ICT365

Software Development Frameworks

Dr Giles Oatley

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Microsoft .NET Framework Overview

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Aims

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This topic aims to provide a brief introduction to Visual Basic .NET

Understand the concept of language interoperability and the basic steps for developing cross-language programs

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.NET Framework

- Programming model for .NET
- Platform for running .NET managed code in a virtual machine
- Provides a very good environment to develop networked applications and Web Services
- Provides programming API and unified language-independent development framework

The Core of .NET Framework: FCL & CLR

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- Common Language Runtime
  - Garbage collection
  - Language integration
  - Multiple versioning support (no more DLL hell!)
  - Integrated security
- Framework Class Library
  - Provides the core functionality:
    - ASP.NET, Web Services, ADO.NET, Windows Forms, IO, XML, etc.

.NET Framework

Common Language Runtime

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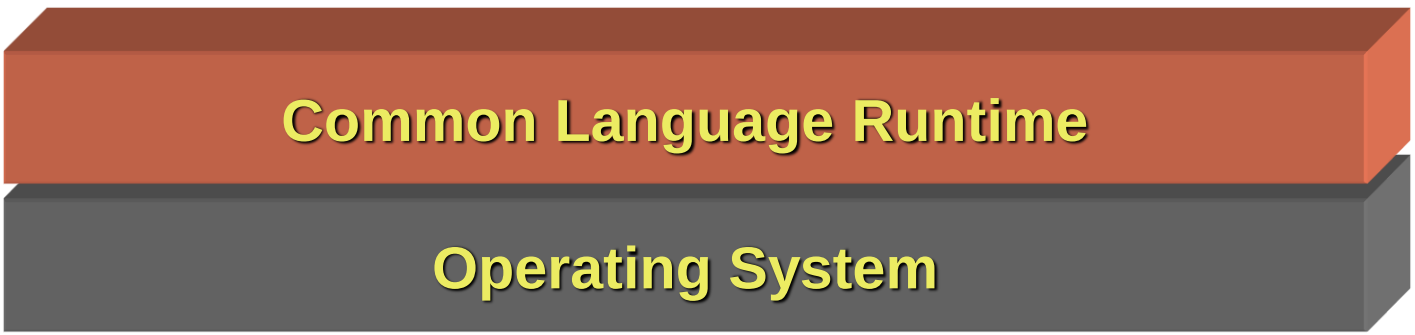
CLR manages code execution at runtime

Memory management, thread management, etc.



.NET Framework
Base Class Library

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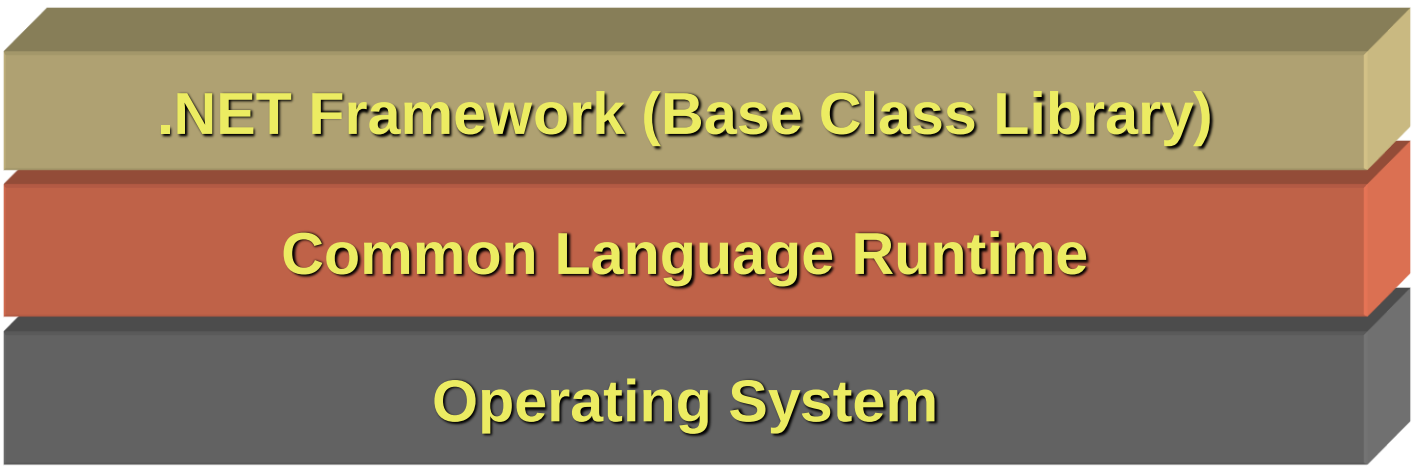
Object-oriented collection of reusable types

Collections, I/O, Strings, …



.NET Framework
Data Access Layer

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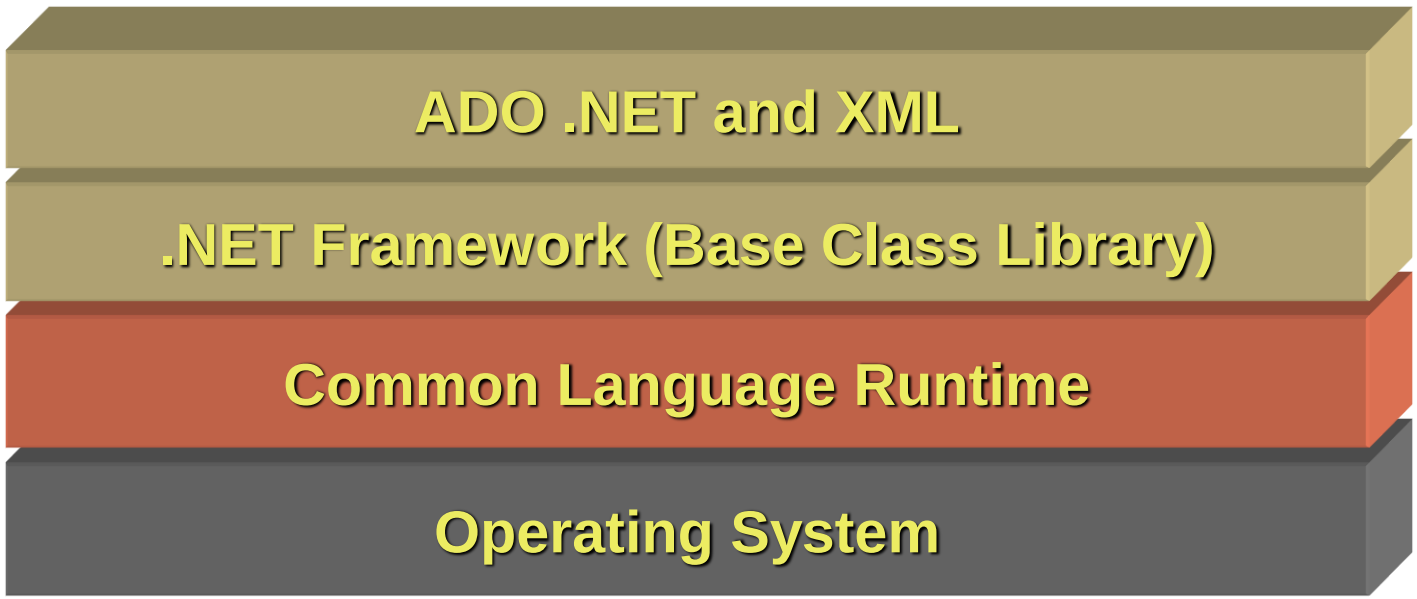
Access relational databases

Disconnected data model

Work with XML



.NET Framework
ASP.NET & Windows Forms

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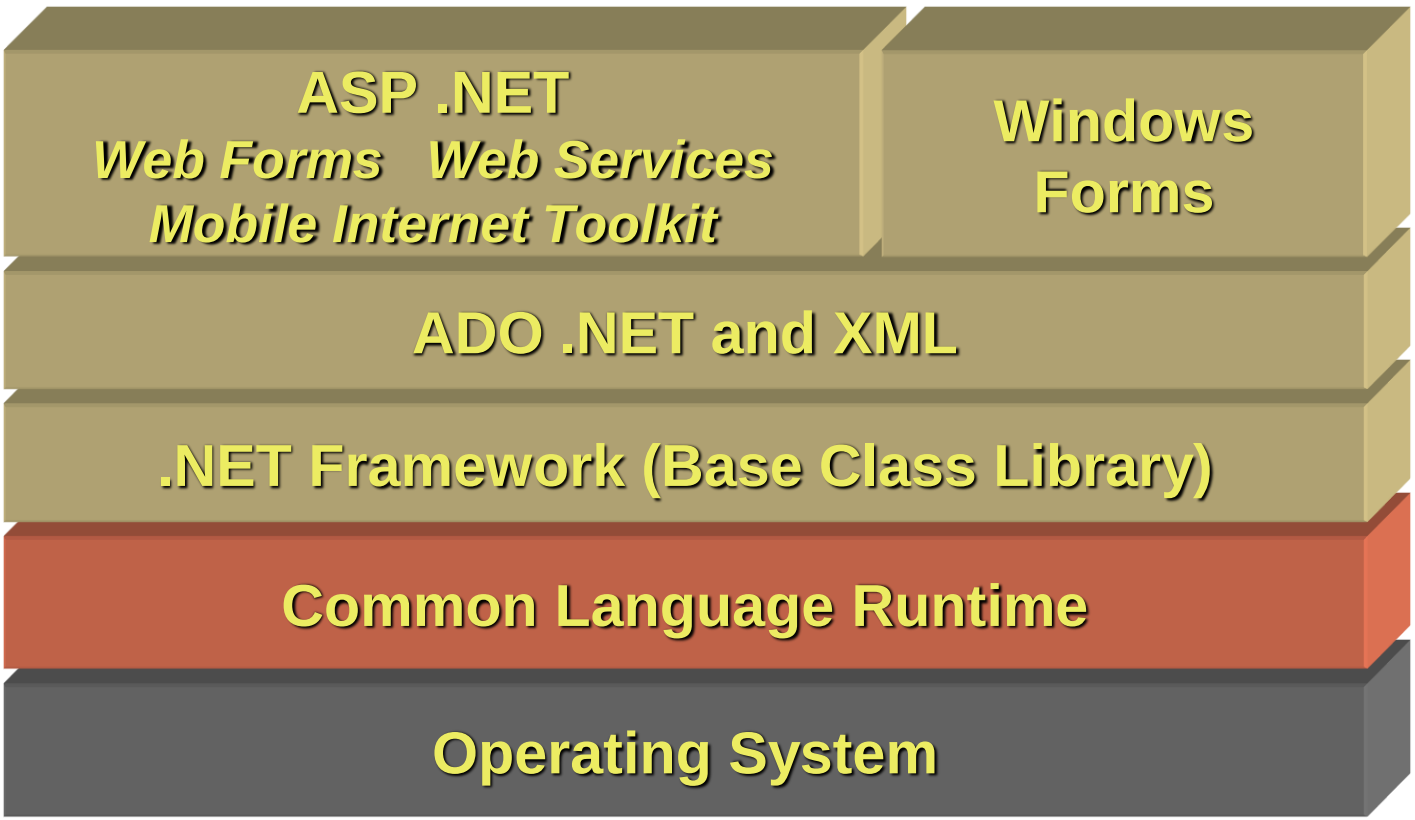
Create application's front-end – Web-based user interface, Windows GUI, Web services, …



