

LINQ & Operator Overload

Peter Levinsky IT Roskilde

06.04.2022

LINQ – A query language – like SQL

- Preconditions

- For every Data structure that support the interface:

```
public interface IEnumerable<out T>  
{  
    IEnumerator<T> GetEnumerator();  
}
```

- The **IEnumerator** interface consists of three methods:

```
bool MoveNext();  
void Reset();  
T Current { get; }
```

LINQ – A query language – like SQL

```
foreach (var t in anyDataStructure){ // initial Reset  
  
    the variable t // point at Current  
  
} // MoveNext -> true if a next element exists otherwise false  
    conditional for continuing looping
```

LINQ – A query language – like SQL

- What can you do with LINQ
- Make queries into the datastructure
- You have two forms
 - Query Language
 - Fluent syntax (Method calls)

LINQ – A query language – like SQL

- Example Query Language

```
var titlesAndYears =  
  
from m in movies  
where (m.Year < 1996 && m.Year > 1980)  
orderby m.Year  
select new {m.Title, m.Year};
```

LINQ – A query language – like SQL

- Example Fluent syntax

```
var titlesAndYears =
```

```
movies.Where(m => m.Year < 1996 && m.Year > 1980).  
OrderBy(m => m.Year).Select new {m.Title, m.Year};
```

LINQ – A query language – like SQL

- **Strength of LINQ**
 - Can be used on any datastructure if only the **IEnumerable** interface is implemented
 - I.e on a datastructure of your own, if the **IEnumerable** interface is implemented

You can use Select, Where, Orderby,

LINQ – A more advanced use

- LINQ as **Data Transformation**
 - Direct transformation
 - Aggregate functionality
- **Set-oriented** operation with LINQ
- **Parallel** LINQ (PLINQ)

LINQ – Data Transformation

- I have
- Movie: Title, Year, DurationInMins, StudioName

- I wish
- MovieInfo: Title, YearSince1900, TimeHours

```
List<MovieInfo> miList =  
    movies.Select(m => new MovieInfo(  
        m.Title,  
        m.Year - 1900,  
        m.DurationInMins / 60.0)  
    )  
    .ToList();
```

LINQ – Data Transformation

```
public static List<V> TransformItems<T, V>(
    List<T> items, Func<T,V> transformer)
{
    List<V> transformedItems = new List<V>();
    foreach (T item in items)
    {
        V transformedItem = transformer(item);
        transformedItems.Add(transformedItem);
    }
    return transformedItems;
}
```

Convert from T to V



Call:

```
List<MovieInfo> miList = Transformer.TransformItems<Movie, MovieInfo>(
    movies, m => new MovieInfo(
        m.Title, m.Year - 1900, m.DurationInMins / 60.0)
    );
```

LINQ – Actions at the object level

I wish:

```
movies.Select(m => Console.WriteLine(m)); // not working !
```

On List:

```
movies.ForEach(m => Console.WriteLine(m));  
movies.ForEach(Console.WriteLine);
```

LINQ convert to List:

```
movies  
    .Select(m => $"{m.Title}, made in {m.Year}")  
    .ToList() // this do the trick ☺  
    .ForEach(Console.WriteLine);
```

LINQ – Aggregation (different functions)

Examples:

```
List<int> numbers = new List<int>{ 21, 8, 14, 45, 30, 9, 22 };
```

```
int sum = numbers.Sum();
```

```
int max = numbers.Max();
```

```
double avg = numbers.Average();
```

LINQ – Aggregation (different functions)

General description:

```
public static T Aggregate(  
    IEnumerable<V> collection,    // the collection  
    Func<T> initialValueFunc,    // the starting value  
    Func<T,V,T> updateValueFunc) // what to do in each iteration  
{  
    T value = initialValueFunc();  
    foreach (V item in collection)  
    {  
        value = updateValueFunc(value, item);  
    }  
    return value;  
}
```

LINQ – Aggregation (different functions)

```
List<int> numbers = new List<int> { 21, 8, 14, 45 };
int product = AggregateCalculator<int,int>.Aggregate(
    numbers,                // collection
    () => 1,                // initial value
    (val, item) => val * item); // each iteration
Console.WriteLine($"Product is {product}");
```

```
List<string> words = new List<string>{ "This ", "is ", "Sparta!" };
string concatStr = AggregateCalculator<string, string>.Aggregate(
    words,                // collection
    () => "",            // initial value
    (val, item) => val + item); // each iteration
Console.WriteLine(concatStr);
```

LINQ – Set-oriented operation with LINQ

Method	Called on	Argument	Description
Except	A	B	Returns items which are in A but <u>not</u> in B.
Intersect	A	B	Returns items which are in both A <u>and</u> B.
Union	A	B	Returns items which are in either A <u>or</u> B.
Distinct	A	(none)	Removes duplicate items from A
Concat	A	B	Concatenates B to A.

