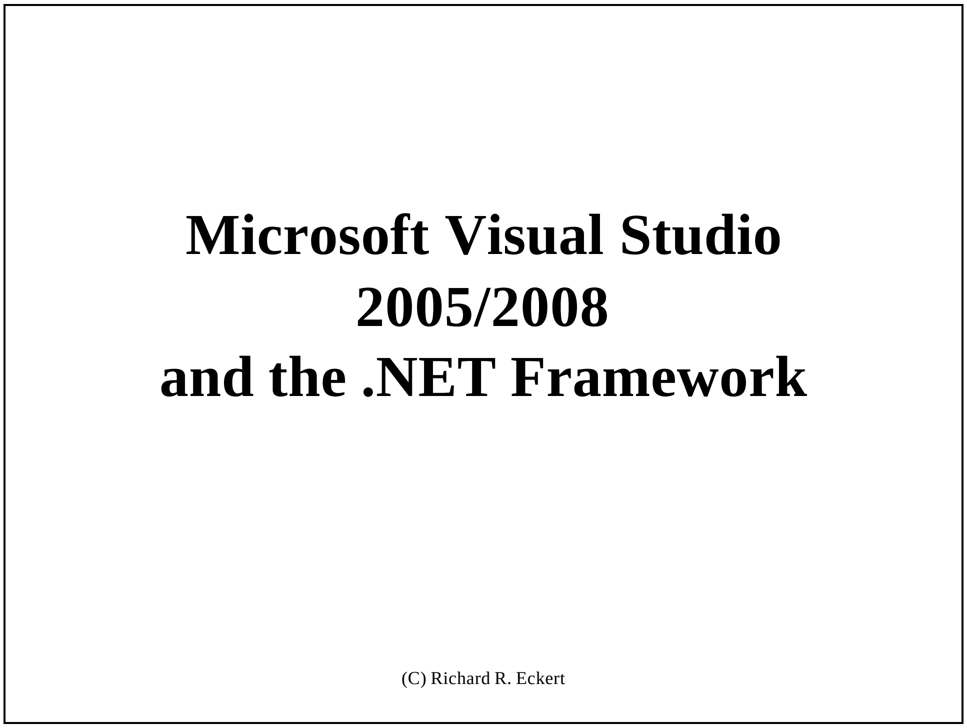
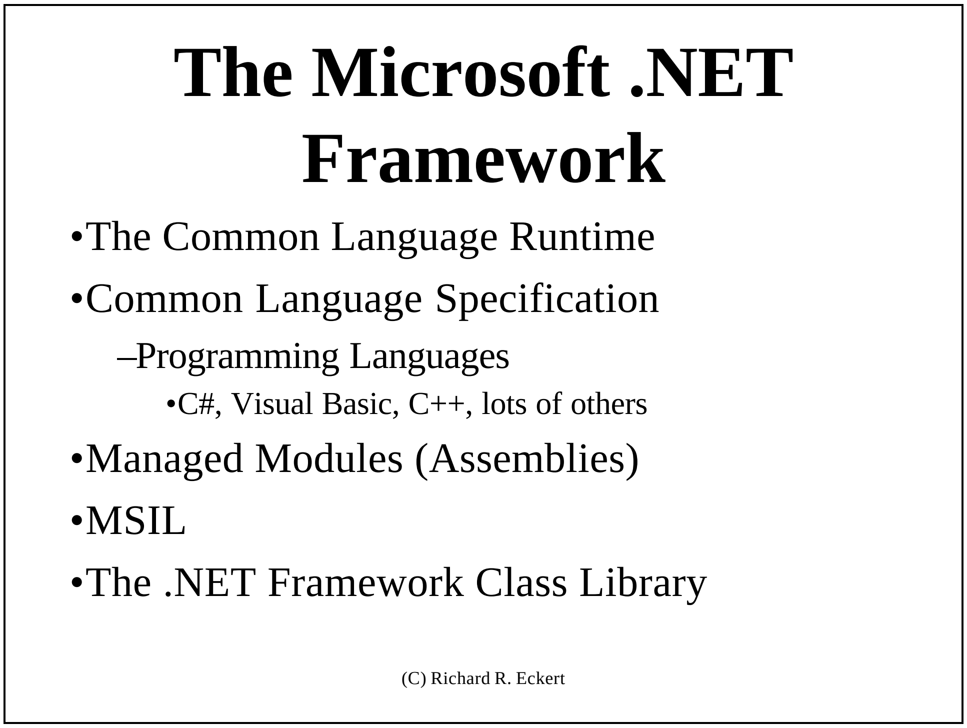


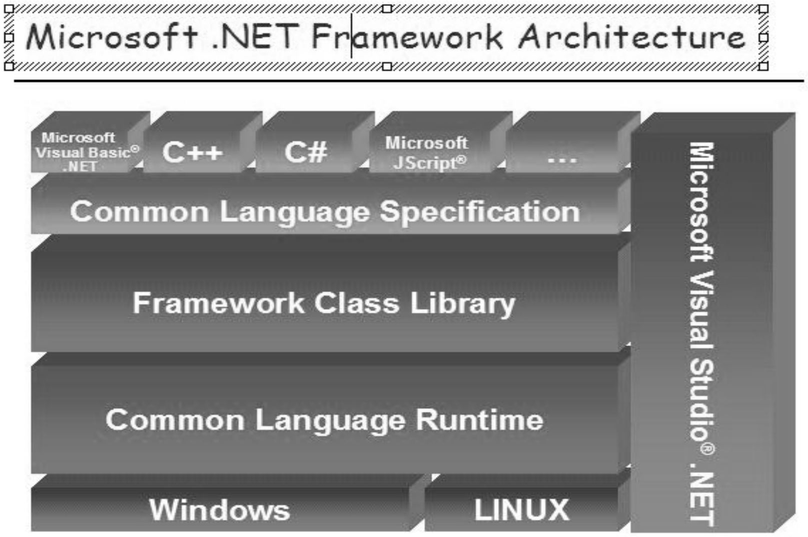
Microsoft Visual Studio 2005/2008 and the .NET Framework



