Sistemi Distribuiti Corso di Laurea in Ingegneria

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PARTE 9: **C#**

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C# – Introduction

- The first component oriented language in the C/C++ family
- Everything really is an object
- Next generation robust and durable software
- Preservation of investment

C# – A component oriented language

- C# is the first "component oriented" language in the C/C++ family
- Component concepts are first class:
  - ♣ Properties, methods, events
  - ♣ Design-time and run-time attributes
  - ♣ Integrated documentation using XML
- Enables one-stop programming
  - ♣ No header files, IDL, etc.
  - ♣ Can be embedded in web pages

C# – Everything is an Object

- Traditional views
  - C++, Java: Primitive types are **magic** and do not interoperate with objects
  - Smalltalk, Lisp: Primitive types are objects, but at great performance cost
- C# unifies with no performance cost
  - Deep simplicity throughout system
- Improved extensibility and reusability
  - New primitive types: Decimal, SQL…
  - Collections, etc., work for all types

C# – Features

- Garbage collection
  - No memory leaks and stray pointers
- Exceptions
  - Error handling is not an afterthought
- Type-safety
  - No uninitialized variables, unsafe casts
- Versioning
  - Pervasive versioning considerations in all aspects of language design

C# – Learning from the others

- C++ heritage
  - Namespaces, enums, unsigned types, pointers (in unsafe code), etc.
  - No unnecessary sacrifices
- Interoperability
  - What software is increasingly about
  - MS C# implementation talks to XML, SOAP, COM, DLLs, and any .NET language

C# and OOP

- C# is designed for the .NET Framework
  - The .NET Framework is Object Oriented
- In C#
  - Your access to the OS is through objects
  - You have the ability to create first class objects
  - The FCL is designed for extension and integration by your code

Hello World

```
using System;

class Hello
{
   static void Main() {
      Console.WriteLine("Hello world");
   }
}
```

C# Program Structure

- Namespaces
  - Contain types and other namespaces
- Type declarations
  - Classes, structs, interfaces, enums, and delegates
- Members
  - Constants, fields, methods, properties, indexers, events, operators, constructors, destructors
- Organization
  - No header files, code written “in-line”
  - No declaration order dependence

C# Program Structure

```
using System;

namespace System.Collections
{
   public class Stack
   {
      Entry top;

      public void Push(object data) {
         top = new Entry(top, data);
      }

      public object Pop() {
         if (top == null) throw new InvalidOperationException();
         object result = top.data;
         top = top.next;
         return result;
     }
   }
}
```

C# - Namespaces

- Code is structured in namespaces
  - Orthogonal to code-files and assemblies
  - Namespaces can be nested
- Full name of a type: namespace.typename
  - `MySpace.Subset1.HelloWorld`

Namespaces: Example

```
using System;

namespace MySpace.Subset1
{
        public class HelloWorld
        {
                public static void Main(string[] argv)
                {
                        Console.WriteLine("Hello World!");
                }
        }
}
```

import the **System** namespace

Same as :
```
namespace MySpace {
  namespace Subset1 {
```

from the **System** namespace

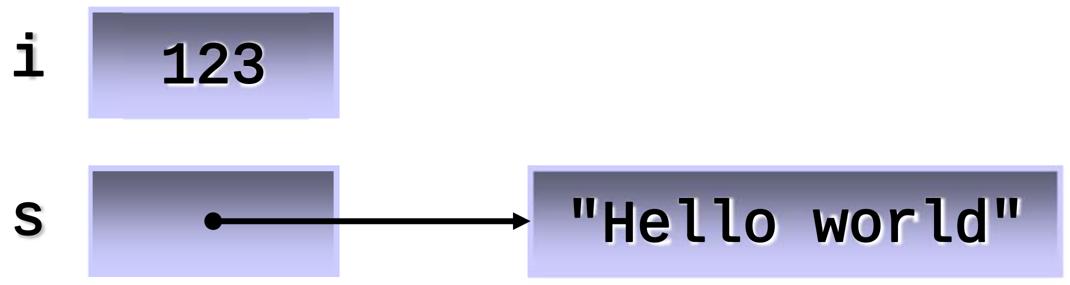
.NET Types

- All types are compatible with **`object`** (System.Object)
- Reference types (classes, arrays, delegates)
  - Stored on heap
  - Assignment copies reference
  - Initialized with **`null`**
- Value types (simple types, structs, enums)
  - Stored on stack
  - Assignment copies value
  - Initialized with **`0, false, '\0'`**