.NET Framework
Programming Languages

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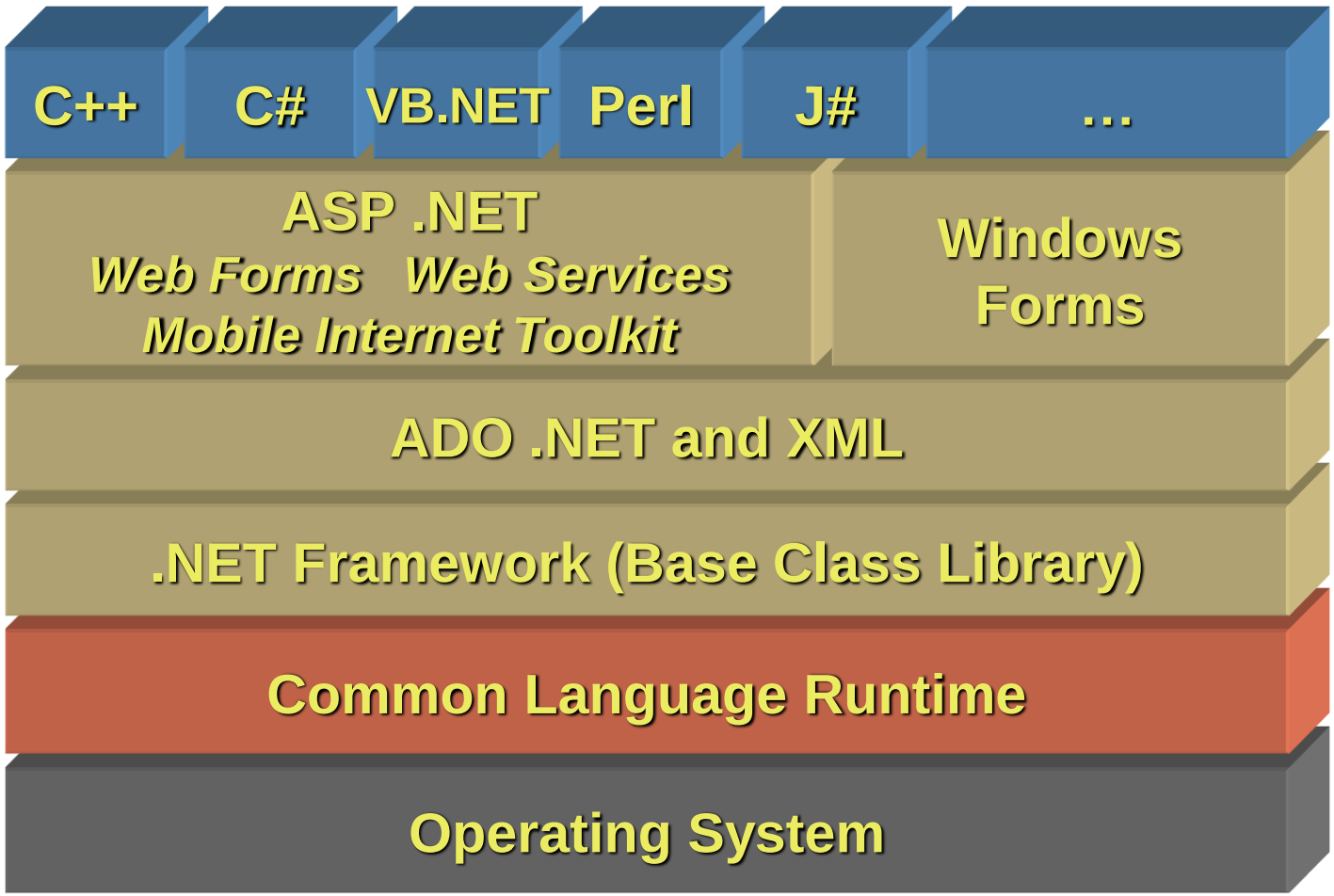
Use your favorite language



.NET Framework
Common Language Specification

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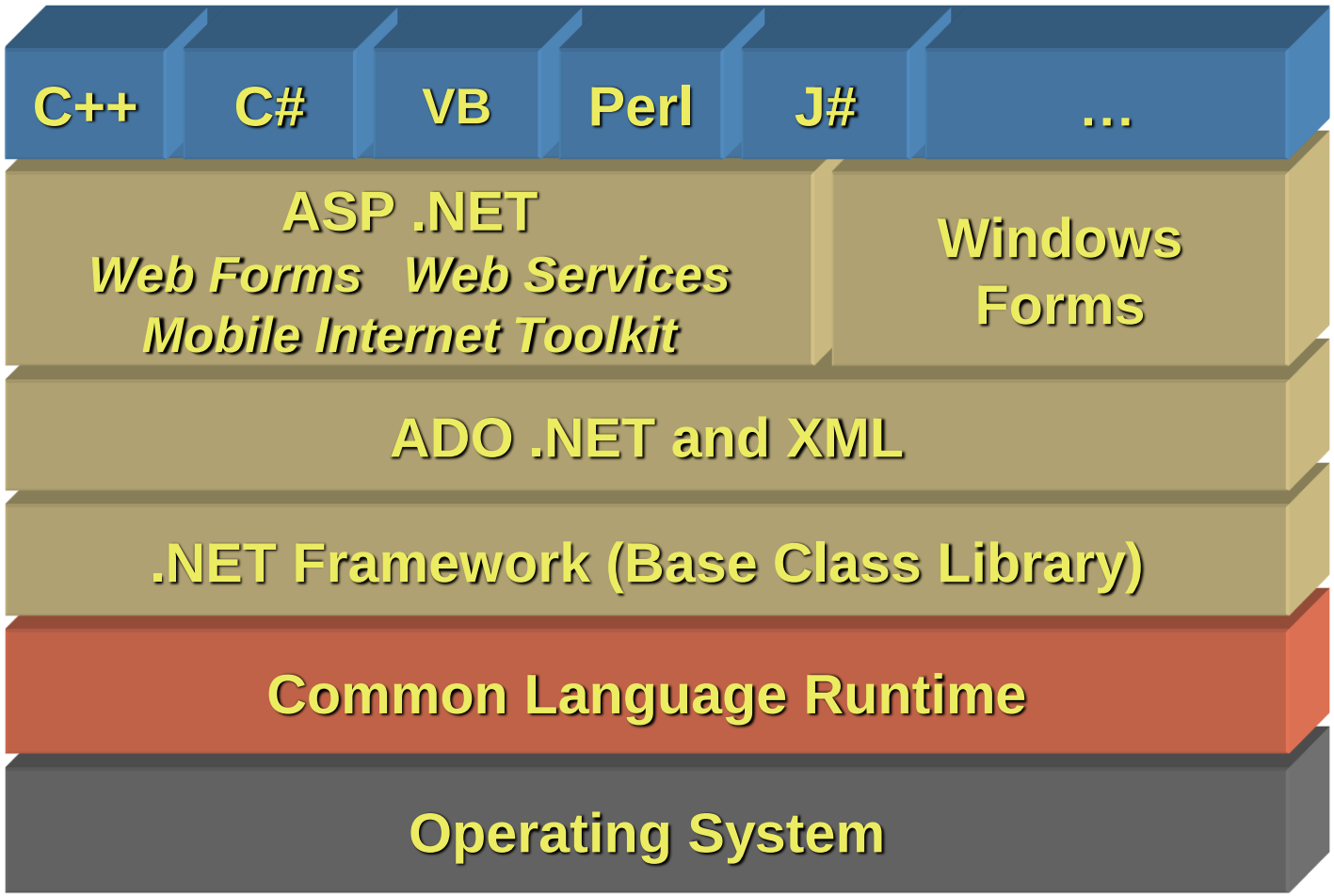

