Pattern in .NET Core

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## Patterns Book - examples from .NET Core source code

This book is a collection of patterns from the .NET Core source code. The patterns are presented in a way that makes them easy to understand and use in your own projects. Each pattern is accompanied by a detailed explanation and example code that demonstrates how it can be implemented in practice.

If you find something that is not clear or incorrect, please open an issue at <https://github.com/ignatandrei/patterns>

Thank you for reading!



## Pattern: AbstractFactory

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/AbstractFactory>

Abstract Factory is a creational design pattern that lets you produce families of related objects without specifying their concrete classes.

### Purpose of .NET implementation

You want to create commands for any specific database type in order to obtain data from a database. This means you can switch between different databases (e.g., SQL Server, MySQL, PostgreSQL) without changing the core logic of your application. The factory will provide the appropriate concrete implementation of the DBConnection for the database in use.. By using an Abstract Factory, your application can remain agnostic of the specific type of database it is interacting with.

### Example in .NET :

#### AbstractFactory

using Microsoft.Data.SqlClient;  
using System.Data.Common;  
  
namespace AbstractFactory;  
internal class AbstractFactoryDemo  
{  
 public static void Demo()  
 {  
 //create DbConnection factory by using the instance of SqlConnection  
 DbConnection connection = new SqlConnection();  
 //create DbCommand instance by using the instance of SqlConnection  
 DbCommand command = connection.CreateCommand();  
 //really, the DBCommand is a SqlCommand  
 SqlCommand? sqlCommand = command as SqlCommand;  
 //check if the DbCommand is a SqlCommand  
 Console.WriteLine($"DbCommand is SqlCommand: {sqlCommand != null}");  
 }  
}

### See Source Code for Microsoft implementation of AbstractFactory

[SourceCode DbConnection](https://source.dot.net/#System.Data.Common/System/Data/Common/DbConnection.cs) : <https://source.dot.net/#System.Data.Common/System/Data/Common/DbConnection.cs>

### Learn More

[Wikipedia](https://en.wikipedia.org/wiki/Abstract_factory_pattern) : <https://en.wikipedia.org/wiki/Abstract_factory_pattern>

### Homework

Imagine you want to produce loggers. You have a logger that logs to a file and a logger that logs to a console and a Nothing Logger - a logger that does nothing. Implement an abstract factory that will allow you to create a logger factory that will create a logger that logs to a file or to a console or nothing.

## Pattern: Adapter

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/Adapter>

Adapter design pattern allows the interface of an existing class to be used as another interface.It is often used to make existing classes work with others without modifying their source code.

### Purpose of .NET implementation

You want to transfer data from a database Command to a DataTable. The SQLiteDataAdapter serves as an adapter between the SQLiteCommand object (which represents a SQL command or stored procedure to execute against a SQLite database) and the DataTable object (which represents in-memory data in a tabular format).

### Examples in .NET :

#### SQLiteDataAdapter

namespace Adaptor;  
internal class SQLiteDataAdapterDemo  
{  
 /// <summary>  
 ///Adaptee - Command   
 ///Target - DataTable  
 ///Adapter - SqlDataAdapter  
 ///Target Method - Fill(Dataset instance)  
 /// </summary>  
 /// <returns></returns>  
 public static async Task MainSqliteAdapterAsync()  
 {  
 //Target: Creates a DataTable instance to hold the data fetched from the database.  
 var dataFormats = new DataTable();  
 Console.WriteLine(dataFormats.Rows.Count);  
 Console.WriteLine(dataFormats.Columns.Count);  
 using (var con = new SQLiteConnection())  
 {  
 con.ConnectionString = "Data Source=CatalogRo.sqlite3";  
 await con.OpenAsync();  
  
 using (var cmd = new SQLiteCommand())  
 {  
 // Adaptee: Sets the SQL command text to fetch all records from the 'Format' table.  
 cmd.CommandText = "select \* from Format";  
 cmd.Connection = con;  
 using (var adapt = new SQLiteDataAdapter(cmd))  
 {  
 // Adapter: Fills the DataTable (Target) with data fetched using the SQLiteCommand (Adaptee).  
 adapt.Fill(dataFormats);  
 }  
 }  
  
 }  
 Console.WriteLine(dataFormats.Rows.Count);  
 Console.WriteLine(dataFormats.Columns.Count);  
 }  
}

#### EncodingAdapter

namespace Adaptor;  
internal class EncodingAdapterDemo  
{  
 /// <summary>  
 ///Adaptee - string   
 ///Target - bytes  
 ///Adapter - encoding  
 ///Target Method - GetBytes  
 /// </summary>  
 public static void AdapterStringByte()  
 {  
 var url = "http://msprogrammer.serviciipeweb.ro";  
 Encoding e = new ASCIIEncoding();  
 var b = e.GetBytes(url);  
  
 Console.WriteLine($"from {e.EncodingName} number bytes {b.Length}");  
  
 e = new UTF32Encoding();  
 b = e.GetBytes(url);  
 Console.WriteLine($"from {e.EncodingName} number bytes {b.Length}");  
  
 }  
  
  
}

### See Source Code for Microsoft implementation of Adapter

[SourceCode AsciiEncoding](https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/Text/ASCIIEncoding.cs) : <https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/Text/ASCIIEncoding.cs>

[SourceCode SqliteDataAdapter](https://github.com/mono/mono/blob/9bb01f57a126dab35f070ce238457931e9814c33/mcs/class/Mono.Data.Sqlite/Mono.Data.Sqlite_2.0/SQLiteDataAdapter.cs#L20) : <https://github.com/mono/mono/blob/9bb01f57a126dab35f070ce238457931e9814c33/mcs/class/Mono.Data.Sqlite/Mono.Data.Sqlite_2.0/SQLiteDataAdapter.cs#L20>

[SourceCode UTF32Encoding](https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/Text/UTF32Encoding.cs) : <https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/Text/UTF32Encoding.cs>

### Learn More

[C2Wiki](http://wiki.c2.com/?AdapterPattern) : <http://wiki.c2.com/?AdapterPattern>

[dofactory](http://www.dofactory.com/net/Adapter-design-pattern) : <http://www.dofactory.com/net/Adapter-design-pattern>

[DPH](https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-Adapter) : <https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-Adapter>

[Wikipedia](https://en.wikipedia.org/wiki/Adapter_pattern) : <https://en.wikipedia.org/wiki/Adapter_pattern>

### Homework

iPhone 7 does not have a headphone jack. Implement an adapter that will allow you to use your old headphones , that have jack, with the iPhone 7.

