Comparison of C++ and C#

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Software Modeling

Both Are Important

- C++ has a huge installed base.
  - C++ provides almost complete control over the allocation of resources and execution behavior of programs.
- C# is the dominant .Net language.
  - C#, a managed language, is simpler than C++, takes over control of memory resources and manages the execution of programs.
- CSE681—Software Modeling and Analysis
  - Focuses almost exclusively on C# and .Net.
- CSE687—Object-Oriented Design:
  - Focuses almost exclusively on C++ and the Standard Library.

C# Language

- Looks a lot like Java
  - A strong similarity between:
    - Java Virtual Machine and .Net CLR
    - Java bytecodes and .Net Intermediate Language
    - Java packages and CRL components and assemblies
    - Both have just-in-time (JIT) compilers
    - Both support reflection, used to obtain class information at run time
    - Both languages support generics (not as useful as C++ templates)
- Differences:
  - Java and C# do have significant differences
    - C# has most of the operators and keywords of C++
    - C# code supports attributes—tagged metadata, Java uses annotations
    - C# provides deep access to the Windows platform through FCL
    - Java supports network programming and GUI development on many platforms

C# Hello World Program

```
using System;

namespace HelloWorld
{
   class Chello
   {
      string Title(string s)
      {
         int len = s.Length;
         string underline = new string('=',len+2);
         string temp = "\n  " + s + "\n" + underline;
         return temp;
      }
      string SayHello()
      {
         return "Hello World!";
      }
      [STAThread]
      static void Main(string[] args)
      {
         Chello ch = new Chello();
         Console.Write(ch.Title("HelloWorld Demonstration"));
         Console.Write("\n\n  {0}\n\n",ch.SayHello());
      }
   }
}
```

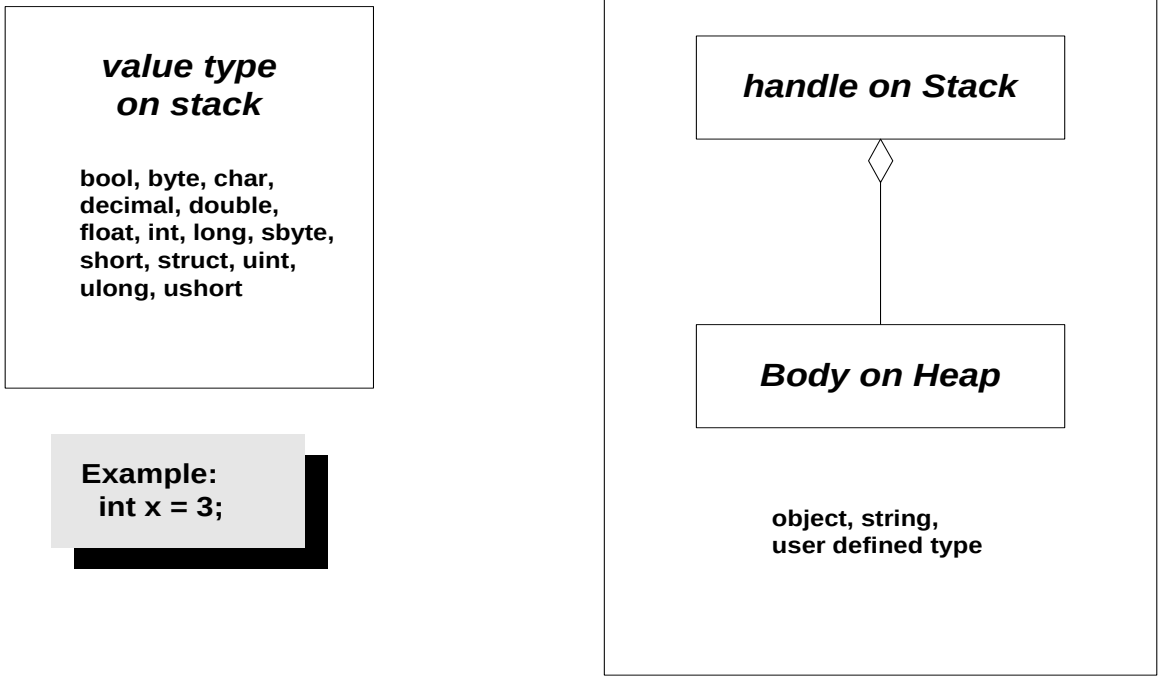
Differences between C# and C++

- In C# there are no global functions. Everything is a class.
  - Main(string args[]) is a static member function of a class.
- The C# class libraries are like Java Packages, not like the C and C++ Standard Libraries.
  - System, System.Drawing, System.Runtime.Remoting, System.Text, System.Web
  - C# class hierarchy is rooted in a single “Object” class
- C# does not separate class declaration and member function definitions.
  - Every function definition is inline in the class declaration—like the Java structure.
  - There are no header files.
  - Instead of #include, C# uses using statements:
    - using System;
    - using System.ComponentModel;

