Seminar 12
week 12 (16 December 2019 – 20 December 2019)

A. Discussion of some possible issues regarding concurrency in your current Java project:
1. Concurrent HashMap or syncronized methods
2. Unique key generation (sync, AtomicInteger)
3. sync heap {read ... write}

B. Discuss LINQ from C# using the following examples.

Please note that the following notes and examples are taken from some LINQ tutorials available free on the web.

Before LINQ:

```
1.int[] numbers = { 3, 6, 7, 9, 2, 5, 3, 7 };
2.int i = 0;
3.
4.// Display numbers larger than 5
5.while (i < numbers.GetLength(0))
6.{
7.if (numbers[i] > 5)
8.Console.WriteLine(numbers[i]);

9.++i;
10.}
```

With LINQ, data sources could now be queried in an **SQL-like syntax**, as shown in the rewritten code snippet below:

```
int[] numbers = { 3, 6, 7, 9, 2, 5, 3, 7 };
var res = from n in numbers
          where n > 5
          select n;

foreach (int n in res)
Console.WriteLine(n);
```

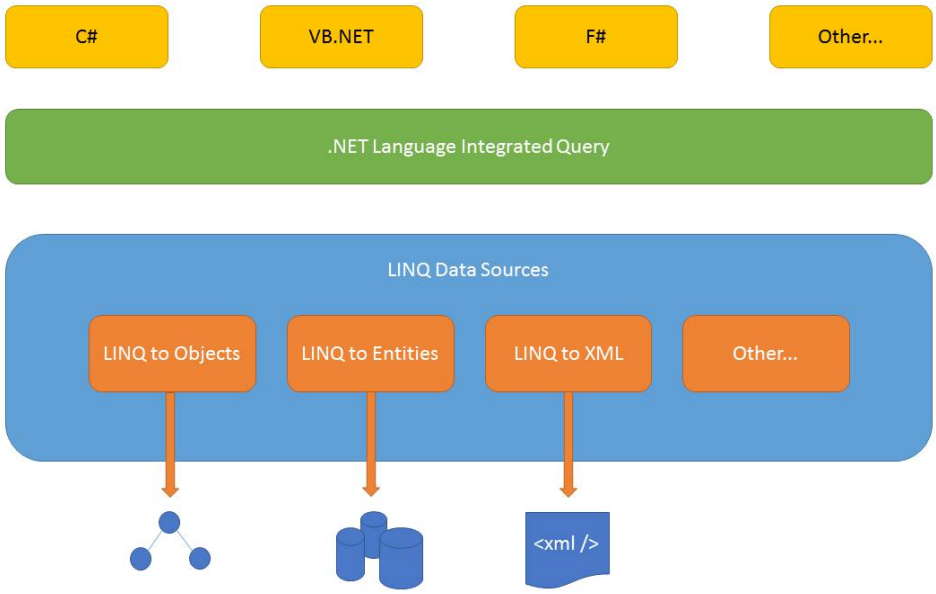
You may be interested in querying data from various sources, such as arrays, dictionaries, xml and entities created from entity framework. But instead of having to use a different API for each data source, LINQ provides a consistent and uniform programming model to work with all supported data sources.
Some of the most used LINQ data sources, which are all part the .NET framework, are:

- **LINQ to Objects**: for in-memory collections based on *IEnumerable*, such as *Dictionary* and *List*.
- **LINQ to Entities**: for Entity Framework on object context.

•**LINQ to XML**: for in-memory XML documents.

As long as you include the namespace System.Linq in your code, you are good to go with all of the above data sources.

You can use LINQ from all the popular .NET languages (C#, VB.NET and F#) as illustrated in the architecture overview below.



Example: In a collection of random numbers we want to retrieve only values greater than 50, sort them in ascending order, and lastly cast the result into strings:

LINQ offers two ways to write queries:

1) with SQL-like syntax called *Query expressions*

```
int[] numbers = { 7, 53, 45, 99 };
```

```
        var res = from n in numbers
                  where n > 50
                  orderby n
                  select n.ToString();
```

2) a method like approach called *Lambda expressions*

```
int[] numbers = { 7, 53, 45, 99 };

        var res = numbers.Where(n => n > 50)
                         .OrderBy(n => n)
                         .Select(n => n.ToString());
```

LINQ queries can execute in two different ways: deferred and immediate.

