C# programming language
Benoît Prieur

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C# programming language

Majeure big data & analytics (M1)
ECE Paris, January-March 2020

V 0.8 (20 of January 2020)
## Document history

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
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<tbody>
<tr>
<td>V 0.7</td>
<td>27 of January 2020</td>
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<tr>
<td>V 0.6</td>
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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 Piirainen [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.
```csharp
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 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.
- 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#

<table>
<thead>
<tr>
<th>Visibility:</th>
<th>Instance construction:</th>
</tr>
</thead>
<tbody>
<tr>
<td>● public, no restriction</td>
<td>● Default constructor</td>
</tr>
<tr>
<td>● protected, limited to class and derivatives</td>
<td>● Explicit constructor</td>
</tr>
<tr>
<td>● internal, limited to the current assembly</td>
<td>● Copy constructor</td>
</tr>
<tr>
<td>● private, limited to the current instance</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instance destruction:</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Garbage collector, automatically called at the end of scope.</td>
</tr>
<tr>
<td>● Usage of <em>Dispose</em> for non-managed resources.</td>
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</tbody>
</table>
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;
    }

destructor
{
    //implementation
}

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.

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

class Car : Vehicle
{
    ...
}
```
C# and oriented object programming (3)

Polymorphism:

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

```csharp
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

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

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.

```csharp
struct Coord
{
    public float latitude, longitude;
    public Coord(float lat, float lon)
    {
        latitude = lat;
        longitude = lon;
    }
}
```
C# class accessors

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

```csharp
class Foo
{
    public int Data { get; set; }
}
```
Nullable type

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

```csharp
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.
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

```csharp
// Help
string str = Console.ReadLine();
int i = double.Parse(str);
```
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
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 \textit{String} which provides methods:
  ○ \textit{SubString}, \textit{StartsWith}, \textit{EndWith} etc..
● Type string is \textit{immutable}.
● Another type is \textit{mutable} in C#: \textit{StringBuilder}. 
Exception management in C#

try {
    // ...
}
catch (System.Exception e) {
    // ...
    throw new Exception();
}
finally {
    // ...
}
Interfaces in C#, syntax

```csharp
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.

```csharp
// 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**, **Dictionary**.
- 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)
        {
        }
    }
}
Reflection in C#

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

```csharp
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)

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).

```xml
<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

```csharp
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

```csharp
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

WPF Controls (4) - ListView

WPF Controls (5) - Styles

Final Dev - Option 1 - OpenFoodFacts

- An example of category in French:
  - [https://fr.openfoodfacts.org/categorie/pains.json](https://fr.openfoodfacts.org/categorie/pains.json)
- List of categories:
  - [https://fr.openfoodfacts.org/categories.json](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/Fog (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

```csharp
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#

```csharp
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](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.*