# Introduction to C#

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# C# – The Big Ideas

- 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# – The Big Ideas
## 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# – The Big Ideas
## Everything really 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# – The Big Ideas
## Robust and durable software

- 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# – The Big Ideas
## Preservation of Investment

- 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
- Millions of lines of C# code in .NET
  - Short learning curve
  - Increased productivity

# 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

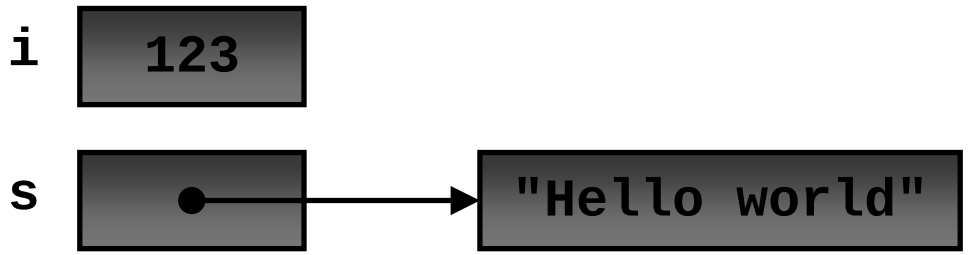
# C# Program Structure

```
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;
     }
   }
}
```

# 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();`

# Predefined Types

- C# predefined types
  - Reference — object, string
  - Signed — sbyte, short, int, long
  - Unsigned — byte, ushort, uint, ulong
  - Character — char
  - Floating-point — float, double, decimal
  - Logical — bool
- Predefined types are simply aliases for system-provided types
  - For example, int == System.Int32

# Classes

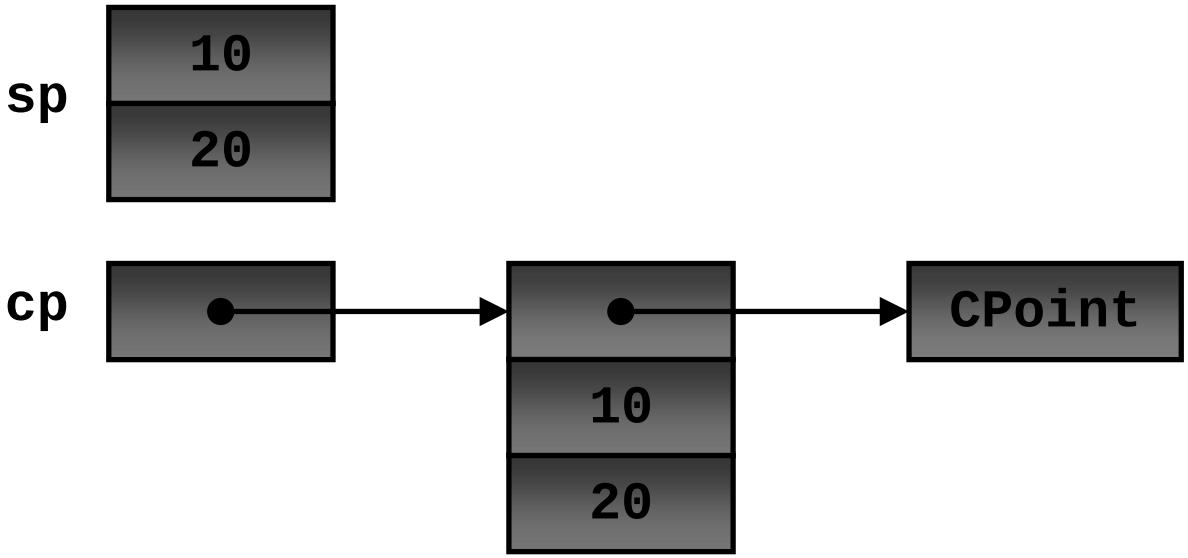
- Single inheritance
- Multiple interface implementation
- Class members
  - Constants, fields, methods, properties, indexers, events, operators, constructors, destructors
  - Static and instance members
  - Nested types
- Member access
  - public, protected, internal, private

# 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

```
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,
}
```

