C# programming language

Majeure big data & analytics (M1)

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V 0.5 (20 of January 2020)

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Document history

V 0.5	20 of January 2020
V 0.4	20 of January 2020
V 0.3	13 of January 2020
V 0.2	13 of January 2020
V 0.1	6 of January 2020

Personal background

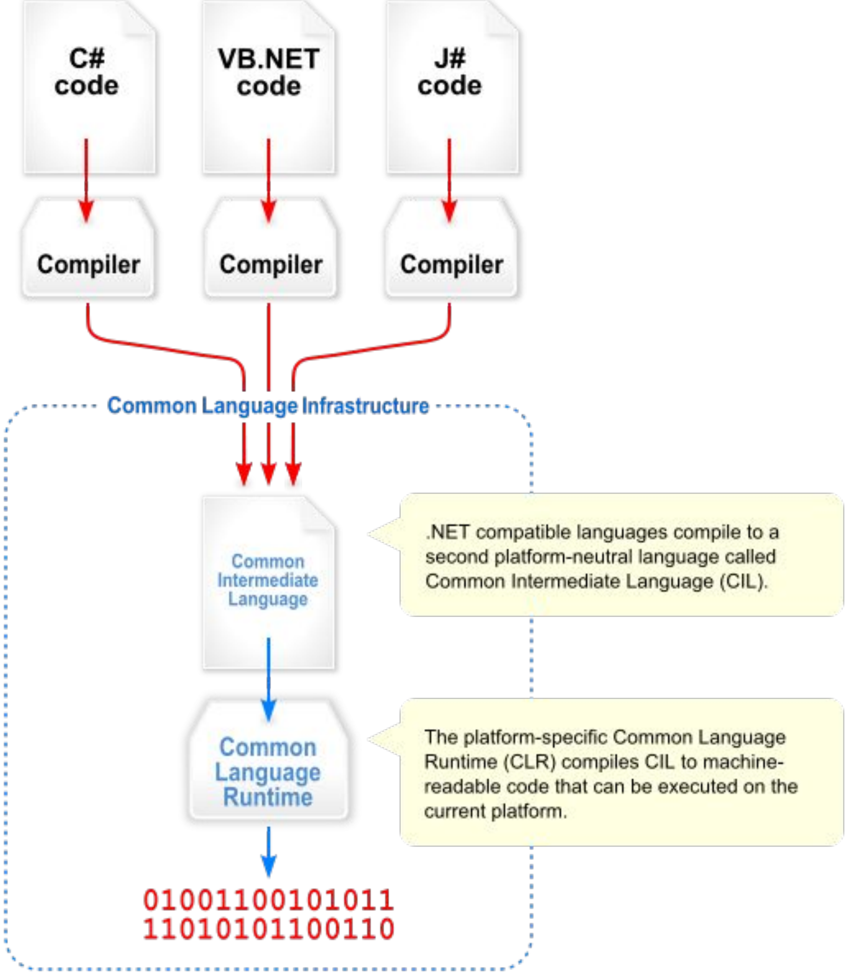
- Benoît Prieur, Soarthec (own company)
- (.Net) Freelance Software developer for years (MCP), C# & VB.NET
- 2 books in French about .Net:
  - *Programmation en C# - Préparation aux certifications MCSA - Examen 70-483* (2018)
  - *WPF - Développez des applications structurées (MVVM, XAML...)* (2017)
- Practical course on quantum computing gave at ECE Paris (2019)

Native *vs* Managed

- C/C++ building (compiling/linking) => Win32 application (binary)
- Virtual machine
    - JVM, Java
    - CLR (Common Language Runtime) .Net
        - C#/VB.NET => Common Intermediate Language (CIL) => Binary (Assembly, Executable)

CIL & CLR architecture

Credit: Jarkko Piiroinen [Public domain], Wikimedia Commons



.NET compatible languages compile to a second platform-neutral language called Common Intermediate Language (CIL).

The platform-specific Common Language Runtime (CLR) compiles CIL to machine-readable code that can be executed on the current platform.

