

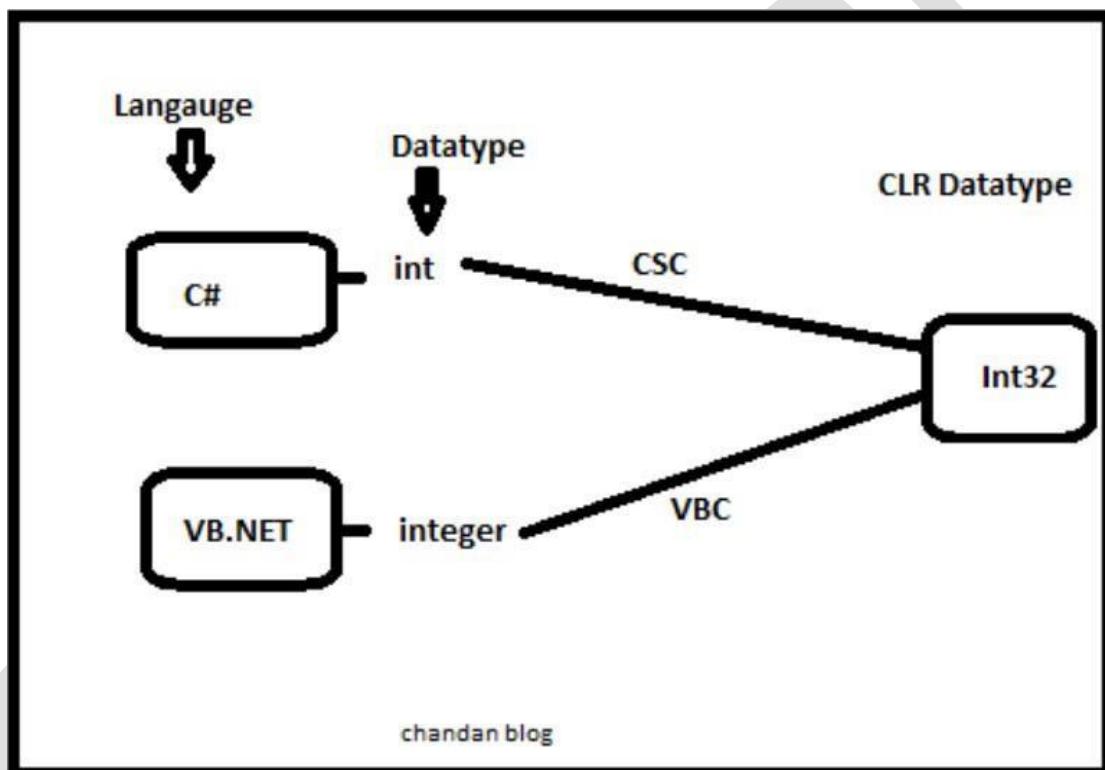
Framework Basics

CTS:-

Common Type System (CTS) describes the datatypes that can be used by managed code. CTS defines how these types are declared, used and managed in the runtime. It facilitates cross-language integration, type safety, and high-performance code execution. The rules defined in CTS can be used to define your own classes and values.

OR we can also understand like,

CTS deals with the data type. So here we have several languages and each and every language has its own data type and one language data type cannot be understandable by other languages but .NET Framework language can understand all the data types. C# has an **int** data type and VB.NET has **Integer** data type. Hence a variable declared as an int in C# and Integer in VB.NET, finally after compilation, uses the same structure Int32 from CTS.



Note

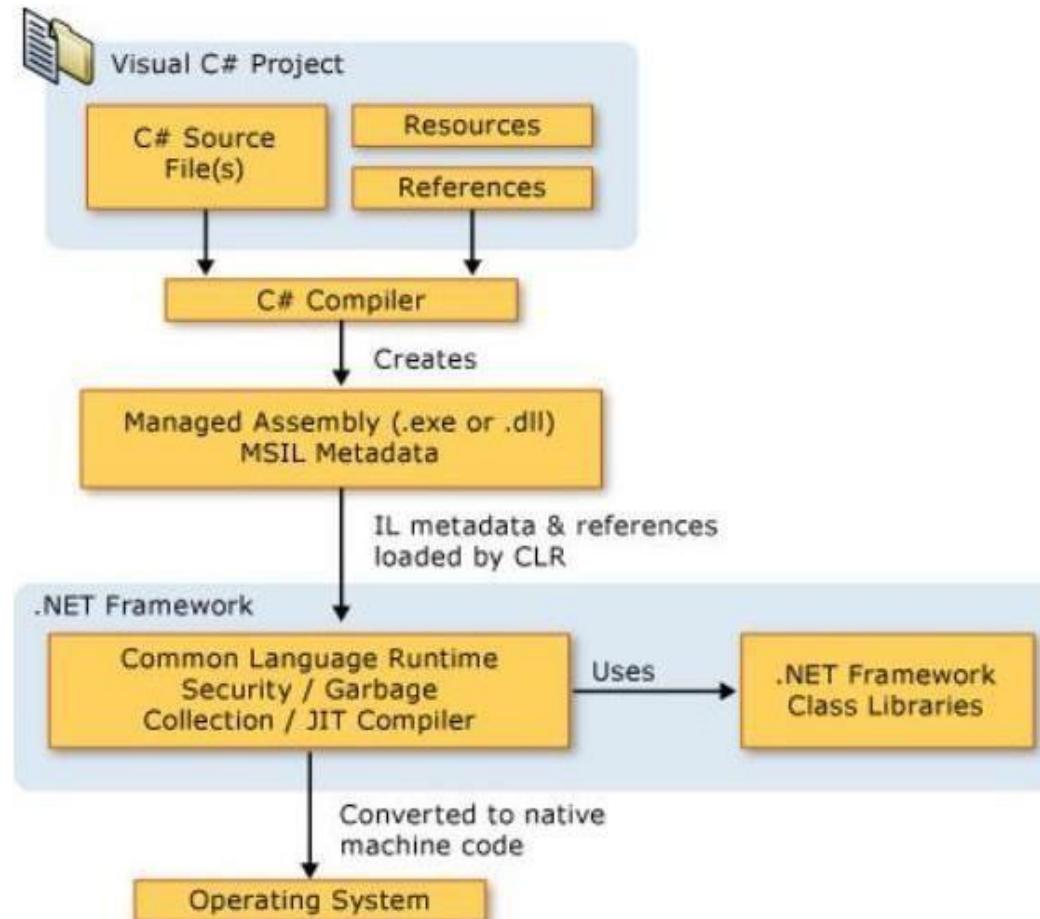
All the structures and classes available in CTS are common for all .NET Languages and the purpose of these is to support language independence in .NET. Hence it is called CTS.

Common Language Runtime (CLR) :-

The Common Language Runtime (CLR) is a core component of .NET Framework that manages the execution and the lifecycle of all .NET applications (code). It provides various services, including automatic memory management, exception handling, security, and type safety. When a .NET application is compiled, it generates an intermediate language code called Common Intermediate Language (CIL). The CLR is responsible for translating this CIL into machine code and managing the execution of the resulting program. The CLR also provides a platform for interoperability between different programming languages that target the .NET Framework. This means that a program written in one .NET language can easily use libraries written in another .NET language. Overall, the CLR is an essential component of the .NET Framework that enables developers to create robust, secure, and interoperable applications.

Key attributes of .NET CLR :-

- As part of the Microsoft .NET Framework, the Common Language Runtime (CLR) is the programming (Virtual Machine component) that manages the execution of programs written in any language that uses the .NET Framework, for example, C#, VB.Net, F# and so on.
- Programmers write code in any language, including VB.Net, C#, and F#, when they compile their programs into an intermediate form of code called CLI in a portable execution file (PE) that can be managed and used by the CLR. Then the CLR converts it into machine code to be will be executed by the processor.
- The information about the environment, programming language, its version, and what class libraries will be used for this code are stored as metadata with the compiler that tells the CLR how to handle this code.
- The CLR allows an instance of a class written in one language to call a method of the class written in another language.



As you can see from the above diagram, the CLR provides several services.

Functions of .NET CLR:-

- Convert code into CLI
- Exception handling
- Type safety
- Memory management (using the Garbage Collector)
- Security
- Improved performance
- Language independency
- Platform independency
- Architecture independency

Components of .NET CLR:-

- Performance improvements.
- The ability to easily use components developed in other languages.
- A class library provides extensible types.
- Language features such as inheritance, interfaces, and overloading for object-oriented programming.
- Support for explicit free threading that allows the creation of multithreaded, scalable applications.
- Support for structured exception handling.
- Support for custom attributes.
- Garbage collection.
- Use of delegates instead of function pointers for increased type safety and security.

IL Code:-

IL code stands for intermediate code.

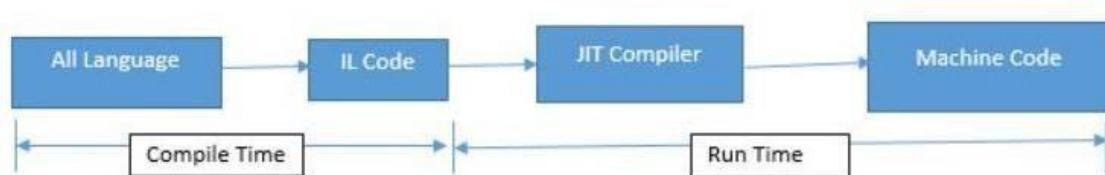
In Microsoft visual studio supports too many language. In same different user have different machine configuration and different operating system whose unknown to visual studio. That is the main problem. To avoid this problem Microsoft Creates a code that is called as IL Code.

It's called as IL code or half compiled code, it's creates at compile time.

Now why it is called as half compiled?

Visual studio does not know that what is system configuration of user, so in compile time it's compiled the language code and converted into IL code.

When this program will run at user system, this run time IL code is converted into machine code by JIT (just-in-time) compiler.



Summary

- IL code is half compiled code.
- IL Code is created at compile time.
- IL code is compiled by JIT Compiler.
- JIT Compiler converted IL Code into Machine Code.

What is a .Net Assembly?

The .NET assembly is the standard for components developed with the Microsoft.NET. Dot NET assemblies may or may not be executable, i.e., they might exist as the executable (.exe) file or dynamic link library (DLL) file. All the .NET assemblies contain the definition of types, versioning information for the type, meta-data, and manifest. The designers of .NET have worked a lot on the component (assembly) resolution.

An assembly can be a single file or it may consist of the multiple files. In the case of multi-file, there is one master module containing the manifest while other assemblies exist as non-manifest modules. A module in .NET is a subpart of a multi-file .NET assembly. Assembly is one of the most interesting and extremely useful areas of .NET architecture along with reflections and attributes.

.NET supports three kinds of assemblies:

1. private
2. shared
3. satellite

Private Assembly

Private assembly requires us to copy separately in all application folders where we want to use that assembly's functionalities; without copying, we cannot access the private assembly features and power. Private assembly means every time we have one, we exclusively copy into the BIN folder of each application folder.

Public Assembly

Public assembly is not required to copy separately into all application folders. Public assembly is also called Shared Assembly. Only one copy is required in system level, there is no need to copy the assembly into the application folder.

Public assembly should install in GAC.

Shared assemblies (also called strong named assemblies) are copied to a single location (usually the Global assembly cache). For all calling assemblies within the same application, the same copy of the shared assembly is used from its original location. Hence, shared assemblies

are not copied in the private folders of each calling assembly. Each shared assembly has a four-part name including its name, version, public key token, and culture information. The public key token and version information makes it almost impossible for two different assemblies with the same name or for two similar assemblies with a different version to mix with each other.

GAC (Global Assembly Cache)

When the assembly is required for more than one project or application, we need to make the assembly with a strong name and keep it in GAC or in the Assembly folder by installing the assembly with the GACUtil command.

Satellite Assembly

Satellite assemblies are used for deploying language and culture-specific resources for an application.

What are the basic components of the .NET platform?

The basic components of .NET platform (framework) are:

.Net Applications <i>(Win Forms, Web Applications, Web Services)</i>
Data(ADO.Net) and XML Library
FrameWork Class Library(FCL) <i>(IO, Streams, Sockets, Security, Reflection, UI)</i>
Common Language Runtime(CLR) <i>(Debugger, Type Checker, JITer, GC)</i>
Operating System <i>(Windows, Linux, UNIX, Macintosh, etc.,)</i>

Common Language Runtime (CLR)

The most important part of the .NET Framework is the .Net Common Language Runtime (CLR) also called .Net Runtime in short. It is a framework layer that resides above the Operating System and handles/manages the execution of the .NET applications. Our .Net programs don't directly communicate with the Operating System but through CLR.

MSIL (Microsoft Intermediate Language) Code

When we compile our .Net Program using any .Net compliant language like (C#, VB.NET, C++.NET) it does not get converted into the executable binary code but to an intermediate code, called MSIL or IL in short, understandable by CLR. MSIL is an OS and H/w independent code. When the program needs to be executed, this MSIL or intermediate code is converted to binary

executable code, called native code. The presence of IL makes it possible for the Cross-Language Relationship as all the .Net compliant languages produce the similar standard IL code.

Just In Time Compilers

When our IL compiled code needs to be executed, CLR invokes JIT compilers which compile the IL code to native executable code (.exe or .dll) for the specific machine and OS. JITers in many ways is different from traditional compilers as they, as their name suggests, compile the IL to native code only when desired e.g., when a function is called, IL of function's body is converted to native code; just in time of need. So, the part of code that is not used by a particular run is not converted to native code. If some IL code is converted to native code then the next time when it's needed to be used, the CLR uses the same copy without re-compiling. So, if a program runs for some time, then it won't have any just in time performance penalty. As JITers are aware of processor and OS exactly at runtime, they can optimize the code extremely efficiently resulting in very robust applications. Also, since JITer knows the exact current state of executable code, they can also optimize the code by in-lining small function calls (like replacing body of small function when its called in a loop, saving the function call time). Although Microsoft stated that C# and .Net are not competing with languages like C++ in efficiency, speed of execution, JITers can make your code even faster than C++ code in some cases when the program is run over an extended period of time (like web-servers).

Framework Class Library (FCL)

.NET Framework provides a huge set of Framework (or Base) Class Library (FCL) for common, usual tasks. FCL contains thousands of classes to provide them access to Windows API and common functions like String Manipulation, Common Data Structures, IO, Streams, Threads, Security, Network Programming, Windows Programming, Web Programming, Data Access, etc. It is simply the largest standard library ever shipped with any development environment or programming language. The best part of this library is they follow extremely efficient OO design (design patterns) making their access and use very simple and predictable. You can use the classes in FCL in your program just as you use any other class and can even apply inheritance and polymorphism on these.

Common Language Specification (CLS)

Earlier we used the term '.NET Compliant Language' and stated that all the .NET compliant languages can make use of CLR and FCL. But what makes a language '.NET compliant language'? The answer is the Common Language Specification (CLS). Microsoft has released a small set of specifications that each language should meet to qualify as a .NET Compliant Language. As IL is a very rich language, it is not necessary for a language to implement all the IL functionality, rather it meets the small subset of it, CLS, to qualify as a .NET compliant language, which is the reason why so many languages (procedural and OO) are now running under .Net umbrella. CLS basically addresses to language design issues and lays certain standards like there should be no global function declaration, no pointers, no multiple

inheritance and things like that. The important point to note here is that if you keep your code within the CLS boundary, your code is guaranteed to be usable in any other .Net language.

Common Type System (CTS)

.NET also defines a Common Type System (CTS). Like CLS, CTS is also a set of standards. CTS defines the basic data types that IL understands. Each .NET compliant language should map its data types to these standard data types. This makes it possible for the 2 languages to communicate with each other by passing/receiving parameters to/from each other. For example, CTS defines a type Int32, an integral data type of 32 bits (4 bytes) which is mapped by C# through int and VB.Net through its Integer data type.

Garbage Collector (GC)

CLR also contains Garbage Collector (GC) which runs in a low-priority thread and checks for un-referenced dynamically allocated memory space. If it finds some data that is no more referenced by any variable/reference, it re-claims it and returns the occupied memory back to the Operating System; so that it can be used by other programs as necessary. The presence of standard Garbage Collector frees the programmer from keeping track of dangling data.

C#

Basics

C# (C-Sharp) is a high-level, object-oriented programming language developed by Microsoft that runs on the .NET Framework.

C# is widely used to develop applications for web, desktop, mobile, games and much more.

Compilation

Compilation is the process of converting source code into a form that can be executed by a computer. The C# compiler converts C# source code into a Common Intermediate Language (CIL) assembly. The CIL assembly is then executed by the Common Language Runtime (CLR).

Roselyn Compiler Purpose

Roslyn is the open-source compiler platform for C# and Visual Basic.NET developed by Microsoft. It provides APIs for analyzing and manipulating code, enabling powerful code analysis and refactoring tools.

Command Line Compilation

To compile a C# program from the command line, you can use the csc.exe compiler. The csc.exe compiler is located in the .NET Framework installation directory.

Step 1: Open the text editor like Notepad or Notepad++, and write the code that you want to execute. Now save the file with **.cs** extension.

```
// C# program to print Hello World!
using System;
// namespace declaration
namespace HelloWorldApp {
    // Class declaration
    class Geeks {
        // Main Method
        static void Main(string[] args)
        {
            // statement
            // printing Hello World!
            Console.WriteLine("Hello World!");

            // To prevents the screen from
            // running and closing quickly
            Console.ReadKey();
        }
    }
}
```

Step 2: Compile your C# source code with the use of command:

```
csc File_name.cs
```

If your program has no error, then it will create a filename.exe file in the same directory where you have saved your program. Suppose you saved the above program as Hello.cs. So you will write **csc Hello.cs** on cmd. This will create a *Hello.exe* file.

Step 3: Now there are two ways to execute the Hello.exe. First, you have to simply type the filename i.e. Hello on the cmd and it will give the output. Second, you can go to the directory where you saved your program and there you find filename.exe. You have to simply double-click that file and it will give the output.

```
C:\users\Shubham>Hello  
Hello world!  
C:\users\Shubham>Hello.exe  
Hello World!
```

Types

C# supports a variety of data types, including integers, floating-point numbers, strings, and Boolean. C# also supports user-defined types, such as classes and structs.

Loops

C# supports three types of loops: for loops, while loops, and do-while loops.

Basic Syntax

In C#, a basic program consists of the following:

- A Namespace Declaration
- Class Declaration & Definition
- Class Members (like variables, methods etc.)
- Main Method
- Statements or Expressions

Creating Assembly using C# On Windows Platform

EXE

An EXE file is an executable file that can be run on a Windows computer. To create an EXE file from a C# program, you need to compile the program with the csc.exe compiler.

DLL

A DLL file is a dynamic link library or class library that can be used by other programs. To create a DLL file from a C# program, you need to compile the program with the csc.exe compiler and specify the /target: library option.

Creating and Using DLL (Class Library) in C#

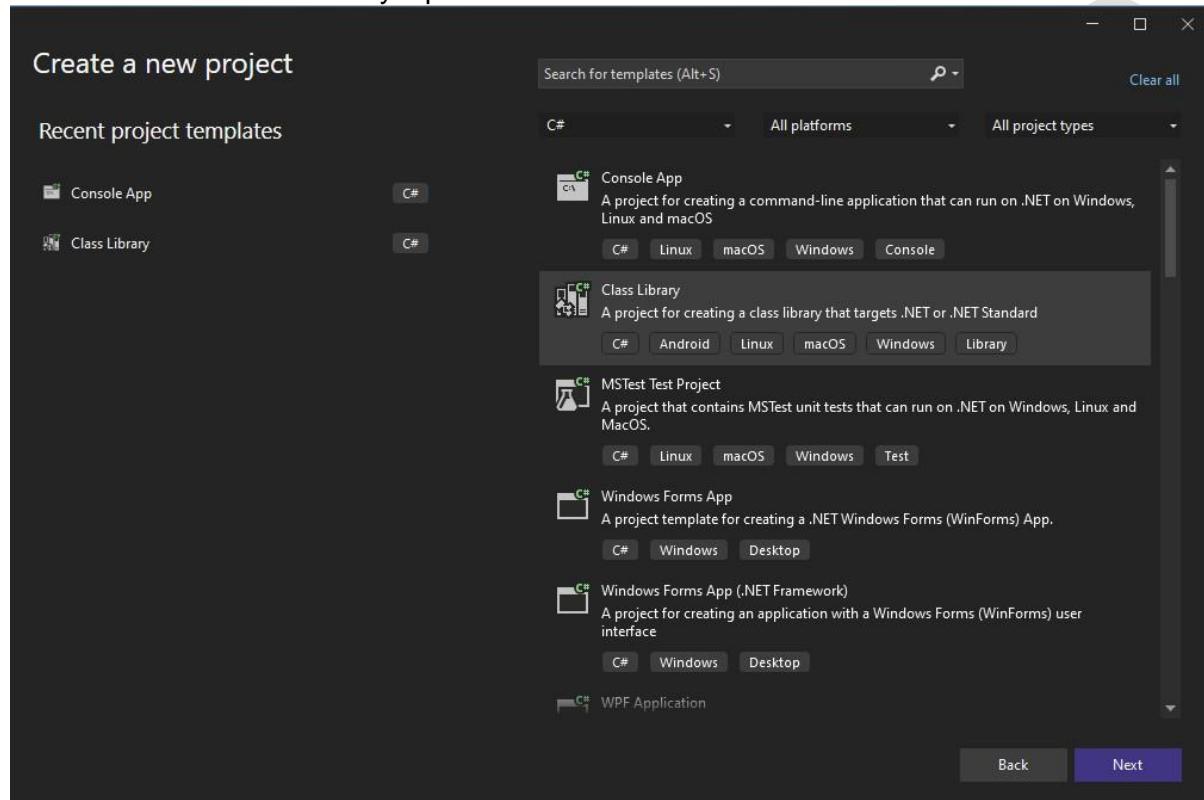
A class library file is a collection of classes and namespaces in C# without any entry point method like **Main**. Once we create a class library file it can be used in the C# project and classes inside it can be used as required. Class Library makes it convenient to use functionalities by importing DLL inside the program rather than redefining everything. So, Let's make our own class library in C#.

Terminologies

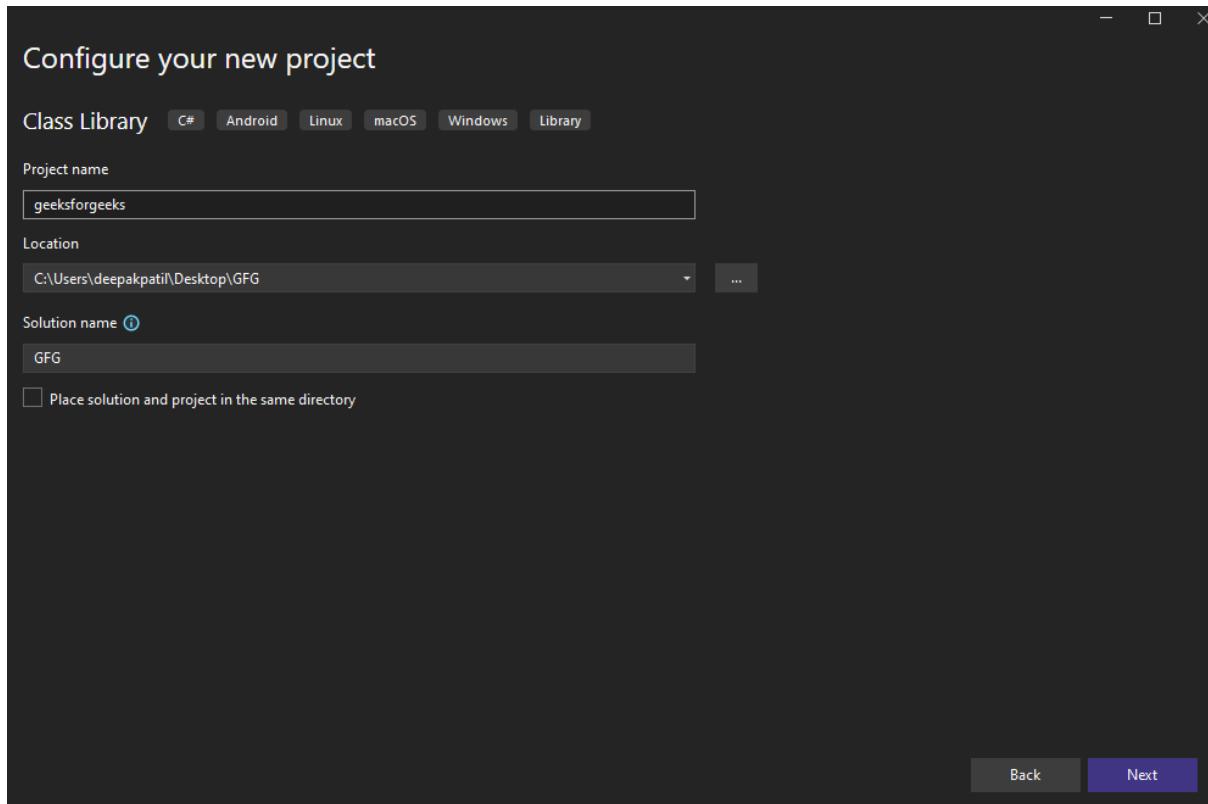
Class Library: It is a package or file that contains different namespaces and class definitions that are used by other programs.

Steps to Create and Use DLL in Visual Studio

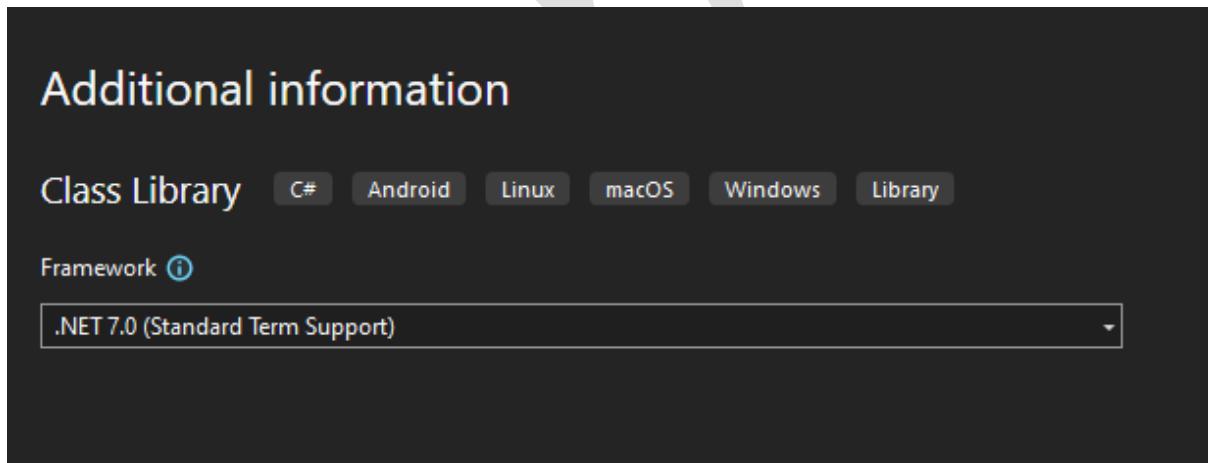
Step 1: Create a New Project in Visual Studio. Once You open visual studio it should open Create New Project OR You can click on the file and select the new project option. Select C# as language and then Select Class Library Option. Click Next.



Step 2: On the next screen configure your class library project name. Make sure you give a different name for the Solution. Then click next.



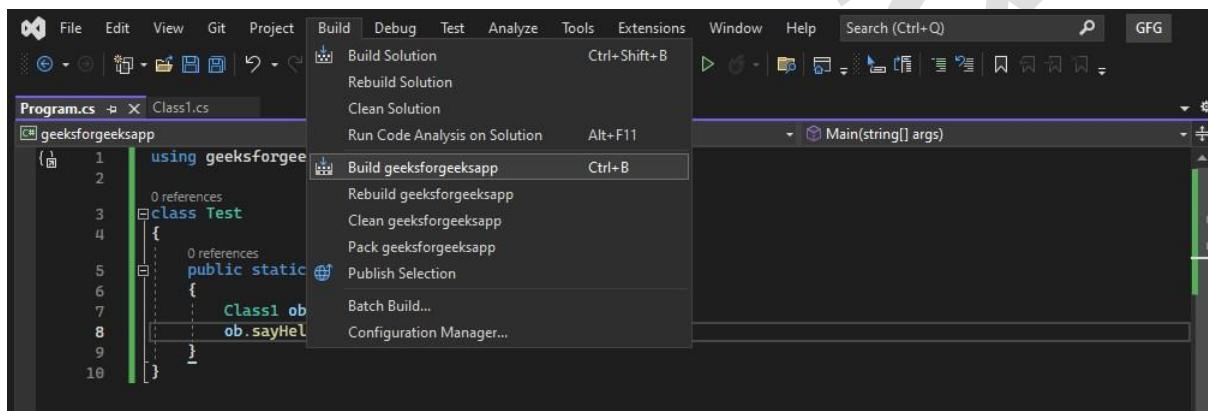
Step 3: On the next screen select the .NET version. I have selected 7.0. Then click create which will create a project.



Step 4: Once the Project is created a C# file will already be created with namespace as project name and class Class1. Let's add some code inside the class that will print something when the method **sayHello()** inside the class is called.

```
Class1.cs  X
C# geeksforgeeks
1  using System;
2
3  namespace geeksforgeeks
4  {
5      public class Class1
6      {
7          public void sayHello()
8          {
9              Console.WriteLine("Hello From GeeksForGeeks");
10         }
11     }
12 }
```

Step 5: After writing the code click on the build in the menu bar and click build geeksforgeeks.

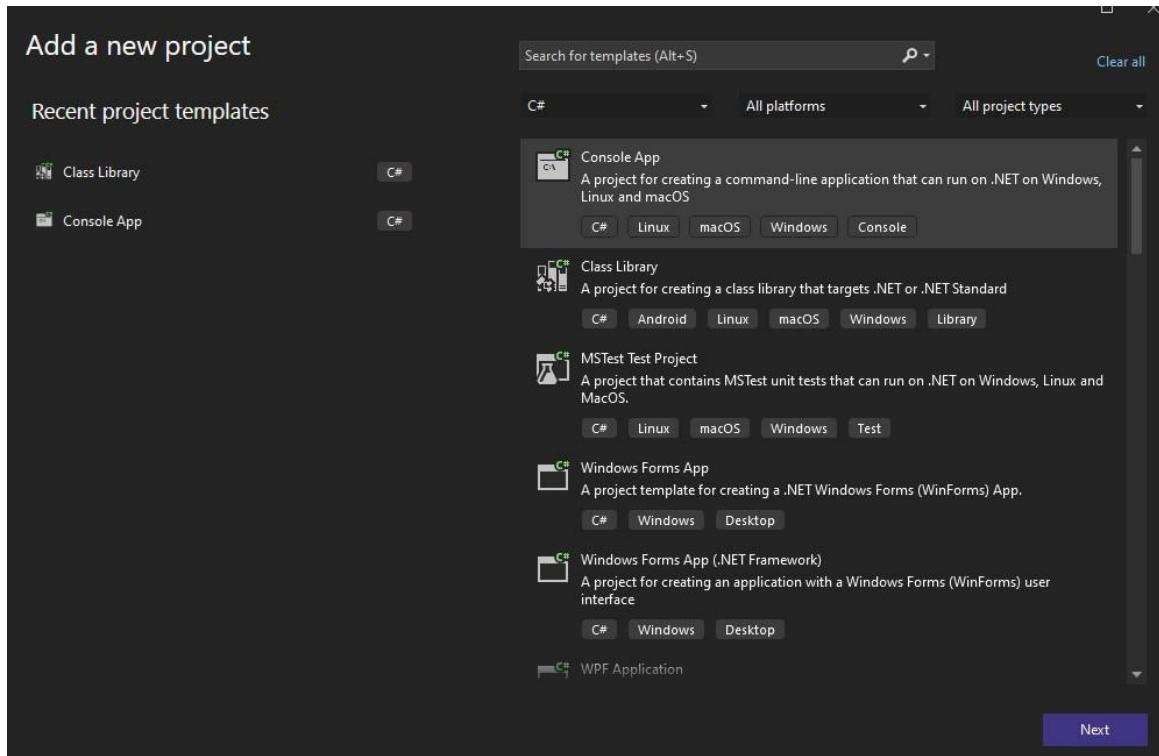


Step 6: If everything is correct you should get build success in the output below the editor.

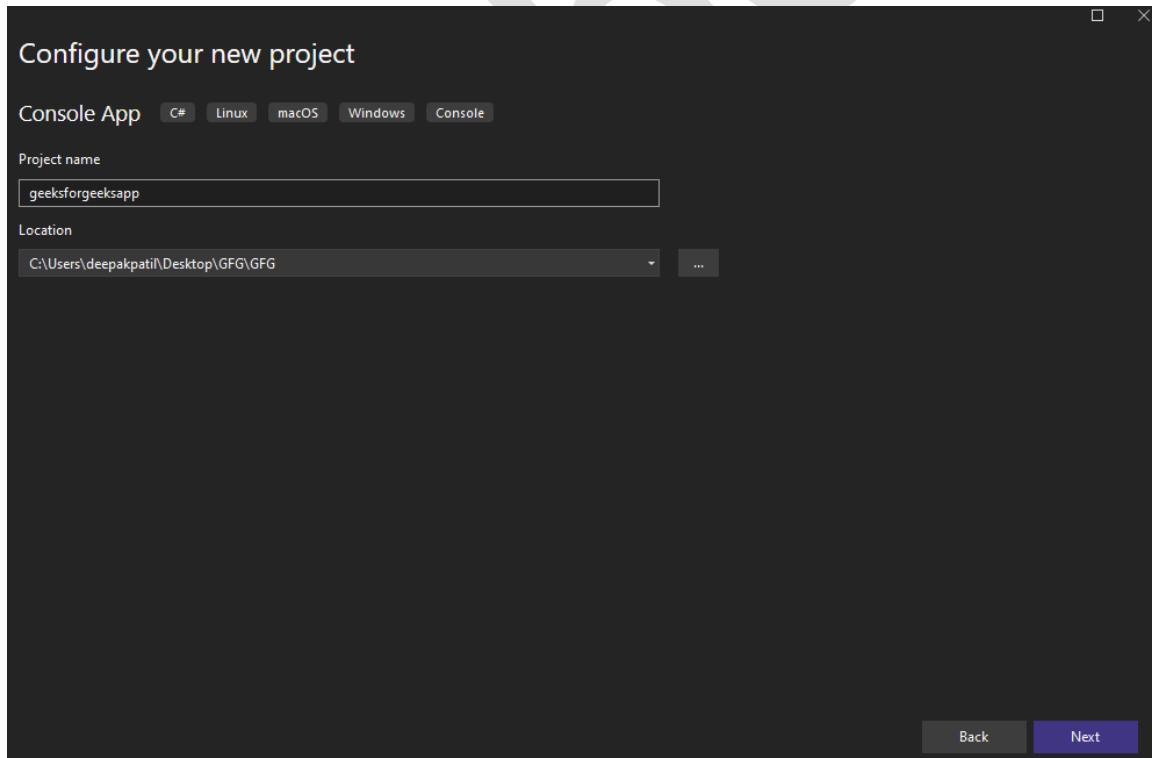
```
Output
Show output from: Build
Build started...
1>----- Build started: Project: geeksforgeeks, Configuration: Debug Any CPU -----
1>geeksforgeeks -> C:\Users\deepakpatil\Desktop\GFG\GFG\geeksforgeeks\bin\Debug\net7.0\geeksforgeeks.dll
===== Build: 1 succeeded, 0 failed, 0 up-to-date, 0 skipped =====
===== Elapsed 00:10.412 =====
```

Step 7: Now the DLL file is created inside the project-folder/bin/Debug/net7.0 folder which can be used.

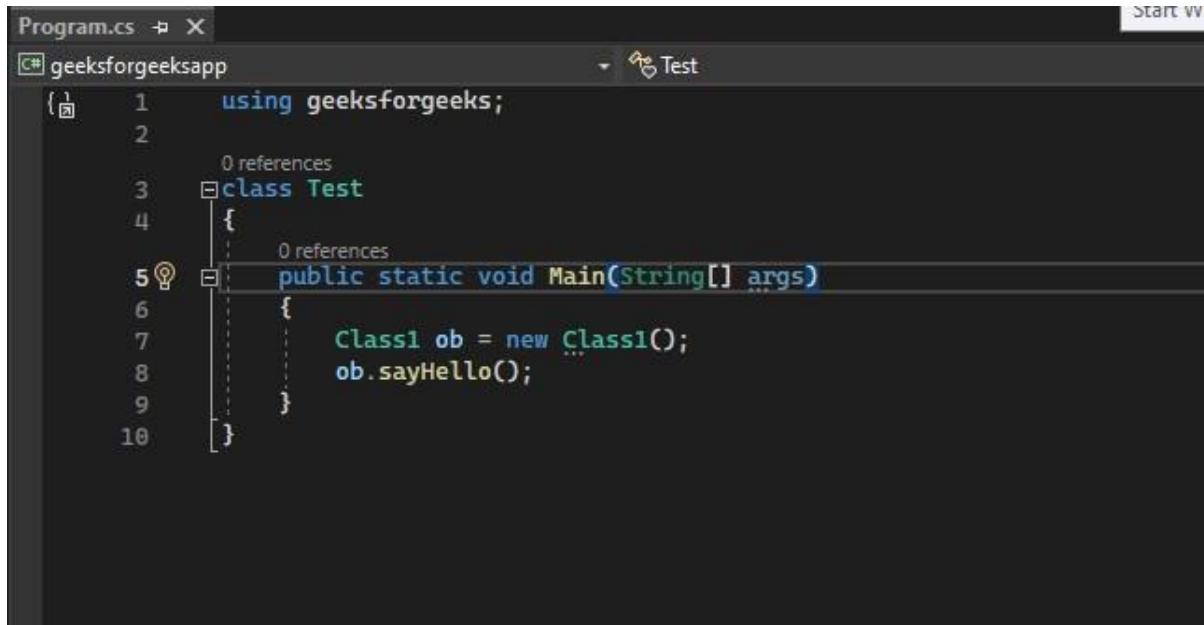
Step 8: Let's create a new project to use this DLL file. For the new project select Console App from the list and click next.



Step 9: Configure a new project with a name and give the same name for the solution as given for creating a Class library project OR just select the same folder for a solution.



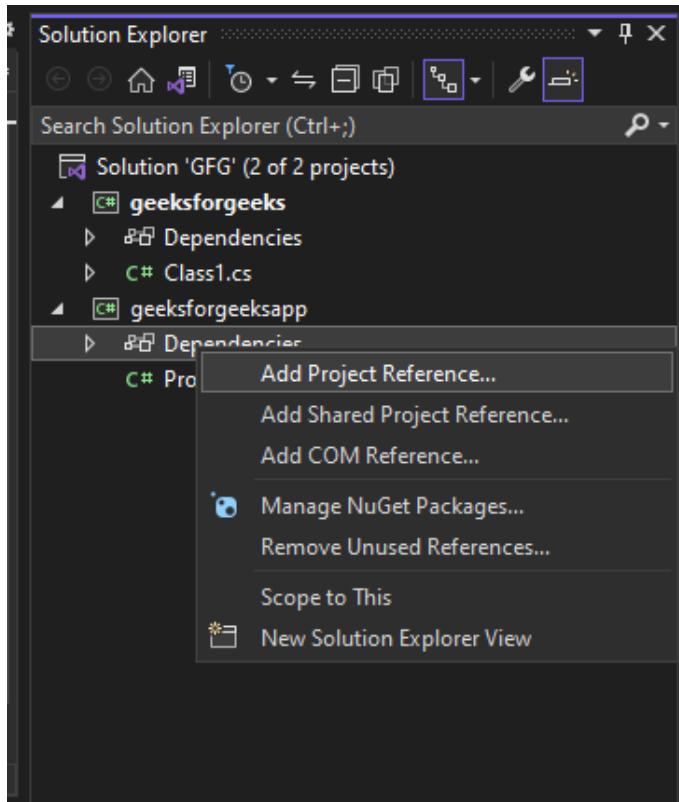
Step 10: Once the project is created it should have a program.cs file opened. Type the Code inside the program.cs file. import the DLL file inside the program by putting “using geeksforgeeks” at the top. Now we can use Class1 inside our program. Call the sayHello() method by creating an object of Class1.



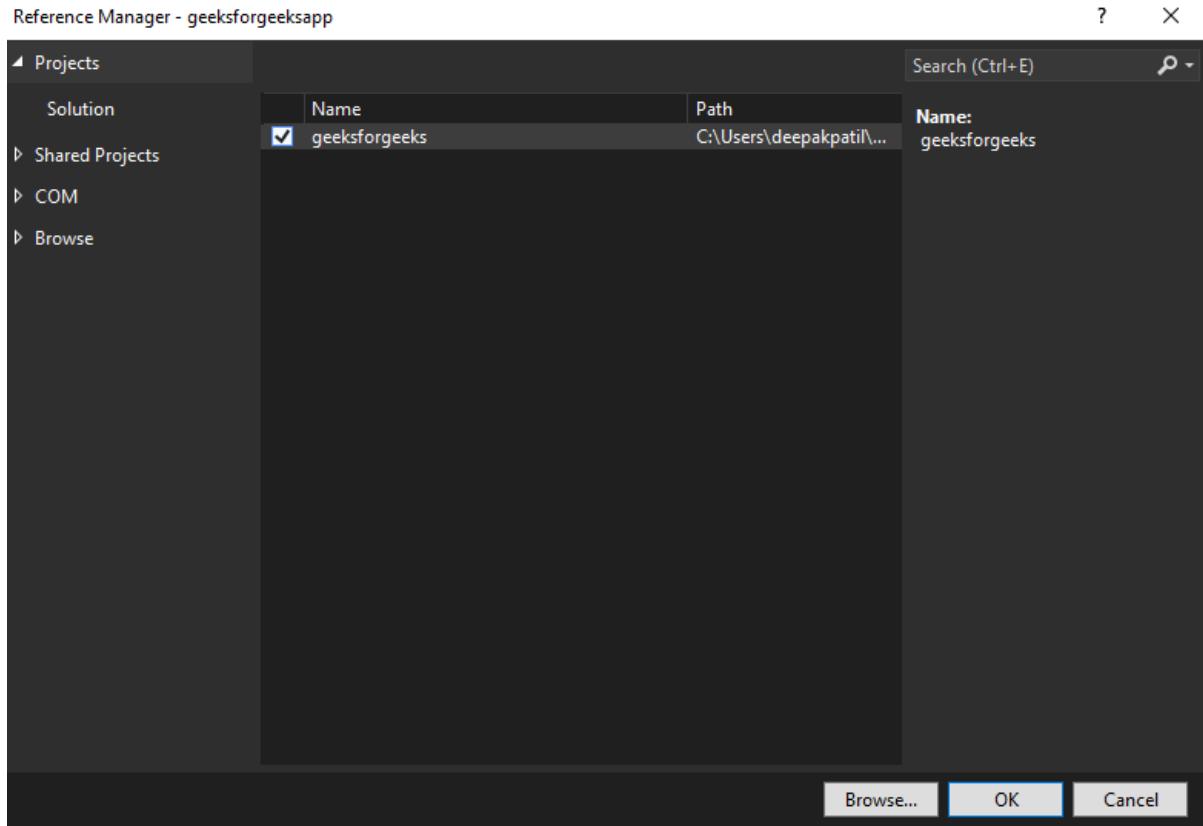
The screenshot shows a code editor window with the file 'Program.cs' open. The code defines a class 'Test' with a static main method that creates an instance of 'Class1' and calls its 'sayHello' method. The code is as follows:

```
1  using geeksforgeeks;
2
3  class Test
4  {
5      public static void Main(String[] args)
6      {
7          Class1 ob = new Class1();
8          ob.sayHello();
9      }
10 }
```

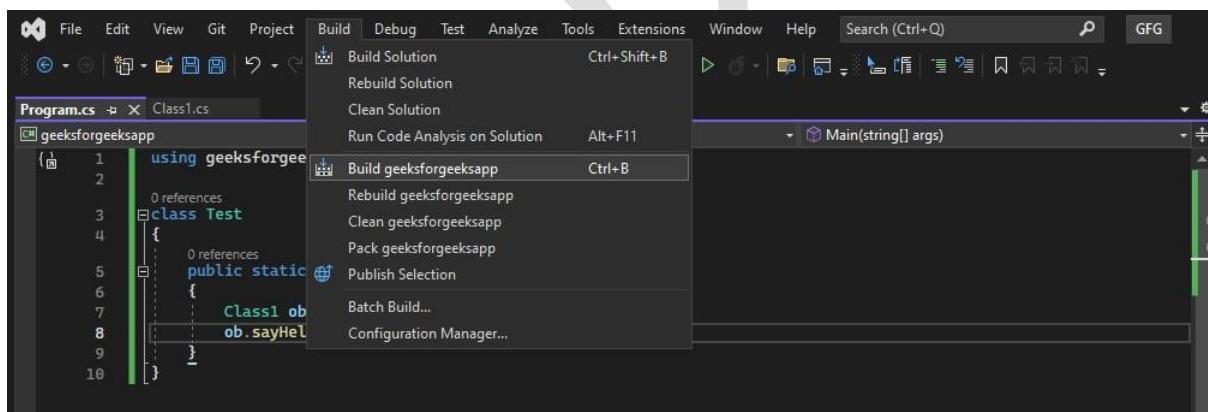
Step 11: Afterwards we have to add a reference of the DLL file to our project. For that in Solution Explorer select dependencies under our project name and right-click to select “Add Project reference”.



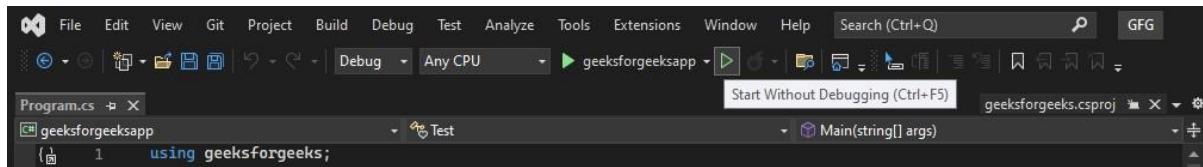
Step 12: Now select our Class Library project name from the list. Click Ok. Now we can build our project.



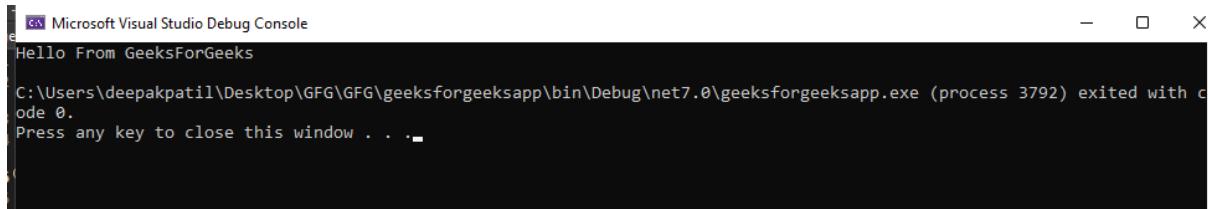
Step 13: From the menu click build and select build “geeksforgeeksapp” or your console project name. You should see the build succeeded at the output.



Step 14: Once Build is succeeded right click on Class Library Project from Solution Explorer and select unload the project. Then click on run without debugging on the sub-menu bar at the top (play button).



Step 15: You should see a console window opened with say hello message printed.

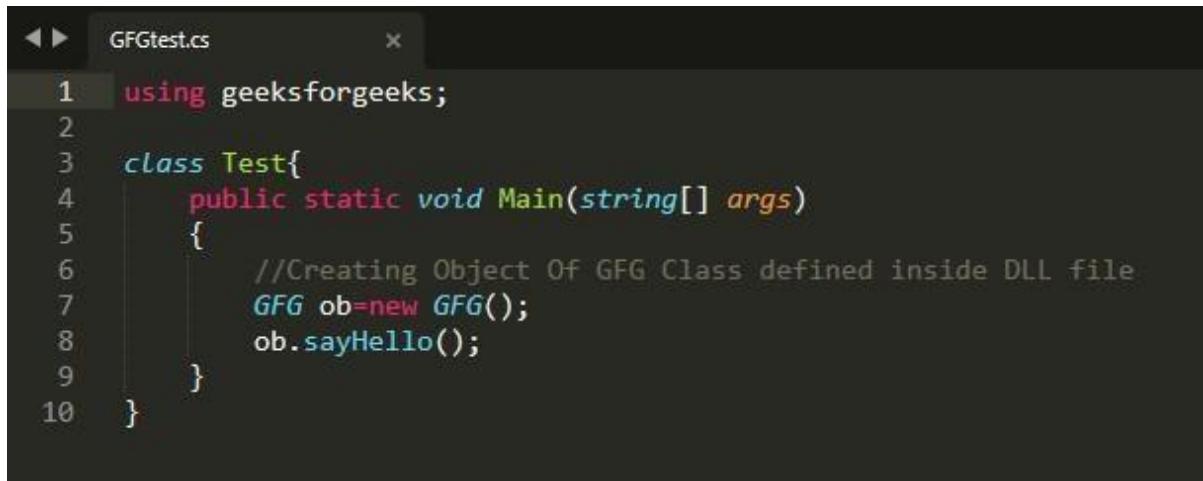


Steps to Create DLL file with C# Compiler

Step 1: Create a new blank file inside your favourite editor and save it as a “.cs” file with the name you want for DLL. Add the Code to the file with namespace and class with any method. I have added the same method as above which prints “Hello From GeeksForGeeks”.

Step 2: Open Command Prompt or Terminal where the CS file is saved. Compile the program with the CSC compiler and make sure you add the target file as a library which will generate a DLL file. If there is no error, then you should see a DLL file created inside a folder with the name as the filename.

Step 3: Now let's use this DLL. Create another file inside the same folder where DLL is located and save it as “.cs”. Type your code to use the DLL. I have written the same code as above.



```
1 using geeksforgeeks;
2
3 class Test{
4     public static void Main(string[] args)
5     {
6         //Creating Object Of GFG Class defined inside DLL file
7         GFG ob=new GFG();
8         ob.sayHello();
9     }
10 }
```

Step 4: Then save the file and compile it with CSC as follows. We have used /r to provide references for our DLL file.

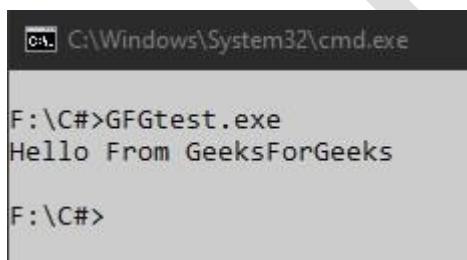


```
F:\C#>csc /r:GFG.dll GFGtest.cs
Microsoft (R) Visual C# Compiler version 4.8.4084.0
for C# 5
Copyright (C) Microsoft Corporation. All rights reserved.

This compiler is provided as part of the Microsoft (R) .NET Framework, but only supports language versions up to C# 5, w
hich is no longer the latest version. For compilers that support newer versions of the C# programming language, see http
://go.microsoft.com/fwlink/?LinkId=533240

F:\C#>
```

Step 5: If no error compilation is successful and we can run our program type filename.exe to run the program. You should see the output printed.



```
F:\C#>GFGtest.exe
Hello From GeeksForGeeks

F:\C#>
```

Consuming DLL in EXE

To consume a DLL in an EXE file, you need to add a reference to the DLL file in the EXE project. You can do this by right-clicking on the References node in the Solution Explorer and selecting Add Reference.

Console | Convert Class & Methods

Convert class provides different methods to convert a base data type to another base data type. The base types supported by the Convert class are Boolean, Char, SByte, Byte, Int16, Int32, Int64, UInt16, UInt32, UInt64, Single, Double, Decimal, DateTime, and String. It also provides methods that support other conversions. This class is defined under System namespace.

Characteristics of Convert class:

- It provides methods that are used to convert every base type into every other base type.
- It provides methods that are used to convert integer values to the non-decimal string representation, also convert the string represent the non-decimal numbers to integer values.
- It provides methods that are used to convert any custom object to any base type.
- It provides a set of methods that supports base64 encoding.
- An OverFlowException can occur if a narrowing conversion results in a loss of data.

Field:

- DBNull: It is a constant which represents a database column that is absent of data i.e. database null.

Method	Description
ChangeType()	It returns an object of a specified type whose value is equivalent to a specified object.
FromBase64CharArray(Char[], Int32, Int32)	Converts a subset of a Unicode character array, which encodes binary data as base-64 digits, to an equivalent 8-bit unsigned integer array. Parameters specify the subset in the input array and the number of elements to convert.
FromBase64String(String)	Converts the specified string, which encodes binary data as base-64 digits, to an equivalent 8-bit unsigned integer array.
GetTypeCode(Object)	Returns the TypeCode for the specified object.
IsDBNull(Object)	Returns an indication whether the specified object is of type DBNull.
ToBase64CharArray()	Converts a subset of an 8-bit unsigned integer array to an equivalent subset of a Unicode character array encoded with base-64 digits.
ToBase64String()	Converts the value of an array of 8-bit unsigned integers to its equivalent string representation that is encoded with base-64 digits.
ToBoolean()	Converts a specified value to an equivalent Boolean value.

ToByte()	Converts a specified value to an 8-bit unsigned integer.
ToChar()	Converts a specified value to a Unicode character.
ToDateTime()	Converts a specified value to a DateTime value.
ToDecimal()	Converts a specified value to a decimal number.
ToDouble()	Converts a specified value to a double-precision floating-point number.
ToInt16()	Converts a specified value to a 16-bit signed integer.
ToInt32()	Converts a specified value to a 32-bit signed integer.
ToInt64()	Converts a specified value to a 64-bit signed integer.
ToSByte()	Converts a specified value to an 8-bit signed integer.
ToSingle()	Converts a specified value to a single-precision floating-point number.
ToUInt16()	Converts a specified value to a 16-bit unsigned integer.
ToUInt32()	Converts a specified value to a 32-bit unsigned integer.
ToUInt64()	Converts a specified value to a 64-bit unsigned integer.

Example :

```
// C# program to illustrate the
// use of ToDecimal(Int16) method
using System;
```

```
class GFG {

    // Main method
    static public void Main()
    {

        // Creating and initializing
        // an array
```

```

short[] ele = {1, Int16.MinValue,
              -00, 106, -32};
decimal sol;

// Display the elements
Console.WriteLine("Elements are:");
foreach(short i in ele)
{
    Console.WriteLine(i);
}

foreach(short num in ele)
{
    // Convert the given Int16
    // values into decimal values
    // using ToDecimal(Int16) method
    sol = Convert.ToDecimal(num);

    // Display the elements
    Console.WriteLine("convert value is: {0}", sol);
}
}
}

```

Output:

Elements are:

```

1
-32768
0
106
-32
convert value is: 1
convert value is: -32768
convert value is: 0
convert value is: 106
convert value is

```

OOP Concepts

Object-Oriented Programming (OOP) is a programming paradigm based on the concept of "objects," which can contain data in the form of fields (attributes or properties) and code in the form of procedures (methods or functions). C# is a language that fully supports OOP principles. Here are the key OOP concepts in C#:

Classes and Objects:

Classes are blueprints or templates for creating objects. They define the structure and behavior of objects.

Objects are instances of classes. They represent real-world entities and contain data and behavior.

```
class Car
{
    public string Model { get; set; }
    public string Color { get; set; }
    public void StartEngine()
    {
        Console.WriteLine("Engine started!");
    }
}
Car myCar = new Car();
myCar.Model = "Toyota";
myCar.Color = "Red";
myCar.StartEngine();
```

Encapsulation:

Encapsulation is the bundling of data (fields) and methods that operate on the data within a single unit (class).

It helps in hiding the internal state of an object and restricting access to it through public methods.

Inheritance:

Inheritance allows a class (subclass or derived class) to inherit properties and behavior from another class (superclass or base class).

It promotes code reusability and establishes an "is-a" relationship between classes.

```
class Animal
{
    public void Eat()
    {
        Console.WriteLine("Animal is eating.");
    }
}
class Dog : Animal
{
    public void Bark()
    {
        Console.WriteLine("Dog is barking.");
    }
}
Dog myDog = new Dog();
myDog.Eat();
myDog.Bark();
```

Polymorphism:

Polymorphism allows objects of different types to be treated as objects of a common base type. It enables methods to be defined in a base class and overridden in derived classes to provide different implementations.

```
class Shape
{
    public virtual void Draw()
    {
        Console.WriteLine("Drawing a shape.");
    }
}
```

```

    }
    class Circle : Shape
    {
        public override void Draw()
        {
            Console.WriteLine("Drawing a circle.");
        }
    }
    Shape myShape = new Circle();
    myShape.Draw(); // Outputs: Drawing a circle.

```

Abstraction:

Abstraction is the process of hiding the complex implementation details and exposing only the necessary features of an object.

It allows you to focus on what an object does rather than how it does it.

Interfaces:

Interfaces define a contract for classes to implement. They specify the methods and properties that implementing classes must provide.

They support multiple inheritance of behavior and promote loose coupling between classes.

```

interface IShape
{
    void Draw();
}
class Rectangle : IShape
{
    public void Draw()
    {
        Console.WriteLine("Drawing a rectangle.");
    }
}

```

Inheritance

Inheritance is a fundamental concept in object-oriented programming (OOP) that allows a class (called a derived class or subclass) to inherit properties and behavior from another class (called a base class or superclass). In C#, inheritance is implemented using the : symbol followed by the name of the base class. Here's an overview of inheritance in C#:

Base Class and Derived Class:

A base class is a class that provides the foundation or common behavior that can be shared by one or more derived classes. A derived class is a class that inherits from a base class and can extend or specialize its behavior.

```

// Base class
public class Animal
{
    public void Eat()
    {
        Console.WriteLine("Animal is eating.");
    }
}

// Derived class
public class Dog : Animal
{
}

```

```
public void Bark()
{
    Console.WriteLine("Dog is barking.");
}
```

Syntax:

To declare a class as a derived class, use a colon (:) followed by the name of the base class. The derived class inherits all non-private members (fields, properties, methods) of the base class.

```
public class DerivedClass : BaseClass
{
    // Members of the derived class
}
```

Access Modifiers:

Inheritance respects access modifiers such as public, protected, internal, and private. Derived classes can access public and protected members of the base class.

