Unit-I: Introduction to .NET

1. Concept and Features of .NET Framework

The .NET Framework is a software development platform created by Microsoft. It provides tools, libraries, and runtime environments to develop a variety of applications such as web, desktop, and mobile. Its goal is to create platform-independent and language-independent applications that run on different operating systems like Windows, macOS, and Linux.

Features of .NET Framework

1. **Platform Independence**
   - The .NET Core and .NET 5+ frameworks offer cross-platform capabilities, allowing developers to build applications for multiple platforms.
2. **Language Interoperability**
   - Languages like C#, VB.NET, and F# can work together seamlessly because they share a common intermediate language and runtime.
3. **Object-Oriented Programming (OOP)**
   - Supports features such as inheritance, polymorphism, and encapsulation, making it easier to create complex applications with reusable components.
4. **Unified Development Environment**
   - Tools like Visual Studio and Visual Studio Code offer integrated environments for coding, debugging, and deployment, supporting multiple .NET languages.
5. **Security**
   - .NET provides built-in security features, such as Code Access Security (CAS), which restricts what code can do based on its origin and identity, and Role-Based Security (RBS), which controls what users can do based on their roles.
6. **Rich Standard Library**
   - .NET includes a comprehensive Base Class Library (BCL) that simplifies the development of various applications, providing classes for UI, networking, file I/O, and more.

7. **ASP.NET and ADO.NET**
   - **ASP.NET**: For building dynamic websites, APIs, and web services.
   - **ADO.NET**: Provides components for data access and database connectivity.

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2. Microsoft Intermediate Language (MSIL)

MSIL (Microsoft Intermediate Language) is the intermediate language that .NET source code is compiled into. It is platform-agnostic and allows .NET to be language-independent.

Explanation

- When a developer writes code in a .NET language (e.g., C# or VB.NET), it is first compiled into MSIL, not directly into machine code.
- MSIL is then converted to native machine code by the **Just-In-Time (JIT) compiler** at runtime, which allows .NET applications to be executed on different platforms.

Benefits of MSIL

- **Platform Independence**: Since MSIL is not specific to any hardware, .NET code can run on multiple platforms.
- **Optimization**: JIT compilation optimizes code based on the specific machine where it runs.

Example

Consider the following simple C# program:

```
Console.WriteLine("Hello, World!");
```

When compiled, it turns into MSIL code like:

```
ldstr "Hello, World!"
call void [System.Console]::WriteLine(string)
```

This MSIL code is then converted to machine-specific code by the JIT compiler when executed.

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3. Metadata in .NET

Metadata is a set of information that describes the types, methods, and other members defined in your program. In .NET, metadata is automatically generated during the compilation process and stored within the same .NET assembly alongside the MSIL code.

Components of Metadata

1. **Assembly Metadata**: Includes the name, version, culture, and public key of the assembly.
2. **Type Metadata**: Contains information about classes, interfaces, structures, enumerations, and delegates.
3. **Member Metadata**: Describes properties, methods, fields, events, and parameters.

Benefits of Metadata

- **Type Safety**: Ensures that data types used in different components are compatible.
- **Code Integration**: Makes reflection and dynamic code generation easier.
- **Self-Describing**: Metadata allows an assembly to describe itself, making it easier for developers and other assemblies to understand the types and members it contains.

Example

When a C# class is defined:

```
public class Student
{
    public string Name { get; set; }
    public int RollNo { get; set; }
}
```

Metadata is created for the `Student` class, including details about the class name, its properties, and their data types.

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4. .NET Namespaces

A namespace in .NET is a logical grouping of classes, interfaces, structs, enums, and delegates, used to organize code into a hierarchical structure and avoid naming conflicts.

Purpose of Namespaces

- To avoid collisions between identifiers that have the same name.
- To make code more readable and maintainable by categorizing similar types together.

Common Namespaces in .NET

- `System`: The core namespace containing fundamental data types (e.g., `System.String`, `System.Int32`) and basic operations.
- `System.IO`: Contains classes for reading and writing to files and data streams.
- `System.Collections`: Provides classes for managing collections of objects (e.g., lists, dictionaries).
- `System.Net`: Used for network programming, including HTTP and FTP operations.
- `System.Threading`: Offers classes for multithreaded programming.

Example Usage

```
using System.IO;
class Example
{
    public void WriteToFile()
    {
        File.WriteAllText("example.txt", "Hello, .NET!");
    }
}
```

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5. Common Language Runtime (CLR)

The CLR (Common Language Runtime) is the execution engine for .NET applications, responsible for managing code execution, memory management, and providing runtime services.

Functions of CLR

- **Memory Management**: Automatically handles memory allocation and deallocation using the Garbage Collector (GC).
- **Exception Handling**: Provides a structured approach to catching and handling runtime errors.
- **Type Safety**: Ensures that variables and objects are used according to their type definition.
- **Thread Management**: Manages the creation, execution, and synchronization of threads.

Key Components of CLR

- **Just-In-Time (JIT) Compiler**: Converts MSIL to native machine code at runtime.
- **Garbage Collector (GC)**: Frees up memory by removing objects that are no longer in use.

- **Code Manager**: Handles code execution and safety verification.

Example

In a .NET application, when you create an object like `Student student = new Student();`, the CLR allocates memory for the object, and when `student` is no longer in use, the GC cleans it up.

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6. Common Type System (CTS)

The Common Type System (CTS) is a standard that defines how types are declared and used in the .NET runtime. It ensures that types defined in different .NET languages are treated the same.

Type Categories

- **Value Types**: Contain their data directly. Examples include primitive data types like `int`, `float`, and `bool`.
- **Reference Types**: Store a reference to the memory location of the data. Examples include classes, interfaces, arrays, and strings.

Benefits of CTS

- Ensures language interoperability.
- Guarantees type safety and allows for better performance optimizations.

Example

The C# `int` and the VB.NET `Integer` are equivalent under the CTS, allowing them to be used interchangeably across these languages.

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7. Common Language Specification (CLS)

The CLS is a set of rules and guidelines for language interoperability in .NET. It is a subset of CTS, which all .NET languages must follow to be considered CLS-compliant.

Rules of CLS

- No use of language-specific features that are not supported by other languages.
- Avoid pointers and case-sensitive names if they conflict across languages.

Purpose

- Ensures that code written in one .NET language can be used in another without modifications.

Example

Using only the `int` data type (CLS-compliant) instead of `uint` (not CLS-compliant), as some .NET languages do not support unsigned types.

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8. Overview of .NET Applications

Types of Applications

1. **Console Applications**: Run in a command-line environment, useful for utilities or background processes.
2. **Windows Forms Applications**: Provide a rich user interface for desktop applications.
3. **Web Applications**: Developed using ASP.NET to create dynamic websites.
4. **Mobile Applications**: Built using Xamarin or .NET MAUI for cross-platform mobile app development.
5. **Cloud Applications**: Designed using Azure services for scalability.

Layers in a .NET Application

- **Presentation Layer**: UI components like forms and pages.
- **Business Logic Layer**: Manages business rules and data processing.
- **Data Access Layer**: Handles interactions with databases (e.g., SQL Server).