MSIL example

```
using System;

public class Hello
{
        public static void Main()
        {
                Console.WriteLine("Hello
World");
        }
}
```

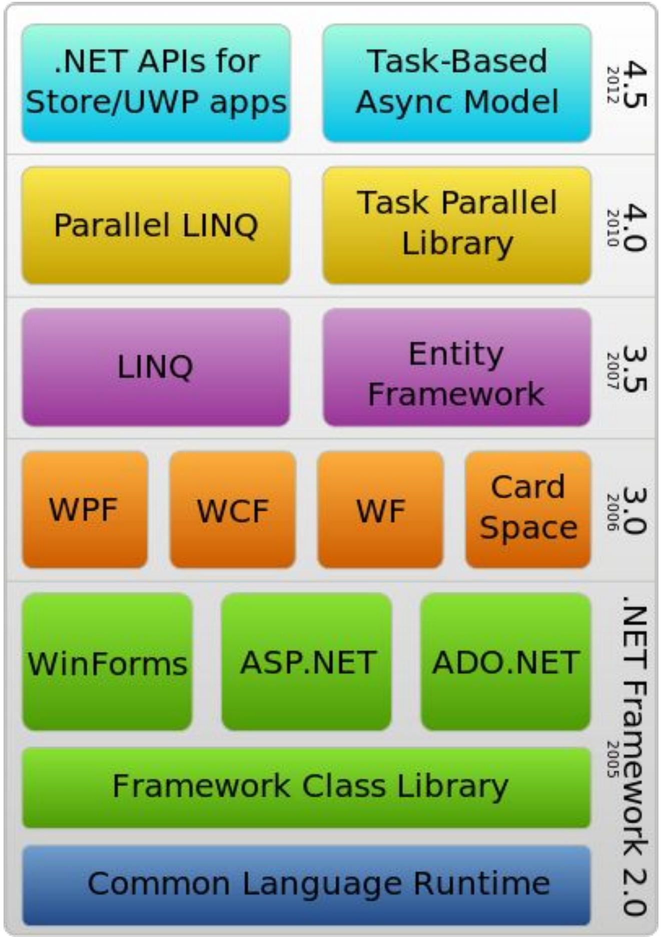
=>

```
.assembly Hello {}
.assembly extern mscorlib {}
.method static void Main()
{
   .entrypoint
   .maxstack 1
   ldstr "Hello, world!"
   call void [mscorlib]System.Console::WriteLine(string)
   ret
}
```

.Net history

- Beta Version (2001)
- Version 1 (2002)
- Version 3.5 (2008), LINQ (*Language Integrated Query*)
- Version 4.5 (2012), asynchronism
- Version 4.6 (2015), Linux support

Credit: Soumyasch [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0/)]



.NET APIs for Store/UWP apps

Task-Based Async Model

4.5 2012

Parallel LINQ

Task Parallel Library

4.0 2010

LINQ

Entity Framework

3.5 2007

WPF

WCF

WF

Card Space

3.0 2006

WinForms

ASP.NET

ADO.NET

Framework Class Library

Common Language Runtime

.NET Framework 2.0 2005

.Net Framework

- Composed by *namespaces* including *classes*.
- Namespaces and classes (similarities with Java language).
- About 10.000 classes included in specialized namespaces.
- Every class inherits from *Object* class (directly or not).

Beginning with C# language and VS Studio

```
using System;

public class Main
{
          public static void Main()
          {
             Console.WriteLine("Hello World");
          }
}
```

***Hello world* program:**

- Create a new project.
- Keyword ***using*** for referencing a namespace.
- *Console*, ***static*** class included in *System*.
- VS Studio: *Quick action and refactoring*.
- ***System.Diagnostics.Debug***
- Add a breakpoint.
- VS Studio: debug *vs* release.

C# syntax introduction

Deeply inspired from C/C++:

- Block definition with brackets: **{ … }**
- Statement separator (end of statement): **;**
- Flow control, conditions, loops: **if switch for while**
- Arithmetic operators: **+ - * / % ^**
- Logical operators: **& && | ||**

Before oriented object programming in C#

Visibility:

- *public*, no restriction
- *protected*, limited to class and derivatives
- *internal*, limited to the current assembly
- *private, limited to the current instance*

Instance construction:

- Default constructor
- Explicit constructor
- Copy constructor

Instance destruction:

- Garbage collector, automatically called at the end of scope.
- Usage of ***Dispose*** for non-managed resources.