.NET Framework

Visual Studio .NET

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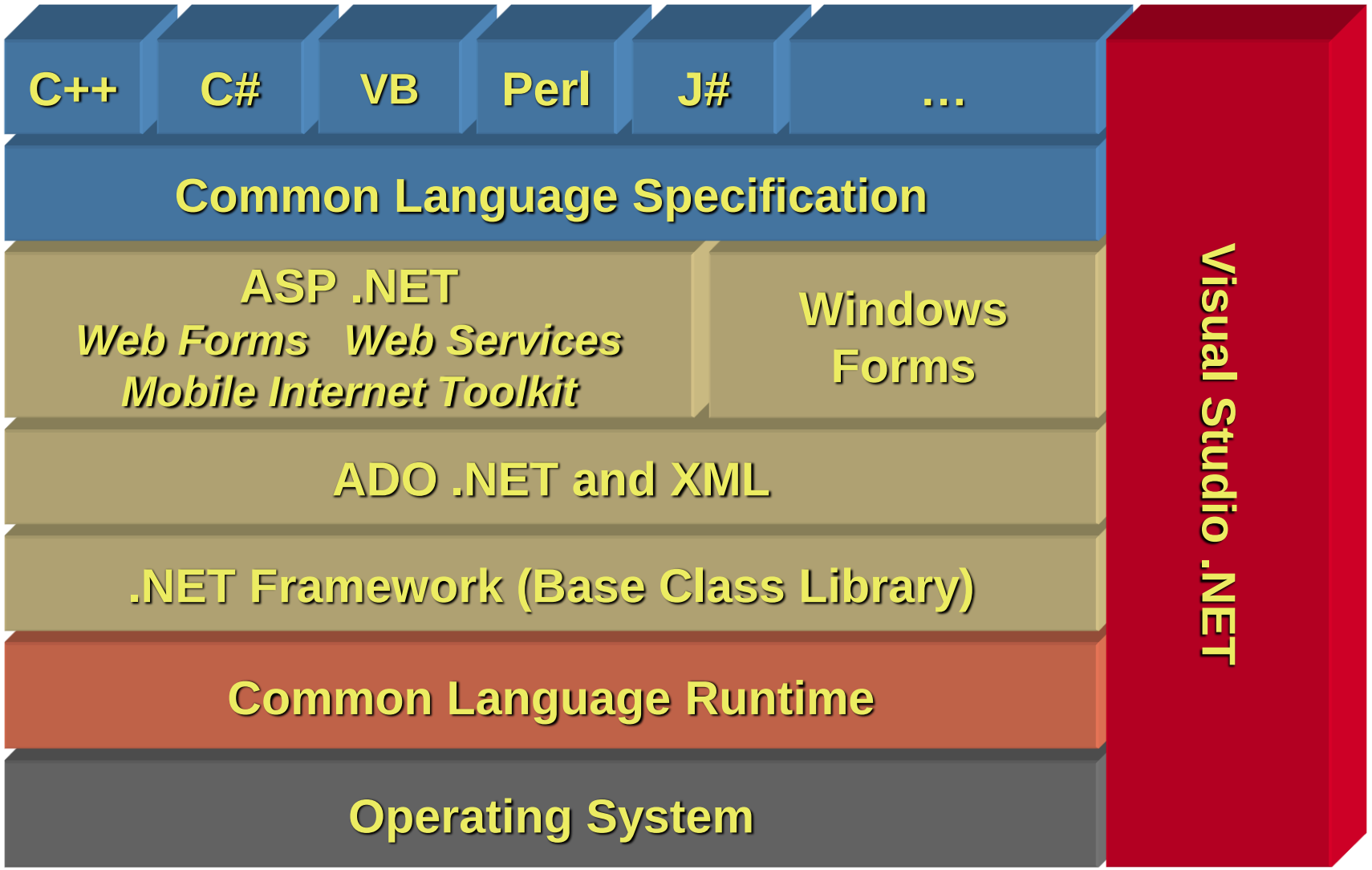

.NET Framework
Standards Compliance

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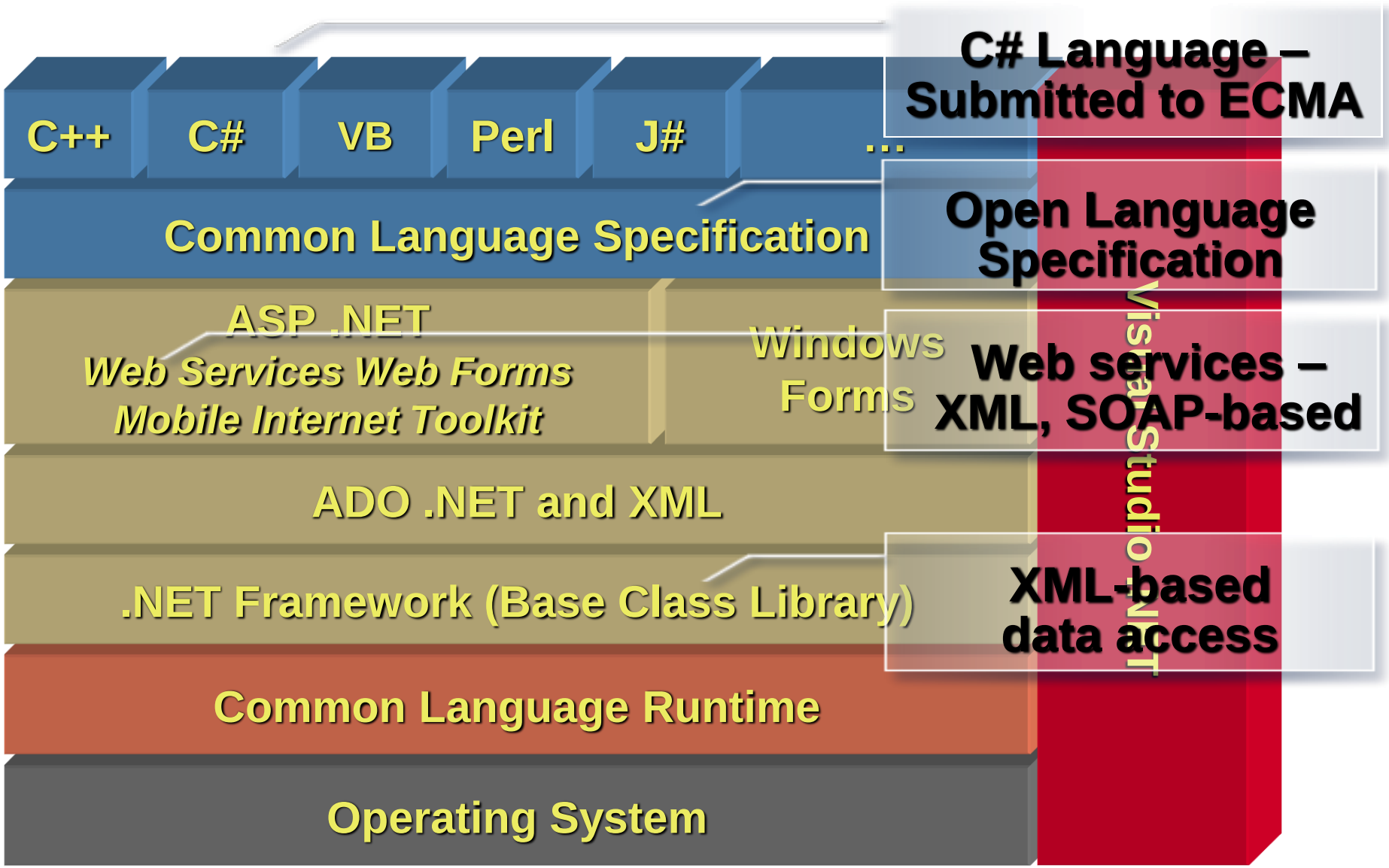

Common Language Runtime

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- Manages running code – like a virtual machine
  - Threading
  - Memory management
  - No interpreter: JIT-compiler produces native code – during the program installation or at run time
- Fine-grained evidence-based security
  - Code access security
    - Code can be verified to guarantee type safety
    - No unsafe casts, no un-initialized variables and no out-of-bounds array indexing
  - Role-based security

Managed Code

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- Code that targets the CLR is referred to as managed code
- All managed code has the features of the CLR
  - Object-oriented
  - Type-safe
  - Cross-language integration
  - Cross language exception handling
  - Multiple version support
- Managed code is represented in special Intermediate Language (IL)

Automatic Memory Management

- The CLR manages memory for managed code
  - All allocations of objects and buffers made from a *Managed Heap*
  - Unused objects and buffers are cleaned up automatically through *Garbage Collection*
- Some of the worst bugs in software development are not possible with managed code
  - Leaked memory or objects
  - References to freed or non-existent objects
  - Reading of uninitialised variables
- Pointerless environment

Multiple Language Support

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- IL (MSIL or CIL) – Intermediate Language
  - It is low-level (machine) language, like Assembler, but is Object-oriented
- CTS is a rich type system built into the CLR
  - Implements various types (int, float, string, …)
  - And operations on those types
- CLS is a set of specifications that all languages and libraries need to follow
  - This will ensure interoperability between languages

Intermediate Language

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- .NET languages are compiled to an Intermediate Language (IL)
- IL is also known as MSIL or CIL
- CLR compiles IL in just-in-time (JIT) manner – each function is compiled just before execution
- The JIT code stays in memory for subsequent calls
- Recompilations of assemblies are also possible

