

# Mono

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Miguel de Icaza  
miguel@novell.com



Novell.



# Agenda.

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A brief introduction to Mono.

Most of this talk focuses on:

- The JVM vs CLI differences.
- C# vs Java language differences.

Today's Mono state



# What is Mono?

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An Open Source implementation of ECMA CLI and C#

- Cross platform:
  - Unix family: Linux, MacOS X, Solaris, HP-UX, etc.
  - Windows family: 2000, NT, XP.
  - Embedded systems (tiny profile).
- Native CodeGen:
  - 32 bits: x86, sparc, s390
  - 64 bits: x86-64, sparc v9
- Open Source compilers and tools:
  - Today: C# 2.0, Java, Python, Boo, Nemerle.
  - Preview: VB.NET, Jscript.



# The Two Stacks

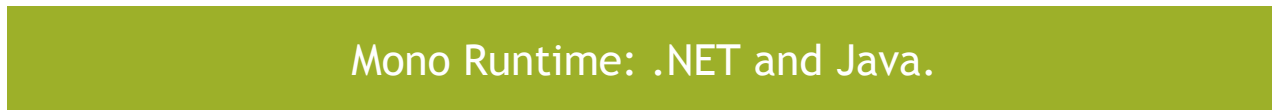
MIT X11



GPL



LGPL





# Developers.

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Mono is a fairly large open source effort:

- 30+ full time developer from various companies.
- ~330 SVN accounts.
- ~60-70 different people committing per month.

Companies developing Mono:

- Novell.
- Mainsoft.
- Voelcker.
- Embedded system vendor.

# Common Language Infrastructure



# Common Language Infrastructure

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## A managed runtime:

- Very similar to Java's VM in spirit.
- Common Intermediate Language (CIL)
- Strong focus on Multi-language support.

## Object Model:

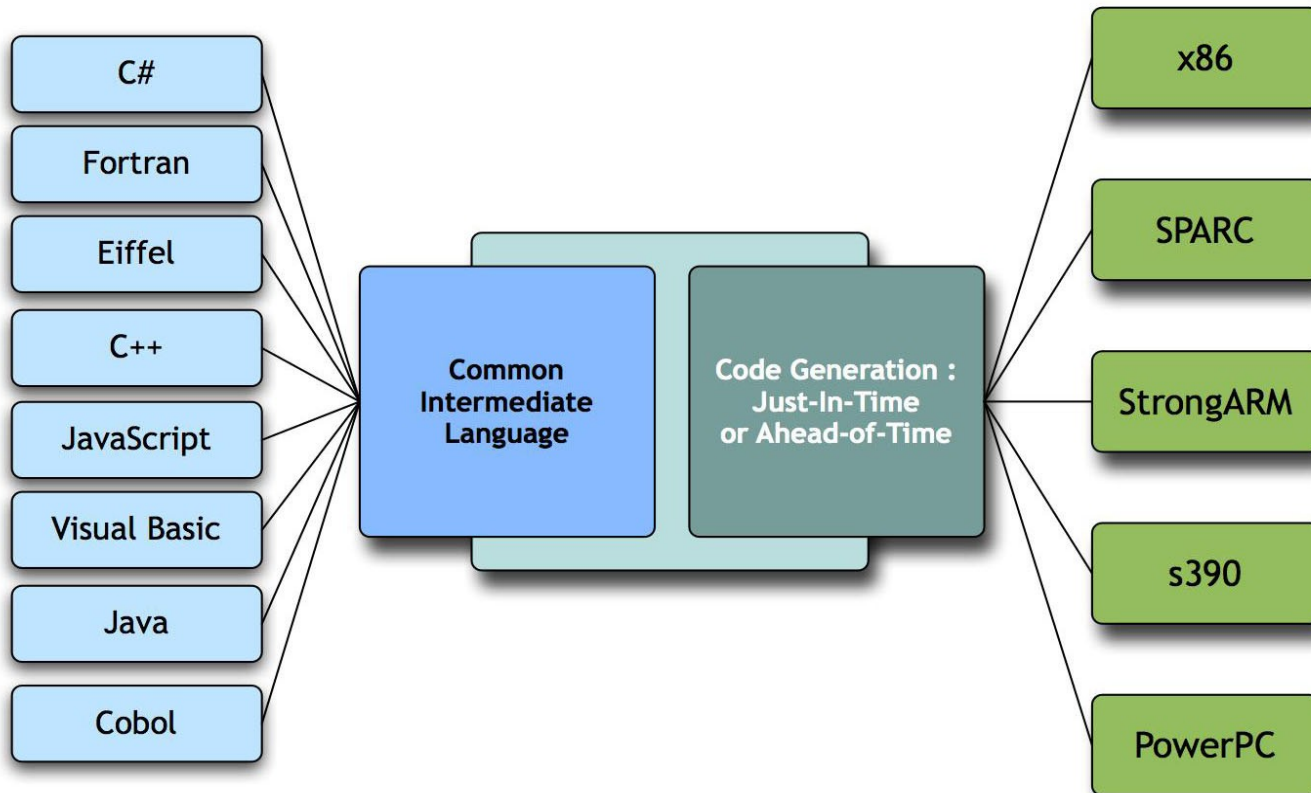
- Single inheritance, multiple-interface implementation.