## Pattern: Builder

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/Builder>

The intent of the Builder design pattern is to separate the construction of a complex object from its representation.

### Purpose of .NET implementation

You want to let the developer construct a SqlConnectionString. The SqlConnectionStringBuilder class provides a way to construct connection strings for SQL Server databases. Instead of requiring the developer to construct a connection string in one go, potentially leading to mistakes or omissions, SqlConnectionStringBuilder allows for the step-by-step construction of a connection string. This can help to ensure that all necessary parameters are included and that the connection string is correctly formatted. Once all necessary parameters have been set, the ConnectionString property of the SqlConnectionStringBuilder object can be used to retrieve the constructed connection string.

### Examples in .NET :

#### SqlConnectionStringBuilder

namespace Builder;  
internal class ConnectionStringDemo  
{  
 public static void ConnectionString()  
 {  
 //start example 2  
 SqlConnectionStringBuilder build = new ();  
 build.DataSource = ".";  
 build.InitialCatalog = "MyDatabase";  
 build.ConnectTimeout = 30;  
 // Outputs the constructed connection string to the console. This demonstrates the final product of the Builder pattern.  
 Console.WriteLine(build.ConnectionString);  
 //end example 2  
 }  
}

#### UriBuilder

namespace Builder;  
static class UriBuilderDemo  
{  
 public static void UriMod()  
 {  
 //start example 1  
 var uri = new Uri("https://msprogrammer.serviciipeweb.ro/category/friday-links/");  
 var b = new UriBuilder(uri);  
 //changing part  
 b.Scheme = "http";  
 //now we have http://msprogrammer.serviciipeweb.ro/category/friday-links/  
 Console.WriteLine(b.Uri);  
 //changing part  
 b.Path = "2018/03/05/design-patterns-class/";  
 //now we have http://msprogrammer.serviciipeweb.ro/2018/03/05/design-patterns-class/  
 Console.WriteLine(b.Uri);  
 //end example 1  
 }  
}

### See Source Code for Microsoft implementation of Builder

[SourceCode SqlConnectionStringBuilder](https://referencesource.microsoft.com/#System.Data/fx/src/data/System/Data/SqlClient/SqlConnectionStringBuilder.cs) : <https://referencesource.microsoft.com/#System.Data/fx/src/data/System/Data/SqlClient/SqlConnectionStringBuilder.cs>

[SourceCode UriBuilder](https://source.dot.net/#System.Private.Uri/System/UriBuilder.cs) : <https://source.dot.net/#System.Private.Uri/System/UriBuilder.cs>

### Learn More

[C2Wiki](http://wiki.c2.com/?BuilderPattern) : <http://wiki.c2.com/?BuilderPattern>

[dofactory](http://www.dofactory.com/net/Builder-design-pattern) : <http://www.dofactory.com/net/Builder-design-pattern>

[DPH](https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-Builder) : <https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-Builder>

[Wikipedia](https://en.wikipedia.org/wiki/Builder_pattern) : <https://en.wikipedia.org/wiki/Builder_pattern>

### Homework

Imagine that you have a logger that logs to a file and to a console. Implement a builder that will allow you to create a logger with different configurations. For example, you can set the log level, the log format, and the log destination.

## Pattern: Chain

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/Chain>

Chain of responsibility pattern allows an object to send a command without knowing what object will receive and handle it.Chain the receiving objects and pass the request along the chain until an object handles it.

### Purpose of .NET implementation

You want to pass the exception to the possible handlers / catch blocks in the all functions in the call stack. Exception bubbling in .NET exemplifies the Chain of Responsibility pattern by allowing exceptions to be passed along a chain of potential handlers (catch blocks) until one is found that can handle the exception. This can be useful when you want to ensure that exceptions are handled at the appropriate level of abstraction, rather than being caught and handled at a lower level where they may not be fully understood or properly addressed. By allowing exceptions to bubble up the call stack, you can ensure that they are handled in a consistent and appropriate manner, regardless of where they occur in the code. This mechanism decouples the thrower of the exception from the handlers, providing a flexible and dynamic way of managing errors that occur during runtime.

### Example in .NET :

#### Chain

namespace Chain;  
  
public static class ChainDemo  
{  
 public static int SecondException()  
 {  
 try  
 {  
 // Calls 'FirstException' method which is known to throw an exception.  
 FirstException();  
 return 5;  
 }  
 catch (Exception ex)  
 {  
 // Throws a new exception, chaining the caught exception 'ex' as the inner exception.  
 // This adds context to the exception, indicating it originated from 'SecondException'.  
 throw new Exception($"from {nameof(SecondException)}", ex);  
 }  
 }  
 static int FirstException()  
 {  
  
 throw new ArgumentException("argument");  
 }  
}

### See Source Code for Microsoft implementation of Chain

[SourceCode ApplicationBuilderExtensions.UseMiddleware](https://source.dot.net/#Microsoft.AspNetCore.Builder/ApplicationBuilderExtensions.cs) : <https://source.dot.net/#Microsoft.AspNetCore.Builder/ApplicationBuilderExtensions.cs>

[SourceCode UseMiddlewareExtensions.UseMiddleware](https://source.dot.net/#System.Private.CoreLib/src/System/Object.CoreCLR.cs) : <https://source.dot.net/#System.Private.CoreLib/src/System/Object.CoreCLR.cs>

### Learn More

[C2Wiki](https://wiki.c2.com/?ChainOfResponsibilityPattern) : <https://wiki.c2.com/?ChainOfResponsibilityPattern>

[dofactory](http://www.dofactory.com/net/chain-design-pattern) : <http://www.dofactory.com/net/chain-design-pattern>

[DPH](https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-chain) : <https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-chain>

[Wikipedia](https://en.wikipedia.org/wiki/Chain-of-responsibility_pattern) : <https://en.wikipedia.org/wiki/Chain-of-responsibility_pattern>

### Homework

Implement a middleware in ASP. NET Core that intercepts the exception and logs it to the database. The middleware should be able to pass the exception to the next middleware in the chain.