Constructor Inheritance:

Constructors are not inherited by derived classes, but the derived class must invoke a constructor of the base class.

This can be done explicitly using the base keyword.

```
public class DerivedClass : BaseClass
{
    public DerivedClass() : base(/* parameters */) { }
```

Method Overriding:

Derived classes can override base class methods by providing a new implementation. Use the override keyword to indicate that a method overrides a base class method.

```
public class Dog : Animal
{
    public override void Eat()
    {
        Console.WriteLine("Dog is eating.");
    }
}
```

Sealed

In C#, the sealed modifier is used to prevent inheritance of a class or overriding of virtual methods. When a class is marked as sealed, it cannot be used as a base class for further derivation. Similarly, when a method is marked as sealed, it cannot be overridden in derived classes. Here's how sealed works in C#:

Sealed Classes:

When a class is marked as sealed, it means that the class cannot be used as a base class for inheritance. It prevents other classes from deriving from it.

```
public sealed class SealedClass
{
    // Class members
}
```

Sealed Methods:

When a method in a base class is marked as sealed, it means that the method cannot be overridden in derived classes. This is useful when you want to prevent further specialization of behavior defined in the base class method.

```
public class BaseClass
{
    public virtual void MyMethod()
    {
        // Method implementation
    }
}
public class DerivedClass : BaseClass
{
    public sealed override void MyMethod()
    {
        // Sealed method implementation
    }
}
```

Usage:

The sealed modifier is used to restrict inheritance and overriding in scenarios where further derivation or overriding is not desired. It can be applied to both classes and methods.

Benefits:

Helps in code optimization and performance improvements by preventing unnecessary virtual method calls in the inheritance hierarchy. Enhances code security by restricting unintended derivation or overriding of classes and methods.

Considerations:

Use sealed sparingly and only when necessary to prevent further derivation or overriding. Overuse of sealed can limit the flexibility and extensibility of the codebase.

Inheritance and Sealed Classes:

A class can be marked as sealed even if it doesn't have any virtual members. A sealed class cannot be used as a base class for inheritance, regardless of whether it has virtual members or not.

Static

In C#, the static keyword is used to define members (fields, methods, properties, constructors, and nested types) that belong to the type itself rather than to instances of the type. Here's how static works in various contexts:

Static Fields:

Static fields are shared across all instances of a class. They belong to the class rather than to any specific instance. Static fields are initialized once when the class is loaded into memory and are shared among all instances of the class.

```
public class MyClass
{
    public static int StaticField = 10;
}
```

Static Methods:

Static methods belong to the class rather than to instances of the class. They can be called directly

on the class without creating an instance. Static methods cannot access instance members directly but can access other static members.

```
public class MyClass
{
    public static void StaticMethod()
    {
        Console.WriteLine("Static method called.");
    }
}
```

```
MyClass.StaticMethod(); // Calling static method
```

Static Properties:

Static properties are similar to static fields but provide a getter and setter to access and modify the underlying static field.

```
public class MyClass
{
    private static int staticField;

    public static int StaticProperty
    {
        get { return staticField; }
        set { staticField = value; }
    }
}
```

```
MyClass.StaticProperty = 20; // Setting static property
int value = MyClass.StaticProperty; // Getting static property
```

Static Constructors:

Static constructors are called only once, when the class is first accessed or instantiated. They are used to initialize static fields or perform any one-time initialization for the class.

```
public class MyClass
{
    static MyClass()
    {
        // Static constructor
    }
}
```

Static Classes:

A static class is a class that only contains static members. It cannot be instantiated, and all its members are accessed directly through the class name.

```
public static class UtilityClass
{
    public static void DoSomething()
    {
        // Static method in a static class
    }
}
UtilityClass.DoSomething(); // Calling static method from a static class
```

Static Members in Interfaces:

Starting from C# 8.0, interfaces can contain static members.

```
public interface IMyInterface
{
    static void StaticMethod()
    {
        // Static method in an interface
    }
}
```

Static members are used when the behavior or data is shared across all instances of a class or when the behavior does not depend on the state of any specific instance. They provide a way to organize and access common functionality without requiring an instance of the class.

Abstract

In C#, the abstract keyword is used to define abstract classes and abstract members within those classes. Abstract classes cannot be instantiated directly, and they may contain abstract methods that must be implemented by non-abstract derived classes. Here's an overview of how abstract works:

Abstract Classes:

An abstract class is a class that cannot be instantiated directly. It serves as a base class for other classes and may contain abstract and non-abstract members.

```
public abstract class Animal
{
    public abstract void MakeSound(); // Abstract method
    public void Eat() // Non-abstract method
    {
        Console.WriteLine("Animal is eating.");
    }
}
```

Abstract Methods:

An abstract method is a method without a body, declared using the abstract keyword. It must be implemented by non-abstract derived classes.

```
public abstract void MakeSound();
```

Abstract Properties:

Abstract properties are similar to abstract methods but represent properties instead. They do not have an implementation and must be implemented by derived classes.

```
public abstract int MyProperty { get; set; }
```

Derived Classes:

Derived classes from abstract classes must provide concrete implementations for all abstract members declared in the base abstract class.

```
public class Dog : Animal
{
    public override void MakeSound()
    {
```

```
        Console.WriteLine("Woof!");
    }
}
```

Instantiation:

Abstract classes cannot be instantiated directly. However, they can be used as a base for other classes, which provide implementations for all abstract members.

```
Animal myAnimal = new Dog();
myAnimal.MakeSound(); // Outputs: Woof!
```

Use Cases:

Abstract classes are useful when you want to define a common interface for a group of related classes but don't want to provide a default implementation for some methods or properties. They are also handy when you want to enforce certain behaviors to be implemented by derived classes.

Abstract Members in Interfaces:

Starting from C# 8.0, interfaces can also contain abstract members. These members are implicitly abstract and must be implemented by classes that implement the interface.

```
public interface IMyInterface
{
    void MyMethod(); // Implicitly abstract
}
```

Abstract classes provide a way to define a common interface for a group of related classes while allowing for flexibility in their implementation. They are essential for building hierarchies of classes with shared behavior and contracts.

Interface - Concepts:

In C#, an interface is a reference type that defines a contract for classes to implement. It contains only the declaration of methods, properties, events, or indexers but not their implementation. Here's an overview of the key concepts related to interfaces in C#:

Interface Declaration:

An interface is declared using the `interface` keyword followed by the interface name and a list of members.

```
public interface IMyInterface
{
    void Method1();
    int Property1 { get; set; }
}
```

Interface Members:

Interface members include methods, properties, events, and indexers. These members are implicitly public and abstract, and they cannot contain any access modifiers. They define a contract that implementing classes must adhere to.

Implementing Interfaces:

A class implements an interface by providing concrete implementations for all the members declared in the interface.

```
public class MyClass : IMyInterface
{
    public void Method1()
    {
        // Implementation for Method1
    }

    public int Property1 { get; set; }
}
```

Multiple Interface Implementation:

A class can implement multiple interfaces by separating them with commas in the class declaration.

```
public class MyClass : IMyInterface1, IMyInterface2
{
    // Implementations for interface members
}
```

Implicit Interface Implementation:

Starting from C# 8.0, classes can provide implicit implementation of interface members.

```
public class MyClass : IMyInterface
{
    public void Method1()
    {
        // Implementation for Method1
    }

    public int Property1 { get; set; }
}
```

Interface Inheritance:

Interfaces can inherit from one or more other interfaces using the : syntax.

```
public interface IMyInterface2 : IMyInterface1
{
    // Interface members
}
```

Interface Segregation Principle (ISP):

ISP is a design principle that states that no client should be forced to depend on methods it does not use. It suggests splitting large interfaces into smaller, more specific ones.

Use Cases:

Interfaces are commonly used to define contracts for classes that have similar behavior but different implementations. They facilitate polymorphism and decoupling in software design by allowing objects to be treated uniformly based on their interfaces. Interfaces are a powerful tool in C# for designing flexible and extensible systems. They enable code reusability, maintainability, and testability by promoting loose coupling between components.

Events and Delegates :-

In C#, events and delegates are fundamental concepts used for implementing the observer design pattern, enabling communication between objects in an application. Here's an overview of each:

Delegates:

Delegates are a type-safe, object-oriented function pointers that allow methods to be passed as parameters to other methods. They define the signature and return type of the method(s) they can reference.

Declaration:

```
delegate returnType DelegateName(parameters);
```

```
public delegate void MyDelegate(string message);
```

Events:

Events are special types of delegates that encapsulate methods to be called when a certain action or notification occurs. They are used to implement the publisher-subscriber pattern.

Declaration:

```
public event DelegateName EventName;
```

```
public event EventHandler ButtonClicked;
```

Basic Usage:

Define Delegate: Define a delegate that matches the signature of the methods you want to encapsulate.

Declare Event: Declare an event based on the delegate.

Subscribe to Event: Subscribe methods to the event using the `+ =` operator.

Raise Event: Call the event, which will execute all subscribed methods.

```
using System;

public class Program
{
    // Step 1: Define delegate
    public delegate void EventHandler(string message);

    // Step 2: Declare event
    public event EventHandler Notify;

    // Step 3: Subscribe to event
    public void Subscribe(EventHandler method)
    {
        Notify += method;
    }
}
```

```
// Step 4: Raise event
public void RaiseEvent(string message)
{
    Notify?.Invoke(message);
}

static void Main(string[] args)
{
    Program program = new Program();

    // Subscribe methods to
    // event
    program.Subscribe(Method1);
    program.Subscribe(Method2);

    // Raise event
    program.RaiseEvent("Event
triggered!");

    Console.ReadLine();
}

static void Method1(string message)
{
    Console.WriteLine("Method 1: " + message);
}

static void Method2(string message)
{
    Console.WriteLine("Method 2: " + message);
}
```

This will output:

mathematica

Method 1: Event triggered!
Method 2: Event triggered!

Events and delegates are extensively used in C# for implementing various patterns like observer, command, etc., as well as in frameworks like Windows Forms and WPF for handling UI events.

File IO and Reflection

File IO :

File handling is a very crucial and important feature for many enterprise applications around us. To support this feature Microsoft .NET Framework offers the System.IO namespace, that provides various classes to enable the developers to do I/O.

Objectives:

- Using the File class for reading and writing data.
- Using the File and FileInfo class to manipulate files.
- Using the DirectoryInfo and Directory classes to manipulate directories.

The File class of the System.IO namespace offers various static methods that enable a developer to do direct reading and writing of files. Typically, to read data from a file, you:

1. Get a hold on the file handle.
2. Open a stream to the file.
3. Buffer the file data into memory.
4. Release the hold of file handle once done.

Reading Data from Files : data is read from a file

The "ReadAllText" method reads the data of a file.

```
string filePath = @"C:\MyData\TestFile.txt";
string testData = File.ReadAllText(filePath);
```

The "ReadAllLines" method reads all the contents of a file and stores each line at a new index in an array of string type.

```
string filePath = @"C:\MyData\TestFile.txt";
string[] testDataLineByLine = File.ReadAllLines(filePath);
```

The "ReadAllBytes" method reads the contents of a file as binary data and stores the data in a byte array.

```
string filePath = @"C:\MyData\TestFile.txt";
byte[] testDataRawBytes = File.ReadAllBytes(filePath);
```

Each of these methods enable the developer to read the contents of a file and load into memory. The ReadAllText method will enable the developer to cache the entire file in memory via a single operation. Whereas the ReadAllLines method will read line-by-line into an array.

Writing Data to Files : data is written to a file. By default, all existing contents are removed from the file, and new content is written.

The "WriteAllText" method enables the developers to write the contents of string variable into a file. If the file exists, its contents will be overwritten. The following code example shows how to write the contents of a string named settings to a new file named settings.txt.

```
string filePath = @"C:\MyData\TestFile.txt";
string data = "C# Corner MVP & Microsoft MVP;";
File.WriteAllText(filePath, data);
```

The "WriteAllLines" method enables the developers to write the contents of a string array to a file. Each entry in the string array will be a new line in the new file.

```
String filePath = @"C:\MyData\TestFile.txt";
string[] data = {"MCT", "MCPD", "MCTS", "MCSD.NET", "MCAD.NET", "CSM"};
File.WriteAllLines(filePath, data)
```

Appending Data to Files – writing information to a file. The only difference is that the existing data in a file is not overwritten. The new data to be written is added at the end of the file.

The "AppendAllText" method enables the developers to write the contents of a string variable at the end of an existing file.

```
String filePath = @"C:\MyData\TestFile.txt";
string data = "Also Certified from IIT Kharagpur";
File.AppendAllText(filePath, data);
```

The "AppendAllLines" method enables the developers to write the contents of a string array to the end of an existing file.

```
String filePath = @"C:\MyData\TestFile.txt";
string[] otherData = { "Worked with Microsoft", "Lived in USA" };
File.AppendAllLines(filePath, otherData);
```

File IO Steps :

1. Creating a file :

We use the Create() method of the File class to create a new file in C#. For example,

```
//create a file at patName
```

```
FileStream fs = File.Create(pathName);
```

Here, the File class creates a file at pathName.

Note: If the file already exists, the Create() method overwrites the file.

Example:

```
using System;
using System.IO;
class Program
{
    static void Main()
    {
        // path of the file that we want to create
        string pathName = @"C:\Program\myFile.txt";

        // Create() creates a file at pathName
        FileStream fs = File.Create(pathName);

        // check if myFile.txt file is created at the specified path
        if (File.Exists(pathName))
        {
            Console.WriteLine("File is created.");
        }
        else
        {
            Console.WriteLine("File is not created.");
        }
    }
}
```

2. Open a file :

We use the Open() method of the File class to open an existing file in C#. The method opens a FileStream on the specified file.

Example:

```
using System;
using System.IO;
class Program
{
    static void Main()
    {
```

```
string pathName = @"C:\Program\myFile.txt";

// open a file at pathName
FileStream fs = File.Open(pathName, FileMode.Open);
}

}
```

In the above example, notice the code,

```
//opens the file at pathName
FileStream fs = File.Open(pathName, FileMode.Open);
```

Here, theOpen() method opens myFile.txt file. Here, FileMode.Open specifies **-open the existing file.**

3. Write to a file :

We use theWriteAllText() method of theFile class to write to a file. The method creates a new file and writes content to that file

Example:

```
using System;
using System.IO;
class Program
{
    static void Main()
    {
        string pathName = @"C:\Program\myFile.txt";

        // create a file at pathName and write "Hello World" to the file
        File.WriteAllText(pathName, "Hello World");
    }
}
```

In the above example, notice the code,

```
File.WriteAllText(pathName, "Hello World");
```

Here, the WriteAllText() method creates myFile.txt at c:\Program directory and writes “Hello Word” to the file.

4. Read a file :

We use the `ReadAllText()` method of the `File` class to read contents of the file. The method returns a string containing all the text in the specified file.

Let's read the content of the file `myFile.txt` where we had written "Hello World".

```
Exam  
ple:  
using  
Syste  
m;  
using  
System.IO;  
class  
Program  
{  
    static void Main()  
    {  
        string pathName = @"C:\Program\myFile.txt";  
  
        // read the content of myFile.txt file  
        string readText = File.ReadAllText(pathName);  
  
        Console.WriteLine(readText);  
    }  
}
```

In the above example, notice the code,

```
//read the content of myFile.txt file  
string readText= File.ReadAllText(pathName);
```

The `ReadAllText()` method read the file `myFile.txt` and returns "Hello World".

Serialization :

serialization is the process of converting object into byte stream so that it can be saved to memory, file or database

Generics

Generics in C# allow you to write flexible and reusable code by creating classes, structures, interfaces, and methods that can work with any data type. They provide type safety without sacrificing flexibility. Here's an overview of how generics work:

Basic Syntax:

```
class ClassName<T>
{
    // Members, methods, properties, etc.
}
```

T is a type parameter, representing any data type. You can use any valid identifier instead of T.

Example:

```
public class GenericList<T>
{
    private T[] _items;
    private int _currentIndex = 0;

    public GenericList(int capacity)
    {
        _items = new T[capacity];
    }

    public void Add(T item)
    {
        if (_currentIndex < _items.Length)
        {
            _items[_currentIndex] = item;
            _currentIndex++;
        }
    }

    public T GetItem(int index)
    {
        if (index >= 0 && index < _items.Length)
        {
            return _items[index];
        }
        throw new IndexOutOfRangeException();
    }
}
```

Usage:

```
GenericList<int> intList = new GenericList<int>(5);
intList.Add(1);
intList.Add(2);
intList.Add(3);

int item = intList.GetItem(1); // item = 2
```

```
GenericList<string> stringList = new GenericList<string>(3);
stringList.Add("apple");
stringList.Add("banana");

string fruit = stringList.GetItem(0); // fruit = "apple"
```

Constraints:

You can apply constraints on generic type parameters to specify capabilities that generic types must have. Common constraints include where T : class, where T : struct, where T : interface, where T : new() (parameterless constructor), and custom constraints.

Example with Constraints:

```
public class MyClass<T> where T : IDisposable
{
    // Methods can use IDisposable methods on T
}
```

Generics are extensively used in .NET framework collections (like List<T>), LINQ, and various other scenarios where type safety and code reuse are essential. They help to avoid code duplication and increase the flexibility and maintainability of your codebase.

Boxing and Unboxing

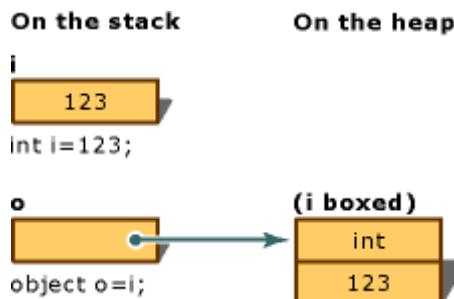
Boxing

Boxing is the process of converting a value type to the type object or to any interface type implemented by this value type. Boxing a value type allocates an object instance on the heap and copies the value into the new object.

The following statement implicitly applies the boxing operation on the variable i:

```
int i = 123;
// The following line boxes i.
object o = i;
```

The result of this statement is creating an object reference o, on the stack, that references a value of the type int, on the heap. This value is a copy of the value-type value assigned to the variable i. The difference between the two variables, i and o, is illustrated in the following image of boxing conversion



It is also possible to perform the boxing explicitly as in the following example, but explicit boxing is never required:

```
int i = 123;
object o = (object)i; // explicit boxing
```

Unboxing

Unboxing is an explicit conversion from the type object to a value type or from an interface type to a value type that implements the interface. An unboxing operation consists of:

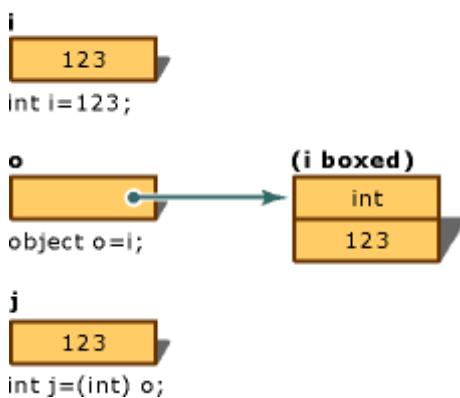
- Checking the object instance to make sure that it is a boxed value of the given value type.
- Copying the value from the instance into the value-type variable.

The following statements demonstrate both boxing and unboxing operations:

```
int i = 123;      // a value type
object o = i;    // boxing
```

```
int j = (int)o; // unboxing
```

On the stack On the heap



Arrays

You can store multiple variables of the same type in an array data structure. You declare an array by specifying the type of its elements. If you want the array to store elements of any type, you can specify object as its type.

```
type[] arrayName;
```

An array has the following properties:

- An array can be single-dimensional, multidimensional, or jagged.
- The number of dimensions are set when an array variable is declared. The length of each dimension is established when the array instance is created. These values can't be changed during the lifetime of the instance.
- A jagged array is an array of arrays, and each member array has the default value of null.
- Arrays are zero indexed: an array with n elements is indexed from 0 to n-1.
- Array elements can be of any type, including an array type.
- Array types are reference types derived from the abstract base type **Array**. All arrays implement **IList** and **IEnumerable**. You can use the **foreach** statement to iterate through an array. Single-dimensional arrays also implement **IList** and **IEnumerable**.

```
// Declare a single-dimensional array of 5 integers.
int[] array1 = new int[5];

// Declare and set array element values.
int[] array2 = [1, 2, 3, 4, 5, 6];

// Declare a two dimensional array.
int[,] multiDimensionalArray1 = new int[2, 3];

// Declare and set array element values.
int[,] multiDimensionalArray2 = { { 1, 2, 3 }, { 4, 5, 6 } };
```

```
// Declare a jagged array.  
int[][] jaggedArray = new int[6][];  
  
// Set the values of the first array in the jagged array structure.  
jaggedArray[0] = [1, 2, 3, 4];
```

Single-dimensional arrays

A single-dimensional array is a sequence of like elements. You access an element via its index. The index is its ordinal position in the sequence. The first element in the array is at index 0. You create a single-dimensional array using the new operator specifying the array element type and the number of elements.

The following example declares and initializes single-dimensional arrays:

```
int[] array = new int[5];  
string[] weekDays = ["Sun", "Mon", "Tue", "Wed", "Thu", "Fri", "Sat"];  
  
Console.WriteLine(weekDays[0]);  
Console.WriteLine(weekDays[1]);  
Console.WriteLine(weekDays[2]);  
Console.WriteLine(weekDays[3]);  
Console.WriteLine(weekDays[4]);  
Console.WriteLine(weekDays[5]);  
Console.WriteLine(weekDays[6]);  
  
/*Output:  
Sun  
Mon  
Tue  
Wed  
Thu  
Fri  
Sat  
*/
```

The first declaration declares an uninitialized array of five integers, from array[0] to array[4]. The elements of the array are initialized to the default value of the element type, 0 for integers. The second declaration declares an array of strings and initializes all seven values of that array. A series of Console.WriteLine statements prints all the elements of the weekDay array.

Multidimensional arrays

Arrays can have more than one dimension. For example, the following declarations create four arrays: two have two dimensions, two have three dimensions. The first two declarations declare the length of each dimension, but don't initialize the values of the array. The second two declarations use an initializer to set the values of each element in the multidimensional array.

```

int[,] array2DDeclaration = new int[4, 2];

int[, ,] array3DDeclaration = new int[4, 2, 3];

// Two-dimensional array.
int[,] array2DInitialization = { { 1, 2 }, { 3, 4 }, { 5, 6 }, { 7, 8 } };
// Three-dimensional array.
int[, ,] array3D = new int[, ,] { { { 1, 2, 3 }, { 4, 5, 6 } },
                                  { { 7, 8, 9 }, { 10, 11, 12 } } };

// Accessing array elements.
System.Console.WriteLine(array2DInitialization[0, 0]);
System.Console.WriteLine(array2DInitialization[0, 1]);
System.Console.WriteLine(array2DInitialization[1, 0]);
System.Console.WriteLine(array2DInitialization[1, 1]);

System.Console.WriteLine(array2DInitialization[3, 0]);
System.Console.WriteLine(array2DInitialization[3, 1]);
// Output:
// 1
// 2
// 3
// 4
// 7
// 8

System.Console.WriteLine(array3D[1, 0, 1]);
System.Console.WriteLine(array3D[1, 1, 2]);
// Output:
// 8
// 12

// Getting the total count of elements or the length of a given dimension.
var allLength = array3D.Length;
var total = 1;
for (int i = 0; i < array3D.Rank; i++)
{
    total *= array3D.GetLength(i);
}
System.Console.WriteLine($"{allLength} equals {total}");
// Output:
// 12 equals 12

```

For multi-dimensional arrays, elements are traversed such that the indices of the rightmost dimension are incremented first, then the next left dimension, and so on, to the leftmost index. The following example enumerates both a 2D and a 3D array:

```

int[,] numbers2D = { { 9, 99 }, { 3, 33 }, { 5, 55 } };

foreach (int i in numbers2D)

```

```

{
    System.Console.WriteLine($"{i} ");
}
// Output: 9 99 3 33 5 55

int[,] array3D = new int[,] { { { 1, 2, 3 }, { 4, 5, 6 } },
                             { { 7, 8, 9 }, { 10, 11, 12 } } };
foreach (int i in array3D)
{
    System.Console.WriteLine($"{i} ");
}
// Output: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

```

In a 2D array, you can think of the left index as the row and the right index as the column. However, with multidimensional arrays, using a nested for loop gives you more control over the order in which to process the array elements:

```

int[,] array3D = new int[,] { { { 1, 2, 3 }, { 4, 5, 6 } },
                             { { 7, 8, 9 }, { 10, 11, 12 } } };

for (int i = 0; i < array3D.GetLength(0); i++)
{
    for (int j = 0; j < array3D.GetLength(1); j++)
    {
        for (int k = 0; k < array3D.GetLength(2); k++)
        {
            System.Console.Write($"{array3D[i, j, k]} ");
        }
        System.Console.WriteLine();
    }
    System.Console.WriteLine();
}
// Output (including blank lines):
// 4 5 6
//
// 7 8 9
// 10 11 12
//

```

Jagged arrays

A jagged array is an array whose elements are arrays, possibly of different sizes. A jagged array is sometimes called an "array of arrays." Its elements are reference types and are initialized to null. The following examples show how to declare, initialize, and access jagged arrays. The first example, jaggedArray, is declared in one statement. Each contained array is created in subsequent statements. The second example, jaggedArray2 is declared and initialized in one statement. It's possible to mix jagged and multidimensional arrays. The final

example, jaggedArray3, is a declaration and initialization of a single-dimensional jagged array that contains three two-dimensional array elements of different sizes.

```
int[][] jaggedArray = new int[3][];  
  
jaggedArray[0] = [1, 3, 5, 7, 9];  
jaggedArray[1] = [0, 2, 4, 6];  
jaggedArray[2] = [11, 22];  
  
int[][] jaggedArray2 =  
[  
    [1, 3, 5, 7, 9],  
    [0, 2, 4, 6],  
    [11, 22]  
];  
  
// Assign 77 to the second element ([1]) of the first array ([0]):  
jaggedArray2[0][1] = 77;  
  
// Assign 88 to the second element ([1]) of the third array ([2]):  
jaggedArray2[2][1] = 88;  
  
int[,][] jaggedArray3 =  
[  
    new int[,] { {1,3}, {5,7} },  
    new int[,] { {0,2}, {4,6}, {8,10} },  
    new int[,] { {11,22}, {99,88}, {0,9} }  
];  
  
Console.WriteLine("{0}", jaggedArray3[0][1, 0]);  
Console.WriteLine(jaggedArray3.Length);
```

A jagged array's elements must be initialized before you can use them. Each of the elements is itself an array. It's also possible to use initializers to fill the array elements with values. When you use initializers, you don't need the array size.

Implicitly typed arrays

You can create an implicitly typed array in which the type of the array instance is inferred from the elements specified in the array initializer. The rules for any implicitly typed variable also apply to implicitly typed arrays.

The following examples show how to create an implicitly typed array:

```
int[] a = new[] { 1, 10, 100, 1000 }; // int[]  
  
// Accessing array  
Console.WriteLine("First element: " + a[0]);  
Console.WriteLine("Second element: " + a[1]);  
Console.WriteLine("Third element: " + a[2]);  
Console.WriteLine("Fourth element: " + a[3]);
```

```

/* Outputs
First element: 1
Second element: 10
Third element: 100
Fourth element: 1000
*/

```

```

var b = new[] { "hello", null, "world" }; // string[]

// Accessing elements of an array using 'string.Join' method
Console.WriteLine(string.Join(" ", b));
/* Output
hello world
*/

```

```

// single-dimension jagged array
int[][] c =
[
    [1,2,3,4],
    [5,6,7,8]
];
// Looping through the outer array
for (int k = 0; k < c.Length; k++)
{
    // Looping through each inner array
    for (int j = 0; j < c[k].Length; j++)
    {
        // Accessing each element and printing it to the console
        Console.WriteLine($"Element at c[{k}][{j}] is: {c[k][j]}");
    }
}
/* Outputs
Element at c[0][0] is: 1
Element at c[0][1] is: 2
Element at c[0][2] is: 3
Element at c[0][3] is: 4
Element at c[1][0] is: 5
Element at c[1][1] is: 6
Element at c[1][2] is: 7
Element at c[1][3] is: 8
*/

```

```

// jagged array of strings
string[][] d =
[
    ["Luca", "Mads", "Luke", "Dinesh"],
    ["Karen", "Suma", "Frances"]
];

// Looping through the outer array
int i = 0;
foreach (var subArray in d)
{
    // Looping through each inner array

```

```

int j = 0;
foreach (var element in subArray)
{
    // Accessing each element and printing it to the console
    Console.WriteLine($"Element at d[{i}][{j}] is: {element}");
    j++;
}
i++;
}
/* Outputs
Element at d[0][0] is: Luca
Element at d[0][1] is: Mads
Element at d[0][2] is: Luke
Element at d[0][3] is: Dinesh
Element at d[1][0] is: Karen
Element at d[1][1] is: Suma
Element at d[1][2] is: Frances
*/

```

In the previous example, notice that with implicitly typed arrays, no square brackets are used on the left side of the initialization statement. Also, jagged arrays are initialized by using new [] just like single-dimensional arrays.

When you create an anonymous type that contains an array, the array must be implicitly typed in the type's object initializer. In the following example, contacts is an implicitly typed array of anonymous types, each of which contains an array named PhoneNumbers. The var keyword isn't used inside the object initializers.

```

var contacts = new[]
{
    new
    {
        Name = "Eugene Zabokritski",
        PhoneNumbers = new[] { "206-555-0108", "425-555-0001" }
    },
    new
    {
        Name = "Hanying Feng",
        PhoneNumbers = new[] { "650-555-0199" }
    }
};

```

Collections and Data Structures

All collections provide methods for adding, removing, or finding items in the collection. In addition, all collections that directly or indirectly implement the `ICollection` interface or the `IList` interface share these features:

- The ability to enumerate the collection

.NET collections either implement System.Collections.IEnumerable or System.Collections.Generic.IEnumerable to enable the collection to be iterated through. An enumerator can be thought of as a movable pointer to any element in the collection. The foreach, in statement and the For Each...Next Statement use the enumerator exposed by the GetEnumerator method and hide the complexity of manipulating the enumerator. In addition, any collection that implements System.Collections.Generic.IEnumerable is considered a queryable type and can be queried with LINQ. LINQ queries provide a common pattern for accessing data. They're typically more concise and readable than standard foreach loops and provide filtering, ordering, and grouping capabilities. LINQ queries can also improve performance. For more information, see LINQ to Objects (C#), LINQ to Objects (Visual Basic), Parallel LINQ (PLINQ), Introduction to LINQ Queries (C#), and Basic Query Operations (Visual Basic).

- The ability to copy the collection contents to an array

All collections can be copied to an array using the CopyTo method. However, the order of the elements in the new array is based on the sequence in which the enumerator returns them. The resulting array is always one-dimensional with a lower bound of zero.

In addition, many collection classes contain the following features:

- Capacity and Count properties

The capacity of a collection is the number of elements it can contain. The count of a collection is the number of elements it actually contains. Some collections hide the capacity or the count or both.

Most collections automatically expand in capacity when the current capacity is reached. The memory is reallocated, and the elements are copied from the old collection to the new one. This design reduces the code required to use the collection. However, the performance of the collection might be negatively affected. For example, for List, if Count is less than Capacity, adding an item is an O(1) operation. If the capacity needs to be increased to accommodate the new element, adding an item becomes an O(n) operation, where n is Count. The best way to avoid poor performance caused by multiple reallocations is to set the initial capacity to be the estimated size of the collection.

A BitArray is a special case; its capacity is the same as its length, which is the same as its count.

- A consistent lower bound

The lower bound of a collection is the index of its first element. All indexed collections in the System.Collections namespaces have a lower bound of zero, meaning they're 0-indexed. Array has a lower bound of zero by default, but a different lower bound can be defined when creating an instance of the Array class using Array.CreateInstance.

- Synchronization for access from multiple threads (System.Collections classes only).

Non-generic collection types in the System.Collections namespace provide some thread safety with synchronization; typically exposed through the SyncRoot and IsSynchronized members. These collections aren't thread-safe by default. If you require scalable and efficient multi-threaded access to a collection, use one of the classes in the System.Collections.Concurrent namespace or consider using an immutable collection. For more information, see Thread-Safe Collections.

Choose a collection

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In general, you should use generic collections. The following table describes some common collection scenarios and the collection classes you can use for those scenarios. If you're new to generic collections, the following table will help you choose the generic collection that works best for your task:

I want to...	Generic collection options	Non-generic collection options	Thread-safe or immutable collection options
Store items as key/value pairs for quick look-up by key	Dictionary< TKey, TValue >	Hashtable (A collection of key/value pairs that are organized based on the hash code of the key.)	ConcurrentDictionary< TKey, TValue > ReadOnlyDictionary< TKey, TValue > ImmutableDictionary< TKey, TValue >
Access items by index	List< T >	Array ArrayList	ImmutableList< T > ImmutableArray
Use items first-in-first-out (FIFO)	Queue< T >	Queue	ConcurrentQueue< T > ImmutableQueue< T >
Use data Last-In-First-Out (LIFO)	Stack< T >	Stack	ConcurrentStack< T > ImmutableStack< T >
Access items sequentially	LinkedList< T >	No recommendation	No recommendation
Receive notifications when items are removed or added to the collection. (implements INotifyPropertyChanged and INotifyCollectionChanged)	ObservableCollection< T >	No recommendation	No recommendation
A sorted collection	SortedDictionary< TKey, TValue >	SortedList	ImmutableSortedDictionary< TKey, TValue > ImmutableSortedSet< T >
A set for mathematical functions	HashSet< T > SortedSet< T >	No recommendation	ImmutableHashSet< T > ImmutableSortedSet< T >

ArrayList

Definition

- Namespace: System.Collections
- Assembly: System.Runtime.dll

Implements the IList interface using an array whose size is dynamically increased as required.

```
public class ArrayList : ICloneable, System.Collections.IList
```

Derived System.Windows.Forms.DomainUpDown.DomainUpDownItemCollection Implements ICollection
IEnumerable IList ICloneable

Examples

The following example shows how to create and initialize an ArrayList and how to display its values.

```
using System;
using System.Collections;
public class SamplesArrayList {

    public static void Main() {

        // Creates and initializes a new ArrayList.
        ArrayList myAL = new ArrayList();
        myAL.Add("Hello");
        myAL.Add("World");
        myAL.Add("!");

        // Displays the properties and values of the ArrayList.
        Console.WriteLine("myAL");
        Console.WriteLine("Count: {0}", myAL.Count);
        Console.WriteLine("Capacity: {0}", myAL.Capacity);
        Console.Write("Values:");
        PrintValues(myAL);
    }

    public static void PrintValues( IEnumerable myList ) {
        foreach ( Object obj in myList )
            Console.Write(" {0}", obj );
        Console.WriteLine();
    }
}

/*
This code produces output similar to the following:

myAL
Count: 3
Capacity: 4

```

```
Values: Hello World !
```

```
*/
```

Remarks

The ArrayList is not guaranteed to be sorted. You must sort the ArrayList by calling its Sort method prior to performing operations (such as BinarySearch) that require the ArrayList to be sorted. To maintain a collection that is automatically sorted as new elements are added, you can use the SortedSet class.

The capacity of an ArrayList is the number of elements the ArrayList can hold. As elements are added to an ArrayList, the capacity is automatically increased as required through reallocation. The capacity can be decreased by calling TrimToSize or by setting the Capacity property explicitly.

.NET Framework only: For very large ArrayList objects, you can increase the maximum capacity to 2 billion elements on a 64-bit system by setting the enabled attribute of the configuration element to true in the run-time environment.

Elements in this collection can be accessed using an integer index. Indexes in this collection are zero-based.

The ArrayList collection accepts null as a valid value. It also allows duplicate elements.

Using multidimensional arrays as elements in an ArrayList collection is not supported.

Constructors

ArrayList()	Initializes a new instance of the ArrayList class that is empty and has the default initial capacity.
ArrayList(IList)	Initializes a new instance of the ArrayList class that contains elements copied from the specified collection and that has the same initial capacity as the number of elements copied.
ArrayList(Int32)	Initializes a new instance of the ArrayList class that is empty and has the specified initial capacity.

Properties

Capacity	Gets or sets the number of elements that the ArrayList can contain.
Count	Gets the number of elements actually contained in the ArrayList.
IsFixedSize	Gets a value indicating whether the ArrayList has a fixed size.
IsReadOnly	Gets a value indicating whether the ArrayList is read-only.
IsSynchronized	Gets a value indicating whether access to the ArrayList is synchronized (thread safe).
Item[Int32]	Gets or sets the element at the specified index.
SyncRoot	Gets an object that can be used to synchronize access to the ArrayList.

Methods

Adapter(IList)	Creates an ArrayList wrapper for a specific IList.
Add(Object)	Adds an object to the end of the ArrayList.
AddRange(ICollection)	Adds the elements of an ICollection to the end of the ArrayList.
BinarySearch(Int32, Int32, Object, IComparer)	Searches a range of elements in the sorted ArrayList for an element using the specified comparer and returns the zero-based index of the element.
BinarySearch(Object)	Searches the entire sorted ArrayList for an element using the default comparer and returns the zero-based index of the element.
BinarySearch(Object, IComparer)	Searches the entire sorted ArrayList for an element using the specified comparer and returns the zero-based index of the element.
Clear()	Removes all elements from the ArrayList.
Clone()	Creates a shallow copy of the ArrayList.
Contains(Object)	Determines whether an element is in the ArrayList.
CopyTo(Array)	Copies the entire ArrayList to a compatible one-dimensional Array, starting at the beginning of the target array.
CopyTo(Array, Int32)	Copies the entire ArrayList to a compatible one-dimensional Array, starting at the specified index of the target array.
CopyTo(Int32, Array, Int32, Int32)	Copies a range of elements from the ArrayList to a compatible one-dimensional Array, starting at the specified index of the target array.
Equals(Object)	Determines whether the specified object is equal to the current object. (Inherited from Object)

FixedSize(ArrayList)	Returns an ArrayList wrapper with a fixed size.
FixedSize(IList)	Returns an IList wrapper with a fixed size.
GetEnumerator()	Returns an enumerator for the entire ArrayList.
GetEnumerator(Int32, Int32)	Returns an enumerator for a range of elements in the ArrayList.
GetHashCode()	Serves as the default hash function. (Inherited from Object)
GetRange(Int32, Int32)	Returns an ArrayList which represents a subset of the elements in the source ArrayList.
GetType()	Gets the Type of the current instance. (Inherited from Object)
IndexOf(Object)	Searches for the specified Object and returns the zero-based index of the first occurrence within the entire ArrayList.
IndexOf(Object, Int32)	Searches for the specified Object and returns the zero-based index of the first occurrence within the range of elements in the ArrayList that extends from the specified index to the last element.

IndexOf(Object, Int32, Int32)	Searches for the specified Object and returns the zero-based index of the first occurrence within the range of elements in the ArrayList that starts at the specified index and contains the specified number of elements.
Insert(Int32, Object)	Inserts an element into the ArrayList at the specified index.
InsertRange(Int32, ICollection)	Inserts the elements of a collection into the ArrayList at the specified index.

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LastIndexOf(Object)	Searches for the specified Object and returns the zero-based index of the last occurrence within the entire ArrayList .
LastIndexOf(Object, Int32)	Searches for the specified Object and returns the zero-based index of the last occurrence within the range of elements in the ArrayList that extends from the first element to the specified index.
LastIndexOf(Object, Int32, Int32)	Searches for the specified Object and returns the zero-based index of the last occurrence within the range of elements in the ArrayList that contains the specified number of elements and ends at the specified index.
MemberwiseClone()	Creates a shallow copy of the current Object . (Inherited from Object)
ReadOnly(ArrayList)	Returns a read-only ArrayList wrapper.
ReadOnly(IList)	Returns a read-only IList wrapper.
Remove(Object)	Removes the first occurrence of a specific object from the ArrayList .
RemoveAt(Int32)	Removes the element at the specified index of the ArrayList .
RemoveRange(Int32, Int32)	Removes a range of elements from the ArrayList .
Repeat(Object, Int32)	Returns an ArrayList whose elements are copies of the specified value.
Reverse()	Reverses the order of the elements in the entire ArrayList .
Reverse(Int32, Int32)	Reverses the order of the elements in the specified range.
SetRange(Int32, ICollection)	Copies the elements of a collection over a range of elements in the ArrayList .
Sort()	Sorts the elements in the entire ArrayList .

Sort(IComparer) Sorts the elements in the entire [ArrayList](#) using the specified comparer.

Sort(Int32, Int32, IComparer) Sorts the elements in a range of elements in [ArrayList](#) using the specified comparer.

Synchronized(ArrayList) Returns an [ArrayList](#) wrapper that is synchronized (thread safe).

Synchronized(IList) Returns an [IList](#) wrapper that is synchronized (thread safe).

ToArray() Copies the elements of the [ArrayList](#) to a new [Object](#) array.

ToArray(Type) Copies the elements of the [ArrayList](#) to a new array of the specified element type.

ToString() Returns a string that represents the current object.
[\(Inherited from Object\)](#)

TrimToSize() Sets the capacity to the actual number of elements in the [ArrayList](#).

Hashtable

- Namespace: System.Collections
- Assembly: System.Runtime.dll

Represents a collection of key/value pairs that are organized based on the hash code of the key.

```
public class Hashtable : ICloneable, System.Collections.IDictionary,  
System.Runtime.Serialization.IDeserializationCallback,  
System.Runtime.Serialization.ISerializable
```

- Derived: System.Configuration.SettingsAttributeDictionary System.Configuration.SettingsContext
System.Data.PropertyCollection System.Printing.IndexedProperties.PrintPropertyDictionary
- Implements: ICollection IDictionary IEnumerable ICloneable IDeserializationCallback ISerializable

The following example shows how to create, initialize and perform various functions to a Hashtable and how to print out its keys and values.

```
using System;  
using System.Collections;  
  
class Example  
{  
    public static void Main()  
    {  
        // Create a new hash table.  
        //  
        Hashtable openWith = new Hashtable();  
  
        // Add some elements to the hash table. There are no  
        // duplicate keys, but some of the values are duplicates.  
        openWith.Add("txt", "notepad.exe");  
        openWith.Add("bmp", "paint.exe");  
        openWith.Add("dib", "paint.exe");  
        openWith.Add("rtf", "wordpad.exe");  
  
        // The Add method throws an exception if the new key is  
        // already in the hash table.  
        try  
        {  
            openWith.Add("txt", "winword.exe");  
        }  
        catch  
        {  
            Console.WriteLine("An element with Key = \"txt\" already exists.");  
        }  
  
        // The Item property is the default property, so you  
        // can omit its name when accessing elements.  
        Console.WriteLine("For key = \"rtf\", value = {0}.", openWith["rtf"]);
```

```
// The default Item property can be used to change the value
// associated with a key.
openWith["rtf"] = "winword.exe";
Console.WriteLine("For key = \"rtf\", value = {0}.", openWith["rtf"]);

// If a key does not exist, setting the default Item property
// for that key adds a new key/value pair.
openWith["doc"] = "winword.exe";

// ContainsKey can be used to test keys before inserting
// them.
if (!openWith.ContainsKey("ht"))
{
    openWith.Add("ht", "hypertrm.exe");
    Console.WriteLine("Value added for key = \"ht\": {0}",
openWith["ht"]);
}

// When you use foreach to enumerate hash table elements,
// the elements are retrieved as KeyValuePair objects.
Console.WriteLine();
foreach( DictionaryEntry de in openWith )
{
    Console.WriteLine("Key = {0}, Value = {1}", de.Key, de.Value);
}

// To get the values alone, use the Values property.
ICollection valueColl = openWith.Values;

// The elements of the ValueCollection are strongly typed
// with the type that was specified for hash table values.
Console.WriteLine();
foreach( string s in valueColl )
{
    Console.WriteLine("Value = {0}", s);
}

// To get the keys alone, use the Keys property.
ICollection keyColl = openWith.Keys;

// The elements of the KeyCollection are strongly typed
// with the type that was specified for hash table keys.
Console.WriteLine();
foreach( string s in keyColl )
{
    Console.WriteLine("Key = {0}", s);
}

// Use the Remove method to remove a key/value pair.
Console.WriteLine("\nRemove(\"doc\")");
openWith.Remove("doc");

if (!openWith.ContainsKey("doc"))
{
```

```

        Console.WriteLine("Key \"doc\" is not found.");
    }
}
}

/* This code example produces the following output:

An element with Key = "txt" already exists.
For key = "rtf", value = wordpad.exe.
For key = "rtf", value = winword.exe.
Value added for key = "ht": hypertrm.exe

Key = dib, Value = paint.exe
Key = txt, Value = notepad.exe
Key = ht, Value = hypertrm.exe
Key = bmp, Value = paint.exe
Key = rtf, Value = winword.exe
Key = doc, Value = winword.exe

Value = paint.exe
Value = notepad.exe
Value = hypertrm.exe
Value = paint.exe
Value = winword.exe
Value = winword.exe

Key = dib
Key = txt
Key = ht
Key = bmp
Key = rtf
Key = doc

Remove("doc")
Key "doc" is not found.
*/

```

Each element is a key/value pair stored in a `DictionaryEntry` object. A key cannot be null, but a value can

- be.
- The objects used as keys by a `Hashtable` are required to override the `Object.GetHashCode` method (or the `IHashCodeProvider` interface) and the `Object.Equals` method (or the `IComparer` interface). The implementation of both methods and interfaces must handle case sensitivity the same way; otherwise, the `Hashtable` might behave incorrectly. For example, when creating a `Hashtable`, you must use the `CaseInsensitiveHashCodeProvider` class (or any case-insensitive `IHashCodeProvider` implementation) with the `CaseInsensitiveComparer` class (or any case-insensitive `IComparer` implementation).
- Furthermore, these methods must produce the same results when called with the same parameters while the key exists in the `Hashtable`. An alternative is to use a `Hashtable` constructor with an `IEqualityComparer` parameter. If key equality were simply reference equality, the inherited implementation of `Object.GetHashCode` and `Object.Equals` would suffice.

- Key objects must be immutable as long as they are used as keys in the Hashtable.
- When an element is added to the Hashtable, the element is placed into a bucket based on the hash code of the key. Subsequent lookups of the key use the hash code of the key to search in only one particular bucket, thus substantially reducing the number of key comparisons required to find an element.
- The load factor of a Hashtable determines the maximum ratio of elements to buckets. Smaller load factors cause faster average lookup times at the cost of increased memory consumption. The default load factor of 1.0 generally provides the best balance between speed and size. A different load factor can also be specified when the Hashtable is created.
- As elements are added to a Hashtable, the actual load factor of the Hashtable increases. When the actual load factor reaches the specified load factor, the number of buckets in the Hashtable is automatically increased to the smallest prime number that is larger than twice the current number of Hashtable buckets.
- Each key object in the Hashtable must provide its own hash function, which can be accessed by calling GetHash. However, any object implementing IHashCodeProvider can be passed to a Hashtable constructor, and that hash function is used for all objects in the table.
- The capacity of a Hashtable is the number of elements the Hashtable can hold. As elements are added to a Hashtable, the capacity is automatically increased as required through reallocation.
- .NET Framework only: For very large Hashtable objects, you can increase the maximum capacity to 2 billion elements on a 64-bit system by setting the enabled attribute of the configuration element to true in the run-time environment.
- The foreach statement of the C# language (For Each in Visual Basic) returns an object of the type of the elements in the collection. Since each element of the Hashtable is a key/value pair, the element type is not the type of the key or the type of the value. Instead, the element type is DictionaryEntry.

```
foreach(DictionaryEntry de in myHashtable)
{
    // ...
}
```

- The foreach statement is a wrapper around the enumerator, which only allows reading from, not writing to, the collection.
- Because serializing and deserializing an enumerator for a Hashtable can cause the elements to become reordered, it is not possible to continue enumeration without calling the Reset method.

Constructors

Hashtable()	Initializes a new, empty instance of the Hashtable class using the default initial capacity, load factor, hash code provider, and comparer.
Hashtable(IDictionary)	Initializes a new instance of the Hashtable class by copying the elements from the specified dictionary to the new Hashtable object. The new Hashtable object has an initial capacity equal to the number of elements copied, and uses the default load factor, hash code provider, and comparer.
Hashtable(IDictionary, IEqualityComparer)	Initializes a new instance of the Hashtable class by copying the elements from the specified dictionary to a new Hashtable object. The new Hashtable object has an initial capacity equal to the number of elements copied, and uses the default load factor and the specified IEqualityComparer object.
Hashtable(IDictionary, IHashCodeProvider, IComparer)	Obsolete. Initializes a new instance of the Hashtable class by copying the elements from the specified dictionary to the new Hashtable object. The new Hashtable object has an initial capacity equal to the number of elements copied, and uses the default load factor, and the specified hash code provider and comparer. This API is obsolete. For an alternative, see Hashtable(IDictionary, IEqualityComparer) .
Hashtable(IDictionary, Single)	Initializes a new instance of the Hashtable class by copying the elements from the specified dictionary to the new Hashtable object. The new Hashtable object has an initial capacity equal to the number of elements copied, and uses the specified load factor, and the default hash code provider and comparer.
Hashtable(IDictionary, Single, IEqualityComparer)	Initializes a new instance of the Hashtable class by copying the elements from the specified dictionary to the new Hashtable object. The new Hashtable object has an initial capacity equal to the number of elements copied, and uses the specified load factor and IEqualityComparer object.
Hashtable(IDictionary, Single, IHashCodeProvider, IComparer)	Obsolete. Initializes a new instance of the Hashtable class by copying the elements from the specified dictionary to the new Hashtable object. The new Hashtable object has an initial capacity equal to the number of elements copied, and uses the specified load factor, hash code provider, and comparer.
Hashtable(IEqualityComparer)	Initializes a new, empty instance of the Hashtable class using the default initial capacity and load factor, and the specified IEqualityComparer object.
Hashtable(IHashCodeProvider, IComparer)	Obsolete. Initializes a new, empty instance of the Hashtable class using the default initial capacity and load factor, and the specified hash code provider and comparer.
Hashtable(Int32)	Initializes a new, empty instance of the Hashtable class using the specified initial capacity, and the default load factor, hash code provider, and comparer.
Hashtable(Int32, IEqualityComparer)	Initializes a new, empty instance of the Hashtable class using the specified initial capacity and IEqualityComparer , and the default load factor.
Hashtable(Int32, IHashCodeProvider)	Obsolete.

<code>Provider, IComparer)</code>	Initializes a new, empty instance of the <code>Hashtable</code> class using the specified initial capacity, hash code provider, comparer, and the default load factor.
<code>Hashtable(Int32, Single)</code>	Initializes a new, empty instance of the <code>Hashtable</code> class using the specified initial capacity and load factor, and the default hash code provider and comparer.
<code>Hashtable(Int32, Single, IEqualityComparer)</code>	Initializes a new, empty instance of the <code>Hashtable</code> class using the specified initial capacity, load factor, and <code>IEqualityComparer</code> object.
<code>Hashtable(Int32, Single, IHashCodeProvider, IComparer)</code>	Obsolete. Initializes a new, empty instance of the <code>Hashtable</code> class using the specified initial capacity, load factor, hash code provider, and comparer.
<code>Hashtable(SerializationInfo, StreamingContext)</code>	Obsolete. Initializes a new, empty instance of the <code>Hashtable</code> class that is serializable using the specified <code>SerializationInfo</code> and <code>StreamingContext</code> objects.

Properties

<code>comparer</code>	Obsolete. Gets or sets the <code>IComparer</code> to use for the <code>Hashtable</code> .
<code>Count</code>	Gets the number of key/value pairs contained in the <code>Hashtable</code> .
<code>EqualityComparer</code>	Gets the <code>IEqualityComparer</code> to use for the <code>Hashtable</code> .
<code>hcp</code>	Obsolete. Gets or sets the object that can dispense hash codes.
<code>IsFixedSize</code>	Gets a value indicating whether the <code>Hashtable</code> has a fixed size.
<code>IsReadOnly</code>	Gets a value indicating whether the <code>Hashtable</code> is read-only.
<code>IsSynchronized</code>	Gets a value indicating whether access to the <code>Hashtable</code> is synchronized (thread safe).
<code>Item[Object]</code>	Gets or sets the value associated with the specified key.
<code>Keys</code>	Gets an <code>ICollection</code> containing the keys in the <code>Hashtable</code> .
<code>SyncRoot</code>	Gets an object that can be used to synchronize access to the <code>Hashtable</code> .
<code>Values</code>	Gets an <code>ICollection</code> containing the values in the <code>Hashtable</code> .

Methods

Add(Object, Object)	Adds an element with the specified key and value into the Hashtable.
Clear()	Removes all elements from the Hashtable.
Clone()	Creates a shallow copy of the Hashtable.
Contains(Object)	Determines whether the Hashtable contains a specific key.
ContainsKey(Object)	Determines whether the Hashtable contains a specific key.
ContainsValue(Object)	Determines whether the Hashtable contains a specific value.
CopyTo(Array, Int32)	Copies the Hashtable elements to a one-dimensional Array instance at the specified index.
Equals(Object)	Determines whether the specified object is equal to the current object. (Inherited from Object)
GetEnumerator()	Returns an IDictionaryEnumerator that iterates through the Hashtable.
GetHash(Object)	Returns the hash code for the specified key.
GetHashCode()	Serves as the default hash function. (Inherited from Object)
GetObjectData(SerializationInfo, StreamingContext)	Obsolete. Implements the ISerializable interface and returns the data needed to serialize the Hashtable.
GetType()	Gets the Type of the current instance. (Inherited from Object)
KeyEquals(Object, Object)	Compares a specific Object with a specific key in the Hashtable.
MemberwiseClone()	Creates a shallow copy of the current Object. (Inherited from Object)
OnDeserialization(Object)	Implements the ISerializable interface and raises the deserialization event when the deserialization is complete.
Remove(Object)	Removes the element with the specified key from the Hashtable.
Synchronized(Hashtable)	Returns a synchronized (thread-safe) wrapper for the Hashtable.
ToString()	Returns a string that represents the current object. (Inherited from Object)

Thread Safety

Hashtable is thread safe for use by multiple reader threads and a single writing thread. It is thread safe for multi-thread use when only one of the threads perform write (update) operations, which allows for lock-free reads provided that the writers are serialized to the Hashtable. To support multiple writers all operations on the Hashtable must be done through the wrapper returned by the Synchronized(Hashtable) method, provided that there are no threads reading the Hashtable object.

Generic Collections

- Namespace: System.Collections.Generic
- Contains interfaces and classes that define generic collections, which allow users to create strongly typed collections that provide better type safety and performance than non-generic strongly typed collections.

Classes

CollectionExtensions	Provides extension methods for generic collections.
Comparer<T>	Provides a base class for implementations of the IComparer<T> generic interface.
Dictionary< TKey, TValue >.KeyCollection	Represents the collection of keys in a Dictionary< TKey, TValue > . This class cannot be inherited.
Dictionary< TKey, TValue >.ValueCollection	Represents the collection of values in a Dictionary< TKey, TValue > . This class cannot be inherited.
Dictionary< TKey, TValue >	Represents a collection of keys and values.
EqualityComparer<T>	Provides a base class for implementations of the IEqualityComparer<T> generic interface.
HashSet<T>	Represents a set of values.
KeyedByTypeCollection< TItem >	Provides a collection whose items are types that serve as keys.
KeyNotFoundException	The exception that is thrown when the key specified for accessing an element in a collection does not match any key in the collection.
KeyValuePair	Creates instances of the KeyValuePair< TKey, TValue > struct.
LinkedList<T>	Represents a doubly linked list.
LinkedListNode<T>	Represents a node in a LinkedList< T > . This class cannot be inherited.
List<T>	Represents a strongly typed list of objects that can be accessed by index. Provides methods to search, sort, and manipulate lists.
PriorityQueue< TElement, TPriority >.UnorderedItemsCollection	Enumerates the contents of a PriorityQueue< TElement, TPriority > , without any ordering guarantees.
PriorityQueue< TElement, TPriority >	Represents a collection of items that have a value and a priority. On dequeue, the item with the lowest priority value is removed.
Queue<T>	Represents a first-in, first-out collection of objects.
ReferenceEqualityComparer	An IEqualityComparer< T > that uses reference equality (ReferenceEquals(Object, Object)) instead of value equality (Equals(Object)) when comparing two object instances.
SortedDictionary< TKey, TValue >.KeyCollection	Represents the collection of keys in a SortedDictionary< TKey, TValue > . This class cannot be inherited.
SortedDictionary< TKey, TValue >.ValueCollection	Represents the collection of values in a SortedDictionary< TKey, TValue > . This class cannot be inherited.

Collection	SortedDictionary< TKey, TValue > . This class cannot be inherited.
SortedDictionary< TKey, TValue >	Represents a collection of key/value pairs that are sorted on the key.
SortedList< TKey, TValue >	Represents a collection of key/value pairs that are sorted by key based on the associated IComparer< T > implementation.
SortedSet< T >	Represents a collection of objects that is maintained in sorted order.
Stack< T >	Represents a variable size last-in-first-out (LIFO) collection of instances of the same specified type.
SynchronizedCollection< T >	Provides a thread-safe collection that contains objects of a type specified by the generic parameter as elements.
SynchronizedKeyedCollection< K,T >	Provides a thread-safe collection that contains objects of a type specified by a generic parameter and that are grouped by keys.
SynchronizedReadOnlyCollection< T >	Provides a thread-safe, read-only collection that contains objects of a type specified by the generic parameter as elements.

