



## C# programming language

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# C# programming language

Majeure big data & analytics (M1)

ECE Paris, January-March 2020

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## Document history

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# Personal background

- Benoît Prieur, Soartheç (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)

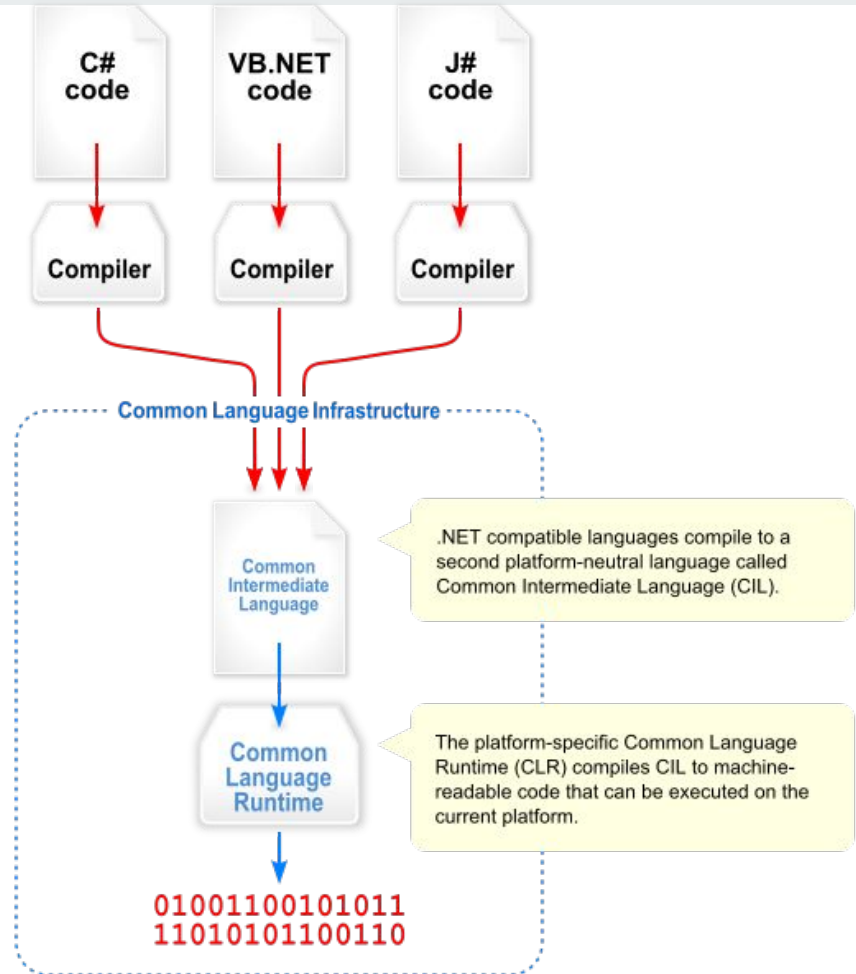


# Native vs Managed

- 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 Piironen [Public domain], [Wikimedia Commons](#)





# MSIL example

```
using System;

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

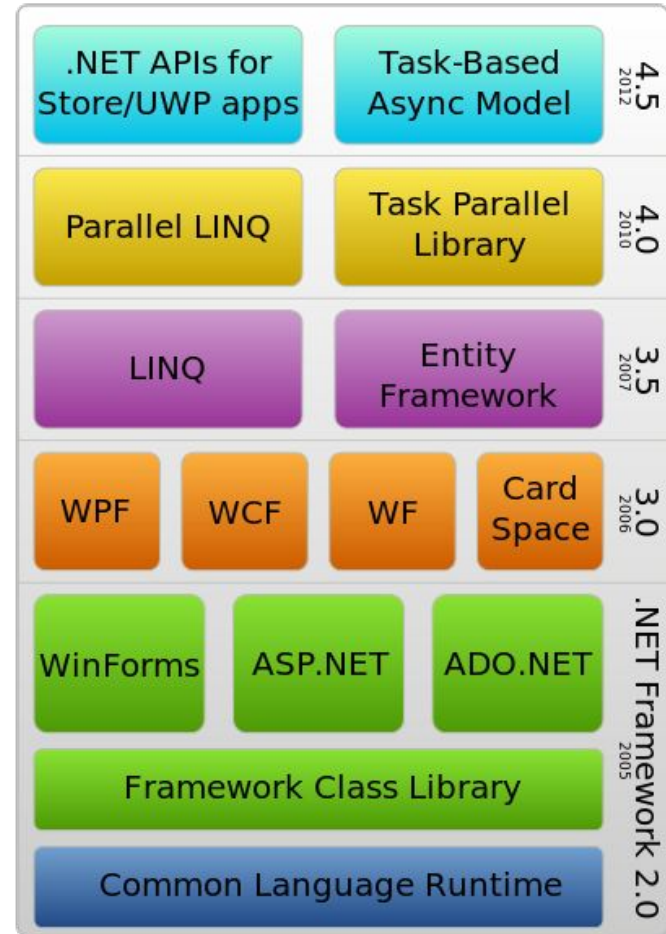


