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Questions

Software University

sli.do

#csharp-advanced

What? Why? Where? When?

Reflection

What is Metaprogramming?

- **Programming technique**, in which computer programs have the ability to treat other **programs as their data**
- Programs can be designed to:
  - **Read**
  - **Generate**
  - **Analyze**
  - **Transform**
  - **Modify itself** while **running**

What is Reflection?

- The ability of a programming language to be its **own metalanguage**
- Programs can examine information about **themselves**

When to Use Reflection?

- Whenever we want:
  - Code to become more **extendible** (e.g. plugins)
  - To **reduce code** length significantly (e.g. mapping)
  - Dynamic object **initialization** (e.g. IoC containers)
  - **Assembly** information at run time (e.g. ASP.NET Core)
  - Examine other **programs** (e.g. unit testing)

When Not to Use Reflection?

- If it is **possible** to **perform** an operation **without** using **reflection**, then it is preferable to **avoid using it**
- Cons from using Reflection
  - **Performance** overhead
  - **Security** restrictions
  - Exposure of **internals**

Reflecting Class and Members

Reflection API

Type Class

- Primary way to access **metadata**
- Obtained at **compile time**, if you know its **name**:

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

- Can be obtained at **runtime**, if the name is **unknown**:

```
Type myType = Type.GetType("Namespace.ClassName");
```

You need fully qualified class name as string

- Get the type of an instance

```
obj.GetType();
```

Class Name

- Obtain Class name
  - Fully qualified class name - Type.FullName

```
string fullName = typeOf(SomeClass).FullName;
```

  - Class name without the namespace - Type.Name

```
string simpleName = typeOf(SomeClass).Name;
```

Base Class and Interfaces

- Obtain **base type**

```
Type baseType = testClass.BaseType;
```

- Obtain **interfaces**

```
Type[] interfaces = testClass.GetInterfaces();
```

  - All the **interfaces that the class implements** are returned
    - Even interfaces from **base classes**

Creating New Instances Dynamically

- `Activator.CreateInstance`
  - Creates an instance of a type by invoking the constructor that **matches** the specified **arguments**

```
var sbType = Type.GetType("System.Text.StringBuilder");
StringBuilder sbInstance =
  (StringBuilder) Activator.CreateInstance(sbType);
StringBuilder sbInstCapacity = (StringBuilder)Activator
  .CreateInstance(sbType, new object[] { 10 });
```

Reflect Fields

- Obtain public fields

```
FieldInfo field = type.GetField("name");
FieldInfo[] publicFields = type.GetFields();
```

- Obtain all fields

```
FieldInfo[] allFields = type.GetFields(
  BindingFlags.Static |
  BindingFlags.Instance |
  BindingFlags.Public |
  BindingFlags.NonPublic);
```

Binding Flags

- The `BindingFlags` enum specifies what kinds of types we are looking up

```
FieldInfo[] allFields =
  type.GetFields(BindingFlags.NonPublic);
```

- Can be combined with bitwise OR (| operator):

```
FieldInfo[] allFields = type.GetFields(
  BindingFlags.Public |
  BindingFlags.NonPublic);
```

Returns both public and nonpublic fields

Field Type and Name

- Get **public** field **name and type**

```
FieldInfo field = type.GetField("fieldName");
string fieldName = field.Name;
Type fieldType = field.FieldType;
```

- Use **BindingFlags** to specify access modifiers, if the field is not public, otherwise **GetField** returns **null**

Changing a Field's State

```
Type testType = typeof(Test);
Test testInstance =
    (Test) Activator.CreateInstance(testType);
FieldInfo field = testType.GetField("testInt");

field.SetValue(testInstance, 5);
int fieldValue =
        (int)field.GetValue(testInstance);
```

Changes the object's state

Access Modifiers

- Each modifier is **a flag bit** that is either set or cleared
- Check **access modifier** of a **member** of the class

```
field.IsPrivate      // private
field.IsPublic       // public
field.IsNonPublic    // everything but public
field.IsFamily       // protected
field.IsAssembly     // internal
```

Reflect Constructors

- Obtain **constructors**

```
ConstructorInfo[] publicCtors =
  type.GetConstructors();
```

- Obtain **all non static constructors**

```
ConstructorInfo[] allNonStaticCtors =
  type.GetConstructors(
   BindingFlags.Instance |
   BindingFlags.Public |
   BindingFlags.NonPublic);
```

Reflect Constructors(2)

- Obtain a certain constructor

```
ConstructorInfo constructor =
  type.GetConstructor(new Type[] parametersType);
```

- Get constructor parameters

```
Type[] parameterTypes =
  constructor.GetParameters();
```

- Instantiating objects using a specific constructor

```
StringBuilder builder =
  (StringBuilder)constructor.Invoke(
    new object[] { "gosho", 5 });
```

Supply positional parameters in an object array

Reflect Methods

- Obtain all **public** methods

```
MethodInfo[] publicMethods = sbType.GetMethods();
```

- Obtain a **certain** method

```
MethodInfo appendMethod =
                        sbType.GetMethod("Append");
MethodInfo overloadMethod = sbType.GetMethod(
            "Append", new [] { typeof(array) });
```

Method Invoke

- Obtain method **parameters** and **return type**

```
ParameterInfo[] appendParameters =
  appendMethod.GetParameters();
Type returnType = appendMethod.ReturnType;
```

- **Invoke** methods

```
appendMethod.Invoke(builder, new object[] { "hi!" });
```

Target object instance

Parameters for the method

Data about Data

Attributes

Attributes

- **Data holding** class
- **Describes** parts of your code
- Applied to:
  - **Classes**, **Fields**, **Methods**, etc.

```
[Obsolete]
public void DeprecatedMethod
{
  Console.WriteLine("Deprecated!");
}
```

Attributes Usage

- Generate **compiler messages** or **errors**

```
[Obsolete]
public enum Coin // Enum 'Coin' is osbolete
```

- Tools, which rely on attributes:
  - **Code generation** tools
  - **Documentation generation** tools
  - **Testing** Frameworks
- Runtime - **ORM**, **Serialization** etc.