Type System

- Value types
  - Directly contain data
  - Cannot be null
- Reference types
  - Contain references to objects
  - May be null

```
int i = 123;
string s = "Hello world";
```



Type System

- Value types
  - Primitives `int i;`
  - Enums `enum State { Off, On }`
  - Structs `struct Point { int x, y; }`
- Reference types
  - Classes `class Foo: Bar, IFoo {...}`
  - Interfaces `interface IFoo: IBar {...}`
  - Arrays `string[] a = new string[10];`
  - Delegates `delegate void Empty();`

Classes

- Single inheritance
- Multiple interface implementation
- Use of ":" for both extends and implements
- Class members
  - Constants, fields, methods, properties, indexers, events, operators, constructors, destructors
  - Static and instance members
  - Nested types
- Member access
  - public, protected, internal, private

Defining Classes

```
class Name:BaseType{
   // Members
}
```

```
Namespace NameName{
   class Name:BaseType{
   }
}
```

```
class MyType{
   public static String someTypeState;
   public Int32 x;
   public Int32 y;
}
```

Classes

- Are reference types
- System.Object (**`object`**) is the base class of all classes
- Inheritance
  - Single for implementation
  - Multiple for interfaces
- Methods are non-virtual by default!

Example: Classes

```
public interface IFoo
{
      void Bar(int x);
}

public class A : IFoo
{
      public void Bar(int x) { … }
}

public class B : A
{
      …
}
```

Classes Accessibility

- In C#, `private` is the default accessibility
- Accessibilities options
  - `public` – Accessible to all
  - `private` – Accessible to containing class
  - `protected` – Accessible to containing or derived classes
  - `internal` – Accessible to code in same assembly
  - `protected internal` – means `protected` or `internal`
- Classes can be marked as `public` or `internal`
  - By default they are `private`
  - Accessible only to code in the same source module

Type Members in C#

- Fields
  - The state of an object or type
- Methods
  - Constructors
  - Functions
  - Properties (smart fields)
- Members come in two basic forms
  - Instance – per object data and methods
    - Default
  - Static – per type data and methods
    - Use the `static` keyword

Methods

- Declared inline with type definition

```
class MyType{
   public Int32 SomeMethod(){
      return x;
   }

   public static void StaticMethod(){
      // Do something
   }
}
```

Methods: Parameters I

- Call-by-value
  - Formal parameter is copy of actual parameter
  - `int Double(int i) { return 2*i; }`
- Call-by-reference
  - Formal parameter is alias (address, ref.) for the actual parameter
  - `void Double(ref int i) { i = 2*i; }`
  - `int a = 5; Double(ref a);`

Aliasing must be done explicitly.

`i` is an alias. The result is assigned to the variable that the alias points to.

Methods: Parameters II

- Out-parameters
  - Same as call-by-reference but parameter may not be initialized
  - `void Double(int i, out int d) { d = 2*i; }`
  - `int  a = 5; Double(a, out a);`

The value of **d** cannot be accessed before something has been assigned to the aliased variable.

- CbV and CbR are orthogonal to value-t types
- CbR is handy when methods yield more than one result

  -
    ```
    void ParseNameString(string name,
      out string first, out string last) { … }
    ```

Methods: Parameters III

- Variable parameter list
  - Array at the end of the parameter-list

  -
    ```
    void ChargePhaserBanks(params int[] banks) {
        foreach (int b in banks) Charge(b);
    }
    ```
  - `ChargePhaserBanks(1, 7, 9);` is the same as
  - `ChargePhaserBanks(new int[] {1, 7, 9});`
- Extremely useful:
  - `Console.WriteLine(“({0}, {1})”, x, y);`

Instance Constructors

- Constructors are used to initialize fields
- You can implement simpler constructors in terms of more complex ones with the `this` keyword (suggested)

```
class Point{
   Int32 x;
   Int32 y;

   public Point():this(0, 0){}

   public Point(Int32 x, Int32 y){
      this.x = x;
      this.y = y;
   }
}
```