Differences between C++ and C#

- The C# object model is very different from the C++ object model.
  - Illustrated on the next slide
- C# supports only single inheritance of implementation but multiple inheritance of interfaces
- C# does not support use of pointers, only references, except in “unsafe” code.
- Use of a C# variable before initialization is a compile-time error.

C# Object Model



Example:
```
int x = 3;
```

Example:
```
myClass mc = new myClass(args);
string myStr = "this is some text";
```

Comparison of Object Models

- ***C++ Object Model***
  - All objects share a rich memory model:
    - Static, stack, and heap
  - Rich object life-time model:
    - Static objects live for the duration of the program.
    - Objects on stack live within a scope defined by { and }.
    - Objects on heap live at the designer's discretion.
  - Semantics based on a deep copy model.
    - That's the good news.
    - That's the bad news.
  - For compilation, clients carry their server's type information via headers.
    - That's definitely bad news.
    - But it has a work-around, e.g., design to interface not implementation. Use object factories.

- ***.Net Object Model***
  - More Spartan memory model:
    - Value types are static and stack based only.
    - Reference types (all user-defined types and library types) live on the managed heap.
  - Nondeterministic lifetime model:
    - All reference types are garbage collected.
    - That's the good news.
    - That's the bad news.
  - Semantics based on a shallow reference model.
  - For compilation, clients use their server's metadata.
    - That is great news.
    - It is this property that makes .Net components so simple.

C# Primitive Types

.Net Base Class	C# Types
System.Byte	byte
System.SByte	sbyte
System.Int16	short
System.Int32	int
System.Int64	long
System.UInt16	ushort
System.UInt32	uint
System.UInt64	ulong
System.Single	float
System.Double	double
System.Object	object
System.Char	char
System.String	string
System.Decimal	decimal
System.Boolean	bool

C# Object Type

- Object is the root class of the C# library
- Object's members:
  - Public Object();
  - Public virtual Boolean Equals(Object obj);
    - Returns true if obj and invoker handles point to the same body.
  - Public virtual Int32 GetHashCode();
    - Return value identifies object instance.
  - Public Type GetType();
    - Type object supports RTTI – see next page
  - Public virtual String ToString();
    - Returns namespace.name
  - Protected virtual void Finalize();
    - Called to free allocated resources before object is garbage collected.
  - Protected Object MemberwiseClone();
    - Performs shallow copy
    - To have your class instances perform deep copies you need to implement the ICloneable interface.

Common Type System

- Reference types
  - Classes
    - Methods
    - Fields
    - Properties
    - Events
    - Member adornments:
      public, protected, private, abstract, static
  - Interfaces
    - Class can inherit more than one
    - Must implement each base interface
  - Delegates
    - Instances used for notifications

Common Type System

- Value types
  - Primitive types
    - See page 13
  - Structures
    - Methods
    - Fields
    - Properties
    - Events
    - Member adornments:
      public, protected, private, abstract, static
  - Enumerations

Type Class

You get type object this way:

- Type t = myObj.GetType();
- Type t = Type.GetType("myObj");

An instance of Type is a container for reflection information, and has many methods to use that information.

Some of Type's members:

- IsAbstract
- IsArray
- IsClass
- IsComObject
- IsEnum
- IsInterface
- IsPrimitive
- IsSealed
- IsValueType
- InvokeMember()
- GetType() returns Type Object
- FindMembers() returns MemberInfo array
- GetEvents() returns EventInfo array
- GetFields() :
- GetMethods() :
- GetInterfaces() :
- GetMembers() :
- GetProperties() :

More Differences

- The CLR defines a new delegate type, used for callbacks.
- Event is a keyword in all CLR languages.
  - Events modify the delegate interface, eliminating actions by a subscriber that might affect other subscribers.
- All memory allocations are subject to garbage collection—you don't call delete.
- There are no #includes in C#. There are in both managed and unmanaged C++.
- In C# all class data members are primitive types or C# references. In managed C++ all class data members are either primitive value types, C++ references, or C++ pointers. Nothing else is allowed.
- The CLR provides directory services, and remoting. The Standard C++ Library provides neither of these, although they are relatively easy to provide yourself.