Example of MSIL Code

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```
.method private hidebysig static void  Main()
  cil managed
{
  .entrypoint
  // Code size       11 (0xb)
  .maxstack  8
  IL_0000:  ldstr      "Hello, world!"
  IL_0005:  call       void
  [mscorlib]System.Console::WriteLine(string)
  IL_000a:  ret
} // end of method HelloWorld::Main
```

Common Type System (CTS)

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- All .NET languages have the same primitive data types. An *int* in C# is the same as an *int* in VB.NET
- When communicating between modules written in any .NET language, the types are guaranteed to be compatible on the binary level
- Types can be:
  - Value types – passed by value, stored in the stack
  - Reference types – passed by reference, stored in the heap
- Strings are a primitive data type now

Common Language Specification (CLS)

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- Any language that conforms to the CLS is a .NET language
- A language that conforms to the CLS has the ability to take full advantage of the Framework Class Library (FCL)
- CLS is standardized by ECMA

.NET Languages

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- Languages provided by Microsoft

  C++, C#, J#, VB.NET, JScript

- Third-parties languages

  Perl, Python, Pascal, APL, COBOL, Eiffel, Haskell, ML, Oberon, Scheme, Smalltalk…

- Advanced multi-language features

  Cross-language inheritance and exceptions handling

- Object system is built in, not bolted on

  No additional rules or API to learn

C# Language

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- Mixture between C++, Java and Delphi
- Component-oriented
  Properties, Methods, Events
  Attributes, XML documentation
  All in one place, no header files, IDL, etc.
  Can be embedded in ASP+ pages
- Everything really is an object
  Primitive types aren't magic
  Unified type system == Deep simplicity
  Improved extensibility and reusability

C# Language – Example

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```
using System;

class HelloWorld
{
   public static void main()
   {
      Console.WriteLine("Hello, world!");
   }
}
```

Code Compilation and Execution

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Also called Assembly (.EXE or .DLL file)

Before installation or the first time each method is called

Assemblies

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- DLL or EXE file
- Smallest deployable unit in the CLR
- Have unique version number
- No version conflicts (known as DLL hell)
- Contains IL code to be executed
- Security boundary – permissions are granted at the assembly level
- Type boundary – all types include the assembly name they are a part of
- Self-describing manifest – metadata that describes the types in the assembly

Metadata in Assembly

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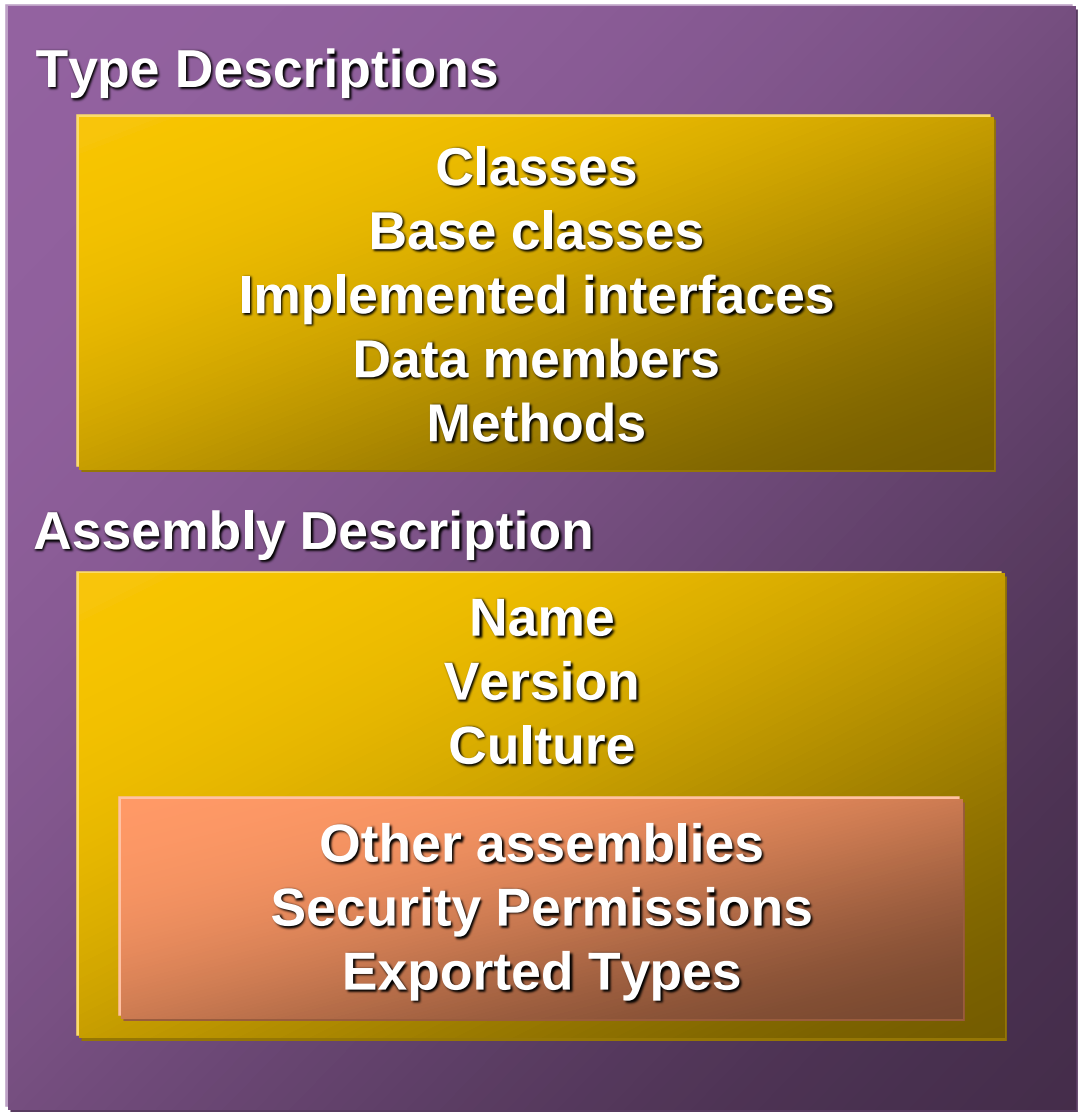

Applications

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- One or more assemblies
- Assemblies conflict resolution

  Using metadata

    Local (preferred)

    Global Assembly Cache (GAC)
- Different applications may use different versions of an assembly

  Easier software updates

  Easier software removal

Visual Studio .NET

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- Development tool that contains a rich set of productivity and debugging features
  - Supports managed and unmanaged applications
  - Supports C#, C++, VB.NET, …
  - Many useful tools and wizards
  - Windows Forms Designer
  - ASP.NET Web Forms Designer
  - Web Services support
  - SQL Server integration with ADO.NET and XML
- VS.NET is not part of the .NET Framework
  - Not necessary to build or run managed code
  - The .NET Framework SDK includes command line compilers

VS.NET – Single Development Environment & Skill Set

- From Visual Studio.NET you can:

  Write code

  Design user interface

  Study documentation

  Debug

  Test

  Deploy
- Same tools for all languages
- Same tools for all platforms

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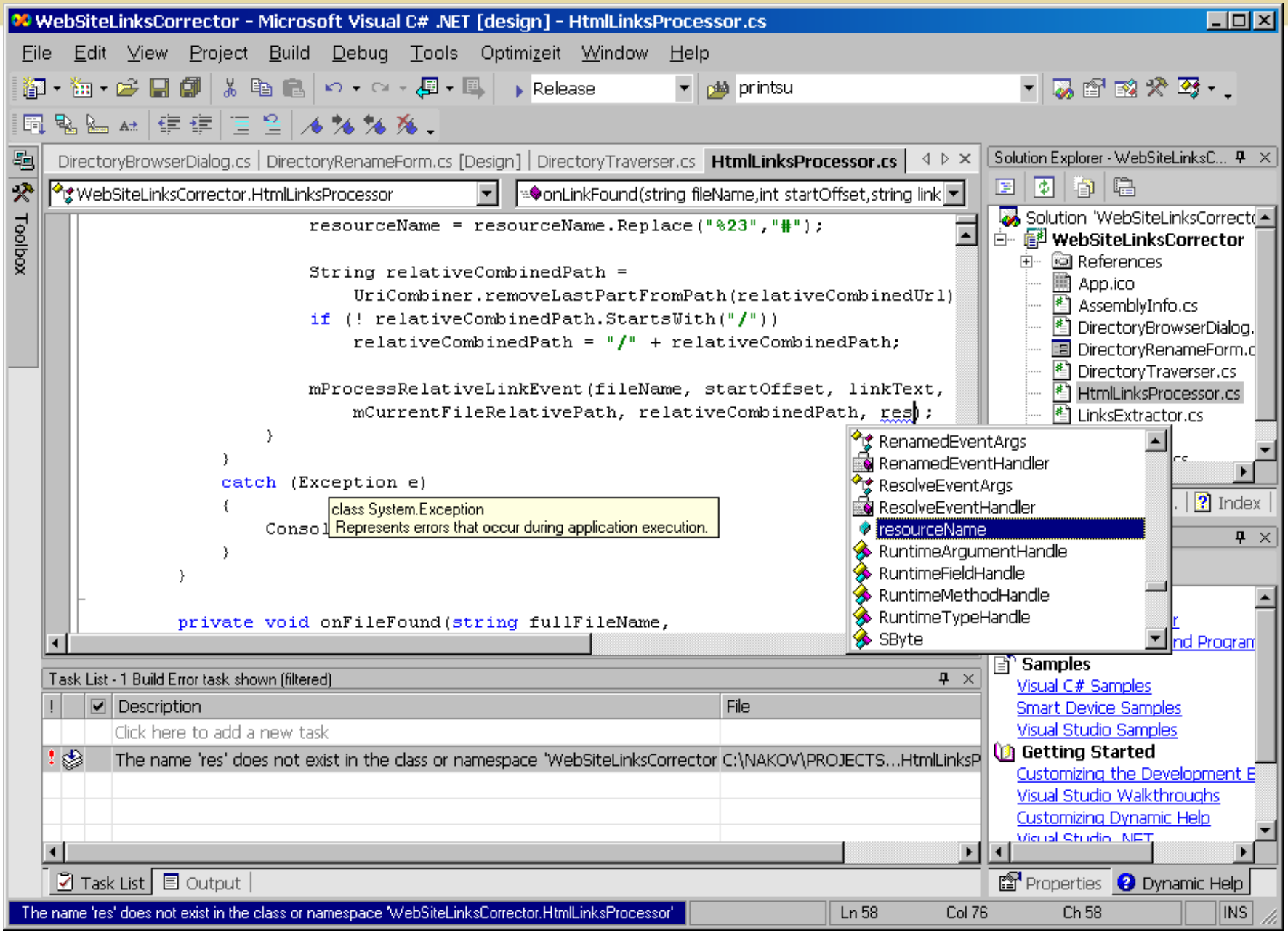