With deferred execution, the resulting sequence of a LINQ query is not generated until it is required. The following query does not actually execute until Max() is called, and a final result is required:

```
int[] numbers = { 1, 2, 3, 4, 5 };
        var result = numbers.Where(n => n >= 2 && n <= 4);
        Console.WriteLine(result.Max()); // <- query executes at this point

        // Output:
        //4
```

Example:
Instead of LINQ having to first iterate over all three chains (first Select(), then Where() and lastly ToList()) the result is not generated until it meets ToList():

```
string[] words = { "one", "two", "three" };
        var result = words.Select((w, i) => new { Index = i, Value = w }).Where(w =>
        w.Value.Length == 3).ToList();

        Debug.WriteLine("Prints index for words that have a string length of 3:");
        foreach(var word in result)
        Debug.WriteLine (word.Index.ToString());

        // Output:
        // Prints index for words that have a string length of 3:
        // 0
        // 1
```

Adding items to an existing query is another benefit of deferred execution. The following example shows the concept:

```
List vegetables = new List { "Carrot", "Selleri" };
        var result = from v in vegetables select v;
        Debug.WriteLine("Elements in vegetables array (before add): " + result.Count());
        vegetables.Add("Broccoli");
        Debug.WriteLine("Elements in vegetables array (after add): " + result.Count());
        // Output:
        // Elements in vegetables array (before add): 2
        // Elements in vegetables array (after add): 3
```

Deferred execution makes it useful to combine or extend queries. Have a look at this example, which creates a base query and then extends it into two new separate queries:

```
int[] numbers = { 1, 5, 10, 18, 23};
var baseQuery = from n in numbers select n;
var oddQuery = from b in baseQuery where b % 2 == 1 select b;

Debug.WriteLine("Sum of odd numbers: " + oddQuery.Sum()); // <- query executes at this point

var evenQuery = from b in baseQuery where b % 2 == 0 select b;
Debug.WriteLine("Sum of even numbers: " + evenQuery.Sum()); // <- query executes at this point

// Output:
// Sum of odd numbers: 29
// Sum of even numbers: 28
```

LINQ Operators(some of them)

Aggregate: Performs a specified operation to each element in a collection, while carrying the result forward.

```
var numbers = new int[] { 1, 2, 3, 4, 5 };

    var result = numbers.Aggregate((a, b) => a * b);

    Debug.WriteLine("Aggregated numbers by multiplication:");
    Debug.WriteLine(result);

//Output:
//Aggregated numbers by multiplication:
//120
```

Any: Checks if any elements in a collection satisifies a specified condition.

```
string[] names = { "Bob", "Ned", "Amy", "Bill" };

    var result = names.Any(n => n.StartsWith("B"));

    Debug.WriteLine("Does any of the names start with the letter 'B':");
    Debug.WriteLine(result);
```

ElementAtOrDefault: Retrieves element from a collection at specified (zero-based) index, but gets default value if out-of-range.

```
string[] colors = { "Red", "Green", "Blue" };

    var resultIndex1 = colors.ElementAtOrDefault(1);

    var resultIndex10 = colors.ElementAtOrDefault(10);

    Debug.WriteLine("Element at index 1 in the array contains:");
    Debug.WriteLine(resultIndex1);

    Debug.WriteLine("Element at index 10 in the array does not exist:");
    Debug.WriteLine(resultIndex10 == null);
```

Output:

```
//Element at index 1 in the array contains:
//Green
//Element at index 10 in the array does not exist:
//True
```

SelectMany: Flattens collections into a single collection (similar to cross join in SQL).

```
 string[] fruits = { "Grape", "Orange", "Apple" };
    int[] amounts = { 1, 2, 3 };

    var result = fruits.SelectMany(f => amounts, (f, a) => new
    {
        Fruit = f,
        Amount = a
    });

    Debug.WriteLine("Selecting all values from each array, and mixing them:");
    foreach (var o in result)
        Debug.WriteLine(o.Fruit + ", " + o.Amount);
}
```

Output:
Selecting all values from each array, and mixing them:
Grape, 1
Grape, 2
Grape, 3
Orange, 1
Orange, 2
Orange, 3
Apple, 1
Apple, 2
Apple, 3