Delegates

- Delegates are used for callbacks:
  - In response to some event they invoke one or more functions supplied to them.
  - Library code that generates an event will define a delegate for application developers to use—the developer defines application-specific processing that needs to occur in response to an event generated by the library code.
  - A delegate defines one specific function signature to use:

```
public delegate rtnType delFun(args…);
```

  - This declares a new type, delFun whose instances can invoke functions with that signature.
  - The developer supplies functions this way:

```
libClass.delFun myDel = new libClass.delFun(myFun);
```

  - This declares a new instance, myDel, of the delFun type.

Events

- Events are specialized delegates that are declared and invoked by a class that wants to publish notifications.

  The event handlers are functions created by an event subscriber and given to the delegate.

- Many C# events use the specialized delegate event handler of the form:

```
public delegate void evDelegate(
  object sender, userEventArgs eArgs
);
```

- userEventArgs is a subscriber-defined class, derived from System.EventArgs. You usually provide it with a constructor to allow you to specify information for the event to use.

- The event is then declared by the publisher as:

```
public event evDelegate evt;
```

- Either publisher or subscriber has to create a delegate object, eveDel, and pass it to the other participant.

- The event is invoked by the publisher this way:

```
evDel(
  this, new userEventArgs(arg)
);
```

- The subscriber adds an event handler function, myOnEvent, to the event delegate this way:

```
Publisher.evDelegate evDel +=
                new Publisher.evDelegate(myOnEvent);
```

Threads

- A C# thread is created with the statement:

```
Thread thrd = new Thread();
```

- System.Threading declares a delegate, named ThreadStart, used to define the thread's processing.
  - ThreadStart accepts functions that take no arguments and have void return type.
- You define a processing class, MyProc that uses constructor arguments or member functions to supply whatever parameters the thread processing needs.
- To start the thread you simply do this:

```
MyProc myProc = new myProc(args, …);
Thread thrd = new Thread();
ThreadStart thrdProc = new ThreadStart(myProc);
thrd.Start(thrdProc);
```

Thread Synchronization

- The simplest way to provide mutually exclusive access to an object shared between threads is to use lock:

```
lock(someObject) {
    // do some processing on
    // someObject
 }
```