Structs

Dictionary<TKey,TValue>.Enumerator	Enumerates the elements of a Dictionary<TKey,TValue> .
Dictionary<TKey,TValue>.KeyCollection.Enumerator	Enumerates the elements of a Dictionary<TKey,TValue>.KeyCollection .
Dictionary<TKey,TValue>.ValueCollection.Enumerator	Enumerates the elements of a Dictionary<TKey,TValue>.ValueCollection .
HashSet<T>.Enumerator	Enumerates the elements of a HashSet<T> object.
KeyValuePair<TKey,TValue>	Defines a key/value pair that can be set or retrieved.
LinkedList<T>.Enumerator	Enumerates the elements of a LinkedList<T> .
List<T>.Enumerator	Enumerates the elements of a List<T> .
PriorityQueue<TElement,TPriority>.UnorderedItemsCollection.Enumerator	Enumerates the element and priority pairs of a PriorityQueue<TElement,TPriority> , without any ordering guarantees.
Queue<T>.Enumerator	Enumerates the elements of a Queue<T> .
SortedDictionary<TKey,TValue>.Enumerator	Enumerates the elements of a SortedDictionary<TKey,TValue> .
SortedDictionary<TKey,TValue>.KeyCollection.Enumerator	Enumerates the elements of a SortedDictionary<TKey,TValue>.KeyCollection .
SortedDictionary<TKey,TValue>.ValueCollection.Enumerator	Enumerates the elements of a SortedDictionary<TKey,TValue>.ValueCollection .
SortedSet<T>.Enumerator	Enumerates the elements of a SortedSet<T> object.
Stack<T>.Enumerator	Enumerates the elements of a Stack<T> .

Interfaces



IAsyncEnumerable<T>	Exposes an enumerator that provides asynchronous iteration over values of a specified type.
IAsyncEnumerator<T>	Supports a simple asynchronous iteration over a generic collection.
ICollection<T>	Defines methods to manipulate generic collections.
IComparer<T>	Defines a method that a type implements to compare two objects.
IDictionary< TKey, TValue >	Represents a generic collection of key/value pairs.
IEnumerable<T>	Exposes the enumerator, which supports a simple iteration over a collection of a specified type.
IEnumerator<T>	Supports a simple iteration over a generic collection.
IEqualityComparer<T>	Defines methods to support the comparison of objects for equality.
IList<T>	Represents a collection of objects that can be individually accessed by index.
IReadOnlyCollection<T>	Represents a strongly-typed, read-only collection of elements.
IReadOnlyDictionary< TKey, TValue >	Represents a generic read-only collection of key/value pairs.
IReadOnlyList<T>	Represents a read-only collection of elements that can be accessed by index.
IReadOnlySet<T>	Provides a readonly abstraction of a set.
ISet<T>	Provides the base interface for the abstraction of sets.

- Many of the generic collection types are direct analogs of nongeneric types. Dictionary< TKey, TValue > is a generic version of Hashtable; it uses the generic structure KeyValuePair< TKey, TValue > for enumeration instead of DictionaryEntry. List is a generic version of ArrayList. There are generic Queue and Stack classes that correspond to the nongeneric versions. There are generic and nongeneric versions of SortedList< TKey, TValue >. Both versions are hybrids of a dictionary and a list. The SortedDictionary< TKey, TValue > generic class is a pure dictionary and has no nongeneric counterpart. The LinkedList generic class is a true linked list and has no nongeneric counterpart.

List Class

- Namespace: System.Collections.Generic
- Assembly: System.Collections.dll

Represents a strongly typed list of objects that can be accessed by index. Provides methods to search, sort, and manipulate lists.

```
public class List<T> : System.Collections.Generic.ICollection<T>,
System.Collections.Generic.IEnumerable<T>, System.Collections.Generic.IList<T>,
```

Type Parameters

T :The type of elements in the list

Inheritance : Object -> List

Implements : ICollection I Enumerable IList IReadOnlyCollection IReadOnlyList ICollection I Enumerable IList
List class represents the list of objects which can be accessed by index. It comes under the

- System.Collections.Generic namespace. List class can be used to create a collection of different types like integers, strings etc. List class also provides the methods to search, sort, and manipulate lists.

Characteristics:

- It is different from the arrays. A List can be resized dynamically but arrays cannot.
- List class can accept null as a valid value for reference types and it also allows duplicate elements.
- If the Count becomes equals to Capacity, then the capacity of the List increased automatically by reallocating the internal array. The existing elements will be copied to the new array before the addition of the new element.
- List class is the generic equivalent of ArrayList class by implementing the IList generic interface.
- This class can use both equality and ordering comparer.
- List class is not sorted by default and elements are accessed by zero-based index.
- For very large List objects, you can increase the maximum capacity to 2 billion elements on a 64-bit system by setting the enabled attribute of the configuration element to true in the run-time environment.

Constructors

List<T>()	Initializes a new instance of the List<T> class that is empty and has the default initial capacity.
List<T> (IEnumerable<T>)	Initializes a new instance of the List<T> class that contains elements copied from the specified collection and has sufficient capacity to accommodate the number of elements copied.
List<T>(Int32)	Initializes a new instance of the List<T> class that is empty and has the specified initial capacity.

Example

```
// C# program to create a List<T>
using System;
using System.Collections.Generic;
```

Properties

Capacity	Gets or sets the total number of elements the internal data structure can hold without resizing.
Count	Gets the number of elements contained in the List<T>.
Item[Int32]	Gets or sets the element at the specified index.

Methods

Add(T)	Adds an object to the end of the List<T>.
AddRange(IEnumerable<T>)	Adds the elements of the specified collection to the end of the List<T>.
AsReadOnly()	Returns a read-only ReadOnlyCollection<T> wrapper for the current collection.
BinarySearch(Int32, Int32, T, IComparer<T>)	Searches a range of elements in the sorted List<T> for an element using the specified comparer and returns the zero-based index of the element.
BinarySearch(T)	Searches the entire sorted List<T> for an element using the default comparer and returns the zero-based index of the element.
BinarySearch(T, IComparer<T>)	Searches the entire sorted List<T> for an element using the specified comparer and returns the zero-based index of the element.
Clear()	Removes all elements from the List<T>.
Contains(T)	Determines whether an element is in the List<T>.
ConvertAll<TOutput> (Converter<T,TOutput>)	Converts the elements in the current List<T> to another type, and returns a list containing the converted elements.
CopyTo(Int32, T[], Int32, Int32)	Copies a range of elements from the List<T> to a compatible one-dimensional array, starting at the specified index of the target array.
CopyTo(T[])	Copies the entire List<T> to a compatible one-dimensional array, starting at the beginning of the target array.
CopyTo(T[], Int32)	Copies the entire List<T> to a compatible one-dimensional array, starting at the specified index of the target array.
EnsureCapacity(Int32)	Ensures that the capacity of this list is at least the specified <code>capacity</code> . If the current capacity is less than <code>capacity</code> , it is increased to at least the specified <code>capacity</code> .

Equals(Object)	Determines whether the specified object is equal to the current object. (Inherited from Object)
Exists(Predicate<T>)	Determines whether the List<T> contains elements that match the conditions defined by the specified predicate.
Find(Predicate<T>)	Searches for an element that matches the conditions defined by the specified predicate, and returns the first occurrence within the entire List<T>.
FindAll(Predicate<T>)	Retrieves all the elements that match the conditions defined by the specified predicate.
FindIndex(Int32, Int32, Predicate<T>)	Searches for an element that matches the conditions defined by the specified predicate, and returns the zero-based index of the first occurrence within the range of elements in the List<T> that starts at the specified index and contains the specified number of elements.
FindIndex(Int32, Predicate<T>)	Searches for an element that matches the conditions defined by the specified predicate, and returns the zero-based index of the first occurrence within the

	range of elements in the List<T> that extends from the specified index to the last element.
FindIndex(Predicate<T>)	Searches for an element that matches the conditions defined by the specified predicate, and returns the zero-based index of the first occurrence within the entire List<T>.
FindLast(Predicate<T>)	Searches for an element that matches the conditions defined by the specified predicate, and returns the last occurrence within the entire List<T>.
FindLastIndex(Int32, Int32, Predicate<T>)	Searches for an element that matches the conditions defined by the specified predicate, and returns the zero-based index of the last occurrence within the range of elements in the List<T> that contains the specified number of elements and ends at the specified index.
FindLastIndex(Int32, Predicate<T>)	Searches for an element that matches the conditions defined by the specified predicate, and returns the zero-based index of the last occurrence within the range of elements in the List<T> that extends from the first element to the specified index.
FindLastIndex(Predicate<T>)	Searches for an element that matches the conditions defined by the specified predicate, and returns the zero-based index of the last occurrence within the entire List<T>.
ForEach(Action<T>)	Performs the specified action on each element of the List<T>.
GetEnumerator()	Returns an enumerator that iterates through the List<T>.
GetHashCode()	Serves as the default hash function. (Inherited from Object)
GetRange(Int32, Int32)	Creates a shallow copy of a range of elements in the source List<T>.
GetType()	Gets the Type of the current instance. (Inherited from Object)
IndexOf()	Searches for the specified object and returns the zero-based index of the first occurrence within the entire List<T>.
IndexOf(T, Int32)	Searches for the specified object and returns the zero-based index of the first occurrence within the range of elements in the List<T> that extends from the specified index to the last element.
IndexOf(T, Int32, Int32)	Searches for the specified object and returns the zero-based index of the first occurrence within the range of elements in the List<T> that starts at the specified index and contains the specified number of elements.
Insert(Int32, T)	Inserts an element into the List<T> at the specified index.

InsertRange(Int32, IEnumerable<T>)	Inserts the elements of a collection into the List<T> at the specified index.
LastIndexOf(T)	Searches for the specified object and returns the zero-based index of the last occurrence within the entire List<T> .
LastIndexOf(T, Int32)	Searches for the specified object and returns the zero-based index of the last occurrence within the range of elements in the List<T> that extends from the first element to the specified index.
LastIndexOf(T, Int32, Int32)	Searches for the specified object and returns the zero-based index of the last occurrence within the range of elements in the List<T> that contains the specified number of elements and ends at the specified index.
MemberwiseClone()	Creates a shallow copy of the current Object . <small>(Inherited from Object)</small>
Remove(T)	Removes the first occurrence of a specific object from the List<T> .
RemoveAll(Predicate<T>)	Removes all the elements that match the conditions defined by the specified predicate.
RemoveAt(Int32)	Removes the element at the specified index of the List<T> .
RemoveRange(Int32, Int32)	Removes a range of elements from the List<T> .
Reverse()	Reverses the order of the elements in the entire List<T> .
Reverse(Int32, Int32)	Reverses the order of the elements in the specified range.
Slice(Int32, Int32)	Creates a shallow copy of a range of elements in the source List<T> .
Sort()	Sorts the elements in the entire List<T> using the default comparer.
Sort(Comparison<T>)	Sorts the elements in the entire List<T> using the specified Comparison<T> .
Sort(IComparer<T>)	Sorts the elements in the entire List<T> using the specified comparer.
Sort(Int32, Int32, IComparer<T>)	Sorts the elements in a range of elements in List<T> using the specified comparer.
ToArray()	Copies the elements of the List<T> to a new array.
ToString()	Returns a string that represents the current object. <small>(Inherited from Object)</small>
TrimExcess()	Sets the capacity to the actual number of elements in the List<T> , if that number is less than a threshold value.
TrueForAll(Predicate<T>)	Determines whether every element in the List<T> matches the conditions defined by the specified predicate.

Example

```
// C# Program to remove the element at
// the specified index of the List<T>
using System;
using System.Collections.Generic;

class Demo {

    // Main Method
    public static void Main(String[] args)
    {

        // Creating an List<T> of Integers
        List<int> firstlist = new List<int>();

        // Adding elements to List
        firstlist.Add(17);
        firstlist.Add(19);
        firstlist.Add(21);
        firstlist.Add(9);
        firstlist.Add(75);
        firstlist.Add(19);
        firstlist.Add(73);

        Console.WriteLine("Elements Present in List:\n");

        int p = 0;

        // Displaying the elements of List
        foreach(int k in firstlist)
        {
            Console.Write("At Position {0}: ", p);
            Console.WriteLine(k);
            p++;
        }

        Console.WriteLine(" ");

        // removing the element at index 3
        Console.WriteLine("Removing the element at index 3\n");

        // 9 will remove from the List
        // and 75 will come at index 3
        firstlist.RemoveAt(3);

        int p1 = 0;

        // Displaying the elements of List
        foreach(int n in firstlist)
        {
            Console.Write("At Position {0}: ", p1);
            Console.WriteLine(n);
            p1++;
        }
    }
}
```

```
        }
    }
/*
Elements Present in List:
```

```
At Position 0: 17
At Position 1: 19
At Position 2: 21
At Position 3: 9
At Position 4: 75
At Position 5: 19
At Position 6: 73
```

Removing the element at index 3

```
At Position 0: 17
At Position 1: 19
At Position 2: 21
At Position 3: 75
At Position 4: 19
At Position 5: 73
*/
```

Reference

Stack class

- Stack represents a last-in, first out collection of objects. It is used when you need a last-in, first-out access to items. When you add an item in the list, it is called pushing the item and when you remove it, it is called popping the item. This class comes under System.Collections.Generic namespace.

Characteristics of Stack Class:

- Stack is implemented as an array.
- Stacks and queues are useful when you need temporary storage for information; that is, when you might want to discard an element after retrieving its value. Use Queue if you need to access the information in the same order that it is stored in the collection. Use System.Collections.Generic.Stack if you need to access the information in reverse order.
- Use the System.Collections.Concurrent.ConcurrentStack and System.Collections.Concurrent.ConcurrentQueue types when you need to access the collection from multiple threads concurrently.
- A common use for System.Collections.Generic.Stack is to preserve variable states during calls to other procedures.
- Three main operations can be performed on a System.Collections.Generic.Stack and its elements: - Push inserts an element at the top of the Stack. - Pop removes an element from the top of the Stack. - Peek returns an element that is at the top of the Stack but does not remove it from the Stack.

- The capacity of a Stack is the number of elements the Stack can hold. As elements are added to a Stack, the capacity is automatically increased as required by reallocating the internal array. The capacity can be decreased by calling TrimExcess.
- Stack accepts null as a valid value for reference types and allows duplicate elements.
- The following example shows how to create and add values to a Stack and how to display its values.

```
using System;
using System.Collections.Generic;

class Example
{
    public static void Main()
    {
        Stack<string> numbers = new Stack<string>();
        numbers.Push("one");
        numbers.Push("two");
        numbers.Push("three");
        numbers.Push("four");
        numbers.Push("five");

        // A stack can be enumerated without disturbing its contents.
        foreach( string number in numbers )
        {
            Console.WriteLine(number);
        }

        Console.WriteLine("\nPopping '{0}'", numbers.Pop());
        Console.WriteLine("Peek at next item to destack: {0}",
            numbers.Peek());
        Console.WriteLine("Popping '{0}'", numbers.Pop());

        // Create a copy of the stack, using the ToArray method and the
        // constructor that accepts an IEnumerable<T>.
        Stack<string> stack2 = new Stack<string>(numbers.ToArray());

        Console.WriteLine("\nContents of the first copy:");
        foreach( string number in stack2 )
        {
            Console.WriteLine(number);
        }

        // Create an array twice the size of the stack and copy the
        // elements of the stack, starting at the middle of the
        // array.
        string[] array2 = new string[numbers.Count * 2];
        numbers.CopyTo(array2, numbers.Count);

        // Create a second stack, using the constructor that accepts an
        // IEnumerable<of T>.
        Stack<string> stack3 = new Stack<string>(array2);

        Console.WriteLine("\nContents of the second copy, with duplicates and
```

```
nulls:");
    foreach( string number in stack3 )
    {
        Console.WriteLine(number);
    }

    Console.WriteLine("\nstack2.Contains(\"four\") = {0}",
        stack2.Contains("four"));

    Console.WriteLine("\nstack2.Clear()");
    stack2.Clear();
    Console.WriteLine("\nstack2.Count = {0}", stack2.Count);
}
}
```

/* This code example produces the following output:

```
five
four
three
two
one
```

```
Popping 'five'
Peek at next item to destack: four
Popping 'four'
```

Contents of the first copy:

```
one
two
three
```

Contents of the second copy, with duplicates and nulls:

```
one
two
three
```

```
stack2.Contains("four") = False
stack2.Clear()
stack2.Count = 0
*/
```

Constructors

Stack()	Initializes a new instance of the Stack class that is empty and has the default initial capacity.
Stack(ICollection)	Initializes a new instance of the Stack class that contains elements copied from the specified collection and has the same initial capacity as the number of elements copied.
Stack(Int32)	Initializes a new instance of the Stack class that is empty and has the specified initial capacity or the default initial capacity, whichever is greater.

Properties

Count	Gets the number of elements contained in the Stack.
IsSynchronized	Gets a value indicating whether access to the Stack is synchronized (thread safe).
SyncRoot	Gets an object that can be used to synchronize access to the Stack.

Methods

Clear()	Removes all objects from the Stack.
Clone()	Creates a shallow copy of the Stack.
Contains(Object)	Determines whether an element is in the Stack.
CopyTo(Array, Int32)	Copies the Stack to an existing one-dimensional Array , starting at the specified array index.
Equals(Object)	Determines whether the specified object is equal to the current object. (Inherited from Object)
GetEnumerator()	Returns an IEnumerator for the Stack.
GetHashCode()	Serves as the default hash function. (Inherited from Object)
GetType()	Gets the Type of the current instance. (Inherited from Object)
MemberwiseClone()	Creates a shallow copy of the current Object. (Inherited from Object)
Peek()	Returns the object at the top of the Stack without removing it.
Pop()	Removes and returns the object at the top of the Stack.
Push(Object)	Inserts an object at the top of the Stack.
Synchronized(Stack)	Returns a synchronized (thread safe) wrapper for the Stack.
ToArray()	Copies the Stack to a new array.
ToString()	Returns a string that represents the current object. (Inherited from Object)

[Reference](#)

Queue class

Namespace: System.Collections.Generic Inheritance: Object -> Queue Implements: [IEnumerable](#)
[IReadOnlyCollection](#) [ICollection](#) [IEnumerable](#)

- This class implements a generic queue as a circular array. Objects stored in a Queue are inserted at one end and removed from the other. Queues and stacks are useful when you need temporary storage for information; that is, when you might want to discard an element after retrieving its value. Use Queue if you need to access the information in the same order that it is stored in the collection. Use Stack if you need to access the information in reverse order. Use ConcurrentQueue or ConcurrentStack if you need to access the collection from multiple threads concurrently.
- Three main operations can be performed on a Queue and its elements: - Enqueue adds an element to the end of the Queue. - Dequeue removes the oldest element from the start of the Queue. - Peek peek

returns the oldest element that is at the start of the Queue but does not remove it from the Queue.

- The capacity of a Queue is the number of elements the Queue can hold. As elements are added to a Queue, the capacity is automatically increased as required by reallocating the internal array. The capacity can be decreased by calling TrimExcess.
- Queue accepts null as a valid value for reference types and allows duplicate elements.

Examples

The following code example demonstrates several methods of the Queue generic class. The code example creates a queue of strings with default capacity and uses the Enqueue method to queue five strings. The elements of the queue are enumerated, which does not change the state of the queue. The Dequeue method is used to dequeue the first string. The Peek method is used to look at the next item in the queue, and then the Dequeue method is used to dequeue it.

The ToArray method is used to create an array and copy the queue elements to it, then the array is passed to the Queue constructor that takes IEnumerable, creating a copy of the queue. The elements of the copy are displayed.

An array twice the size of the queue is created, and the CopyTo method is used to copy the array elements beginning at the middle of the array. The Queue constructor is used again to create a second copy of the queue containing three null elements at the beginning.

The Contains method is used to show that the string "four" is in the first copy of the queue, after which the Clear method clears the copy and the Count property shows that the queue is empty.

```
using System;
using System.Collections.Generic;

class Example
{
    public static void Main()
    {
        Queue<string> numbers = new Queue<string>();
        numbers.Enqueue("one");
        numbers.Enqueue("two");
        numbers.Enqueue("three");
        numbers.Enqueue("four");
        numbers.Enqueue("five");

        // A queue can be enumerated without disturbing its contents.
        foreach( string number in numbers )
        {
            Console.WriteLine(number);
        }

        Console.WriteLine("\nDequeuing '{0}'", numbers.Dequeue());
        Console.WriteLine("Peek at next item to dequeue: {0}",
            numbers.Peek());
        Console.WriteLine("Dequeuing '{0}'", numbers.Dequeue());
    }
}
```

```
// Create a copy of the queue, using the ToArray method and the
// constructor that accepts an IEnumerable<T>.
Queue<string> queueCopy = new Queue<string>(numbers.ToArray());

Console.WriteLine("\nContents of the first copy:");
foreach( string number in queueCopy )
{
    Console.WriteLine(number);
}

// Create an array twice the size of the queue and copy the
// elements of the queue, starting at the middle of the
// array.
string[] array2 = new string[numbers.Count * 2];
numbers.CopyTo(array2, numbers.Count);

// Create a second queue, using the constructor that accepts an
// IEnumerable(Of T).
Queue<string> queueCopy2 = new Queue<string>(array2);

Console.WriteLine("\nContents of the second copy, with duplicates and
nulls:");
foreach( string number in queueCopy2 )
{
    Console.WriteLine(number);
}

Console.WriteLine("\nqueueCopy.Contains(\"four\") = {0}",
    queueCopy.Contains("four"));

Console.WriteLine("\nqueueCopy.Clear()");
queueCopy.Clear();
Console.WriteLine("\nqueueCopy.Count = {0}", queueCopy.Count);
}

/*
 * This code example produces the following output:
 *
one
two
three
four
five

Dequeuing 'one'
Peek at next item to dequeue: two
Dequeuing 'two'

Contents of the first copy:
three
four
five
```

Constructor

<code>Queue<T>()</code>	Initializes a new instance of the <code>Queue<T></code> class that is empty and has the default initial capacity.
<code>Queue<T>(IEnumerable<T>)</code>	Initializes a new instance of the <code>Queue<T></code> class that contains elements copied from the specified collection and has sufficient capacity to accommodate the number of elements copied.
<code>Queue<T>(Int32)</code>	Initializes a new instance of the <code>Queue<T></code> class that is empty and has the specified initial capacity.

Properties

<code>Count</code>	Gets the number of elements contained in the <code>Queue<T></code> .
--------------------	----------------------------------------------------------------------------

Methods

Clear()	Removes all objects from the Queue<T>.
Contains(T)	Determines whether an element is in the Queue<T>.
CopyTo(T[], Int32)	Copies the Queue<T> elements to an existing one-dimensional Array , starting at the specified array index.
Dequeue()	Removes and returns the object at the beginning of the Queue<T>.
Enqueue(T)	Adds an object to the end of the Queue<T>.
Ensure Capacity(Int32)	Ensures that the capacity of this queue is at least the specified capacity . If the current capacity is less than capacity , it is increased to at least the specified capacity .
Equals(Object)	Determines whether the specified object is equal to the current object. (Inherited from Object)
GetEnumerator()	Returns an enumerator that iterates through the Queue<T>.
GetHashCode()	Serves as the default hash function. (Inherited from Object)
GetType()	Gets the Type of the current instance. (Inherited from Object)
Memberwise Clone()	Creates a shallow copy of the current Object. (Inherited from Object)
Peek()	Returns the object at the beginning of the Queue<T> without removing it.
ToArray()	Copies the Queue<T> elements to a new array.
ToString()	Returns a string that represents the current object. (Inherited from Object)
TrimExcess()	Sets the capacity to the actual number of elements in the Queue<T>, if that number is less than 90 percent of current capacity.
TryDequeue(T)	Removes the object at the beginning of the Queue<T>, and copies it to the result parameter.
TryPeek(T)	Returns a value that indicates whether there is an object at the beginning of the Queue<T>, and if one is present, copies it to the result parameter. The object is not removed from the Queue<T>.

Dictionary class

- In C#, Dictionary is a generic collection which is generally used to store key/value pairs. The working of Dictionary is quite similar to the non-generic hashtable. The advantage of Dictionary is, it is generic type. Dictionary is defined under System.Collections.Generic namespace. It is dynamic in nature means the size of the dictionary is grows according to the need.

Important Points:

- The Dictionary class implements the - `IDictionary<TKey,TValue>` Interface - `IReadOnlyCollection<KeyValuePair<TKey,TValue>>` Interface - `IReadOnlyDictionary<TKey,TValue>` Interface - `IDictionary` Interface
- In Dictionary, the key cannot be null, but value can be.
- In Dictionary, key must be unique. Duplicate keys are not allowed if you try to use duplicate key then compiler will throw an exception.
- In Dictionary, you can only store same types of elements.
- The capacity of a Dictionary is the number of elements that Dictionary can hold.

Examples

The following code example creates an empty `Dictionary<TKey,TValue>` of strings with string keys and uses the `Add` method to add some elements. The example demonstrates that the `Add` method throws an `ArgumentException` when attempting to add a duplicate key.

The example uses the `Item[]` property (the indexer in C#) to retrieve values, demonstrating that a `KeyNotFoundException` is thrown when a requested key is not present, and showing that the value associated with a key can be replaced.

The example shows how to use the `TryGetValue` method as a more efficient way to retrieve values if a program often must try key values that are not in the dictionary, and it shows how to use the `ContainsKey` method to test whether a key exists before calling the `Add` method.

The example shows how to enumerate the keys and values in the dictionary and how to enumerate the keys and values alone using the `Keys` property and the `Values` property.

Finally, the example demonstrates the `Remove` method.

```
// Create a new dictionary of strings, with string keys.
//
Dictionary<string, string> openWith =
    new Dictionary<string, string>();

// Add some elements to the dictionary. There are no
// duplicate keys, but some of the values are duplicates.
openWith.Add("txt", "notepad.exe");
openWith.Add("bmp", "paint.exe");
openWith.Add("dib", "paint.exe");
openWith.Add("rtf", "wordpad.exe");

// The Add method throws an exception if the new key is
// already in the dictionary.
try
{
    openWith.Add("txt", "winword.exe");
}
catch (ArgumentException)
{
```

```
        Console.WriteLine("An element with Key = \"txt\" already exists.");
    }

// The Item property is another name for the indexer, so you
// can omit its name when accessing elements.
Console.WriteLine("For key = \"rtf\", value = {0}.",
    openWith["rtf"]);

// The indexer can be used to change the value associated
// with a key.
openWith["rtf"] = "winword.exe";
Console.WriteLine("For key = \"rtf\", value = {0}.",
    openWith["rtf"]);

// If a key does not exist, setting the indexer for that key
// adds a new key/value pair.
openWith["doc"] = "winword.exe";

// The indexer throws an exception if the requested key is
// not in the dictionary.
try
{
    Console.WriteLine("For key = \"tif\", value = {0}.",
        openWith["tif"]);
}
catch (KeyNotFoundException)
{
    Console.WriteLine("Key = \"tif\" is not found.");
}

// When a program often has to try keys that turn out not to
// be in the dictionary, TryGetValue can be a more efficient
// way to retrieve values.
string value = "";
if (openWith.TryGetValue("tif", out value))
{
    Console.WriteLine("For key = \"tif\", value = {0}.", value);
}
else
{
    Console.WriteLine("Key = \"tif\" is not found.");
}

// ContainsKey can be used to test keys before inserting
// them.
if (!openWith.ContainsKey("ht"))
{
    openWith.Add("ht", "hypertrm.exe");
    Console.WriteLine("Value added for key = \"ht\": {0}",
        openWith["ht"]);
}

// When you use foreach to enumerate dictionary elements,
// the elements are retrieved as KeyValuePair objects.
```

```

Console.WriteLine();
foreach( KeyValuePair<string, string> kvp in openWith )
{
    Console.WriteLine("Key = {0}, Value = {1}",
                      kvp.Key, kvp.Value);
}

// To get the values alone, use the Values property.
Dictionary<string, string>.ValueCollection valueColl =
    openWith.Values;

// The elements of the ValueCollection are strongly typed
// with the type that was specified for dictionary values.
Console.WriteLine();
foreach( string s in valueColl )
{
    Console.WriteLine("Value = {0}", s);
}

// To get the keys alone, use the Keys property.
Dictionary<string, string>.KeyCollection keyColl =
    openWith.Keys;

// The elements of the KeyCollection are strongly typed
// with the type that was specified for dictionary keys.
Console.WriteLine();
foreach( string s in keyColl )
{
    Console.WriteLine("Key = {0}", s);
}

// Use the Remove method to remove a key/value pair.
Console.WriteLine("\nRemove(\"doc\")");
openWith.Remove("doc");

if (!openWith.ContainsKey("doc"))
{
    Console.WriteLine("Key \"doc\" is not found.");
}

/* This code example produces the following output:

An element with Key = "txt" already exists.
For key = "rtf", value = wordpad.exe.
For key = "rtf", value = winword.exe.
Key = "tif" is not found.
Key = "tif" is not found.
Value added for key = "ht": hypertrm.exe

Key = txt, Value = notepad.exe
Key = bmp, Value = paint.exe
Key = dib, Value = paint.exe
Key = rtf, Value = winword.exe
Key = doc, Value = winword.exe
*/

```

```

Key = ht, Value = hypertrm.exe

Value = notepad.exe
Value = paint.exe
Value = paint.exe
Value = winword.exe
Value = winword.exe
Value = hypertrm.exe

Key = txt
Key = bmp
Key = dib
Key = rtf
Key = doc
Key = ht

Remove("doc")
Key "doc" is not found.
*/

```

Remarks

- The Dictionary<TKey,TValue> generic class provides a mapping from a set of keys to a set of values. Each addition to the dictionary consists of a value and its associated key. Retrieving a value by using its key is very fast, close to O(1), because the Dictionary<TKey,TValue> class is implemented as a hash table.
- As long as an object is used as a key in the Dictionary<TKey,TValue>, it must not change in any way that affects its hash value. Every key in a Dictionary<TKey,TValue> must be unique according to the dictionary's equality comparer. A key cannot be null, but a value can be, if its type TValue is a reference type.
- Dictionary<TKey,TValue> requires an equality implementation to determine whether keys are equal. You can specify an implementation of the IEqualityComparer generic interface by using a constructor that accepts a comparer parameter; if you do not specify an implementation, the default generic equality comparer EqualityComparer.Default is used. If type TKey implements the System.IEquatable generic interface, the default equality comparer uses that implementation.
- The capacity of a Dictionary<TKey,TValue> is the number of elements the Dictionary<TKey,TValue> can hold. As elements are added to a Dictionary<TKey,TValue>, the capacity is automatically increased as required by reallocating the internal array.
- .NET Framework only: For very large Dictionary<TKey,TValue> objects, you can increase the maximum capacity to 2 billion elements on a 64-bit system by setting the enabled attribute of the configuration element to true in the run-time environment.
- For purposes of enumeration, each item in the dictionary is treated as a KeyValuePair<TKey,TValue> structure representing a value and its key. The order in which the items are returned is undefined.

Constructor

<code>Dictionary<TKey,TValue>()</code>	Initializes a new instance of the <code>Dictionary<TKey,TValue></code> class that is empty, has the default initial capacity, and uses the default equality comparer for the key type.
<code>Dictionary<TKey,TValue>(IDictionary<TKey,TValue>)</code>	Initializes a new instance of the <code>Dictionary<TKey,TValue></code> class that contains elements copied from the specified <code>IDictionary<TKey,TValue></code> and uses the default equality comparer for the key type.
<code>Dictionary<TKey,TValue>(IDictionary<TKey,TValue>, IEqualityComparer<TKey>)</code>	Initializes a new instance of the <code>Dictionary<TKey,TValue></code> class that contains elements copied from the specified <code>IDictionary<TKey,TValue></code> and uses the specified <code>IEqualityComparer<T></code> .
<code>Dictionary<TKey,TValue>(IEnumerable<KeyValuePair<TKey,TValue>>)</code>	Initializes a new instance of the <code>Dictionary<TKey,TValue></code> class that contains elements copied from the specified <code>IEnumerable<T></code> .
<code>Dictionary<TKey,TValue>(IEnumerable<KeyValuePair<TKey,TValue>>, IEqualityComparer<TKey>)</code>	Initializes a new instance of the <code>Dictionary<TKey,TValue></code> class that contains elements copied from the specified <code>IEnumerable<T></code> and uses the specified <code>IEqualityComparer<T></code> .
<code>Dictionary<TKey,TValue>(IEqualityComparer<TKey>)</code>	Initializes a new instance of the <code>Dictionary<TKey,TValue></code> class that is empty, has the default initial capacity, and uses the specified <code>IEqualityComparer<T></code> .
<code>Dictionary<TKey,TValue>(Int32)</code>	Initializes a new instance of the <code>Dictionary<TKey,TValue></code> class that is empty, has the specified initial capacity, and uses the default equality comparer for the key type.
<code>Dictionary<TKey,TValue>(Int32, IEqualityComparer<TKey>)</code>	Initializes a new instance of the <code>Dictionary<TKey,TValue></code> class that is empty, has the specified initial capacity, and uses the specified <code>IEqualityComparer<T></code> .
<code>Dictionary<TKey,TValue>(SerializationInfo, StreamingContext)</code>	Obsolete. Initializes a new instance of the <code>Dictionary<TKey,TValue></code> class with serialized data.

Properties

Comparer	Gets the <code>IEqualityComparer<T></code> that is used to determine equality of keys for the dictionary.
Count	Gets the number of key/value pairs contained in the <code>Dictionary<TKey,TValue></code> .
Item[TKey]	Gets or sets the value associated with the specified key.
Keys	Gets a collection containing the keys in the <code>Dictionary<TKey,TValue></code> .
Values	Gets a collection containing the values in the <code>Dictionary<TKey,TValue></code> .

Methods

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OnDeserialization(Object)	Implements the ISerializable interface and raises the deserialization event when the deserialization is complete.
Remove(TKey)	Removes the value with the specified key from the Dictionary<TKey,TValue>.
Remove(TKey, TValue)	Removes the value with the specified key from the Dictionary<TKey,TValue>, and copies the element to the <code>value</code> parameter.
ToString()	Returns a string that represents the current object. (Inherited from Object)
TrimExcess()	Sets the capacity of this dictionary to what it would be if it had been originally initialized with all its entries.
TrimExcess(Int32)	Sets the capacity of this dictionary to hold up a specified number of entries without any further expansion of its backing storage.
TryAdd(TKey, TValue)	Attempts to add the specified key and value to the dictionary.
TryGetValue(TKey, TValue)	Gets the value associated with the specified key.
Add(TKey, TValue)	Adds the specified key and value to the dictionary.
Clear()	Removes all keys and values from the Dictionary<TKey,TValue>.
ContainsKey(TKey)	Determines whether the Dictionary<TKey,TValue> contains the specified key.
ContainsValue(TValue)	Determines whether the Dictionary<TKey,TValue> contains a specific value.
EnsureCapacity(Int32)	Ensures that the dictionary can hold up to a specified number of entries without any further expansion of its backing storage.
Equals(Object)	Determines whether the specified object is equal to the current object. (Inherited from Object)
GetEnumerator()	Returns an enumerator that iterates through the Dictionary<TKey,TValue>.
GetHashCode()	Serves as the default hash function. (Inherited from Object)
GetObjectData(SerializationInfo, StreamingContext)	Obsolete. Implements the ISerializable interface and returns the data needed to serialize the Dictionary<TKey,TValue> instance.
GetType()	Gets the Type of the current instance. (Inherited from Object)
MemberwiseClone()	Creates a shallow copy of the current Object.

Reflection :

Reflection objects are used for obtaining type information at runtime.

The classes that give access to the metadata of a running program are in the System.Reflection namespace.

- Reflection has the following applications :
- It allows view attribute information at runtime.
- It allows examining various types in an assembly and instantiate these types.
- It allows late binding to methods and properties
- It allows creating new types at runtime and then performs some tasks using those types.

The MemberInfo object of the System.Reflection class needs to be initialized for discovering the attributes associated with a class.

```
System.Reflection.MemberInfo info = typeof(MyClass);
```

Reflection Attributes :

Attributes provide a powerful method of associating metadata, or declarative information, with code (assemblies, types, methods, properties, and so forth). After an attribute is associated with a program entity, the attribute can be queried at run time by using a technique called reflection.

Creating Custom Attributes :

Custom attributes are essentially traditional classes that derive directly or indirectly from System.Attribute

- Attributes are metadata extensions that give additional information to the compiler about the elements in the program code at runtime.
- Attributes are used to impose conditions or to increase the efficiency of a piece of code
- The primary steps to properly design custom attribute classes :
 1. Applying the AttributeUsageAttribute
 2. Declaring the attribute class
 3. Declaring constructors
 4. Declaring properties

1. Applying the AttributeUsageAttribute :

Finally, the class YourClass is inherited from the base class MyClass. The method MyMethod shows MyAttribute but not YourAttribute

```
public class YourClass : MyClass
{
    // MyMethod will have MyAttribute but not YourAttribute.
    public override void MyMethod()
    {
        //...
    }
}
```

2. Declaring the attribute class :

[AttributeUsage(AttributeTargets.Method)]

```
public class MyAttribute : Attribute
{
    // ...
}
```

3. Declaring constructors :

```
public MyAttribute(bool myvalue)
{
    this.myvalue = myvalue;
}
```

```
}
```

4. Declaring properties :

```
public bool MyProperty
{
    get {return
        this.myvalue;} set
    {this.myvalue =
        value;}
}
```

Loading Assembly at Runtime :

The act of loading external assemblies on demand is known as Dynamic Loading. Using the

`using Assembly.Reflection; Session11Demo` we can dynamically load both private and shared assemblies from the local location to a remote location as well as, explore its properties.

```
using Assembly.Reflection;
namespace Session11Demo
{
    One reference
    public class Program
    {
        0 references
        static void Main(string[] args)
        {
            Assembly assembly = Assembly.LoadFile(@"E:\MSVS2022CDAC\SharedAssemblyDemo.dll");
            Type[] t = assembly.GetTypes();
            foreach (var i in t)
            {
                Console.WriteLine(i);
            }
        }
    }
}
```

Steps to create and use Shared Assembly:

Step 1 : Open VS.NET and Create a new Class Library

Step 2 : Generating Cryptographic Key Pair using the tool SN.Exe

- Make sure that you start Administrator “Developer Command Prompt for VS 2022”
- Write the following command on command prompt **C:\> sn -k "C:\mynewkey.snk"**

Step 3 : Sign the component with the key and build the class library project (Go to properties of the project in solution explorer -> select signing -> Check the checkbox of Sign the assembly and browse for the key).

Step 4 : Host the signed assembly in Global Assembly Cache
C:\>gacutil -i "E:\MyClassLibrary\bin\Debug\MyClassLibrary.dll"

Step 5 : Test the assembly by creating the client application.
Just add the project reference and browse for the shared
assembly recently created.

Step 6 : Execute the client program

Features in C#

- Partial Class
- Anonymous Methods
- Nullable Type
- Iterator
- Implicit Type
- Auto Property
- Object Initializer
- Anonymous Type
- Extension Methods
- Lambda Expression
- LINQ
- Partial Methods
- Dynamic Type
- Optional | Named Parameters
- Async | Await

Partial Class

In C#, a partial class is a class that can be split into multiple files. Each part of the partial class is declared with the `partial` keyword. When compiled, all the parts are combined into a single class definition.

Partial classes are often used in large projects or codebases to organize code more effectively, especially when multiple developers are working on different parts of the same class or when a class contains a significant amount of code. Here are some key points about partial classes:

1. **Syntax:** To declare a partial class, you use the `partial` keyword followed by the `class` keyword. For example.

```
public partial class MyClass
{
    // Class members and methods
}
```

2. **Multiple Files:** Each part of the partial class can be defined in a separate file within the same namespace. All parts of the partial class must have the same access level modifier (public, internal, etc.) and be declared within the same assembly.
3. **Method Definitions:** Partial methods are a special feature of partial classes. A partial method is a method declaration without an implementation. One part of the partial class may declare a partial method, and another part may provide the implementation. If the implementation is not provided, the compiler removes the method call at compile time.

```
public partial class MyClass
{
    partial void MyMethod();
}

// In another file:
public partial class MyClass
```

```
{  
partial void MyMethod()  
{  
// Method implementation  
}  
}
```

4. **Benefits:** Partial classes can improve code organization, readability, and maintainability by allowing developers to focus on specific parts of a class without cluttering a single file with a large amount of code.
5. **Usage:** Partial classes are commonly used in GUI applications generated by visual designers (e.g., Windows Forms, WPF) to separate auto-generated code from developer-written code. They are also useful in frameworks and libraries where code generation or extension points are involved.

Anonymous Methods

Anonymous methods in C# allow you to define a method inline without specifying a name. They are particularly useful for defining event handlers or delegates where a simple, short method is required and defining a separate named method would be overkill. Here are some key points about anonymous methods:

1. **Syntax:** Anonymous methods are defined using the delegate keyword followed by a parameter list (if any) and a code block enclosed in curly braces. For example:

```
delegate(int x, int y)  
{  
    return x + y;  
};
```

2. **Usage with Delegates:** Anonymous methods are often used in conjunction with delegates. Instead of defining a separate named method and then passing it to a delegate, you can define the method inline where it's needed.

For example:

```
Action<string> printMessage = delegate(string message)  
{  
    Console.WriteLine(message);  
};  
  
printMessage("Hello, world!");
```

3. **Capture of Outer Variables:** Anonymous methods can capture variables from the outer scope. This means they can access variables defined outside of their own scope. However, they can only capture variables by reference, not by value. This can lead to unexpected behavior if the outer variables are modified after the anonymous method is created.
4. **Replacement with Lambda Expressions:** Anonymous methods were largely replaced by lambda expressions in C# 3.0. Lambda expressions provide a more concise and expressive syntax for defining inline functions. The same functionality achieved with anonymous methods can usually be achieved more cleanly with lambda expressions.

```
Action<string> printMessage = (message) =>
{
    Console.WriteLine(message);
};
```

5. **Limitations:** Anonymous methods have some limitations compared to named methods or lambda expressions. For example, they cannot have a return type other than void, and they cannot be recursive
6. **Event Handlers:** Anonymous methods are commonly used for event handling in graphical user interfaces (GUIs). They allow you to define event handler logic inline, making the code more concise and easier to understand.

Anonymous methods provide a convenient way to define short, inline functions without the need for a separate named method. While they have largely been superseded by lambda expressions in modern C# code, they are still occasionally used in scenarios where lambda expressions are not applicable or where they would make the code less readable.

Nullable Type

In C#, a nullable type allows you to represent both a value type (like int, float, etc.) and the absence of a value (null). This is particularly useful when dealing with database fields or other scenarios where a value may or may not be present. Nullable types were introduced in C# 2.0.

The syntax for defining a nullable type is to append a question mark ? to the type declaration. For example.

```
int? nullableInt;  
float? nullableFloat;
```

Here are some key points about nullable types:

1. **Value or Null:** Nullable types allow a variable to hold either the underlying value type or a null reference. For example, int? can hold any integer value or be null.
2. **Nullable<T>:** Behind the scenes, nullable types are implemented using the Nullable<T> struct (also written as T?). This struct has two properties: HasValue which indicates whether the nullable type has a value, and Value which returns the underlying value if HasValue is true, or throws an exception if HasValue is false.

Iterator

In C#, an iterator is a block of code that enables you to iterate over a collection of items sequentially. It simplifies the process of iterating over collections like arrays, lists, or custom data structures by abstracting away the underlying implementation details of iteration. Iterators are commonly used with foreach loops.

Here's how iterators work in C#:

1. **Iterator Method:** To create an iterator, you define a method that returns an IEnumerable<T> or IEnumerator<T> object. This method uses the yield keyword to return each element of the collection one at a time.

2. **Yield Keyword:** The yield keyword is used within the iterator method to return each element of the collection. When the iterator method is called, execution starts from the beginning of the method until the first yield statement is reached. The method then returns the value specified by yield and suspends its execution. When the iterator is iterated again, execution resumes from where it left off until the next yield statement is encountered, and so on.
3. **IEnumerable<T> and IEnumerator<T>:** IEnumerable<T> represents a collection of items that can be enumerated, while IEnumerator<T> provides a way to iterate over the elements of the collection one at a time. The yield return statement is typically used with IEnumerable<T>, while the yield break statement can be used to prematurely end the iteration.

Implicit Type

Implicit typing in C# allows you to declare variables without explicitly specifying their data types. Instead, the compiler infers the data type based on the value assigned to the variable. This feature was introduced in C# 3.0 with the var keyword.

Here's how implicit typing works:

1. **Syntax:** Instead of explicitly specifying the data type, you use the var keyword followed by the variable name and an optional initializer. For example:

```
var number = 10;
var message = "Hello, world!";
```
2. **Type Inference:** When the compiler encounters a variable declared with var, it analyzes the expression on the right-hand side of the assignment operator (=) to determine its data type. The compiler then assigns the inferred type to the variable.
3. **Compile-Time Checking:** Although the type of the variable is not explicitly specified, the compiler performs type checking at compile time to ensure type safety. This means that the variable's type is determined at compile time, and the compiler enforces type rules accordingly.
4. **Static Typing:** Implicit typing does not change the statically-typed nature of C#. Once a variable's type is inferred, it cannot be changed. The variable is still statically typed, meaning its type is determined at compile time and cannot change during runtime.
5. **Readability:** Implicit typing can improve code readability by reducing verbosity, especially when variable names are descriptive and the inferred types are obvious from the assigned values.
6. **Limitations:** Implicit typing cannot be used in certain scenarios, such as when declaring fields, method parameters, or return types, where the data type must be explicitly specified. Additionally, using var with complex types or when the inferred type is not immediately obvious can reduce code clarity.

Here's an example illustrating the usage of implicit typing:

```
class Program
{
    static void Main()
```

```

{
    var number = 10;
    var message = "Hello, world!";

    Console.WriteLine($"Number: {number}, Type: {number.GetType()}");
    Console.WriteLine($"Message: {message}, Type: {message.GetType()}");
}

```

In this example, the `number` variable is implicitly typed as an `int`, and the `message` variable is implicitly typed as a `string`. The `GetType()` method is used to retrieve the runtime type of each variable for demonstration purposes.

Auto Property

Auto-implemented properties in C# provide a shorthand syntax for defining properties of a class without explicitly declaring the backing field. This feature was introduced in C# 3.0.

Here's how auto-implemented properties work:

- Syntax:** Instead of explicitly declaring a backing field and writing separate getter and setter methods, you can use a simplified syntax to define the property directly within the class. The compiler automatically generates a private backing field for the property.

```

public class MyClass
{
    public int MyProperty { get; set; }
}

```

- Access Modifiers:** You can specify access modifiers (public, private, protected, etc.) for auto-implemented properties just like regular properties. By default, auto-implemented properties are public.
- Initialization:** You can provide an initial value for an auto-implemented property directly within the property declaration.

```

public class MyClass
{
    public int MyProperty { get; set; } = 42;
}

```

- Read-Only Auto Properties:** You can create read-only auto-implemented properties by omitting the setter. In this case, the property can only be assigned a value within the constructor or initializer.

```

public class MyClass
{
    public int MyReadOnlyProperty { get; } = 42;
}

```

- Backing Field:** While auto-implemented properties do have a backing field generated by the compiler, you cannot directly access this field from within the class. It's purely an implementation detail.

Auto-implemented properties offer a concise and readable way to define properties in C#, especially for simple scenarios where custom getter/setter logic is not required. However, they are limited in flexibility compared to traditional properties, as you cannot directly manipulate the backing field or provide custom logic within the getter/setter methods.

Object Initializer

In C#, object initializers provide a concise syntax for initializing objects without explicitly invoking a constructor and setting individual properties one by one. This feature was introduced in C# 3.0 as part of the language enhancements.

Here's how object initializers work:

1. **Syntax:** Instead of using a constructor followed by property assignments, you can use the object initializer syntax to set properties directly within curly braces {} after the object creation expression.

```
// Without object initializer  
MyClass obj = new MyClass();  
obj.Property1 = value1;  
obj.Property2 = value2;
```

```
// With object initializer  
MyClass obj = new MyClass  
{  
    Property1 = value1,  
    Property2 = value2  
};
```

2. **Multiple Properties:** You can initialize multiple properties within the same object initializer block, separated by commas.

3. **Nested Object Initializers:** Object initializers can be nested to initialize properties of objects within objects.

```
MyClass obj = new MyClass  
{  
    NestedProperty = new NestedClass  
    {  
        Property1 = value1,  
        Property2 = value2  
    }  
};
```

4. **Anonymous Types:** Object initializers are often used with anonymous types to create objects with ad-hoc structures, especially in LINQ queries.

```
var person = new { Name = "John", Age = 30 };
```

5. **Collection Initializers:** In addition to object initializers, C# also supports collection initializers, which allow you to initialize collections (such as lists, arrays, and dictionaries) using a similar syntax.

```
List<int> numbers = new List<int> { 1, 2, 3, 4, 5 };
```

Object initializers provide a concise and readable way to initialize objects, especially when creating objects with many properties or nested objects. They contribute to cleaner and more expressive code, improving code maintainability and reducing verbosity.

Anonymous Type

In C#, an anonymous type is a type defined dynamically at compile-time without explicitly declaring a class structure. Anonymous types are useful when you need to create simple data structures on the fly without the overhead of defining a formal class.

Here are the key points about anonymous types:

1. **Syntax:** Anonymous types are defined using the new keyword followed by an object initializer within curly braces {}. The compiler infers the type of each property based on the assigned values.

```
var person = new { Name = "John", Age = 30 };
```

2. **Properties:** Anonymous types have read-only properties. Once created, the properties cannot be modified. The property names and types are determined by the names and types of the assigned values.
3. **Use Cases:** Anonymous types are commonly used in LINQ queries when you want to project data into a temporary structure for immediate use. They are also useful for passing data between different parts of your code when defining a formal class would be overkill.
4. **Equality:** Anonymous types have value-based equality semantics. Two instances of the same anonymous type are considered equal if their corresponding properties have the same values.

```
var person1 = new { Name = "John", Age = 30 };
var person2 = new { Name = "John", Age = 30 };
Console.WriteLine(person1.Equals(person2)); // Outputs: True
```

5. **Scope:** Anonymous types are generally scoped to the method or block in which they are defined. They cannot be used outside of their defining scope.
6. **Limitations:** Anonymous types cannot contain methods or events. They also cannot be used as method parameters or return types, as their type information is not available outside the scope where they are defined.

Extension Methods

Extension methods in C# allow you to add new methods to existing types (classes, structs, or interfaces) without modifying the original type. This feature enables you to "extend" the functionality of classes or interfaces that you don't control or can't modify, such as framework types or types from third-party libraries. Extension methods were introduced in C# 3.0.

Here are the key points about extension methods:

1. **Syntax:** Extension methods are defined as static methods within static classes. The first parameter of an extension method specifies the type that the method operates on, preceded by the `this` modifier. This indicates to the compiler that the method is an extension method.

```
public static class StringExtensions
{
    public static int WordCount(this string str)
    {
        return str.Split(new char[] { ' ', '.', '?' }, StringSplitOptions.RemoveEmptyEntries).Length;
    }
}
```

2. **Usage:** Once defined, extension methods can be called as if they were instance methods of the extended type. The compiler automatically binds the call to the appropriate extension method based on the type of the first parameter

```
string text = "Hello world!";
int count = text.WordCount(); // Calls the extension method
```

3. **Visibility:** Extension methods are accessible wherever the containing namespace is visible. You don't need to import the namespace explicitly to use extension methods defined within it.
4. **Extension Method Chaining:** Extension methods can be chained together, allowing for fluent API design and concise code.

```
string text = "Hello world!";
int count = text.Trim().ToUpper().WordCount();
```

5. **Limitations:** Extension methods cannot access private or protected members of the extended type. They are also resolved statically, so they cannot be overridden in derived types.
6. **Naming:** It's a convention to name extension method classes with a suffix like "Extensions" to make their purpose clear.

Lambda Expression

Lambda expressions in C# provide a concise way to write anonymous functions or delegates. They are particularly useful for writing inline functions, especially when passing small pieces of code as arguments to methods or for defining event handlers, LINQ queries, and more. Lambda expressions were introduced in C# 3.0 as part of the language enhancements.

Here's how lambda expressions work:

1. **Syntax:** Lambda expressions consist of three parts: the parameter list, the lambda operator `=>`, and the expression or statement block. The parameter list can be empty or contain one or more parameters, enclosed in parentheses. The lambda operator separates the parameter list from the expression or statement block.

```
// Syntax: (parameters) => expression
Func<int, int, int> add = (x, y) => x + y;
```

2. **Type Inference:** Lambda expressions can be assigned to delegate types or used as arguments in method calls where the delegate type is expected. The compiler infers the delegate type based on the context in which the lambda expression is used.
3. **Single Statement:** If the body of the lambda expression consists of a single statement, you can omit the curly braces { }. The result of the expression is the result of the single statement.

```
Func<int, int> square = x => x * x;
```

4. **Multiple Statements:** If the body of the lambda expression contains multiple statements, you must enclose them in curly braces { }. You can use the return keyword to return a value explicitly.

```
Func<int, int> increment = x =>
{
    int result = x + 1;
    return result;
};
```

5. **Capture of Outer Variables:** Lambda expressions can capture variables from the outer scope (i.e., variables defined outside the lambda expression). The captured variables are kept alive as long as the delegate that holds the lambda expression is alive.
6. **Parameter Types:** Lambda expressions can have implicit or explicit parameter types. If the parameter types can be inferred from the context, you can omit them. Otherwise, you must specify them explicitly.

```
// Implicit parameter types
Func<int, int, int> add = (x, y) => x + y;
```

```
// Explicit parameter types
Func<int, int, int> add = (int x, int y) => x + y;
```

Lambda expressions provide a concise and expressive way to define inline functions in C#. They are widely used in modern C# programming, especially in LINQ queries, asynchronous programming with `async` and `await`, event handling, and functional programming paradigms.

LINQ

LINQ (Language Integrated Query) is a powerful feature in C# that enables developers to query and manipulate data using a SQL-like syntax directly within the C# language. LINQ was introduced in C# 3.0 as part of the .NET Framework 3.5.

Here are the key components and concepts of LINQ:

1. **Query Expressions:** LINQ allows you to write query expressions that resemble SQL queries. These expressions operate on collections of objects (e.g., arrays, lists, databases) and can include operations like filtering, sorting, grouping, joining, and projecting data.

```
var result = from person in people
             where person.Age > 18
             select person.Name;
```

2. **Standard Query Operators:** LINQ provides a set of standard query operators (methods) defined as extension methods in the System.Linq namespace. These operators allow you to perform various operations on collections, such as Where, Select, OrderBy, GroupBy, Join, Aggregate, and more.
3. **Deferred Execution:** LINQ queries use deferred execution, meaning that the query is not executed immediately when it's defined. Instead, the query is executed when the results are enumerated (e.g., when iterating over the query result with a foreach loop).
4. **Integration with Lambda Expressions:** LINQ can be used with lambda expressions to provide more concise and flexible syntax for writing queries. Lambda expressions allow you to define inline functions for filtering, projecting, and sorting data.
5. **LINQ to Objects:** LINQ can be used to query in-memory collections such as arrays, lists, and dictionaries. LINQ to Objects provides standard query operators for querying and manipulating these collections.
6. **LINQ to SQL, LINQ to Entities:** LINQ can be used to query relational databases using LINQ to SQL or LINQ to Entities. LINQ to SQL translates LINQ queries into SQL queries and executes them against the database, while LINQ to Entities works with Entity Framework to query and manipulate data stored in a database.
7. **LINQ to XML:** LINQ provides support for querying and manipulating XML documents using LINQ to XML. LINQ to XML allows you to write queries to search, filter, transform, and create XML documents.

LINQ is a versatile and powerful feature in C# that simplifies data querying and manipulation, improves code readability, and reduces the amount of boilerplate code needed for common data operations. It's widely used in various types of applications, including desktop, web, and mobile development.

Partial Methods

Partial methods in C# are methods that allow for separation of the method declaration (signature) from the method implementation. They enable you to define a method in one part of a partial class and provide the implementation in another part of the class, or optionally not provide an implementation at all. Partial methods are primarily used in code generation scenarios, such as when working with visual designers or auto-generated code.

Here are some key points about partial methods:

1. **Declaration:** Partial methods are declared using the partial keyword in one part of a partial class. The method signature is defined without specifying the method body.

```
public partial class MyClass
{
    partial void MyPartialMethod();
}
```

2. **Implementation:** The implementation of a partial method is provided in another part of the partial class. If an implementation is not provided, the compiler removes the method call at compile time.

```
public partial class MyClass
{
    partial void MyPartialMethod()
    {
        // Method implementation
    }
}
```

3. **Optional Implementation:** Partial methods are optional, meaning that you can define them in one part of the class and choose not to provide an implementation in another part. In this case, the method call is removed by the compiler, and any calls to the method are effectively no-ops.
4. **Usage:** Partial methods are commonly used in code generated by visual designers, such as Windows Forms or WPF designers in Visual Studio. They provide a way for developers to extend or customize the behavior of auto-generated code without modifying the generated code itself.
5. **Event Handlers:** Partial methods are also used as event handlers, especially in scenarios where the event may or may not have any subscribers. This allows for cleaner code and better performance by avoiding unnecessary event invocation.
6. **Return Type:** Partial methods can have void return type only. They cannot have any other return type, parameters, or access modifiers other than partial.

Partial methods provide a way to decouple method declaration from implementation, allowing for flexibility in extending or customizing code generated by tools or frameworks. They help improve code organization, readability, and maintainability, especially in large-scale projects or when working with code generated by automated tools.

Dynamic Type

In C#, the dynamic type allows you to declare variables whose types are resolved at runtime rather than compile time. This provides flexibility when working with types that are not known until runtime, such as objects from dynamic languages, COM objects, or objects whose types are determined dynamically.