Applying Attributes – Example

- Attribute's name is surrounded by **square brackets**: []
  - Placed before their target declaration

```
[Flags] // System.FlagsAttribute
public enum FileAccess
{
   Read = 1,
   Write = 2,
   ReadWrite = Read | Write
}
```

- `[Flags]` attribute indicates that the enum type can be treated like a set of bit flags, stored as a single integer

Attributes with Parameters

- Attributes can accept **parameters** for their constructors and public properties

```
[DllImport("user32.dll", EntryPoint="MessageBox")]
public static extern int ShowMessageBox(int hWnd,
  string text, string caption, int type);
…
ShowMessageBox(0, "Some text", "Some caption", 0);
```

- The `[DllImport]` attribute refers to:
  - **`System.Runtime.InteropServices.DllImportAttribute`**
  - "**`user32.dll`**" is passed to the constructor
  - "**`MessageBox`**" value is assigned to **`EntryPoint`**

Custom Attributes Requirements

- Must **inherit** the `System.Attribute` class
- Their **names** must end with "`Attribute`"
- Possible **targets** must be defined via `[AttributeUsage]`
- Can define **constructors** with parameters
- Can define public **fields** and **properties**

Problem: Create Attribute

- Create an attribute **Author** with a **string** element called **name** that:
  - Can be used over **classes and methods**
  - Allow multiple attributes of same type

```
[Author("Victor")]
public class StartUp
{
  [Author("Georg")]
  static void Main(string[] args)
  { … }
}
```

Check your solution here: https://judge.softuni.bg/Contests/1520/Reflection-and-Attributes-Lab

Solution: Create Attribute

```
[AttributeUsage(AttributeTargets.Class |
                AttributeTargets.Method,
                AllowMultiple = true)]
public class AuthorAttribute : Attribute
{
  public AuthorAttribute(string name)
  {
    this.Name = name;
  }

  public string Name { get; set; }
}
```

Problem: Coding Tracker

- Create a class `Tracker` with a method:
  - `void PrintMethodsByAuthor()`
- Print to the console authors for all methods
  - Use `SoftUni attribute` and `reflection`

Check your solution here: https://judge.softuni.bg/Contests/1520/Reflection-and-Attributes-Lab

Solution: Coding Tracker

```
var type = typeof(StartUp);
var methods =
  type.GetMethods(
    BindingFlags.Instance | BindingFlags.Public |
    BindingFlags.Static);
foreach (var method in methods) {
  if(method.CustomAttributes
      .Any(n => n.AttributeType == typeof(AuthorAttribute))){
    var attributes = method.GetCustomAttributes(false);
    foreach(AuthorAttribute attr in attributes){
      Console.WriteLine("{0} iw written by {1}",
                                    method.Name, attr.Name);
// Add the missing brackets
```

Summary

- **Reflection**:
  - Allows us to get **information about types**
  - Allows us to dynamically **call methods**, **get**/**set** values, etc.
- **Attributes** allow adding metadata in classes / types / etc.
  - Built-in attributes
  - Custom attributes
  - Can be accessed at runtime

Questions?

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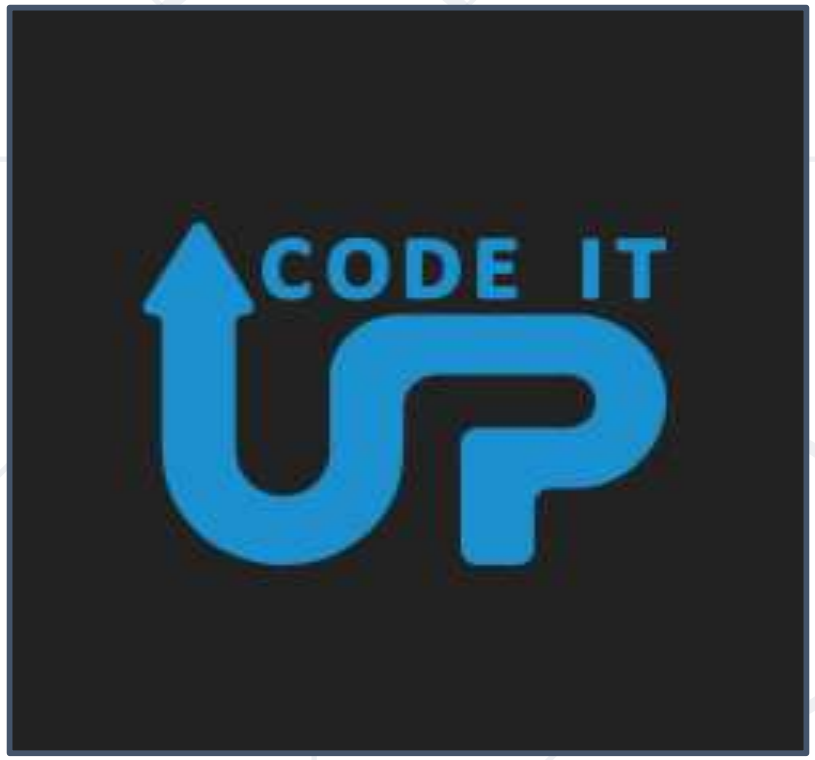

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