ToDictionary: Converts collection into a Dictionary with Key and Value.

```
class English2German
{
   public string EnglishSalute { get; set; }
   public string GermanSalute { get; set; }
}

static void Sample_ToDictionary_Lambda_Simple()
{
   English2German[] english2German =
   {
      new English2German { EnglishSalute = "Good morning", GermanSalute = "Guten Morgen" },
      new English2German { EnglishSalute = "Good day", GermanSalute = "Guten Tag" },
      new English2German { EnglishSalute = "Good evening", GermanSalute = "Guten Abend" },
   };

   var result = english2German.ToDictionary(k => k.EnglishSalute, v => v.GermanSalute);

   Debug.WriteLine("Values inserted into dictionary:");
   foreach (KeyValuePair<string, string> dic in result)
      Debug.WriteLine(String.Format("English salute {0} is {1} in German", dic.Key, dic.Value));
}
```

Output:
Values put into dictionary:
English salute Good morning is Guten Morgen in German
English salute Good day is Guten Tag in German
English salute Good evening is Guten Abend in German

AsEnumerable: casts a collection to IEnumerable of same type.

```
string[] names = { "John", "Suzy", "Dave" };

    var result = names.AsEnumerable();

    Debug.WriteLine("Iterating over IEnumerable collection:");
    foreach (var name in result)
        Debug.WriteLine(name);
```

Concat: Concatenates (combines) two collections.

```
int[] numbers1 = { 1, 2, 3 };
    int[] numbers2 = { 4, 5, 6 };

    var result = numbers1.Concat(numbers2);

    Debug.WriteLine("Concatenating numbers1 and numbers2 gives:");
    foreach (int number in result)
        Debug.WriteLine(number);
}
```

Output:

```
Concatenating numbers1 and numbers2 gives:
1
2
3
4
5
6
```

Distinct: Removes duplicate elements from a collection

```
int[] numbers = { 1, 2, 2, 3, 5, 6, 6, 6, 8, 9 };

    var result = (from n in numbers.Distinct()
                  select n);

    Debug.WriteLine("Distinct removes duplicate elements:");
    foreach (int number in result)
        Debug.WriteLine(number);
}
```

Output:

```
Distinct removes duplicate elements:
1
2
```

3
5
6
8
9

Except: Removes all elements from one collection which exist in another collection.

```
int[] numbers1 = { 1, 2, 3 };
   int[] numbers2 = { 3, 4, 5 };

   var result = (from n in numbers1.Except(numbers2)
                 select n);

   Debug.WriteLine("Except creates a single sequence from numbers1 and removes the duplicates
found in numbers2:");
   foreach (int number in result)
      Debug.WriteLine(number);
}
```

Output:
Except creates a single sequence from numbers1 and removes the duplicates found in numbers2:
1
2

GroupBy: Projects elements of a collection into groups by key.

```
int[] numbers = { 10, 15, 20, 25, 30, 35 };

   var result = from n in numbers
                group n by (n % 10 == 0) into groups
                select groups;

   Debug.WriteLine("GroupBy has created two groups:");
   foreach (IGrouping<bool, int> group in result)
   {
      if (group.Key == true)
         Debug.WriteLine("Divisible by 10");
      else
         Debug.WriteLine("Not Divisible by 10");

      foreach (int number in group)
         Debug.WriteLine(number);
   }
}
```

Output:
GroupBy has created two groups:
Divisible by 10
10
20

30
Not Divisible by 10
15
25
35

Intersect: Takes only the elements that are shared between two collections.

```
 int[] numbers1 = { 1, 2, 3 };
   int[] numbers2 = { 3, 4, 5 };

   var result = (from n in numbers1.Intersect(numbers2)
                 select n);

   Debug.WriteLine("Intersect creates a single sequence with only the duplicates:");
   foreach (int number in result)
      Debug.WriteLine(number);
}
```

Output:
Intersect creates a single sequence with only the duplicates:
3

Join: Joins two collections by a common key value, and is similar to inner join in SQL

```
string[] warmCountries = { "Turkey", "Italy", "Spain", "Saudi Arabia", "Etiopia" };
   string[] europeanCountries = { "Denmark", "Germany", "Italy", "Portugal", "Spain" };

   var result = (from w in warmCountries
                 join e in europeanCountries on w equals e
                 select w);

   Debug.WriteLine("Joined countries which are both warm and European using Query Syntax:");
   foreach (var country in result)
      Debug.WriteLine(country);
}
```

Output:
Joined countries which are both warm and European using Query Syntax:
Italy
Spain