C# and oriented object programming (1)

Encapsulation:

```
class Car
{
      protected string color;
      protected int numberDoors;

      public Car(string c, int n)
      {
         color = c;
         numberDoors = n;
      }
```

```
      public void start() {
         //implementation
      }

      public void stop() {
         //implementation
      }
}
```

```
static void Main(string[] args){
  Car mycar = new Car("red", 5);
}
```

C# and oriented object programming (2)

Inheritance:

- Possibility to declare a visibility.
- ***abstract*** class can be used (cannot be instantiated).
- Keyword ***sealed***: class cannot be derived.
- A method should be ***virtual*** (or *abstract*) to allow overriding (keyword ***override***)
- The base class behavior can be called with ***base*** keyword.

```
abstract class Vehicle
{
  public string Brand { get; set; }
}

class Car : Véhicule
{
 ...
}
```

C# and oriented object programming (3)

Polymorphism:

- Inheritance of more than class (can be from classes or interfaces).
- Precisions about interfaces.

```
interface INavigation
{
  void navigate();
}

class Car : Vehicle, INavigation
{
  ...

  public void navigate()
  {
    // implementation
  }
}
```

Value type *vs* reference type

- A value type is stored directly on the stack.
- A reference type is stored on the heap.
- **In C#, value types are:**
  - *struct* (structure)
  - *enum* (enumeration)
  - Numeric types: *int*, *float*, *decimal*, *bool* etc.
- **in C#, reference types are kind of pointers:**
  - *class*
  - *interface*
  - *delegate* (a delegate is an object which refers to a method).
  - Types like *string*, *dynamic*, *object.*

Define a C# enumeration

```
enum DAYS : int { MONDAY = 1,
    TUESDAY,
    WEDNESDAY,
    THURSDAY,
    FRIDAY,
    SATURDAY,
    SUNDAY }
```

Attribute [FLAGS]:

```
using System;

namespace Example
{
  [Flags]
  enum COLOR : int
  {
     RED = 1,
     GREEN = 2,
     BLUE = 4
   };
}
```

```
// Main
COLOR mycolor =
COLOR.RED | COLOR.BLUE;
string s = mycolor.ToString();
console.WriteLine("Current
color : " + s);
```

Structure in C#

- Public visibility by default.
- No empty constructor.
- No inheritance.

```
struct Coord
{
  public float latitude, longitude;
  public Coord(float lat, float lon)
  {
    latitude = lat;
    longitude = lon;
  }
}
```

C# class accessors

```
classe  Foo
{
    public int Data { get; set; }
}
```

<=>

```
classe  Foo
{
    private int data;
    public int Data
    {
        get { return data; }
        set { data = value; }
    }
}
```

Nullable type

- Value types cannot be ***null***.
- Usage of the operator **?** to declare nullable value types.

```
int? ii = 42;
double? dd = 42.42;
bool? bb = null;
char? cc = '42';
double?[] tt = double int?[10];
```

```
int? ii = 42
if (x.HasValue)
{
   System.Console.WriteLine(ii.Value);
}
else
{
   System.Console.WriteLine("No value");
}
```

Parameters modifiers in functions/methods

- Value types are passed by value (copy).
- ***ref*** modifier
  - Can be modified.
  - Must be initialized.
- ***out*** modifier
  - Can be modified.
  - Can be not initialized.

Constant variables/attributes

- Two keywords:
  - ***const***, must be initialized.
  - ***readonly***, initialization is not mandatory.

Dev 1

Write a C# Sharp program to find the sum of first n natural numbers.
The user gives the number n.

Expected Output :

```
        The first 10 natural number is:
1 2 3 4 5 6 7 8 9 10
        The Sum is : 55
```

```
// Help
string str = Console.ReadLine();
int i = double.Parse(str);
```

- *overrid*
- *e*

Dev 2

Provide a scalar product calculation for 2D, 3D

- *Define an abstract class Vector including an abstract method Scalar.*
- *Define two classes Vector2D and Vector3D which inherit from Vector.*
    - *Each class includes a override method Scalar.*
    - *Dimension (2 or 3) can be defined in the base class*