Here are some key points about the dynamic type:

1. **Type Resolution at Runtime:** When a variable is declared as dynamic, the type of the variable is determined at runtime rather than compile time. This means that method and property resolution for dynamic variables is also deferred until runtime.

```
dynamic dynamicVariable = 10;  
dynamicVariable = "Hello";
```

2. **No Compile-Time Type Checking:** Because the type of dynamic variables is determined at runtime, the compiler performs minimal type checking at compile time. This allows you to call methods and access properties that may not exist at compile time, but may be resolved at runtime.

```
dynamic dynamicObject = GetDynamicObject();  
dynamicObject.SomeMethod(); // No compile-time error even if SomeMethod doesn't exist
```

3. **Late Binding:** Operations on dynamic variables are resolved at runtime through late binding, meaning that method calls and property accesses are resolved dynamically based on the actual type of the object at runtime.
4. **No IntelliSense Support:** Because the type of dynamic variables is determined at runtime, IDE features such as IntelliSense cannot provide compile-time information about members of dynamic objects. This can lead to reduced developer productivity and potential runtime errors.
5. **Performance Overhead:** Using dynamic can incur a performance overhead compared to statically typed code because of the late binding and runtime type resolution involved. However, this overhead is typically negligible in most scenarios.
6. **Use Cases:** The dynamic type is particularly useful when working with interoperability scenarios, such as calling dynamic languages like Python or JavaScript from C#, working with COM objects, or dealing with data from external sources where the schema is not known until runtime.

```
dynamic excelApp = GetExcelApplication();  
dynamic worksheet = excelApp.Worksheets[1];  
var cellValue = worksheet.Cells[1, 1].Value;
```

While the dynamic type provides flexibility in certain scenarios, it should be used judiciously, as it bypasses compile-time type checking and can lead to harder-to-debug runtime errors if misused. It's typically best to use dynamic only when interacting with truly dynamic or unknown types, and to favor statically typed code wherever possible for improved safety and performance.

Optional | Named Parameters

Optional and named parameters in C# provide flexibility and readability when working with method parameters. Here's a breakdown of each feature:

Optional Parameters:

Optional parameters allow you to specify default values for parameters in method declarations. If a value is not provided when the method is called, the default value is used.

They are defined in method signatures by assigning a default value to parameters.

All optional parameters must be at the end of the parameter list.

Example:

```
public void SendMessage(string message, int priority = 1)
{
    Console.WriteLine($"Message: {message}, Priority: {priority}");
}

// Calling the method without specifying the optional parameter
SendMessage("Hello"); // Output: Message: Hello, Priority: 1
```

Named Parameters:

Named parameters allow you to specify arguments by name when calling methods, rather than by position.

This provides clarity and flexibility, especially when methods have many parameters or the order of parameters is not obvious.

Named parameters are specified by providing the parameter name followed by a colon (:) before the argument.

Example:

```
public void DisplayInfo(string name, int age)
{
    Console.WriteLine($"Name: {name}, Age: {age}");
}
```

```
// Calling the method with named parameters
DisplayInfo(age: 30, name: "Alice"); // Output: Name: Alice, Age: 30
```

Combining Optional and Named Parameters:

You can use optional and named parameters together.

Named parameters allow you to skip optional parameters or specify them out of order.

Example:

```
public void SendEmail(string to, string subject = "Hello", string cc = "")
{
    Console.WriteLine($"To: {to}, Subject: {subject}, CC: {cc}");
}
```

```
// Calling the method with named parameters and skipping optional parameters
SendEmail("example@example.com", cc: "copy@example.com"); // Output: To:
example@example.com, Subject: Hello, CC: copy@example.com
```

Optional and named parameters enhance code readability and maintainability by allowing for more expressive method calls. However, they should be used judiciously to avoid confusion, especially in public APIs where parameter changes may affect existing callers.

Async | Await

In C#, the `async` and `await` keywords are used to write asynchronous code in a more straightforward and readable manner. Here's how they work:

Async Methods:

The `async` modifier is used to define asynchronous methods. These methods can perform time-consuming operations without blocking the calling thread.

```
async Task MyAsyncMethod()
```

```
{  
    // Asynchronous operations  
}
```

Await Operator:

Inside an async method, the await operator is used to asynchronously wait for the completion of another asynchronous operation, such as a Task or Task<T>.

```
async Task<string> DownloadDataAsync()  
{  
    HttpClient client = new HttpClient();  
    string data = await client.GetStringAsync("https://example.com");  
    return data;  
}
```

Awaiting Task:

When calling an async method, you use the await keyword before the method call. This allows the calling method to asynchronously wait for the completion of the async method.

```
string result = await DownloadDataAsync();
```

Exception Handling:

Async methods can use regular try-catch blocks to handle exceptions. Exceptions thrown during asynchronous operations are captured and propagated as if the code were synchronous.

```
try  
{  
    string result = await DownloadDataAsync();  
    Console.WriteLine(result);  
}
```

```
catch (Exception ex)
{
    Console.WriteLine($"An error occurred: {ex.Message}");
}
```

Async Event Handlers:

Async methods can be used as event handlers. For example, in UI applications, async event handlers can perform asynchronous operations without blocking the UI thread.

```
async void Button_Click(object sender, EventArgs e)
{
    string result = await
        DownloadDataAsync();
    MessageBox.Show(result);
}
```

Performance Benefits:

Asynchronous programming with `async` and `await` can improve the responsiveness and scalability of applications, especially in scenarios involving I/O-bound or CPU-bound operations.

```
Task.Run(() => MyMethod()); // Run CPU-bound operation asynchronously
```

`Async` and `await` keywords provide a more natural way to write asynchronous code in C#, making it easier to understand and maintain. They are widely used in modern C# applications for handling asynchronous operations efficiently and elegantly.

ADO.NET

What is ADO.NET:-

The .NET Framework includes its own data access technology, ADO.NET.

ADO.NET consists of managed classes that allow .NET applications to Connect to data sources (usually relational databases), execute commands, and manage disconnected data.

Connected Architecture

Connection:

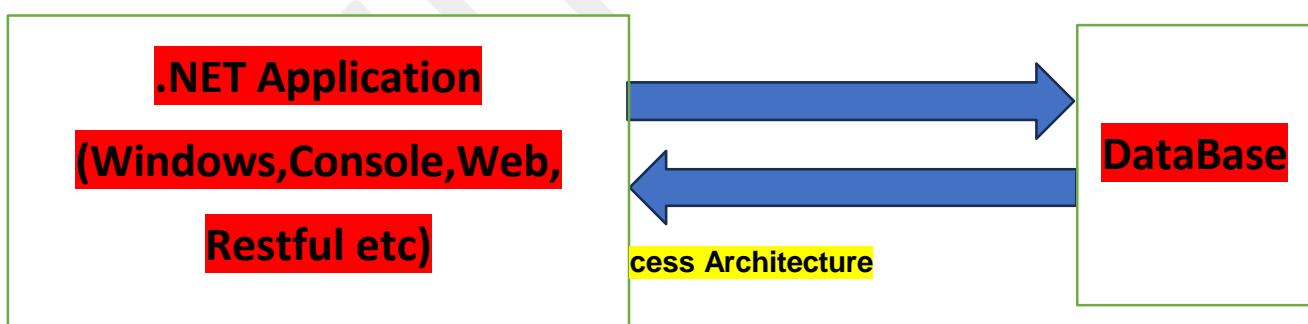
Manages the connection to the database. In the case of Connection-Oriented Data Access Architecture, an open and active connection is always required between the .NET Application and the database. When we access data from the database, the Data Reader object requires an active and open connection to access the data. If the connection is closed, we cannot access the data from the database; in that case, we will get the runtime error.

Command:

Executes SQL queries, stored procedures, or commands on the database. The second important component is the command object. When we discuss databases such as SQL Server, Oracle, MySQL, then speak SQL, it is the command object that we use to create SQL queries. After you create your SQL queries, you can execute them over the connection using the command object.

DataReader:

Reads data from the database in a forward-only, read-only manner. The ADO.NET DataReader object reads the data from the database using Connected Oriented Architecture. It requires an active and open connection while reading the data from the database.



Select Query

```
string connectionDetails = @"Data Source=(LocalDB)\MSSQLLocalDB;Initial Catalog=kdac;Integrated Security=True";
```

```
SqlConnection connection =
    new SqlConnection(connectionDetails);
connection.Open();
```

```
SqlCommand command =
    new SqlCommand("select * from Emp", connection);
```

```

SqlDataReader reader = command.ExecuteReader();

List<Emp> emps = new List<Emp>();

while (reader.Read())
{
    Emp emp = new Emp();
    emp.No = Convert.ToInt32(reader["No"]);
    emp.Name = reader["Name"].ToString();
    emp.Address = reader["address"].ToString();

    emps.Add(emp);
}
connection.Close();

foreach (Emp emp in emps)
{
    Console.WriteLine(emp.ToString());
}

SqlConnection connection=new SqlConnection(connectionDetails);

```

1. SqlConnection:

This is a class provided by the .NET framework for working with SQL Server databases. It represents a connection to a SQL Server database. This class is part of the **System.Data.SqlClient** namespace.

2. connection: This is the variable name that hold the `SqlConnection` object.

3. new: This keyword is used to create a new instance of a class.

```
SqlCommand command = new SqlCommand("select * from Emp", connection);
```

1. SqlCommand command :

This line declares a variable named `command` of type `SqlCommand`. `SqlCommand` is a class provided by the ADO.NET framework, which is used to execute SQL commands against a database.

2. new SqlCommand("select * from Emp",connection): SqlCommand class takes two parameters

- a. **select * from Emp** - This is the SQL command that you want to execute.select statement that retrieves all columns from a table.
- b. **connection** – This is an instance of a `SqlConnection` class. It represents the connection to the database where you want to execute the SQL command.

```
SqlDataReader reader = command.ExecuteReader();
```

1. SqlDataReader reader:

This line declares a variable named `reader` of type `SqlDataReader`. `SqlDataReader` is a class provided by the ADO.NET for reading a forward-only streams of rows from database.

2. `command.ExecuteReader()`:

This method is used to execute the SQL command represented by the `command` object and retrieve the resulting data as a data reader. When you call `'ExecuteReader()'`, it sends the SQL command to the database server for execution.

DisConnected Architecture

- **DataAdapter:** This object performs two tasks. First, you can use it to fill a `DataSet` (a disconnected collection of tables and relationships) with information extracted from a data source. Second, you can use it to apply changes to a datasource, according to the modifications you've made in a `DataSet`. The ADO.NET DataAdapter object acts as an interface between the .NET application and the database.
- **DataSet:** A `DataSet` is made up of a collection of tables, relationships, and constraints. In ADO.NET, `DataTable` objects are used to represent the tables in a `DataSet`.

The ADO.NET `DataSet` is a memory-resident representation of data that provides a consistent relational programming model regardless of the source of the data it contains. A `DataSet` represents a complete set of data including the tables that contain, order, and constrain the data, as well as the relationships between the tables.

Creating a DataSet:

You can create an instance of a `DataSet` by calling the `DataSet` constructor. Optionally specify a name argument. If you do not specify a name for the `DataSet`, the name is set to "NewDataSet". You can also create a new `DataSet` based on an existing `DataSet`.

The new `DataSet` can be an exact copy of the existing `DataSet`, a clone of the `DataSet` that copies the relational structure or schema but that does not contain any of the data from the existing `DataSet`; or a subset of the `DataSet`, containing only the modified rows from the existing `DataSet` using the `GetChanges` method.

▪ **Data Table:**

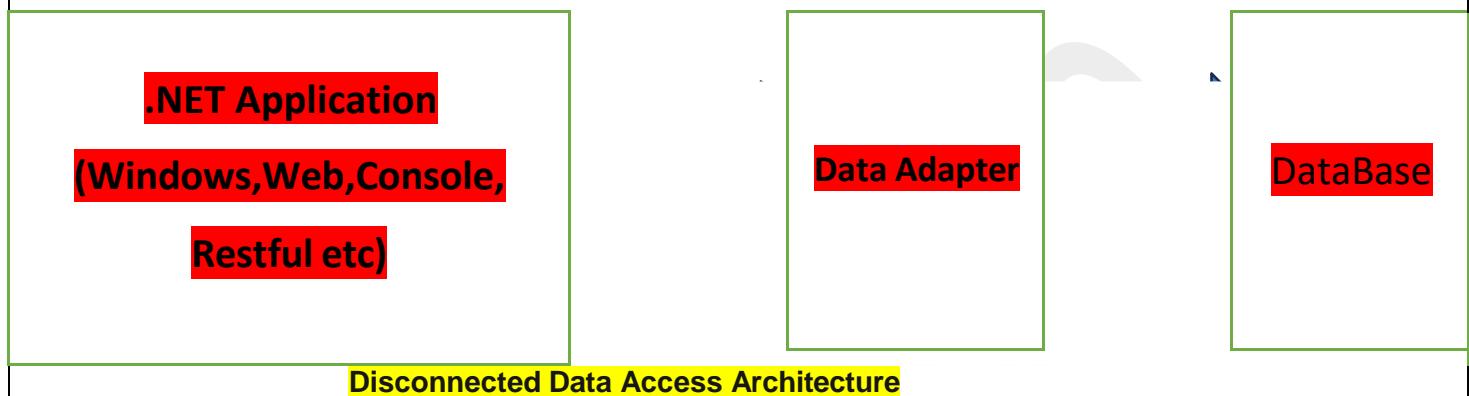
The `DataTable` class is a member of the `System.Data` namespace within the .NET Framework class library. You can create and use a `DataTable` independently or as a member of a `DataSet`, and `DataTable` objects can also be used in conjunction with other .NET Framework objects, including the `DataView`. You access the collection of tables in a `DataSet` through the `Tables` property of the `DataSet` objects.

Creating a DataTable:

A `DataTable`, which represents one table of in-memory relational data, can be created and used independently, or can be used by other .NET Framework objects, most commonly as a member of a `DataSet`.

You can create a `DataTable` object by using the appropriate `DataTable` constructor. You can add it to the `DataSet` by using the `Add` method to add it to the `DataSet` objects `Tables` collection.

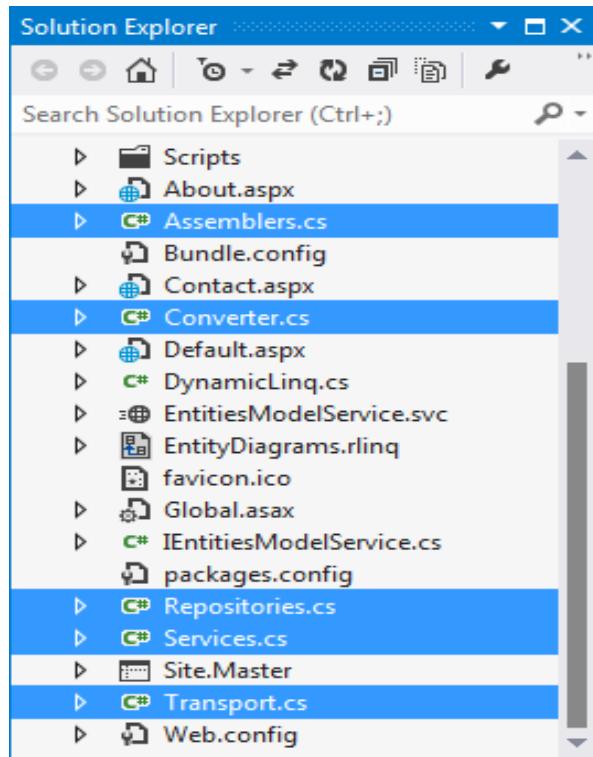
When you first create a DataTable, it does not have a schema (that is, a structure). To define the schema of the table, you must create and add objects to the Columns collection of the table. You can also define a primary key column for the table, and create and add Constraint objects to the Constraints collection of the table. After you have defined the schema for a DataTable, you can add rows of data to the table by adding DataRow objects to the Rows collection of the table.



- **Writing DTO Layer:-**

Data Transfer Objects (DTO) are used to transfer data between the **Application Layer** and the **Presentation Layer** or other type of clients.

A DTO is nothing more than a container class that exposes properties but no methods. A data transfer object (DTO) holds all data that is required for the remote call. Your remote method will accept the DTO as a parameter and return a DTO to the client.

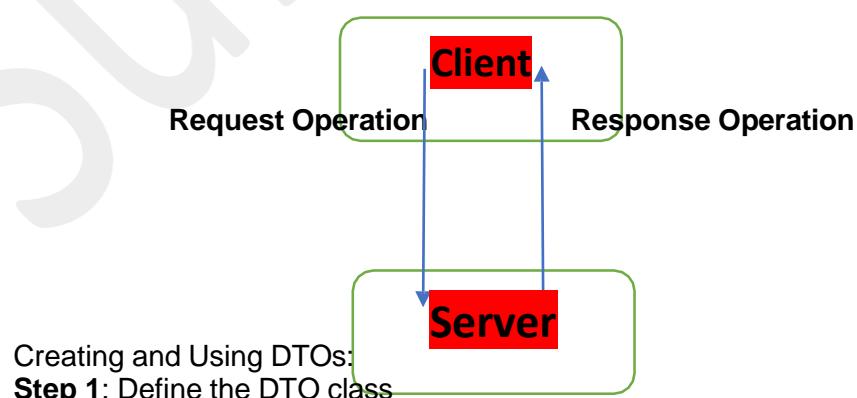


Why Use DTOs?

The use of DTOs is very common in web development. They provide solutions for many needs. Below are some of them:

- Separate the service layer from the database layer.
- Hide specific properties that clients don't need to receive.
- Manipulate nested objects to make them more convenient for clients.

DTOs provide an efficient way to separate domain objects from the presentation layer. This way, you can change the presentation layer without affecting the existing domain layers, and vice versa.



Suppose we have a basic entity class representing employees.

```
public class Employee
{
    public int Empld { get; set; }
    public string FirstName { get; set; }
```

```

        public string LastName { get; set; }
        public string Department { get; set; }

    }

```

Now Lets create a DTO class for the Employee entity.

```

public class EmployeeDTO
{
    public int Empld { get; set; }
    public string FullName { get; set; }
    public string Department { get; set; }
}

```

In this EmployeeDTO class, we're selecting specific fields (EmployeeId, FullName, and Department) that we want to transfer between different parts of our application. The FullName property is a computed property, as it's not present in the original Employee entity.

Step 2: Converting Entity To DTO:

```

public static class EmployeeMapper
{
    public static EmployeeDTO MapToDTO(Employee employee)
    {
        return new EmployeeDTO
        {
            Empld = employee.EmployeeId,
            FullName = $"{employee.FirstName}{employee.LastName}",
            Department = employee.Department
        };
    }
}

```

Step 3: Using DTOs in Our Application:

Suppose we have a service that retrieves employee data from a database.

```

public class EmployeeService
{
    private List<Employee> _employees = new List<Employee>
    {
        new Employee { EmployeeId = 1, FirstName = "Amit", LastName = "Patil", Department = "IT" },
        new Employee { EmployeeId = 2, FirstName = "raj", LastName = "Sutar", Department = "HR" },
        new Employee { EmployeeId = 3, FirstName = "Bhaiya", LastName = "Magnum", Department = "Finance" },
    };
}

```

```

public EmployeeDTO GetEmployeeById(int employeeId)
{
    var employee = _employees.FirstOrDefault(e => e.EmployeeId == employeeId);

    if(employee == null)
    {
        return null;
    }

    return EmployeeMapper.MapToDTO(employee);
}

```

In this EmployeeService, we have a method GetEmployeeById that retrieves an employee by their ID and maps the retrieved Employee object to an EmployeeDTO using the EmployeeMapper class

- **Entity Framework:-**

Entity Framework is an open source object-relational mapping framework for ADO.NET

Entity Framework is an Object Relational Mapper (ORM) which is a type of tool that simplifies mapping between objects in your software to the tables

commands, as well as taking query results and automatically materializing those results as your application objects.

- **Writing POCO:-**

POCO stands for "Plain Old CLR Object," and in the context of Entity Framework, POCO classes are simple, non-framework-specific classes that do not depend on any Entity Framework types.

These classes are used to represent entities in the domain model, and they can be used with Entity Framework for data access without requiring any dependencies on the framework itself.

POCO classes are often used to create a more maintainable and testable domain model, as they are not tied to a specific data access technology.

Creating POCO Classes:

1. **Define Your Classes:** You start by defining your entity classes as plain C# classes. For example, if you have a "Customer" entity, you would create a class named 'Customer'.
2. **Add Properties:** Add properties to your classes to represent the attributes of your entities. Each property typically corresponds to a column in a database table.
3. **Decorate with Attributes:** You can use attributes such as [Key], [Required], [StringLength].

Mapping POCO Classes to Database Tables:

1. **DbContext:** You need to create a '**DbContext**' class, which represents a session with the database and acts as a bridge between your domain classes and the database.
2. **DbSet< TEntity >:** Inside your 'DbContext' class, you define `DbSet< TEntity >` properties, where `` is your POCO class.

The Code Given Below Defines a POCO Class.

```
public class Customer
{
    public int CustomerID {get; set;}
    public string Name { get; set; }
    public string Address { get; set; }
}

public class MyDbContext : DbContext {
    public DbSet<Customer> Customers { get; set; }
}
```

In this example, Customer is a POCO class representing a customer entity, and `MyDbContext` is a `DbContext` class containing a `DbSet<Customer>` property for accessing the “Customers” table in the database.

▪ Using Attributes:-

Attributes are like adjectives, which are used for metadata annotation that can be applied to a given type, assembly, module, method and so on. The .NET framework stipulates two types of attribute implementations, which are Predefined Attributes and Custom Attributes. Attributes are types derived from the System.Attribute class. This is an abstract class defining the required services of any attribute. The following is the syntax of an attribute; [type: attributeName(parameter1,parameter2, ----- n)]

Role Of Attributes-

Attributes might be useful for documentation purposes. They fulfill many roles, including describing serialization, indicating conditional compilation, specifying import linkage and setting class blueprint and so on. Attributes allow information to be defined and applied to nearly any metadata table entry.

Prefined Attributes-

The System.Attribute base class library provides a number of attributes in various namespaces. The following table gives a snapshot of some predefined attributes.

Attributes	Description
[Serialization]	By marking this attributes, a class is able to persist its current state into stream.

[NonSerialization]	It specify that a given class or field should not persisted during the serialization process.
--------------------	-----------------------------------------------------------------------------------------------

Here, assume that you have developed a Test class that can be persisted in a binary format using the [Serialization] attribute.

```
[Serializable]
public class test
{
    public Test() {}
    string name;
    string country;

    [NonSerialized]
    int salary;
}
```

1. Table Attribute-

The **Table** attribute is applied to an entity to specify the name of the database table that the entity should map to. The following example specifies that the **Book** entity should map to a database table named **tbl_Book**:

```
[Table("tbl_book")]
public class Book
{
    public int BookId { get; set; }
    public string Title { get; set; }
    public Author Author { get; set; }

}
```

2. Column Attribute-

The **Column** attribute is applied to a property to specify the database column that the property should map to when the entity's property name and the database column name differ. The following example maps the **Title** property in the **Book** entity to a database column named **Description**:

```
public class Book
{
    public int BookId { get; set; }
    [Column("Description")]
    public string Title { get; set; }
    public Author Author { get; set; }
}
```

3. ForeignKey-

The **ForeignKey** attribute is used to specify which property is the foreign key in a relationship.

```
public class Author
```

```

{
    public int AuthorId { get; set; }
    public string FirstName { get; set; }
    public string LastName { get; set; }
    [ForeignKey("AuthorFK")]
    public ICollection<Book> Books { get; set; }
}

```

4. DatabaseGenerated-

The DatabaseGenerated attribute specifies how values are generated for a property by the database. The attribute takes a DatabaseGeneratedOption enumeration value.

Computed-

The Computed option specifies that the property's value will be generated *by the database* when the value is first saved, and subsequently regenerated every time the value is updated.

```

public class Contact
{
    public int Id { get; set; }
    public String FullName { get; set; }
    public String Email { get; set; }
    [DatabaseGenerated(DatabaseGeneratedOption.Computed)]
    public DateTime LastAccessed { get; set; }

}

```

Identity-

The Identity option specifies that the value will only be generated by the database when a value is first added to the database.

Database providers differ in the way that values are automatically generated. Some will generate values for selected data types such as **Identity, rowversion**.

```

public class Contact
{
    public int Id { get; set; }
    public String FullName { get; set; }
    public String Email { get; set; }
    [DatabaseGenerated(DatabaseGeneratedOption.Computed)]
    public DateTime Created { get; set; } = DateTime.UtcNow;
}

```

5. MaxLength-

The MaxLength attribute is applied to a property to specify a maximum number of characters or bytes for the column that the property should map to.

The following example specifies that the **Title** column in the Books table is to have a maximum length of 150 characters.

```

public class Book
{
    public int BookId { get; set; }
    [MaxLength(140)]
    public String Title { get; set; }
    public Author Author { get; set; }

}

```

- **Entity Framework Packages-:**

Entity Framework core is shipped as NuGet packages. The packages needed by an application depends on:

- The type of database system being used (SQL Server, SQLite etc)
- The EF core features needed.

The usual process for installing packages is:

- Decide on a database provider and install the appropriate package.
- Also install Microsoft.EntityFrameworkCore and SQprovider. This helps ensure that consistent versions are being used, and also means that NuGet will let you know when new package versions are shipped.
- Optionally decide which kind of tooling you need and install the appropriate packages for that

Database providers:

EF Core supports different database systems through the use of “database providers”. Each system has its own database provider, which is shipped as NuGet package. Applications should install one or more of these provider packages. Common database providers are listed in the table below.

Database System	Package
SQL Server	Microsoft.EntityFrameworkCore.SqlServer
PostgreSQL	Npgsql.EntityFrameworkCore.PostgreSQL
MySQL	EntityFrameworkCore.MySql

- **Commands-:**

The command-line interface tools for Entity Framework core perform design-time development tasks. For Example they create migrations, apply migrations and generate code for a model based on an existing database. The commands are an extension to the cross-platform dotnet command, which is part of the .NET Core SDK.

When using Visual Studio, consider using the Package Manager Console tools instead of the CLI tools. Package Manager Console tools automatically.

- Works with the current project selected in the Package Manager Console without requiring that you manually switch directories.
- Opens files generated by a command after the command is completed.
- Provides tab completion of commands, parameters, project names, context types and migration names.

dotnet ef database update

Updates the database to the last migration or to a specified migration.

Argument	Description

<MIGRATION>	The target migration. Migrations may be identified by name or by ID. The number 0 is a special case that means <i>before the first migration</i> and causes all migrations to be reverted.
-------------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

dotnet ef dbcontext info

Gets information about a DbContext type.

The common options are listed above.

1. dotnet ef dbcontext optimize

- Generates a compiled version of the model used by the DbContext.

2. dotnet ef dbcontext scaffold

- Generates code for a DbContext and entity types for a database. In order for this command to generate an entity type, the database table must have a primary key.

Arguments:

<CONNECTION>

<PROVIDER>

dotnet ef migrations add

Adds a new migration.

<NAME>	Name Of Migrations.
--------	---------------------

dotnet ef migrations remove

Removes the last migration, rolling back the code changes that were done for the latest migration.

--force	Revert the latest migration, rolling back both code and database changes that were done for the latest migration.
---------	-------------------------------------------------------------------------------------------------------------------

Different Approaches

The Entity Framework provides three approaches to create an entity model and each one has their own pros and cons.

- Code First
- Database First
- Model First

- **Model First Approach:-**

- Model First is good when you are starting a new project where the database doesn't even exist yet.
- The model is stored in an EDMX file and can be viewed and edited in the Entity Framework Designer.
- In Model First, you define your model in an Entity Framework designer then generate SQL, which will create database schema to match your model and then you execute the SQL to create the schema in your database.
- The classes that you interact with in your application are automatically generated from the EDMX file.

General overview of how you can use the Model First approach with relations in Entity Framework:

1. Create the Conceptual Model:

- Use Entity Framework Designer in Visual Studio or any other tool that supports Entity Framework modeling to create your conceptual model.
- Define entities (classes) representing your domain objects. Each entity typically corresponds to a table in the database.
- Define relationships between entities by specifying navigation properties. These navigation properties represent the associations between entities.

2. Configure Relationship:

- In the conceptual model, you can define relationships between entities. These relationships can be one-to-one, one-to-many, or many-to-many.
- Configure the cardinality and navigation properties for each relationship. For example, if you have a one-to-many relationship between Department and Employee, you would specify a collection navigation property in the Department entity to represent the employees associated with that department.

3. Generate Database Schema:

- Once you have defined your conceptual model with relationships, can generate the database schema from it.
- Entity Framework provides tools to generate SQL scripts or directly create the database based on your conceptual model.
- When generating the database schema, Entity Framework will create

tables, columns, and foreign key constraints according to the relationships you defined in the conceptual model.

4. Update and Synchronize:

- As your conceptual model evolves, you can make changes to it (e.g., adding new entities or modifying relationships).
- Entity Framework provides mechanisms to update the database schema to reflect these changes.

5. Use the Model in your Application:

- Once the database schema is generated , you can use Entity Framework to perform CRUD (Create, Read, Update, Delete) operations on your entities.
- Entity Framework will handle the translation of your LINQ queries into SQL and the mapping of database results back to your entity objects.



Client Server Architecture

What is Client-Server Architecture?

At its core, **client-server architecture** resembles the process of ordering a pizza for delivery. Imagine you call a pizza store to place an order. Someone at the store takes your order and then delivers the pizza to your doorstep. Simple, right? This analogy captures the fundamental principle of client-server architecture:

1. **Server:** The server provides requested services. It hosts, manages, and delivers resources.
2. **Clients:** Clients are the ones who request services from the server.

In the world of computing, client-server architecture refers to a model where most of the resources and services are managed by a central server. Here are the key points:

- **Definition:** Client-server architecture is a computing model in which clients (such as workstations or personal computers) connect to a central server over a network or the internet.
- **Resource Sharing:** In this model, various systems share computing resources via the network.
- **Server Role:** The server hosts and delivers services requested by clients.
- **Network Delivery:** All requests and services flow over the network.

Components of Client-Server Architecture

The architecture consists of the following components:

1. **Clients:** These are the end-user devices (workstations, laptops, or personal computers) that interact with the server to request services.
2. **Server:** The central server manages resources, processes requests, and delivers services.
3. **Network:** The communication medium (wired or wireless) that connects clients and the server.

How Does Client-Server Architecture Work?

1. A client sends a request (such as fetching a web page or accessing a database) to the server.
2. The server processes the request, retrieves the necessary data, and sends it back to the client.
3. The client displays the received information to the user.

Types of Client-Server Architecture

1. 1-Tier Architecture:

- Also known as the **single-tier architecture**.
- In this model, the client and server are tightly coupled, often running on the same machine.
- Commonly used for standalone applications.

2. 2-Tier Architecture:



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- Also called the **client-server architecture**.
- The client interacts directly with the server.
- Commonly used for database-driven applications.

3. 3-Tier Architecture:

- Divides the system into three layers:
 - **Presentation Layer:** Handles user interface and interaction (client-side).
 - **Application Layer:** Contains business logic (server-side).
 - **Data Layer:** Manages data storage (database server).
- Commonly used for web applications.

4. N-Tier Architecture:

- Extends the 3-tier model by adding more layers (such as security, caching, etc.).
- Scalable and flexible for large-scale applications.

Advantages and Disadvantages

Advantages:

- **Resource Centralization:** Centralized management of resources simplifies maintenance.
- **Scalability:** Easily scale by adding more servers or clients.
- **Security:** Centralized security measures.
- **Load Distribution:** Distributes load across servers.

Disadvantages:

- **Single Point of Failure:** If the server fails, all clients are affected.
- **Network Dependency:** Relies on network connectivity.
- **Complexity:** Managing servers and clients can be complex.

Conclusion

Client-server architecture plays a crucial role in modern computing, enabling efficient resource sharing and service delivery. Whether you're browsing the web, using online banking, or shopping online, you're interacting with client-server systems!

ASP.NET Web Forms VS ASP.NET MVC VS ASP.NET Core MVC

The differences between **ASP.NET Web Forms**, **ASP.NET MVC**, and **ASP.NET Core MVC** to understand their unique features and use cases:



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1. ASP.NET Web Forms:

- **Development Model:** Web Forms follow a **traditional event-driven development model**. Each page typically has a code-behind file where you write server-side logic.
- **Server Controls:** Web Forms heavily rely on **server controls** for building UI components.
- **View State:** Web Forms use **View State** for client-side state management.
- **Pros:**
 - Familiarity for developers accustomed to desktop application development.
 - Rapid application development using drag-and-drop controls.
 - Rich server controls library.
- **Cons:**
 - Tightly coupled code-behind model.
 - Complex page lifecycle.
 - Heavy reliance on ViewState can lead to larger page sizes.

2. ASP.NET MVC:

- **Design Pattern:** MVC stands for **Model-View-Controller**. It is a **software design pattern** that emphasizes separation of concerns.
- **Components:**
 - **Model:** Represents business logic, data manipulation, and database access.
 - **View:** Responsible for UI presentation (HTML, CSS, JavaScript).
 - **Controller:** Acts as an intermediary between Model and View, handling requests and responses.
- **Features:**
 - **Separation of Concerns:** MVC decouples the UI (View) from the business logic (Model) and request handling (Controller).
 - **SEO-Friendly URLs:** MVC provides clean and customizable URLs.
 - **HTML Helpers:** Offers HTML helpers for form controls (though plain HTML can also be used).
- **Pros:**
 - Better testability and maintainability.
 - Flexibility in choosing technologies (HTML5, Ajax, Web API, etc.).
 - Good for SEO.
- **Cons:**
 - Learning curve for developers new to MVC.
 - Requires understanding of the MVC pattern.

3. ASP.NET Core MVC:

- **Cross-Platform:** ASP.NET Core is a **cross-platform framework**, allowing you to build applications that run on Windows, Linux, or macOS.
- **Lightweight and Modern:**
 - **MVC pattern-based development.**
 - **HTML helpers** for form controls.
 - No reliance on ViewState.
- **Pros:**
 - Cross-platform compatibility.
 - Lightweight and modular.
 - Keeps you updated with modern web technologies.
- **Cons:**



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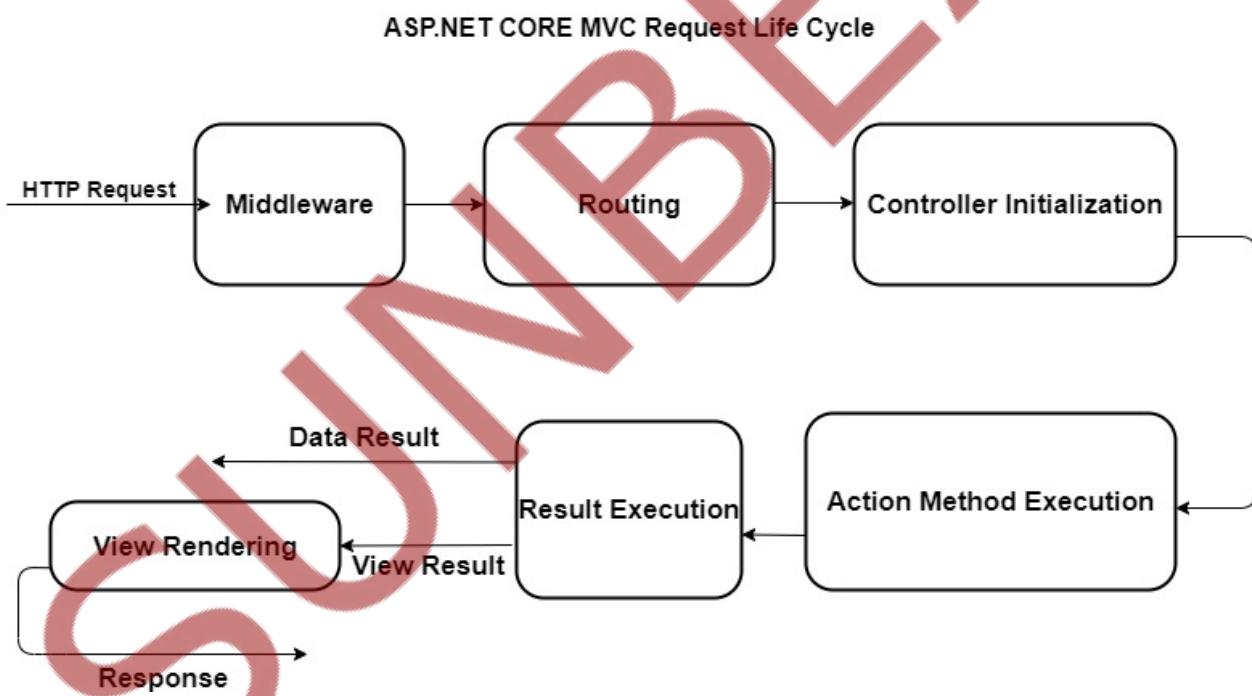
- Learning curve if transitioning from Web Forms.
- Some legacy libraries may not be available.

In summary, choose [ASP.NET Web Forms](#) if you prefer the traditional event-driven model, [ASP.NET MVC](#) for better separation of concerns and SEO-friendly URLs, and [ASP.NET Core MVC](#) for cross-platform development and modern features.

Life Cycle of MVC

Introduction

The ASP.NET Core MVC Request Life Cycle is a sequence of events, stages or components that interact with each other to process an HTTP request and generate a response that goes back to the client. In this article, we will discuss each and every stage of ASP.NET Core MVC Request Life Cycle in detail.



The request life cycle consists of various stages which are:

Middleware

Middleware component forms the basic building block of application HTTP pipeline. These are a series of components that are combined to form a request pipeline in order to handle any incoming request.



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Routing

Routing is a middleware component that implements MVC framework. The routing Middleware component decides how an incoming request can be mapped to Controllers and actions methods, with the help of convention routes and attribute routes.

Controller Initialization

At this stage of ASP.NET MVC Core Request Life Cycle, the process of initialization and execution of controllers takes place. Controllers are responsible for handling incoming requests. The controller selects the appropriate action methods on the basis of route templates provided.

Action method execution

After the controllers are initialized, the action methods are executed and returns a view which contains Html document to be returned as response to the browser.

Result Execution

During this stage of ASP.NET MVC Core Request Life Cycle, result i.e. the response generated to the original HTTP request, is executed. If an action method returns a view result, the MVC view engine renders a view and returns the HTML response. If result is not of view type, then action method will generate its own response.

Now, we will discuss each stage briefly

Middleware

Middleware component forms the basic building block of the application's HTTP pipeline. These are a series of components that are combined to form a request pipeline in order to handle any incoming request. Whenever a new request comes, it is passed to the first middleware component. The component then decides, whether to generate a response after handling that incoming request or to pass it to the next component. The response is sent back along these components, once the request has been handled.

Most middleware components are implemented as standalone classes, which are content generating middleware. Now, we will be creating a content generating middleware component by adding ContentComponent.cs class.

Example

```
using System.Text;
using System.Threading.Tasks;
using Microsoft.AspNetCore.Http;
namespace WebApplication
{
    public class ContentComponent
    {
        private RequestDelegate nextComponent;
        public ContentComponent(RequestDelegate nextMiddleware) =>
```



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```
nextComponent = nextMiddleware;
public async Task Invoke(HttpContext httpContext)
{
    if (httpContext.Request.Path.ToString().ToLower() == "/edit")
    {
        await httpContext.Response.WriteAsync("This is edit URL
component", Encoding.UTF8);
    }
    else
    {
        await nextComponent.Invoke(httpContext);
    }
}
```

This ContentComponent middleware component is defining a constructor, and inside constructor its taking RequestDelegate object. This RequestDelegate object represents the next middleware component. ContentComponent component also defines an Invoke method. When ASP.NET Core application receives an incoming request, the Invoke method is called.

The HttpContext argument of the Invoke method provides information about the incoming HTTP request and the generated response that will be sent back to the client. The invoke method of ContentComponent class checks whether incoming request is sent to /edit URL or not. If the request has been sent to /edit url then, in response a text message is sent.

Routing

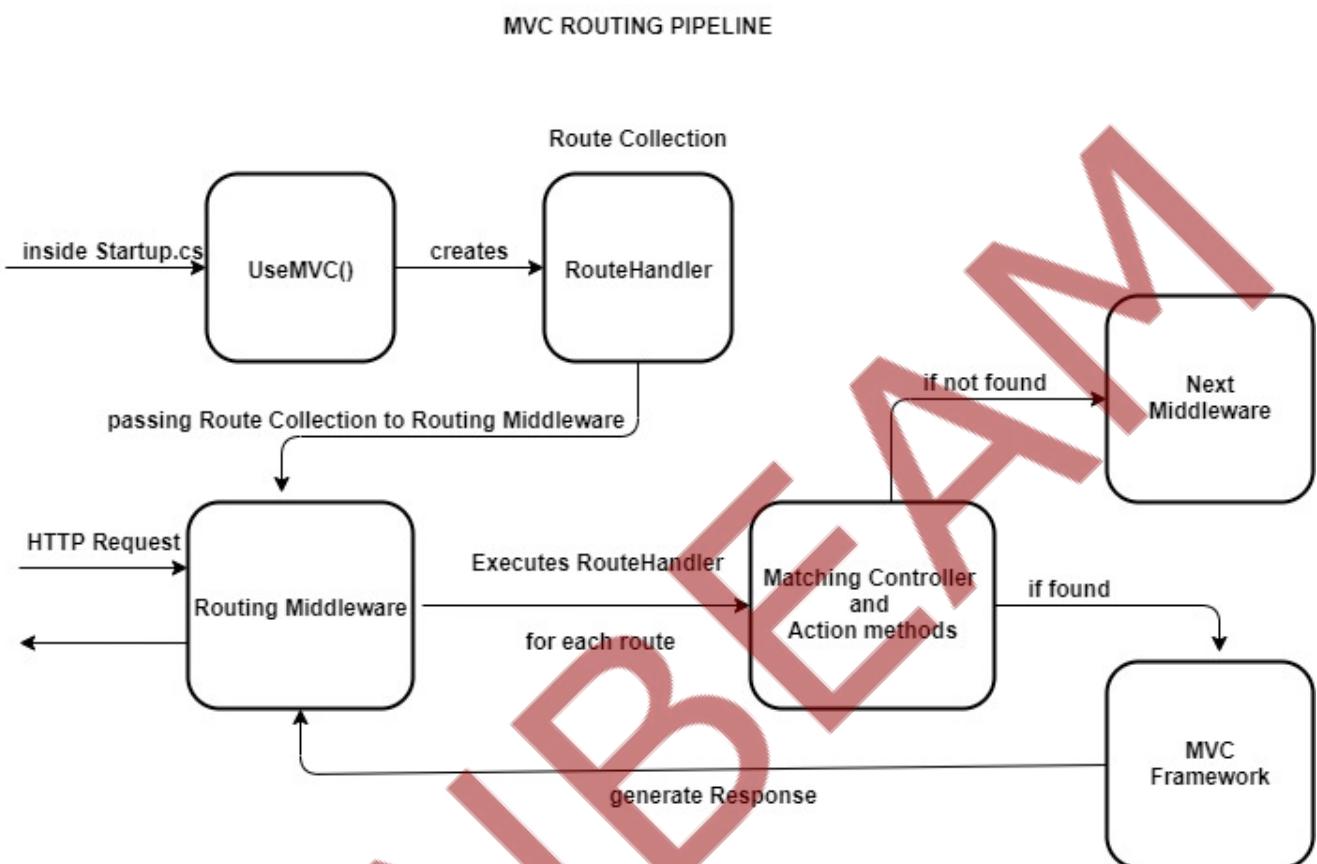
Routing is a middleware component that implements MVC framework. In ASP.NET Core, the routing system is used to handle MVC URLs. The routing Middleware component decides how an incoming request can be mapped to Controllers and actions methods, with the help of convention routes and attribute routes. Routing bridges middleware and MVC framework by mapping incoming request to controller action methods.

In a particular application, MVC registers one or more routes using MapRoute method. MVC provides default routes that are given a name and a template to match incoming request URLs. The Controllers and action variables are placeholders that are replaced by matching segments of the URL.

These routes are passed into and consumed by routing middleware.



The MVC routing pipeline



In ASP.NET Core, routing maps an incoming request to `RouteHandler` class, which is then passes as the collection of routes to the routing middleware. The routing middleware executes MVC `RouteHandler` for each route. If a matching controller and action method is found on a particular route, then the requested data is forwarded to the rest of the MVC framework which will generate a response.

There are two types of routing available in MVC which are:

1. Convention routing

- This routing type uses application wide patterns to match a different URL to various controller action methods. Convention routes represent default possible routes that can be defined with the help of controller and action methods.

2. Attribute routing

- This type of routing is implemented through attributes and applied directly to a specific controller or action method.

The convention routing methodology is implemented inside `startup.cs` file. In `startup.cs`, the `UseMvc()` method registers the routes, that are being supplied to it as a parameter inside `MapRoute` method.



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Example

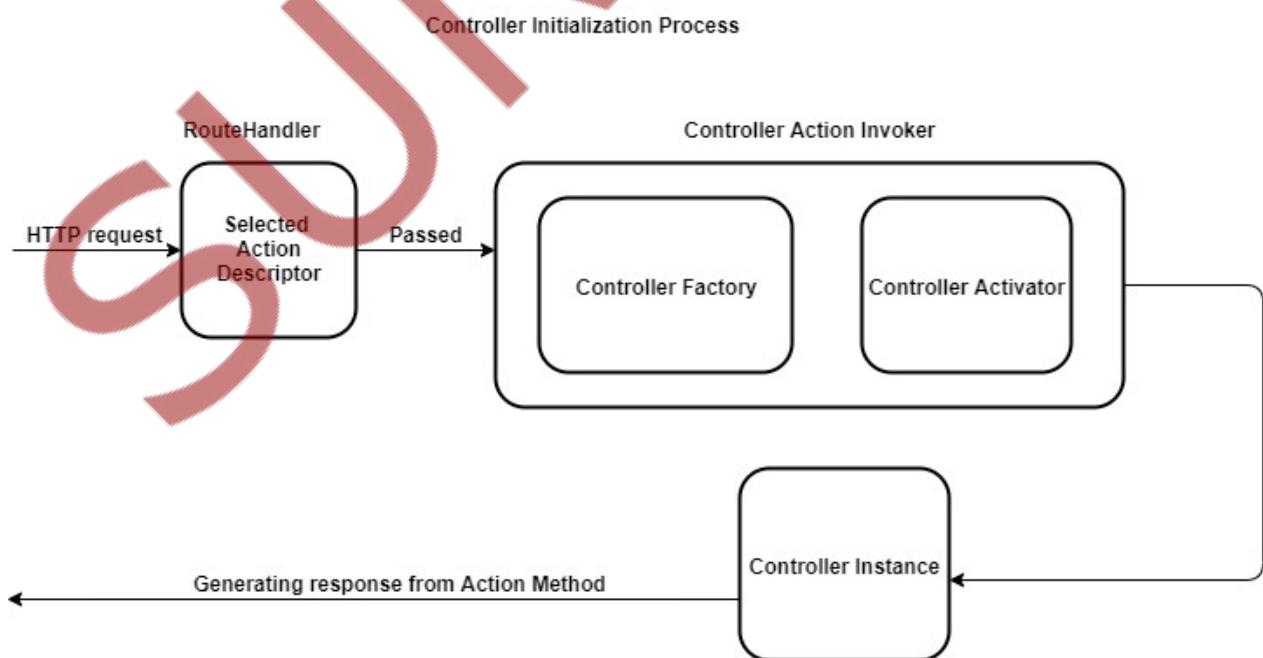
```
public void Configure(IApplicationBuilder app, IHostingEnvironment env) {  
    app.UseMvc(routes => {  
        routes.MapRoute(  
            name: "default",  
            template: "{controller=Home}/{action=Index}/{id?}");  
    });  
}
```

A route attribute is defined on top of an action method inside controller class.

```
public class MoviesController: Controller {  
    [Route("movies / released / {year}/{month:regex(\\d{4})}")]
    public ActionResult ByReleaseYear(int year, int month) {  
        return Content(year + "/" + month);  
    }  
}
```

Controller Initialization

At this stage, the process of initialization and execution of controllers takes place. Controllers are responsible for handling incoming requests which is done by mapping request to appropriate action method. The controller selects the appropriate action methods (to generate response) on the basis of route templates provided. A controller class inherits from controller base class. A controller class suffix class name with the Controller keyword.





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The MVC RouteHandler is responsible for selecting an action method candidate in the form of action descriptor. The RouteHandler then passes the action descriptor into a class called Controller action invoker. The class called Controller factory creates instance of a controller to be used by controller action method. The controller factory class depends on controller activator for controller instantiation.

After action method is selected, instance of controller is created to handle request. Controller instance provides several features such as action methods, action filters and action result. The activator uses the controller type info property on action descriptor to instantiate the controller by name. once the controller is created, the rest of the action method execution pipeline can run.

The controller factory is the component that is responsible for creating controller instance. The controller factory implements an interface called IControllerFactory. This interface contains two methods which are called CreateController and ReleaseController.

Action Method Execution Process

Authorization Filters

Authorization filters authorize or deny any incoming request.

Controller Creation

Instantiate Controller object.

Model Binding

Model Binding bind incoming request to Action method parameters.

Action Filters

OnActionExecuting method is always called before the action method is invoked.

Action Method Execution

Action method inside controller classes executes logic to create Action Result. Action method returns action results to generate response.

Action Filters

OnActionExecuted method called is always called after the action method has been invoked.

Authorization Filters

In ASP.NET Core MVC, there is an attribute called Authorize. Authorize is a filter, which can be applied to an action and it will be called by a MVC Core framework before and after that action or its result are executed.



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These filters are used to provide security to application, including user authorization. If authorize attribute is applied to an action method, before the action is executed, the attribute will check if the current user is logged in or not. If not it will redirect the user to the login page. Authorization filters authorize or deny any incoming request.

In the below code example, Authorize Authorization filter(predefined filter) has been used over Index action method.

```
[Authorize]
public ViewResult Index() {
    return View();
}
```

The OnAuthorization method authorizes an HTTP request.

```
namespace WebApplication {
    public interface IAuthorizationFilter: IFilterMetadata {
        void OnAuthorization(AuthorizationFilterContext content);
    }
}
```

Now I have demonstrated, how to create a custom Authorization filter. A class file called OnlyHttpsAttribute.cs has been created which defines the action filter.

```
using System;
using Microsoft.AspNetCore.Http;
using Microsoft.AspNetCore.Mvc;
using Microsoft.AspNetCore.Mvc.Filters;
namespace WebApplication {
    public class OnlyHttpsAttribute: IAuthorizationFilter {
        public void OnAuthorization(AuthorizationFilterContext approve) {
            if (!approve.HttpContext.Request.IsHttps) {
                approve.Result =
                    new StatusCodeResult(StatusCodes.Status403Forbidden);
            }
        }
    }
}
```

In the below example, OnlyHttps attribute has been applied to the Home controller

```
using Microsoft.AspNetCore.Mvc;
using WebApplication;
namespace Controllers {
    [OnlyHttps]
    public class HomeController: Controller {
        public ViewResult Index() => View("Message",
            "this URL is working fine");
    }
}
```



Model Binding

Model binding maps incoming request to action method parameters. Action method parameters are inputs for an action method. Using data values acquired from HTTP request, model binding creates objects that an action method takes as an argument.

The model binders are the components which provide data values from incoming request to invoke action methods. The model binders search for these data values under three scenarios which are:

- Form data values
- Routing variables
- Query strings

Each of these sources are examined in sequence until and unless an argument value is found.

Let's consider a controller class as follows

```
using System.Linq;
using System.Web.Mvc;
namespace project.Controllers {
    public class CustomerController: Controller {
        public ActionResult Edit(int id) {
            return Content("id=", +id);
        }
    }
}
```

Now, suppose I requested an URL as /Customer/Edit/1

Here 1 is the value of id property. MVC translated that part of the URL and used it as the argument when it called the Edit method in the Customer controller class to service the request. To invoke the Edit method, MVC requires a certain type of value for the argument id, therefore model binding provides data values to invoke action methods.

Action Filters

Action filters are used to execute tasks instantly before and after action method execution is performed. In order to apply some logic to action methods, without having to add extra code to the controller class, action filters can be used either above the action method itself or above the Controller class. Action filter implements two types of interfaces which are IActionFilter and IAsyncActionFilter.

The IActionFilter interface which defines action filter is as follows:

```
public interface IActionFilter: IFilterMetadata {
    void OnActionExecuting(ActionExecutingContext content);
    void OnActionExecuted(ActionExecutedContext content); }
```



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The method `OnActionExecuting` is always called before the action method is invoked, and the method `OnActionExecuted` is always called after the action method has been invoked, whenever an action filter is applied to an action method.

Whenever an action filter is created, the data is provided using two different context classes, `ActionExecutingContext` and `ActionExecutedContext`.

Now I will demonstrate, how to create a custom action filter by deriving a class from the `ActionFilterAttribute` class. A class file called `ActionAttribute.cs` has been created which defines the action filter.

```
using Microsoft.AspNetCore.Mvc.Filters;
namespace WebApplication {
    public class ActionAttribute: ActionFilterAttribute {
        private Stopwatch a;
        public override void OnActionExecuting(ActionExecutingContext content)
        {
            a = Stopwatch.StartNew();
        }
        public override void OnActionExecuted(ActionExecutedContext content) {
            a.Stop();
            string output = "<div> calculated time is: " + $"{{a.Elapsed.TotalMilliseconds}} ms </div>";
            byte[] bytes = Encoding.ASCII.GetBytes(output);
            content.HttpContext.Response.Body.Write(bytes, 0, bytes.Length);
        }
    }
}
```

In the below example, Action attribute has been applied to the Home controller

```
using Microsoft.AspNetCore.Mvc;
using WebApplication;
namespace Controllers {
    [Action]
    public class HomeController: Controller {
        public ViewResult Index() => View("Message",
            "This index action is executed between action attribute");
    }
}
```

Action Method Execution

Action methods return objects that implements the `IActionResult` interface from the `Microsoft.AspNetCore.Mvc` namespace. The various types of response from the controller such as rendering a view or redirecting the client to another URL, all these responses are handled by `IActionResult` object, commonly known as action result.



Microsoft.NET

When an action result is returned by a specific action method, MVC calls its `ExecuteResultAsync` method, which generates response on behalf of the action method. The `ActionContext` argument provides context data for generating the response, including the `HttpResponse` object.

Controllers contain Action methods whose responsibility is to generate a response to an incoming request. An action method is any public method inside a controller that responds to incoming requests.

```
Public class HomeController: Controller {  
    Public IActionResult Edit() {  
        Return View();  
    }  
}
```

Here, `Edit` action method is defined inside Home controller.

```
using Microsoft.AspNetCore.Mvc;  
using WebApplication23;  
namespace WebApplication23.Controllers {  
    public class HomeController: Controller {  
        public ViewResult Index() => View("Form");  
    }  
}
```

Here, `Index` method is defined inside Home controller, which is returning a view.

Result Execution

The action method returns action result. This action result is the base class for all action results in asp.net mvc. Depending on the result of an action method, it will return an instance of one of the classes that derive from action result.

Different types of action result are

TYPES	HELPER METHOD	DESCRIPTION
ViewResult	View()	Renders a view and return HTML content
PartialViewResult	PartialView()	Returns partial view
ContentResult	Content()	Returns simple text
RedirectResult	Redirect()	Redirect result to URL
RedirectToRouteResult	RedirectToAction()	Redirect to an action method
JsonResult	Json()	Returns serialized json object



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FileResult	File()	Returns a file
HttpNotFoundResult	HttpNotFound()	Returns not found or 404 error
EmptyResult		When action does not return values

During this stage of ASP.NET MVC Core Request Life Cycle, result i.e. the response generated to the original HTTP request, is executed. If an action method returns a view result, the MVC view engine renders a view and returns the HTML response. If result is not of view type, then action method will generate its own response.

```
using Microsoft.AspNetCore.Mvc;
using WebApplication23.example;
namespace WebApplication23.Controllers {
    public class HomeController: Controller {
        public ViewResult Index() => View("Form");
        public ViewResult ReceiveForm(string name, string state) =>
View("Details", $"{name} lives in {state}");
    }
}
```

In the above example Index action method is returning a view result, therefore the MVC view engine renders a view and returns the HTML response, which is a simple form.

Summary

In this article, we have discussed each and every stage of ASP.NET Core MVC Request Life Cycle in detail. All of the stages have been described with proper coding examples and life cycle diagrams.

Services and Dependency Injection

What Are Services?

- A service is a component intended for common consumption within an application.
- Services are made available through dependency injection (DI).

What is Dependency Injection?

Dependency Injection is a software development and design pattern that helps in eliminating the dependency of one class on the other class. Using dependency injection or DI primarily aims to build loosely coupled applications instead of tightly coupled ones.

The following are the top advantages of using dependency injection in .NET Core web API and applications:



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- **Reusability:** Dependency injection enables developers to reuse a code block, as they can share dependencies between classes.
- **Easy Testing:** During unit testing procedures, dependency injection enables the developers to use mock objects for testing the application. It provides accurate results, leading to patching loopholes, fixing errors, and streamlining code maintenance in .NET Core.
- **Loose Coupling:** DI helps to remove the dependency of one class over another class. This will result in accurate output even if you modify a single class, and it will not impact the dependent class.
- **Extensibility:** With the use of dependency injection, the application becomes more flexible and scalable, allowing it to remove dependencies while retaining uptime.

The Need for Dependency Injection in .NET Core

Let's see an example below to understand the need for dependency injection.