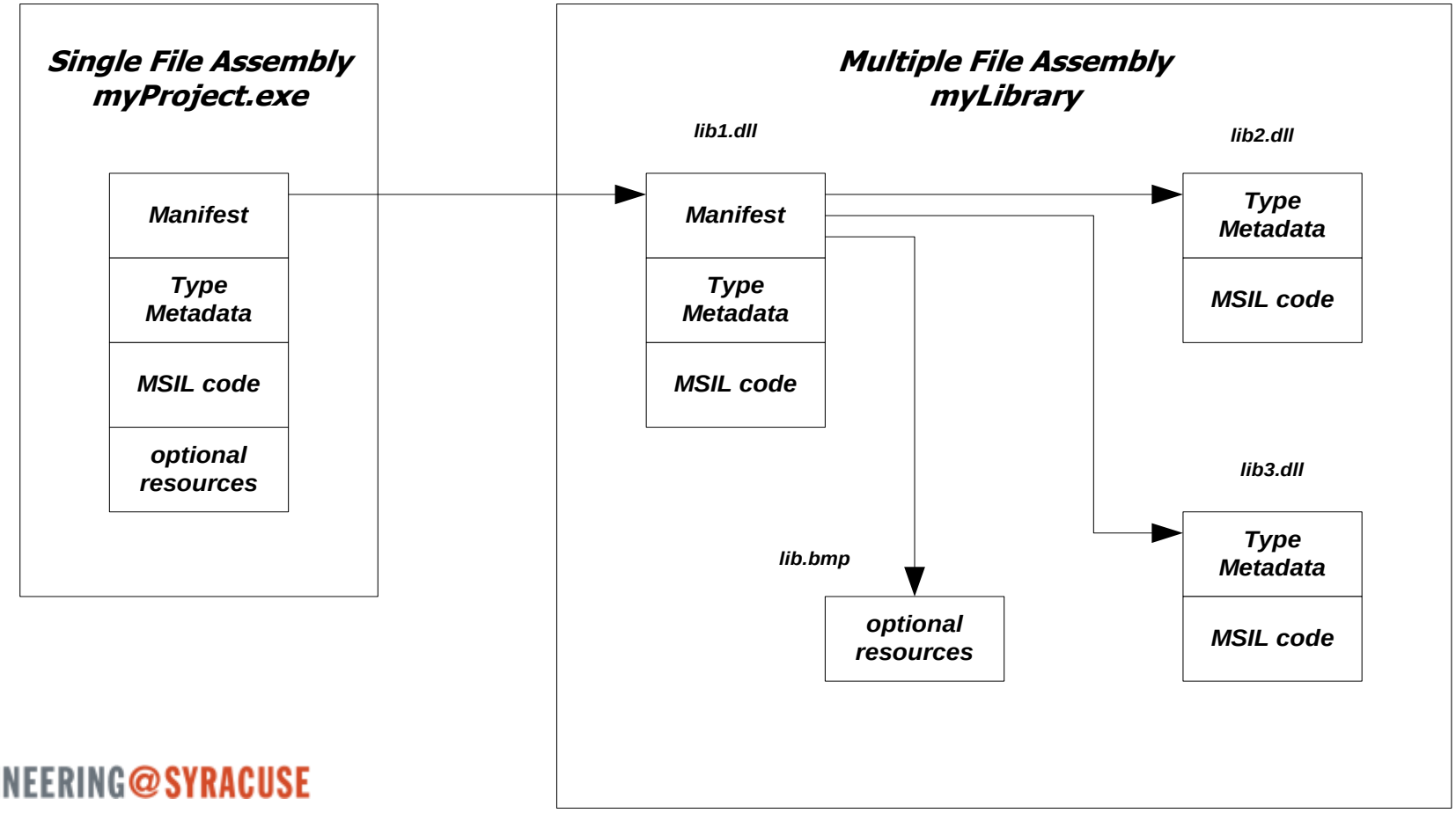
While a thread is processing the code inside the lock statement no other thread is allowed to enter the lock.

