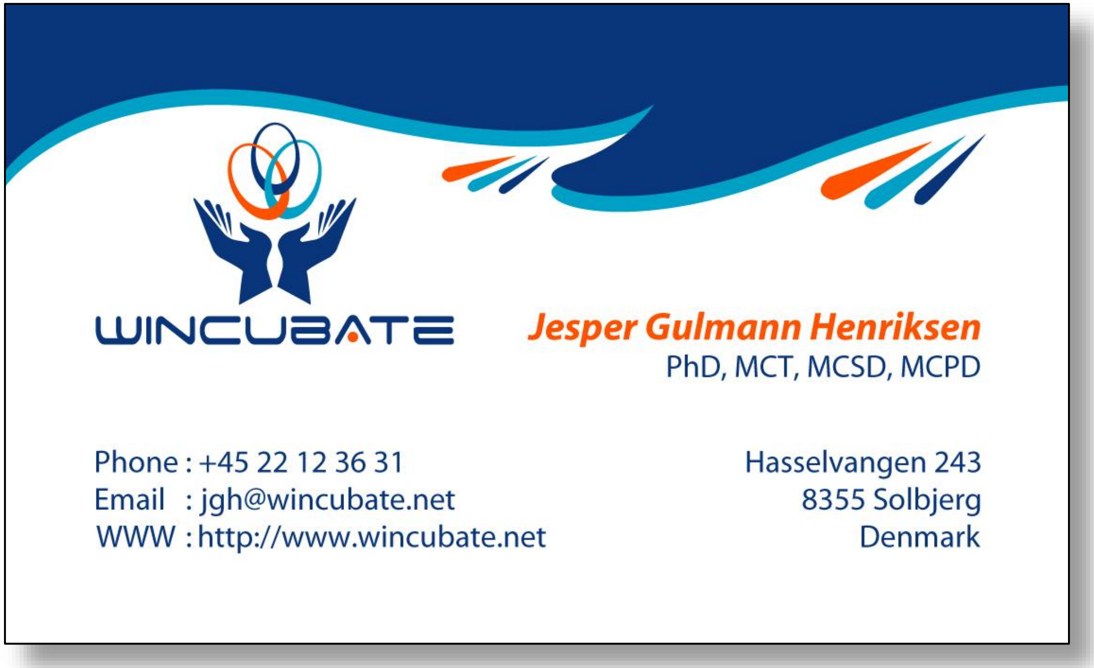

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