```
.assembly Hello {}
.assembly extern mscorlib {}
.method static void Main()
{
    .entrypoint
    .maxstack 1
    ldstr "Hello, world!"
    call void [mscorlib]System.Console::WriteLine(string)
    ret
}
```

# .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 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.

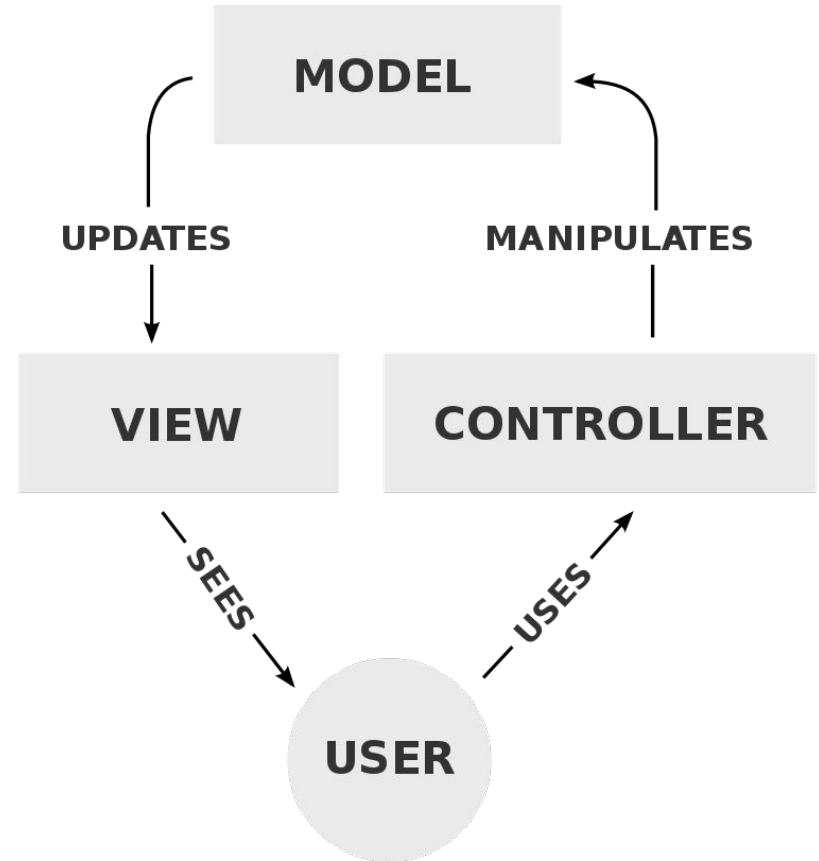
```
int i = 42;  
Type type = i.GetType();  
Console.WriteLine(type);
```

```
Type myType =(typeof(MyTypeClass));  
  