OrderBy: Sorts a collection in ascending order.

```
class Car
{
   public string Name { get; set; }
   public int HorsePower { get; set; }
}

static void Sample_OrderBy_Linq_Objects()
{
   Car[] cars =
      {
         new Car { Name = "Super Car", HorsePower = 215 },
         new Car { Name = "Economy Car", HorsePower = 75 },
         new Car { Name = "Family Car", HorsePower = 145 },
      };

   var result = from c in cars
                orderby c.HorsePower
                select c;

   Debug.WriteLine("Ordered list of cars by horsepower using Query Syntax:");
   foreach (Car car in result)
      Debug.WriteLine(String.Format("{0}: {1} horses", car.Name, car.HorsePower));
}
```

Output:

```
Ordered list of cars by horsepower using Query Syntax:
Economy Car: 75 horses
Family Car: 145 horses
Super Car: 215 horses
```

Range: Generates sequence of numeric values.

```
 var result = from n in Enumerable.Range(0, 10)
                select n;

   Debug.WriteLine("Counting from 0 to 9:");
   foreach (int number in result)
      Debug.WriteLine(number);
}
```

Output:

```
Counting from 0 to 9:
0
1
2
3
4
```

5
6
7
8
9

Repeat: Creates a collection of repeated elements, where first argument is value to repeat, and second argument is number of times to repeat.

```
string word = "Banana";

    var result = from w in Enumerable.Repeat(word, 5)
                 select w;

    Debug.WriteLine("String is repeated 5 times:");
    foreach (string str in result)
        Debug.WriteLine(str);
}
```

Output:
String is repeated 5 times:
Banana
Banana
Banana
Banana
Banana

Reverse: Reverses elements in a collection.

```
char[] characters = { 's', 'a', 'm', 'p', 'l', 'e' };

    var result = (from c in characters.Reverse()
                  select c);

    Debug.WriteLine("Characters in reverse order:");
    foreach (char character in result)
        Debug.WriteLine(character);
}
```

Output:
Characters in reverse order:
e
l
p
m
a
s

SkipWhile: Skips elements in a collection while specified condition is met.

```
string[] words = { "one", "two", "three", "four", "five", "six" };

    var result = words.SkipWhile(w => w.Length == 3);

    Debug.WriteLine("Skips words while the condition is met:");
    foreach (string word in result)
        Debug.WriteLine(word);
}
```

Output:

```
Skips words while the condition is met:
three
four
five
```

Take: Takes specified number of elements in a collection, starting from first element.

```
 int[] numbers = { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 };

    var result = numbers.Take(5);

    Debug.WriteLine("Takes the first 5 numbers only:");
    foreach (int number in result)
        Debug.WriteLine(number);
}
```

Output:

```
Takes the first 5 numbers only:
1
2
3
4
5
```

ThenBy: Use after earlier sorting, to further sort a collection in ascending order.

```
string[] capitals = { "Berlin", "Paris", "Madrid", "Tokyo", "London", "Athens", "Beijing",
"Seoul" };

    var result = (from c in capitals
                  orderby c.Length
                  select c)
                 .ThenBy(c => c);

    Debug.WriteLine("Ordered list of capitals, first by length and then alphabetical:");
    foreach (string capital in result)
        Debug.WriteLine(capital);
```

```
}
```
Output:
Ordered list of capitals, first by length and then alphabetical:
Paris
Seoul
Tokyo
Athens
Berlin
London
Madrid
Beijing

Union: Combines two collections and removes duplicate elements.

```
int[] numbers1 = { 1, 2, 3 };
   int[] numbers2 = { 3, 4, 5 };

   var result = (from n in numbers1.Union(numbers2)
                 select n);

   Debug.WriteLine("Union creates a single sequence and eliminates the duplicates:");
   foreach (int number in result)
      Debug.WriteLine(number);
}
```
Output:
Union creates a single sequence and eliminates the duplicates:
1
2
3
4
5

Zip: Processes two collections in parallel with func instance, and combines result into a new collection.

```
int[] numbers1 = { 1, 2, 3 };
   int[] numbers2 = { 10, 11, 12 };

   var result = numbers1.Zip(numbers2, (a, b) => (a * b));

   Debug.WriteLine("Using Zip to combine two arrays into one (1*10, 2*11, 3*12):");
   foreach (int number in result)
      Debug.WriteLine(number);
}
```
Output:
Using Zip to combine two arrays into one (1*10, 2*11, 3*12):
10
22
36