```
public class Car
{
    private AUDI _tata;
    public Car()
    {
        _tata = new TATA();
    }
}
public class TATA {
    public TATA()
    {
    }
}
```

In the above code, two classes are present: class Car and class TATA. The class Car depends on class TATA for providing the output. Therefore, both these classes are tightly coupled, and due to this, each time the program runs, a TATA class object needs to be created.

Now, suppose that you add a ModelName parameter in the TATA class constructor. Then, you need to add and pass the same parameter in the Car class, similar to the following code example. Otherwise, your program will not provide the output, which is, in our case, the model name.

```
public class Car {
    private TATA _tata;
    public Car()
    {
        _tata = new TATA("Nexon EV");
    }
}
public class TATA
```



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```
public TATA(string ModelName)
{
}
}
```

Due to the tight coupling of these classes, modification made in one class impacts the other. It's not a good practice for large projects, as it's a time, cost, and effort-consuming task. Thus, you need dependency injection to break hard coupling and make your .NET application loosely coupled.

This is where the ASP.NET Core's DI framework comes in. The Responsibility of creating the object is now rests with the framework. The object that does this is called DI Container or IoC Container.

There are many frameworks available like Autofac, Unity etc. which you can use with the ASP.NET Core.

It involves the use of an interface or base class to abstract the dependency implementation, and registration of the dependency in a service container.

.NET provides a built-in service container, `IServiceProvider`, and services are typically registered at the app's start-up and appended to an `IServiceCollection`.

When designing services for dependency injection, it is important to avoid stateful, static classes and members, creating global state, and direct instantiation of dependent classes within services.

Demo of Dependency Injection

Create Web Application

Create an ASP.NET Core project using the empty template and name it **DependencyInjection**. Add the **HomeController** with index method. You can follow these tutorials

Creating View Model

Create the **Models** folder and create the following **viewModel**.

```
1  public class ProductViewModel
2  {
3      public int Id { get; set; }
4      public string Name { get; internal set; }
5  }
```



Microsoft.NET

Adding the Service

Create the folder **Services** and add a class with the name **ProductService.cs**.

```
1  using DependencyInjection.Models;
2  using System.Collections.Generic;
3
4
5  namespace DependencyInjection.Service
6  {
7
8      public interface IProductService
9      {
10         List<ProductViewModel> getAll();
11     }
12
13     public class ProductService : IProductService
14     {
15         public List<ProductViewModel> getAll()
16         {
17             return new List<ProductViewModel>
18             {
19                 new ProductViewModel {Id = 1, Name = "Pen Drive" },
20                 new ProductViewModel {Id = 2, Name = "Memory Card" },
21                 new ProductViewModel {Id = 3, Name = "Mobile Phone" },
22                 new ProductViewModel {Id = 4, Name = "Tablet" },
23                 new ProductViewModel {Id = 5, Name = "Desktop PC" } ,
24             };
25         }
26     }
27 }
28 }
```

First, we added the **IProductService** interface, and then **ProductService** which implements that Interface.

The **ProductService** returns the list of Products. The Product List is hardcoded into the service. In real life, you go into the database to fetch the product List.



Microsoft.NET

Using the Service in Controller

Next, Open the HomeController and add the following code.

```
1  using DependencyInjection.Service;
2  using Microsoft.AspNetCore.Mvc;
3
4
5  namespace DependencyInjection.Controllers
6  {
7      public class HomeController : Controller
8      {
9          private IProductService _ productService;
10
11         public HomeController(IProductService productService)
12         {
13             _ productService = productService;
14         }
15
16         public IActionResult Index()
17         {
18             return View(_ productService.getAll());
19         }
20     }
21 }
22 }
```

The constructor of the **HomeController** asks for **ProductService** and stores the instance in local variable **_ productService**.

The **index** method calls the view with the list of products by invoking the **getAll** method.

Creating View

The View just displays the list of Products as shown below.

```
2  @model List<DependencyInjection.Models.ProductViewModel>;
3
4  @{
5      ViewData["Title"] = "Index";
6  }
7
8  <h2>Index</h2>
9
10 @foreach (var product in Model)
11 {
12     <p>@product.Id @product.Name</p>
13 }
14 }
```



Microsoft.NET

Register the Service

The last step is to register the service in the Dependency Injection container.

Open the **startup.cs** and go to **ConfigureServices** method. This is where all services are configured for dependency injection.

```
2 public void ConfigureServices(IServiceCollection services)
3 {
4     services.AddMvc();
5     services.AddTransient<IPrductService, ProductService>();
6 }
7
```

We have registered the **ProductService** using the **AddTransient** method. The other method available is **AddScoped** & **AddSingleton**.

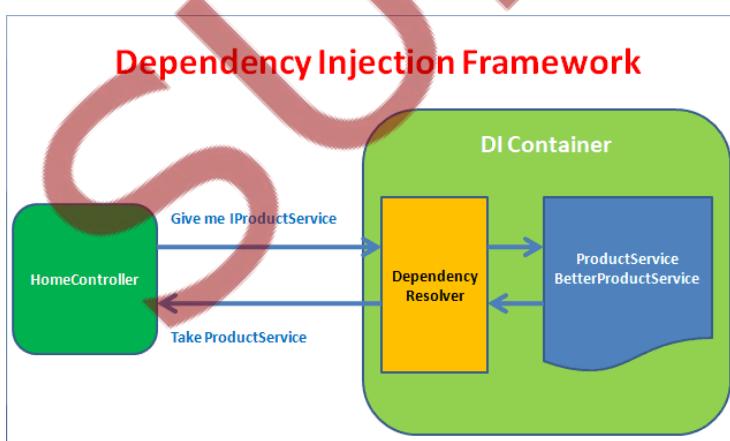
There are three ways, by which you can do that, and it in turn decides how the DI Framework manages the lifecycle of the services.

1. **Transient**: creates a new instance of the service, every time you request it.
2. **Scoped**: creates a new instance for every scope. (Each request is a Scope). Within the scope, it reuses the existing service.
3. **Singleton**: Creates a new Service only once during the application lifetime, and uses it everywhere

Now, run the application and you should be able to see the list of products.

How Dependencies are injected

The following image shows how **ProductService** was injected into the **HomeController**.



When the new **HomeController** is requested, the MVC asks the Dependency injection framework to provide an instance of the **HomeController** class.

The DI Container inspects the constructor of the **HomeController** and determines its dependencies.

It then searches for the dependencies in the services registered in the service collection and finds the matching service and creates an instance of it.

Then it creates the **HomeController** and passes the dependencies in its constructor.



Database Design

Creating database and Table

First of all, we will create a database named "StudentManagement".

1. **CREATE DATABASE** StudentManagement

Then, we will create a table named "Student".

```
2. Create table Student(  
3.     Id int IDENTITY(1,1) NOT NULL,  
4.     FirstName varchar(50) NOT NULL,  
5.     LastName varchar(50) NOT NULL,  
6.     Email varchar(30) NOT NULL,  
7.     Mobile varchar(20) NOT NULL,  
8.     Address varchar(220) NULL,  
9. )
```

Now, we will create stored procedures to add, delete, update, and get student data.

To Insert a student record

```
1. Create procedure spAddStudent  
2. (  
3.     @FirstName VARCHAR(50),  
4.     @LastName VARCHAR(50),  
5.     @Email VARCHAR(30),  
6.     @Mobile VARCHAR(20),  
7.     @Address VARCHAR(220)  
8. )  
9. as  
10. Begin  
11.     Insert into Student (FirstName,LastName,Email, Mobile,Address)  
12.         Values (@FirstName,@LastName,@Email, @Mobile,@Address)  
13. End
```

To Update a student record

```
1. Create procedure spUpdateStudent  
2. (  
3.     @Id INTEGER ,
```



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```
4.      @FirstName VARCHAR(50),  
5.      @LastName VARCHAR(50),  
6.      @Email VARCHAR(30),  
7.      @Mobile VARCHAR(20),  
8.      @Address VARCHAR(220)  
9. )  
10. as  
11. begin  
12.   Update Student  
13.     set FirstName=@FirstName,  
14.     LastName=@LastName,  
15.     Email=@Email,  
16.     Mobile=@Mobile,  
17.     Address=@Address  
18.   where Id=@Id  
19. End
```

To Delete a Student Record

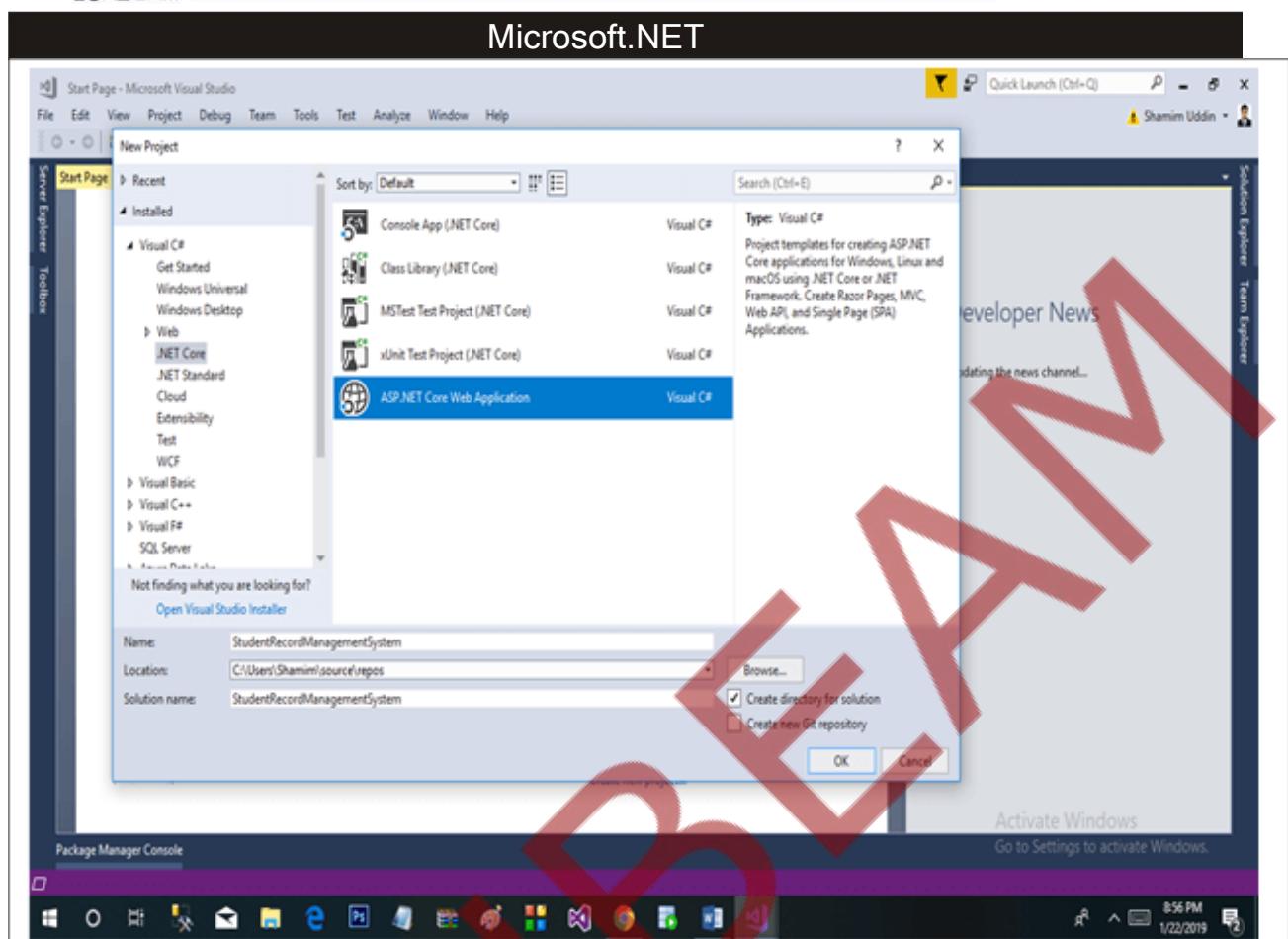
```
1. Create procedure spDeleteStudent  
2. (  
3.   @Id int  
4. )  
5. as  
6. begin  
7.   Delete from Student where Id=@Id  
8. End
```

To View all Student Records

```
1. Create procedure sp GetAllStudent  
2. as  
3. Begin  
4.   select *  
5.   from Student  
6.   order by Id  
7. End
```

Create the ASP.NET MVC Web Application

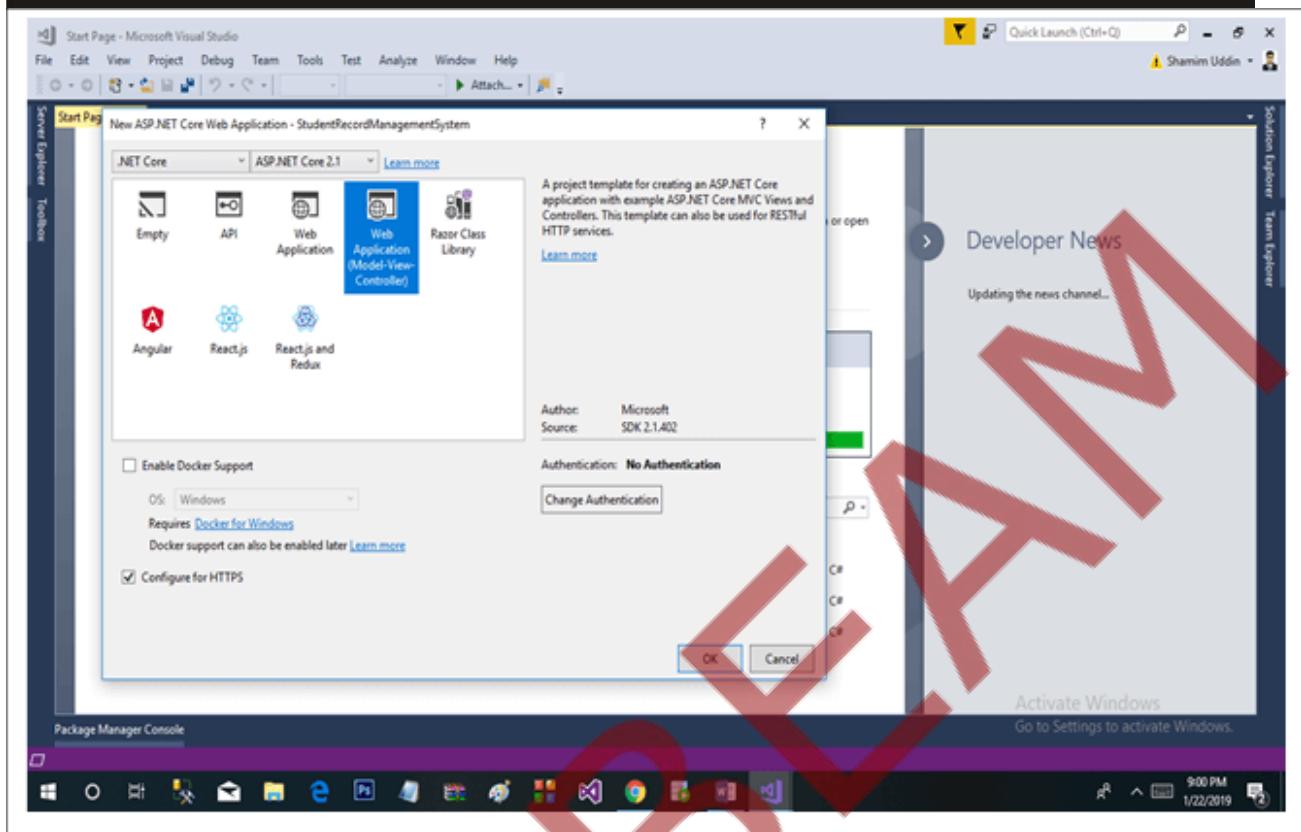
Now, we are going to create an ASP.NET MVC Web Application. The project name is "StudentRecordManagementSystem".



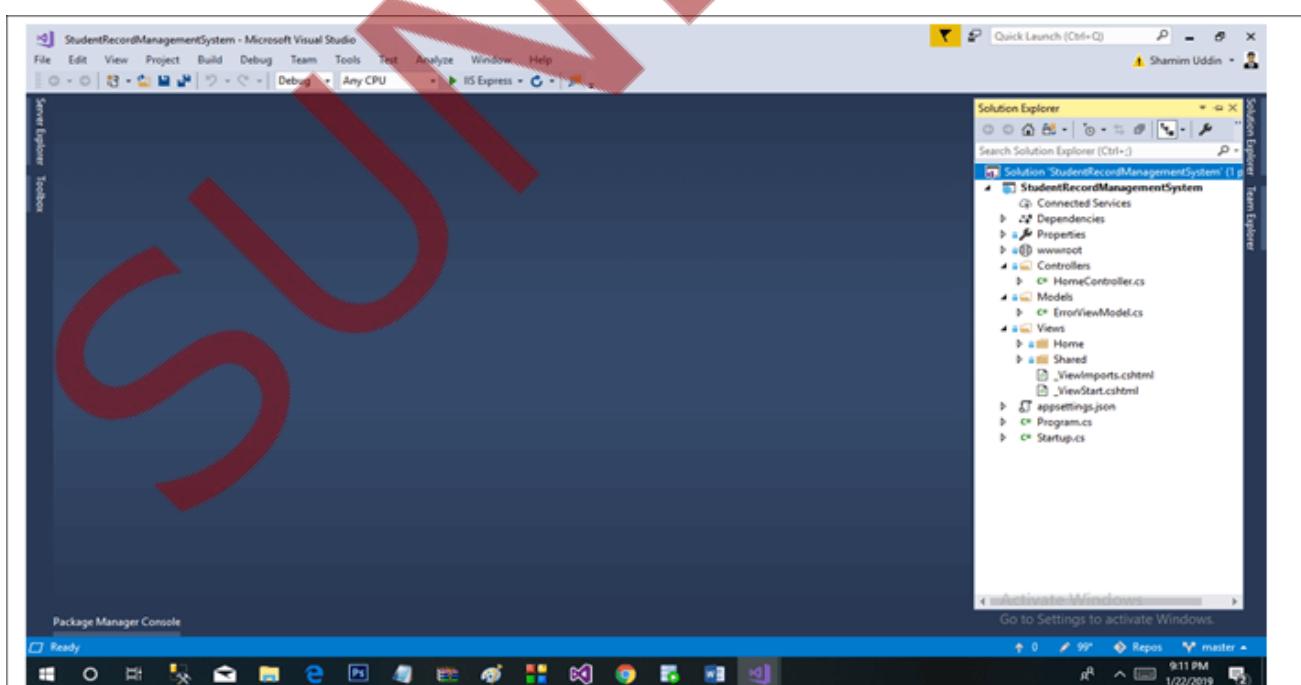
Click OK. The below window will appear on the screen.



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Click OK. The solution creation is done with the loading of all needed files. Given below is the picture of the solution structure.



Create Utility folder in your project



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Create a folder named “Utility” in the project. Now, we will create a class named “ConnectionString” within the Utility folder.

```
1. public static class ConnectionString
2. {
3.     private static string cName = "Data Source=.; Initial Catalog=StudentManagement;User ID=sa;Password=123";
4.     public static string CName { get => cName;
5. }
6. }
```

Creating a Model

After that, we will create a class named “Student” within model folder.

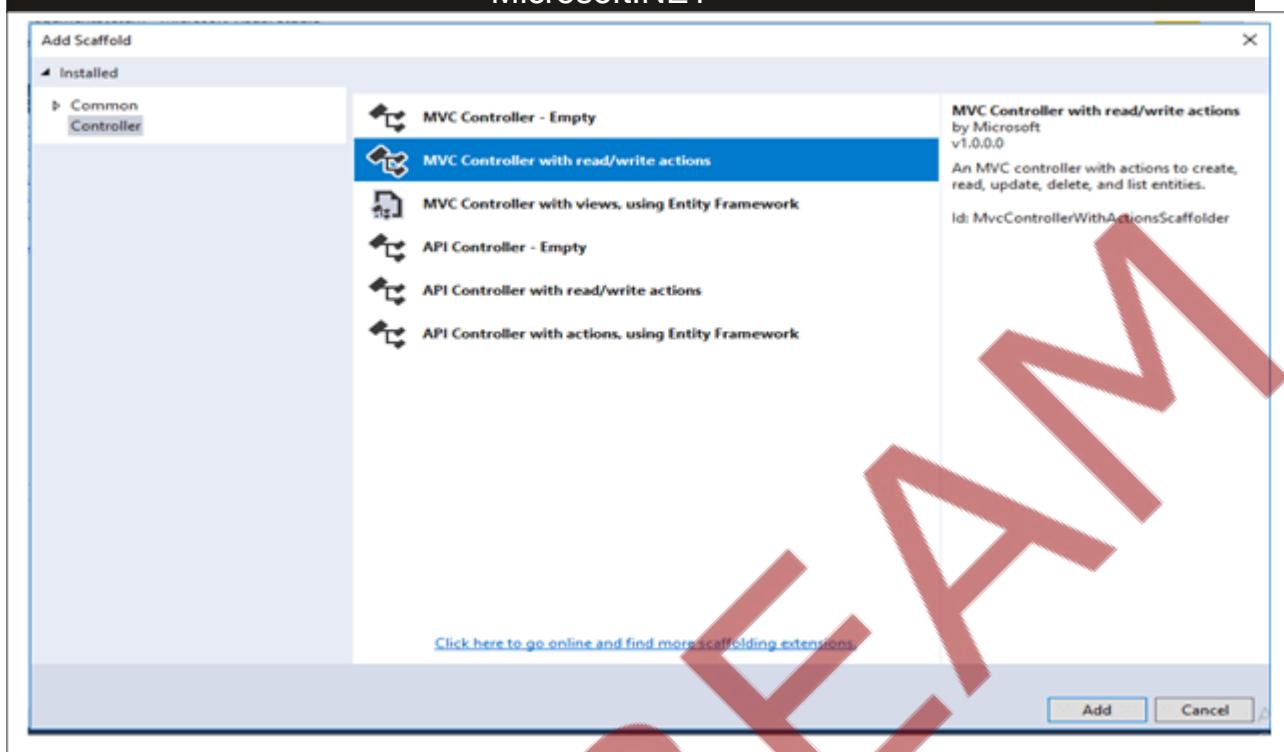
```
1. public class Student
2. {
3.     public int Id { set; get; }
4.     [Required]
5.     public string FirstName { set; get; }
6.     [Required]
7.     public string LastName { set; get; }
8.     [Required]
9.     public string Email { set; get; }
10.    [Required]
11.    public string Mobile { set; get; }
12.    public string Address { set; get; }
13. }
```

Creating a Controller

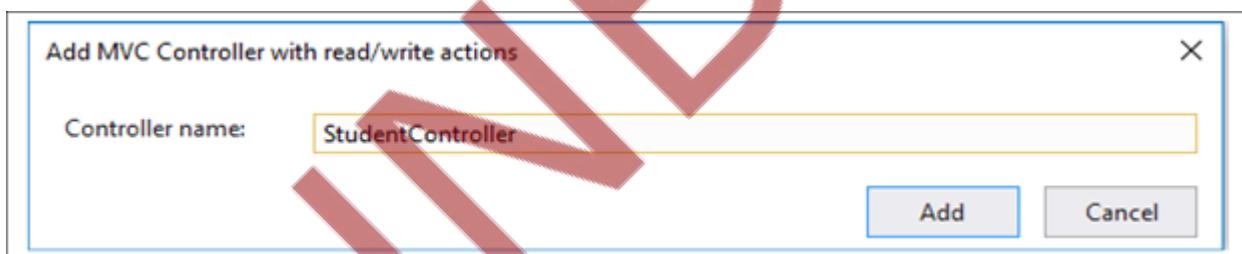
We will Rebuild our solution and create a “StudentController” within Controller folder. Right-Add-Controller-Select MVC Controller with read/write actions and click add.



Microsoft.NET



Another window will appear on screen



Creating Data Access Layer

We have to work with the database so we will create a data access layer class within model folder named "StudentDataAccessLayer"

```
1. public class StudentDataAccessLayer
2. {
3.     string connectionString = ConnectionString.CName;
4.
5.     public IEnumerable<Student> GetAllStudent()
6.     {
7.         List<Student> 1stStudent = new List<Student>();
8.         using (SqlConnection con = new SqlConnection(connectionString))
9.     }
```



Microsoft.NET

```
10.         SqlCommand cmd = new SqlCommand("spGetAllStudent", c
on);
11.         cmd.CommandType = CommandType.StoredProcedure;
12.         con.Open();
13.         SqlDataReader rdr = cmd.ExecuteReader();
14.
15.         while (rdr.Read())
16.         {
17.             Student student = new Student();
18.             student.Id = Convert.ToInt32(rdr["Id"]);
19.             student.FirstName = rdr["FirstName"].ToString();

20.             student.LastName = rdr["LastName"].ToString();
21.             student.Email = rdr["Email"].ToString();
22.             student.Mobile = rdr["Mobile"].ToString();
23.             student.Address = rdr["Address"].ToString();
24.
25.             lstStudent.Add(student);
26.         }
27.         con.Close();
28.     }
29.     return lstStudent;
30. }
31. public void AddStudent(Student student)
32. {
33.     using (SqlConnection con = new SqlConnection(connectionString))
34.     {
35.         SqlCommand cmd = new SqlCommand("spAddStudent", con)
36.         ;
37.
38.         cmd.CommandType = CommandType.StoredProcedure;
39.         cmd.Parameters.AddWithValue("@FirstName", student.Fi
rstName);
40.         cmd.Parameters.AddWithValue("@LastName", student.Las
tName);
41.         cmd.Parameters.AddWithValue("@Email", student.Email)
42.         cmd.Parameters.AddWithValue("@Mobile", student.Mobil
e);
43.         cmd.Parameters.AddWithValue("@Address", student.Addr
ess);
44.         con.Open();
45.         cmd.ExecuteNonQuery();
46.         con.Close();
    }
```



Microsoft.NET

```
47.        }
48.
49.        public void UpdateStudent(Student student)
50.        {
51.            using (SqlConnection con = new SqlConnection(connectionString))
52.            {
53.                SqlCommand cmd = new SqlCommand("spUpdateStudent", con);
54.                cmd.CommandType = CommandType.StoredProcedure;
55.
56.                cmd.Parameters.AddWithValue("@Id", student.Id);
57.                cmd.Parameters.AddWithValue("@FirstName", student.FirstName);
58.                cmd.Parameters.AddWithValue("@LastName", student.LastName);
59.                cmd.Parameters.AddWithValue("@Email", student.Email);
60.                cmd.Parameters.AddWithValue("@Mobile", student.Mobile);
61.                cmd.Parameters.AddWithValue("@Address", student.Address);
62.
63.                con.Open();
64.                cmd.ExecuteNonQuery();
65.                con.Close();
66.            }
67.
68.        public Student GetStudentData(int? id)
69.        {
70.            Student student = new Student();
71.
72.            using (SqlConnection con = new SqlConnection(connectionString))
73.            {
74.                string sqlQuery = "SELECT * FROM Student WHERE Id= "
75.                    + id;
76.
77.                SqlCommand cmd = new SqlCommand(sqlQuery, con);
78.                con.Open();
79.                SqlDataReader rdr = cmd.ExecuteReader();
80.
81.                while (rdr.Read())
82.                {
83.                    student.Id = Convert.ToInt32(rdr["Id"]);
84.                    student.FirstName = rdr["FirstName"].ToString();
```



Microsoft.NET

```
83.         student.LastName = rdr["LastName"].ToString();
84.         student.Email = rdr["Email"].ToString();
85.         student.Mobile = rdr["Mobile"].ToString();
86.         student.Address = rdr["Address"].ToString();
87.     }
88. }
89. return student;
90. }
91.
92. public void DeleteStudent(int? id)
93. {
94.     using (SqlConnection con = new SqlConnection(connectionString))
95.     {
96.         SqlCommand cmd = new SqlCommand("spDeleteStudent", c
97.             on);
98.         cmd.CommandType = CommandType.StoredProcedure;
99.         cmd.Parameters.AddWithValue("@Id", id);
100.        con.Open();
101.        cmd.ExecuteNonQuery();
102.        con.Close();
103.    }
104. }
```

Action Methods

Create Action

Now we will work with Create Action within Student Controller. There are two Create Actions one is GET and another is POST. Now we will create a view for creating action.

Before creating a view we will create a constructor

```
1. StudentDataAccessLayer studentDataAccessLayer = null;
2. public StudentController()
3. {
4.     studentDataAccessLayer = new StudentDataAccessLayer();
5. }
```

Right click on create (GET) action then click add view; the below window will appear on the screen.



Microsoft.NET

Add MVC View

View name:

Template:

Model class:

Options:

Create as a partial view

Reference script libraries

Use a layout page:
 ...

(Leave empty if it is set in a Razor _viewstart file)

Click Add

```
1. @model StudentRecordManagementSystem.Models.Student
2. @{
3.     ViewData["Title"] = "Create";
4. }
5. <h2>Create</h2>
6.
7. <h4>Student</h4>
8. <hr />
9. <div class="row">
10.    <div class="col-md-4">
11.        <form asp-action="Create">
12.            <div asp-validation-summary="ModelOnly" class="text-
danger"></div>
13.            <div class="form-group">
14.                <label asp-for="Id" class="control-label"></label>
15.                <input asp-for="Id" class="form-control" />
16.                <span asp-validation-for="Id" class="text-
danger"></span>
17.            </div>
18.            <div class="form-group">
19.                <label asp-for="FirstName" class="control-
label"></label>
20.                <input asp-for="FirstName" class="form-control" />
21.                <span asp-validation-for="FirstName" class="text-
danger"></span>
```



Microsoft.NET

```
22.          </div>
23.          <div class="form-group">
24.              <label asp-for="LastName" class="control-
    label"></label>
25.              <input asp-for="LastName" class="form-control" />
26.              <span asp-validation-for="LastName" class="text-
    danger"></span>
27.          </div>
28.          <div class="form-group">
29.              <label asp-for="Email" class="control-
    label"></label>
30.              <input asp-for="Email" class="form-control" />
31.              <span asp-validation-for="Email" class="text-
    danger"></span>
32.          </div>
33.          <div class="form-group">
34.              <label asp-for="Mobile" class="control-
    label"></label>
35.              <input asp-for="Mobile" class="form-control" />
36.              <span asp-validation-for="Mobile" class="text-
    danger"></span>
37.          </div>
38.          <div class="form-group">
39.              <label asp-for="Address" class="control-
    label"></label>
40.              <input asp-for="Address" class="form-control" />
41.              <span asp-validation-for="Address" class="text-
    danger"></span>
42.          </div>
43.          <div class="form-group">
44.              <input type="submit" value="Create" class="btn btn-
    default" />
45.          </div>
46.      </form>
47.  </div>
48. </div>
49.
50. <div>
51.     <a asp-action="Index">Back to List</a>
52. </div>
53.
54. @section Scripts {
55.     @{await Html.RenderPartialAsync("_ValidationScriptsPartial");}
56. }
```

Now run our application,



Microsoft.NET

The screenshot shows a web browser displaying a 'Create' page for a 'Student' record. The URL in the address bar is <https://localhost:44347/student/Create>. The page title is 'StudentRecordManagementSystem'. The main content is a 'Create' form for a 'Student'. The form fields are: Id (text input), FirstName (text input), LastName (text input), Email (text input), Mobile (text input), and Address (text input). Below the form is a 'Create' button and a 'Back to List' link. At the bottom, there is a copyright notice: © 2019 - StudentRecordManagementSystem.

We will remove Id field from view. We have done auto increment of Id field in database.

Now we will work with Create (POST),

```
1. [HttpPost]
2. [ValidateAntiForgeryToken]
3. public ActionResult Create(Student student)
4. {
5.     try
6.     {
7.         // TODO: Add insert logic here
8.         studentDataAccessLayer.AddStudent(student);
9.
10.        return RedirectToAction(nameof(Index));
11.    }
12.    catch(Exception ex)
13.    {
```



Microsoft.NET

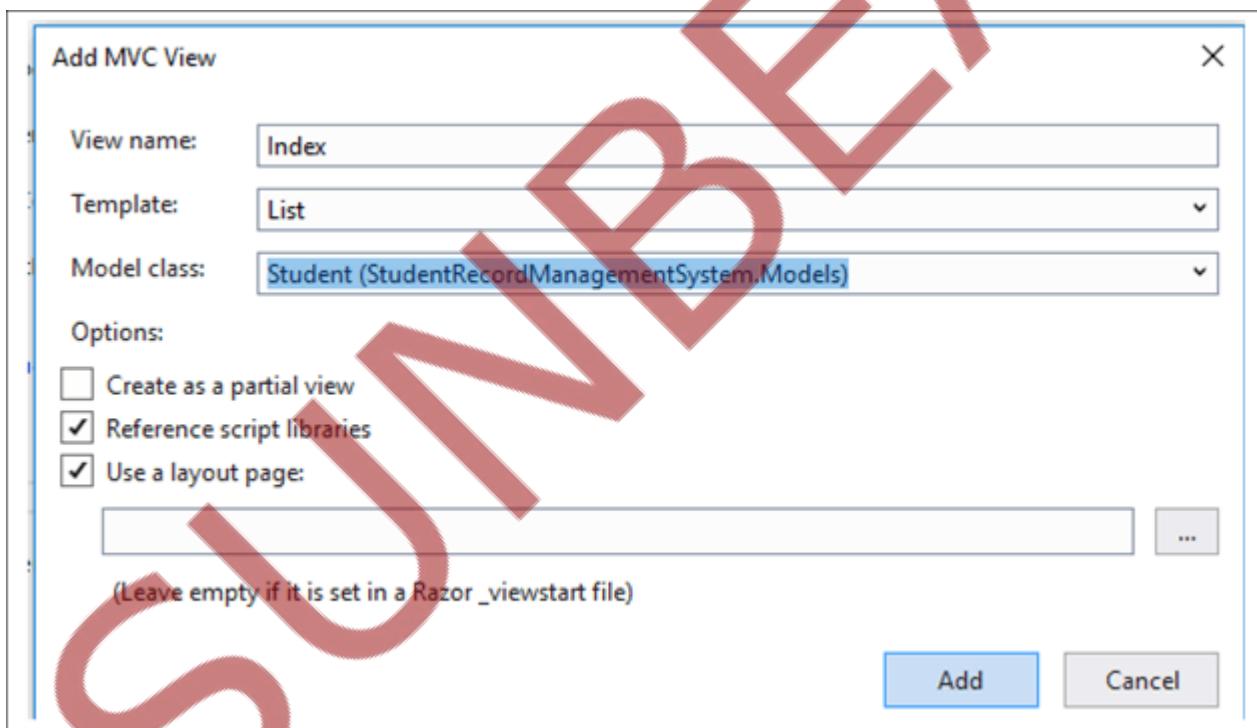
```
14.         return View();  
15.     }  
16. }
```

Index Action

We have to call GetAllStudent method from StudentDataAccessLayer class for getting all students in Index action,

```
1. public ActionResult Index()  
2. {  
3.     IEnumerable<Student> students = studentDataAccessLayer.Ge  
tAllStudent();  
4.     return View(students);  
5. }
```

Right click on Index action then click add view and the below window will appear on screen.



Click add

```
1. @model IEnumerable<StudentRecordManagementSystem.Models.Student>  
2. {@  
3.     ViewData["Title"] = "Index";  
4. }  
5. <h2>Index</h2>  
6.  
7. <p>
```



Microsoft.NET

```
8.      <a asp-action="Create">Create New</a>
9.  </p>
10. <table class="table">
11.   <thead>
12.     <tr>
13.       <th>
14.         @Html.DisplayNameFor(model => model.Id)
15.       </th>
16.       <th>
17.         @Html.DisplayNameFor(model => model.FirstName)
18.       </th>
19.       <th>
20.         @Html.DisplayNameFor(model => model.LastName)
21.       </th>
22.       <th>
23.         @Html.DisplayNameFor(model => model.Email)
24.       </th>
25.       <th>
26.         @Html.DisplayNameFor(model => model.Mobile)
27.       </th>
28.       <th>
29.         @Html.DisplayNameFor(model => model.Address)
30.       </th>
31.       <th></th>
32.     </tr>
33.   </thead>
34.   <tbody>
35. @foreach (var item in Model) {
36.   <tr>
37.     <td>
38.       @Html.DisplayFor(modelItem => item.Id)
39.     </td>
40.     <td>
41.       @Html.DisplayFor(modelItem => item.FirstName)
42.     </td>
43.     <td>
44.       @Html.DisplayFor(modelItem => item.LastName)
45.     </td>
46.     <td>
47.       @Html.DisplayFor(modelItem => item.Email)
48.     </td>
49.     <td>
50.       @Html.DisplayFor(modelItem => item.Mobile)
51.     </td>
52.     <td>
53.       @Html.DisplayFor(modelItem => item.Address)
```



Microsoft.NET

```
54.          </td>
55.          <td>
56.          @Html.ActionLink("Edit", "Edit", new { id=item.Id })
57.          | @Html.ActionLink("Details", "Details", new { id=ite
58.          m.Id }) |
59.          @Html.ActionLink("Delete", "Delete", new { id=item.
60.          Id }) |
61.          </td>
62.        </tr>
63.      </tbody>
64.    </table>
```

Show student list:

Id	FirstName	LastName	Email	Mobile	Address
1	Shamim	Uddin	shamim.cse19@gmail.com	01751503102	Gulshan 1,Dhaka,Bangladesh

Edit Action

Now we will work with Edit Action within Student Controller. There are two Edit Actions; one is GET and another is POST. Now we will create a view for creating action.

We have to call GetStudentData method from StudentDataAccessLayer class for getting student by Id.

```
1. public ActionResult Edit(int id)
2. {
3.   Student student = studentDataAccessLayer.GetStudentData(id);
4.   return View(student);
5. }
```

Right click on Edit (GET) action then click add view; the below window will appear on screen.



Microsoft.NET

Add MVC View

View name:

Template:

Model class:

Options:

Create as a partial view
 Reference script libraries
 Use a layout page:

(Leave empty if it is set in a Razor _viewstart file)

Click Add

```
1. @model StudentRecordManagementSystem.Models.Student
2. @{
3.     ViewData["Title"] = "Edit";
4. }
5. <h2>Edit</h2>
6.
7. <h4>Student</h4>
8. <hr />
9. <div class="row">
10.    <div class="col-md-4">
11.        <form asp-action="Edit">
12.            <div asp-validation-summary="ModelOnly" class="text-
danger"></div>
13.            <div class="form-group">
14.                <label asp-for="Id" class="control-label"></label>
15.                <input asp-for="Id" class="form-
control" readonly/>
16.                <span asp-validation-for="Id" class="text-
danger"></span>
17.            </div>
18.            <div class="form-group">
19.                <label asp-for="FirstName" class="control-
label"></label>
20.                <input asp-for="FirstName" class="form-control" />
```



Microsoft.NET

```
21.          <span asp-validation-for="FirstName" class="text-
  danger"></span>
22.      </div>
23.      <div class="form-group">
24.          <label asp-for="LastName" class="control-
  label"></label>
25.          <input asp-for="LastName" class="form-control" />
26.          <span asp-validation-for="LastName" class="text-
  danger"></span>
27.      </div>
28.      <div class="form-group">
29.          <label asp-for="Email" class="control-
  label"></label>
30.          <input asp-for="Email" class="form-control" />
31.          <span asp-validation-for="Email" class="text-
  danger"></span>
32.      </div>
33.      <div class="form-group">
34.          <label asp-for="Mobile" class="control-
  label"></label>
35.          <input asp-for="Mobile" class="form-control" />
36.          <span asp-validation-for="Mobile" class="text-
  danger"></span>
37.      </div>
38.      <div class="form-group">
39.          <label asp-for="Address" class="control-
  label"></label>
40.          <input asp-for="Address" class="form-control" />
41.          <span asp-validation-for="Address" class="text-
  danger"></span>
42.      </div>
43.      <div class="form-group">
44.          <input type="submit" value="Update" class="btn btn-
  default" />
45.      </div>
46.  </form>
47. </div>
48. </div>
49.
50. <div>
51.     <a asp-action="Index">Back to List</a>
52. </div>
53.
54. @section Scripts {
55.     @{await Html.RenderPartialAsync("_ValidationScriptsPartial");}
56. }
```



Microsoft.NET

Now we will work with Edit (POST):

```
1. [HttpPost]
2.     [ValidateAntiForgeryToken]
3.     public ActionResult Edit(Student student)
4.     {
5.         try
6.         {
7.             // TODO: Add update logic here
8.             studentDataAccessLayer.UpdateStudent(student);
9.             return RedirectToAction(nameof(Index));
10.        }
11.        catch
12.        {
13.            return View();
14.        }
15.    }
```

Edit option has been done. Now we will test if it works or not.

The screenshot shows the 'Edit Student' page of the 'StudentRecordManagementSystem'. The page has a header with 'StudentRecordManagementSystem' and links for 'Home', 'About', and 'Contact'. The main content area has a title 'Edit Student'. It contains the following form fields:

- Id:** 1
- FirstName:** Shamim123
- LastName:** Uddin
- Email:** shamim.cse19@gmail.com
- Mobile:** 01751503102
- Address:** Gulshan 1, Dhaka, Bangladesh

At the bottom of the form are 'Update' and 'Back to List' buttons. The footer of the page includes the copyright notice '© 2019 - StudentRecordManagementSystem'.



Microsoft.NET

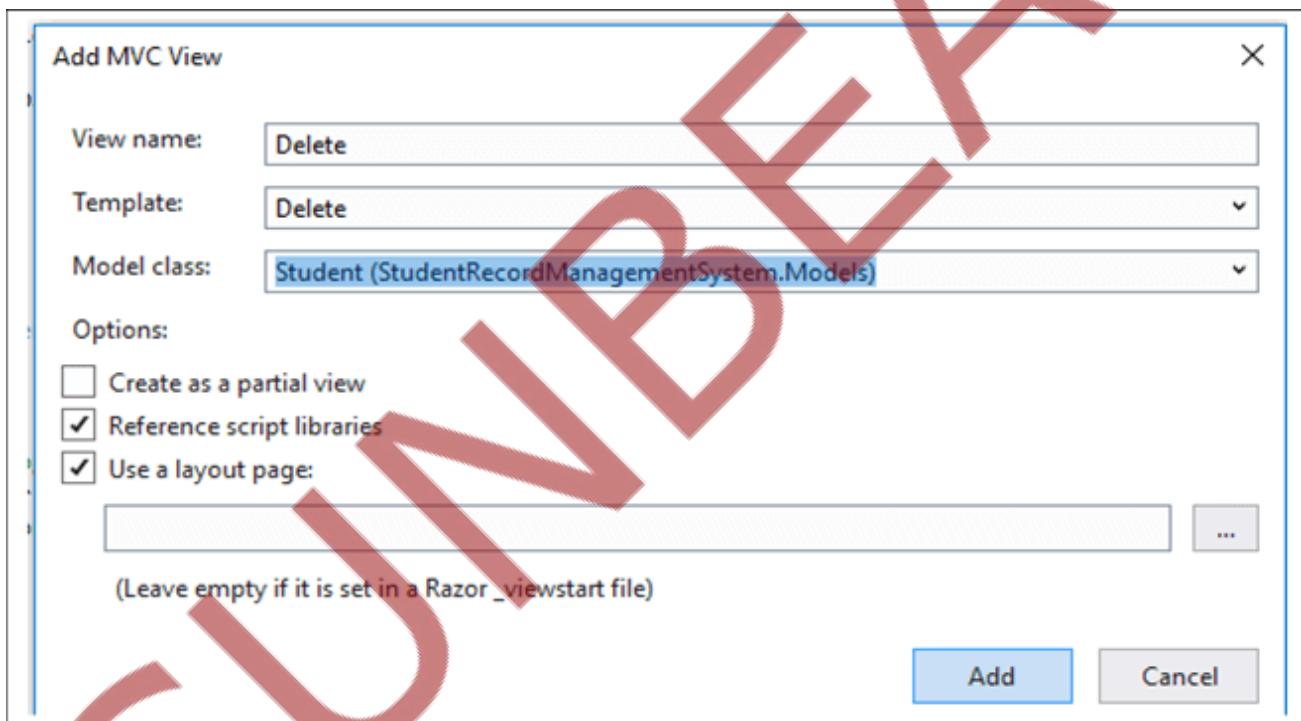
Delete Action

Now we will work with Delete Action within Student Controller. There are two Delete Actions, one is GET and another is POST. Now we will create a view for deleting action.

We have to call GetStudentData method from StudentDataAccessLayer class for getting student by Id.

```
1. public ActionResult Delete(int id)
2. {
3.     Student student = studentDataAccessLayer.GetStudentData(i
d);
4.     return View(student);
5. }
```

Right click on Delete (GET) action then click add view; the below window will appear on screen.



Click Add

```
1. @model StudentRecordManagementSystem.Models.Student
2.
3. @{
4.     ViewData["Title"] = "Delete";
5. }
6.
7. <h2>Delete</h2>
8.
9. <h3>Are you sure you want to delete this?</h3>
10. <div>
```



Microsoft.NET

```
11.      <h4>Student</h4>
12.      <hr />
13.      <dl class="dl-horizontal">
14.          <dt>
15.              @Html.DisplayNameFor(model => model.Id)
16.          </dt>
17.          <dd>
18.              @Html.DisplayFor(model => model.Id)
19.          </dd>
20.          <dt>
21.              @Html.DisplayNameFor(model => model.FirstName)
22.          </dt>
23.          <dd>
24.              @Html.DisplayFor(model => model.FirstName)
25.          </dd>
26.          <dt>
27.              @Html.DisplayNameFor(model => model.LastName)
28.          </dt>
29.          <dd>
30.              @Html.DisplayFor(model => model.LastName)
31.          </dd>
32.          <dt>
33.              @Html.DisplayNameFor(model => model.Email)
34.          </dt>
35.          <dd>
36.              @Html.DisplayFor(model => model.Email)
37.          </dd>
38.          <dt>
39.              @Html.DisplayNameFor(model => model.Mobile)
40.          </dt>
41.          <dd>
42.              @Html.DisplayFor(model => model.Mobile)
43.          </dd>
44.          <dt>
45.              @Html.DisplayNameFor(model => model.Address)
46.          </dt>
47.          <dd>
48.              @Html.DisplayFor(model => model.Address)
49.          </dd>
50.      </dl>
51.
52.      <form asp-action="Delete">
53.          <input type="submit" value="Delete" class="btn btn-
 default" /> |
54.          <a asp-action="Index">Back to List</a>
55.      </form>
```



Microsoft.NET

56. </div>

Now we will work with Delete (POST)

```
1. [HttpPost]
2.      [ValidateAntiForgeryToken]
3.      public ActionResult Delete(Student student)
4.      {
5.          try
6.          {
7.              // TODO: Add delete logic here
8.              studentDataAccessLayer.DeleteStudent(student.Id);
9.              return RedirectToAction(nameof(Index));
10.         }
11.         catch
12.         {
13.             return View();
14.         }
15.     }
```

Details Action

We have to call GetStudentData method from StudentDataAccessLayer class for getting student by Id in Index action

```
1. public ActionResult Details(int id)
2.     {
3.         Student student = studentDataAccessLayer.GetStudentData(i
d);
4.         return View(student);
5.     }
```

Right click on Details action then click add view; the below window will appear on screen.



Microsoft.NET

Add MVC View

View name:

Template:

Model class:

Options:

Create as a partial view

Reference script libraries

Use a layout page:

(Leave empty if it is set in a Razor _viewstart file)

A large red 'SUNBEAM' watermark is diagonally across the form.

Click add

```
1. @model StudentRecordManagementSystem.Models.Student
2. @{
3.     ViewData["Title"] = "Details";
4. }
5.
6. <h2>Details</h2>
7.
8. <div>
9.     <h4>Student</h4>
10.    <hr />
11.    <dl class="dl-horizontal">
12.        <dt>
13.            @Html.DisplayNameFor(model => model.Id)
14.        </dt>
15.        <dd>
16.            @Html.DisplayFor(model => model.Id)
17.        </dd>
18.        <dt>
19.            @Html.DisplayNameFor(model => model.FirstName)
20.        </dt>
21.        <dd>
22.            @Html.DisplayFor(model => model.FirstName)
23.        </dd>
24.        <dt>
25.            @Html.DisplayNameFor(model => model.LastName)
```



Microsoft.NET

```
26.      </dt>
27.      <dd>
28.          @Html.DisplayFor(model => model.LastName)
29.      </dd>
30.      <dt>
31.          @Html.DisplayNameFor(model => model.Email)
32.      </dt>
33.      <dd>
34.          @Html.DisplayFor(model => model.Email)
35.      </dd>
36.      <dt>
37.          @Html.DisplayNameFor(model => model.Mobile)
38.      </dt>
39.      <dd>
40.          @Html.DisplayFor(model => model.Mobile)
41.      </dd>
42.      <dt>
43.          @Html.DisplayNameFor(model => model.Address)
44.      </dt>
45.      <dd>
46.          @Html.DisplayFor(model => model.Address)
47.      </dd>
48.  </dl>
49. </div>
50. <div>
51.     @Html.ActionLink("Edit", "Edit", new { id = Model.Id }) |
52.     <a asp-action="Index">Back to List</a>
53. </div>
```



<https://localhost:44347/student/Details/1>

StudentRecordManagementSystem

Home

About

Contact

Details

Student

Id	1
FirstName	Shamim123
LastName	Uddin
Email	shamim.cse19@gmail.com
Mobile	01751503102
Address	Gulshan 1,Dhaka,Bangladesh

[Edit](#) | [Back to List](#)

ASP.NET Core MVC CRUD Operations using EF

Open Visual Studio and click on Create New Project



Microsoft.NET

Visual Studio 2022

Open recent

Search recent (Alt+S)

- ▷ Today
- ▷ Yesterday
- ▷ This week
- ▷ This month

Get started



Clone a repository

Get code from an online repository like GitHub or Azure DevOps



Open a project or solution

Open a local Visual Studio project or .sln file



Open a local folder

Navigate and edit code within any folder



Create a new project

Choose a project template with code scaffolding to get started

[Continue without code →](#)

Select ASP.NET Core Web App (Model-View-Controller) – [C#] and click next button

Create a new project

Recent project templates

ASP.NET Core Web App (Model-View-Controller)

ASP.NET Core Web App

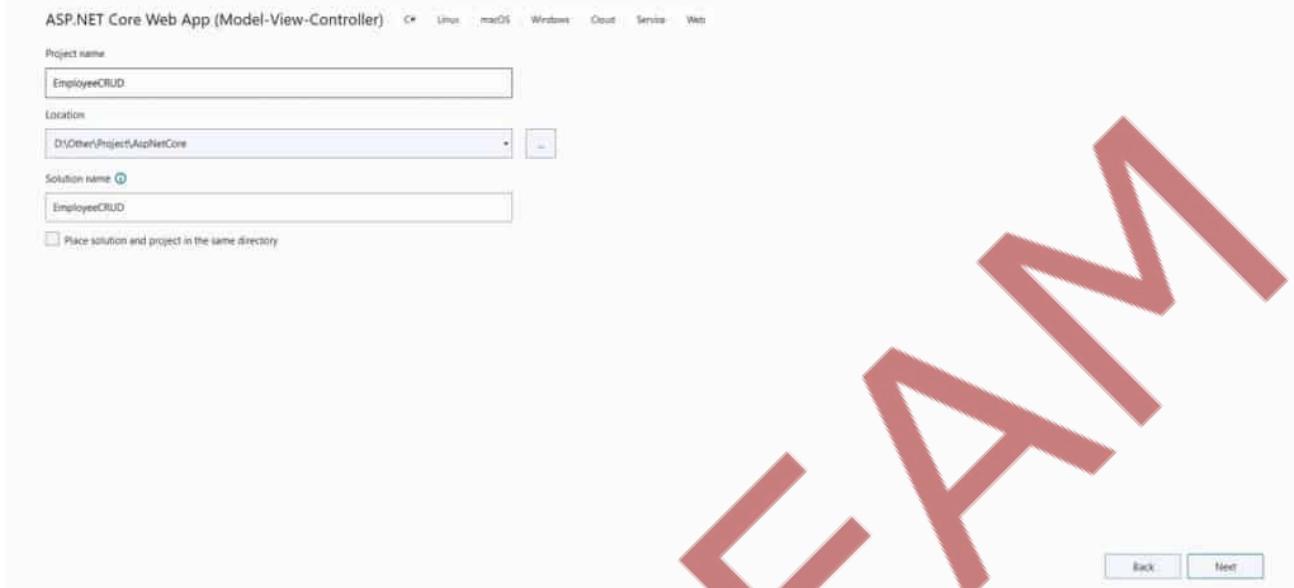
The screenshot shows the 'Create a new project' dialog in Visual Studio 2022. The 'ASP.NET Core Web App (Model-View-Controller)' template is selected and highlighted with a red box. Other templates listed include Blazor WebAssembly App, ASP.NET Core Empty, ASP.NET Core Web App (Model-View-Controller), Blazor Server App, and ASP.NET Core Web API. The 'C#' filter is applied. At the bottom right, there are 'Back' and 'Next' buttons.

Enter the project name and click on next button

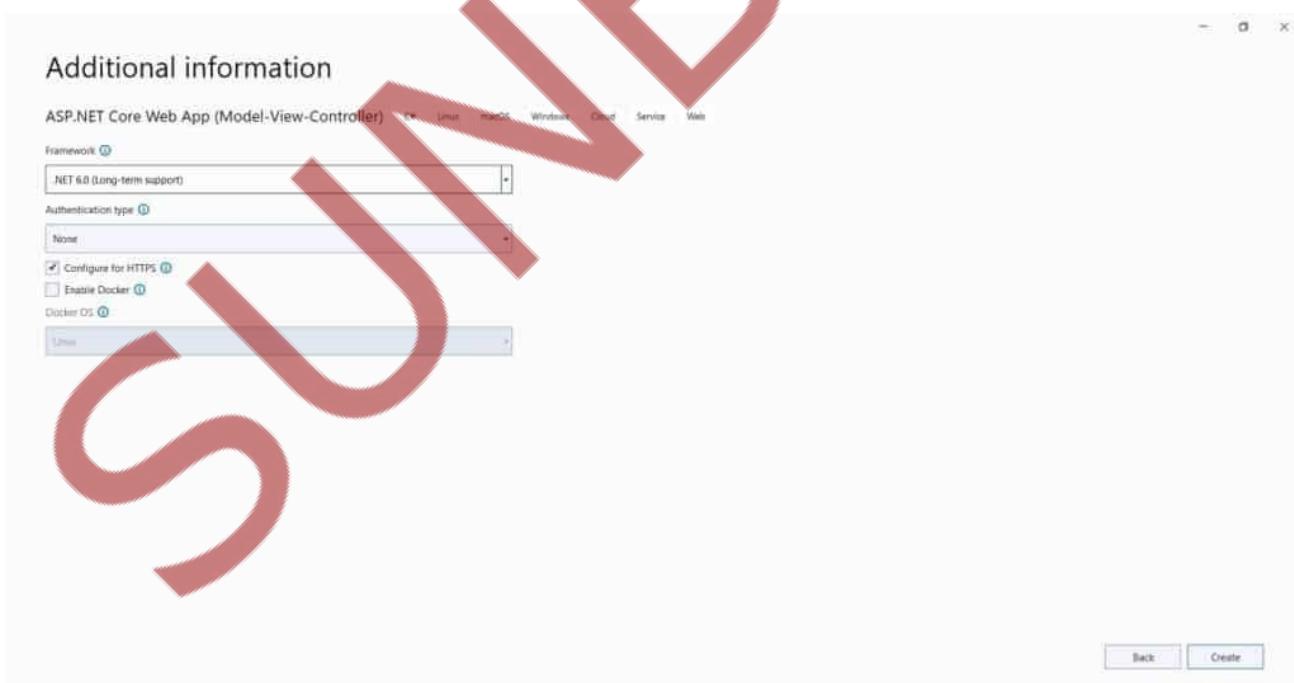


Microsoft.NET

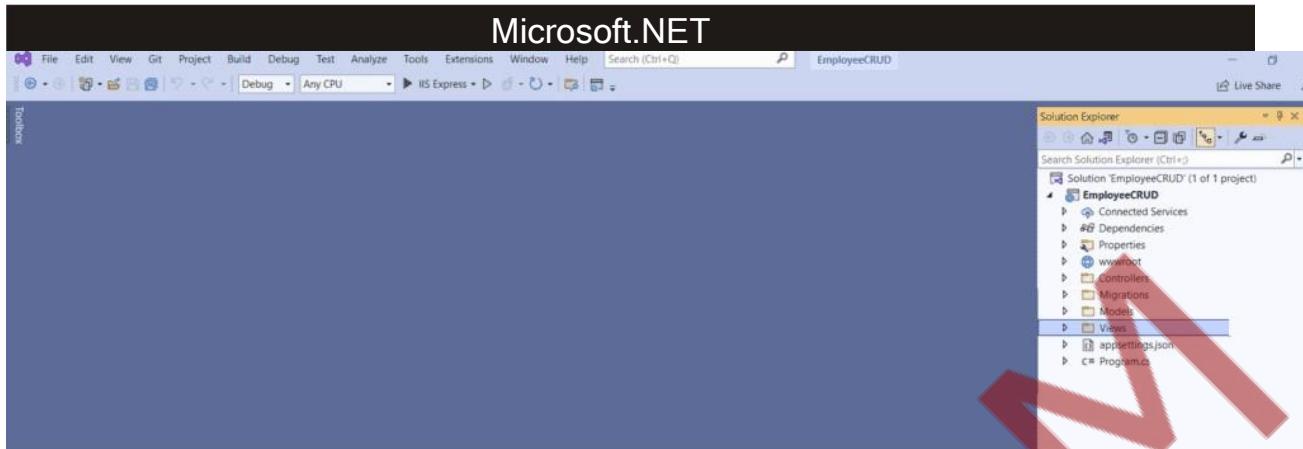
Configure your new project



Select .Net 6.0 , authentication type None and click on create button



Once created, your project will look like following



Open Models folder and create an Employee class

Enter the following code in the employee class