## Pattern: Decorator

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/Decorator>

Decorator allows behavior to be added to an individual object, either statically or dynamically, without affecting the behavior of other objects from the same class.

### Purpose of .NET implementation

Stream is a perfect example of the Decorator pattern. Imagine you want to write a text to a file, but you want to add some additional functionality(or not, at will) to the stream, such as compression or encryption.. By using the Decorator pattern, you can easily compose streams with different behaviors to create custom stream objects that meet specific requirements. Each stream class focuses on a single responsibility. FileStream handles file I/O, CryptoStream handles encryption and decryption, and GZipStream handles compression and decompression. This makes the classes easier to understand, test, and maintain..

### Example in .NET :

#### Decorator

namespace Decorator;  
internal class DecoratorDemo  
{  
 public static void Stream\_Crypto\_Gzip()  
 {  
 string nameFile = "test.txt";  
 if (File.Exists(nameFile))  
 File.Delete(nameFile);  
 byte[] data = ASCIIEncoding.ASCII.GetBytes("Hello World!");  
 // Creates a FileStream (the ConcreteComponent in the Decorator pattern context).  
 using (var stream = new FileStream(nameFile, FileMode.OpenOrCreate, FileAccess.Write))  
 {  
 //stream.Write(data, 0, data.Length);  
 //return;  
   
 var cryptic = new DESCryptoServiceProvider();  
  
 cryptic.Key = ASCIIEncoding.ASCII.GetBytes("ABCDEFGH");  
 cryptic.IV = ASCIIEncoding.ASCII.GetBytes("ABCDEFGH");  
 // Decorates the FileStream with a CryptoStream (the first Decorator).  
 using (var crStream = new CryptoStream(stream, cryptic.CreateEncryptor(), CryptoStreamMode.Write))  
 {  
 // Further decorates the CryptoStream with a GZipStream (the second Decorator).  
 using (var gz = new GZipStream(crStream, CompressionLevel.Optimal))  
 {  
 gz.Write(data, 0, data.Length);  
 }  
  
 }  
 }  
 }  
}

### See Source Code for Microsoft implementation of Decorator

[SourceCode CryptoStream](https://source.dot.net/#System.Security.Cryptography/System/Security/Cryptography/CryptoStream.cs) : <https://source.dot.net/#System.Security.Cryptography/System/Security/Cryptography/CryptoStream.cs>

[SourceCode GZipStream](https://source.dot.net/#System.IO.Compression/System/IO/Compression/GZipStream.cs) : <https://source.dot.net/#System.IO.Compression/System/IO/Compression/GZipStream.cs>

### Learn More

[C2Wiki](http://wiki.c2.com/?DecoratorPattern) : <http://wiki.c2.com/?DecoratorPattern>

[dofactory](http://www.dofactory.com/net/decorator-design-pattern) : <http://www.dofactory.com/net/decorator-design-pattern>

[DPH](https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-decorator) : <https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-decorator>

[Wikipedia](https://en.wikipedia.org/wiki/Prototype_pattern) : <https://en.wikipedia.org/wiki/Prototype_pattern>

### Homework

1.Create a LoggingDbConnectionDecorator class that adds logging functionality to a DbConnection object.. This class should log the details of the operations performed on the DbConnection (like opening a connection, closing a connection, executing a command, etc.) to a log file or console.. 2.Your task is to model a coffee shop ordering system using the Decorator design pattern. The base component will be a coffee, and you will create decorators for adding milk, sugar, and chocolate.. The coffee should be able to display the condiments in a Display method and calculate the price of the coffee with milk, sugar, and chocolate.

## Pattern: Facade

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/Facade>

Facade is is an object that provides a simplified interface to a larger body of code, such as a class library.

### Purpose of .NET implementation

You are the creator of EFCore that provides ORM capabilities to the developers. You want also to have a simplified interface to interact with the underlying database and provide simple methods like EnsureCreated(), BeginTransaction(), etc. The Facade pattern provides a unified interface to a set of interfaces in a subsystem. It defines a higher-level interface that makes the subsystem easier to use by providing a single entry point for common operations.

### Example in .NET :

#### Facade

using Microsoft.EntityFrameworkCore;  
using Microsoft.EntityFrameworkCore.Infrastructure;  
  
namespace Facade;  
internal class FacadeDemo  
{  
 public static void ExecuteSql()  
 {  
 MyDbContext cnt = new();  
  
 DatabaseFacade dbFacade = cnt.Database;  
 //calling the facade for create the database  
 dbFacade.EnsureCreated();   
 //calling the facade for begin a transaction  
 dbFacade.BeginTransaction();  
 }  
}  
  
public class MyDbContext:DbContext  
{  
   
}

### See Source Code for Microsoft implementation of Facade

[SourceCode DatabaseFacade](https://github.com/dotnet/efcore/blob/3163cb9a0677f94bd986dcdbe3d6026d4f743c73/src/EFCore/Infrastructure/DatabaseFacade.cs#L15) : <https://github.com/dotnet/efcore/blob/3163cb9a0677f94bd986dcdbe3d6026d4f743c73/src/EFCore/Infrastructure/DatabaseFacade.cs#L15>

### Learn More

[C2Wiki](http://wiki.c2.com/?FacadePattern) : <http://wiki.c2.com/?FacadePattern>

[dofactory](http://www.dofactory.com/net/facade-design-pattern) : <http://www.dofactory.com/net/facade-design-pattern>

[DPH](https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-facade) : <https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-facade>

[Wikipedia](https://en.wikipedia.org/wiki/Facade_pattern) : <https://en.wikipedia.org/wiki/Facade_pattern>

### Homework

Implement a Facade that will allow you to display a question in a MessageBox with a single method call in a console application and return yes/no as a result.