- You can indicate which base constructor to call
  - Use the `base` keyword

Type (static) Constructors

- Type constructors are used to initialize `static` fields for a type
- Only one static constructor per type
  - Called by the Common Language Runtime
  - Guaranteed to be called before any reference to the type or an instance of the type
  - Must have no parameters
- Use the `static` keyword to indicate a type constructor

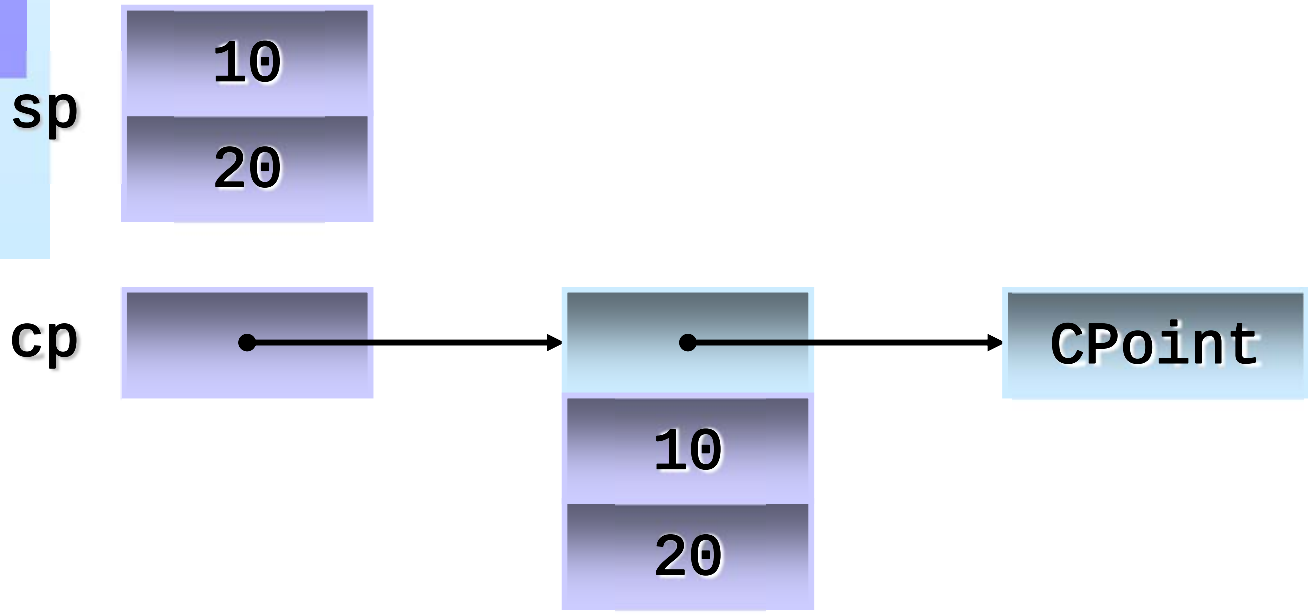
Structs

- Like classes, except
  - Stored in-line, not heap allocated
  - Assignment copies data, not reference
  - No inheritance
- Ideal for light weight objects
  - Complex, point, rectangle, color
  - int, float, double, etc., are all structs
- Benefits
  - No heap allocation, less GC pressure
  - More efficient use of memory

Classes And Structs

```
 class CPoint { int x, y; ... }
struct SPoint { int x, y; ... }

CPoint cp = new CPoint(10, 20);
SPoint sp = new SPoint(10, 20);
```



Interfaces

- Multiple inheritance
- Can contain methods, properties, indexers, and events
- Private interface implementations
- Your types can implement interfaces
  - Must implement all methods in the interface
- ♣ Interfaces can contain methods but no fields
- Constructors are not supported in interfaces

```
interface IDataBound
{
   void Bind(IDataBinder binder);
}

class EditBox: Control, IDataBound
{
   void IDataBound.Bind(IDataBinder binder) {...}
}
```

Enums

- Strongly typed
  - No implicit conversions to/from int
  - Operators: +, -, ++, --, &, |, ^, ~
- Can specify underlying type
  - Byte, short, int, long

```
enum Color: byte
{
   Red   = 1,
   Green = 2,
   Blue  = 4,
   Black = 0,
   White = Red | Green | Blue,
}
```