## Standard Services:

- GC, Threading, Reflection.
- JIT/AOT compilation.
- Instruction set with support for generics.



# Multi-language and multi-platform.





# CLI: Assemblies and Versioning.

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Assemblies are the unit of deployment.

- As simple as a single .exe or a single .dll
- Or might be made up of multiple files (held in a directory)
- Or multiple resources in a single file.

Public assemblies are versioned and signed.

- Installed into a system-managed location.
- Strong backwards-compatibility support.
- Versioning of symbols encoded into references.



# Sample

---

```
.assembly extern mscorlib
{
  .ver 1:0:5000:0
  .publickeytoken = (B7 7A 5C 56 19 34 E0 89 )
}
.assembly extern System
{
  .ver 1:0:5000:0
  .publickeytoken = (B7 7A 5C 56 19 34 E0 89 )
}

newarr [mscorlib]System.Object
```

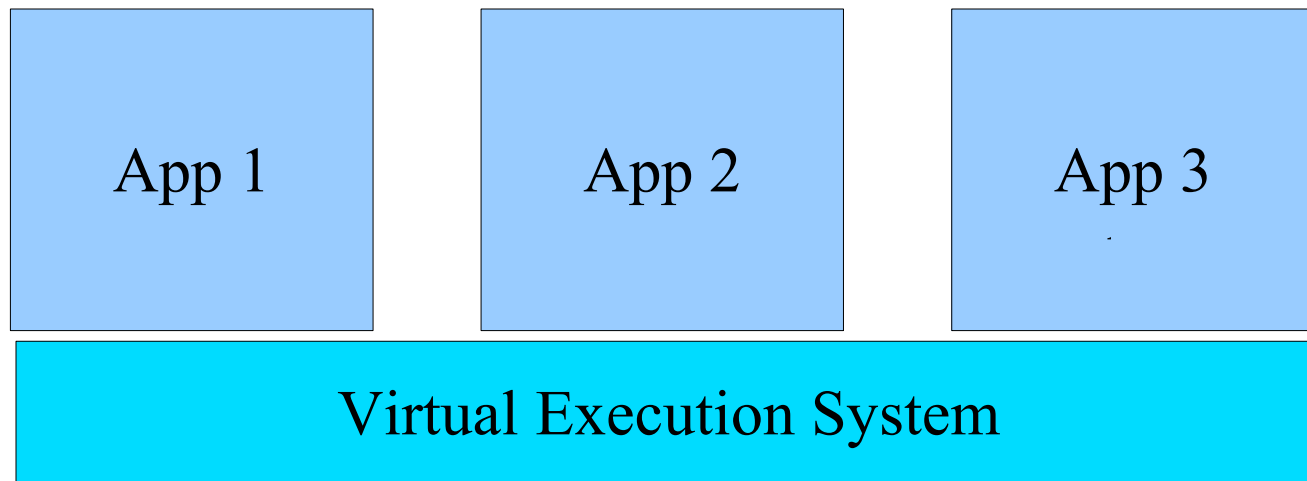


# CLI: Application Domains.

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Similar to processes in Unix.

- Can run more than one application on the same VM.
- Used extensively for hosting multiple applications.
- Isolates failures across applications.





# CLI: Reflection.Emit.

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An extension to the system reflection.

- Used to produce and execute code at runtime.

Dynamically:

- Used by the IKVM Java VM
  - JITs JVM bytecodes into CIL bytecodes.
- Used by IronPython/JScript:
  - Produces code dynamically.