## Pattern: Factory

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/Factory>

A factory is a function or method that returns objects of a varying prototype or class from some method call, which is assumed to be new.

### Purpose of .NET implementation

For getting data from Web, you can have a HttpWebRequest or FtpWebRequest. The type of the request depends on the protocol you want to use : HTTP or FTP. You want to make easier for the developer to create the appropriate request object based on the string that starts with the protocol. So you can have the Factory pattern method : WebRequest.Create.

### Example in .NET :

#### Factory

using Microsoft.AspNetCore.Mvc;  
using Microsoft.AspNetCore.Mvc.Controllers;  
using Microsoft.AspNetCore.Mvc.Internal;  
using System.Data.Common;  
using System.Globalization;  
using System.Net;  
using System.Web.Mvc;  
  
namespace Factory;  
internal class FactoryDemo  
{  
 public static void DemoWebRequest()  
 {  
  
 //WebRequest.Create is a factory - can create HttpWebRequest or FtpWebRequest  
 HttpWebRequest hwr = (HttpWebRequest)WebRequest.Create("http://www.yahoo.com");  
   
 }  
 public static void DemoConvert()  
 {  
 string value = "1,500";  
 Thread.CurrentThread.CurrentCulture = CultureInfo.CreateSpecificCulture("en-US");  
  
 Console.WriteLine(Convert.ToDouble(value));  
  
 Thread.CurrentThread.CurrentCulture = CultureInfo.CreateSpecificCulture("fr-FR");  
 Console.WriteLine(Convert.ToDouble(value));  
  
 }  
 static void RegisterControllerFactory()  
 {  
 ControllerBuilder.Current.SetControllerFactory(new MyControllerFactory());  
 }  
}  
  
//default controller factory is a factory of controllers  
class MyControllerFactory : System.Web.Mvc.DefaultControllerFactory  
{  
  
 public override IController CreateController(System.Web.Routing.RequestContext requestContext, string controllerName)  
 {  
 if (controllerName == "andrei")  
 return null;//maybe controller not found  
  
 return base.CreateController(requestContext, controllerName);  
 }  
}

### See Source Code for Microsoft implementation of Factory

[SourceCode Convert.ToDouble](https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/Convert.cs) : <https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/Convert.cs>

[SourceCode DefaultControllerFactory](https://source.dot.net/#Microsoft.AspNetCore.Mvc.Core/Controllers/DefaultControllerFactory.cs) : <https://source.dot.net/#Microsoft.AspNetCore.Mvc.Core/Controllers/DefaultControllerFactory.cs>

[SourceCode WebRequest.Create](https://referencesource.microsoft.com/#System/net/System/Net/WebRequest.cs) : <https://referencesource.microsoft.com/#System/net/System/Net/WebRequest.cs>

### Learn More

[C2Wiki](http://wiki.c2.com/?FactoryPattern) : <http://wiki.c2.com/?FactoryPattern>

[dofactory](http://www.dofactory.com/net/factory-design-pattern) : <http://www.dofactory.com/net/factory-design-pattern>

[DPH](https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-factory) : <https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-factory>

[Hammer Factories](https://www.danstroot.com/posts/2018-10-03-hammer-factories) : <https://www.danstroot.com/posts/2018-10-03-hammer-factories>

[Wikipedia](https://en.wikipedia.org/wiki/Factory_pattern) : <https://en.wikipedia.org/wiki/Factory_pattern>

### Homework

You want to create multiple types of drinks( water, tea, coffee). With an IDrink interface create a factory method ( with a parameter ) to create a drink.

## Pattern: FluentInterface

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/FluentInterface>

Fluent interface allows you do have method chaining.

### Purpose of .NET implementation

The methods of a service collection instance is called multiple times( e.g. for .AddSingleton). You want to ensure that the programmer can write code that is easy to write, easy to read, and easy to maintain. So from each method you return the instance of the service collection, so you can chain the methods.

### Example in .NET :

#### FluentInterface

using Microsoft.Extensions.DependencyInjection;  
using System.Data;  
using System.Data.Common;  
  
namespace FluentInterface;  
internal static class FluentInterfaceDemo  
{  
 public static ServiceCollection AddServices(this ServiceCollection sc)  
 {  
 //just for demo, does not make sense  
 sc  
 .AddSingleton<IComparable>((sp) =>  
 {  
 //does not matter  
 return 1970;  
 })  
 .AddSingleton<IComparable<Int32>>((sp) =>  
 {  
 //does not matter  
 return 16;  
 });  
 //this way you can chain the calls , making a fluent interface   
 return sc;  
  
  
 }  
}

### See Source Code for Microsoft implementation of FluentInterface

[SourceCode Microsoft.Extensions.DependencyInjection.ServiceCollectionServiceExtensions.AddSingleton](https://source.dot.net/#Microsoft.Extensions.DependencyInjection.Abstractions/ServiceCollectionServiceExtensions.cs) : <https://source.dot.net/#Microsoft.Extensions.DependencyInjection.Abstractions/ServiceCollectionServiceExtensions.cs>

### Learn More

[Wikipedia](https://en.wikipedia.org/wiki/Software_design_pattern) : <https://en.wikipedia.org/wiki/Software_design_pattern>

### Homework

Implement a class person that you can see the first name and last name as fluent interface.