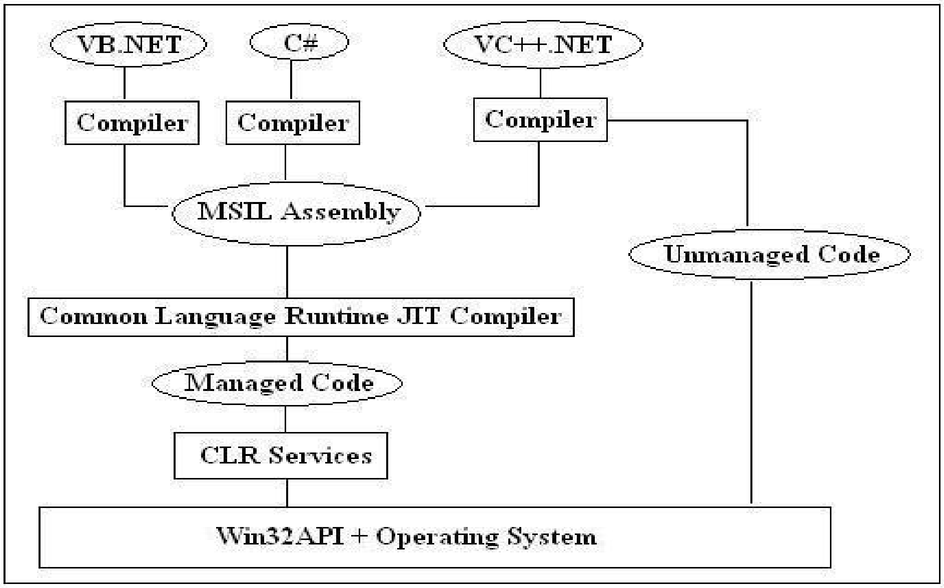
The Microsoft .NET Framework

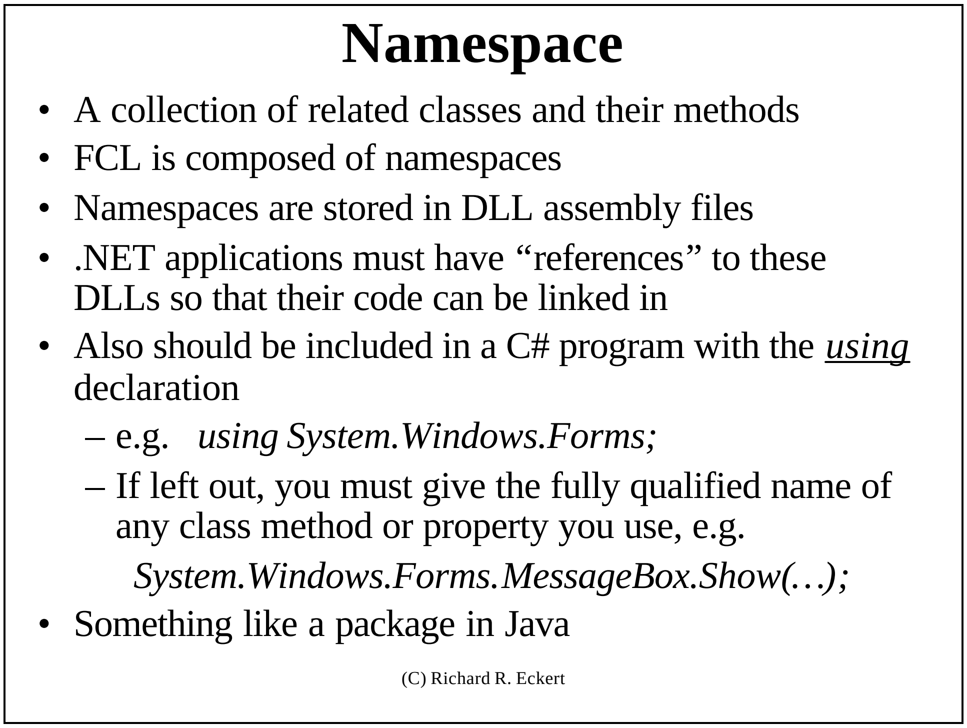
- The Common Language Runtime
- Common Language Specification
  - Programming Languages
    - C#, Visual Basic, C++, lots of others
- Managed Modules (Assemblies)
- MSIL
- The .NET Framework Class Library

.NET Architecture


Microsoft .NET Framework Architecture
Microsoft Visual Basic® .NET
C++
C#
Microsoft JScript®
...
Common Language Specification
Framework Class Library
Common Language Runtime
Windows
LINUX
Microsoft Visual Studio® .NET