Statically: Batch compilers

- Mono's C# and VB compilers.
- IKVM .jar to .dll compiler.



# CIL: Value Types (structures).

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ValueTypes are blobs of memory.

- Similar to C structs.
- No vtable/class pointer at the beginning of each.
- Efficient to allocate
- Minimizes pressure on the GC.
- Can be allocated on the stack.

Sample structs:

- `System.Byte`, `System.Int32`
- `struct Point { int x, y; }`

Limitation: structs can not contain virtual methods.



# CLI: Support for other languages.

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## Project 7

- Commercial and research languages.

## Pointer arithmetic opcodes:

- Required for efficient support of C, C++, Fortran, Cobol.
- Only trusted assemblies can use these operations.
- Verifier ensures that code that contains unsafe operations can not execute without the required permissions.

## Functional language support:

- The `tail' instruction.
- Extended-IL research project.



# CLI: Generics support.

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The VM is aware of generic instructions.

- Generics in C# are not only syntactic sugar.
- They actually have a performance benefit.
- Generated code is tuned for datatype (or shared).

Metadata is preserved, not lost.

Works on any datatype

- No limitations on what can be used:
  - `new List<int>`, `new List<Calendar>`

C#



# C# basics.

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## New Microsoft language

- Inspired by Java.
- Incorporates feedback from the community.
- Follows simple recipe for 'A better Java'.

## Strong focus on:

- Versioning and evolution of software:
  - Ubiquitous versionin/evolution considerations.
  - Deal gracefully with core upgrades.
- Event-based programming.



# C# Source Code and Properties.

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Programmer is in control of layout

- No forced directory structure to match class naming.
- Many classes-per file.
- or many files for a class.

Properties: syntactic sugar:

- `b.Text = "hello";`
- ...
- `class Button {`
  - `string Text {`
    - `get { return _text; }`
    - `set { _text = value; ForceRepaint (); }`
  - `}`



# C# - delegates.

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A delegate points to a method/object.

- Similar to C function pointer + context.
- Avoids creating class with a simple method.

Usage:

```
delegate bool Compare (object a, object b);  
Compare c = MyComparer;
```

...

```
BubbleSort (object [] data, Comparer c)  
{  
}
```



## C# - events.

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Builds on the delegate concept.

- Similar to “signals” in Gtk+
- Invoke every method.

Declaration:

- event Action Clicked;

Adding/Removing:

- button.Clicked += method;
- button.Clicked -= method;

Invoking:

- button.Clicked ();

Consumed directly by GUI designers



# C# - Anonymous Methods.

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Allows creation of code-blocks inline:

- `button.Clicked += delegate { print (“clicked”); }`

Unlike Java's Inner classes, it is not macro expansion:

- Field members, parameters, locals can be captured.
- Captured variables retain activation frame semantics:
- `for (int i = 0; i < 10; i++) {`
  - `int j = i;`
  - `b [i].Clicked += delegate { print (“{0} {1}”, i, j);`
- `}`



# C# Defaults.

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In C# methods are not virtual by default.

- Programmer has to explicitly flag method as virtual.

Contract-wise:

- Explicit contract with consumer, not implicit.
- It is a bad idea to start with.

Side effect:

- JIT engines do not require complex optimization for callvirt inlining to achieve reasonable performance.



# C# iterators.

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Simplifies implementation of IEnumerable, IEnumerator:

- IEnumerable GetRange (int start, int end)
- {
  - for (int i = start; i < end; i++)
  - yield record [i];
- }
- ...
- foreach (Record r in GetRange (2, 20)){
  - print (r.Name);
- }



# Platform Invocation.

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Allows simple consumption of native APIs

- No need for separate C/C++ stub file.
- C# source code can be self-contained.

Example:

- [DllImport (“libc”)]
- extern static int system (string s);

Runtime provides extensive marshalling features

- Arrays, string conversions.
- Custom-marshallers for complex data types.
  - To/From methods must be implemented.

Universal Runtime.



# A Unifying VM

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Mono's VM can be embedded:

- Similar to Tcl, Python, Perl, others.
- Can run side-by-side with other Vms.
- Bridges built to expose various languages to others:
  - MonoConnect (XPCOM)
  - PythonNet (CPython interpreter connector.)
  - Perl.NET (Perl connector).

Mono can produce native code:

- No JIT performance hit.

In addition:

- Languages that target IL can speak to each other freely.