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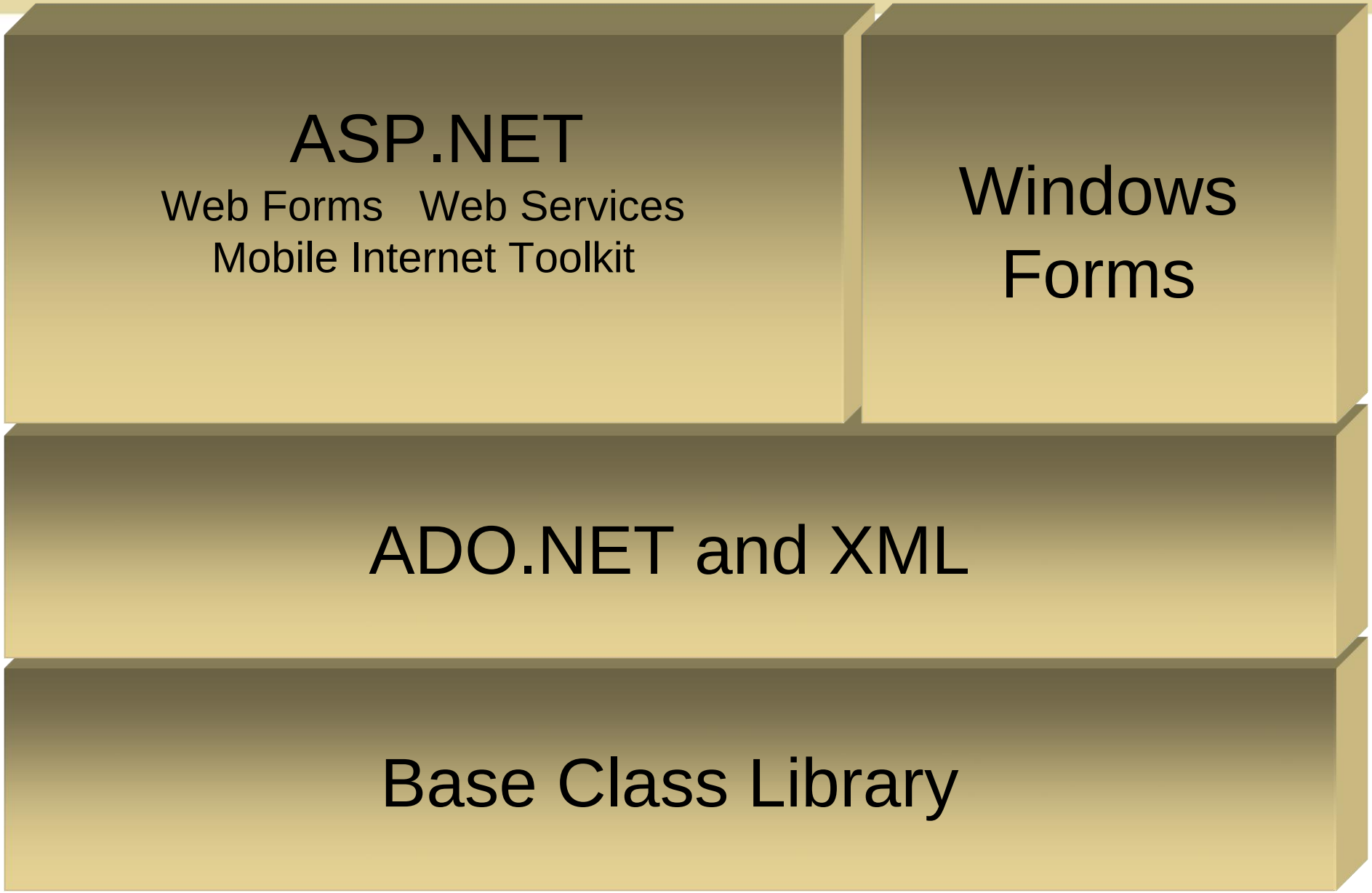

.NET Framework Namespaces

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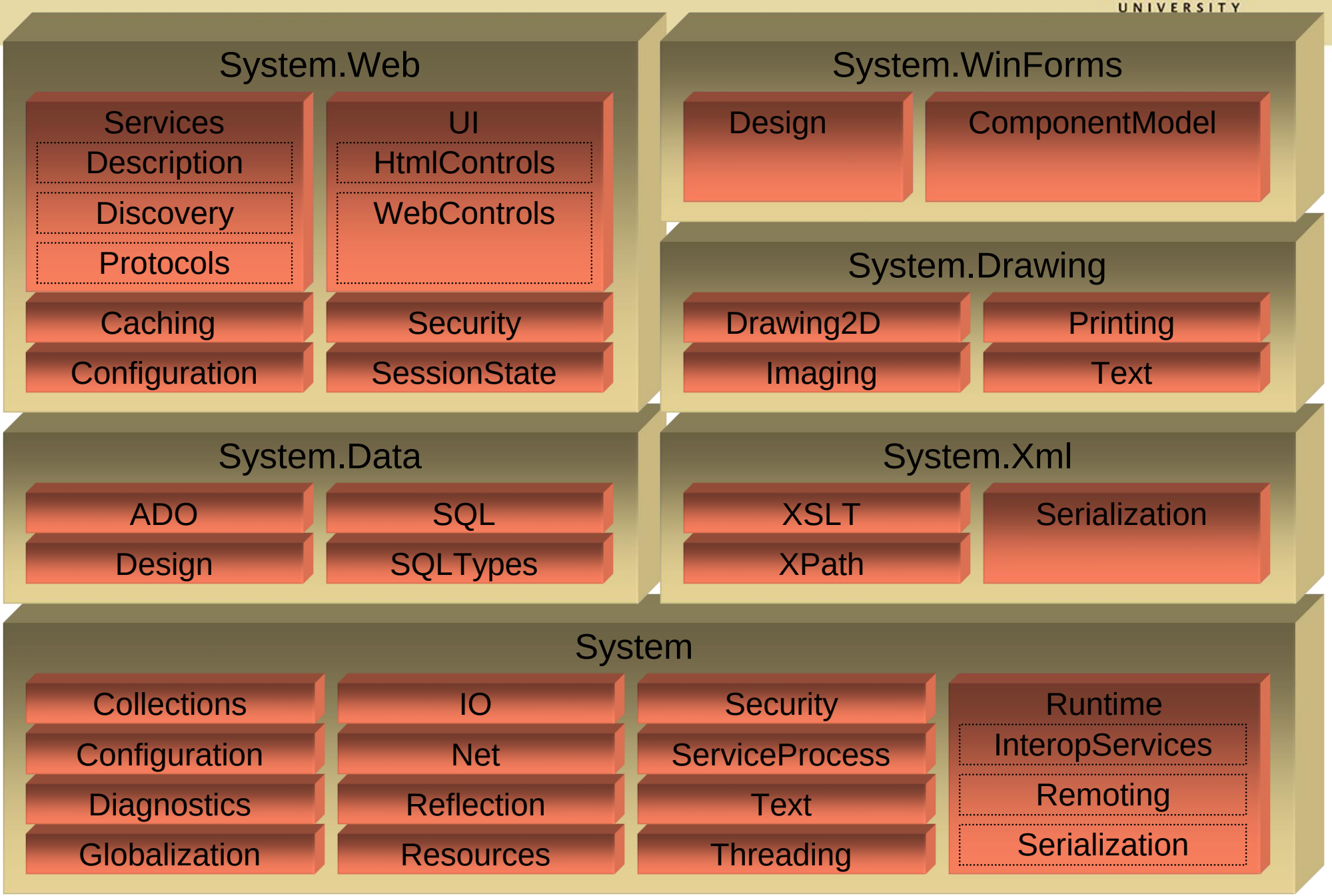

Base Class Library Namespaces

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Base Class Library

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- Data types, conversions, formatting
- Collections: ArrayList, Hashtable, etc.
- Globalization: Cultures, sorting, etc.
- I/O: Binary and text streams, files, etc.
- Networking: HTTP, TCP/IP sockets, etc.
- Reflection: Metadata and IL emit
- Security: Permissions, cryptography
- Text: Encodings, regular expressions