Enums - Example

```
enum WhiskeyKind {
    Scotch, Irish, Bourbon, Canadian }

enum WhiskeyMode : byte
{
    OnTheRocks = 1,
    WithWater = 2,
    WithTonic = 4,
    WithCola = 8
}
```

Default base-type is **int** (0, 1, 2, …)

Enumeration base-type must be integral

Usage:

```
WhiskeyKind k = WhiskeyKind.Irish;
WhiskeyMode m =
WhiskeyMode.OnTheRocks | WhiskeyMode.WithCola;
```

Delegates

- Object oriented function pointers
- Multiple receivers
  - Each delegate has an invocation list
  - Thread-safe + and - operations
- Foundation for events

```
delegate void MouseEvent(int x, int y);

delegate double Func(double x);

Func func = new Func(Math.Sin);
double x = func(1.0);
```

Callback Methods (Delegates)

Delegates.cs

```
using System;
delegate void MyDelegate(String message);
class App{
   public static void Main(){
      MyDelegate call = new MyDelegate(FirstMethod);
      call += new MyDelegate(SecondMethod);
      call("Message A");
      call("Message B");
   }
   static void FirstMethod(String str){
      Console.WriteLine("1st method: "+str);
   }
   static void SecondMethod(String str){
      Console.WriteLine("2nd method: "+str);
   }
}
```

Delegates I

- Typed method references
- Delegate type
  - `delegate void HullBreach(Deck d, Section s);`

Type name

Delegate arguments

Delegate return type

- Delegate variables
  - `HullBreach hullFatality;`
- Delegate invocation
  - `hullFatality(10, Section.Forward);`

Delegates II

- Creating delegates
-
```
public class ShipFatalityHandler
{
    public void OnHullBreach(Deck d, Section s)
    {
        structuralIntegrity.PowerLevel++;
    }
    public ShipFatalityHandler(Ship ship)
    {
        ship.hullFatality = new
            HullBreach(this.OnHullBreach);
    }
}
```

Delegates III

- `new DelegateType(target.method);`
  - In C# 2.0: `target.method;`
- Method may be **`static`** (target is a class)
- Method may be **`virtual`**, **`override`**, or **`new`**
- Method must not be **`abstract`**
- Method signature and delegate type must match
  - Same number of parameters
  - Same parameter types (including return type)
  - Same parameter kinds (CbV, CbR)
  - Method name can be freely chosen

Delegates IV

- Are first class objects
  - Reference type
  - Can be passed around or stored in arrays/collections
  - Value can be **`null`** (exception on invocation)
- Store methods and their receivers
  - **`Target`** property to query receiver
  - As long as the delegate is alive target will not be collected
- Are equal if they have the same method *and* target

Delegates V

- Delegate variable can hold multiple values → **multicast**
- Adding/Removing a delegate to a variable

  -
    ```
    ship.hullFatality +=
      new HullBreach(hullHandler.OnHullBreach);
    ship.hullFatality += new
      HullBreach(evacuationHandler.Evacuate);
    ```

  -
    ```
    ship.hullFatality -= new
      HullBreach(evacuationHandler.Evacuate);
    ```
- Invocation calls all delegates
- What about return or out values?
  - Last call determines returned values

Polymorphism and Virtual Functions

- Use the `virtual` keyword to make a method virtual
- In derived class, override method is marked with the `override` keyword
- Example
  - `ToString()` method in Object class

```
public virtual string ToString();
```

  - Example derived class overriding `ToString()`

```
class SomeClass:Object{
   public override String ToString(){
      return “Some String Representing State”;
   }
}
```

Polymorphism.cs

Component Development

- What defines a component?
  - Properties, methods, events
  - Integrated help and documentation
  - Design-time information
- C# has first class support
  - Not naming patterns, adapters, etc.
  - Not external files
- Components are easy to build and consume

Properties

- Properties are “smart fields”
  - Natural syntax, accessors, inlining

```
public class Button: Control
{
   private string caption;

   public string Caption {
      get {
         return caption;
      }
      set {
         caption = value;
         Repaint();
      }
   }
}
```

```
Button b = new Button();
b.Caption = "OK";
String s = b.Caption;
```