Compilation in the .NET Framework

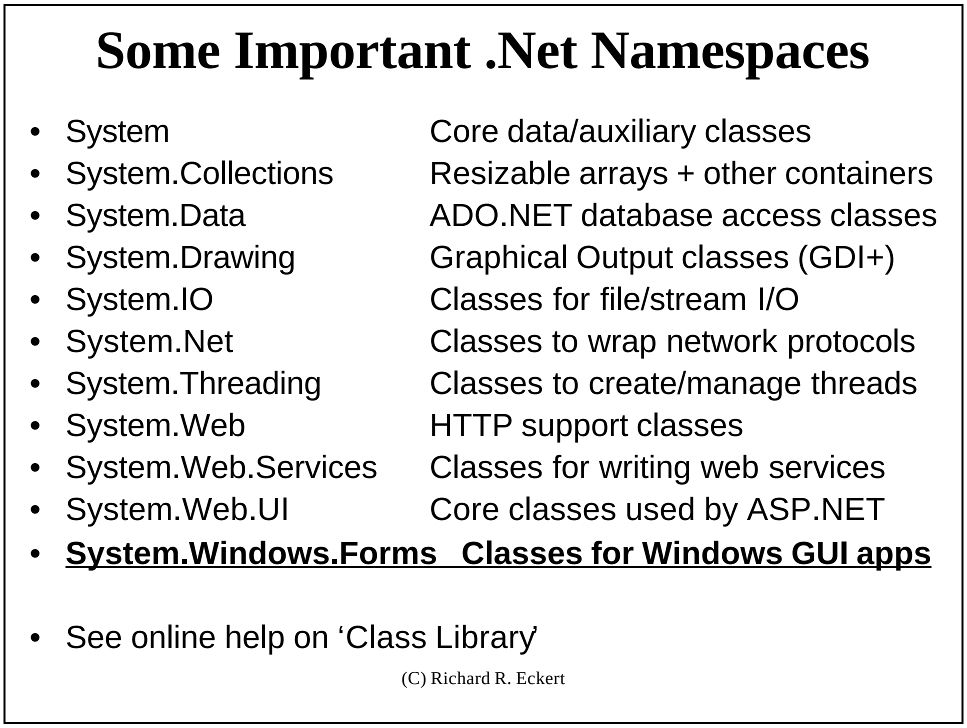




Namespace

- A collection of related classes and their methods
- FCL is composed of namespaces
- Namespaces are stored in DLL assembly files
- .NET applications must have “references” to these DLLs so that their code can be linked in
- Also should be included in a C# program with the *using* declaration
  - e.g. *using System.Windows.Forms;*
  - If left out, you must give the fully qualified name of any class method or property you use, e.g.

    System.Windows.Forms.MessageBox.Show(…);
- Something like a package in Java



Some Important .Net Namespaces

• System	Core data/auxiliary classes
• System.Collections	Resizable arrays + other containers
• System.Data	ADO.NET database access classes
• System.Drawing	Graphical Output classes (GDI+)
• System.IO	Classes for file/stream I/O
• System.Net	Classes to wrap network protocols
• System.Threading	Classes to create/manage threads
• System.Web	HTTP support classes
• System.Web.Services	Classes for writing web services
• System.Web.UI	Core classes used by ASP.NET
• **System.Windows.Forms**	**Classes for Windows GUI apps**

- See online help on ‘Class Library’

C#

- A new component & object oriented language
  - Emphasis on the use of classes
- Power of C++ and ease of use of Visual Basic
- Combines the best aspects of C++ and Java
  - Conceptually simpler and more clear than C++
  - More structured than Visual Basic
  - More powerful than Java
- Syntax very similar to C/C++
  - No header files
- Managed pointers only
  - “Almost no pointers” ✍ “almost no bugs”

C# Classes

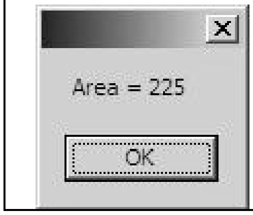
- Can contain:
  - **“<u>Fields</u>”:** Data members (like C++ variables)
  - **“<u>Methods</u>”:** Code members (like C++ functions)
  - **“<u>Properties</u>”:** In-between members that expose data
    - To the user program they look like data fields
    - Within the class they look like code methods
    - Often they provide <u>controlled access</u> to private data fields
      - Validity checks can be performed
      - Values can be obtained or set after validity checks
        - » Properties use <u>Accessor</u> methods <u>get()</u> and <u>set()</u>
        - » <u>get() to retrieve the value of a data field</u> … *<u>return</u> data-field;*
        - » <u>set() to change the value of a data field</u> … *data-field = <u>value</u>;*
      - Other classes use Properties just like data fields
  - “**<u>Events</u>**”: Define the notifications a class is capable of firing in response to user actions

Example: Square class

```
public class Square
{
    private int side_length = 1;                          // A Field

    public int Side_length                                // A Property
    {
        get { return side_length; }                       // “return”: specifies value going out
        set
        {
            if (value>0)
                side_length = value;                      // “value”: specifies value that came in
            else
                throw (new ArgumentOutOfRangeException());
        }
    }

    public int area()                                     // A Method
    {
        return (side_length * side_length);
    }

    public Square(int side)                               // The Constructor method
    {
        side_length = side;
    }
}
```

Instantiating and Using the Square Class

```
Square sq = new Square(10);       // Construct a Square object called sq
                                  // of side_length = 10
                                  // Instantiates the object and invokes
                                  // the class constructor
int x = sq.Side_length;           // Retrieve object’s Side_Length Property
sq.Side_length = 15;              // Change object’s Side_length Property
int sq_area = sq.area();          // Define an integer variable and use
                                  // the class area() method to compute
                                  // the area of the square
MessageBox.Show(“Area= “ + sq_area.ToString());
                                  // Display result in a Message Box
                                  // Note use of ToString() method
                                  // to convert an integer to a string.
                                  // Show() is a static method of MessageBox
                                  // class
```


Area = 225

Windows Forms

- A Windows Form: In .NET it’s just a window
- Forms depend on classes in the namespace ‘System.Windows.Forms’
- **<u>Form</u>** class is in ‘System.Windows.Forms’:
  - – The heart of every Windows Forms application is a class derived from <u>Form</u>
    - An instance of this derived class represents the application’s main window
    - Inherits many properties and methods from <u>Form</u> that determine the look and behavior of the window
      - – E.g., Text property to change the window’s caption
- **<u>Application</u>**: Another important class from ‘System.Windows.Forms'
  - – Its <u>static</u> method Run(…) drives the Windows Form application
    - Argument is the <u>Form</u> to be run
  - – Invoked in the program’s entry point function: Main()
  - – Causes the program to create the form passed to it and enter the message loop
    - Implies form’s constructor will run (typically code to set initial window properties)
  - – The form passed to Run( ) has code to post a QUIT message when form is closed
  - – Returns to Main( ) when done and program terminates properly

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A Simple Windows Form App in C# -- HelloWorld

```
using System.Windows.Forms;      // the namespace containing
                                 // the Form class
public class HelloWorld : System.Windows.Forms.Form
{                                // our class is derived from Form
   public HelloWorld()           // our class constructor
   {
       this.Text = "Hello World";  // Set this form’s Text Property
   }

   static void Main()            // Application’s entry point
   {
        Application.Run(new HelloWorld());   // Run our form
   }
}
```

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Compiling a C# Application from the Command Line