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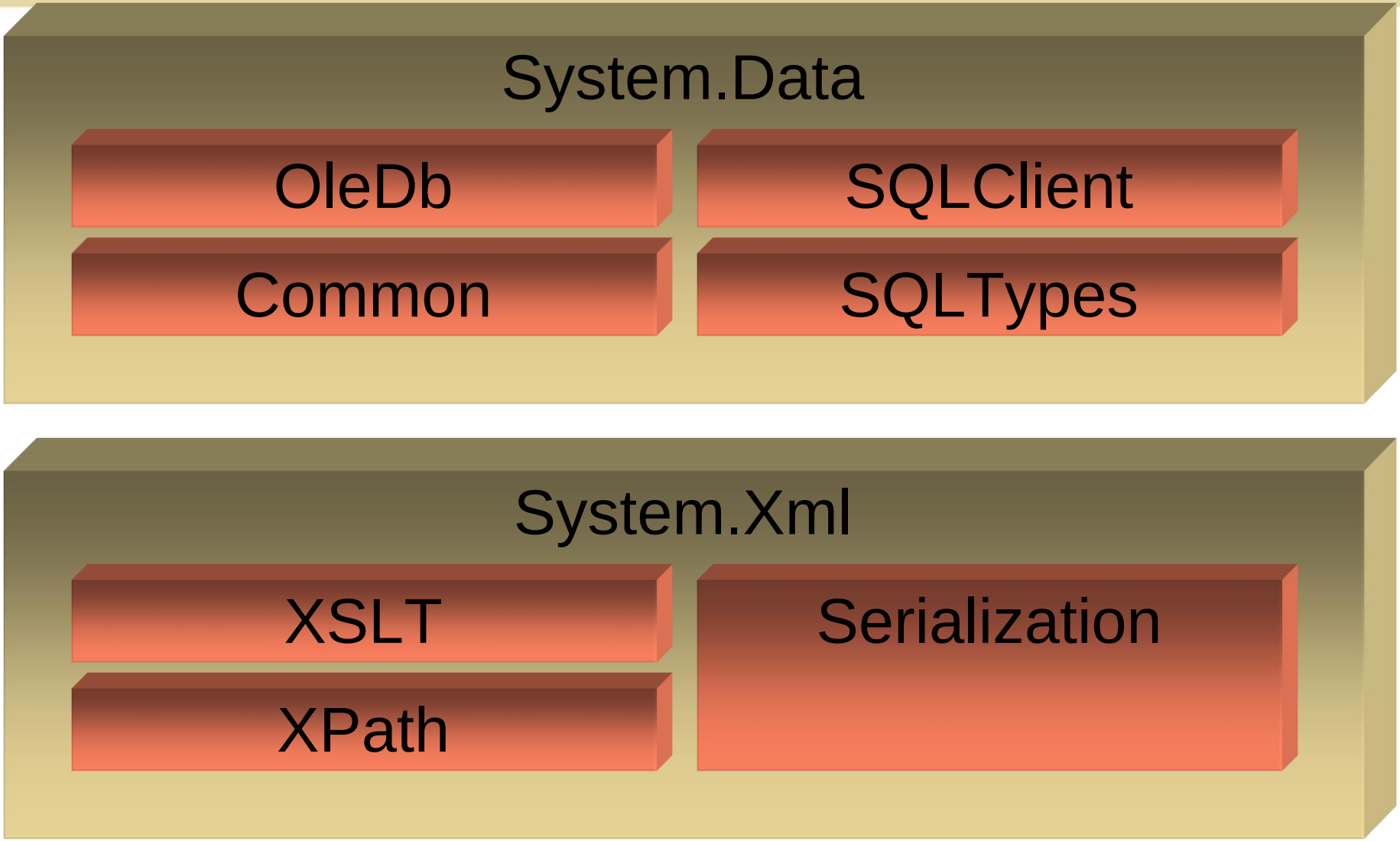

ADO.NET And XML

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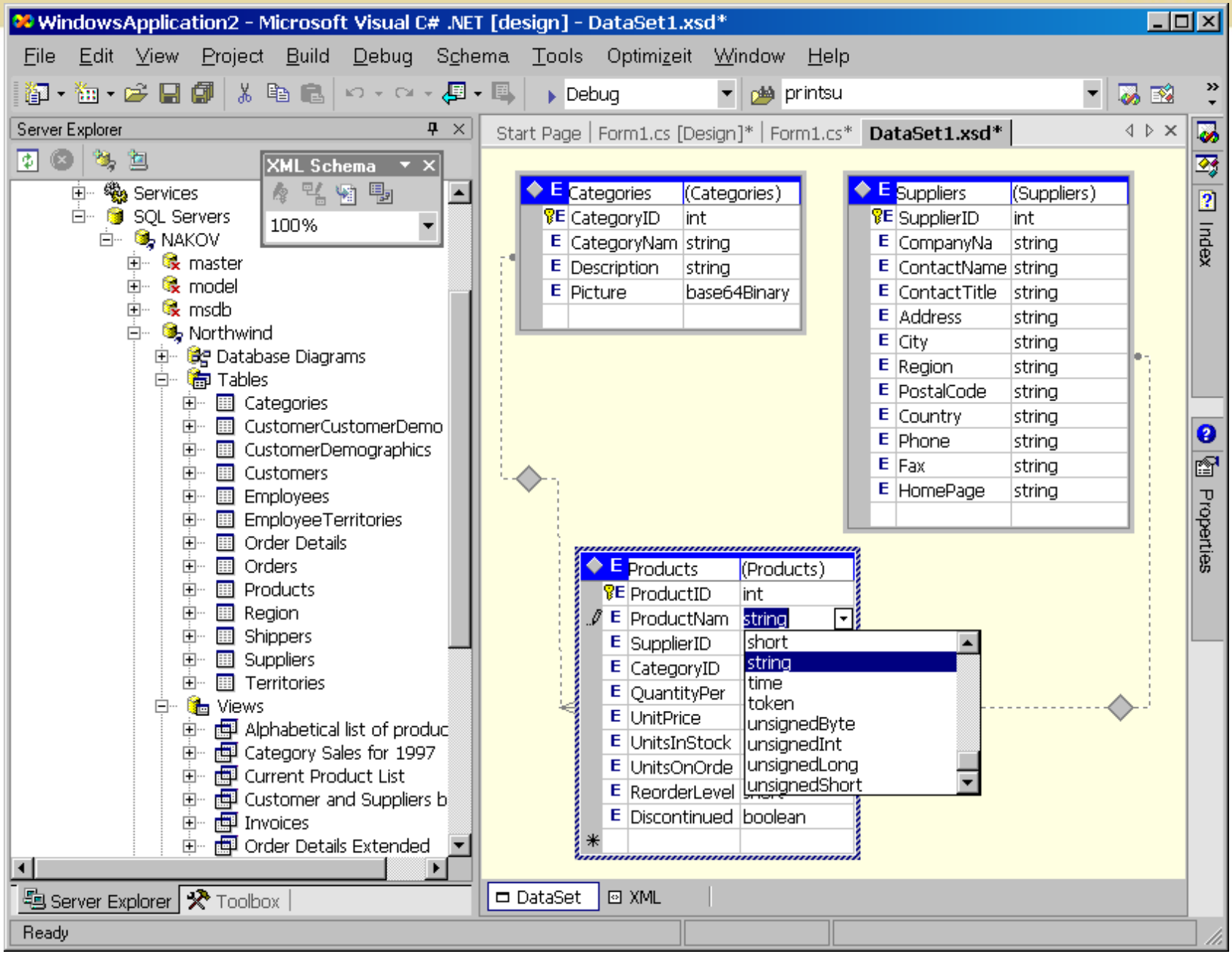
- ADO.NET consumes all types of data
  - XML (hierarchical), relational, etc.
- Powerful in-memory data cache (DataSet)
  - DataSet contains various data objects: tables, views, relations, constraints, etc.
  - Lightweight, stateless, disconnected
  - Supports both relational and XML access
- High-performance, low overhead stream access
- Great XML support including:
  - W3C DOM, XSL/T, XPath, and Schema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Form1.cs*
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Categories (Categories)
CategoryID int
CategoryNam string
Description string
Picture base64Binary
Suppliers (Suppliers)
SupplierID int
CompanyNa string
ContactName string
ContactTitle string
Address string
City string
Region string
PostalCode string
Country string
Phone string
Fax string
HomePage string
Products (Products)
ProductID int
ProductNam string
SupplierID
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Server Explorer
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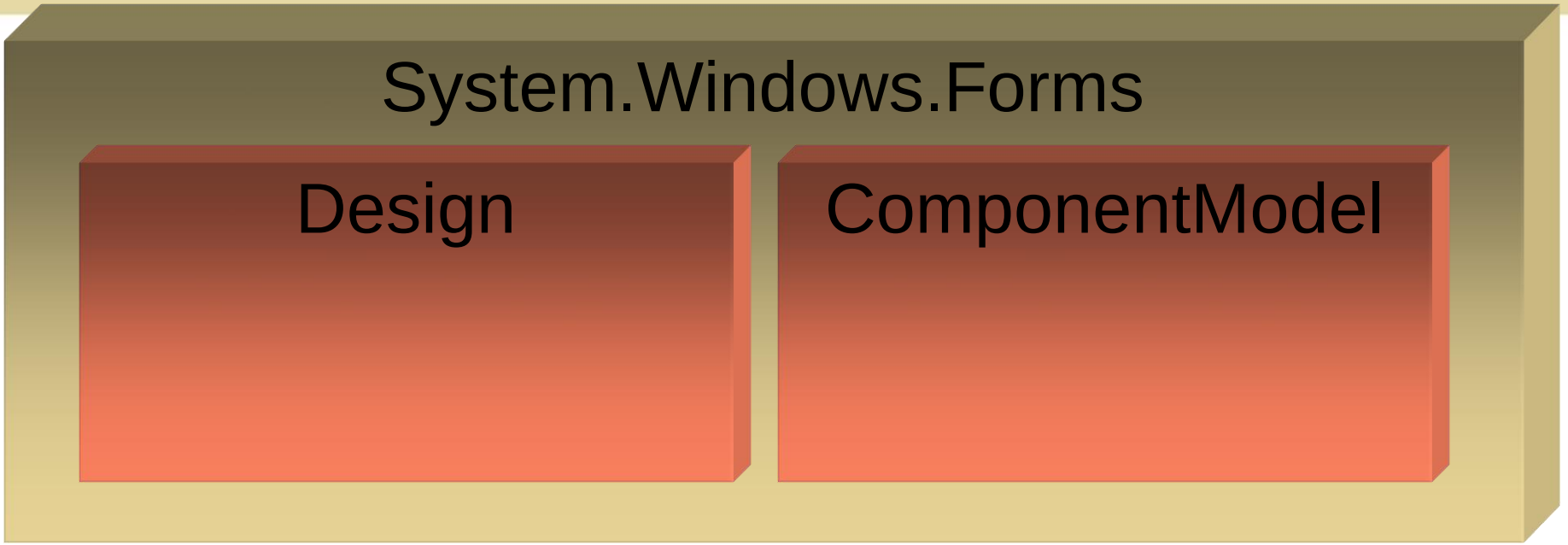
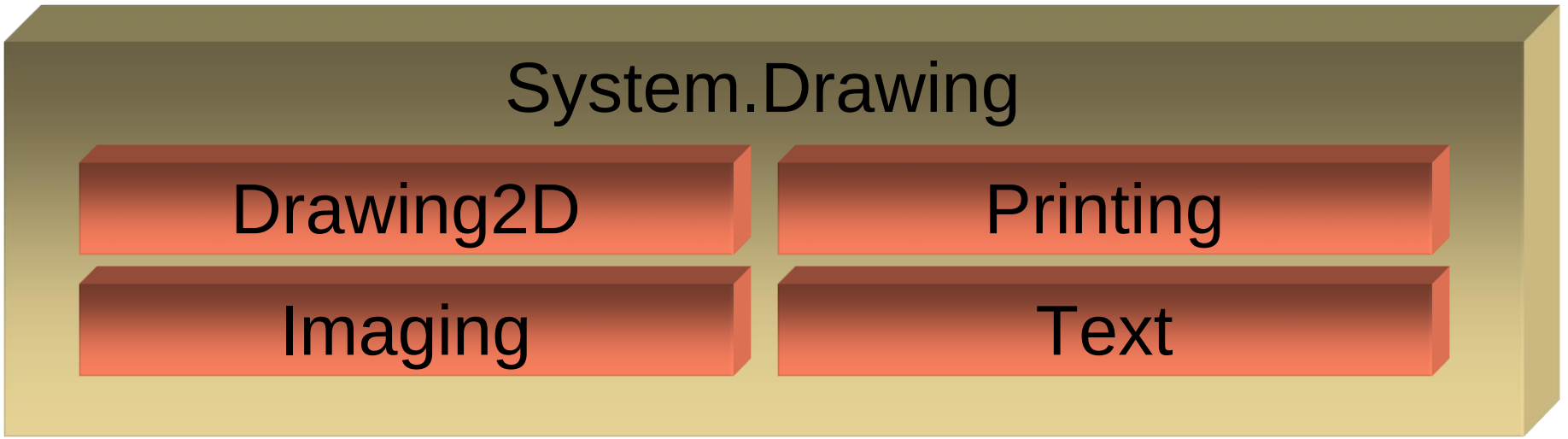