## Pattern: Flyweight

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/Flyweight>

Flyweight pattern is used to reduce the memory and resource usage for complex models containing a large number of similar objects.

### Purpose of .NET implementation

String is costly as allocation in .NET, so you want to reuse the same string in the memory. The string.Intern method is used to retrieve a reference to a string from the intern pool, which is a table of unique strings maintained by .NET. If the string you are trying to intern is already in the intern pool, the method returns a reference to the string in the intern pool instead of creating a new string object.

### Example in .NET :

#### Flyweight

using System.Text;  
  
namespace Flyweight;  
internal class FlyweightDemo  
{  
 public static void Demo()  
 {  
 var str = "Andrei Ignat";  
 var str2 = string.Intern(str);  
 var str3 = new StringBuilder("Andrei").Append(" Ignat").ToString();  
 Console.WriteLine($"str == str2: Value {str==str2} Reference {Object.ReferenceEquals(str,str2)}");  
 Console.WriteLine($"str == str3: Value {str==str3} Reference {Object.ReferenceEquals(str,str3)}");  
  
 }  
}

### See Source Code for Microsoft implementation of Flyweight

[SourceCode String.Intern](https://source.dot.net/#System.Private.CoreLib/src/System/Object.CoreCLR.cs) : <https://source.dot.net/#System.Private.CoreLib/src/System/Object.CoreCLR.cs>

### Learn More

[Wikipedia](https://en.wikipedia.org/wiki/Flyweight_pattern) : <https://en.wikipedia.org/wiki/Flyweight_pattern>

### Homework

Make an exchange rate system. The symbol and names of the currency are the same for all the currencies. The exchange rate is different for each currency. Implement a flyweight that will allow you to create a currency with a symbol and a name and to get the exchange rate for the currency.

## Pattern: IOC

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/IOC>

Inversion of Control is a principle in software engineering by which the control of objects or portions of a program is transferred to a container or framework.It's a design principle in which custom-written portions of a computer program receive the flow of control from a generic framework.

### Purpose of .NET implementation

You want people to work with the file system . Possibly without a file or a directory that exists, but just with implementation. You want to be able to test the code without the file system. So you want to abstract the file system. See file system abstraction in the links below.

### Examples in .NET :

#### IOC

namespace IOC;  
public class NotificationService  
{  
 private readonly IMessageService \_messageService;  
  
 public NotificationService(IMessageService messageService)  
 {  
 \_messageService = messageService;  
 }  
  
 public void SendNotification(string message)  
 {  
 \_messageService.SendMessage(message);  
 }  
}  
public interface IMessageService  
{  
 void SendMessage(string message);  
}

#### DI

namespace IOC;  
public class SMSService : IMessageService  
{  
 public void SendMessage(string message)  
 {  
 Console.WriteLine("Sending SMS: " + message);  
 }  
}  
  
public class EmailService : IMessageService  
{  
 public void SendMessage(string message)  
 {  
 Console.WriteLine("Sending email: " + message);  
 }  
}

### See Source Code for Microsoft implementation of IOC

[SourceCode ServiceCollection](https://source.dot.net/#Microsoft.Extensions.DependencyInjection.Abstractions/ServiceCollection.cs) : <https://source.dot.net/#Microsoft.Extensions.DependencyInjection.Abstractions/ServiceCollection.cs>

### Learn More

[dofactory](http://www.dofactory.com/net/InversionOfControl-design-pattern) : <http://www.dofactory.com/net/InversionOfControl-design-pattern>

[DPH](https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-InversionOfControl) : <https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-InversionOfControl>

[File Providers in ASP.NET Core](https://learn.microsoft.com/en-us/aspnet/core/fundamentals/file-providers?view=aspnetcore-8.0) : <https://learn.microsoft.com/en-us/aspnet/core/fundamentals/file-providers?view=aspnetcore-8.0>

### Homework

Implement a simple IoC container that will allow you to register and resolve dependencies. The container should be able to resolve dependencies by type and by name.

## Pattern: Iterator

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/Iterator>

Iterator design pattern allows to traverse a container and access the container's elements.

### Purpose of .NET implementation

Any collection should be able to loop through its elements. So the iterator pattern could be retrieved almost anywhere in Array, IEnumerable , Hashset, List, and more.

### Example in .NET :

#### DirectoryEnumerable

namespace Iterator;  
internal class DirectoryEnumerableDemo  
{  
 public static void DirectoryEnumerableFiles(int nrMaxFiles)  
 {  
 var count = 0;  
 //what if we called Directory.GetFiles   
 foreach (var file in Directory.EnumerateFiles(@"c:\","\*.\*",SearchOption.AllDirectories))  
 {  
 count++;  
 if (count > nrMaxFiles)  
 break;  
 Console.WriteLine(file);  
 }  
 }  
}

### See Source Code for Microsoft implementation of Iterator

[SourceCode Directory.GetFiles](https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/IO/Directory.cs) : <https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/IO/Directory.cs>

[SourceCode IEnumerable](https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/Collections/IEnumerable.cs) : <https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/Collections/IEnumerable.cs>

[SourceCode IEnumerator](https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/Collections/IEnumerator.cs) : <https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/Collections/IEnumerator.cs>

### Learn More

[C2Wiki](https://wiki.c2.com/?IteratorPattern) : <https://wiki.c2.com/?IteratorPattern>

[dofactory](http://www.dofactory.com/net/Iterator-design-pattern) : <http://www.dofactory.com/net/Iterator-design-pattern>

[DPH](https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-Iterator) : <https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-Iterator>

[Wikipedia](https://en.wikipedia.org/wiki/iterator_pattern) : <https://en.wikipedia.org/wiki/iterator_pattern>

### Homework

With the Yield keyword implement a function that return an IEnumerable of generic int that will return the first 10 numbers of the Fibonacci sequence.