Assemblies

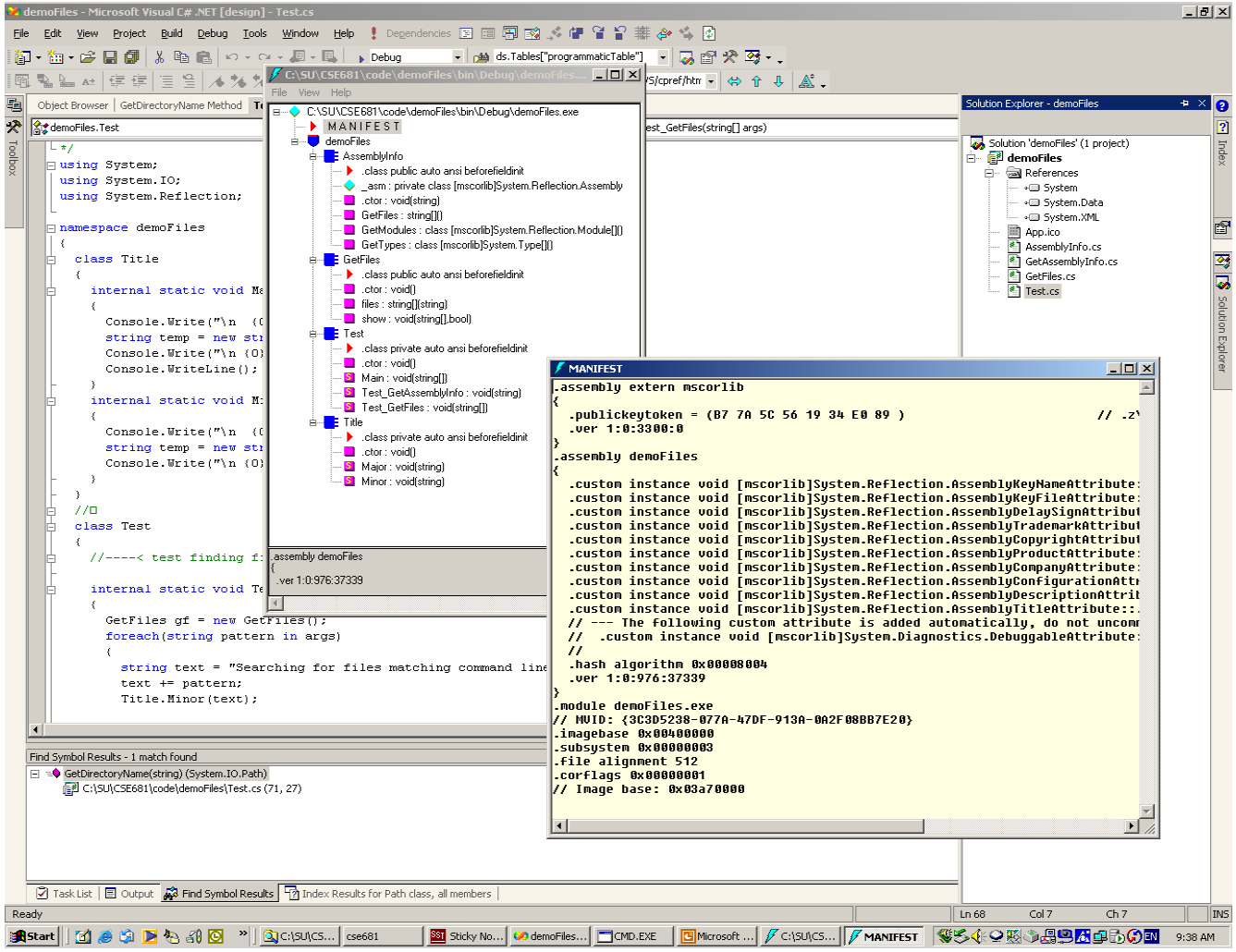
- An assembly is a versioned, self-describing binary (dll or exe)
- An assembly is the unit of deployment in .Net
- An assembly is one or more files that contain:
  - A manifest
    - Documents each file in the assembly
    - Establishes the assembly version
    - Documents external assemblies referenced
  - Type metadata
    - Describes all the methods, properties, fields, and events in each module in the assembly
  - MSIL code
    - Platform-independent intermediate code
    - JIT transforms IL into platform-specific code
  - Optional resources
    - Bitmaps, string resources, …

Assembly Structure

- Visual Studio does most of the work in configuring an assembly for you.



Metadata in demoFiles.exe



Versioning

- Assemblies can be public or private:
  - A private assembly is used only by one executable, and no version information is checked at load time.
    - Private assemblies are contained in the project directory or, if there is a config file, in a subdirectory of the project directory.
  - A shared assembly is used by more than one executable, and is loaded only if the version number is compatible with the using executable.
    - Shared assemblies reside in the Global Assembly Cache (GAC), a specific directory.
    - Version compatibility rules can be configured by the user.
  - Since no registry entries are made for the assembly, each user executable can attach to its own version of the assembly. This is called side-by-side execution by Microsoft.
  - A shared assembly is created from a private assembly, using one of Microsoft's utilities provided for that purpose.

Useful Interfaces

- IComparable—method
  - Int CompareTo(object obj);
    - Return:
      - Negative => less
      - Zero => equal
      - Positive => greater
- ICloneable—method
  - object clone();
- ICollection—properties and method
  - int count { get; }
  - bool IsSynchronized { get; }
  - object SyncRoot { get; }
  - void CopyTo(Array array, int index);

Useful Interfaces

- IEnumerable—method
  - System.Collections.IEnumerator GetEnumerator();
- IEnumerator—property and methods
  - object Current { get; }
  - bool MoveNext();
  - void Reset();

Useful Interfaces

- IDictionary
  - bool IsFixedSize { get; }
  - bool IsReadOnly { get; }
  - object this[object key] { get; set; }
  - ICollection keys { get; }
  - ICollection values { get; }
  - void Add(object key, object value);
  - void Clear();
  - bool Contains(object key);
  - System.Collections.IDictionaryEnumerator GetEnumerator();
  - void Remove(object key);
- IList
  - bool IsFixedSize { get; }
  - bool IsReadOnly { get; }
  - object this[object key] { get; set; }
  - void Add(object key, object value);
  - void Clear();
  - bool Contains(object key);
  - int IndexOf(object value);
  - void Insert(int index, object value);
  - void Remove(object value);
  - void RemoveAt(int index);