Properties

- Methods that look like fields (smart fields)

```
class Point{
   Int32 x;
   Int32 y;
   public Int32 X{
      get{return x;}
      set{x = value;}
   }
   public Int32 Y{
      get{return y;}
      set{y = value;}
   }
}
```

Properties III

- Properties can be declared in interfaces

```
interface IShip {
    string Captain { get; set; }
}
```

- Properties can be abstract

```
public abstract class GalaxyClass : IShip {
    abstract Captain { get; set; }
}
```

- Properties can be static

```
public sealed class Universe {
    public static ulong GalaxyCount { get {…}
}
}
```

- Getter or setter can be omitted (read-only or write-only property)

Indexers

- Indexers are “smart arrays”
  - Can be overloaded

```
public class ListBox: Control
{
   private string[] items;

   public string this[int index] {
      get {
         return items[index];
      }
      set {
         items[index] = value;
         Repaint();
      }
   }
}
```

```
ListBox listBox = new ListBox();
listBox[0] = "hello";
Console.WriteLine(listBox[0]);
```

C# and Events

- C# has built in support for events
- Great for dealing with objects in an event-driven operating system
- Improved performance and flexibility over an all-virtual-function solution
- More than one type can register interest in a single event
- A single type can register interest in any number of events

Handling an Event

EventHand.cs

```
using System;
using System.Windows.Forms;
class MyForm:Form{
   MyForm(){
      Button button = new Button();
      button.Text = "Button";
      button.Click += new EventHandler(HandleClick);
      Controls.Add(button);
   }
   void HandleClick(Object sender, EventArgs e){
      MessageBox.Show("The Click event fired!");
   }
   public static void Main(){
      Application.Run(new MyForm());
   }
}
```

Defining an Event

- Based on a callback mechanism called a `delegate`

```
class EventInt{
   Int32 val;
   public Int32 Value{
      get{return val;}
      set{
         if(Changed != null)
            Changed(value, val);
         val = value;
      }
   }
   public event Callback Changed;
   public delegate
      void Callback(Int32 newVal, Int32 oldVal);
}
```

EventInt.cs

Events - Firing

```
public delegate void EventHandler(object sender, EventArgs e);
```

- Define the event and firing logic

```
public class Button
{
   public event EventHandler Click;

   protected void OnClick(EventArgs e) {
      if (Click != null) Click(this, e);
   }
}
```

Events - Handling

```
public class MyForm: Form
{
   Button okButton;

   public MyForm() {
      okButton = new Button(...);
      okButton.Caption = "OK";
      okButton.Click += new EventHandler(OkButtonClick);
   }

   void OkButtonClick(object sender, EventArgs e) {
      ShowMessage("You pressed the OK button");
   }
}
```

Attributes

- How do you associate information with types and members?
  - Documentation URL for a class
  - Transaction context for a method
  - XML persistence mapping
- Traditional solutions
  - Add keywords or pragmas to language
  - Use external files, e.g., .IDL, .DEF
- C# solution: Attributes

Attributes - Example

```
public class OrderProcessor
{
   [WebMethod]
   public void SubmitOrder(PurchaseOrder order) {...}
}

[XmlRoot("Order", Namespace="urn:acme.b2b-schema.v1")]
public class PurchaseOrder
{
   [XmlElement("shipTo")]  public Address ShipTo;
   [XmlElement("billTo")]  public Address BillTo;
   [XmlElement("comment")] public string Comment;
   [XmlElement("items")]   public Item[] Items;
   [XmlAttribute("date")]  public DateTime OrderDate;
}

public class Address {...}

public class Item {...}
```

Attributes - Features

- Attributes can be
  - Attached to types and members
  - Examined at run-time using reflection
- Completely extensible
  - Simply a class that inherits from System.Attribute
- Type-safe
  - Arguments checked at compile-time
- Extensive use in .NET Framework
  - XML, Web Services, security, serialization, component model, COM and P/Invoke interop, code configuration…