- Start a Command Window with the proper paths to the compiler/linker set
  - Easiest way: From Task Bar:
    - ‘Start’ | ‘All Programs’ | ‘Microsoft Visual Studio 2005’ | ‘Visual Studio Tools’ | ‘Visual Studio 2005 Command Prompt’
    - Starts the DOS Box Command Window
  - Navigate to the directory containing the source code file(s)
  - From the command prompt Invoke the C# compiler and linker
  - For example, to build an executable from the C# source file myprog.cs, type one of the following:

```
csc myprog.cs                    (easiest way, creates a console app)
csc /target:exe myprog.cs        (also creates a console application)
csc /t:winexe myprog.cs          (creates a Windows executable)
csc /t:winexe /r:System.dll,System.Windows.Forms.dll myprog.cs
                                (to provide access to needed .NET DLLs)
```

Using Visual Studio to Develop a Simple C# Application “Manually”

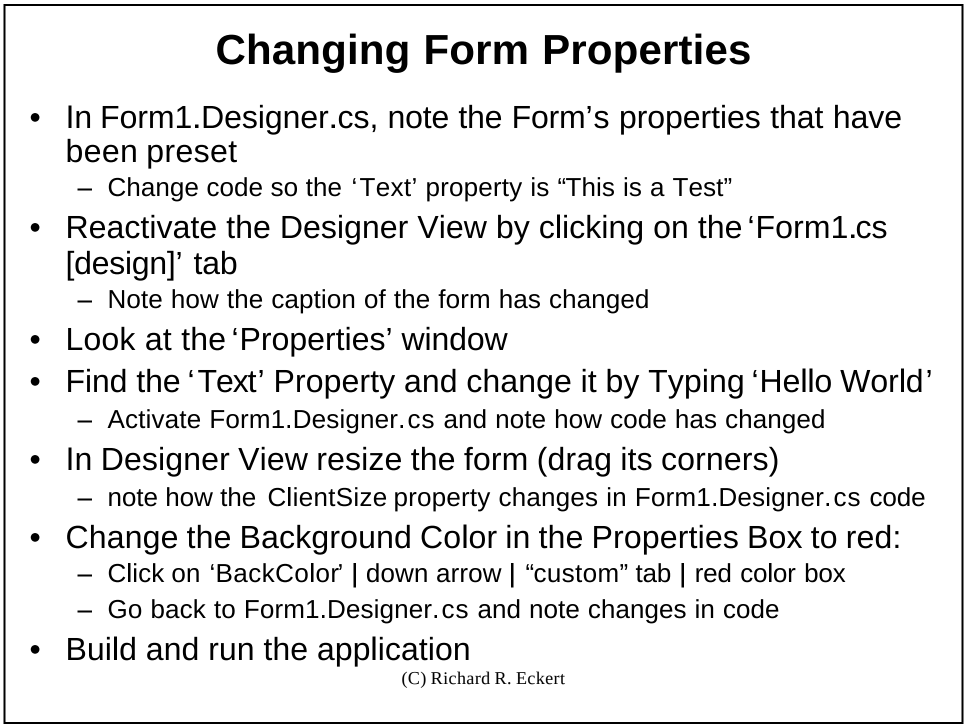
- Start Visual Studio as usual
- ‘File’ | ‘New’ | ‘Project’ | ‘Visual C#’ | ‘Windows’ | ‘Empty Project’
- To create the program
  - ‘Project’ | ‘Add New Item’
    - Visual Studio installed templates: ‘C# Code File’
  - This will bring up the code editor
  - Type in or copy and paste the C# source code
- But you must also provide access to some additional .NET Common Language Runtime DLLs
- Do this by adding ‘References’:
  - ‘Project’ | ‘Add Reference’ … ‘.NET’ tab
  - Select: System and System.Windows.Forms
- Build project as usual (‘Build’ | ‘Build Solution’)

Using Visual Studio's Designer to Develop a Simple C# Application

- Start Visual Studio as usual
- 'File' | 'New' | 'Project' | 'Visual C#' | 'Windows' | 'Windows Application'
  - Gives a "designer view" of the Windows Form the project will create
  - Also skeleton code
    - Right click on form & select 'View Code' to see it
    - Note how it's broken up into 'Regions' (+ and - boxes on the left)
    - These can be expanded and contracted
  - This is only part of the code
  - To see code generated by the Visual Studio designer:
    - In Solution Explorer, expand Form1.cs & double click on Form1.Designer.cs
    - Expand the 'Windows Form Designer generated code' Region

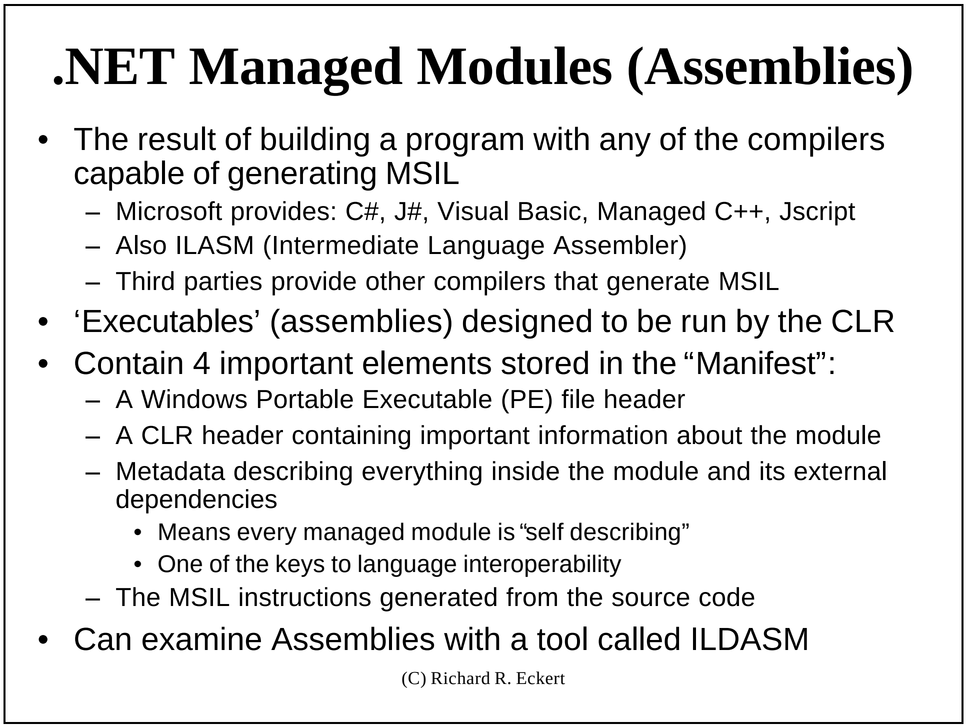
Where is Main()?