```
using System.ComponentModel.DataAnnotations;
namespace EmployeeCRUD.Models
{
    public class Employee
    {
        [Key]
        public int Id { get; set; }
        [Required]
        [Display(Name = "Employee Name")]
        public string Name { get; set; }
        public string Designation { get; set; }
        [DataType(DataType.MultilineText)]
        public string Address { get; set; }
        public DateTime? RecordCreatedOn { get; set; }
    }
}
```

Install the following packages according to your .NET Core version

```
<PackageReference Include="Microsoft.EntityFrameworkCore"
Version="6.0.1" />
```



Microsoft.NET

```
<PackageReference  
Include="Microsoft.EntityFrameworkCore.SqlServer" Version="6.0.1"  
/>  
<PackageReference  
Include="Microsoft.EntityFrameworkCore.Tools" Version="6.0.1">
```

Create a class ApplicationDbContext of DbContext Class to link the database with data model class

```
using EmployeeCRUD.Models;  
using Microsoft.EntityFrameworkCore;  
  
namespace EmployeeCRUD.Data  
{  
    public class ApplicationDbContext : DbContext  
    {  
        public ApplicationDbContext(DbContextOptions<ApplicationDbContext>  
options) : base(options)  
        {  
        }  
  
        public DbSet<Employee> Employees { get; set; }  
    }  
}
```

Open appsettings.json and configure the connection string

```
{  
    "ConnectionStrings": {  
        "DefaultConnection": "Server=EnterServerName;  
Database=EmployeeDatabase; User Id=sa; Password=EnterPassword;  
Trusted_Connection=True; MultipleActiveResultSets=true"  
    },
```



Microsoft.NET

```
"Logging": {  
    "LogLevel": {  
        "Default": "Information",  
        "Microsoft.AspNetCore": "Warning"  
    }  
},  
"AllowedHosts": "*"  
}
```

Open the program.cs file and add the required services

```
using EmployeeCRUD.Data;  
using Microsoft.EntityFrameworkCore;  
  
var builder = WebApplication.CreateBuilder(args);  
  
// Add services to the container.  
builder.Services.AddControllersWithViews();  
  
// add  
builder.Services.AddDbContext<ApplicationContext>(  
    options => options.UseSqlServer(  
  
builder.Configuration.GetConnectionString("DefaultConnection")  
));  
  
var app = builder.Build();  
  
// Configure the HTTP request pipeline.  
if (!app.Environment.IsDevelopment())  
{  
    app.UseExceptionHandler("/Home/Error");  
    app.UseHsts();  
}  
  
app.UseHttpsRedirection();
```



```
app.UseStaticFiles();

app.UseRouting();

app.UseAuthorization();

app.MapControllerRoute(
    name: "default",
    pattern: "{controller=Home}/{action=Index}/{id?}");

app.Run();
```

Run the migration

Open the package manager console and execute following commands

- add-migration 'initial'
- update-database

Add Employee Controller

1. Right click on Controllers folder
2. click on add
3. click on empty controller and name file as EmployeeController.cs file

```
using EmployeeCRUD.Data;
using EmployeeCRUD.Models;
using Microsoft.AspNetCore.Mvc;

namespace EmployeeCRUD.Controllers
{
    public class EmployeeController : Controller
    {
        private readonly ApplicationDbContext _context;
        public EmployeeController(ApplicationDbContext context)
        {
            _context = context;
        }
        public IActionResult Index()
```



Microsoft.NET

```
{  
    IEnumerable<Employee> objCatlist =  
    _context.Employees;  
    return View(objCatlist);  
}  
  
public IActionResult Create()  
{  
    return View();  
}  
  
[HttpPost]  
[ValidateAntiForgeryToken]  
public IActionResult Create(Employee empobj)  
{  
    if (ModelState.IsValid)  
    {  
        _context.Employees.Add(empobj);  
        _context.SaveChanges();  
        TempData["ResultOk"] = "Record Added Successfully  
!";  
        return RedirectToAction("Index");  
    }  
    return View(empobj);  
}  
  
public IActionResult Edit(int? id)  
{  
    if (id == null || id == 0)  
    {  
        return NotFound();  
    }  
    var empfromdb = _context.Employees.Find(id);  
  
    if (empfromdb == null)
```



Microsoft.NET

```
{  
    return NotFound();  
}  
return View(empfromdb);  
  
}  
  
[HttpPost]  
[ValidateAntiForgeryToken]  
public IActionResult Edit(Employee empobj)  
{  
    if (ModelState.IsValid)  
    {  
        _context.Employees.Update(empobj);  
        _context.SaveChanges();  
        TempData["ResultOk"] = "Data Updated Successfully  
!";  
        return RedirectToAction("Index");  
    }  
  
    return View(empobj);  
}  
  
public IActionResult Delete(int? id)  
{  
    if (id == null || id == 0)  
    {  
        return NotFound();  
    }  
    var empfromdb = _context.Employees.Find(id);  
  
    if (empfromdb == null)  
    {  
        return NotFound();  
    }  
    return View(empfromdb);  
}
```



```
[HttpPost]
[ValidateAntiForgeryToken]
public IActionResult DeleteEmp(int? id)
{
    var deleterecord = _context.Employees.Find(id);
    if (deleterecord == null)
    {
        return NotFound();
    }
    _context.Employees.Remove(deleterecord);
    _context.SaveChanges();
    TempData["ResultOk"] = "Data Deleted Successfully !";
    return RedirectToAction("Index");
}
```

Add view files

Create one Employee folder under View folder and create the following files

1. Index.cshtml
2. Create.cshtml
3. Edit.cshtml
4. Delete.cshtml

Code of Index.cshtml

```
@model IEnumerable<Employee>

@{
    ViewData["Title"] = "Index";
}

@if (TempData["ResultOk"] != null)
{
    <h1 class="alert-success">@TempData["ResultOk"]</h1>
}
```



```
<div class="container shadow p-5">

    <h1 class="text-center mb-3">CRUD Operations Using .NET Core
6 & Microsoft.EntityFrameworkCore </h1>
```

```
    <div class="col mb-3">
        <a asp-controller="Employee" asp-action="Create"
class="btn btn-lg btn-primary"><i class="bi bi-file-plus-
fill"></i>Add Employee</a>
    </div>
```

```
    <table class="table table-bordered table-hover">
```

```
        <thead>
```

```
            <tr>
```

```
                <th scope="col">Employee Name</th>
```

```
                <th scope="col">Designation</th>
```

```
                <th scope="col">Address</th>
```

```
                <th scope="col">CreatedOn</th>
```

```
                <th></th>
```

```
            </tr>
```

```
        </thead>
```

```
        <tbody>
```

```
            @foreach (var item in Model)
```

```

{
```

```
    <tr>
```

```
        <td width="20%">
```

```
            @item.Name
        </td>
```

```
        <td width="20%">
```

```
            @item.Designation
        </td>
```

```
        <td width="25%">
```

```
            @item.Address
        </td>
```

```
        <td width="20%">
```



Microsoft.NET

```
@item.RecordCreatedOn  
    </td>  
    <td>  
        <div role="group" class="w-60 btn-group">  
            <a asp-controller="Employee" asp-  
action="Edit" asp-route-id="@item.Id" class="btn btn-sm btn-  
primary"><i class="bi bi-pencil-square"></i>Edit</a>&ampnbsp  
            <a asp-controller="Employee" asp-  
action="Delete" asp-route-id="@item.Id" class="btn btn-sm btn-  
danger"><i class="bi bi-trash-fill"></i>Delete</a>  
        </div>  
    </td>  
    </tr>  
}</tbody>  
</table>  
</div>
```

Code of Create.cshtml

```
@model Employee  
<div class="container shadow p-5">  
    <div class="row pb-2">  
        <h2>Add Employee</h2>  
    </div>  
    <form method="post">  
        <div asp-validation-summary="All"></div>  
        <div class="form-row">  
            <div class="form-group col-md-6">  
                <label asp-for="Name">Employee Name</label>  
                <input type="text" class="form-control mb-3" asp-  
for="Name" placeholder="Enter Name">  
                <span asp-validation-for="Name" class="alert-  
danger"></span>  
            </div>  
            <div class="form-group col-md-6">  
                <label asp-for="Designation">Designation</label>  
                <input type="text" class="form-control mb-3" asp-
```



Microsoft.NET

```
for="Designation" placeholder="Enter Designation">
    <span asp-validation-for="Designation" class="alert-danger"></span>
</div>
</div>
<div class="form-row">
    <div class="form-group col-md-6">
        <label asp-for="Address">Address</label>
        <input type="text" class="form-control mb-3" asp-for="Address" placeholder="Enter Address">
        <span asp-validation-for="Address" class="alert-danger"></span>
    </div>
    <div class="form-group col-md-6 mb-3">
        <label asp-for="RecordCreatedOn">Created On</label>
        <input type="datetime-local" class="form-control" asp-for="RecordCreatedOn">
        <span asp-validation-for="RecordCreatedOn" class="alert-danger"></span>
    </div>
    <button type="submit" class="btn btn-lg btn-primary p-2"><i class="bi bi-file-plus-fill"></i>Save</button>
    <a asp-controller="Employee" asp-action="Index" class="btn btn-lg btn-warning p-2">Back To List</a>
</form>
</div>
@section Scripts{
    @{
        <partial name="_ValidationScriptsPartial" />
    }
}
```

Code of Edit.cshtml

```
@model Employee
<div class="container shadow p-5">
```



Microsoft.NET

```
<div class="row pb-2">
    <h2>Edit Employee</h2>
</div>
<form method="post" asp-action="Edit">
    <div asp-validation-summary="All"></div>
    <div class="form-row">
        <div class="form-group col-md-6">
            <label asp-for="Name">Employee Name</label>
            <input type="text" class="form-control mb-3" asp-
for="Name">
                <span asp-validation-for="Name" class=" alert-
danger"></span>
            </div>
        <div class="form-group col-md-6">
            <label asp-for="Designation">Designation</label>
            <input type="text" class="form-control mb-3" asp-
for="Designation">
                <span asp-validation-for="Designation" class=" alert-
danger"></span>
            </div>
        </div>
        <div class="form-row">
            <div class="form-group col-md-6">
                <label asp-for="Address">Address</label>
                <input type="text" class="form-control mb-3" asp-
for="Address">
                    <span asp-validation-for="Address" class=" alert-
danger"></span>
                </div>
            <div class="form-group col-md-6 mb-3">
                <label asp-for="RecordCreatedOn">Created
On</label>
                <input type="datetime-local" class="form-control"
asp-for="RecordCreatedOn">
                    <span asp-validation-for="RecordCreatedOn"
class=" alert-danger"></span>
```



Microsoft.NET

```
</div>
</div>
<button type="submit" class="btn btn-lg btn-primary p-2"><i class="bi bi-file-plus-fill"></i>Update</button>
<a asp-controller="Employee" asp-action="Index" class="btn btn-lg btn-warning p-2">Back To List</a>
</form>
</div>
@section Scripts{
    @{
        <partial name="_ValidationScriptsPartial" />
    }
}
```

Code of Delete.cshtml

```
@model Employee

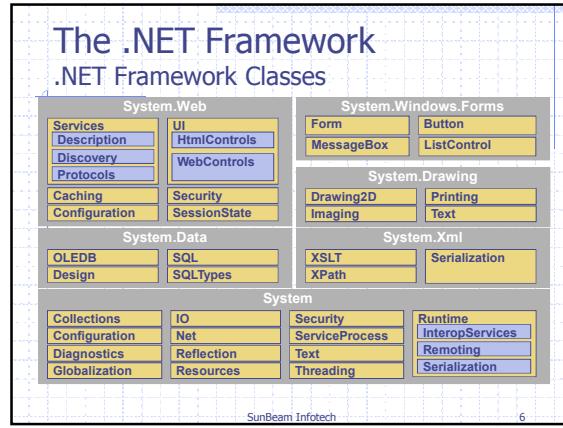
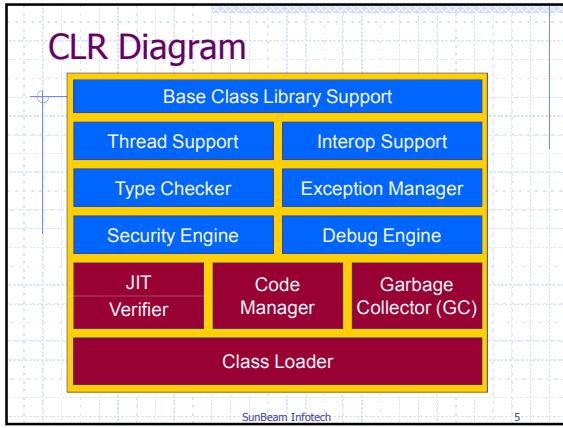
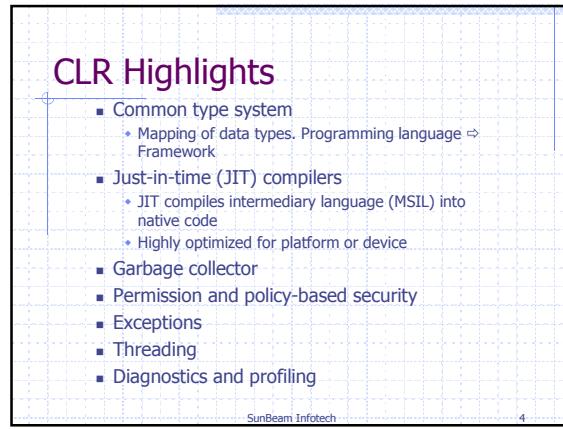
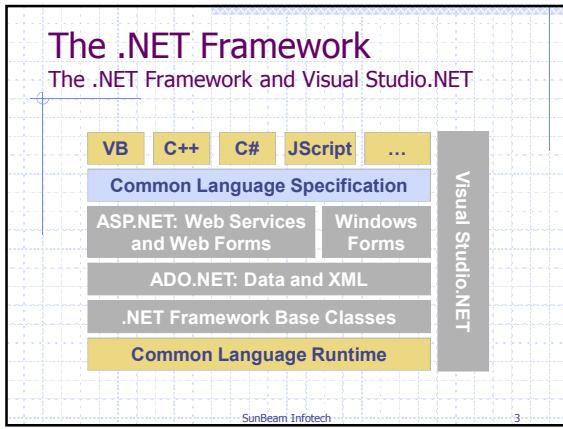
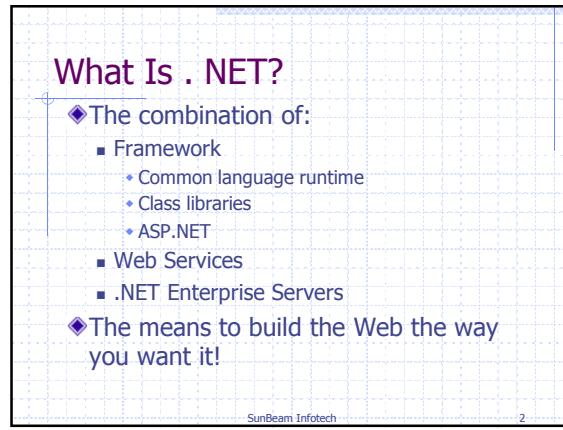
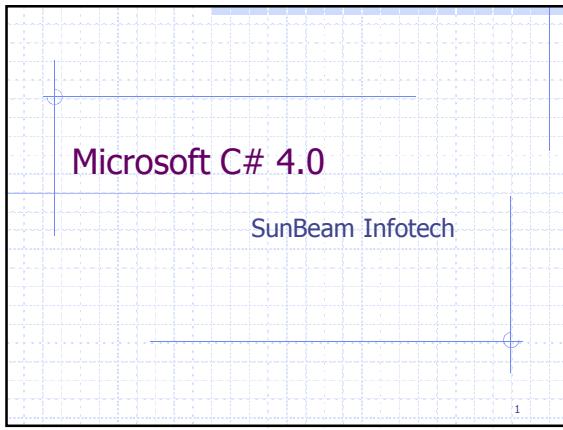

<div class="row pb-2">
        <h2>Delete Employee</h2>
    </div>
    <form method="post" asp-action="DeleteEmp">
        <input asp-for="Id" hidden />
        <div asp-validation-summary="All"></div>
        <div class="form-row">
            <div class="form-group col-md-6">
                <label asp-for="Name">Employee Name</label>
                <input type="text" class="form-control mb-3" asp-for="Name" disabled>
                <span asp-validation-for="Name" class="alert-danger"></span>
            </div>
            <div class="form-group col-md-6">
                <label asp-for="Designation">Designation</label>
                <input type="text" class="form-control mb-3" asp-for="Designation" disabled>
                <span asp-validation-for="Designation" class="alert-danger"></span>
            </div>
        </div>
    </form>

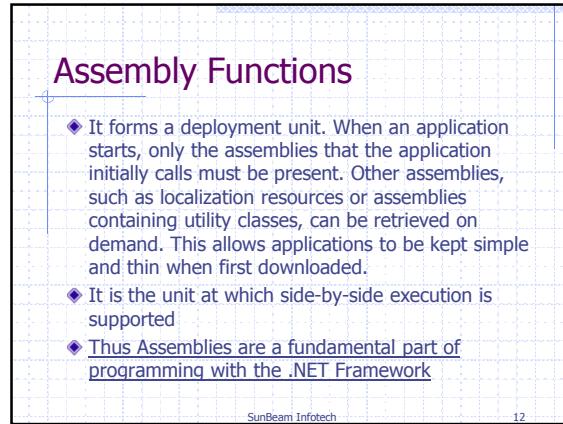
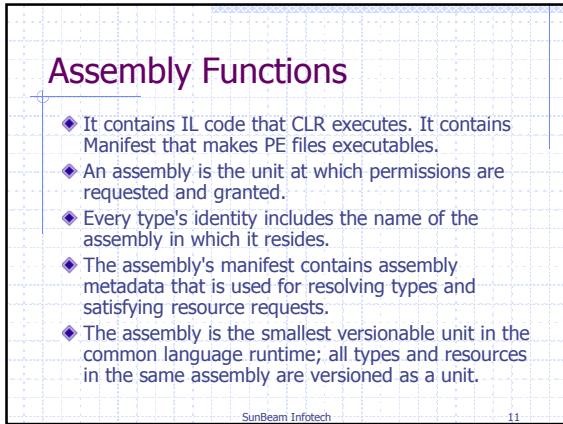
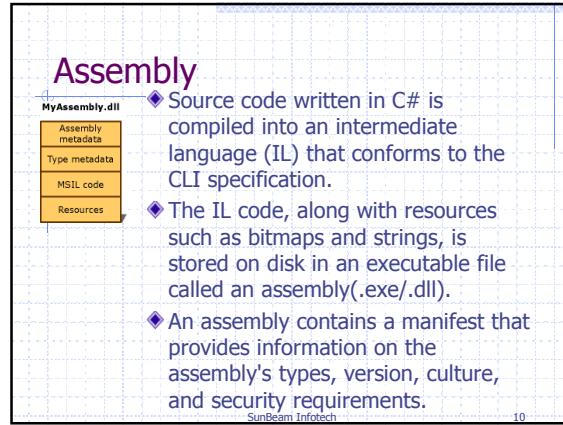
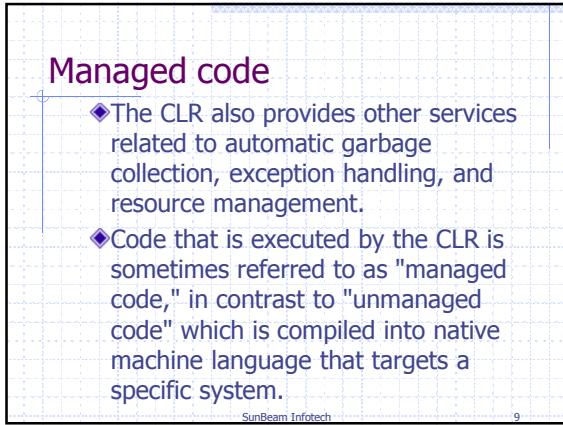
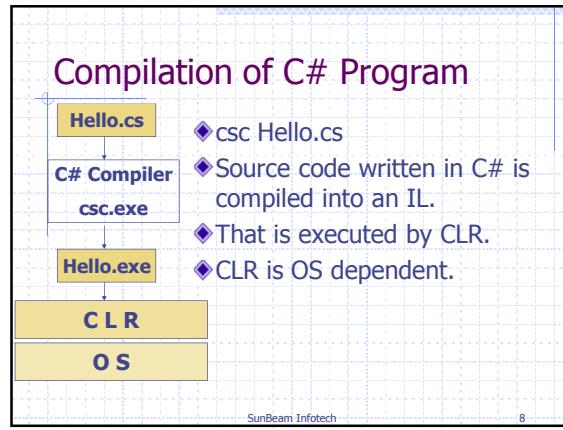
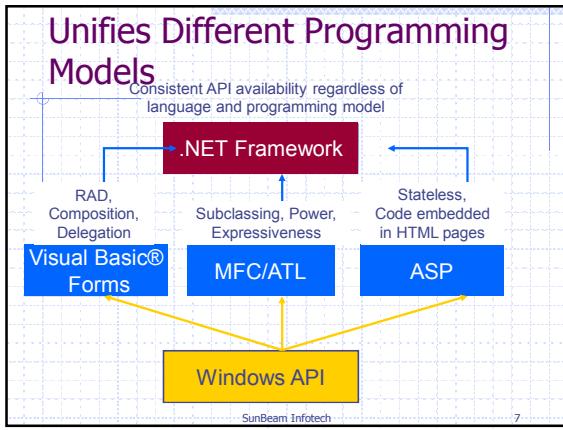

```



Microsoft.NET

```
</div>
</div>
<div class="form-row">
    <div class="form-group col-md-6">
        <label asp-for="Address">Address</label>
        <input type="text" class="form-control mb-3" asp-for="Address" disabled>
        <span asp-validation-for="Address" class="alert-danger"></span>
    </div>
    <div class="form-group col-md-6 mb-3">
        <label asp-for="RecordCreatedOn">Created On</label>
        <input type="datetime-local" class="form-control" asp-for="RecordCreatedOn" disabled>
        <span asp-validation-for="RecordCreatedOn" class="alert-danger"></span>
    </div>
    <button type="submit" class="btn btn-lg btn-danger p-2"><i class="bi bi-trash-fill"></i>Delete</button>
    <a asp-controller="Employee" asp-action="Index" class="btn btn-lg btn-warning p-2">Back To List</a>
</form>
</div>
@section Scripts{
    @{
        <partial name="_ValidationScriptsPartial" />
    }
}
```





Assembly Contents

- ◆ static assembly can consist of four elements:
 - * Assembly Manifest (Most Important)
 - * Type metadata * IL code * Resources
- ◆ Assembly can be Single file assembly or multifile assembly.
- ◆ Multifile assembly is linked through Manifest and managed as single unit by CLR.
- ◆ multifile assembly allow to combine modules written in different languages and to optimize downloading an application by putting seldom used types in a module that is downloaded only when needed.

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Assembly Manifest

- ◆ Each assembly's manifest –
 - Enumerates files that make up the assembly.
 - Governs how references to the assembly's types and resources map to the actual files
 - Enumerates other assemblies on which the assembly depends.
 - Provides isolation between assembly clients and the assembly's implementation details.
- ◆ Manifest Contains
 - Assembly name, Version number
 - Culture for satellite assembly
 - List of All files, Exported types, Referenced assemblies

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Assembly Types

- ◆ Assemblies can be static or dynamic.
- ◆ Static assemblies can include .NET Framework types and resources.
- ◆ Static assemblies are stored on disk in portable executable (PE) files.
- ◆ You can also use the .NET Framework to create dynamic assemblies, which are run directly from memory and are not saved to disk before execution.
- ◆ You can also use common language runtime APIs, such as System.Reflection.Emit, to create dynamic assemblies.

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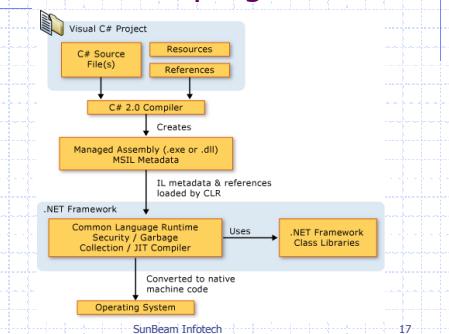
Execution of Assembly

- ◆ When the C# program is executed, the assembly is loaded into the CLR, which might take various actions based on the information in the manifest.
- ◆ Then, if the security requirements are met, the CLR performs just in time (JIT) compilation to convert the IL code into native machine instructions.
- ◆ These can be passed to OS.

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Execution of C# program



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Global Assembly Cache

- ◆ Each computer where the CLR is installed has a machine-wide code cache called GAC.
- ◆ It stores assemblies specifically designated to be shared by several applications on the computer.
- ◆ You should share assemblies by installing them into the GAC only when you need to.
- ◆ There are several ways to deploy an assembly into the global assembly cache:
 - Use an installer designed to work with the GAC.
 - Use a developer tool Gacutil.exe, provided by the .NET Framework SDK.
 - Use Windows Explorer to drag assemblies into the cache.

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Global Assembly Cache

- ◆ It is recommended that only users with Administrator privileges be allowed to delete files from the global assembly cache.
- ◆ When an assembly is added to the global assembly cache, integrity checks are performed on all files that make up assembly.
- ◆ The cache performs these integrity checks to ensure that assembly has not been tampered with.
- ◆ Assembly registered with GAC is shared assembly while assembly placed in application folder is local or private assembly.
- ◆ Assemblies deployed in the global assembly cache must have a strong name.

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Strong named assembly

- ◆ A strong name consists of the assembly's identity – its simple text name, version number, and culture information – plus a public key and a digital signature.
- ◆ It is generated from an assembly file using the corresponding private key.
- ◆ Strong names guarantee name uniqueness by relying on unique key pairs.
- ◆ When you reference a strong-named assembly, you expect to get certain benefits, such as versioning and naming protection.

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Side-by-side Execution

- ◆ Side-by-side execution is the ability to store and execute multiple versions of a component on the same computer.
- ◆ This means that you can have multiple versions of the runtime, and multiple versions of applications that use a version of the runtime, on the same computer at the same time.
- ◆ Side-by-side execution gives you more control over what versions of a component and runtime an application binds to.
- ◆ Support for side-by-side storage and execution of different versions is possible due to strong naming and is built into the infrastructure of the runtime.

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C# Advantages

- ◆ C# syntax simplifies many of the complexities of C++ while providing powerful features such as nullable value types, enumerations, delegates, anonymous methods and direct memory access, which are not found in Java.
- ◆ The C# build process is simple compared to C and C++ and more flexible than in Java.
- ◆ A C# source file may define any number of classes, structs, interfaces, and events.

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Common Language Runtime

- ◆ C# programs run on the .NET Framework, an integral component of Windows that includes a virtual execution system called the common language runtime (CLR) and a unified set of class libraries.
- ◆ The CLR is Microsoft's commercial implementation of the common language infrastructure (CLI), an international standard that is the basis for creating execution and development environments in which languages and libraries work together seamlessly.

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// First C# Program

```
/* File Name : Hello.cs*/
namespace HelloWorld {
    class Hello {
        static void Main() {
            System.Console.WriteLine
                ("Hello World!");
        }
    }
}
```

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Main method

- ◆ Possible prototypes for main:
 - static void Main();
 - static int Main();
 - static void Main(string[] args);
 - static int Main(string[] args);
- ◆ Command line arguments: args[0], ...
- ◆ Command line argument count: args.length

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Input / Output in C#

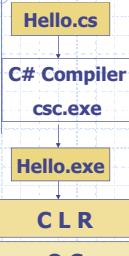
- ◆ System.Console.WriteLine("Hello");
 - Namespace – System
 - Class – Console
 - Static Method – WriteLine
- ◆ If System namespace is declared already as :


```
using namespace System;
```
- ◆ Console.WriteLine(""); is correct.
- ◆ string msg=System.Console.ReadLine();
- ◆ int num = int.parse(msg);

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Compilation of C# Program

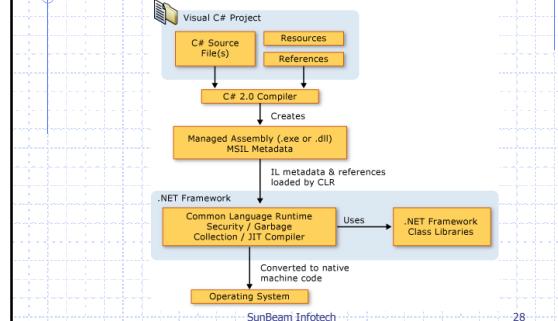


- ◆ csc Hello.cs
- ◆ Source code written in C# is compiled into an IL.
- ◆ That is executed by CLR.
- ◆ CLR is OS dependent.

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Execution of C# program



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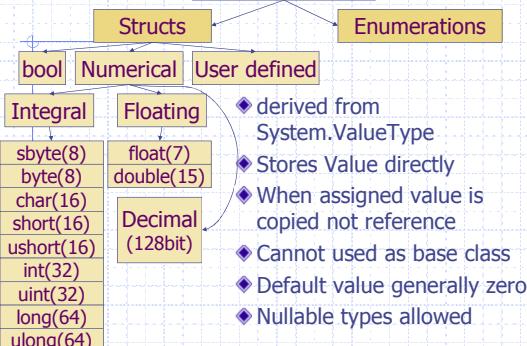
Data types

- ◆ C# is a strongly typed language
- ◆ Classified as
 - Built-in type
 - User-defined type
- ◆ Or Classified as
 - Value type – stores values.
 - Reference type – stores references to data.

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Value Types



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Built in types And Framework Types

bool : System.Boolean	uint : System.UInt32
byte : System.Byte	long : System.Int64
sbyte : System.SByte	ulong : System.UInt64
char : System.Char	short : System.Int16
decimal : System.Decimal	ushort : System.UInt16
double : System.Double	object : System.Object
float : System.Single	string : System.String
int : System.Int32	

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Reference Types

Class
Interface
object
string
delegate

- ◆ store references to actual data
- ◆ Classes and Interfaces are user defined.
- ◆ object is cosmic super class
- ◆ string is also built in type represents immutable strings
- ◆ delegate represent object oriented function pointer

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Boxing and Unboxing

- ◆ By Boxing Value types can be treated as objects.
- ◆ This allows the value type to be stored on the garbage collected heap as an Object.
- ◆ Unboxing extracts the value type from the object.

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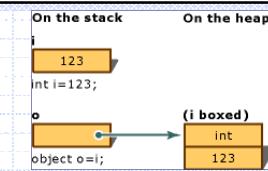
Boxing and Unboxing

- ◆ example, the integer variable i is *boxed* and assigned to object o.
- ◆ `int i = 123;`
- ◆ `object obj = (object) i; // boxing`
- ◆ The object o can then be unboxed and assigned to integer variable i:
- ◆ `object obj = 123;`
- ◆ `i = (int) obj; // unboxing`

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Boxing



- ◆ `object o = i;` // implicit boxing
- ◆ `object o=(object) i;` // explicit boxing(not required)
- ◆ The result of this statement is creating an object reference o, on the stack, that references a value of the type int, on heap.
- ◆ This value is a copy of the value-type value assigned to the variable i.

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Unboxing

- ◆ `int i = 123; // a value type`
- ◆ `object o = i;` // boxing
- ◆ `int j = (int) o;` // unboxing
- ◆ explicit conversion from type object to value type
- ◆ Checking the object instance to make sure it is a boxed value of the given value type.
- ◆ Copying the value from the instance into the value-type variable.
- ◆ Attempting to unbox null or a reference to an incompatible value type will result in an `InvalidCastException`.

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Arrays

- ◆ `int[] a={1,2,3,4,5};`
- ◆ `int[] a=new int[5];`
- ◆ `int[] a=new int[5]{1,2,3,4,5};`
- ◆ `string[] weekDays = new string[] { "Sun", "Mon", "Tue" };`
- ◆ `int[,] a=new int[4,2];`
- ◆ `int[,] a=new int[,]{{1,2},{3,4},{5,6}};`

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Arrays

- ◆ `int[] numbers = { 4, 5, 6, 1, 2, 3, -2, -1, 0 }; foreach (int i in numbers) { System.Console.WriteLine(i); }`
- ◆ `Console.WriteLine(numbers.Length);`

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Arrays

- ◆ A jagged array is an array whose elements are arrays.
- ◆ The elements of a jagged array can be of different dimensions and sizes.
- ◆ A jagged array is sometimes called an "array of arrays."
- ◆ `int[][] jaggedArray = new int[3][];`
- ◆ `jaggedArray[0] = new int[5];`
- ◆ `jaggedArray[1] = new int[4];`
- ◆ `jaggedArray[2] = new int[2];`

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Passing array to Functions by out

- ◆ `static void FillArray(out int[] arr) {`
- ◆ `if (arr == null)`
- ◆ `arr = new int[5];`
- ◆ `arr[4] = 5555;`
- ◆ `}`
- ◆ `static void Main() {`
- ◆ `int[] theArray=null;`
- ◆ `FillArray(out theArray);`
- ◆ `for (int i = 0; i < theArray.Length; i++)`
- ◆ `Console.Write(theArray[i] + " ");`
- ◆ `}`

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Passing array to function

- ◆ In example1, value modified in fn is not reflected back as reference is passed by value
- ◆ In example2, a ref parameter of an array type must be definitely assigned by the caller
- ◆ Therefore, there is no need to be definitely assigned by the callee. A ref parameter of an array type may be altered as a result of the call.
- ◆ In example2, an out parameter of an array type must be assigned before it is used; that is, it must be assigned by the callee.

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string type [mscorlib.dll]

- ◆ sequence of Unicode characters
- ◆ alias for reference type `System.String`
- ◆ `==` and `!=` operators check for values even though it is reference type
- ◆ `+, [], +=` operators can be used
- ◆ To avoid escape seq: `str=@"c:\file.txt";`
- ◆ To modify the same string object use `System.Text.StringBuilder` class
- ◆ `string[] split(char[] separators);`

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Operator Precedence Chart

Primary	x.y, f(x), a[x], x++, x--, new, typeof, checked, unchecked
Unary	+, -, !, ~, ++x, --x, (T)x
Arithmetic — Multiplicative	*, /, %
Arithmetic — Additive	+, -
Shift	<<, >>
Relational and type testing	<, >, <=, >=, is, as
Equality	=, !=
Logical, in order of precedence	&, ^,
Conditional, in order of precedence	&&, , ?:
Assignment	=, +=, -=, *=, /=, %=, &=, =, ^=, <=>=

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checked & unchecked

- ◆ C# statements can execute in either checked or unchecked context.
- ◆ In a checked context, arithmetic overflow raises an exception.
- ◆ In unchecked context, arithmetic overflow is ignored & result is truncated
- ◆ Expressions using the following predefined operators on integral types:
++ — - (unary) + - * /
- ◆ Explicit numeric conversions between integral types

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checked & unchecked demo

```
◆ int z = 0;
  short x=32767, y=32767;
  try {
    z = un checked((short)(x + y));
  }
  catch (System.OverflowException e){
    Console.WriteLine(e.ToString());
  }
  ◆ blocks can be used for expressions
```

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Objects, classes and structs

- ◆ Objects are instances of a given data type. The data type provides a blueprint for the object that is instantiated when application is executed.
- ◆ New data types are defined using classes & structs.
- ◆ Classes and structs form the building blocks of C# applications, containing code and data. C# application will always contain of at least one class.
- ◆ A struct can be considered a lightweight class, ideal for creating data types that store small amounts of data, and does not represent a type that might later be extended via inheritance.
- ◆ C# classes support inheritance, meaning they can derive from a previously defined class.

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class

- ◆ class may have
 - Methods, Fields, Properties, Operators, Indexers, Events & other user defined types
- ◆ Access specifiers
 - private, protected, public
 - internal, protected internal
- ◆ Class definitions can be splitted in files
- ◆ Static classes are sealed classes with static methods
- ◆ Only single inheritance is allowed
- ◆ Multiple interface inheritance is allowed

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struct

- ◆ Structs are value types; classes are reference types
- ◆ When passing a struct to a method, it is passed by value instead of as a reference.
- ◆ Unlike classes, structs can be instantiated without using a new operator.
- ◆ Structs can declare constructors, but they must take parameters.
- ◆ A struct cannot inherit from other struct. A struct can implement interfaces.
- ◆ All structs are inherit from System.ValueType that inherits System.Object
- ◆ It is an error to initialize an instance field in struct

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```

public class test {
    int x, y;
    public test() { }
    public test(int x,int y)
    {   this.x=x;  this.y=y;  }
    ~test() { }
    public int X {
        get { return x; }
        protected set { x=value; }
    }
    public static test operator*(test a, test b)
    {   return new test(a.x*b.x, a.y*b.y); }
    public static explicit operator complex(test t)
    {   return new complex(t.x, t.y); }
}

```

can more strict if needed

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Inheritance & Polymorphism

- ◆ public class derived : base { ... }
- ◆ **is** operator checks for hierarchy relation
- ◆ bool flag = der_obj is base;
- ◆ **as** operator is used for dynamic type casting
- ◆ derived newobj = obj as derived;
- ◆ **abstract** classes & members are solely used for inheritance - to define features of derived, non-abstract classes.
- ◆ **sealed** members cannot be overridden
- ◆ **sealed** classes cannot be further inherited; they are final.

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Operator overloading

- ◆ By operator overloading, we can extend the meaning of the operator. By this we can use operator with user defined classes.
- ◆ The operators are implemented as static functions of the class.
- ◆ &&, ||, [], (), shorthand, =, ., ?:, →, new, is, sizeof operators cannot be overloaded.
- ◆ Relational operators like ==, != should be overloaded in pair.
- ◆ public static Complex operator +(Complex c1, Complex c2);

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Operator overloading

- ◆ Conversion operators are used to convert a class object into any other type and vice versa.
- ◆ Conversions declared as implicit occur automatically when required.
- ◆ Conversions declared as explicit require a cast to be called.
- ◆ public static explicit operator int(Complex c) {
 ◆ return c.real;
 ◆ }
 ◆ public static explicit operator int(Complex c) {
 ◆ return c.real;
 ◆ }

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new Keyword

- ◆ new operator is used to allocated memory.
- ◆ When function is declared as new, it hides all the functions in base class with the same name.
- ◆ Using a derived class reference we can't access any function with same name in base class.
- ◆ We can even declare a function as new virtual, which makes function as a new virtual function hence forth in hierarchy that can be overridden in further derived classes using override keyword.
- ◆ Using a base class reference we cannot access any function with same signature in the derived class.

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sealed Keyword

- ◆ Function declared as sealed cannot be overridden in the derived class.
- ◆ Thus sealed functions finalizes functionality provided by the base class, that cannot be modified or extended in the derived class.
- ◆ The specifier sealed override tells that function is overridden in this class but cannot be overridden further.
- ◆ If we wish to have a new function in the derived class with same name we should use new.
- ◆ If a class is declared as sealed, then that class cannot be further inherited.

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const, readonly Keywords

- ◆ The variable declared as `const`, is a constant variable and cannot be modified anywhere.
- ◆ The `const` field's value should be given at compile time, where it is declared in class.
- ◆ `const double PI = 3.142;`
- ◆ Now value of `PI` is finalized to 3.142.
- ◆ The variable declared as `readonly`, is assigned in constructor and cannot be modified in any other method afterwards.
- ◆ The `readonly` field's value may not be known at the compile time.

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abstract Keyword

- ◆ If function is declared as `abstract` within a class then we cannot create object of that class. Such class must be declared as `abstract`.
- ◆ Functions declared abstract in base class must be overridden in the derived class. Otherwise we cannot even create object of the derived class.
- ◆ Abstract classes are used to implement some common functionality that can be shared by the objects of the derived classes.
- ◆ Function declared as `abstract override` overrides function in base class but make it abstract in derived class.

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virtual, override, sealed, new

```
class A {  
    int x;  
    public A(int x) { this.x = x; }  
    public virtual void f1() {}  
    public virtual void f2() {}  
    public sealed void f3() {}  
    public virtual void f4() {}  
}  
  
class B : A {  
    int y;  
    public B(int x, int y):base(x, y){ this.y=y;}  
    public override void f1() {}  
    public new virtual void f2() {}  
    public sealed override void f4() {}  
}
```

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abstract & sealed classes

```
abstract class A {  
    public abstract void f1() {}  
    public abstract string Name{ get; set; }  
    public virtual void f3() {}  
}  
  
abstract class B : A {  
    public override void f1() {}  
    string nm;  
    public override string Name {  
        get { return nm; }  
        set { nm=value; }  
    }  
    public abstract override void f3() {}  
}  
  
sealed class C : B {  
    public override void f1() {}  
    public override void f3() {}  
}
```

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Use of abstract classes

- ◆ Abstract class references are used to refer to objects of the derived classes.
- ◆ Thus they work like generic references and give specific implementation depending on type of object.
- ◆ Also they implement the common functionality used by the derived class objects.
- ◆ Generally we create collection like array of base class references and now we can store any objects derived from this common base class.
- ◆ Using this technique we can achieve polymorphic behavior.

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interface

- ◆ interface is full abstraction of a class.
- ◆ In interface all methods are by default public & abstract.
- ◆ Interface cannot have any non-abstract method or fields.
- ◆ The fields can be declared only as public static const.
- ◆ Multiple interface inheritance is allowed, even though implementation inheritance is not allowed.
- ◆ If class A is implementing I1 and I2 interfaces, A should override all methods from I1 & I2.
- ◆ **Fragile Base Class Problem:** If base class definition is modified, then all derived classes must be recompiled.
- ◆ To avoid such problem we can go for interfaces, as interfaces are immutable.

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interface

- ◆ Interfaces are service based. It is a contract between service provider and service user.
- ◆ It declares set of rules in form of its methods, that will be implemented by the service provider.
- ◆ Interfaces ensure that rules or services are implemented by the service provider.
- ◆ Using interface you can collect irrelevant objects together, by getting a service common to both.
- ◆ Example: IPrintable interface has Print() method, that can be implemented by Point or Employee class.
- ◆ The implementation will differ according to actual class.

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interface

```
interface A {  
    void f1();  
    void f2();  
}  
  
interface B {  
    void f1();  
    void f2();  
}  
  
class C : A, B {  
    public void f1() {}  
    public void A.f2() {}  
    public void B.f2() {}  
}
```

interface property

```
interface X {  
    public string Name {  
        get;  
        set;  
    }  
}  
  
class Y : X {  
    string nm;  
    public string Name {  
        get{ return nm; }  
        set{ nm=value; }  
    }  
}
```

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Interfaces

- ◆ Classes and structs can inherit from more than one interface.
- ◆ An interface can itself inherit from multiple interfaces.
- ◆ IComparable interface, ICloneable are some of the standard interfaces.
- ◆ Interface can have only static and const members.
- ◆ const should be known at compile time.
- ◆ readonly can be assigned during initialization or constructor

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Constructors

- ◆ Ctors can be parameterized or parameterless.
- ◆ classname() {} or classname(args) {}
- ◆ If constructors are private, object of class cannot be created outside class.
- ◆ We can have copy ctor also
- ◆ classname(classname other);
- ◆ Assuming that f1(), f2(), f3(), f4(), f5(), f6() as static methods of respective classes what will be sequence of their execution?

```
class A {  
    int x= f1();  
    A() { f2(); }  
}  
  
class B : A {  
    int y = f3();  
    B() { f4(); }  
}  
  
class C : B {  
    int z = f5();  
    C() { f6(); }  
}  
  
C ref = new C();
```

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static constructors

- ◆ static classname() {}
- ◆ static constructors has no access specifiers and also no parameters. And a class can have only one static constructor.
- ◆ Static constructor can access only static members.
- ◆ It is called automatically by CLR to initialize class before instance is created or any static members are referenced
- ◆ It cannot be called explicitly.
- ◆ It is used for one time initialization, when class is going to be used for any purpose.
- ◆ use: keep track in log file about class usage.

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Nested types

- ◆ A type defined within a class or struct is called a nested type
- ◆ public class Container {
 public class Nested {
 private Container m_parent;
 public Nested() {}
 public Nested(Container parent)
 {
 m_parent = parent;
 }
 }
}
Container.Nested obj = new Container.Nested();
- ◆ Nested types can access private and protected members of the containing type, including any inherited private or protected members.

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Indexers

- ◆ Indexers enable objects to be indexed in a similar way to arrays.
- ◆ Indexers do not have to be indexed by an integer value.
- ◆ Indexers can be overloaded.
- ◆ Indexers can have more than one formal parameter, for example, when accessing a two-dimensional array.
- ◆ It can be declared as abstract & can be interface member.

```
class test
{
    int[] a=new int[5];
    public int this[int i]
    {
        get
        { return a[i]; }
        set
        { a[i] = value; }
    }
}
test obj = new test();
obj[2] = 20;
num = obj[2];
```

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Partial class

- ◆ Using the partial keyword indicates that other parts of the class, struct, or interface can be defined within the namespace with same access
- ◆ `public partial class Employee { }`
- ◆ `public partial class Employee { }`

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Partial class

- ◆ If any of the parts are declared abstract, then the entire type is considered abstract.
- ◆ If any of the parts are declared sealed, then entire type is considered sealed.
- ◆ If any of the parts declare a base type, then the entire type inherits that class.
- ◆ When working on large projects, spreading a class over separate files allows multiple programmers to work on it simultaneously.
- ◆ When working with automatically generated source, code can be added to the class without having to recreate the source file. Visual Studio uses this approach

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Static class

- ◆ Static classes and class members are used to create data and functions that can be accessed without creating an instance of the class.
- ◆ Static class members can be used to separate data and behavior that is independent of any object identity.
- ◆ Static classes are loaded automatically by the CLR when the program or namespace containing the class is loaded.
- ◆ Creating a static class is therefore much the same as creating a class that contains only static members and a private constructor.

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Static class

- ◆ `static class CompanyInfo { }`
- ◆ `public static string GetCompanyName()`
- ◆ `{ return "CompanyName"; }`
- ◆ `public static string GetCompanyAddress()`
- ◆ `{ return "CompanyAddress"; }`
- ◆ It is useful to organize the methods inside the class in meaningful way, like methods of `System.Math`
- ◆ It contains only static members.
- ◆ Its object cannot be created.
- ◆ It is sealed(final) class.
- ◆ It cannot have instance constructor.

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Object class

- ◆ Supports all classes in the .NET Framework class hierarchy and provides low-level services to derived classes.
- ◆ This is the ultimate base class of all classes in the .NET Framework; it is the root of the type hierarchy.

<code>ToString</code>	Returns a string that represents the current Object.
<code>Equals</code>	Determines equality.
<code>GetType</code>	Returns type of current Object

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Exceptions

- ◆ Exception is flexible way to deal with any unexpected or exceptional situations that arise while a program is running.
- ◆ Exception handling uses the try, catch, and finally keywords to attempt actions that may not succeed, to handle failures and to clean up resources at end
- ◆ When exceptional circumstance is encountered, such as a division by zero or low memory warning, an exception is generated by CLR.
- ◆ Once an exception occurs, the flow of control immediately jumps to an associated exception handler, if one is present. Program stops executing with an error message.

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Exceptions

- ◆ try block contain code that may result in exception
- ◆ An exception handler is catch block of code that is executed when an exception occurs. One try may have multiple catch blocks. The first **catch** statement that can handle the exception is executed.
- ◆ Exceptions can be explicitly generated by a program using the throw keyword.
- ◆ Exception objects contain detailed information about the error, including the state of the call stack and a text description of the error.
- ◆ Code in a finally block is executed even if an exception is thrown, thus allowing a program to release resources

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Exceptions

- ◆ Exceptions are represented by classes derived from Exception.
- ◆ If the statement that throws an exception is not within a try block, the runtime checks the calling method for a try statement and catch blocks.
- ◆ The runtime continues up the calling stack, searching for a compatible catch block. After the catch block is found and executed, control is passed to the first statement after the catch block.
- ◆ Few compiler generated exceptions are OverflowException, DivideByZeroException, IndexOutOfRangeException, InvalidCastException, NullReferenceException, OutOfMemoryException, ...

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Garbage Collection - GC

- ◆ GC manages the allocation and release of memory for your application.
- ◆ Each time you use the new operator to create an object, the runtime allocates memory for the object from the managed heap.
- ◆ The GC's optimizing engine determines the best time to perform a collection, based upon allocations done.
- ◆ When the GC performs a collection, it checks for objects in the managed heap that are no longer being used by the application.

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Destructors and IDisposable

```
using System;
class Class1 {
    static void Main(string[] args) {
        Widget wg = new Widget();
        Console.WriteLine(wg.ToString());
        wg.Dispose(); //specific call to cleanup
        wg = null; //let go of reference and wait for GC
    }
}
public class Widget : IDisposable {
    ~Widget() { +-----+
        //cleanup code called by GC
    }
    public void Dispose() {
        //perform cleanup
    }
}
```

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Delegates

- ◆ delegate is a type that references a method. It can be treated as object oriented function pointer.
- ◆ public delegate int PerformCalculation(int x, int y);
- ◆ Any method that matches the delegate's signature, which consists of the return type and parameters, can be assigned to the delegate.
- ◆ It makes delegates ideal for defining callback methods.
- ◆ Delegates can be chained together called multicast delegate.
- ◆ Delegates are mainly used with Eventing design pattern.

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Delegates

- Delegates without name are called as anonymous methods which reduces coding.
- It can access the variables in the outer class or method.
- When a delegate method has a return type that is more derived than the delegate signature, it is said to be covariant.
- When a delegate method signature has one or more parameters of types that are derived from the types of the method parameters, that method is said to be contravariant.
- Because the method's return type or parameters are more specific than the delegate signature's return type, they can be implicitly converted.

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Events

- Events are used on classes to notify the users of object when some interesting happens related to the object.
- This notification is called raising an event.
- An object raising an event is referred to as the source or sender of the event.
- Objects that represent user interface elements usually raise events in response to user actions like a button click.
- Event has a signature that includes a name and a parameter list & defined by a delegate type.
- Event can be static, virtual, abstract, sealed.

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Events

- Ex: delegate void TestEventDelegate();
public event TestEventDelegate TestEvent;
- .NET framework provide guideline for creating event. The first parameter should be sender object while second should provide information about event derived from EventArgs.
- Event may have more than one handlers that are executed sequentially like multicast delegate.
- add or remove event accessors can written that are executed when += or -= operator is used on event.
- Event can be declared in interface and overridden into derived class.

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ICloneable

- Clone method creates new instance of class with same value as existing instance
- It can be implemented either as a deep copy or a shallow copy.
- In a deep copy, all objects are duplicated.
- In a shallow copy, only the top-level objects are duplicated and the lower levels contain references.

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Collection classes

- Collection classes are defined as part of the System.Collections or System.Collections.Generic namespace.
- Most collection classes derive from the interfaces ICollection, IComparer, IEnumerable, IList, IDictionary, and IDictionaryEnumerator.
- Some important classes are ArrayList, SortedList, Stack, Queue, HashTable, etc.
- Using generic collection classes provides increased type-safety and in some cases can provide better performance, especially when storing value types.

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Generics in C#

- Generics are template classes or functions written by programmer.
- C# generic type substitutions are performed at runtime.
- Use generic types to maximize code reuse, type safety, and performance.
- Collection classes declared in System.Collections.Generic
- Generic interfaces, classes, methods, events and delegates can be created.

```
class MyList<T> {  
    void Add(T val) {}  
    void Del(T val) {}  
}  
  
static void main() {  
    MyList<int> list1 =  
        new MyList<int>();  
  
    MyList<string> list2 =  
        new MyList<string>();  
}
```

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Generics

- ◆ For every new value type parameter specialized version is created at runtime
- ◆ For reference types only version is created for storing references as references of any type have same size.
- ◆ To use any collection with foreach loop it should support iterator or I Enumerable interface.
- ◆ Enumerator can be returned by "yield" keyword. We can write more than one yield return statement.
- ◆ Yield statement cannot be there in unsafe blocks or try-catch blocks, anonymous methods, method with ref & out params.

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Nullable types

- ◆ Nullable types are instances of the System.Nullable struct.
- ◆ A nullable type can represent the normal range of values for its underlying value type, plus an additional **null** value. e.g.
- ◆ A Nullable<bool> can be assigned the values **true** or **false**, or **null**.

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IComparable, IComparer

- ◆ IComparable. CompareTo member functions return 0 for equality and -ve of +ve value for inequality.
- ◆ IComparer.Compare compare two objects. Throws exception if any of two objects won't implement IComparable.
- ◆ Used with Array.Sort
- ◆ The functions should have identity, symmetry, transitivity

```
class Person : IComparable, IComparer{  
    string firstName;  
    public int CompareTo (Object o2){  
        return  
            firstName.CompareTo (o2.firstName);  
    }  
    public int Compare (object o1, object o2) {  
        return o1.CompareTo(o2);  
    }  
}
```

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Attributes

- ◆ Attributes provide a powerful method of associating declarative information with types, methods, properties, etc.
- ◆ Attributes add metadata to your program. Metadata is information embedded in your program such as compiler instructions or descriptions of data.
- ◆ They are classified as predefined(given in framework) and user defined attributes.
- ◆ Predefined attributes are used in PInvoke, Serialization, Interoperability, etc.

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Custom Attributes

- ◆ You can create your own custom attributes by defining an attribute class, a class that derives directly or indirectly from Attribute, which makes identifying attribute definitions in metadata fast and easy.
- ◆ System.AttributeUsage attribute decides usage of the attribute.
 - AttributeTargets – Class, Struct, Field, Property, All, etc.
 - AllowMultiple = true / false
 - Inherited = true / false
- ◆

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Serialization

- ◆ Serialization is the process of converting the state of an object into a form that can be persisted or transported.
- ◆ The complement of serialization is deserialization, which converts a stream into an object.
- ◆ Binary serialization preserves type fidelity, which is useful for preserving the state of an object between different invocations of an application.
- ◆ XML serialization serializes only public properties and fields and does not preserve type fidelity. This is useful when you want to provide or consume data without restricting the application that uses the data.

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Serialization

- ◆ The CLR manages object memory management and provides an automated serialization.
- ◆ When an object is serialized, the name of the class, the assembly, and all the data members of the class instance are written to storage.
- ◆ When the class is serialized, the serialization engine ensure that the same object is not serialized more than once, if object has references.
- ◆ The only requirement placed on object graphs is that all objects, referenced by the serialized object, must also be marked as Serializable.
- ◆ When the serialized class is deserialized, the class is recreated and the values of all the data members are automatically restored.

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Serialization

- ◆ Serialization can be done as Binary or XML or SOAP serialization.
- ◆ Steps for serialization
 - Mark the class with Serializable attribute.
 - Create a formatter object – Binary or SOAP
 - Create FileStream object to store data
 - Serialize object into file using formatter
 - Close the stream
- ◆ If you don't want to store any member then it should be marked with NonSerialized attribute.
- ◆ You can also use XMLSerializer object with StreamWriter object to write in file.

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Platform Invoke

- ◆ Platform invoke is a service that enables managed code to call unmanaged functions implemented in dynamic link libraries (DLLs), such as those in the Win32 API.
- ◆ It locates and invokes an exported function and marshals its arguments across the interoperation boundary as needed

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Unsafe Code Blocks

- ◆ Must set compiler option in project properties

- Project->Properties->Configuration Properties->Build
->Allow Unsafe Code blocks – set to true

```
[DllImport("kernel32", SetLastError=true)]
static extern unsafe bool ReadFile(int hFile,
    void* lpBuffer, int nBytesToRead,
    int* nBytesRead, int overlapped);
public unsafe int Read(byte[] buffer, int index, int
count) {
    int n = 0;
    fixed(byte* p = buffer) {
        ReadFile(handle, p + index, count, &n, 0);
    }
    return n;
}
```

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Reflection

- ◆ CLR loads the assembly into appdomain.
- ◆ Assemblies contain modules, modules contain types, and types contain members.
- ◆ Reflection provides objects that encapsulate assemblies, modules, and types.
- ◆ Reflection can be used to dynamically create an instance of a type, bind the type to an existing object, or get the type from an existing object.
- ◆ The related classes are declared in System.Reflection namespace.
- ◆ The classes of the System.Reflection.Emit namespace provide a specialized form of reflection that enables you to build types at run time.

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Reflection basics

- ◆ The GetType method or typeof operator provides Type structure that keeps information of type.
- ◆ Providing access to nonpublic information involves security risks. Code that is allowed to discover nonpublic information on a type can potentially access code, data, and other information you want to keep private.
- ◆ Therefore, .NET Framework security enforces rules that determine to what degree reflection can be used to discover type info and access types.
- ◆ Depending on the operation being performed, a ReflectionPermission or the SecurityPermission for serialization might be required.

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Reflection classes

- ◆ Use Assembly to define and load assemblies, load modules that are listed in the assembly manifest, and locate a type from this assembly and create an instance of it.
- ◆ Use Module to discover information such as the assembly that contains the module and the classes in the module, all global methods or other specific, nonglobal methods defined on the module.
- ◆ Use ConstructorInfo to discover information such as the name, parameters, access modifiers and implementation details (**abstract** or **virtual**) of a constructor. Use the GetConstructors or GetConstructor method of a Type to invoke a specific constructor.

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Reflection classes

- ◆ Use MethodInfo to discover information such as the name, return type, parameters, access modifiers and implementation details of a method. Use the GetMethods or GetMethod method of a Type to invoke a specific method.
- ◆ Use FieldInfo to discover information such as the name, access modifiers and implementation details of a field, and to get or set field values.
- ◆ Use EventInfo to discover information such as the name, event-handler data type, custom attributes, declaring type, and reflected type of an event, and to add or remove event handlers.

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Reflection classes

- ◆ Use PropertyInfo to discover information such as the name, data type, declaring type, reflected type, and read-only or writable status of a property, and to get or set property values.
- ◆ Use ParameterInfo to discover information such as a parameter's name, data type, whether a parameter is an input or output parameter, and the position of the parameter in a method signature.
- ◆ Use CustomAttributeData to discover information about custom attributes when you are working in the reflection-only context of an application domain. CustomAttributeData allows you to examine attributes without creating instances of them.