MethodInfo[] myArrayMethodInfo =  
myType.GetMethods(BindingFlags.Public|BindingFlags.Instance|BindingF  
lags.DeclaredOnly);
```

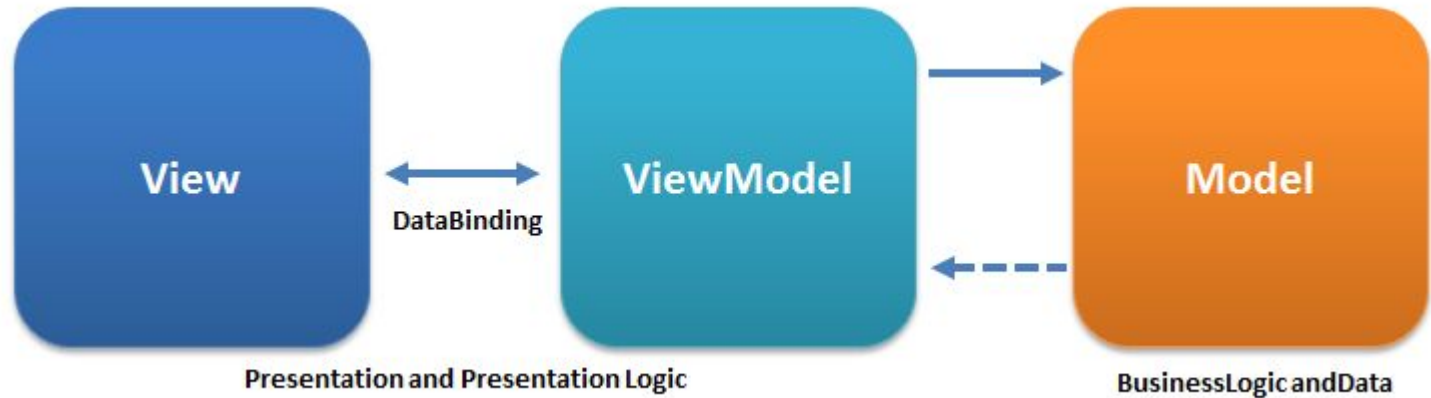


# Model-view-controller (ASP.NET MVC)

Credit: RegisFrey [Public domain]



# Model-view-viewmodel (WPF)



Credit: Ugaya40 [CC BY-SA (<https://creativecommons.org/licenses/by-sa/3.0/>)]



# 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*
  - *CollectionView* (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-contrôles-de-base/le-contrôle-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 ("/23.json" for the page number 23)*
- *Textual search:*  
[https://fr.openfoodfacts.org/cgi/search.pl?search\\_terms=nutella&search\\_simple=1&action=process&json=1](https://fr.openfoodfacts.org/cgi/search.pl?search_terms=nutella&search_simple=1&action=process&json=1)



## Final Dev - Option 2 - Wikidata & Postal code

- SPARQL Request:
  - <https://w.wiki/Foq> (communes)
  - <https://w.wiki/Fqa> (NBA players)
- 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.
- [Teams](#)
- Use action=wbgetentities and format=json; [example](#)



## 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<int> GetProductAsync(string path)  
{  
    Result res = null;  
    HttpResponseMessage response = await client.GetAsync(path);  
    //if (response.IsSuccessStatusCode)  
    return 0;  
}
```



# JSON Serialization/Deserialization

- Use Newtonsoft :
  - <https://www.newtonsoft.com/json>
  - Install with NuGet (Visual Studio)



# Unit tests in C#

- Create a new Test project into the solution.
- A word about TDD.
- A word about Mocks.
- Define a set of unit tests able to be automatized.
- The notion of test coverage.
- *Final project: at least one unit test.*



# Overview of ASP MVC .Net

- Web solution by Microsoft.
- Implements MVC, Model - View - Controller.
  - Derivation from *Controller* class.
  - *ActionResult* for routing.
- *Razor* language used in View.
- IIS but Apache too, etc.
- Extension Ajax MVC.

[Tutorial](#) in French

# Overview of ASP MVC .Net (2)

```
public class Person
{
    public string Surname { get; set; }
    public string FirstName { get; set; }
    public DateTime BirthDate { get; set; }
}
```

Model

```
public class HomeController : Controller
{
    public ActionResult Index()
    {
        Person person = new Person
        {
            Surname = "Doe",
            FirstName = "John",
            BirthDate = new DateTime(1970, 1, 2)
        };

        return View(person);
    }
}
```

Controller

```
@* Commentaire *@
@model Proj.Models.Person

<h2>Salut @Model.FirstName !</h2>

<div>
    <h5>Details:</h5>
    <div>
        @Html.LabelFor(m => m.Surname)
        @Html.DisplayFor(m => m.Surname)
    </div>
    <div>
        @Html.LabelFor(m => m.FirstName)
        @Html.DisplayFor(m => m.FirstName)
    </div>
    <div>
        @Html.LabelFor(m => m.BirthDate)
        @Html.DisplayFor(m => m.BirthDate)
    </div>
</div>
```





# Overview of Entity Framework

- What is an ORM?
- Doctrine (PHP), SQLAlchemy (Python).
- Object *context* which Implements *DbContext*.

[Tutorial](#) in French

```
var team = new FootballTeam{ Name = "Ain Sud Foot", Country = "France" };  
context.Add<FootballTeam>(team);  
context.SaveChanges();
```