- Go to Class View and expand the project's classes
  - Note that there are two classes: the Form and the Program
  - Expand the Program class
    - That is where Main() is
    - It runs the Form just as in our manual code



Changing Form Properties

- In Form1.Designer.cs, note the Form’s properties that have been preset
  - Change code so the ‘Text’ property is “This is a Test”
- Reactivate the Designer View by clicking on the ‘Form1.cs [design]’ tab
  - Note how the caption of the form has changed
- Look at the ‘Properties’ window
- Find the ‘Text’ Property and change it by Typing ‘Hello World’
  - Activate Form1.Designer.cs and note how code has changed
- In Designer View resize the form (drag its corners)
  - note how the ClientSize property changes in Form1.Designer.cs code
- Change the Background Color in the Properties Box to red:
  - Click on ‘BackColor’ | down arrow | “custom” tab | red color box
  - Go back to Form1.Designer.cs and note changes in code
- Build and run the application



.NET Managed Modules (Assemblies)

- The result of building a program with any of the compilers capable of generating MSIL
  - Microsoft provides: C#, J#, Visual Basic, Managed C++, Jscript
  - Also ILASM (Intermediate Language Assembler)
  - Third parties provide other compilers that generate MSIL
- ‘Executables’ (assemblies) designed to be run by the CLR
- Contain 4 important elements stored in the “Manifest”:
  - A Windows Portable Executable (PE) file header
  - A CLR header containing important information about the module
  - Metadata describing everything inside the module and its external dependencies
    - Means every managed module is “self describing”
    - One of the keys to language interoperability
  - The MSIL instructions generated from the source code
- Can examine Assemblies with a tool called ILDASM

The ILDASM Disassembler

- Used to examine an assembly’s metadata and code
- Start a Command Window with proper path to ILDASM set
  - Easiest way: From Task Bar:
    - ‘Start’ | ‘All Programs’ | ‘Microsoft Visual Studio .NET’ | ‘Visual Studio .NET Tools’ |
    - Starts the DOS Box Command Window
  - Navigate to the directory containing the assembly (.exe)
  - Invoke ILDASM
    - e.g., for HelloWorld program:
      ILDASM HelloWorld.exe
    - Displays a window showing the assembly’s Manifest and the classes in the assembly

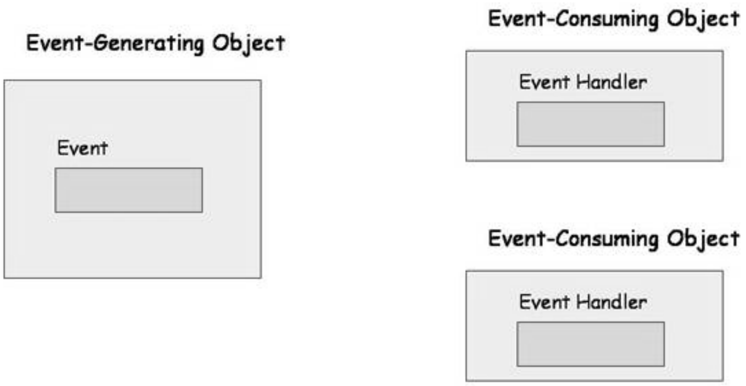
A Session with ILDASM

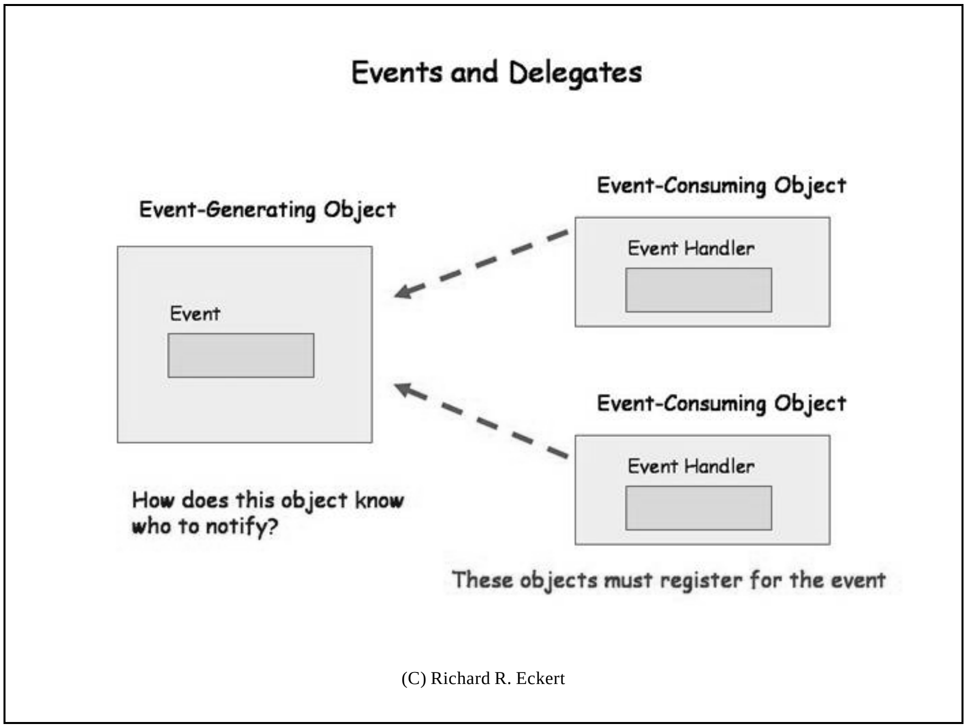
- Double Click on ‘Manifest’
  - List of assemblies that module depends on
  - Assembly name
  - Modules that make up the assembly
    - Because HelloWorld is a single-file assembly, there is only one
- Expand HelloWorld class
  - Class contains two methods:
    - A constructor (.ctor)
    - Main (‘S’ means it’s a static method)
  - Expand Main
    - .entrypoint a directive indicating it’s where execution starts
    - Code instantiates a HelloWorld object and calls Application.Run for the form
  - Expand .ctor
    - Calls parent Form’s constructor
    - Puts “Hello World” string on stack and calls set_Text(…) to set the form’s Text property