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Thread basics

- ◆ Preemptive multitasking OS divides the available processor time among the threads that need it, allocating a processor time slice to each thread one after another.
- ◆ The currently executing thread is suspended when its time slice elapses, and another thread resumes running.
- ◆ When the system switches from one thread to another, it saves the thread context of the preempted thread and reloads the saved thread context of the next thread in the thread queue.
- ◆ The length of the time slice is optimized to get good performance.

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Threading

- ◆ Operating systems use processes to separate the different applications that they are executing.
- ◆ Threads are the basic unit to which an OS allocates processor time, and more than one thread can be executing code inside that process.
- ◆ The .NET Framework subdivides an OS process into lightweight managed subprocesses, called application domains(System.AppDomain).
- ◆ One or more threads (System.Threading.Thread) can run in one or any number of application domains within the same managed process.
- ◆ Each Appdomain is having at least one thread.
- ◆ Thread can easily switch into Appdomains

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Thread basics

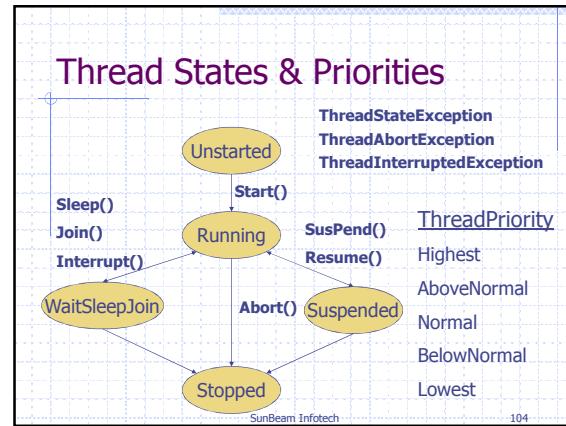
- ◆ Operating systems use processes to separate the different applications that they are executing.
- ◆ Thread is basic unit to which OS allocates cpu time
- ◆ Process may have more than one thread
- ◆ Framework subdivides OS process into lightweight managed subprocesses called AppDomains
- ◆ One or more managed threads can run in one or more of appdomains within the same process
- ◆ Each appdomain starts with a single thread
- ◆ It can create additional application domains and additional threads.
- ◆ Managed thread can move freely between appdomains inside the same managed process

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Win32 API Vs .NET Fns	
CreateThread	new Thread() & Thread.Start()
TerminateThread	Thread.Abort
SuspendThread	Thread.Suspend
ResumeThread	Thread.Resume
Sleep	Thread.Sleep
WaitForSingleObject	Thread.Join
GetCurrentThread	Thread.CurrentThread
SetThreadPriority	Thread.Priority
no equivalent	Thread.Name
no equivalent	Thread.IsBackground

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Thread Synchronization

- To avoid conflicts, you must synchronize, or control the access to, shared resources.
- Failure to synchronize access properly can lead to problems such as deadlocks and race conditions.
- The system provides synchronization objects that can be used to coordinate resource sharing among multiple threads.
- Resources that require synchronization include:
 - System resources (communications ports)
 - Resources shared by multiple processes (such as file handles).
 - The resources of a single application domain accessed by multiple threads.

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Thread synchronization

- Thread synchronization is done by lock keyword. It is internally using Monitor object for that.
- lock(obj) { }
- This is equivalent to
 - Monitor.Enter or Monitor.TryEnter
 - Monitor.Exit
- The object passed to Enter() should be same as Exit(), otherwise Monitor throws SynchronizationLockException.
- You can also use extra methods like Wait(), Pulse() and PulseAll().

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Advantages of Thread

- Using more than one thread is most powerful technique available to increase responsiveness to the user and process the data necessary to get the job done at almost the same time.
- Your single application domain could use multiple threads to accomplish:
 - Communicate over a network, to a Web server, and to a database.
 - Perform operations that take large amount of time
 - Distinguish tasks of varying priority. For example, a high-priority thread manages time-critical tasks, and a low-priority thread performs other tasks.
 - Allow the user interface to remain responsive, while allocating time to background tasks.

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Disadvantages of Thread

- It is recommended that you use as few threads as possible, thereby minimizing the use of OS resources and improving performance.
- The resource requirements are as follows:
 - The system consumes memory for the context information required by processes, AppDomain objects, and threads.
 - Keeping track of a large number of threads consumes significant processor time.
 - Controlling code execution with many threads is complex, and can be a source of many bugs.
 - Destroying threads requires knowing what could happen and handling those issues.
 - Shared access to resources can create conflicts.

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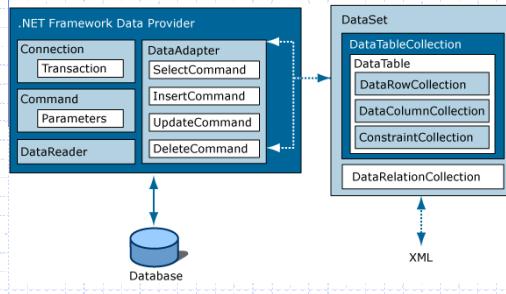
ADO.NET Components

- ◆ Two components of ADO.NET that you can use to access and manipulate data:
 - .NET Framework data provider
 - The DataSet
- ◆ .NET Framework data provider
 - For SQL Server : System.Data.SqlClient
 - For OLEDB : System.Data.OleDb
 - For ODBC : System.Data
 - For Oracle : System.Data.OracleClient
- ◆ DataSet is an in-memory cache of data retrieved from a data source. It is a virtual data store.

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ADO.NET Architecture



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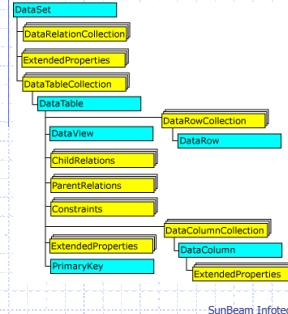
Core Objects of Data Providers

- ◆ Connection : Establishes a connection to a specific data source
- ◆ Command : Executes a command against a data source. Exposes Parameters and can execute within the scope of a Transaction
- ◆ DataReader : Reads a forward-only, read-only stream of data from a data source
- ◆ DataAdapter : Populates a DataSet and resolves updates with the data source
- ◆ Important objects: Transaction, CommandBuilder, Parameter, Exception

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DataSet Object Model



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File IO

- ◆ The abstract base class Stream supports reading and writing bytes.
- ◆ Streams involve these fundamental operations:
 - Streams can be read from.
 - Streams can be written to.
 - Streams can support seeking.
- ◆ Directory and File class provides static methods for create, move, copy, delete dirs and files.
- ◆ DirectoryInfo and FileInfo classes provide instance methods for the same.
- ◆ FileStream class actually open the file.

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Common Stream classes

- ◆ FileStream supports random access to files through its Seek method. FileStream opens files synchronously by default, but supports asynchronous operation as well.
- ◆ A BufferedStream is a Stream that adds buffering to another Stream such as a NetworkStream.
- ◆ A CryptoStream links data streams to cryptographic transformations.
- ◆ A MemoryStream is a nonbuffered stream whose encapsulated data is directly accessible in memory.
- ◆ A NetworkStream represents a Stream over a network connection.

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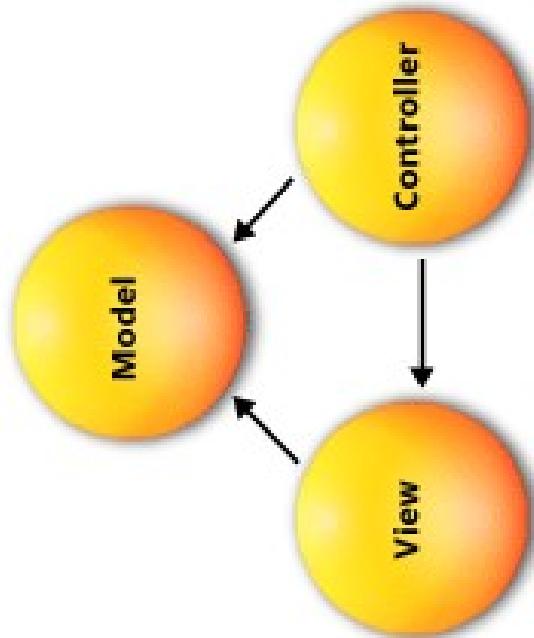
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Reader and Writer classes

- ◆ Basic Stream class provide byte IO support.
- ◆ BinaryReader and BinaryWriter read and write encoded strings and primitive data types from and to Streams.
- ◆ StreamReader reads characters from Streams, using Encoding to convert characters to and from bytes. StreamWriter writes characters to Streams, using Encoding to convert characters to bytes.
- ◆ StringReader reads characters from Strings. StringWriter writes characters to Strings.
- ◆ TextReader/TextWriter are the abstract base classes for Stream & String Reader/Writer classes. They provide unicode char IO.

What is MVC?

- Model-View-Controller (MVC)
- Standard Architectural Pattern
- Separation of concerns:
model, view, controller



ASP .NET MVC Framework

- An alternative to ASP .NET Web Forms
- Presentation framework
 - Lightweight
 - Highly testable
 - Integrated with the existing ASP .NET features:
 - Master pages
 - Membership-Based Authentication
 - ...



ASP .NET MVC Framework

Components

- Models
 - Business/domain logic
 - Model objects, retrieve and store model state in a persistent storage (database).
- Views
 - Display application's UI
 - UI created from the model data
- Controllers
 - Handle user input and interaction
 - Work with model
 - Select a view for rendering UI

When to use MVC approach?

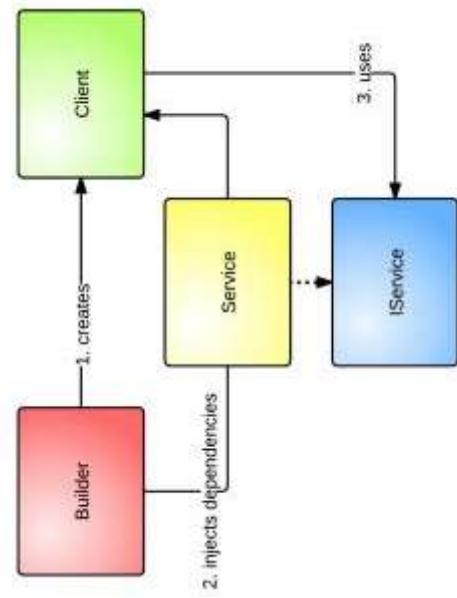
- Advantages:
 - Easier to manage complexity (divide and conquer)
 - It does not use server forms and view state
 - Front Controller pattern (rich routing)
 - Better support for test-driven development
 - Ideal for distributed and large teams
 - High degree of control over the application behavior

ASP .NET MVC Features

- Separation of application tasks
 - Input logic, business logic, UI logic
- Support for test-driven development
 - Unit testing
 - No need to start app server
- Extensible and pluggable framework
 - Components easily replaceable or customized (view engine, URL routing, data serialization,...)

ASP .NET MVC Features (cont.)

- Support for Dependency Injection (DI)
 - Injecting objects into a class
 - Class doesn't need to create objects itself
- Support for Inversion of Control (IOC)
 - If an object requires another object, the first should get the second from an outside source (configuration file)



ASP .NET MVC Features (cont.)

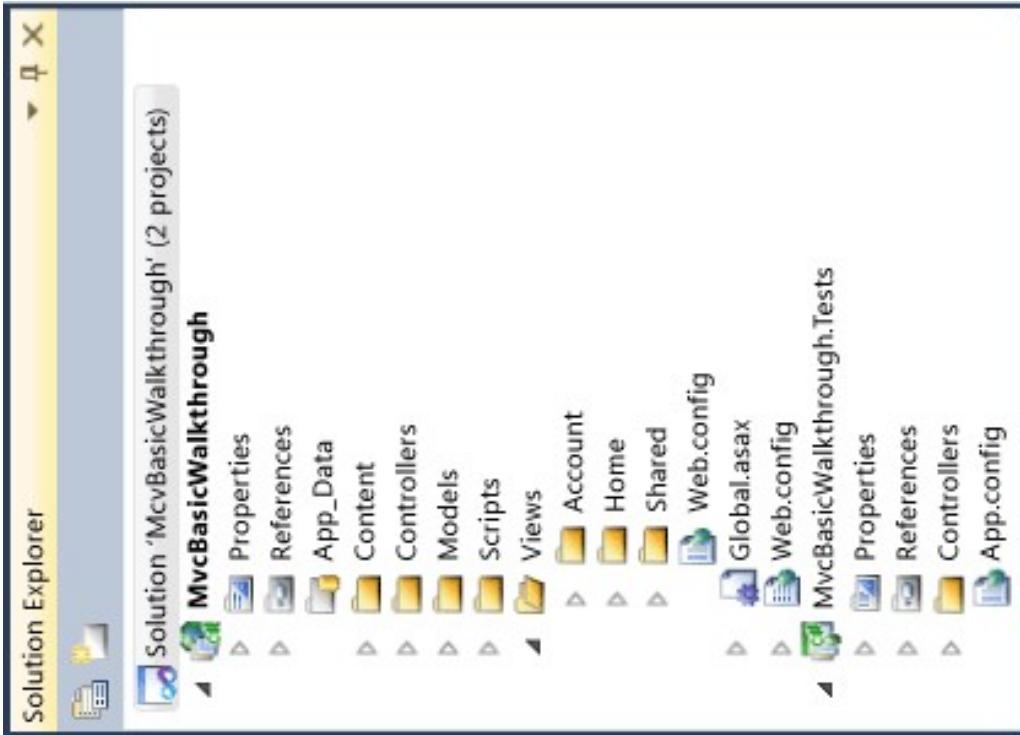
- Extensive support for ASP .NET routing
- Building apps with comprehensible and searchable URLs
- Customizable URLs
 - Adapted to work well with search engines
 - Adapted to REST addressing
 - Decoupled from resource files
- Use of existing ASP .NET features (backward compatibility)

ASP .NET MVC App Structure

- URLs mapped to controller classes
- Controller
 - handles requests,
 - executes appropriate logic and
 - calls a View to generate HTML response
- URL routing
 - ASP .NET routing engine (flexible mapping)
 - Support for defining customized routing rules
 - Automatic passing/parsing of parameters

ASP .NET App Structure

- No Postback interaction!
- All user interactions routed to a controller
- No view state and page lifecycle events



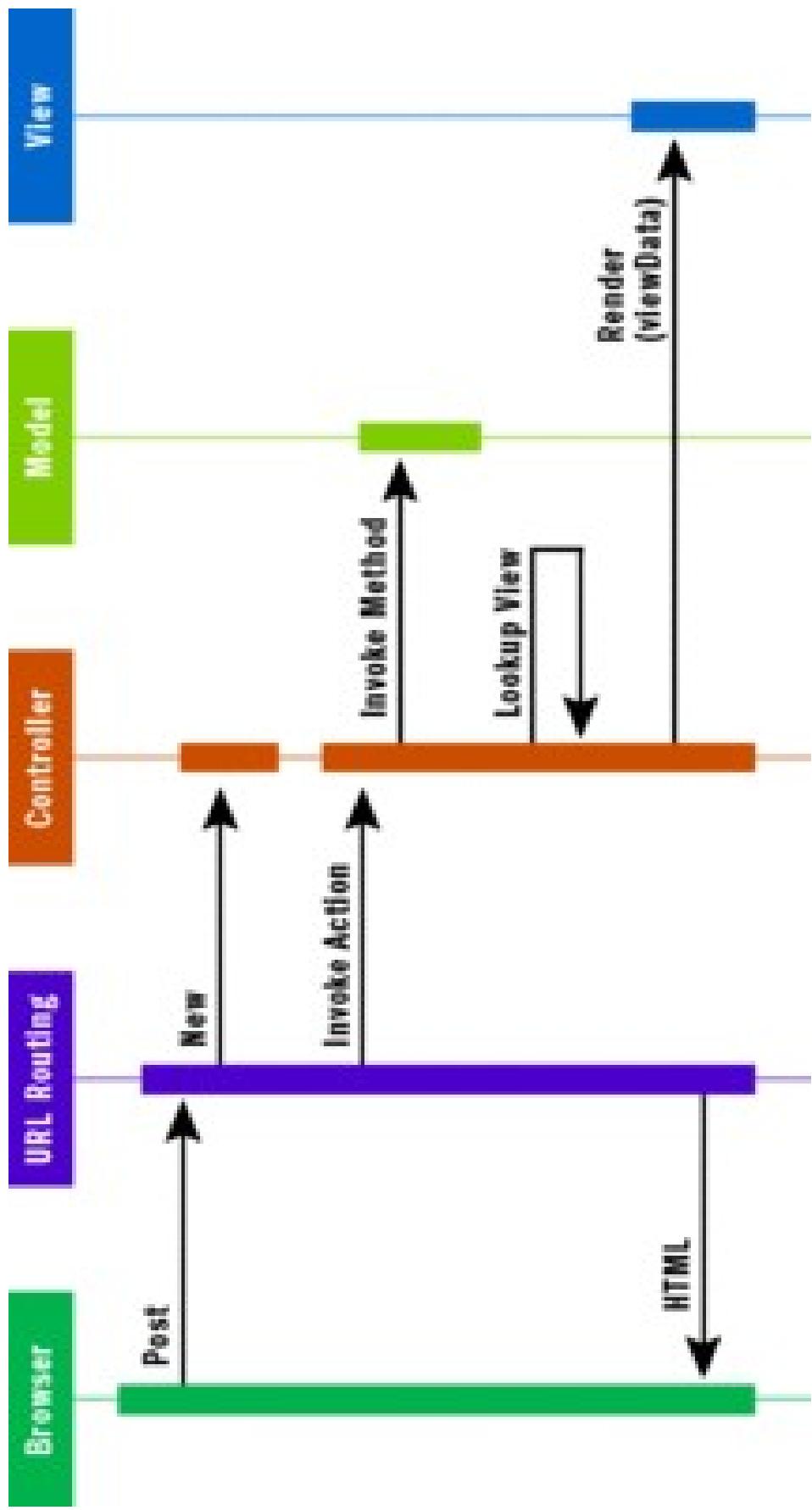
MVC App Execution

- Entry points to MVC:
 - UrlRoutingModule and MvcRouteHandler
- Request handling:
 - Select appropriate controller
 - Obtain a specific controller instance
 - Call the controller's Execute method

MVC App Execution - stages

- Receive first request for the application
 - Populating RouteTable
- Perform routing
- Create MVC Request handler
- Create controller
- Execute controller
- Invoke action
- Execute result
 - ViewResult, RedirectToRouteResult, ContentResult, FileResult, JsonResult, RedirectResult

MVC App Execution



BUILDING VIEW PAGES USING RAZOR LANGUAGE

RAZOR ENGINE

Razor Engine

- A new view-engine
- Optimized around HTML generation
- Code-focused templating approach

Razor Engine – Design goals

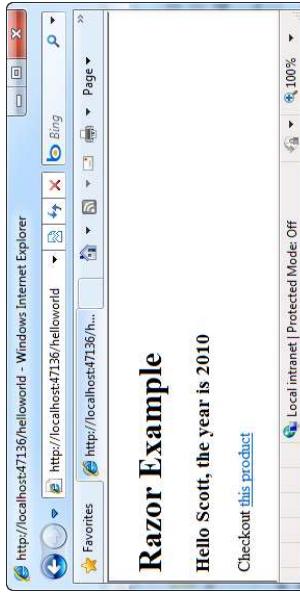
- Compact, Expressive and Fluid
- Easy to learn
- It is not a new language
- Works with any text editor
- Great Intellisense
- Unit-testable
 - Testing views without server, controllers...

Razor – HellоЖorld

- Uses @ for
Razor blocks

razor file

```
<h1>Razor Example</h1>
```



Razor Example

Hello Scott, the year is 2010

[Checkout this product](#)

.aspx file

```
<h1>Code Nugget Example with .ASPx file</h1>
```

```
<h3>Hello <%=name %>, the year is <%= DateTime.Now.Year %></h3>
```

```
<p>Checkout <a href="/Products/Details/<%=productId %>">this product</a></p>
```

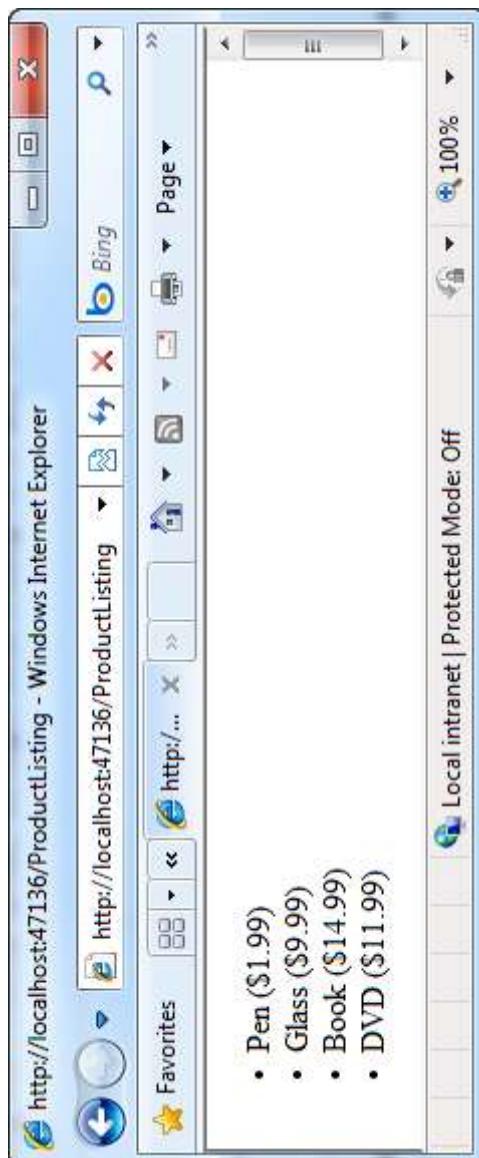
Loops and Nested HTML

Razor syntax

```
<ul id="products">  
    @foreach(var p in products) {  
        <li>@p.Name ($@p.Price)</li>  
    }  
</ul>
```

.aspx syntax

```
<ul id="products">  
    <% foreach(var p in products) { %>  
        <li><%=p.Name%> ($<%=p.Price%>)</li>  
    %>  
</ul>
```



If Blocks and Multi-line Statements

If statement

```
@if(products.Count == 0) {  
    <p>Sorry - no products in this category</p>  
} else {  
    <p>We have a products for you!</p>  
}
```

Multi-Token
statement

```
<p>Your Message: @("Number is: " + number)
```

Multi-line
statement

```
@{  
    int number = 1;  
    string message = "Number is" " + number;  
}  
  
<p>Your Message: @message</p>
```

Variables can span
multiple server
code blocks!

Integrating Content and Code

Parser examines right-hand side of @ character.

```
<p> Send mail to scottgu@microsoft.com telling him the time: @DateTime.Now.</p>
```

```
<p> Send mail to scottgu@microsoft.com telling him the time: 7/2/2010 1:53:12 PM.</p>
```

Identifying nested content with HTML block tag

```
@if (DateTime.Now.Year == 2010) {  
    <span>  
        if year is 2010 then print this <br/>  
        multi-line text block and  
        the date: @DateTime.Now  
    </span>  
}
```

Layout/Master page

```
<!DOCTYPE html>
<html>
  <head>
    <title>Simple Site</title>
  </head>
  <body>

    <div id="header">
      <a href="/">Home</a>
      <a href="/About">About</a>
    </div>

    <div id="body">
      @RenderBody()
    </div>
  </body>
</html>
```

SiteLayout.cshtml

@RenderBody()
Including specific body content.

Content page

```
@{ LayoutPage = "SiteLayout.cshtml"; }
```

Explicitly setting LayoutPage property.

```
<h1>About This Site</h1>
```

```
<p>
```

This is some content that will make up the "about" page of our web-site. We'll use this in conjunction with a layout template. The content you are seeing here comes from the Home.cshtml file.

```
</p>
```

```
<p>
```

And obviously I can have code in here too. Here is the current date/time: **@DateTime.Now**

```
</p>
```

```
<!DOCTYPE html>
```

```
<html>
```

```
<head>
```

```
<title>Simple Site</title>
```

```
</head>
```

```
<body>
```

```
<div id="header">
```

```
<a href="/">Home</a>
```

```
<a href="/About">About</a>
```

```
</div>
```

```
<div id="body">
```

```
<h1>About This Site</h1>
```

```
<p> This is some content that will make up the "about" page of our web-site. We'll use this in conjunction with a layout template. The content you are seeing here comes from the Home.cshtml file.
```

```
</p>
```

```
<p> And obviously I can have code in here too. Here is the current date/time: 7/2/2010 2:53:24 PM
```

```
</p>
```

```
</div>
```

```
</body>
```

```
</html>
```

Complete HTML page.

Master page – section overrides

```
<!DOCTYPE html>
<html>
<head>
    <title>Simple Site</title>
</head>
<body>

    <div id="header">
        <a href="/">Home</a>
        <a href="/About">About</a>
    </div>

    <div id="left-menu">
        @RenderSection("menu", optional:true)
    </div>

    <div id="body">
        @RenderBody()
    </div>

    <div id="footer">
        @RenderSection("footer", optional:true)
    </div>
</body>
</html>
```

This section is optional.

This section is optional.

Master page – section overrides

```
<!DOCTYPE html>
<html>
  <head>
    <title>Simple Site</title>
  </head>
  <body>

    <div id="header">
      <a href="/">Home</a>
      <a href="/About">About</a>
    </div>

    <div id="left-menu">
      @RenderSection("menu", optional:true)
    </div>

    <div id="body">
      @RenderBody()
    </div>

    <div id="footer">
      @RenderSection("footer", optional:true)
    </div>
  </body>
</html>
```

```
<h1>About This Site</h1>
```

```
<p>
  This is some content that will make up the "about"
  page of our web-site. We'll use this in conjunction
  with a layout template. The content you are seeing here
  comes from the Home.cshtml file.
</p>
```

```
<p>
  And obviously I can have code in here too. Here is the
  current date/time: @DateTime.Now
</p>
```

Named section.

```
@section menu {
  <ul id="sub-menu">
    <li>About Item 1</li>
    <li>About Item 2</li>
  </ul>
}
```

Named section.

```
@section footer {
  <p>This is my custom footer for Home</p>
}
```

Master page – result html

```
<!DOCTYPE html>
<html>
<head>
<title>Simple Site</title>
</head>
<body>

<div id="header">
<a href="/">Home</a>
<a href="/about">About</a>
</div>

<div id="left-menu">
<ul id="sub-menu">
<li>About Item 1</li>
<li>About Item 2</li>
</ul>
</div>

<div id="body">
<h1>About This Site</h1>
<p> This is some content that will make up the "about" page of our web-site. We'll use this in conjunction with a layout template. The content you are seeing here comes from the Home.cshtml file.</p>
<p> And obviously I can have code in here too. Here is the current date/time: 7/2/2010 3:34:05 PM</p>
</div>

<div id="footer">
<p>This is my custom footer for Home</p>
</div>
</body>
</html>
```

Re-usable “HTML Helpers”

- Methods that can be invoked within code-blocks
- Encapsulate generating HTML
- Implemented using pure code
- Work with Razor engine

```
<fieldset>
    <legend>Edit Product</legend>
    <div>
        @Html.LabelFor(m => m.ProductID)
    </div>
    <div>
        @Html.TextBoxFor(m => m.ProductID)
        @Html.ValidationMessageFor(m => m.ProductID)
    </div>
</fieldset>
```

Built-in HTML helper

Define own HTML helpers

@helper
declarative syntax

Helper's parameters (full
language and debugging support)

```
@Helper ProductListing(List<Product> products) {  
  
    <ul id="products">  
        @foreach(var p in products) {  
            <li>@p.Name ($@p.Price)</li>  
        }  
    </ul>  
}
```

HTML Helper definition

HTML Helper should be placed
to Views\Helper directory.

```
<body>
```

```
<h1>Here are My Products</h1>
```

```
<div>  
    @ProductListing(Model.Products)  
</div>
```

```
</body>
```

HTML Helper Invocation

Visual Studio support

The screenshot shows the Microsoft Visual Studio interface with the title "RazorSample - Microsoft Visual Studio". The menu bar includes File, Edit, View, Project, Build, Debug, Team, Data, Tools, Architecture, Test, Analyze, Window, Help, and a dropdown for "Any CPU". The toolbar has icons for New, Open, Save, Print, and others.

The Solution Explorer window on the right shows a project named "RazorSample" with files like Properties, References, App_Data, Content, Controllers, Models, Scripts, Views, Account, Home, About.aspx, Index.aspx, Products, Shared, List.cshtml, Global.asax, Web.config, and Web.config.

The main code editor window displays the file "List.cshtml" with the following content:

```
<h1>Products</h1>
<ul id="products">
    @foreach (var p in Model.Products) {
        <li>@p.</li>
    }
</ul>
```

A tooltip is shown over the variable "p" in the foreach loop, listing its properties: Category, Equals, GetHashCode, GetType, Name, ToString, and UnitPrice.

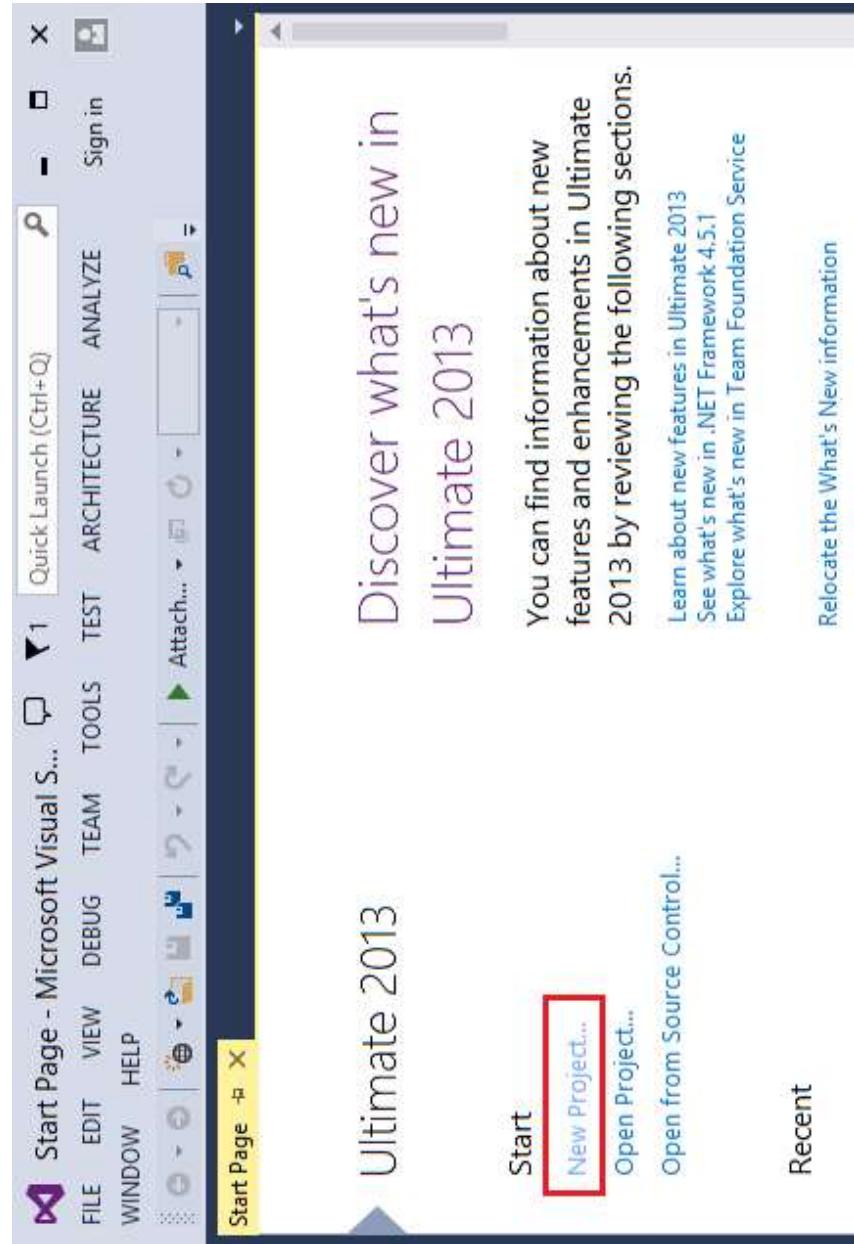
The status bar at the bottom shows "Ready", "Ln 14", "Ch 20", "Col 20", "Ch 20", "Ln 14", "INS", "INS", "100%", and a zoom slider.

Razor – Summary

- A good new view engine
- Code-focused templating
- Fast and expressive
- Compact syntax
- Integrated with C# and VB

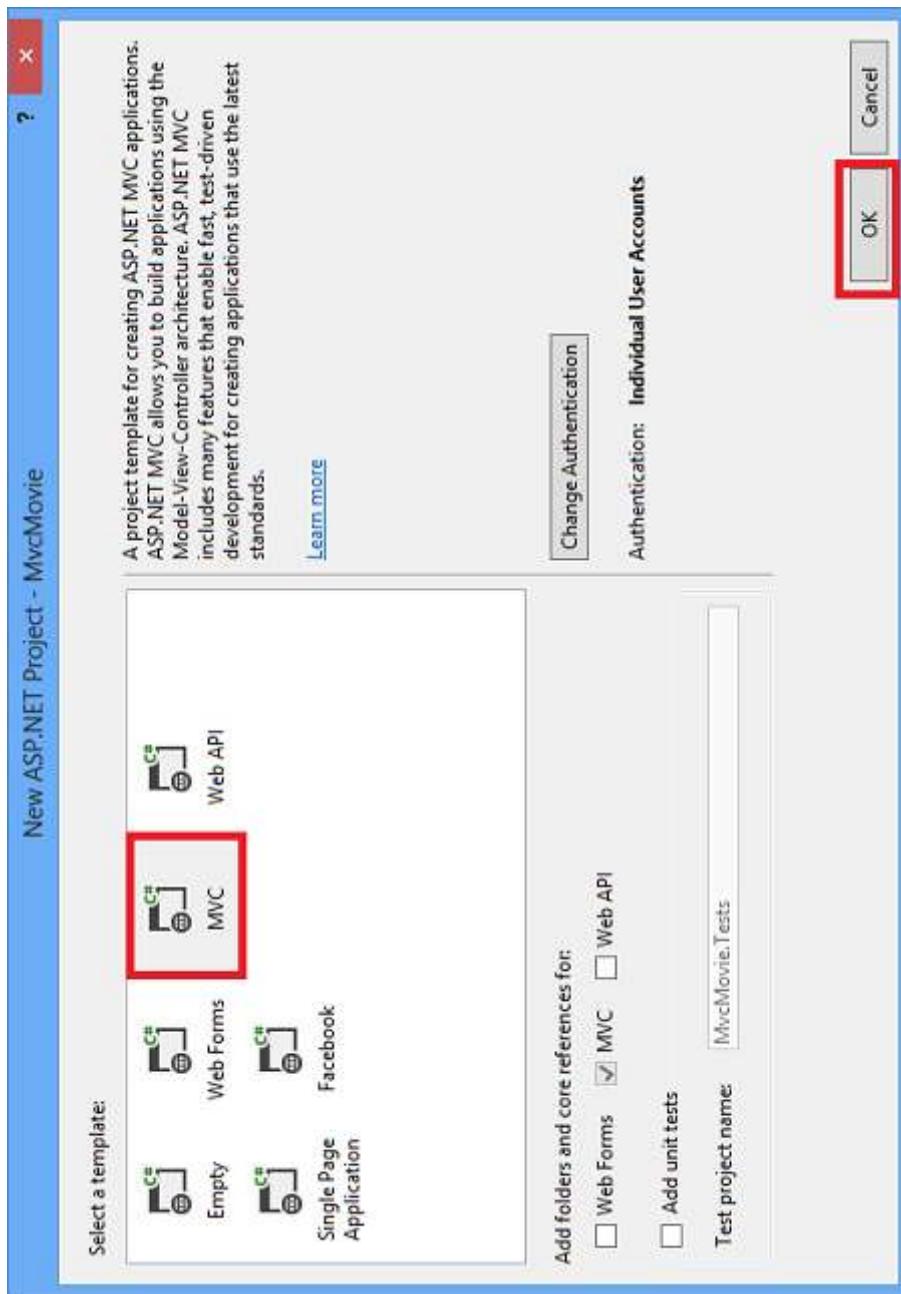
CREATING ASP .NET MVC APPLICATION

New Project ...

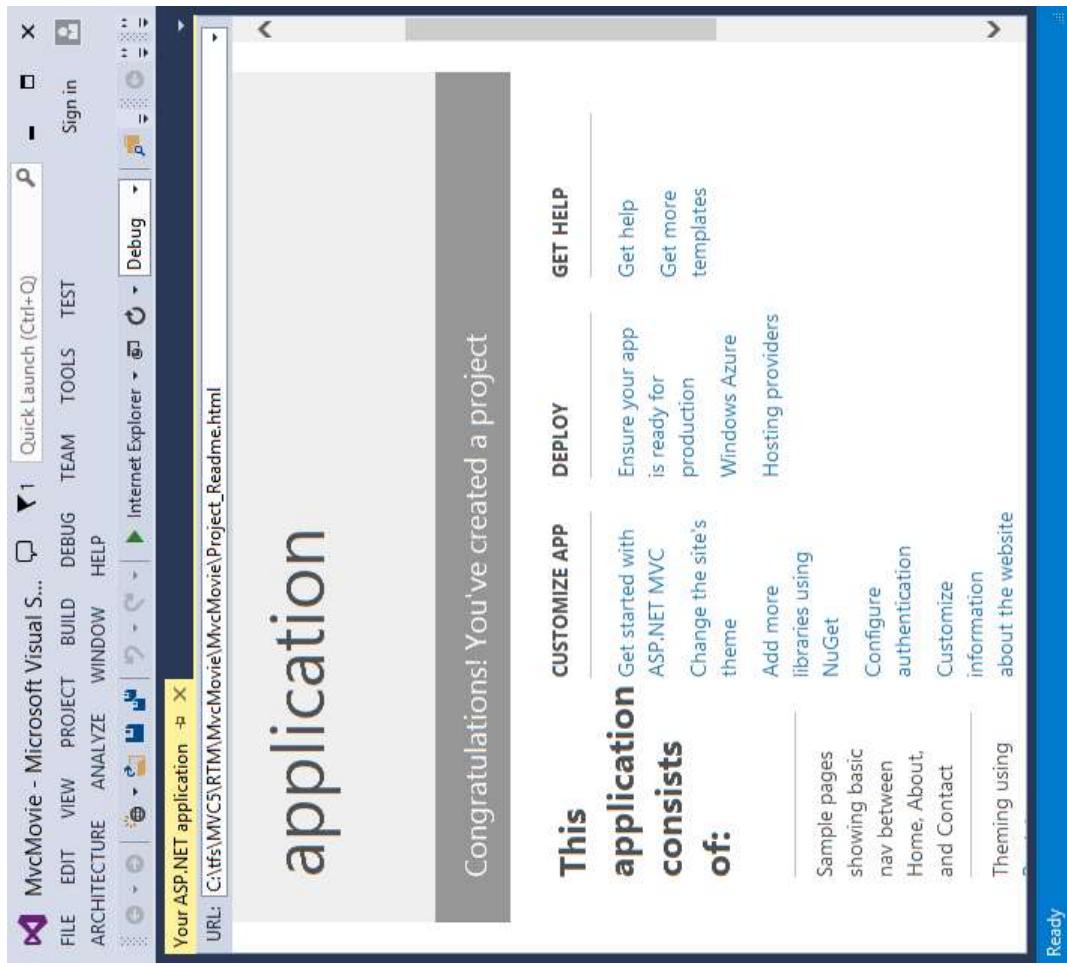




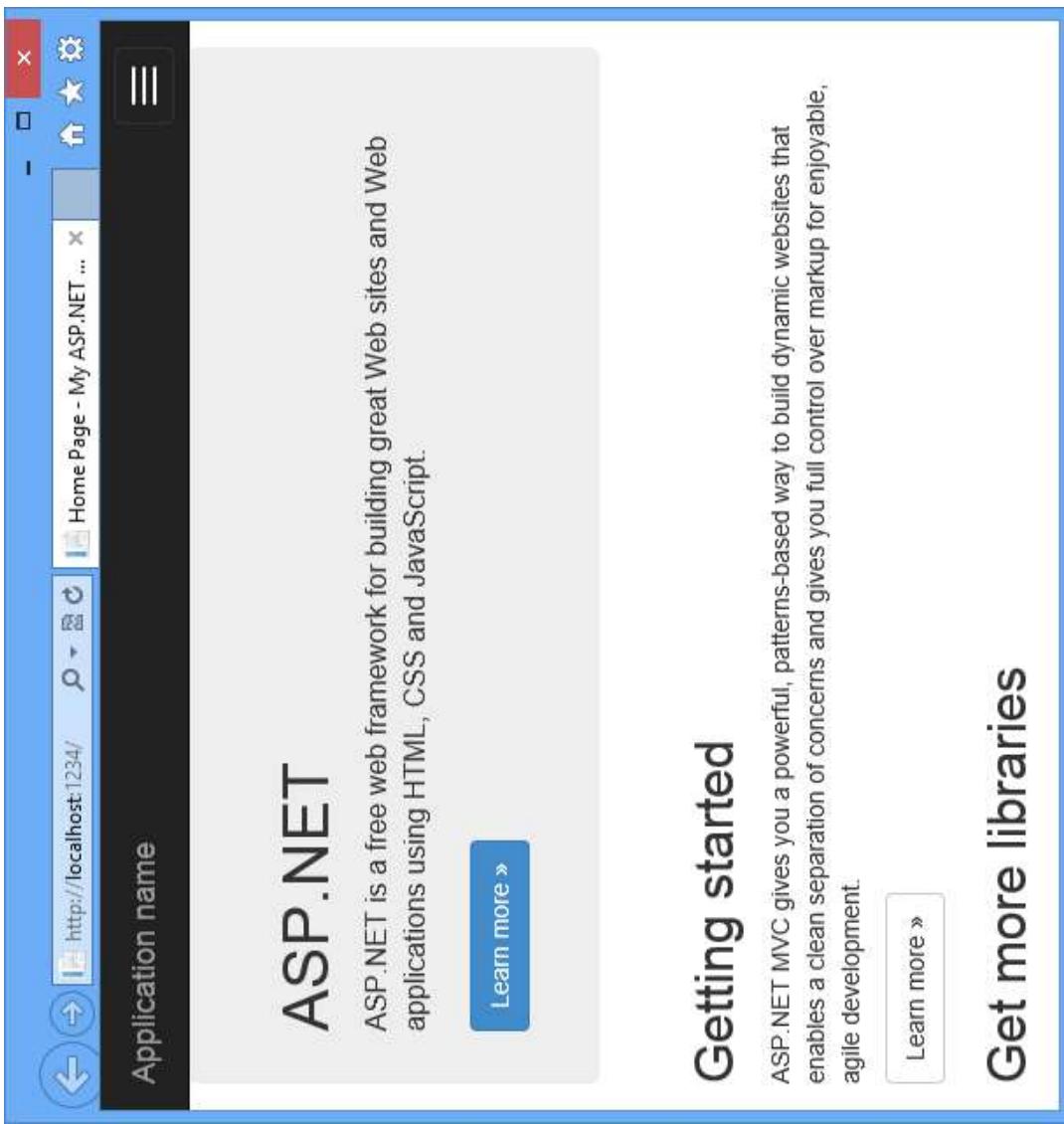
Select the project template



ASP .NET MVC App Home page



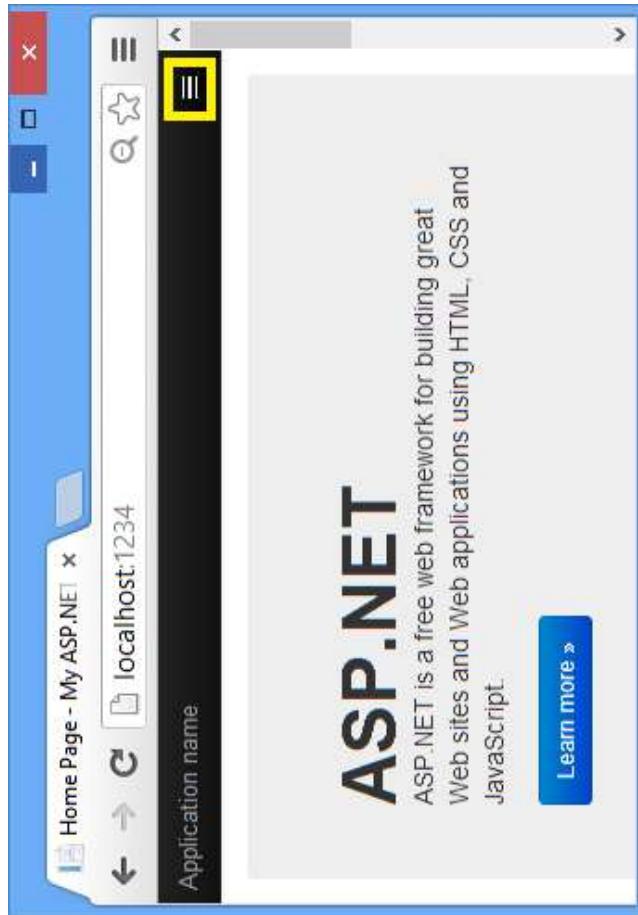
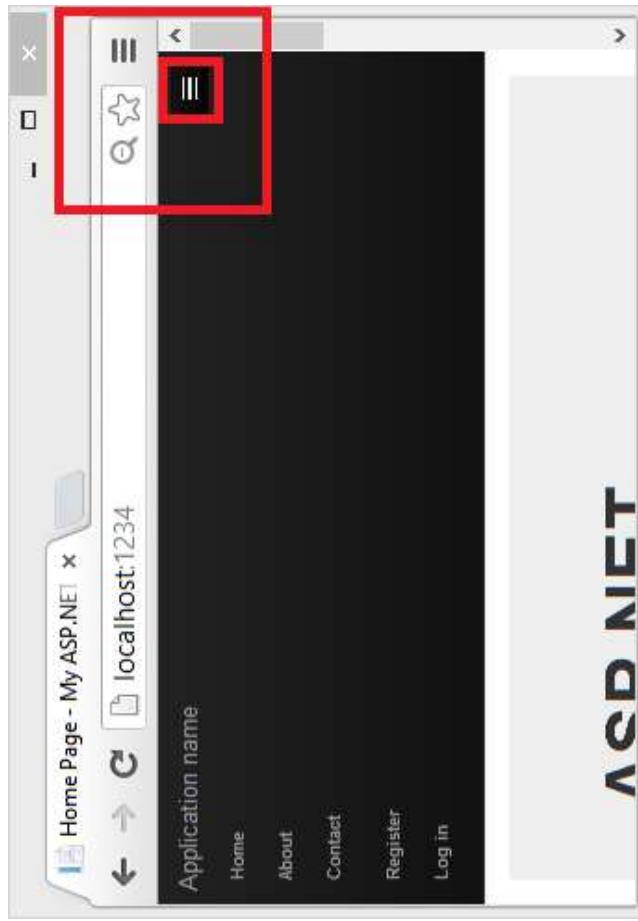
Run the application...



The screenshot shows a web browser window with the following details:

- Title Bar:** Home Page - My ASP.NET ...
- Address Bar:** http://localhost:1234/
- Toolbar:** Back, Forward, Stop, Refresh, Home, Favorites, Settings.
- Header:** Application name (with a three-dot menu icon).
- Main Content Area:**
 - Section Header:** ASP.NET
 - Description:** ASP.NET is a free web framework for building great Web sites and Web applications using HTML, CSS and JavaScript.
 - Link:** Learn more »
- Right Sidebar:**
 - Section Header:** Getting started
 - Description:** ASP.NET MVC gives you a powerful, patterns-based way to build dynamic websites that enables a clean separation of concerns and gives you full control over markup for enjoyable, agile development.
 - Link:** Learn more »
- Bottom Sidebar:**
 - Section Header:** Get more libraries

Expand the default App menu

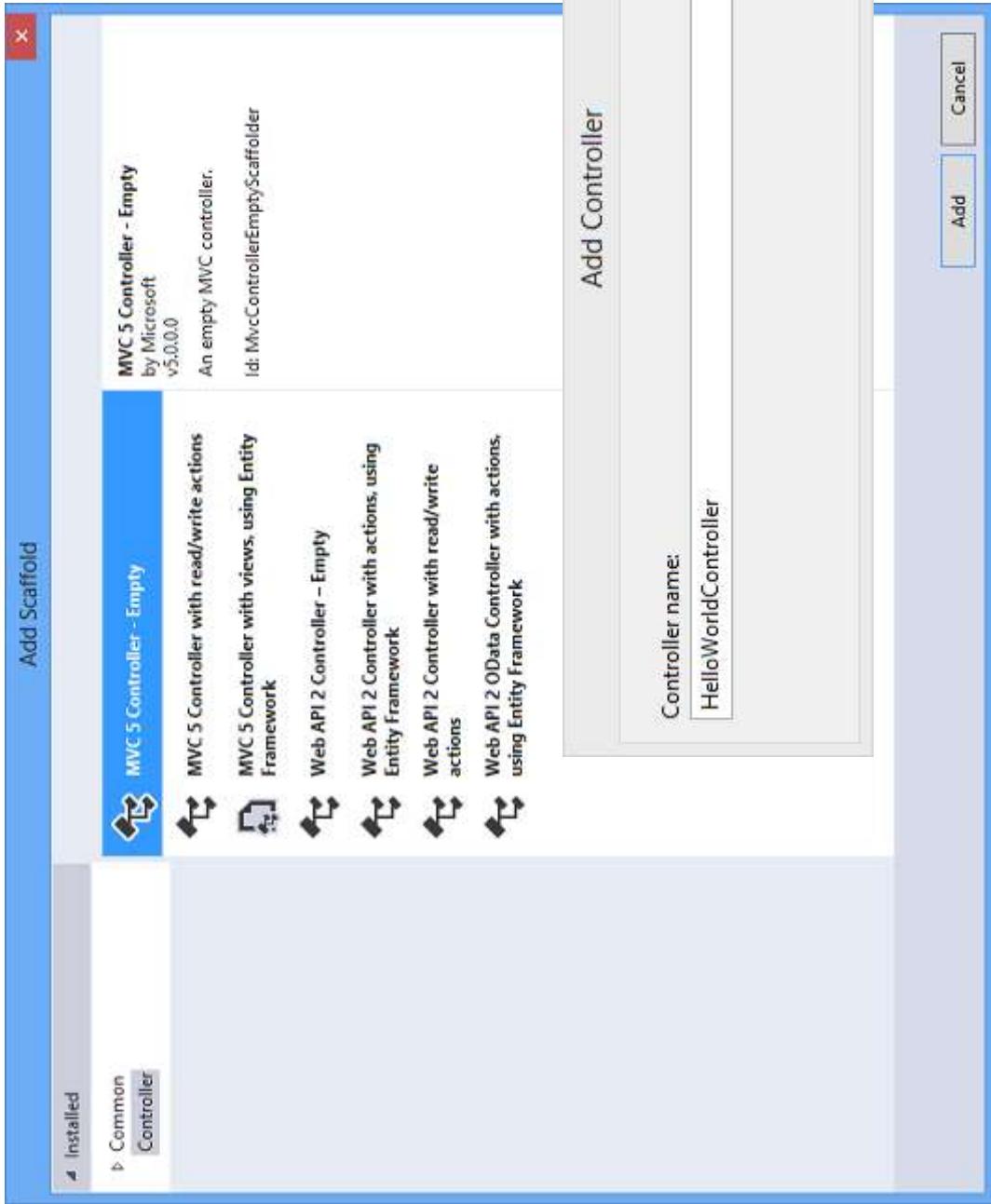


ADDING CONTROLLER

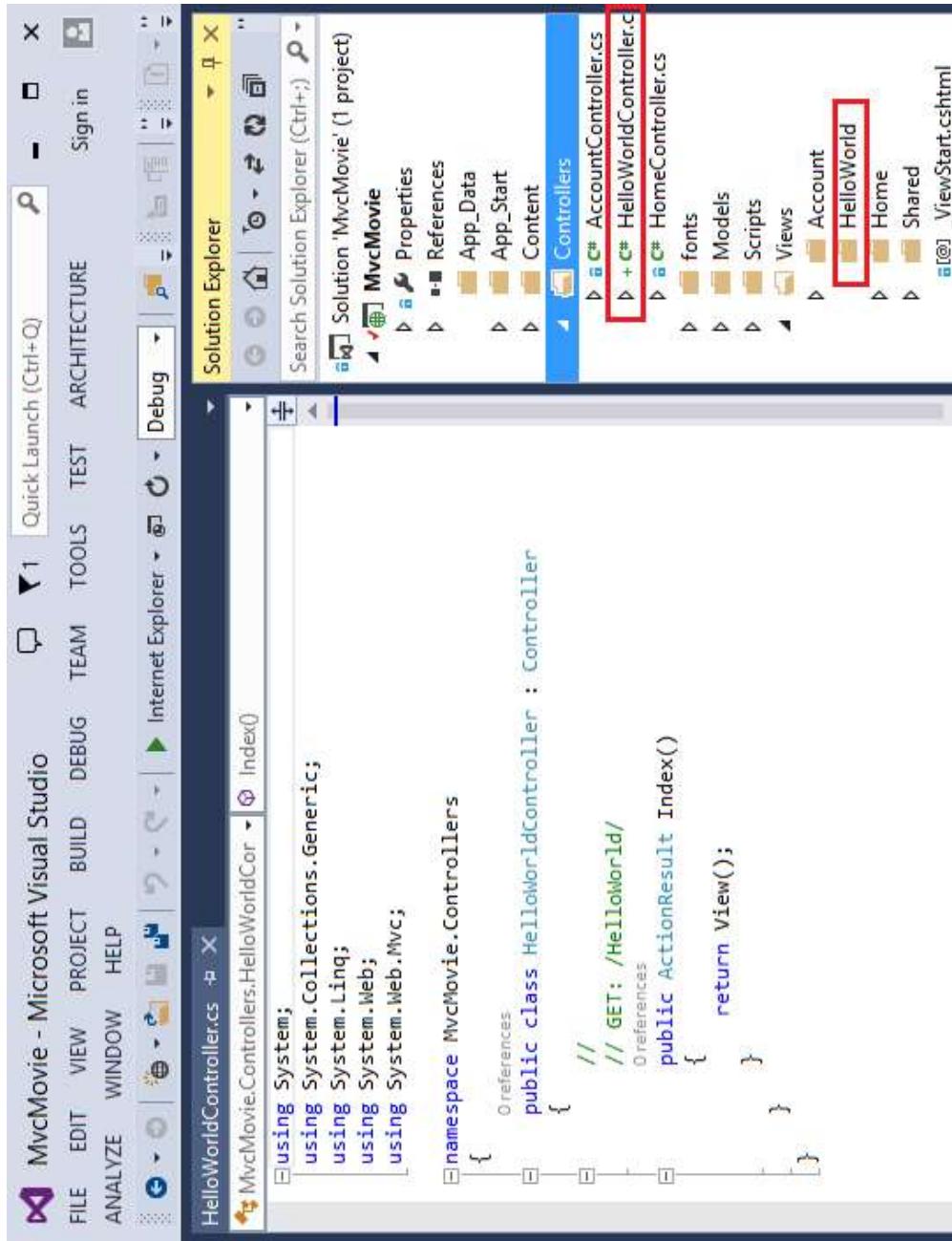
Adding controller



Adding controller (cont.)



Adding a controller (cont.)