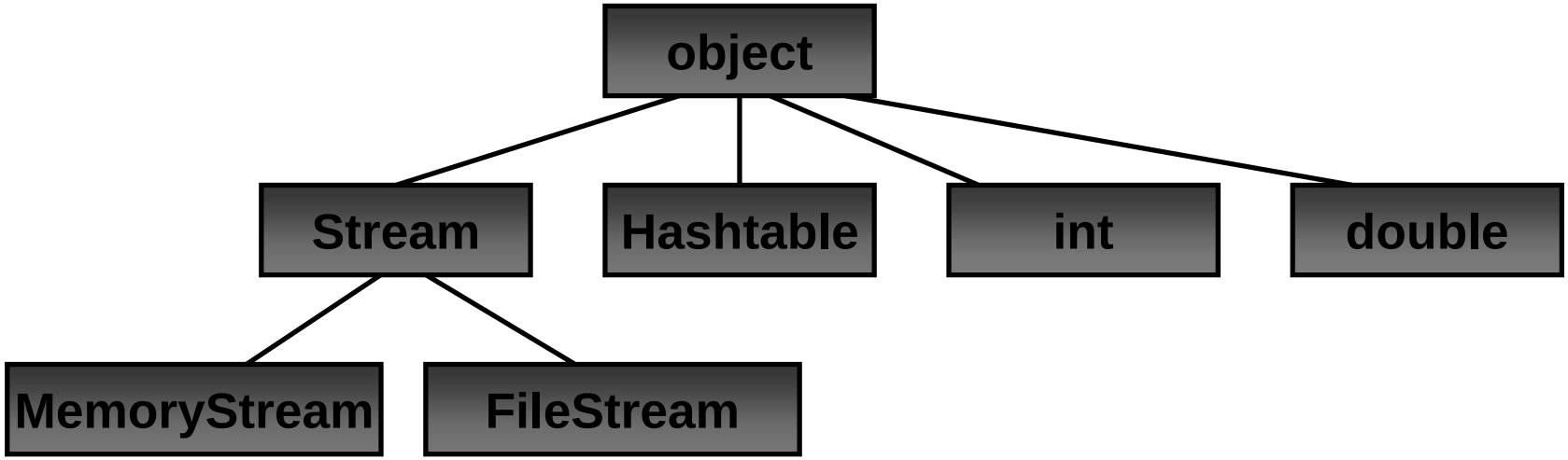
# Delegates

- 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);
```

# Unified Type System

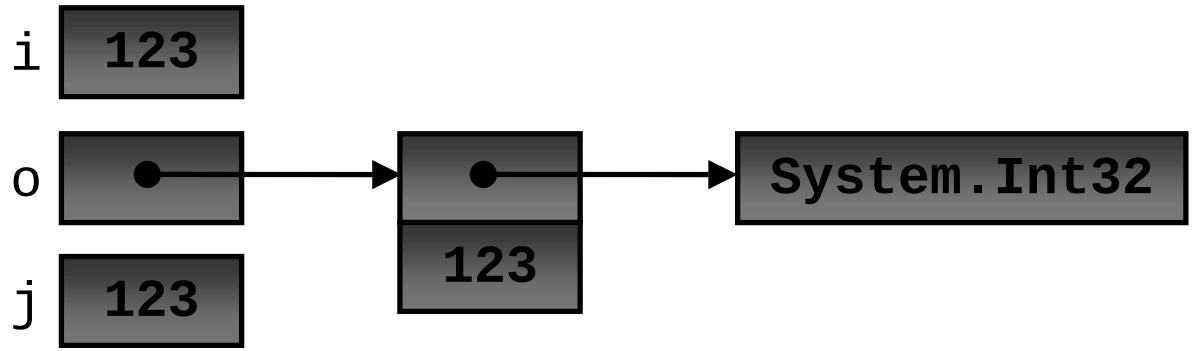
- Everything is an object
  - All types ultimately inherit from object
  - Any piece of data can be stored, transported, and manipulated with no extra work



# Unified Type System

- **Boxing**
  - **Allocates box, copies value into it**
- **Unboxing**
  - **Checks type of box, copies value out**

```
int i = 123;
object o = i;
int j = (int)o;
```



# Unified Type System

- **Benefits**
  - **Eliminates “wrapper classes”**
  - **Collection classes work with all types**
  - **Replaces OLE Automation's Variant**
- **Lots of examples in .NET Framework**

```
string s = string.Format(
   "Your total was {0} on {1}", total, date);

Hashtable t = new Hashtable();
t.Add(0, "zero");
t.Add(1, "one");
t.Add(2, "two");
```

# 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;
```

# 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]);
```

# Events
## Sourcing

- Define the event signature

```
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

- **Define and register event handler**

```
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

```
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

- 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
}
```

# 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) {
      ...
   }
}
```

# Parameter Arrays

- Can write “printf” style methods
  - Type-safe, unlike C++

```
void printf(string fmt, params object[] args) {
   foreach (object x in args) {
      ...
   }
}
```

```
printf("%s %i %i", str, int1, int2);

object[] args = new object[3];
args[0] = str;
args[1] = int1;
Args[2] = int2;
printf("%s %i %i", args);
```

# 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)

# Versioning

```
class Base                              // version 2
{
   public virtual void Foo() {
      Console.WriteLine("Base.Foo");
   }
}
```

```
class Derived: Base                     // version 2b
{
   public override void Foo() {
      base.Foo();
      Console.WriteLine("Derived.Foo");
   }
}
```

# 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);
}
```

# More Information

**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**