XML Comments

```
class XmlElement
{
   /// <summary>
   ///    Returns the attribute with the given name and
   ///    namespace</summary>
   /// <param name="name">
   ///    The name of the attribute</param>
   /// <param name="ns">
   ///    The namespace of the attribute, or null if
   ///    the attribute has no namespace</param>
   /// <return>
   ///    The attribute value, or null if the attribute
   ///    does not exist</return>
   /// <seealso cref="GetAttr(string)"/>
   ///
   public string GetAttr(string name, string ns) {
      ...
   }
}
```

Statements And Expressions

- High C++ fidelity
- If, while, do require bool condition
- goto can't jump into blocks
- Switch statement
  - No fall-through, "goto case" or "goto default"
- foreach statement
- Checked and unchecked statements
- Expression statements must do work

```
void Foo() {
   i == 1;    // error
}
```

Arrays I

- Fixed size collection of homogeneous items
  - Items can be both value-types or reference types
- Arrays are reference types
- `int[] numbers = new int[3];`
  creates an uninitialized array with 3 elements
- `int[] numbers = { 7, 8, 75 };`
  creates an initialized array
- Element access with 0-based index (index-type is **`int`**) :

```
numbers[1] = 42;
Console.WriteLine("{0}", numbers[2]);
```

- **`numbers.Length`** yields number of elements in the array (array-size)

Arrays II

- One dimension is good, multiple dimension are better
- Jagged array (array of arrays)

```
float[][] fs = new float[2][];
fs[0] = new float[15];
fs[1] = new float[23];
fs[1][17] = 12f;
```

- Rectangular (more efficient)

```
float[,] fs = new float[5, 4];
fs[2, 1] = 23f;
fs.GetLength(0) // should be 5
fs.GetLength(1) // should be 4
```

Arrays III

- `System.Array` class has a lot of useful methods
- Reverse, Copy, Sort, BinarySearch, Clear
- Read the fine manual for more info

Collections I

- `System.Collection` namespace
- Classes and interfaces for dealing with data collections
- `IList`: variable sized list of heterogeneous elements
  - `ArrayList, SortedList`
  - Element-type is `object`
- `IDictionary`: variable sized associative array
  - `Hashtable`
  - Element- and key-type are `object`

Collections: List Example

```
IList lst = new ArrayList();

lst.Add("something");
lst.Add(1); // boxing, IList expects a reference

string s = (string)lst[0];
    // cast required IList only knows objects

lst.Remove(1);
lst.RemoveAt(0);
lst[0] = "something else";

Console.WriteLine(lst.Count);

lst.Clear();
```

Collections: Dictionary Example

```
IDictionary dict = new Hashtable();

dict["something"] = 45; // boxing

string s = (string)dict["something else"];
    // s == null → key not in dictionary

object[] keys = dict.Keys;
object[] val = dict.Values;

dict.Remove("something");

Console.WriteLine(dict.Count);
dict.Clear();
```

foreach Statement

- Iteration of arrays

```
public static void Main(string[] args) {
   foreach (string s in args) Console.WriteLine(s);
}
```

- Iteration of user-defined collections

```
foreach (Customer c in customers.OrderBy("name")) {
   if (c.Orders.Count != 0) {
      ...
   }
}
```

Operator Overloading

- First class user-defined data types
- Used in base class library
  - Decimal, DateTime, TimeSpan
- Used in UI library
  - Unit, Point, Rectangle
- Used in SQL integration
  - SQLString, SQLInt16, SQLInt32, SQLInt64, SQLBool, SQLMoney, SQLNumeric, SQLFloat…

Operator Overloading

```
public struct DBInt
{
   public static readonly DBInt Null = new DBInt();

   private int value;
   private bool defined;

   public bool IsNull { get { return !defined; } }

   public static DBInt operator +(DBInt x, DBInt y) {...}

   public static implicit operator DBInt(int x) {...}
   public static explicit operator int(DBInt x) {...}
}
```

```
DBInt x = 123;
DBInt y = DBInt.Null;
DBInt z = x + y;
```

Versioning

- Problem in most languages
  - C++ and Java produce fragile base classes
  - Users unable to express versioning intent
- C# allows intent to be expressed
  - Methods are not virtual by default
  - C# keywords “virtual”, “override” and “new” provide context
- C# can't guarantee versioning
  - Can enable (e.g., explicit override)
  - Can encourage (e.g., smart defaults)