## Pattern: Lazy

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/Lazy>

Lazy initialization is the tactic of delaying the creation of an object, the calculation of a value, or some other expensive process until the first time it is needed.

### Purpose of .NET implementation

You want to access one object that is difficult to create. But you do not know when will be created. You can use the Lazy pattern to create the object only when it is needed. The Lazy of generic T class provides a way to defer the creation of an object until it is actually needed, allowing you to avoid the cost of creating the object until it is actually required.

### Example in .NET :

#### Lazy

namespace Lazy;  
internal class LazyDemo  
{  
 public DateTime dateTimeConstructClass =DateTime.Now;  
   
 public Lazy<DateTime> DateTimeLazy = new(() =>  
 {  
 Console.WriteLine("Lazy<DateTime> is being initialized ONCE!");  
 return DateTime.Now;  
 });  
}

### See Source Code for Microsoft implementation of Lazy

[SourceCode \_defaultLaunchProfile = new Lazy of LaunchProfile](https://github.com/dotnet/project-system/blob/ebc15f3e0fa644bc96b3a7d19b0595bab9d0ab7d/src/Microsoft.VisualStudio.ProjectSystem.Managed/ProjectSystem/Debug/LaunchSettingsProvider.cs#L39)  : <https://github.com/dotnet/project-system/blob/ebc15f3e0fa644bc96b3a7d19b0595bab9d0ab7d/src/Microsoft.VisualStudio.ProjectSystem.Managed/ProjectSystem/Debug/LaunchSettingsProvider.cs#L39>

[SourceCode Lazy](https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/Lazy.cs) : <https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/Lazy.cs>

[SourceCode Lazy of IStreamingFindUsagesPresenter](https://github.com/dotnet/roslyn/blob/d89c824648207390f5be355a782048812ba5f91e/src/VisualStudio/Core/Def/Progression/GraphNavigatorExtension.cs#L27) : <https://github.com/dotnet/roslyn/blob/d89c824648207390f5be355a782048812ba5f91e/src/VisualStudio/Core/Def/Progression/GraphNavigatorExtension.cs#L27>

### Learn More

[C2Wiki](https://wiki.c2.com/?LazyInstantiationPattern) : <https://wiki.c2.com/?LazyInstantiationPattern>

[Wikipedia](https://en.wikipedia.org/wiki/Lazy_initialization) : <https://en.wikipedia.org/wiki/Lazy_initialization>

### Homework

Implement a lazy initialization of a logger that logs to a file and to a console. The logger should be created only when it is needed.

## Pattern: NullObject

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/NullObject>

Instead of returning null , use an object which implements the expected interface, but whose method body is empty.

### Purpose of .NET implementation

You want to log data into the application ( with an ILogger interface ). You do not want to verify if the logger is null or not before logging. You can use the Null Object pattern to provide a default implementation of the ILogger interface that does nothing when its methods are called.

### Examples in .NET :

#### NullLogger

namespace NullObject;  
internal class LogWithData  
{  
 ILogger \_logger;  
 public LogWithData(ILogger? logger=null)  
 {  
 // If logger is null, use NullLogger.Instance  
 // This is the Null Object pattern in action  
 \_logger = logger ?? NullLogger.Instance;   
 }  
 public void DoWork(string message)  
 {  
 // Even if \_logger is NullLogger.Instance, this line won't throw a null reference exception  
 // because NullLogger.Instance is a non-functional implementation of ILogger  
 \_logger.LogInformation($"start work with {message}");  
 }  
}

#### EmptyFolder

using System;  
using System.IO;  
  
namespace NullObject;  
internal class EmptyFolderDemo  
{  
 public static void DemoWithCreateNewFolder()  
 {  
 //start example 1  
 var env = Environment.CurrentDirectory;  
 var guid = Guid.NewGuid().ToString("X");  
 var fldEmpty = Path.Combine(env, guid);  
 //create empty folder  
 Directory.CreateDirectory(fldEmpty);  
 var files= Directory.GetFiles(fldEmpty);  
 Console.WriteLine($"files.Length:{files.Length}");  
 //end example 1  
   
 }  
}

### See Source Code for Microsoft implementation of NullObject

[SourceCode Directory.GetFiles](https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/IO/Directory.cs) : <https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/IO/Directory.cs>

### Learn More

[C2Wiki](https://wiki.c2.com/?NullObject) : <https://wiki.c2.com/?NullObject>

[dofactory](http://www.dofactory.com/net/NullObject-design-pattern) : <http://www.dofactory.com/net/NullObject-design-pattern>

[DPH](https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-NullObject) : <https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-NullObject>

[Wikipedia](https://en.wikipedia.org/wiki/Null_object_pattern) : <https://en.wikipedia.org/wiki/Null_object_pattern>

### Homework

When retrieving data( e. g. a Person with ID =-1 ) from a database , return a NullObject instead of null. How you will verify that the object is a NullObject?.

## Pattern: Observer

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/Observer>

Observer pattern is a behavioral design pattern that defines a one-to-many dependency between objects so that when one object changes state, all its dependents are notified and updated automatically.

### Purpose of .NET implementation

You want to see when properties of an object are modified, to know how to react in the GUI. You can use the Observer pattern to notify the GUI when the properties of the object are modified.