System.Windows.Forms
Design
ComponentModel


System.Drawing
Drawing2D
Printing
Imaging
Text

Windows Forms

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- Windows Forms is framework for building rich GUI applications

RAD (Rapid Application Development)

component-based

event-driven

Rich set of controls

Data aware components

ActiveX® Support

Printing support

Unicode support

UI inheritance

Windows Forms

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- Combines VB and Delphi forms with the power of MFC

  Delegation as well as subclassing
- Advanced features

  Visual forms inheritance, automatic layout

  Advanced graphics support – GDI+

  Easy access to Win32® API
- Controls can be hosted in IE 5.x

  No installation, registration or GUIDs
- Code access security

VS.NET – Windows Forms Designer

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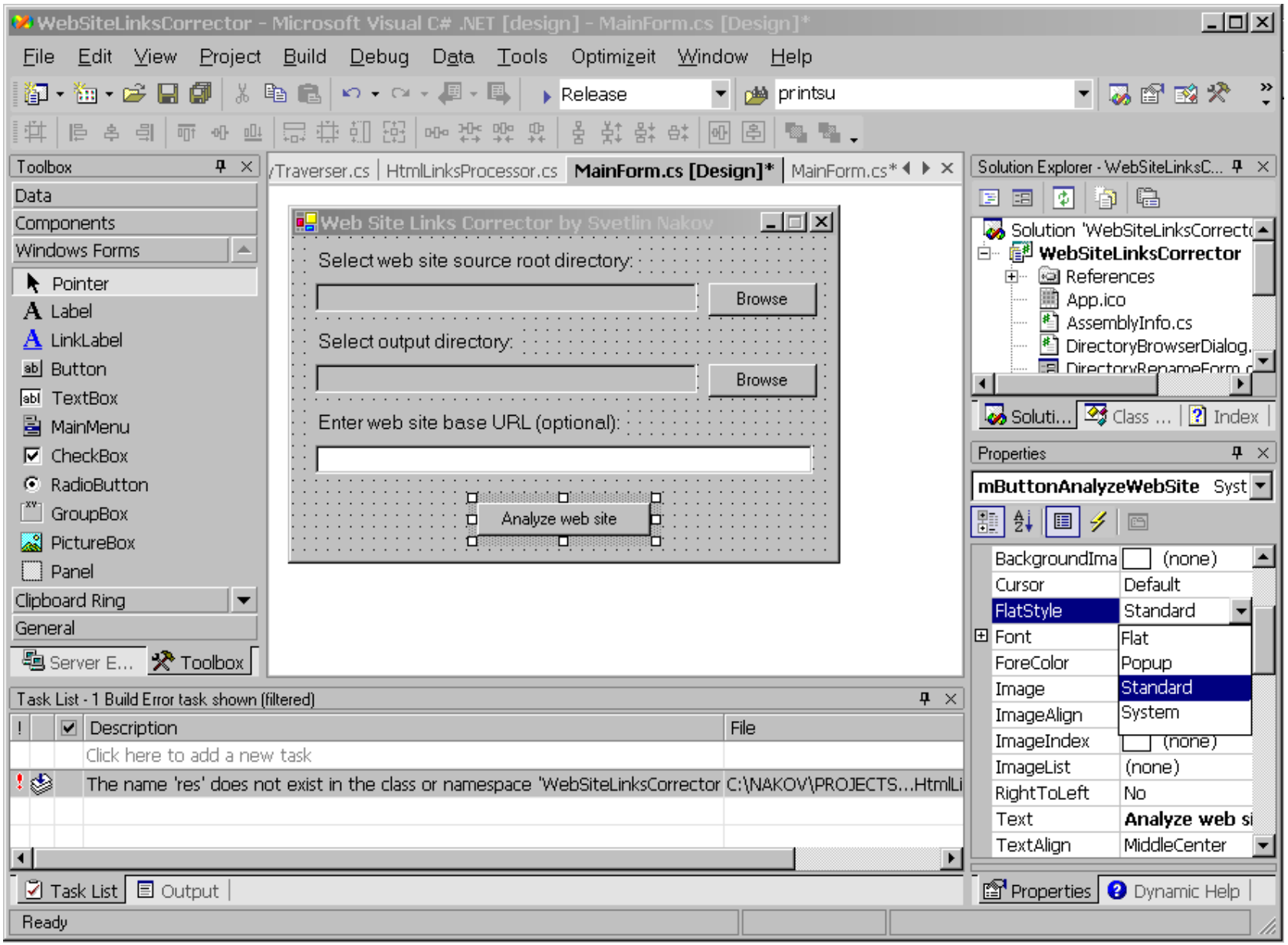