Events, Delegates, and Handlers

- Events: Results of user actions
- But in .NET events are also “class notifications”
- Classes define and publish a set of events that other classes can subscribe to
  - When an object changes its state (the event occurs), all other objects that subscribe to the event are notified
- Events are processed by event *handler methods*
- The arguments to an event handler must match those of a function prototype definition called a *delegate*:
  - A method to whom event handling is delegated
    - A managed pointer to a function
  - A type-safe wrapper around an event handler callback function
    - Handler function must use parameters specified in delegate args
  - “Attaches” the handler function to the event
  - Permits any number of handler methods for a given event

Events and Delegates





Events and Delegates

Event-Generating Object

Event

Event-Consuming Object

Event Handler

Event-Consuming Object

Event Handler

How does this object know who to notify?

These objects must register for the event

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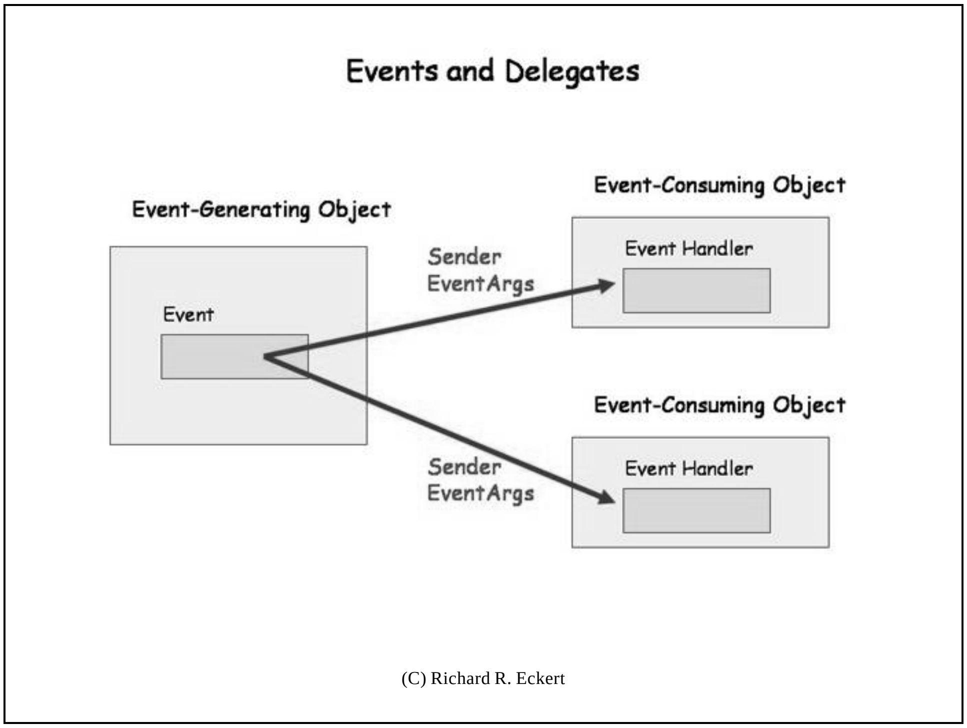

Events and Delegates

Event-Generating Object

Event

Event-Consuming Object

Event Handler

Sender
EventArgs

Event-Consuming Object

Event Handler

Sender
EventArgs

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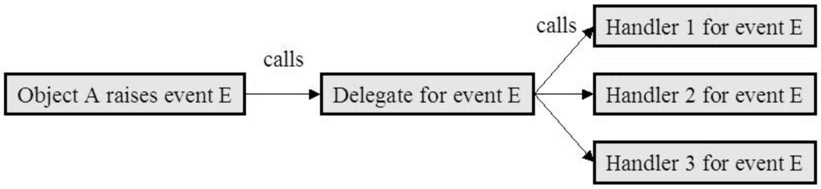
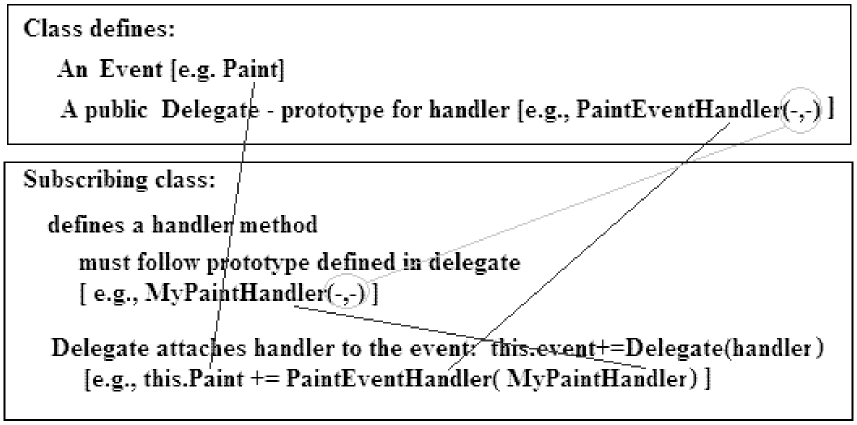
Event-Handling Model



Events, Delegates, Handlers

Events, Delegates, and Handlers in .NET



Class defines:

An Event [e.g. Paint]

A public Delegate - prototype for handler [e.g., PaintEventHandler(-,-)]

Subscribing class:

defines a handler method

must follow prototype defined in delegate
[e.g., MyPaintHandler(-,-)]

Delegate attaches handler to the event: this.event+=Delegate(handler)
[e.g., this.Paint += PaintEventHandler(MyPaintHandler)]

An Example – Handling a Paint Event

- Form class has a Paint event to notify of window exposures
- The delegate is PaintEventHandler, defined as:

```
public delegate void PaintEventHandler(object objSender,
   PaintEventArgs pea);
```