### Example in .NET :

#### Observer

using System.ComponentModel;  
using System.Runtime.CompilerServices;  
  
namespace Observer;  
  
/// <summary>  
/// INotifyPropertyChanged is an interface that provides a mechanism for the object to notify clients that a property value has changed.  
/// </summary>  
public class Person: INotifyPropertyChanged  
{  
 private string name=string.Empty;  
 public string Name  
 {  
 get => name;  
 set  
 {  
 if (name == value) return;  
 name = value;  
 OnPropertyChanged();  
 }  
 }  
  
 public event PropertyChangedEventHandler? PropertyChanged;  
  
 protected virtual void OnPropertyChanged([CallerMemberName] string propertyName = "")  
 {  
 PropertyChanged?.Invoke(this, new PropertyChangedEventArgs(propertyName));  
 }  
}  
internal class ObserverDemo  
{  
 public static void Demo()  
 {  
 Person person = new ();  
 //subscribe to the event to observe the changes  
 person.PropertyChanged += (sender, args) =>  
 {  
 var p = sender as Person;  
 Console.WriteLine($"Property {args.PropertyName} changed to {p?.Name}");  
 };  
 person.Name = "Andrei Ignat" ;  
 }  
}

### See Source Code for Microsoft implementation of Observer

[SourceCode INotifyPropertyChanged](https://source.dot.net/#System.ObjectModel/System/ComponentModel/INotifyPropertyChanged.cs) : <https://source.dot.net/#System.ObjectModel/System/ComponentModel/INotifyPropertyChanged.cs>

### Learn More

[Wikipedia](https://en.wikipedia.org/wiki/Observer_pattern) : <https://en.wikipedia.org/wiki/Observer_pattern>

### Homework

Imagine you have a logger that logs to a file and to a console. Implement an observable logger that will allow you to subscribe to the logger and to be notified when the logger logs a message.

## Pattern: Prototype

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/Prototype>

It is used when the type of objects to create is determined by a prototypical instance, which is cloned to produce new objects.

### Purpose of .NET implementation

If you want to clone an object ( that has members and methods ), the easy way is to copy the members into a new instance. But if you have a complex object, you may want to use the Prototype pattern. You then provide MemberwiseClone is a shallow copy for the members of an object. However, the Prototype pattern is not used very often in .NET, because the ICloneable interface is not very useful.

### Example in .NET :

#### ICloneable

using System;  
  
namespace Prototype;  
class Parent : ICloneable  
{  
 public int Age { get; set; }  
 public Child MyChild { get; set; }  
  
 public object Clone()  
 {  
 //TODO: serialize + unserialize   
 //with System.Text.Json.JsonSerializer  
  
 var p = ShallowClone();  
 //TODO: clone the child   
 var c = new Child();  
 c.Age = this.MyChild.Age;  
  
 p.MyChild = c;  
 return p;  
 }  
  
 public Parent ShallowClone()  
 {  
 return this.MemberwiseClone() as Parent;  
 }  
}

### See Source Code for Microsoft implementation of Prototype

[SourceCode Object.MemberwiseClone](https://source.dot.net/#System.Private.CoreLib/src/System/Object.CoreCLR.cs) : <https://source.dot.net/#System.Private.CoreLib/src/System/Object.CoreCLR.cs>

### Learn More

[C2Wiki](https://wiki.c2.com/?PrototypePattern) : <https://wiki.c2.com/?PrototypePattern>

[dofactory](http://www.dofactory.com/net/Prototype-design-pattern) : <http://www.dofactory.com/net/Prototype-design-pattern>

[DPH](https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-Prototype) : <https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-Prototype>

[Wikipedia](https://en.wikipedia.org/wiki/Prototype_pattern) : <https://en.wikipedia.org/wiki/Prototype_pattern>

### Homework

Imagine that you have a cow farm and you want to create a new cow. Implement a prototype that will allow you to clone a cow. The cow should have a name and a weight.

## Pattern: Singleton

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/Singleton>

Singleton pattern restricts the instantiation of a class to one object.It is used when you want to have one instance of a class that is shared across the application.

### Purpose of .NET implementation

You have a factory to create objects. You want to have a single point of creation for all the objects. You can use the Singleton pattern to ensure that only one instance of the factory is created and that all requests for object creation are handled by that single instance.

### Example in .NET :

#### Singleton

using System.Data.OleDb;  
  
namespace Singleton;  
/// <summary>  
///   
///sealed class Singleton  
///{  
/// private Singleton() { }  
/// public static readonly Singleton Instance = new Singleton();  
///}  
///  
/// </summary>  
internal class SingletonDemo  
{  
 public static void GetFactory()  
 {  
 //cannot do new  
 //OleDbFactory factory=new OleDbFactory();  
 //get singleton instance  
 OleDbFactory factory = OleDbFactory.Instance;  
 }  
}

### See Source Code for Microsoft implementation of Singleton

[SourceCode OleDbFactory.Instance](https://referencesource.microsoft.com/#System.Data/fx/src/data/System/Data/OleDb/OleDbFactory.cs) : <https://referencesource.microsoft.com/#System.Data/fx/src/data/System/Data/OleDb/OleDbFactory.cs>

### Learn More

[C2Wiki](https://wiki.c2.com/?SingletonPattern) : <https://wiki.c2.com/?SingletonPattern>

[dofactory](http://www.dofactory.com/net/singleton-design-pattern) : <http://www.dofactory.com/net/singleton-design-pattern>

[DPH](https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-singleton) : <https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-singleton>

[Wikipedia](https://en.wikipedia.org/wiki/Singleton_pattern) : <https://en.wikipedia.org/wiki/Singleton_pattern>

### Homework

Implement a singleton that will allow you to create a single instance of a logger that logs to a file and to a console.

## Pattern: Strategy

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/Strategy>

Strategy pattern allows a client to choose from a family of algorithms at runtime.It is used when the client expects to have multiple algorithms and wants to choose one of them at runtime.

### Purpose of .NET implementation

You want to have a function that sort objects based on a specific criteria. You want to let the developer to provide the sort criteria. You want also allow the sorting behavior (the strategy) to be selected at runtime. You can use the Strategy pattern to let developer define the sorting criteria and the strategy to be used at runtime.