If you like to support logical equality => implement the Equal-methods in the class!

LINQ – Parallel LINQ (PLINQ)

Seen Threads / Tasks for handling CPU bounds

In LINQ we have a build in functionality to parallel calculations called PLINQ

LINQ – Parallel LINQ (PLINQ)

Example – finding prime numbers – WITHOUT parallel

Method to investigate
if number is a prime

```
Stopwatch watch = new Stopwatch();  
watch.Restart();
```

```
IEnumerable<int> primes = Enumerable.Range(2, 1000000).Where(IsPrime);
```

```
int primesCount = primes.Count();  
watch.Stop();
```

```
Console.WriteLine($"Primes up to 1,000,000: {primesCount}");
```

```
Console.WriteLine($"Time spent: {watch.ElapsedMilliseconds} ms");
```



LINQ – Parallel LINQ (PLINQ)

Same example – finding prime numbers – WITH parallel

```
Stopwatch watch = new Stopwatch();  
watch.Restart();
```

```
IEnumerable<int> primes = Enumerable.Range(2, 1000000)  
    .AsParallel()           // THIS do the trick  
    .AsOrdered()           // Keep the same order  
    .Where(IsPrime);
```

```
int primesCount = primes.Count();  
watch.Stop();  
Console.WriteLine($"Primes up to 1,000,000: {primesCount}");  
Console.WriteLine($"Time spent: {watch.ElapsedMilliseconds} ms");
```

That's it

- Training: PRO.3.4, PRO.3.7

- **And the Mandatory Assignment**



Operator Overload

Peter Levinsky IT Roskilde

06.04.2022

Overload of operators

- Four categories:
 - Indexer (i.e. [])
 - +, -, *, / ... Operator
 - <= and >= Operator
 - == and != Operator

Overload - Indexer (i.e. [])

```
public class NPC
{
    private Dictionary<NPCStateTypes, int> State;

    public NPC()
    {
        State = new Dictionary<NPCStateTypes, int>();
        SetDefaultValues();
    }

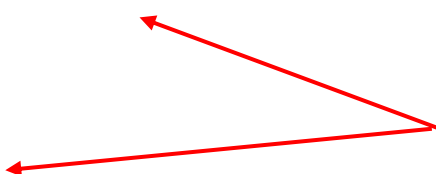
    public void SetStateValue(NPCStateTypes stateType, int
value)
    {
        State[stateType] = value;
    }

    public int GetStateValue(NPCStateTypes stateType)
    {
        return State[stateType];
    }

    private void SetDefaultValues() { ... }
}
```

```
public enum NPCStateTypes
{
    hungry, rested, aggressive, fear, gullible
}
```

**Wish to use [] Instead of
GetStateValue,
SetStateValue**



Overload - Indexer (i.e. [])

- The implementation in the class:

meaning this class

define the brackets + what's inside

```
public int this[NPCStateTypes stateType]
{
    get { return State[stateType]; }
    set { State[stateType] = value; }
}
```

Overload: +, -, *, /, ++ and -- Operator

- Example:

```
public static Time operator +(Time tA, Time tB)
{
...    // this add two time objects and return a new
}
```

Call:

```
Time timeC = timeA + timeB;
```

The general definition

```
public static TReturn operator operatorGoesHere(TA opA, TB opB)
{
...
}
```


Overload: +, -, *, /, ++ and -- Operator

- Example variation:

```
public static Time operator *(int val, Time t)
{
    int totalMin = (t.Hours * 60 + t.Minutes) * val;
    return new Time(totalMin / 60, totalMin % 60);
}
```

Call:

```
Time timeMult3A = 3 * timeA; // OK
```

but

```
Time timeMultA3 = timeA * 3; // Error
```

```
public static Time operator *(Time t, int val) // reverse parameter order
{
    return val * t;
}
```

Overload == and != Operator

If overload == also overload != 😊

```
public static bool operator ==(Time tA, Time tB)
{
    return (tA.Length == tB.Length); // tA.Equals(tB)
}
```

```
public static bool operator !=(Time tA, Time tB)
{
    return !(tA == tB);
}
```

BUT this implementations do not work – risk for NullReferenceException! DO THIS!

1. First override Equals appropriately (i.e. also checking for null)
2. As a consequence of overriding Equals, we must also override the method GetHashCode from Object.
3. Now override == and != by using Equals

Overload: <= and >= Operator (< and >)

If overload >= also overload <= 😊

```
public static bool operator >=(Time tA, Time tB)
{ // ToDo check for null
    return (tA.Length >= tB.Length);
}
```

```
public static bool operator <=(Time tA, Time tB)
{
    return (tA.Length <= tB.Length);
}
```

That's it

- Training: OOP.4.1, OOP.4.2, OOP.4.5

- **And the Mandatory Assignment**