# CLS: Common Language Specification

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CLS is a set of rules:

- For consumers and producers.
- Establishes a subset for consumers/producers
- Intended to establish a common subset for interop.

Languages can be classified:

- Consumers, Producers, Consumer/Producer.

CLS compliance attribute:

- Attached to assemblies, classes, methods.
- Compiler will error out on infringements.



# Importance of CLS

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Enables choice of language for domain application.

- Enables consumption of third-party components.
- Bad idea to write a single project in 10 languages.
- A well specified interop subset.

A level playing field for compiler vendors.



# Java

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## Java:

- With IKVM Java and C# code run side-by-side.
- Java support is as good as GNU Classpath libraries are.
- Eclipse, Derby work out of the box.
- Expose .NET to Java.
- Consume Java from .NET
- Native Java:
  - JVM to CIL byte conversion (ikvmc)
  - CIL to native code conversion (mono's Ahead-of-Time).

## Downsides:

- Two class libraries in memory at once.



# Python.

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Jim Hugunin's Python on .NET implementation.

- Started as a proof that CIL was not good enough.
- Impressive results:
  - Dynamic languages can run fast, or faster on .NET
- IronPython is on average faster than CPython on .NET
  - 90% the speed on Mono: we are working on it.

IronPython can consume all classes available on Mono/.NET



## C/C++

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New Microsoft compiler produces pure CIL

- Available on Whidbey
- No more x86 code embedded.

Managed C++

- Being spec'd out by ECMA.
- ISO chair on the group.
- No plans to support these extensions.

Prototype gcc2whirl, whirl2il can run simple Gtk apps.

- Based on the SGI Whirl work.
- Pathscale compiler maintains the WHIRL backend.
- Today gcc4 might be a better option.



# Debugger.

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The Desktop.



# Mono On The Desktop

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## Novell's desktop development platform

- For new software.
- For extending existing software.
- Beagle, Dashboard, F-Spot, Debugger, Evolution plugins.
- iFolder: multi-host synchronization (files, contacts).

## Gtk# - a binding to the Gtk+ and Gnome APIs.

- MonoDevelop (port of SharpDevelop)
- Tomboy.
- Gnome Fax
- Blam RSS Aggregator
- Muine music player, and many more!



# GUI Libraries.

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## Gtk#

- A binding of the Gtk+/Gnome Libraries.
- Supported and developed by Novell.
- Works on MacOS, Windows and Linux.
  - Uses theme engine on Windows XP.
  - Alien look on MacOS X.

## Windows.Forms:

- Under development at Novell
- Will be available with Mono 1.2
- Unlike Gtk#, absolute positioning.
- Uses theme engine on each OS:
  - Win32, Gtk+, CoreGraphics

## Cocoa#

- Built by OSX community.
- Only available on OSX.
- Native OSX apps.

## wxWidgets:

- Uses native widgets on each platform

Future



# Future of Mono: Short Term.

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Mono 1.2: incremental update.

- Add Windows.Forms.
- ASP.NET, ADO.NET scalability.
- C# 2.1 language release.
- VB.NET compiler.

Mono features:

- Debugger.
- Gtk# 1.2
- Cocoa# 1.0
- Cairo integrated in Gtk#

Estimated: September 2004



# Out-of-Band Development.

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## Ports:

- Itanium.
- StrongARM

## Precise, compacting GC:

- Have an early prototype.
- Post 1.2

## Advanced Compiler Optimizations.



# Mono: Medium Term

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## Mono 2.0:

- Stetic: new GUI designer for Gtk#
- Support the .NET 2.0 profile
  - ASP.NET 2.0:
    - Master pages, new controls, web components.
    - Pre-compiled sites
  - ADO.NET 2.0
  - System.Xml 2.0 (done).
  - Windows.Forms 2.0
- Code Access Security debuts.

Release date: September 2006



# Avalon, Indigo.

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## Avalon

- New UI platform from Microsoft.
- To be released in 2006
- Available for Longhorn and XP.

## Indigo:

- New stack for RPC applications.
  - Upgrade to web services stack.
  - Makes `web' optional.

No plans at this point to work on these



# More Information.

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## Mono:

- <http://www.mono-project.com>
- <http://www.go-mono.com/monologue> (mono blogs)

## Email:

- [miguel@novell.com](mailto:miguel@novell.com)

## Blog:

- [primates.ximian.com/~miguel/activity-log.php](http://primates.ximian.com/~miguel/activity-log.php)

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