C# Libraries

- System
  - Array, Attribute, Console, Convert, Delegate, Enum, Environment, EventArgs, EventHandler, Exception, Math, MTAThreadAttribute, Object, Random, STAThreadAttribute, String, Type
- System.Collections
  - ArrayList, HashTable, Queue, SortedList, Stack
- System.Collections.Specialized
  - ListDictionary, StringCollection, StringDictionary
- System.ComponentModel
  - Used to create components and controls
  - Used by WinForms
- System.ComponentModel.Design.Serialization
  - Used to make state of an object persistant
- System.Data
  - Encapsulates use of ADO.NET

More C# Libraries

- System.Drawing—GDI+ support
  - System.Drawing.Drawing2D—special effects
  - System.Drawing.Imaging—support for .jpg, .gif files
  - System.Drawing.Printing—settings like margins, resolution
- System.Net—support for HTTP, DNS, basic sockets
  - System.Net.sockets—sockets details
- System.Reflection
  - View application's metadata including RTTI
- System.Runtime.InteropServices
  - Access COM objects and Win32 API

Remoting Libraries

- System.Runtime.Remoting
  - System.Runtime.Remoting.Activation
    - Activate remote objects
  - System.Runtime.Remoting.Channels
    - Sets up channel sinks and sources for remote objects
  - System.Runtime.Remoting.Channels.HTTP
    - Uses SOAP protocol to communicate with remote objects
  - System.Runtime.Remoting.Channels.TCP
    - Uses binary transmission over sockets
  - System.Runtime.Remoting.Contexts
    - Set threading and security contexts for remoting
  - System.Runtime.Remoting.Messaging
    - Classes to handle message passing through message sinks
  - System.Runtime.Remoting.Meta data
    - Customize HTTP SoapAction type output and XML Namespace URL
  - System.Runtime.Remoting.Proxies
  - System.Runtime.Remoting.Services

You Must Be Joking—More Libraries!

- System.Runtime.Serialization
  - System.Runtime.Serialization.Formatters
    - System.Runtime.Serialization.Formatters.Soap
- System.Security
- System.ServiceProcess
  - Create windows services that run as Daemons
- System.Text.RegularExpressions
- System.Threading
  - AutoResetEvent, Monitor, Mutex, ReaderWriterLock, Thread, Timeout, Timer, WaitHandle
  - Delegates: ThreadStart, TimerCallBack, WaitCallBack
- System.Timers
  - Fire events at timed intervals, day, week, or month

Web Libraries

- System.Web
  - System.Web.Hosting
    - Communicate with IIS and ISAPI run-time
  - System.Web.Mail
  - System.Web.Security
    - cookies, web authentication, Passport
  - System.Web.Services—close ties to ASP.NET
    - System.Web.Services.Description
    - System.Web.Services.Discovery
    - System.Web.Services.Protocol—raw HTTP and SOAP requests
    - System.Web.SessionState—maintain state between page requests
  - System.Web.UI—access to WebForms

WinForms and XML Libraries

- System.Windows.Forms—Forms-based GUI design

- System.Xml—XML DOM
  - System.Xml.Schema
    - Authenticate XML structure
  - System.Xml.Serialization
    - Serialize to XML
  - System.Xml.XPath
    - Navigate XSL
  - System.Xml.Xsl
    - Support for XSL – XML stylesheets

So How Do We Learn *All* This Stuff!

ClassView -> Class Browser -> Help

to the rescue!

Language Comparison

- Standard C++
  - Is an ANSI and ISO standard.
  - Has a standard library.
  - Universally available:
    - Windows, UNIX, MAC
  - Well-known:
    - Large developer base.
    - Lots of books and articles.
  - Programming models supported:
    - Objects
    - Procedural
    - Generic
  - Separation of interface from implementation:
    - Syntactically excellent
      - Implementation is separate from class declaration.
    - Semantically poor
      - See object model comparison.

- .Net C#
  - Is an ECMA and ISO standard.
  - Has defined an ECMA library.
  - Mono project porting to UNIX
  - Relatively new, but popular in Windows ecosystem
    - Large developer base.
    - Lots of books and articles.
  - Programming models supported:
    - Objects
    - Generic
  - Separation of Interface from Implementation:
    - Syntactically poor
      - Implementation forced in class declaration.
    - Semantically excellent
      - See object model comparison.

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