ASP.NET Namespaces

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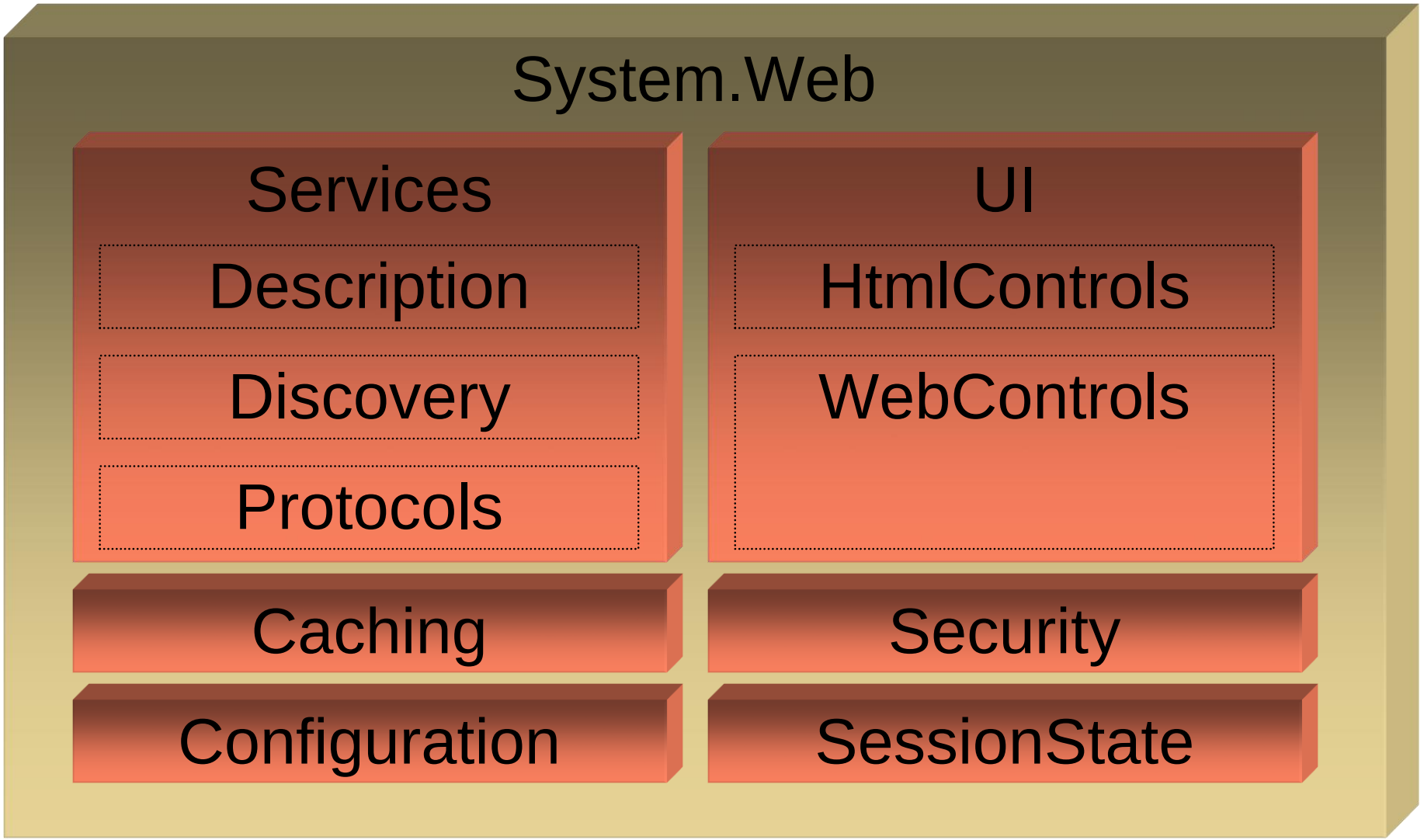

ASP.NET

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- Framework for building Web applications and Web services in any .NET language
  - C#, C++, VB.NET, JScript, etc.
- Automatic multiple clients support
  - DHTML, HTML 3.2, WML, small devices
- Compilation of ASP.NET Web applications into .NET assemblies
  - Cached the first time when called
  - All subsequent calls use the cached version
- Separation of code and content
  - Developers and designers can work independently

ASP.NET

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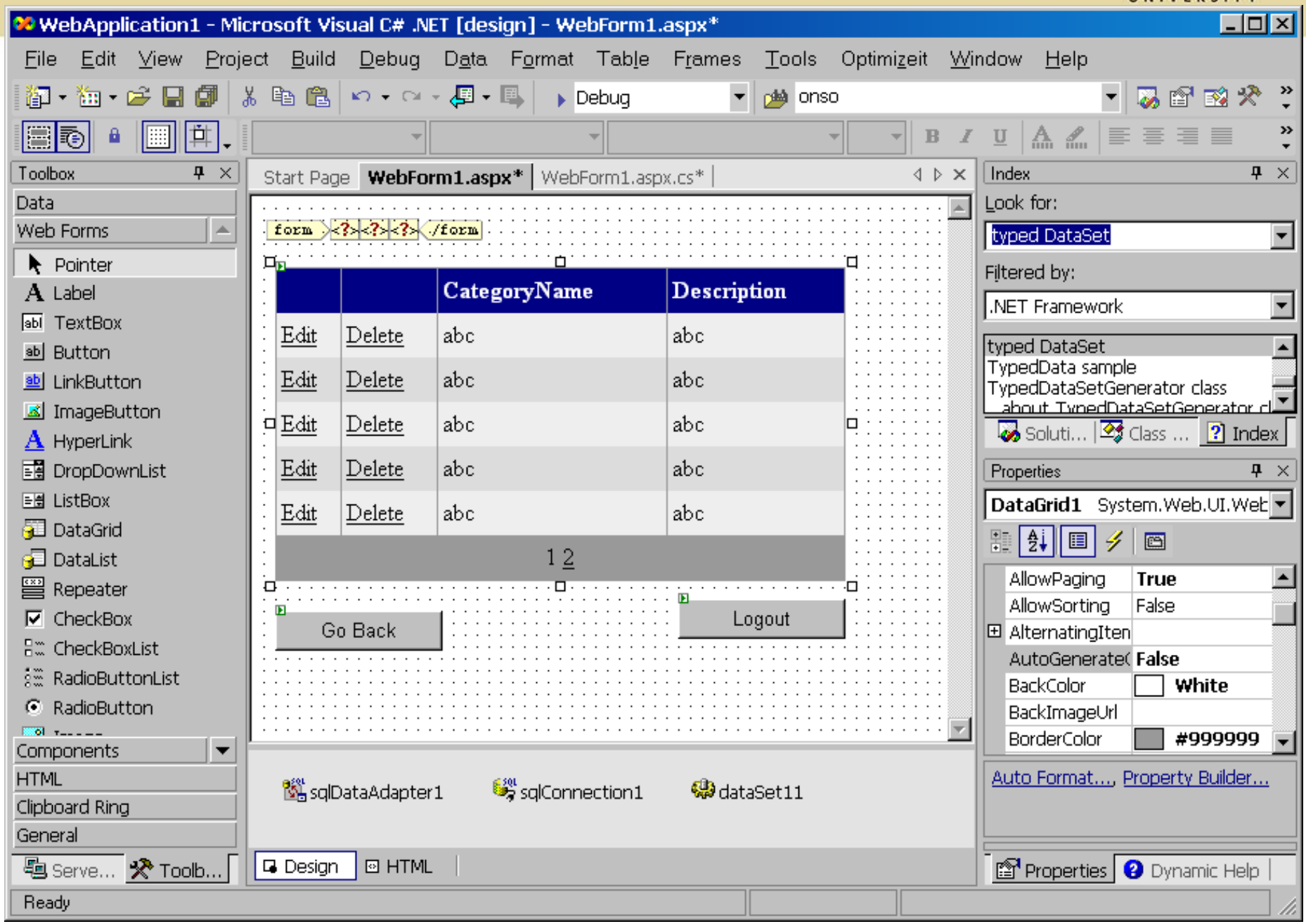
- Rich page architecture – "Web Forms"
- Rich set of ASP.NET server controls

  Data validation

  Data bound grids
- Event-driven execution model
- Great Web-services support
- Easy to deploy
- High reliability and availability
- High performance and scalability
- Scalable handling of state information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Data
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TextBox
Button
LinkButton
ImageButton
HyperLink
DropDownList
ListBox
DataGrid
DataList
Repeater
CheckBox
CheckBoxList
RadioButtonList
RadioButton
Components
HTML
Clipboard Ring
General
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WebForm1.aspx.cs*
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Description
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Delete
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AllowSorting False
AutoGenerate(False
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Properties
Dynamic Help
Ready

Web Services

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- Technical definition – "A programmable application component accessible via standard Web protocols"

  Built on XML and SOAP
- Expose functionality from Web Sites

  Almost like component programming over the Web

  Functionality exposed using XML/HTML
- Standard Web Services include

  Calendar

  MSN Passport

XML Web Services Foundation

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- Simple, Open, Broad Industry Support
- Open standards:

Publish, Find, Use Services: UDDI

Service Interactions: SOAP

Universal Data Format: XML

Ubiquitous Communications: Internet

ASP.NET Web Services

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- Simple programming model

  Author .ASMX files with class methods

  ASP.NET compiles on demand, generates WSDL contract, exposes HTML test page
- Incoming HTTP/SOAP messages invoke methods

  No special HTTP, SOAP or XML knowledge required
- Supports multiple message wire formats

  HTTP GET, POST, and SOAP Requests

Web Service Example in C#

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ParcelTracker.asmx

```
<%@ WebService Language="C#" %>
using System;
using System.Web.Services;

public class ParcelTrackerWebService
{
   [WebMethod]
   public string GetOrderStatus(int orderNumber)
   {
       // Implementation here
   }
}
```

Summary

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- .NET Framework is a code execution platform – the environment which .NET programs run
- .NET Framework consists of two primary parts: Common Language Runtime and .NET Class Libraries
- The CLS (Common Language Specification) allows different languages to interact seamlessly.
- The CTS (Common Type System) allows all languages to share base data types.

Summary (2)

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- .NET languages are compiled to MSIL by their respective compilers
- MSIL code is compiled to machine code by the JIT compiler
- All .NET languages have equal access to the FCL (Framework Class Library) which is a rich set of classes for developing software
- Base Class Library is set of basic classes: Collections, I/O, Networking, Security, etc.
- ADO.NET provides .NET applications with access to relational databases

Summary (3)

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- .NET has great XML support including: DOM, XSLT, XPath, and XSchema
- Windows Forms provides GUI interface for the .NET applications
- ASP.NET allows creating web interface to .NET applications
- Web Services expose functionality from web sites and make it remotely accessible through standard XML-based protocols
- Visual Studio .NET is powerful development IDE for all .NET languages and technologies

.NET Framework – Resources

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.NET Framework Home Site – http://msdn.microsoft.com/netframework/

The Microsoft .NET Framework Community – http://www.gotdotnet.com/

ASP.NET – http://www.asp.net/

.NET Windows Forms – http://www.windowsforms.net/

Code Project – http://www.codeproject.net/

Mono – Open Source .NET Framework – http://www.go-mono.org/

Rotor – Shared Source .NET CLI – http://msdn.microsoft.com/net/sscli/

- Read the news groups:

  news://msnews.microsoft.com/microsoft.public.dotnet.framework

Acknowledgements

.NET framework slides drawn from: Svetlin Nakov, Sofia University