Dev 2 (a code solution)

```
using System;

namespace ConsoleApp1
{
    public abstract class Vector
    {
        int dimension;
        public abstract double scalar(Vector V2);

        public Vector(int d)
        {
            dimension = d;
        }
    }

    partial class Program
    {
        static void Main(string[] args)
        {
            Vector2d v = new Vector2d(5.0, 3.0);
            Vector2d w = new Vector2d(-5.0, -3.0);
            Console.WriteLine(v.scalar(w).ToString());
        }
}
```

```
public class Vector2d : Vector
    {
        double x;
        double y;

        public double X { get => x; set => x = value; }
        public double Y { get => y; set => y = value; }

        public override double scalar(Vector v)
        {
            Vector2d v2 = (Vector2d)v;
            return this.x * v2.X + this.y * v2.Y;
        }

        public Vector2d(double xx, double yy) : base(2)
        {
            this.X = xx;
            this.Y = yy;
        }
    }
}
```

Type casting and conversion

- Numeric types:
    - ***TryParse***, includes a *try...catch* management.
    - **Parse**. no exception management.
- Type ***string*** (reference type):
    - ***ToString()*** when available.
- Casting:
    - *(ExampleType)obj* => can throws an exception.

String in C#

- Is a reference type (address + size).
- There exists a class ***String*** which provides methods:
  - *SubString, StartsWith, EndWith etc..*
- Type string is ***immutable***.
- Another type is ***mutable*** in C#: ***StringBuilder***.

Exception management in C#

```
try {
    // ...
}
catch (System.Exception e) {
     // …
    throw new Exception();
}
finally {
    // ...
}
```

Interfaces in C#, syntax

```
Interface ICar {
        void Start();
        void Stop();
}

class Car : ICar {
        void Start() {}
        void Stop() {}
}
```

Containers and data structure (1): arrays

- Arrays are like in C++.
- It exists a class ***Array*** in C#: set of methods.

```
// Single dimension
int[] a = new int[] { 1, 2 };

// 2-dimensions
int[,] b = new int[,] { { 1, 2 }, { 3, 4 } };
```

```
Array.Reverse(a);

Array.LastIndexOf(a, 1);

Array.Sort(a);

// etc.
```

Containers and data structure (2): ICollection implementation

- Data structure implementing ICollection.
- For example: ***ArrayList***, ***Queue***, ***Stack***, ***HashTable***, ***SortedList***, ***Dictionnary***.
- Generic types: ***Dictionary<T>***.
- Notion of iterator: ***for each***.

Containers and data structure (3): example with Dictionary<T>

```
class Car
{
   public int ID { get; set; }
   public int NbDoors { get; set; }
   public int Year { get; set; }

   public Car(int id, int nb, int yyyy)
   {
      ID = id;
      NbDoors = nb;
      Year = yyyy;
   }
}
```

```
class Program
{
   static void Main(string[] args)
   {
      Dictionary<int, Car> dict = new Dictionary<int, Car>();

      Car car1 = new Car(12345, 5, 2006);
      dict.Add(car1.ID, car1);

      Car car2 = new Car(21345, 3, 2005);
      dict.Add(car2.ID, car2);

      foreach(KeyValuePair<int, Car> entry in dict)
      {
         Console.WriteLine(entry.Key.ToString() + ": " + entry.Value.Year.ToString();
      }
   }
}
```