Conditional Compilation

- #define, #undef
- #if, #elif, #else, #endif
  - Simple boolean logic
- Conditional methods

```
public class Debug
{
   [Conditional("Debug")]
   public static void Assert(bool cond, String s) {
      if (!cond) {
         throw new AssertionException(s);
      }
   }
}
```

Unsafe Code

- Platform interoperability covers most cases
- Unsafe code
  - Low-level code “within the box”
  - Enables unsafe casts, pointer arithmetic
- Declarative pinning
  - Fixed statement
- Basically “inline C”

```
unsafe void Foo() {
   char* buf = stackalloc char[256];
   for (char* p = buf; p < buf + 256; p++) *p = 0;
   ...
}
```

Unsafe Code

```
class FileStream: Stream
{
   int handle;

   public unsafe int Read(byte[] buffer, int index, int count) {
      int n = 0;
      fixed (byte* p = buffer) {
         ReadFile(handle, p + index, count, &n, null);
      }
      return n;
   }

   [dllimport("kernel32", SetLastError=true)]
   static extern unsafe bool ReadFile(int hFile,
      void* lpBuffer, int nBytesToRead,
      int* nBytesRead, Overlapped* lpOverlapped);
}
```

Casting

- Change access type by casting values
  - `IList l = (IList)someObject;`
- Cast may fail
  - e.g. because **`someObject`** doesn't implement **`IList`**
  - **`InvalidCastException`**
- **`is`** operator checks wheter an object is instance of a type
  - **`someObject is IList`** (either **`true`** or **`false`**)
- **`as`** operator for safe casting (only for reference-types)
  - `IList l = someObject as IList;`
  - Yields **`null`** if cast not possible; no exception
  - Combination of **`is`** and cast

Reflection

- Ability of an application *"to **examine** and possibly **modify** its **high level structure** at runtime."* (wikipedia.org)
- Use of type information at runtime
  - ♣ Also referred to as Meta-programming
- Uses of reflection
  - ♣ Serialization, remote method invocation, code generation, documentation and analysis, XML-Type mapping, COM Interop, DBMS Integration, dynamic modules (plug-ins)
- *"The Case for Reflective Middleware"* G. Blair, G. Coulson, 2002

Reflection: Introspection in .NET

- Examine high-level structure
  - Types, members (methods, fields, …), …
  - But not loops, statements, expressions (may be supported in some languages through supporting libraries)
- Meta-information is part of the MSIL stored in an assembly
- Type descriptor for every type
  - Class **`System.Type`**
  - ***`obj`*`.GetType()`**
  - **`typeof(`*`typename`*`)`**
- Type descriptor is starting point to explore a type

Reflection: `System.Type`

- Examine type
  - **`IsPublic, IsPrimitive, IsEnum, IsClass, IsValueType, Assembly …`**
- Access to type members
  - **`GetMethod, GetProperties, GetConstructor`**
- Inheritance hierarchy
  - **`IsSubtypeOf, IsAssignableFrom, IsInstanceOf, GetInterface`**

Reflection: Descriptors for other CTS Constructs

- Namespace: **`System.Reflection`**
- **`ConstructorInfo, PropertyInfo, FieldInfo, MethodInfo, EventInfo, ParameterInfo, …`**
- Example: **`MethodInfo`**
  - **`Attributes`** (public, static, virtual, …)
  - **`GetParameters`** (method parameters)
  - **`Invoke`** (invokes the reflected method)
- There's far more on reflection in the documentation

Reflection: Emit

- Examine code at runtime is nice
- But creating code at runtime is way cool
- Namespace: **`System.Reflection.Emit`**
- CLR is language agnostic → only MSIL possible!!

