



# Language Interoperability and the CLR

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## Overview

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- Introduction
- Background
- .NET Framework
- Examples
- Summary
- Questions

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## Introduction

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- Damien Watkins
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- Project 7 member from Monash University
- MSR invited Monash to join Project 7 in November 1998
- ISE/Monash: Eiffel

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## Background

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- There are a number of different and interesting programming languages
- Interoperability allows programmers to use the right language for the task at hand and then expose the functionality
- There is nothing conceptually new in this idea, there are already a number of architectures that facilitate language interoperability

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## Background

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- Two widely used multi-language architectures are:
  - Object Management Group's (OMG's) Common Object Request Broker Architecture (CORBA)
  - Microsoft's Component Object Model (COM)

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## Background

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- Both use an IDL
- IDL's have built in types and allow developers to create their own types
- IDL compilers can generate metadata about the types that users define
  - Type Library, Interface Repository
- IDL Compilers generate proxy objects for use at runtime

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## Background

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- Limitations
  - Types are limited to value types and interface types
  - Metadata generation is often optional
  - Proxy objects generally allow for cross language method calls only

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## .NET Framework

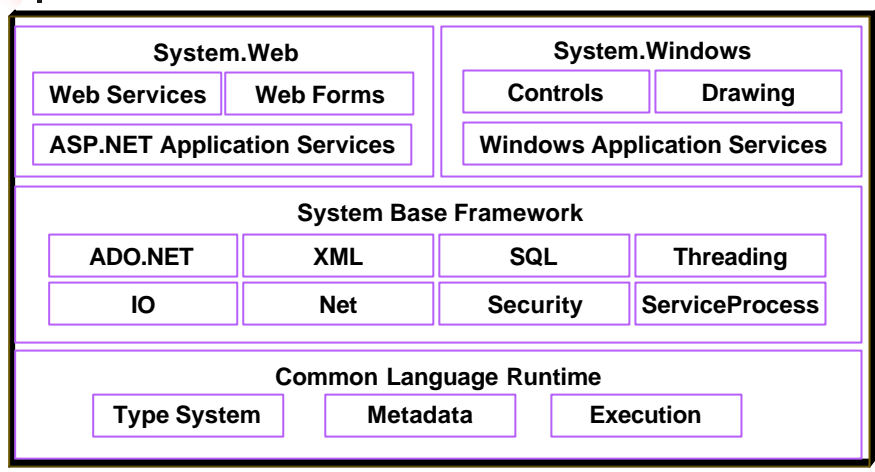
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- The .NET Framework provides multiple language support
- The .NET Framework extends many of the facilities of other architectures
- Many of the extensions are evolutionary rather than revolutionary

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# .NET Framework



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# .NET Framework

- Type System provides built-in and user defined
  - Value types
  - Interface Types
  - Object Types
    - Cross language implementation inheritance

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## .NET Framework

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- Metadata generation is both mandatory and automatic
- Metadata annotations are extensible via Attributes
- Metadata is the essential bridge between language compilers and the execution system

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## .NET Framework

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- The execution provides
  - Type Safety
  - Memory Management
  - JIT Compilation
  - Exception Handling
  - Security

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## Examples – Managed C++

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```
#using <mscorlib.dll>
using namespace System;
__gc public class HelloWorldCPP
{
    public:
    void SayHelloCPP()
    {
        Console::WriteLine("Hello World from C++!");
    }
};
```

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## Examples – Visual Basic

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```
Imports System
Imports HelloWorldCPP

Public Class HelloWorldVB
    Inherits HelloWorldCPP
    Sub SayHelloVB()
        Console.WriteLine ("Hello World from Visual Basic!")
    End Sub
End Class
```