Reflection in C#

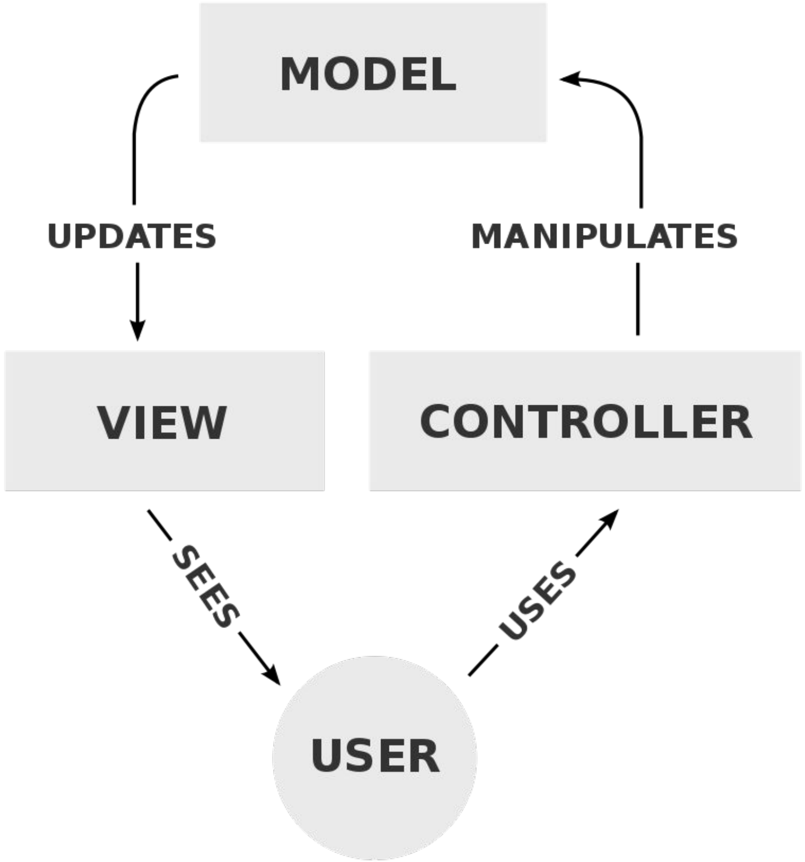
- Capability to describe modules, assemblies, types.
- Get metadata (classe) from an instance.

```
int i = 42;
Type type = i.GetType();
Console.WriteLine(type);
```

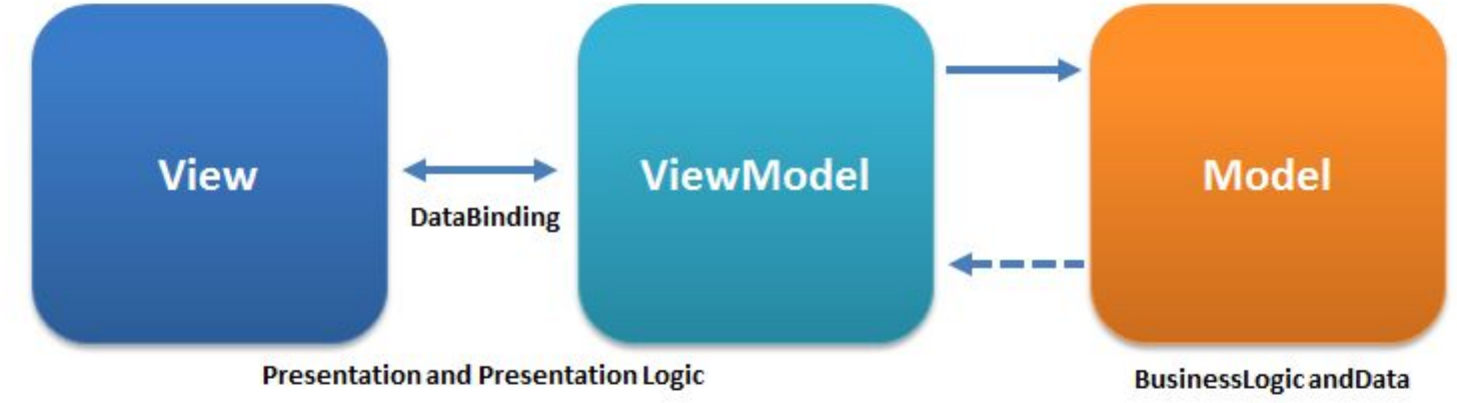
```
Type myType =(typeof(MyTypeClass));

 MethodInfo[] myArrayMethodInfo =
myType.GetMethods(BindingFlags.Public|BindingFlags.Instance|BindingFlags.DeclaredOnly);
```

Model–view–controller (ASP.NET MVC)

Credit: RegisFrey [Public domain]



Model–view–viewmodel (WPF)



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XAML (Extensible Application Markup Language)

- XML extension.
- C# code-behind (in View itself).

```
<Canvas xmlns="http://schemas.microsoft.com/client/2007"
xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml">

  <TextBlock>Hello, world!</TextBlock>

</Canvas>
```

MVVM and WPF: DataContext & Binding

- Windows Presentation Foundation.
- Declaring a DataContext on the View side.
- Binding between View (V) and View-Model (VM).