  - First argument: sender "object" (where event ocurred)
  - Second argument "PaintEventArgs": provides event data
    - A class with properties 'Graphics' and 'ClipRectangle'
      - 'Graphics' property: contains an instantiation of the Graphics class (GDI+)
        - The class is used to draw on a form (like a Device Context)
      - ClipRectangle: Specifies the area of the window that needs to be redrawn
- Any Paint handler method must have these arguments
- And the Paint handler must be "attached" to the Paint event of the Form class (i.e., *delegated to the handler*)

Defining the Paint Event Hander and Attaching it to the Event

- Defining the form's Paint event handler method:

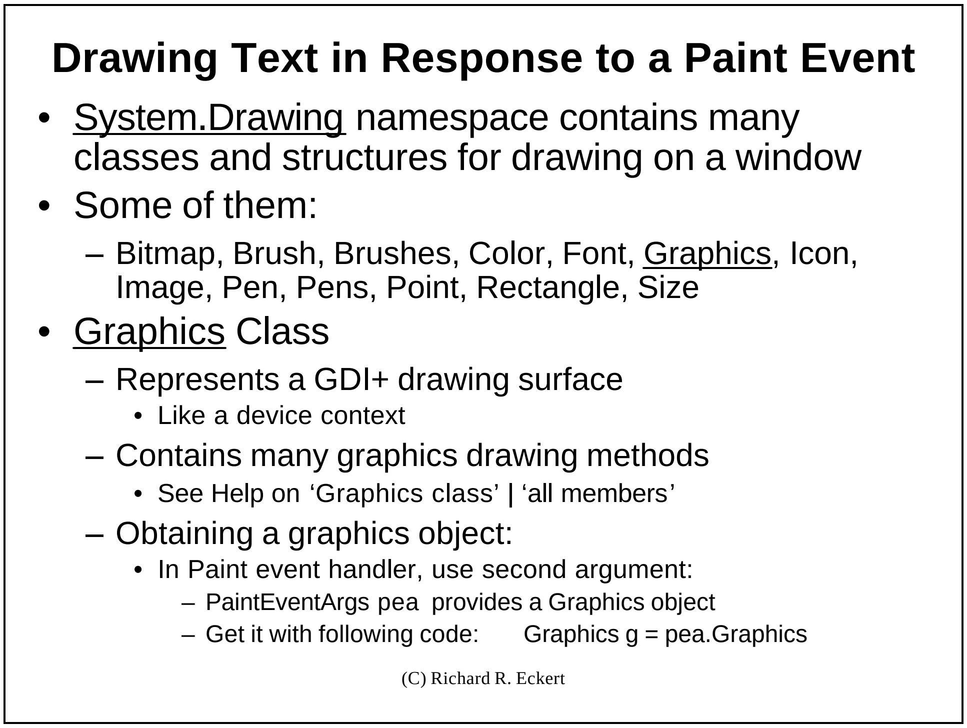
```
private void MyPaintHandler(object objsender, PaintEventArgs pea)
{
  // event handling code goes here
};
```

- Attaching the handler to the form's Event (delegating it to the event handler):

```
form.Paint += new PaintEventHandler(MyPaintHandler);
```

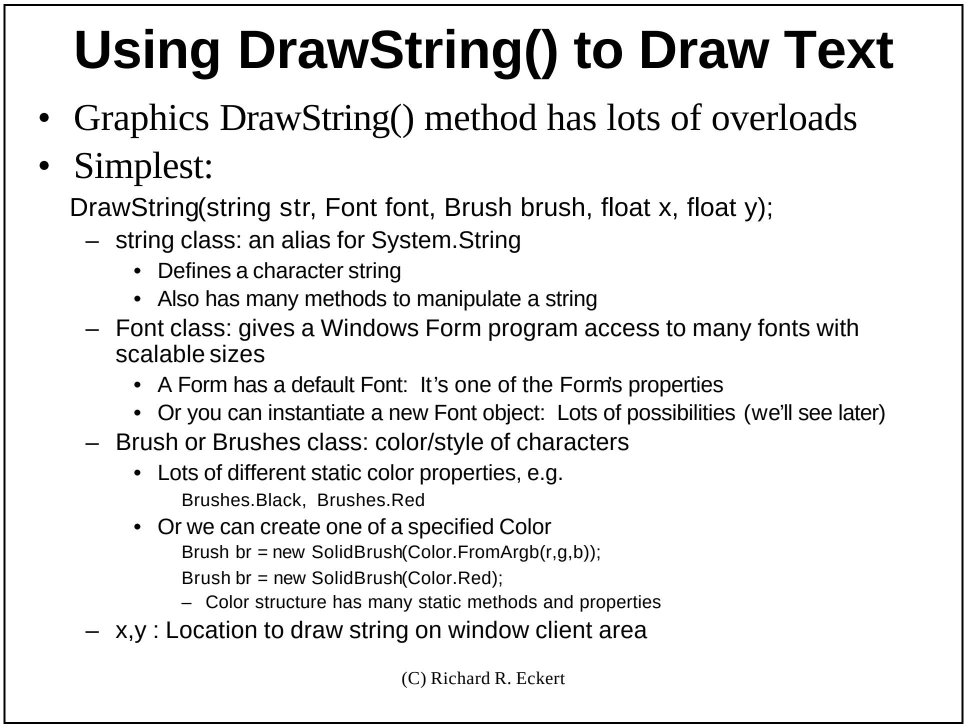
  - From now on MyPaintHandler(-,-) will be called any time the Paint event occurs
- A handler can also be "detached" from an event:

```
object.event -= new delegate(method);
```



Drawing Text in Response to a Paint Event

- System.Drawing namespace contains many classes and structures for drawing on a window
- Some of them:
  - Bitmap, Brush, Brushes, Color, Font, Graphics, Icon, Image, Pen, Pens, Point, Rectangle, Size
- Graphics Class
  - Represents a GDI+ drawing surface
    - Like a device context
  - Contains many graphics drawing methods
    - See Help on ‘Graphics class’ | ‘all members’
  - Obtaining a graphics object:
    - In Paint event handler, use second argument:
      - PaintEventArgs pea provides a Graphics object
      - Get it with following code: Graphics g = pea.Graphics



Using DrawString() to Draw Text

- Graphics DrawString() method has lots of overloads
- Simplest:

DrawString(string str, Font font, Brush brush, float x, float y);

- string class: an alias for System.String
  - Defines a character string
  - Also has many methods to manipulate a string
- Font class: gives a Windows Form program access to many fonts with scalable sizes
  - A Form has a default Font: It’s one of the Form’s properties
  - Or you can instantiate a new Font object: Lots of possibilities (we’ll see later)
- Brush or Brushes class: color/style of characters
  - Lots of different static color properties, e.g.