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## Examples – COBOL

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```
000010 CLASS-ID. HelloWorldCOB INHERITS HelloWorldVB.  
000020 ENVIRONMENT DIVISION.  
000030 CONFIGURATION SECTION.  
000040 REPOSITORY.  
000050     CLASS HelloWorldVB AS "HelloWorldVB"  
000060 OBJECT.  
000070 PROCEDURE DIVISION.  
000080 METHOD-ID. SayHelloCOB.  
000090 PROCEDURE DIVISION.  
000100     DISPLAY "Hello World from COBOL!".  
000110 END METHOD SayHelloCOB.  
000120 END OBJECT.  
000130 END CLASS HelloWorldCOB.
```

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## Examples – C#

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```
using System;  
class HelloWorldCS: HelloWorldCOB  
{  
    public void SayHelloCS()  
    {  
        String message = "Hello World from C#!";  
        Console.WriteLine(message);  
    }  
}
```

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## Examples – C#

```
public static int Main()
{
    HelloWorldCS h = new HelloWorldCS();
    h.SayHelloCPP();
    h.SayHelloVB();
    h.SayHelloCOB();
    h.SayHelloCS();
    return 0;
}
}
```

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## Examples

```
c:\windows\system32\cmd.exe
Directory of C:\Project7\Demos\MultiLanguage\NoPython
13/02/2002  04:39 PM    <DIR>          .
13/02/2002  04:39 PM    <DIR>          ..
13/02/2002  04:39 PM                422 HelloWorldCOB.cob
13/02/2002  04:39 PM                5,632 HelloWorldCOB.dll
13/02/2002  04:28 PM                191 HelloWorldCPP.cpp
13/02/2002  04:39 PM                4,608 HelloWorldCPP.dll
13/02/2002  04:39 PM                2,735 HelloWorldCPP.obj
13/02/2002  04:38 PM                357 HelloWorldCS.cs
13/02/2002  04:39 PM                3,584 HelloWorldCS.exe
13/02/2002  04:39 PM                3,072 HelloWorldVB.dll
06/12/2000  04:03 PM                197 HelloWorldVB.vb
13/02/2002  04:34 PM                596 makefile
                10 File(s)      21,394 bytes
                2 Dir(s)  7,907,381,248 bytes free

C:\Project7\Demos\MultiLanguage\NoPython>HelloWorldCS.exe
Hello World from C++
Hello World from Visual Basic!
Hello World from COBOL!
Hello World from C#

C:\Project7\Demos\MultiLanguage\NoPython>
```

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## Examples - Under the covers

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- ILDASM – a metadata inspection tool
- [ildasm HelloWorldCPP.cpp](#)
- [ildasm HelloWorldVB.vb](#)
- [ildasm HelloWorldCOB.cob](#)
- [ildasm HelloWorldCS.cs](#)

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## Examples

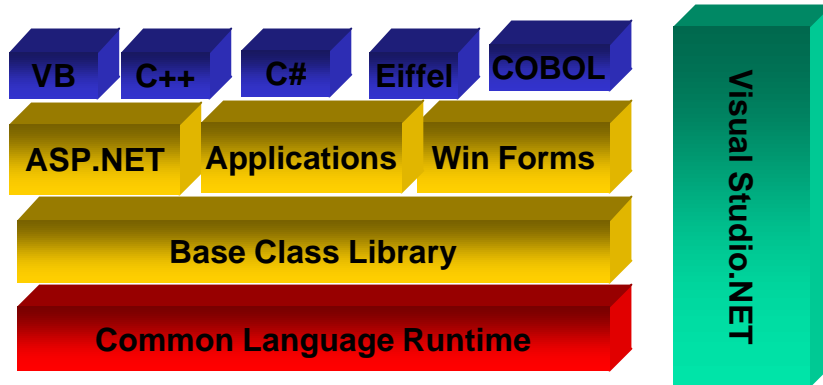
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- Language and architecture [interoperability](#) is possible with the .NET Framework
- COM Interoperability allows COM components to be programmed by different .NET languages
- A [C# program](#) ties this all together

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## Examples – VS.NET



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## Examples – VS.NET

- VS.NET provides an IDE for the development of multiple language solutions for .NET
- Language Interoperability between COBOL and C# with debugging

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## Summary

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- Variety is the spice of life
- The .NET Framework builds on and extends the capabilities and facilities of other architectures
- Interoperability is a cornerstone of .NET
  - Language
  - Architecture (COM and XML)

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## Questions

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