Threading

- Namespace: **`System.Threading`**
- Usage of the **`Thread`** class:

```
public class HoloDeckCharacter
{
   void Perform() {
      …
   }
}

static void RunHoloDeckProgram(){
   HoloDeckCharacter c = new ProfMoriarity();
   Thread t =
      new Thread(new ThreadStart(c.Perform));
   t.Start();
}
```

Threading: Thread States

- **`ThreadState`** property
  - **`Aborted, Running, Stopped, Suspended, Unstarted, …`**
- State can be influenced with thread instance methods
  - **`Start, Suspend, Resume, Abort`**
- Aborting threads throws **`ThreadAbortException`**
  - Can be caught in running thread, which is to be aborted
  - Can be ignored with **`Thread.ResetAbort()`**

Threading: Synchronization I

- Use monitors to protect critical sections

```
Monitor.Enter(someObj);
try {

}
finally {
        Monitor.Exit(someObj);
}
```

Is the same as

```
lock (someObj) {

}
```

Threading: Synchronization II

- Use **`Monitor.Wait(obj)`** to block until **`obj`** is notified
  - Thread must be in the monitor of **`obj`**
  - Monitor is released on **`Wait`** and regained when **`Wait`** returns
- Use **`Monitor.Pulse(obj)`** or **`.PulseAll(obj)`** to notify one or all threads blocking on **`obj`**
  - Thread must be in the monitor of **`obj`**
- Example: Producer-consumer scenario
  - I leave that as an exercise to the reader

Threading: Synchronization III

- There are more synchronization primitives available
  - `ManualResetEvent, AutoResetEvent`
  - `Mutex`
  - `Interlocked`
- See the documentation for details

Asynchronous Method Invocation

- Non-blocking method calls
  - Call method
  - Return immediately
  - Get notified when invocation has completed
- Internally mapped to thread-pools (implementation detail)
  - No need to mess around with threads
- Any delegate object can be invoked asynchronously
  - **`BeginInvoke`**, **`EndInvoke`**, **`IAsyncResult`**, **`AsyncCallback`**

Overview: Input/Output

- Namespace: **`System.IO`**
- Classes and interfaces for working with files and directories
- **`Stream`** as base class for all IO operations
  - **`Read, Write, Flush, Seek, …`**
  - Asynchronous operations: **`BeginRead, BeginWrite, …`**
  - Implementations: **`FileStream, MemoryStream, …`**
- Reader and writer classes for specialised IO Operations
  - **`TextReader/Writer, BinaryReader/Writer, …`**

Overview: Basic Networking

- Namespace **`System.Net`**
- Classes to build Internet applications
  - **`IPAddress`**, **`IPEndpoint`** (host, port), **`Dns`**, …
- Low level **`Socket`** interface (similar to the winsock API)
  - Various domains supported: Inet, IrDA, IPX, …
- High level classes for stream-based networking
  - **`TCPListener`**, **`TCPClient`**, …
- High level HTTP handling
  - **`WebRequest`**, **`WebResponse`**, …

XML

- Namespace: **`System.Xml`**
- There is a rich API for working with XML
  - DOM-based (**`XmlDocument`**)
  - Pull-based (**`XmlReader`**)
- Cool feature: XML-serialization

```
XmlSerializer xs = new
     XmlSerializer(typeof(MyClass))
MyClass m = new MyClass();
xs.Serialize(stream, m);
m = xs.Deserialize(stream);
```

XML Serialization Example

```
public class StarShip {
  [XmlElement,
  XmlArrayItem(Type=typeof(Officer)),
  XmlArrayItem(Type=typeof(Captain))]
  public Person[] Officers;
}
```

```
<StarShip>
  <Officer>Malcolm Reed</Officer>
  <Officer>T'Pol</Officer>
  <Officer>Hoshi Sato</Officer>
  <Captain>
     Jonathan Archer
  </Captain>
</StarShip>
```

Exception

```
try {
  // codice che può portare ad un errore
}
catch (Exception Type [ variable ]) {
  // codice che deve essere eseguito quando avviene
l'errore
}
finally {
  // codice da eseguire che avvenga o meno
  // l'errore
}
```

Exception

```
using System;
using System.IO;

public class App {
   public static void Main() {
      FileStream fs = null;
      try {
         fs = new FileStream(@"C:\NotThere.txt", FileMode.Open);
      }
      catch (Exception e) {
         Console.WriteLine(e.Message);
      }
      finally {
         if (fs != null) fs.Close();
      }
   }
}
```

References

http://msdn.microsoft.com/net

- Download .NET SDK and documentation

http://msdn.microsoft.com/events/pdc

- Slides and info from .NET PDC

news://msnews.microsoft.com

- microsoft.public.dotnet.csharp.general