WPF & XAML: DataContext

```
public partial class MainWindow : Window
{
   public MainWindow()
   {
      InitializeComponent();
      this.DataContext = new VM();
   }
}
```

WPF & XAML: *INotifyPropertyChanged*

```
class VM : INotifyPropertyChanged
{
   public event PropertyChangedEventHandler PropertyChanged;
   protected virtual void OnPropertyChanged(string propertyName)
   {
      if (this.PropertyChanged != null)
      {
         this.PropertyChanged(this, new
PropertyChangedEventArgs(propertyName));
      }
 }
```

```
private int myValue;
public int MyValue
{
   get { return this. myValue;  }
   set
   {
      this. myValue = value;
      OnPropertyChanged("MyValue");
   }
}
```

WPF & XAML: Binding, first example

- *<TextBlock Text="{Binding MyValue}" Width="500" Height="100" />* (XAML code)
- Obtaining updated value:
  - In VM from V.
  - In V from VM.
  - Both (Bidirectional).

WPF & XAML: binding collections, *INotifyCollectionChanged*

- With collection, Binding must monitor every update of every value but also monitors Add/Remove inside the collection itself.
- *INotifyCollectionChanged*
- Objects ever implementing *INotifyCollectionChanged*
    - *ObservableCollection*
    - *DataView* (easily defining from a DataTable).

A word about *DataSet, DataTable, DataRow*

- ADO .NET

```
static DataTable GetTable()
{
   DataTable table = new DataTable();
   table.Columns.Add("ID", typeof(int));
   table.Columns.Add("Name", typeof(string));

   table.Rows.Add(1, "John Doe");
   table.Rows.Add(2, "Benoît Prieur");

  DataView dv = new DataView(table);

  return dv;

}
```

Dev 3: a first WPF client

- *Teams for the final project.*
- *Countries and capital cities stored in a CSV file.*
- *Model in charge to read this file and provides data.*
- *Obligation to respect MVVM.*
- *On the view:*
    - *A ComboBox (or a autocomplete TextBox) in charge to search for a country.*
    - *Displaying the associated capital city.*

A solution here => https://github.com/benprieur/CSharp-WPF-20200113

WPF Controls (1)

- Web site in French: https://www.wpf-tutorial.com/
  - From https://www.wpf-tutorial.com/fr/14/les-controles-de-base/le-controle-textblock/

WPF Controls (2)

- TextBlock
- Label
- TextBox (autocomplete)
- Button
- CheckBox
- Image (very important for the final project)
- ComboBox: https://www.wpf-tutorial.com/list-controls/combobox-control/

WPF Controls (3) - Layout controls

- WrapPanel, DockPanel, StackPanel: https://www.wpf-tutorial.com/fr/25/panels/le-controle-wrappanel/
- Grid: https://www.wpf-tutorial.com/fr/28/panels/la-grid/

WPF Controls (4) - ListView

- https://www.wpf-tutorial.com/listview-control/simple-listview/
- https://www.wpf-tutorial.com/listview-control/listview-data-binding-item-template/

WPF Controls (5) - Styles

- https://www.wpf-tutorial.com/styles/using-styles/

Final Dev - Option 1 - OpenFoodFacts

- An example of category in French:
  - https://fr.openfoodfacts.org/categorie/pains.json
- List of categories:
  - https://fr.openfoodfacts.org/categories.json
- *Display a list with results including for each product: image, ingredients etc. Pagination is a plus.*

Final Dev - Option 2 - Wikidata & Postal code

- SPARQL Request:
    - https://w.wiki/Foq
- Display a list of communes related to this postal code. for each commune display image, area, population+date, maximum of available data in tuning SPARQL request.

Asynchronous call in C#: await & async

```
static async void ExampleAsync()
{
   int t = await Task.Run(() => FunctionAsyncCall());
   Console.WriteLine("Compute: " + t);
}

static int FunctionAsyncCall()
{
   // Long treatment
   return size;
}
```

Http request in C#

```
static HttpClient client = new HttpClient();
 static async Task<Result> GetProductAsync(string path)
 {
    Result res = null;
    HttpResponseMessage response = await client.GetAsync(path);
    if (response.IsSuccessStatusCode)
       res = await response.Content.ReadAsAsync<Product>();
    return res;
 }
```