### Example in .NET :

#### Strategy

using System;  
using System.Collections.Generic;  
  
namespace Strategy;  
internal class StrategyDemo  
{  
 public static void SortWithDifferentStrategies()  
 {  
 List<int> al = new ();  
 al.Add(102);  
 al.Add(201);  
 // Strategy 1: Sorts the list in ascending order.  
 al.Sort((x, y) => x.CompareTo(y));  
  
 for (int i = 0; i < al.Count; i++)  
 {  
 Console.WriteLine(al[i]);  
 }  
  
 Console.WriteLine("---------------");  
  
 // Strategy 2: Sorts the list in descending order.  
 al.Sort((y, x) => x.CompareTo(y));  
 for (int i = 0; i < al.Count; i++)  
 {  
 Console.WriteLine(al[i]);  
 }  
 Console.WriteLine("---------------");  
 // Strategy 3: Sorts the list based on the last digit of each number.  
 al.Sort((x, y) => LastDigit(x).CompareTo(LastDigit(y)));  
 for (int i = 0; i < al.Count; i++)  
 {  
 Console.WriteLine(al[i]);  
 }  
  
 var array = al.FindAll(it => it > 10);  
  
  
 }  
  
 static int LastDigit(int x)  
 {  
 return x % 10;  
 }  
  
}

### See Source Code for Microsoft implementation of Strategy

[SourceCode Array.Sort](https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/Array.cs) : <https://source.dot.net/#System.Private.CoreLib/src/libraries/System.Private.CoreLib/src/System/Array.cs>

### Learn More

[C2Wiki](https://wiki.c2.com/?StrategyPattern) : <https://wiki.c2.com/?StrategyPattern>

[dofactory](http://www.dofactory.com/net/strategy-design-pattern) : <http://www.dofactory.com/net/strategy-design-pattern>

[DPH](https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-strategy) : <https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-strategy>

[Wikipedia](https://en.wikipedia.org/wiki/Strategy_pattern) : <https://en.wikipedia.org/wiki/Strategy_pattern>

### Homework

Image you want to serialize classes to XML,JSON and CSV. Implement a strategy that will allow you to choose between XML , JSON and CSV serialization at runtime.

## Pattern: Visitor

Read online at <https://ignatandrei.github.io/patterns/docs/patterns/Visitor>

Visitor pattern is a way of separating an algorithm from an object structure on which it operates.A practical result of this separation is the ability to add new operations to existing object structures without modifying the structures.

### Purpose of .NET implementation

Roslyn is a syntax analyzer for C#. You want to provide a way for other to analyze/modify the syntax of a C# code. You can use the Visitor pattern to traverse the syntax tree and perform operations on the nodes of the tree. The Visitor pattern allows you to separate the algorithm from the data structure, making it easier to add new operations to the syntax tree without modifying the existing classes.

### Example in .NET :

#### Visitor

using Microsoft.CodeAnalysis;  
using Microsoft.CodeAnalysis.CSharp;  
using Microsoft.CodeAnalysis.CSharp.Syntax;  
  
namespace Visitor;  
internal class VisitorDemo  
{  
 public static void VisitMethods()  
 {  
 var Code = @"""  
using System;  
namespace Test1  
{  
 class Program  
 {  
 static void Main(string[] args)  
 {  
 var dt=DateTime.Now;  
 Console.WriteLine(dt);  
 }  
 }  
}  
  
""";  
 var tree = CSharpSyntaxTree.ParseText(Code);  
  
 var node = tree.GetRoot();  
  
 MethodVisiting LG = new MethodVisiting();  
 //start visiting  
 var sn = LG.Visit(node);  
  
 }  
}  
public class MethodVisiting : CSharpSyntaxRewriter  
{  
 public override SyntaxNode? VisitMethodDeclaration(MethodDeclarationSyntax node)  
 {  
 if (node.Body == null || node.Body.Statements.Count == 0)  
 return base.VisitMethodDeclaration(node);  
  
 var parent = node.Parent as ClassDeclarationSyntax;  
   
 if (parent == null)  
 return base.VisitMethodDeclaration(node);  
  
 var nameMethod = node.Identifier.Text;  
 var nameClass = parent.Identifier.Text;  
 Console.WriteLine($"visiting {nameMethod} from {nameClass}");  
  
 return base.VisitMethodDeclaration(node);  
  
 }  
}

### See Source Code for Microsoft implementation of Visitor

[SourceCode CSharpSyntaxRewriter](https://github.com/dotnet/roslyn/blob/cecdb802007a49e346215c0afdce354d6c111112/src/Compilers/CSharp/Portable/Syntax/CSharpSyntaxRewriter.cs#L17) : <https://github.com/dotnet/roslyn/blob/cecdb802007a49e346215c0afdce354d6c111112/src/Compilers/CSharp/Portable/Syntax/CSharpSyntaxRewriter.cs#L17>

### Learn More

[C2Wiki](http://wiki.c2.com/?VisitorPattern) : <http://wiki.c2.com/?VisitorPattern>

[C2Wiki](https://wiki.c2.com/?VisitorPattern) : <https://wiki.c2.com/?VisitorPattern>

[dofactory](http://www.dofactory.com/net/visitor-design-pattern) : <http://www.dofactory.com/net/visitor-design-pattern>

[DPH](https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-visitor) : <https://github.com/kamranahmedse/design-patterns-for-humans?tab=readme-ov-file#-visitor>

[Wikipedia](https://en.wikipedia.org/wiki/Visitor_pattern) : <https://en.wikipedia.org/wiki/Visitor_pattern>

### Homework

Implement a visitor that will allow you to calculate the total price of a shopping cart. The shopping cart should contain items with a price and a quantity. Visit every item and make the sum.

## Final of Patterns Book - examples from .NET Core source code

I am glad that you have read this book. I hope you have found it useful and that it has helped you to understand the patterns in the .NET Core source code better. If you have any feedback or suggestions for improvement, please feel free to reach out to me. I would love to hear from you.

You can improve it by opening an issue at <https://github.com/ignatandrei/patterns>

Thank you for reading!