The screenshot shows the Microsoft Visual Studio interface with the following details:

- MenuBar:** FILE, EDIT, VIEW, PROJECT, BUILD, DEBUG, TEAM, TOOLS, TEST, ARCHITECTURE.
- Solution Explorer:** Shows the project 'MvcMovie' (1 project) with items: MvcMovie (selected), Properties, References, App_Data, App_Start, Content, Controllers (selected), AccountController.cs, HelloWorldController.cs (highlighted with a red box), HomeController.cs, fonts, Models, Scripts, Views, Account (highlighted with a red box), Home (highlighted with a red box), Shared, and _ViewStart.cshtml.
- Code Editor:** The 'HelloWorldController.cs' file is open, showing the following code:

```
MvcMovie - Microsoft Visual Studio      T1  Quick Launch (Ctrl+Q)  P  -  □  X
FILE  EDIT  VIEW  PROJECT  BUILD  DEBUG  TEAM  TOOLS  TEST  ARCHITECTURE  Sign in
ANALYZE  WINDOW  HELP
Solution Explorer  ▾  Internet Explorer  ▾  Debug  ▾
Solution Explorer (Ctrl+)  P  ▾
Solution 'MvcMovie' (1 project)
  MvcMovie
    Properties
    References
    App_Data
    App_Start
    Content
    Controllers
      AccountController.cs
      + C# HelloWorldController.cs (highlighted with a red box)
      HomeController.cs
      fonts
      Models
      Scripts
      Views
      Account (highlighted with a red box)
      Home (highlighted with a red box)
      Shared
      _ViewStart.cshtml

HelloWorldController.cs  ▾
using System;
using System.Collections.Generic;
using System.Linq;
using System.Web;
using System.Web.Mvc;

namespace MvcMovie.Controllers
{
    public class HelloWorldController : Controller
    {
        // GET: /HelloWorld/
        public ActionResult Index()
        {
            return View();
        }
    }
}
```

Testing the controller

```
using System.Web;
using System.Web.Mvc;

namespace MvcMovie.Controllers
{
    public class HelloWorldController : Controller
    {
        // GET: /HelloWorld/
        public string Index()
        {
            return "This is my <b>default</b> action...";
        }

        // GET: /HelloWorld/Welcome/
        public string Welcome()
        {
            return "This is the Welcome action method...";
        }
    }
}
```



Mapping controller

- Controller selection based on URL
- Default URL routing logic:
/[Controller]/[ActionName]/[Parameters]
- Format for routing in
App_Start/RouteConfig.cs

```
public static void RegisterRoutes(RouteCollection routes)
{
    routes.IgnoreRoute("{resource}.axd/{*pathInfo}");

    routes.MapRoute(
        name: "Default",
        url: "{controller}/{action}/{id}",
        defaults: new { controller = "Home", action = "Index", id = UrlParameter.Optional });
}
```

URL routing

- Webapp URL without URL segments =>
`HomeController::Index()`
- `Index()` – default method of a controller
- `/HelloWorld` => `HelloWorldController`
- `/HelloWorld/Index` =>
`HelloWorldController::Index()`
- `http://webapp:port/HelloWorld/Welcome` =>
`HelloWorldController::Welcome()`

Parameters

- /HelloWorld/Welcome?name=Scott&numTimes=4
- Introducing 2 parameters to Welcome method
- Parameters passed as query strings!

```
public string Welcome(string name, int numTimes = 1) {  
    return HttpUtility.HtmlEncode("Hello " + name + ", NumTimes is: " + numTimes);  
}
```



URL Parameters

- <http://webapp/Helloworld/Welcome/3?name=Rick>



Parameter ID matches URL specification
in RegisterRoutes method.

```
public static void RegisterRoutes(RouteCollection routes)
{
    routes.IgnoreRoute("{resource}.axd/{*pathInfo}");

    routes.MapRoute(
        name: "Default",
        url: "{controller}/{action}/{id}",
        defaults: new { controller = "Home", action = "Index", id = UrlParameter.Optional }
    );
}
```

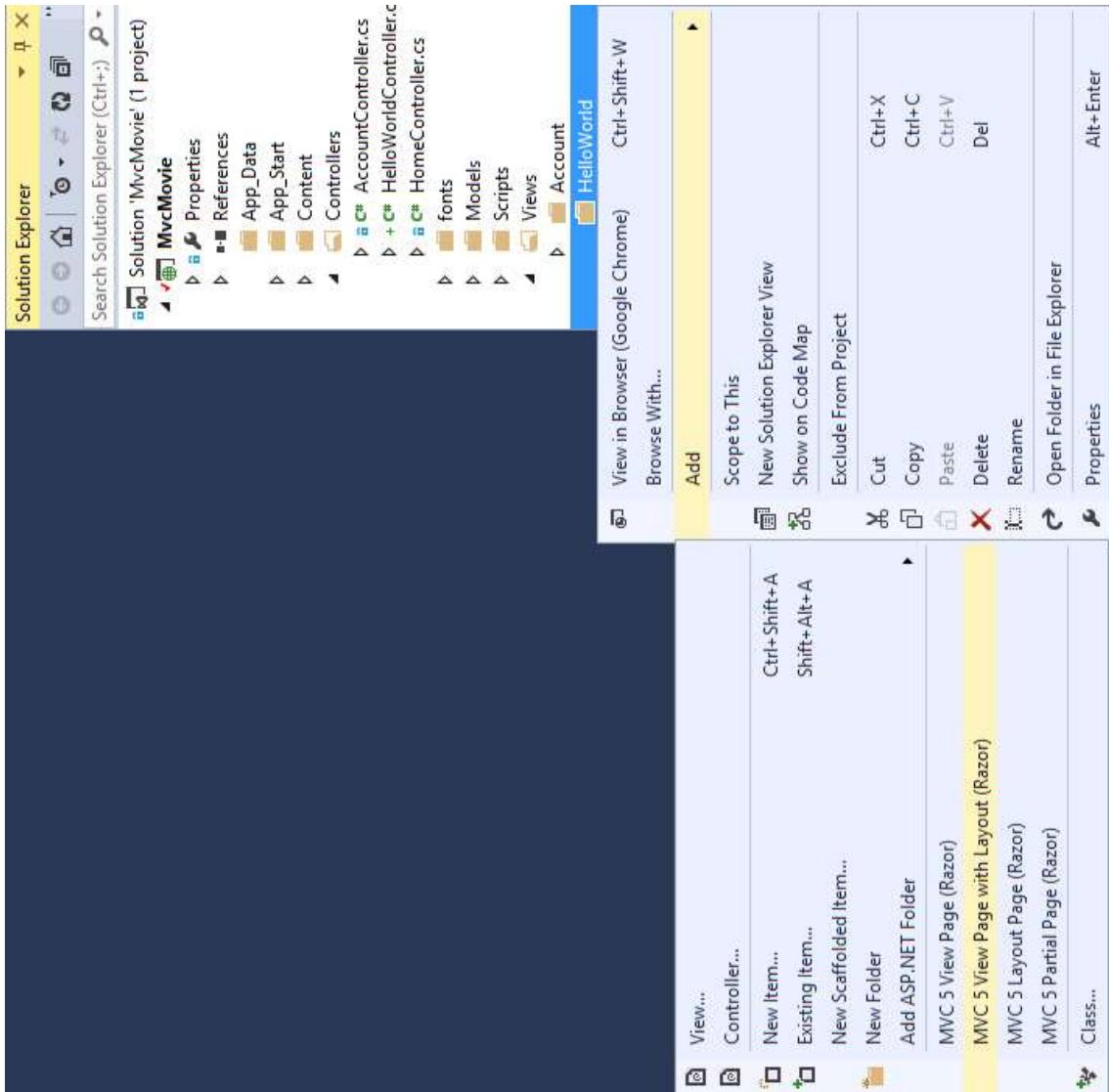
ADDING A VIEW

Views

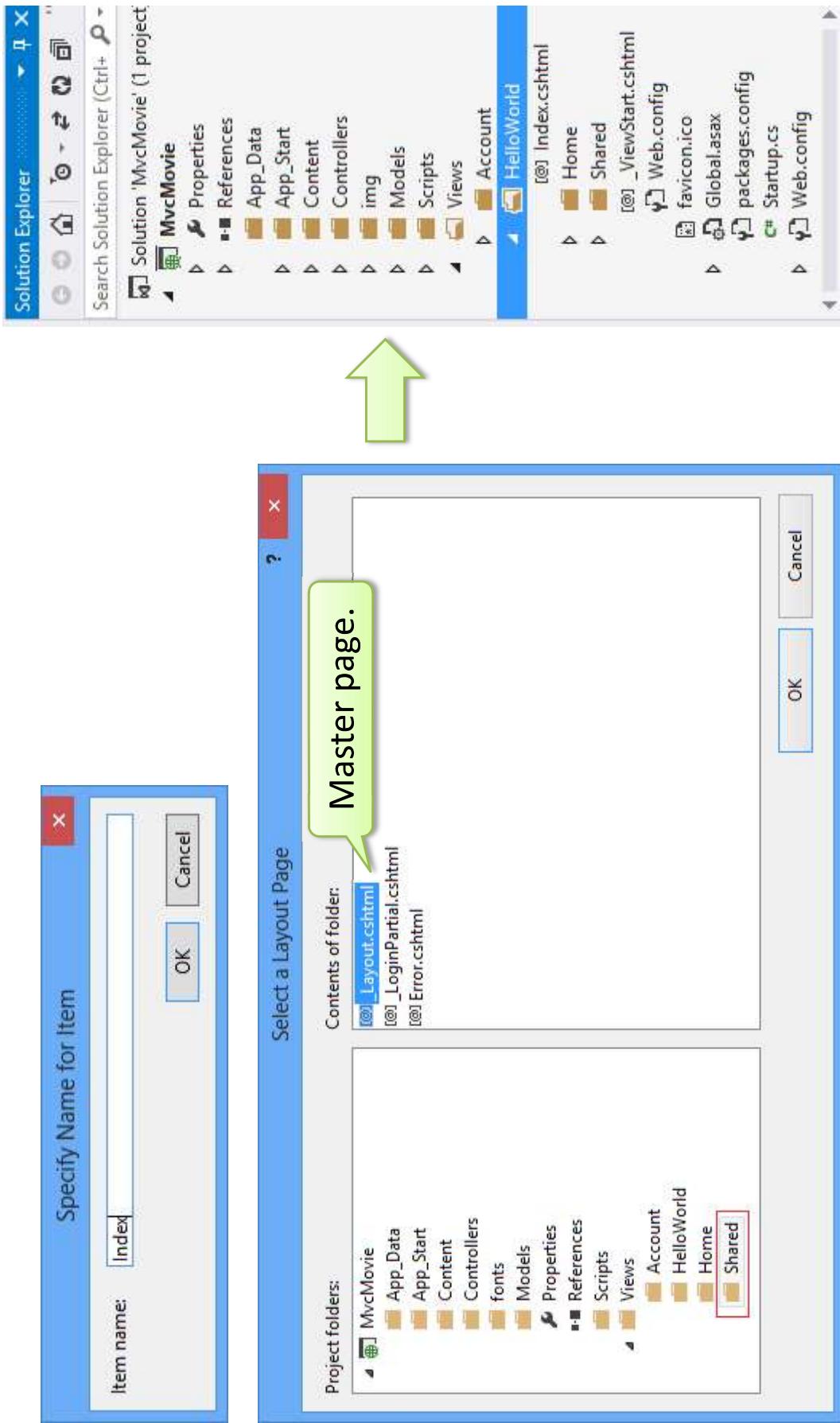
- Views created using Razor view engine
- Controller method returns View object
- Controller method return type is ActionResult
- Common pattern: all view pages share the same master layout page

```
public ActionResult Index()
{
    return View();
}
```

Create View page



Create View page

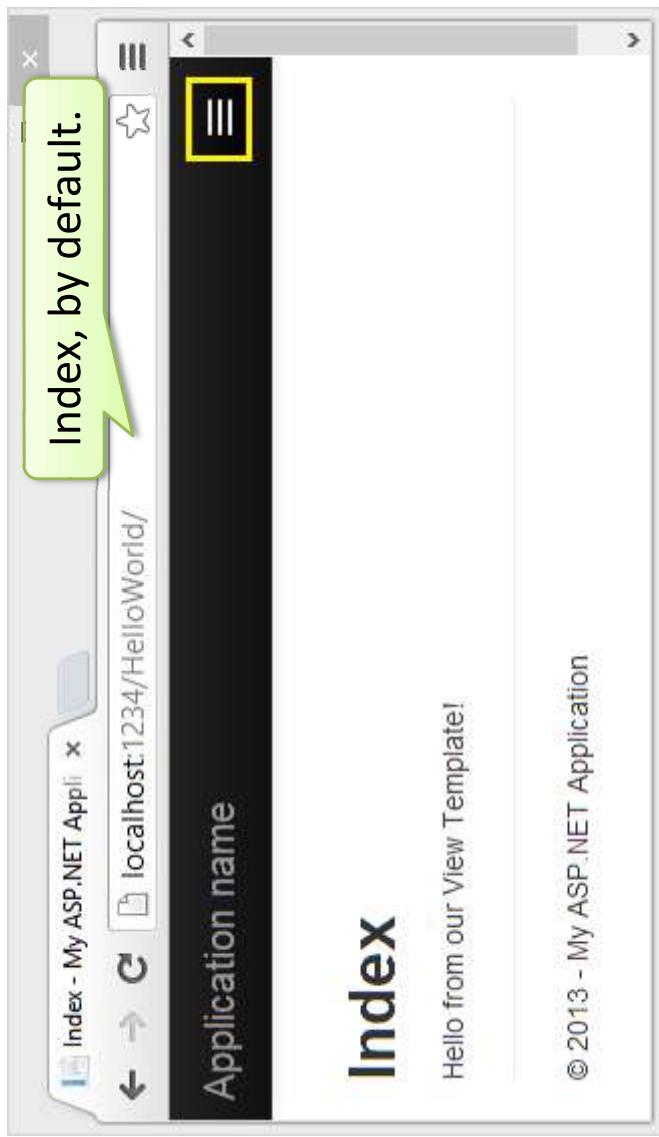


Implementing View page

Selected master page.

```
@{ Layout = "~/Views/Shared/_Layout.cshtml"; }  
@{ ViewBag.Title = "Index"; }  
<h2>Index</h2>  
<p>Hello from our View Template!</p>
```

Index, by default.



```
public ActionResult Index()  
{  
    return View();  
}
```

Change controller's method signature.
The method returns a view object:
searches a view file that is named the
same as the method (Index.cshtml).

ViewBag

- Pass data between view template and layout view file
- ViewBag is a dynamic object
(has no defined properties)

View template file.

```
<!DOCTYPE html>
<html>
<head>
    <meta charset="utf-8" />
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <title>@ViewBag.Title - Movie App</title>
    @Styles.Render("~/Content/css")
    @Scripts.Render("~/bundles/modernizr")
</head>
```

Layout view file.

```
@{
    ViewBag.Title = "Movie List";
}

<h2>My Movie List</h2>
```

```
<p>Hello from our View Template!</p>
```

Passing data from Controller to View

- View is used for data presentation
- Controller must provide a view with the data
 - One approach: using ViewBag
 - Controller puts data to ViewBag,
 - View reads ViewBag and renders the data
 - No data binding!
 - Alternative approach: the view model
 - Strongly typed approach

Passing data from Controller to View

Controller

```
using System.Web;
using System.Web.Mvc;

namespace MvcMovie.Controllers
{
    public class HelloWorldController : Controller
    {
        public ActionResult Index()
        {
            return View();
        }

        public ActionResult Welcome(string name, int numTimes = 1)
        {
            ViewBag.Message = "Hello " + name;
            ViewBag.NumTimes = numTimes;

            return View();
        }
    }
}
```

View

```
@{
    ViewBag.Title = "Welcome"
}

<h2>Welcome</h2>

<ul>
    @for (int i = 0; i < ViewBag.NumTimes; i++)
    {
        <li>@ViewBag.Message</li>
    }
</ul>
```



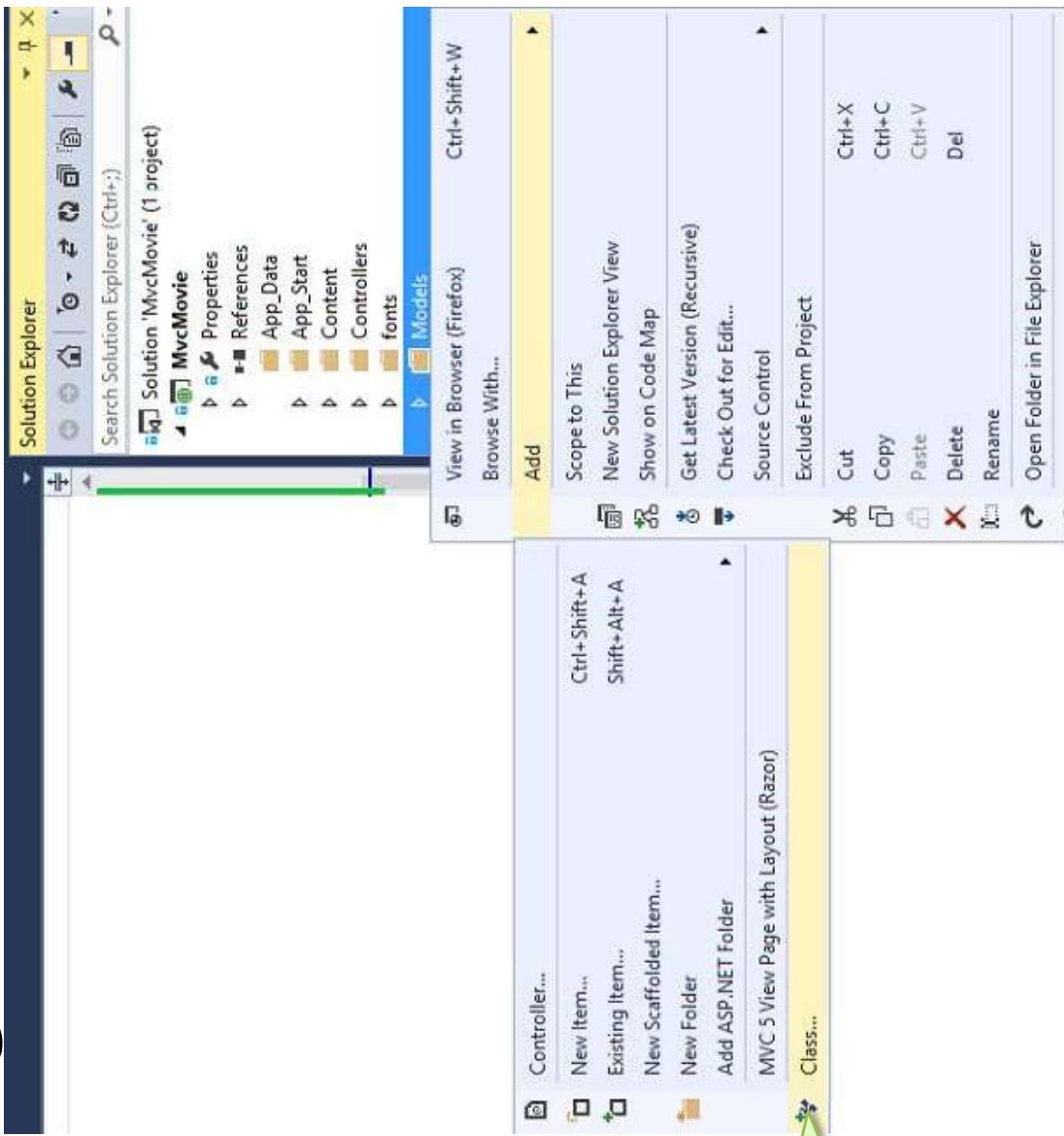
Returns
HelloWorldView
object.

ADDING A MODEL

Model components

- Entity framework - data access technology
- “Code first” development paradigm
(first code classes, then generate DB schema)
- “Database first” development paradigm
define db schema first,
then generate models, controllers and views

Adding a model class



Adding properties to a model class

```
using System;

namespace MvcMovie.Models

{
    public class Movie
    {
        public int ID { get; set; }
        public string Title { get; set; }
        public DateTime ReleaseDate { get; set; }
        public string Genre { get; set; }
        public decimal Price { get; set; }
    }
}
```

Adding a DbContext class

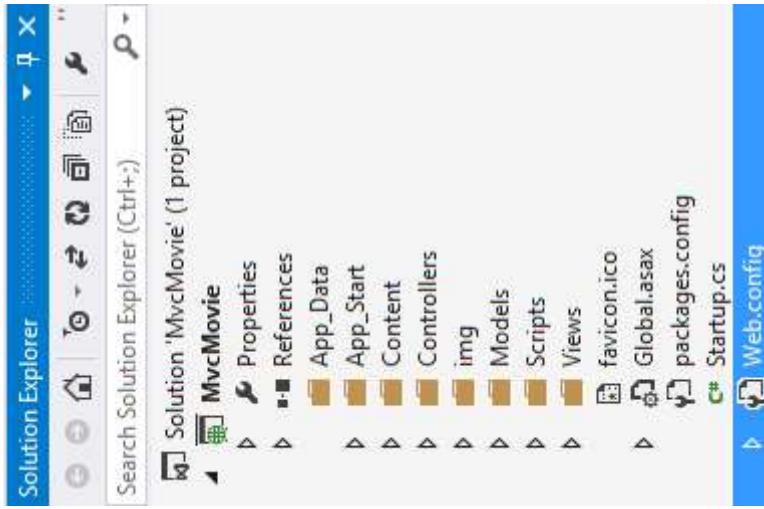
```
using System;
using System.Data.Entity;

namespace MvcMovie.Models
{
    public class Movie
    {
        public int ID { get; set; }
        public string Title { get; set; }
        public DateTime ReleaseDate { get; set; }
        public string Genre { get; set; }
        public decimal Price { get; set; }
    }

    public class MovieDBContext : DbContext
    {
        public DbSet<Movie> Movies { get; set; }
    }
}
```

EF database
context
FETCH,
INSERT,
UPDATE

DB Connection string



```
<?xml version="1.0" encoding="utf-8"?>
<!--
  For more information on how to configure your ASP.NET application, please visit
  http://go.microsoft.com/fwlink/?LinkId=301880
-->

<configuration>
  <configSections>
    <!-- For more information on Entity Framework configuration, visit http://go/
        <section name="entityFramework" type="System.Data.Entity.Internal.ConfigFile
        /></configSections>

  <connectionStrings>
    <add name="DefaultConnection" connectionString="Data Source=(LocalDb)\v11.0"
        providerName="System.Data.SqlClient" />
  </connectionStrings>

  <appSettings>
    <add key="webpages:Version" value="3.0.0.0" />
    <add key="webpages:Enabled" value="false" />
    <add key="PreserveLoginUrl" value="true" />
    <add key="ClientValidationEnabled" value="true" />
    <add key="UnobtrusiveJavaScriptEnabled" value="true" />
  </appSettings>
  <system.web>
```

Separate connection string
for each DbContext class

```
<connectionStrings>
  <add name="MovieDbContext"
    connectionString="Data Source=(LocalDB)\v11.0;AttachDbFilename=|DataDirectory|\Movies.mdf;Integrated Security=True"
    providerName="System.Data.SqlClient" />
  <add name="DefaultConnection"
    connectionString="Data Source=(LocalDB)\v11.0;AttachDbFilename=|DataDirectory|\aspnet-MvcMovie-20130603030321.mdf;
    providerName="System.Data.SqlClient" />
```

Accessing Model from a Controller



Accessing Model from a Controller

The screenshot shows the 'Add Scaffold' dialog in Visual Studio. The 'Installed' tab is selected, displaying several scaffold options:

- MVC 5 Controller - Empty
- MVC 5 Controller with read/write actions
- MVC 5 Controller with views, using Entity Framework** (highlighted)
- Web API 2 Controller - Empty
- Web API 2 Controller with actions, Entity Framework
- Web API 2 Controller with read/write actions
- Web API 2 OData Controller with a using Entity Framework

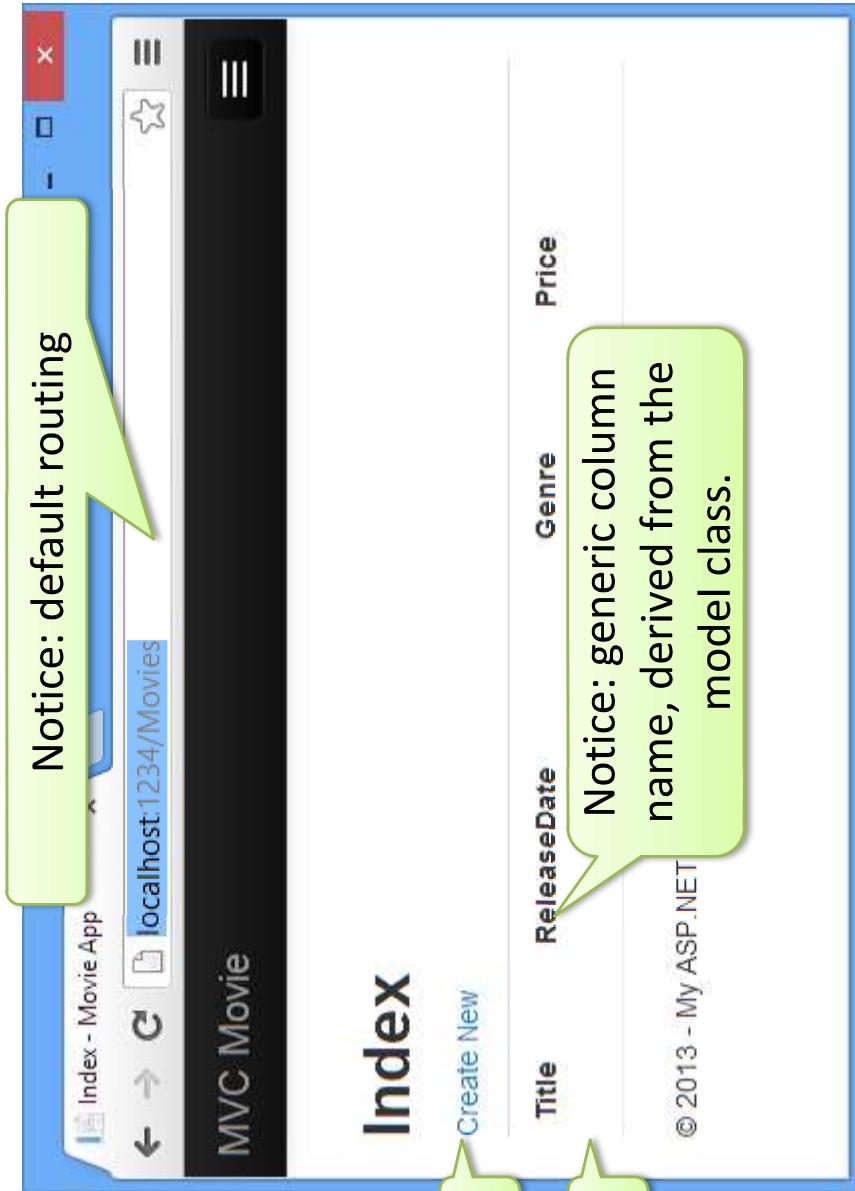
The 'MVC 5 Controller with views, using Entity Framework' option has a detailed description: "An MVC controller with actions and Razor views to create, update, delete, and list entities from an Entity Framework data context." Below this description, there are configuration fields:

- Controller name: `MoviesController`
- Use async controller actions
- Model class: `Movie (MvcMovie.Models)`
- Data context class: `MovieDbContext (MvcMovie.Models)`
- Views:
 - Generate views
 - Reference script libraries
 - Use a layout page

A green callout bubble points to the 'Generate views' checkbox with the text: "Strongly typed approach."

Visual Studio Creates:
A controller `MoviesController.cs` file in Controllers folder,
`Create.cshtml`, `Delete.cshtml`,
`Details.cshtml`, `Index.cshtml` in
`Views\Movies folder.`

Run Application....



Creating a model object

Create

Movie

Title	ReleaseDate	Genre	Price
When Harry Met Sally	1/11/1977	Comedy	\$1.99

Create

Index

Automatically generated form,
based on the model info.

Title	ReleaseDate	Genre	Price	
When Harry Met Sally	1/11/1997	Comedy	\$12.99	Edit Details Delete

63 of 114

Generated Controller class

```
public class MoviesController : Controller
{
    private MovieDbContext db = new MovieDbContext();
    // Instantiated DbContext instance.

    // GET: /Movies/
    public ActionResult Index()
    {
        Index method.
        return View(db.Movies.ToList());
    }
}
```

Strongly typed models

- MVC provides strongly typed way of passing data from Controller to View
- Better compile-time checking
- Richer IntelliSense in VS code editor

Strongly typed models

@model: Specifies class of the model

```
@model MvcMovie.Models.Movie  
{@  
    ViewBag.Title = "Details";  
}  
  
<h2>Details</h2>  
  
<div>  
    <h4>Movie</h4>  
    <hr />  
    <dl class="dl-horizontal">  
        <dt>  
            @Html.DisplayNameFor(model => model.Title)  
        </dt>  
        <dd>  
            @*Markup omitted for clarity.*@  
        </dd>  
    </dl>  
    <p>  
        @Html.ActionLink("Edit", "Edit", new { id = Model.ID }) |  
        @Html.ActionLink("Back to List", "Index")  
    </p>  
}
```

Id parameter generally passed as a part of the route.

```
public ActionResult Details(int? id)  
{  
    if (id == null)  
    {  
        return new HttpStatusCodeResult(HttpStatusCode.BadRequest);  
    }  
    Movie movie = db.Movies.Find(id);  
    if (movie == null)  
    {  
        return HttpNotFound();  
    }  
    return View(movie);  
}
```

Communicates with the master page.

Context-sensitive data access.

Strongly typed models (cont.)

```
@model IEnumerable<MvcMovie.Models.Movie>
```

Index.cshtml

Model object is strongly typed.
Each item is a Movie object.

```
<tr>
    <td>@Html.DisplayFor(modelItem => item.Title)</td>
    <td>@Html.DisplayFor(modelItem => item.ReleaseDate)</td>
    <td>@Html.DisplayFor(modelItem => item.Genre)</td>
    <td>@Html.DisplayFor(modelItem => item.Price)</td>
    <th>@Html.DisplayFor(modelItem => item.Rating)</th>
</tr>
```

The code shows a strongly typed model object (Movie) being used in an ASP.NET MVC view (Index.cshtml). The model is iterated over using a foreach loop, and each item is displayed using the Html.DisplayFor helper method. The strongly typed model allows for the use of Intellisense, as shown by the tooltip for the item variable, which lists properties like ID, GetHashCode, GetType, Equals, GetHashCode, GetID, GetPrice, GetReleaseDate, GetTitle, and ToString.

Full compile-time support.

```
@foreach (var item in Model) {
    <tr>
        <td>@Html.DisplayFor(modelItem => item.Title)</td>
        <td>@Html.DisplayFor(modelItem => item.Genre)</td>
        <td>@Html.DisplayFor(modelItem => item.Price)</td>
        <td>@Html.DisplayFor(modelItem => item.Rating)</td>
        <th>@Html.DisplayFor(modelItem => item.Rating)</th>
    </tr>
}
```

Edit View

The screenshot shows a browser window titled "Index - Movie App". The address bar displays "localhost:1234/movies". The page content is titled "Index" and includes a "Create New" button. Below is a table with three rows of movie data:

Title	Release Date	Genre	Price	Action
When Harry Meet Sally	1/11/1999	Comedy	9.99	Edit Details Delete
Rio Bravo	2/16/1959	Western	3.99	Edit Details Delete
GhostBusters	1/1/1984	Comedy	7.99	Edit Details Delete

A red box highlights the "Edit" link for the "GhostBusters" row. An orange callout bubble points to the URL "localhost:1234/movies/Edit/4". A green callout bubble points to the URL "localhost:1234/movies/Edit/4".

Edit View (cont.)

Firefox ▾

Edit - Movie App

localhost:1234/movies/Edit?id=3

Edit

MVC Movie

Movie

Title: Rio Bravo

Release Date: 2/16/1959

Genre: Western

Price: 3.99

Save

Parameter passed through the URL query.
Works for MVC default URL mapping.

Date format defined in
the model class.

Label defined in the
model class.

Edit View

```
@model MvcMovie.Models.Movie
```

```
@{  
    ViewBag.Title = "Edit";  
}  
} <h2>Edit</h2>
```

```
@using (Html.BeginForm()  
{  
    @Html.AntiForgeryToken()
```

```
<div class="form-horizontal">  
    <h4>Movie</h4>  
    <hr />
```

```
@Html.ValidationSummary(true)  
@Html.HiddenFor(model => model.ID)
```

```
<div class="form-group">  
    @Html.LabelFor(model => model.Title, new { @class = "control-label col-md-2" })
```

```
<div class="col-md-10">  
    @Html.EditorFor(model => model.Title)  
    @Html.ValidationMessageFor(model => model.Title)
```

```
</div>  
</div>
```

```
<input  
    name="RequestVerificationToken"  
    type="hidden"  
    value="Uxy6bkQyJcx03Rkn5AXg-6TxxOj6yyBi9tghHaQ5Lq_qwRvc0jNXXEEfcbn-FGh_0rvw4tS_BRk7QQQH1Jp8AP4_X4torvNoQmp2cd8kXnyks01" />
```

Generates hidden anti-forgery token.

Generates html label.

Generates text box.

Generates validation message.

Property annotations

```
using System;
using System.ComponentModel.DataAnnotations;
using System.Data.Entity;

namespace MvcMovie.Models
{
    public class Movie
    {
        public int ID { get; set; }
        public string Title { get; set; }

        [Display(Name = "Release Date")]
        [DataType(DataType.Date)]
        [DisplayFormat(DataFormatString = "{0:yyyy-MM-dd}", ApplyFormatInEditMode = true)]
        public DateTime ReleaseDate { get; set; }

        public string Genre { get; set; }
        public decimal Price { get; set; }
    }

    public class MovieDbContext : DbContext
    {
        public DbSet<Movie> Movies { get; set; }
    }
}
```

Annotations namespace.

Overrides default label name on the view page.

Specifies type of the data: displays only date part.

Workaround for
a bug in Chrome ☺

ActionLink helper

- `Html.ActionLink` – generates a link according to a given URL mapping policy
- Primer:
`Html.ActionLink("Edit", "Edit", new{id=item.ID})`

Anonymous object – specifies ID of an object

Controller action name.

```
<td>
    [Html.ActionLink("Edit Me", "Edit", new { id=item.ID })]
    [Html. (extension) MvcHtmlString HtmlHelper.ActionLink(string linkText, string actionName, object routeValues)]
    [Html. Returns an anchor element (a element) that contains the virtual path of the specified action,
      Exceptions:
      System.ArgumentException]
```

Edit actions

- Implemented as Controller's operations

HTTP GET operation

```
// GET: /Movies/Edit/5
public ActionResult Edit(int? id)
{
    if (id == null)
    {
        return new HttpStatusCodeResult(HttpStatusCode.BadRequest);
    }
    Movie movie = db.Movies.Find(id);
    if (movie == null)
    {
        return HttpNotFound();
    }
    return View(movie);
}
```

HTTP POST operation

```
[HttpPost]
[ValidateAntiForgeryToken]
public ActionResult Edit([Bind(Include="ID,Title,ReleaseDate,Genre,Price")] Movie movie)
{
    if (ModelState.IsValid)
    {
        db.Entry(movie).State = EntityState.Modified;
        db.SaveChanges();
        return RedirectToAction("Index");
    }
    return View(movie);
}
```

Prevents request forgery

[Bind] attribute – a security mechanism that prevents over-posting data to the model.

[HttpGet] annotation by default.

Processing the POST request

HTTP POST method.

Validates the forgery token.

```
[HttpPost]
[ValidateAntiForgeryToken]
public ActionResult Edit([Bind(Include="ID,Title,ReleaseDate,Genre,Price")] Movie movie)
{
    if (ModelState.IsValid)
    {
        db.Entry(movie).State = EntityState.Modified;
        db.SaveChanges();
        return RedirectToAction("Index");
    }
    return View(movie);
}
```

Checks if sent data are valid – server side validation, compared to client-side validation (javascript)

Redirects after successful update.

In case of invalid data, the original form is returned back to the client, displaying error messages

Movie

Title	<input type="text" value="Rio Bravo"/>
Release Date	<input type="text" value="abc"/> The field Release Date must be a date.
Genre	<input type="text" value="Western"/>
Price	<input type="text" value="XYZ"/> The field Price must be a number.

HTTP methods – best practices

- `HttpGet` and `HttpPost` method overloads
- All methods that modify data **SHOULD** use `HttpPost` method overload
 - Modifying data in `HttpGet` method
 - security risk
 - violates HTTP best practices
 - violates REST architectural pattern
- GET method **SHOULD NOT** have any side effect and **SHOULD NOT** modify persistent data

ADDING SEARCH

Search form – Index.cshtml

The screenshot shows a web browser displaying an ASP.NET MVC application. The title bar says "Index - Movie App". The address bar shows the URL "localhost:1234/Movies/Index". The page has a dark header with a "MVC Movie" logo. Below the header, there's a green callout box containing the text "Enter a text filtering value." A text input field is partially visible, with the word "ghost" typed into it. To the right of the input field is a "Filter" button. On the left, there are "Create New" and "Delete" buttons. The main content area is titled "Index" and contains a table with two rows of movie data. The table columns are "Title", "Release Date", "Genre", "Price", and "Rating". The first row shows "Ghostbusters" (Release Date: 3/13/1984, Genre: Comedy, Price: \$8.99, Rating: G), with "Edit | Details | Delete" links. The second row shows "Ghostbusters 2" (Release Date: 2/23/1986, Genre: Comedy, Price: \$9.99, Rating: G), also with "Edit | Details | Delete" links. At the bottom right of the page, there's a copyright notice: "© 2013 - My ASP.NET Application".

Title	Release Date	Genre	Price	Rating
Ghostbusters	3/13/1984	Comedy	\$8.99	G
Ghostbusters 2	2/23/1986	Comedy	\$9.99	G

View/Controller – changes

View (changes)

```
@model IEnumerable<MvcMovie.Models.Movie>
@{
    ViewBag.Title = "Index";
}

<h2>Index</h2>

<p>
    @Html.ActionLink("Create New", "Create")
    @using (Html.BeginForm())
    {
        <p> Title: @Html.TextBox("SearchString") <br />
        <input type="submit" value="Filter" /></p>
    }
</p>
```

Default form
method = POST!

Controller – changed signature of
the method Index.

```
public ActionResult Index(string searchString)
{
    var movies = from m in db.Movies
                 select m;

    if (!string.IsNullOrEmpty(searchString))
    {
        movies = movies.Where(s => s.Title.Contains(searchString));
    }

    return View(movies);
}

@using (Html.BeginForm("Index", "Movies", FormMethod.Get))
```

Lambda expression

Use overridden BeginForm method
to force HttpGet method.

```
@Html.ActionLink("Create New", "Create")
@using (Html.BeginForm("SearchIndex", "Movies", FormMethod.Get))
{
    <p> Title: @Html.TextBox("SearchString") <br />
    <input type="submit" value="Filter" /></p>
}
```

▲ 5 of 13 ▶ (extension) MvcForm HtmlHelper.BeginForm(string actionName, string controllerName, FormMethod method)

Writes an opening <form> tag to the response. When the user submits the form, the request will be processed by an action method.

method: The HTTP method for processing the form, either GET or POST.

Searching movies – URL query

A screenshot of a web browser window titled "Index - Movie App". The address bar shows "localhost:1234/Movies/Index". The page content is titled "Index" and contains a search bar with the placeholder "Title: ghost". Below the search bar is a "Filter" button. A table lists movie details:

Title	Release Date	Genre	Price	Rating	
Ghostbusters	3/13/1984	Comedy	\$8.99	G	Edit Details Delete
Ghostbusters 2	2/23/1986	Comedy	\$9.99	G	Edit Details Delete

© 2013 - My ASP.NET Application

HTTP POST

A screenshot of a web browser window titled "Index - Movie App". The address bar shows "localhost:1234/Movies?SearchString=ghost". The page content is titled "Index" and contains a search bar with the placeholder "Title: ghost". Below the search bar is a "Filter" button. A table lists movie details:

Title	Release Date	Genre	Price	Rating	
Ghostbusters	3/13/1984	Comedy	\$8.99	G	Edit Details Delete
Ghostbusters 2	2/23/1986	Comedy	\$9.99	G	Edit Details Delete

© 2013 - My ASP.NET Application

HTTP GET

Adding search by Genre

A screenshot of a web browser displaying an ASP.NET MVC application titled "Index - Movie App". The URL in the address bar is "localhost:1234/Movies?movieGenre=Comedy&SearchString=ghost". The page has a header "MVC Movie" and a title "Index". A green callout bubble points from the text "HttpGet method handles the request." to the search bar. The search bar contains "Genre: Comedy" and "Title: ghost". Below the search bar is a "Create New" button. A "Filter" button is also present. The main content area shows a table of movie results:

Title	Release Date	Genre	Price	Rating	
Ghostbusters	3/13/1984	Comedy	\$8.99	G	Edit Details Delete
Ghostbusters 2	2/23/1986	Comedy	\$9.99	G	Edit Details Delete

At the bottom right of the page, there is a copyright notice: "© 2013 - My ASP.NET Application".

HttpGet method handles
the request.

Title	Release Date	Genre	Price	Rating	
Ghostbusters	3/13/1984	Comedy	\$8.99	G	Edit Details Delete
Ghostbusters 2	2/23/1986	Comedy	\$9.99	G	Edit Details Delete

Search by Genre – View

```
@model IEnumerable<MvcMovie.Models.Movie>
@{
    ViewBag.Title = "Index";
}
<h2>Index</h2>
<p>
    @Html.ActionLink("Create New", "Create")
    @using (Html.BeginForm("Index", "Movies", FormMethod.Get))
    {
        <p>
            genre: @Html.DropDownList("movieGenre", "All")
            Title: @Html.TextBox("SearchString")
            <input type="submit" value="Filter" />
        </p>
    }
    </p>
    <table class="table">
```

Preselected value.

Parameter “movieGenre” is
the key for populating
dropdown list from ViewBag.

DropDown list markup.

Search by Genre – Controller

```
public ActionResult Index(string movieGenre, string searchString)
{
    var GenreLst = new List<string>();

    var GenreQry = from d in db.Movies
                   orderby d.Genre
                   select d.Genre;

    GenreLst.AddRange(GenreQry.Distinct());
    ViewBag.movieGenre = new SelectList(GenreLst);

    var movies = from m in db.Movies
                 select m;

    if (!string.IsNullOrEmpty(searchString))
    {
        movies = movies.Where(s => s.Title.Contains(searchString));
    }

    if (!string.IsNullOrEmpty(movieGenre))
    {
        movies = movies.Where(x => x.Genre == movieGenre);
    }

    return View(movies);
}
```

Populating the list of genres in ViewBag.

Key movieGenre is the same as the parameter of the dropdown list.

Details method - Controller

```
public ActionResult Details(int? id)
{
    if (id == null)
    {
        return new HttpStatusCodeResult(HttpStatusCode.BadRequest);
    }
    Movie movie = db.Movies.Find(id);
    if (movie == null)
    {
        return HttpNotFound();
    }
    return View(movie);
}
```

Delete method - Controller

HttpGet method.
Selects an objects and
returns Details page.

```
// GET: /Movies/Delete/5
public ActionResult Delete(int? id)
{
    if (id == null)
    {
        return new HttpStatusCodeResult(HttpStatusCode.BadRequest);
    }
    Movie movie = db.Movies.Find(id);
    if (movie == null)
    {
        return HttpNotFound();
    }
    return View(movie);
}
```

Asp .net maps a segment of URL
to a method.
Attribute ActionName is
necessary to provide valid URL
routing.

The same URL maps to different
action methods, based on used
HTTP method.

```
// POST: /Movies/Delete/5
[HttpPost, ActionName("Delete")]
[ValidateAntiForgeryToken]
public ActionResult DeleteConfirmed(int id)
{
    Movie movie = db.Movies.Find(id);
    db.Movies.Remove(movie);
    db.SaveChanges();
    return RedirectToAction("Index");
}
```

RULE:
Never use a HttpGet method
to modify the model.
Opens security holes,
architecturally bad!

HttpPost method.
Deletes an object
having the given id.

Data Validation

- Keep Things DRY
(Don't Repeat Yourself)
- Declarative validation rules in one place
(Model class)
 - Regular expressions
 - Range validation
 - Length validation
 - NULL values validation
 - Data formatting
- Validation rules enforced before saving changes to the database!

Validation rules – Model

```
public class Movie
{
    public int ID { get; set; }

    [StringLength(60, MinimumLength = 3)]
    public string Title { get; set; }

    [Display(Name = "Release Date")]
    [DataType(DataType.Date)]
    [DisplayFormat(DataFormatString = "{0:yyyy-MM-dd}", ApplyFormatInEditMode = true)]
    public DateTime ReleaseDate { get; set; }

    [RegularExpression(@"^([A-Z]+[a-zA-Z'-'\s]*$)")]
    [Required]
    [StringLength(30)]
    public string Genre { get; set; }

    [Range(1, 100)]
    [DataType(DataType.Currency)]
    public decimal Price { get; set; }

    [RegularExpression(@"^([A-Z]+[a-zA-Z'-'\s]*$)")]
    [StringLength(5)]
    public string Rating { get; set; }
}
```

```
MovieDBContext db = new MovieDBContext();
Movie movie = new Movie();
movie.Title = "Gone with the Wind";
db.Movies.Add(movie);
db.SaveChanges(); // <= Will throw server side validation exception
```

Several validation rules failed.

Data Validation - View

The screenshot shows an 'MVC Movie' application's 'Create' view. The URL in the browser is 'localhost:1234/Movies/Create'. The page has a header 'Create' and a form with a 'Movie' title. The form fields are:

- Title:** 'Go' (highlighted in red) with the error message: "The field Title must be a string with a minimum length of 3 and a maximum length of 60."
- Release Date:** 'abc' (highlighted in red) with the error message: "The field Release Date must be a date."
- Genre:** (empty input)
- Price:** '129' (highlighted in red) with the error message: "The field Price must be between 1 and 100."
- Rating:** 'Probably G' (highlighted in red) with the error message: "The field Rating must be a string with a maximum length of 5."

A green callout box points to the first error message with the text: "Client-side validation: javascript (jQuery).". Another green callout box points to the second error message with the text: "Validation rules picked up from the model class annotations.". A third green callout box points to the fifth error message with the text: "Validation messages derived from the validation constraints in the model class.".

Create

Data Validation – View (cont.)

```
@model MvcMovie.Models.Movie
{
    ViewBag.Title = "Create";
}
<h2>Create</h2>
@using (Html.BeginForm())
{
    @Html.AntiForgeryToken()
    <div class="form-horizontal">
        <h4>Movie</h4>
        <hr />
        @Html.ValidationSummary(true)
        <div class="form-group">
            @Html.LabelFor(model => model.Title, new { @class = "control-label col-md-2" })
            <div class="col-md-10">
                @Html.EditorFor(model => model.Title)
                @Html.ValidationMessageFor(model => model.Title)
            </div>
        </div>
        <div class="form-group">
            <div class="col-md-offset-2 col-md-10">
                <input type="submit" value="Create" class="btn btn-default" />
            </div>
        </div>
    </div>
}
<div>
    @Html.ActionLink("Back to List", "Index")
</div>
@section Scripts {
    @Scripts.Render("~/bundles/jqueryval")
}
```

Validation message derived from the validation constraints specified for the given Property (Title)

Data Validation - Controller

```
public ActionResult Create()
{
    return View();
}

// POST: /Movies/Create
// To protect from overposting attacks, please enable the specific properties you want to bind
// more details see http://go.microsoft.com/fwlink/?LinkId=317598.
```

HttpPost method that does create a new object.

```
[HttpPost]
[ValidateAntiForgeryToken]
public ActionResult Create([Bind(Include = "ID,Title,ReleaseDate,Genre,Price,Rating")] Movie mc)
```

if (ModelState.IsValid) Server-side data validation check.

```
{
    db.Movies.Add(movie);
    db.SaveChanges();
    return RedirectToAction("Index");
}
return View(movie);
}
```

DataType attributes

- Provide only hints for the view engine to format the data
- Date, Time, PhoneNumber, EmailAddress,...
- Automatic provision of type specific features e.g. “mailto: ...” link for EmailAddress
- Do NOT provide any Validation (just presentation hints)

DisplayFormat annotation

- Used to explicitly specify format of the data
- Example: redefining the default date format

```
[DisplayFormat(DataFormatString = "{0:yyyy-MM-dd}", ApplyFormatInEditMode = true)]  
public DateTime EnrollmentDate { get; set; }
```

```
public class Movie  
{  
    public int ID { get; set; }  
    [Required, StringLength(60, MinimumLength = 3)]  
    public string Title { get; set; }  
    [Display(Name = "Release Date"), DataType(DataType.Date)]  
    public DateTime ReleaseDate { get; set; }  
    [Required]  
    public string Genre { get; set; }  
    [Range(1, 100), DataType(DataType.Currency)]  
    public decimal Price { get; set; }  
    [Required, StringLength(5)]  
    public string Rating { get; set; }  
}
```

It is possible to specify validation properties in one line!

LAMBDA EXPRESSIONS



Introduction

- Expressions that use special syntax
- Anonymous functions used as data (variables, fields, parameters, return values)
- The anonymous functions are used to create delegates and expression trees
- Lambda expressions particularly helpful for writing LINQ queries
- Available from .NET 4.5

Operator =>

- Interpreted as “goes to”
- Used for declaring a lambda expression
- The same priority as assignment (=)
- Right associative operator
- Separates the parameters and function body

Left side => Right side

An Empty parameter list

An expression

A formal parameter list

A Statement list inside curly brackets.

An implicit parameter list

Anonymous functions

- Inline statements or expressions
- Used wherever a delegate type is expected
- It can initialize a named delegate
- It can be passed as the parameter where a named delegate type is expected
- Two kinds of anonymous functions
 - Anonymous methods
 - Lambda expressions

Evolution of delegates in C#

```
delegate void TestDelegate(string s);
static void M(string s)
{
    Console.WriteLine(s);
}

static void Main(string[] args)
{
    // Original delegate syntax required
    // initialization with a named method.
    TestDelegate testDelA = new TestDelegate(M);

    // C# 2.0: A delegate can be initialized with
    // inline code, called an "anonymous method." This
    // method takes a string as an input parameter.
    TestDelegate testDelB = delegate(string s) { Console.WriteLine(s); };

    // C# 3.0: A delegate can be initialized with
    // a Lambda expression. The lambda also takes a string
    // as an input parameter (x). The type of x is inferred by the compiler.
    TestDelegate testDelC = (x) => { Console.WriteLine(x); };

    // Invoke the delegates.
    testDelA("Hello. My name is M and I write lines.");
    testDelB("That's nothing. I'm anonymous and ");
    testDelC("I'm a famous author.");

    // Keep console window open in debug mode.
    Console.WriteLine("Press any key to exit.");
    Console.ReadKey();
}
```

Named method

Inline code
(anonymous method)

Lambda expression

Anonymous method

- No name, no overloading
- Created using the delegate keyword
- It is possible to add multiple statements inside its body

```
// Create a handler for a click event.
button1.Click += delegate(System.Object o, System.EventArgs e)
{
    System.Windows.Forms.MessageBox.Show("Click!");
};

// Create a delegate.
delegate void Del(int x);

// Instantiate the delegate using an anonymous method.
Del d = delegate(int k) { /* ... */ };

void StartThread()
{
    System.Threading.Thread t1 = new System.Threading.Thread
    (delegate()
    {
        System.Console.WriteLine("Hello, ");
        System.Console.WriteLine("World!");
    });
    t1.Start();
}
```

Anonymous method (cont.)

- Scope of the parameters is the anonymous method block
 - No jump from inside an anonymous method block to the outside, and vice versa.
- Cannot access ref and out parameters of an outer scope
 - No unsafe code access inside its block
 - Not allowed on the left side of the operator is.

Expression lambdas

- Lambda expression with an expression on the right side of the operator =>
- Used dominantly in construction of expression trees
- (**input parameters**) => **expression**
- Parentheses optional if lambda has one param.
- Input parameters separated by comma

Expression lambdas - examples

- `(x, y) => x == y`
The parameters types inferred by the compiler
- `(int x, string s) => s.Length > x`
Specify types of the parameters when the compiler cannot inferre them from the code.
- `() => SomeMethod()`
Zero input parameters specified with empty parentheses.
Note: a method call cannot be evaluated outside the .NET Framework (e.g. SQL Server)

Statement lambdas

- (**input parameters**) => {statement;}
- Statements enclosed in braces
- The body of a statement lambda can contain multiple statements (in practices, two-three)
- Cannot be used to create expression trees

```
delegate void TestDelegate(string s);  
...  
TestDelegate myDel = n => { string s = n + " " + "World"; Console.WriteLine(s); };  
myDel("Hello");
```

Generic delegates – Func

- **System.Func<T, TResult>**
T – argument type,
TResult – return type (last type parameter)
- Useful for encapsulating user-defined
expressions that are applied to all elements of
a data set

A generic declaration of the delegate Func.

```
public delegate TResult Func<TArg0, TResult>(TArg0 arg0)
```

Func<int, bool> myFunc = x => x == 5; Example of usage.
bool result = myFunc(4); // returns false of course

Func delegate (cont.)

- A lambda expression can be passed where `Expression<Func>` type is required
 - `System.Linq.Queryable`

```
int[] numbers = { 5, 4, 1, 3, 9, 8, 6, 7, 2, 0 };
int oddNumbers = numbers.Count(n => n % 2 == 1);
```

Output: 5, 1, 3, 9, 7

Compiler can infer the type of the parameter n.

```
var firstNumbersLessThan6 = numbers.TakeWhile(n => n < 6);
```

Output: 5, 4, 1, 3

```
var firstSmallNumbers = numbers.TakeWhile((n, index) => n >= index);
```

Output: 5, 4

Type inference in lambdas

- Compiler can infer the type of the parameters based on:
 - Lambda's body
 - Parameter's delegate type
- Example:

```
IEnumerable<Customer> customers = ...  
customers.Where(c => c.City == "London");
```

Standard query operator.

Lambda expressions – general rules

- The lambda must contain the same number of parameters as the delegate type
- Each input parameter in the lambda must be implicitly convertible to its corresponding delegate parameter
- The return value of the lambda (if any) must be implicitly convertible to the delegate's return type

Lambda expressions - examples

- `Func<int,int> f1 = x => x+1;`
- `Func<int,int> f2 = x => {return x+1;}`
- `Func<int,int> f3 = (int x) => x +1;`
- `Func<int,int> f4 = (int x) => {return x+1;}`
- `Func<int,int> f7 = delegate(int x) {return x+1;}`
- Invocation example:
`Console.WriteLine(f1.Invoke(4));`

Lambda expressions - examples

- **Func<int,int> f5 = (x,y) => x*y**
Invocation: Console.WriteLine(f5.Invoke(2,2));
- **Action f6 = () => Console.WriteLine();**
Function instance that does not receive any parameter nor returns value.
Invocation: f6.Invoke();
- **Func<int> f8 = delegate { return 1+1;}**
Invocation: Console.WriteLine(f8());

Language Integrated Query

LINQ

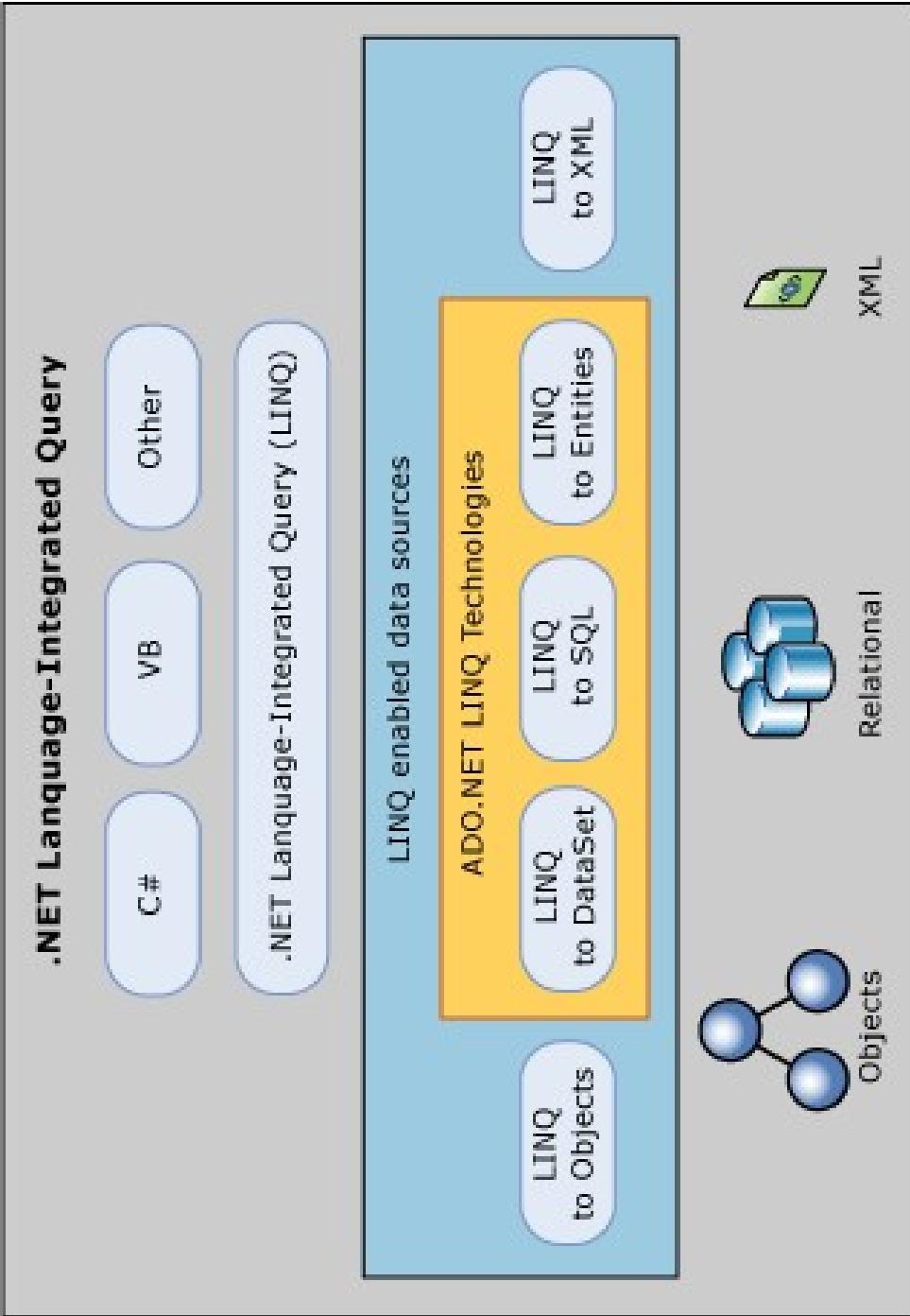
Content

- Understand what LINQ is?
- Learn what problems solves
 - See what its syntax looks like
- Know where LINQ can be used

What is LINQ?

- Language INtegrated Query
- It is part of programming language syntax
- Supported by: C#, VB, Delphi Prism
- Used for querying data
- Supported the following types of data sources
 - Relational data
 - XML data
 - objects

LINQ Architecture



ADO .NET vs. LINQ

ADO .NET

- OO library for relational data access
 - Mapping from relational to OO objects needed!
 - High Impedance Missmatch for mapping data from storage to objects in an application
- SQL-Like syntax that deals with pure objects
 - Reduces the Impedance Mismatch
 - Makes data querying more efficient
 - One still must know the format of the data

LINQ

LINQ Adapters

- LINQ to Objects
- LINQ to SQL
- LINQ to XML
- LINQ to Entities
- It is possible to create own customized adapter
 - E.g. LINQ for Querying Twitter API