    Brushes.Black, Brushes.Red
  - Or we can create one of a specified Color

    Brush br = new SolidBrush(Color.FromArgb(r,g,b));

    Brush br = new SolidBrush(Color.Red);
    - Color structure has many static methods and properties
- x,y : Location to draw string on window client area

Hello_in_window Example Program

- Responds to Paint Event by displaying ‘Hello World’ in window’s client area using several different Brushes
- <u>Manual Project</u>
  - – Define Handler and Attach it to Paint event manually
- <u>Designer Project</u>
  - – Select the Paint event in the form’s Properties window
    - Click on lightning bolt
    - Double click on “Paint” event
  - – Attachment of handler using its delegate is done automatically
  - – Skeleton handler code generated automatically

An Alternative to Installing Event Handlers: Overriding instead of Attaching

- In any class derived from ‘Control’ (e.g. ‘Form’), its protected OnPaint() and other event handlers can be overridden:

```
protected override void OnPaint(PaintEventArgs pea)
{
    // Painting code goes here
};
```

  - – Avoids having to attach the handler to the event using the delegate
- See HelloWorld_override example program

A Separate Class for Main()

- An alternative way of organizing a Windows Form application:
  - Define the Form in one class
  - Place the Main() function in another class
  - Must be done manually
  - See SeparateMain example program

Inheriting Form Classes

- Just as your Form inherits from ‘System.Windows.Forms.Form’, you can set up a new Form that inherits from a previously defined Form
- Be sure its Main() includes keyword ‘new’
- And that Visual Studio knows which class’ Main() is the entry point:
  - In project’s Properties box select ‘Property Pages’ icon
    - ‘Common Properties’ | ‘General’ | Application’ | ‘Startup Object’
    - Select ‘InheritHelloWorld’
- See HelloWorld_inherit example

Multiple Handlers

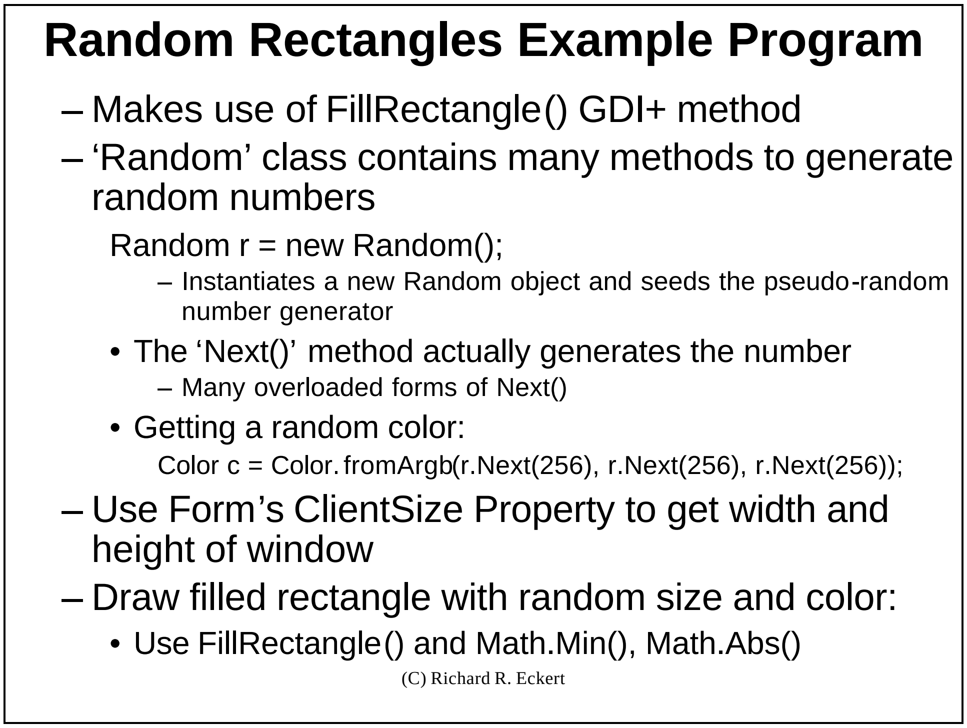
- An advantage of the delegate mechanism is that multiple handlers of the same event can be used
- Just attach each handler to the event
  - For example:

```
Form.Paint += new PaintEventHandler(PaintHandler1);
Form.Paint += new PaintEventHandler(PaintHandler2);
```

- And then write the handlers
- Each time the event occurs, all handlers will be called in sequence
- See TwoPaintHandlers example

Some other GDI+ Drawing Methods

- DrawArc( );
- DrawEllipse( );
- DrawLine( );
- DrawPolygon( );
- DrawRectangle( );
- FillEllipse( );
- FillPolygon( );
- FillRectangle( );
- Lots of others in ‘Graphics’ class
  - See online help on various overloaded forms of calling these functions



Random Rectangles Example Program

- – Makes use of FillRectangle() GDI+ method
- – ‘Random’ class contains many methods to generate random numbers

  Random r = new Random();

  - – Instantiates a new Random object and seeds the pseudo-random number generator

  - • The ‘Next()’ method actually generates the number
    - – Many overloaded forms of Next()
  - • Getting a random color:

    Color c = Color. fromArgb(r.Next(256), r.Next(256), r.Next(256));
- – Use Form’s ClientSize Property to get width and height of window
- – Draw filled rectangle with random size and color:
  - • Use FillRectangle() and Math.Min(), Math.Abs()