Eagle: Tcl Implementation in C#

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Joe Mistachkin

What is Tcl?

- Tcl (Tool Command Language) is an open-source scripting language created by John Ousterhout in 1988.
- Designed to be highly extensible and easily embeddable.
- Is it relatively “typeless”, has minimal syntax, no fixed grammar, and no keywords.

Who uses Tcl/Tk?

- America Online
- ActiveState
- BAE Systems
- BMW
- BitMover
- Boeing
- Broadcom
- Cisco
- DaimlerChrysler
- EDS
- Eolas Technologies
- F5 Networks
- HP
- IBM
- Intel
- Lucent
- Mentor Graphics
- Microsoft (?)
- Motorola
- NASA (JPL and others)
- NBC
- National Instruments
- Northrop Grumman
- Oracle
- Pixar
- Python
- QUALCOMM
- Raytheon
- Sun Microsystems
- Synopsys
- Texas Instruments
- TiVo
- US Department of Defense
- US National Institute of Standards and Technology
- US Postal Service
- ...

What is Eagle?

- Eagle or “Extensible Adaptable Generalized Logic Engine” is an open-source implementation of the Tcl scripting language written in C# for the CLR.
- Designed to be highly extensible and easily embeddable.
- Is it relatively “typeless”, has minimal syntax, no fixed grammar, and no keywords.
- Supports approximately 90% of the Tcl 8.4 core command set.

What is Eagle, really?

- Originally designed for the purpose of providing a first-class library for scripting applications written for the CLR.
- Eagle is the “glue” that allows various and diverse components to work together to accomplish a given task.
- It combines the best things about Tcl/Tk and PowerShell into one language.
- All other considerations were secondary, including performance and full Tcl compatibility.

What Eagle is not.

- Not based on the Microsoft Dynamic Language Runtime (DLR).
- Not intended for stand-alone application development (i.e. writing a large-scale application using the Eagle language by itself is not recommended).
- Unlikely to ever have a compiler.
- Not really a “drop-in” replacement for Tcl or Jacl.

Notable Features

- Dynamic language, loosely coupled with full introspection.
- Uses “duck typing” (like Tcl).
- Supports Unicode (obviously?).
- Integrates with CLR classes.
- Integrates with native libraries.
- Integrates with Tcl/Tk.
- Supports interactive debugging.
- Supports script cancellation.
- Supports read-only variables, commands, etc.
- Supports interpreter-wide variable tracing.
- Supports anonymous procedures and closures.
- Unified unit testing framework.
  - Capable of running tests in Tcl and Eagle.

Notable Features
(continued)

- Support for “custom commands” (more on this later).
  - All commands may be added, renamed, “subclassed”, or removed at any time and can be implemented in any managed language.
- Support for custom math functions.
  - For use with the expression parser (e.g. the **[expr]** command).
- Supports binary plugins (i.e. groups of commands).
  - The default plugin provides all the necessary boilerplate code to integrate with Eagle; however, plugins are free to override any default behaviors.
- Supports versioned “packages” which may refer to a binary plugin or a “pure script” package (as in Tcl).
- Supports “hidden” commands.
  - Preliminary support has been added for “safe” interpreter support and custom command execution policies written in managed code.

Syntax: Grouping
(evaluation, step #1)

```
set x 1

puts "grouping with quotes, x = $x"

puts {grouping with braces, x = $x}

proc argsProc { args } {
  return [info level [info level]]
}

puts [argsProc with brackets, x = $x]
```

Syntax: Substitution

(evaluation, step #2)

```
set name Joe; puts "Hello, $name"

puts [clock format [clock seconds]]

puts "\u2554\u2550\u2557\n\u2551\↩
  ↪\u2551\n\u255A\u2550\u255D"
```

Friendly Errors

```
% set
Error, line 1: wrong # args: should
  be "set varName ?newValue?"


% scope foo
Error, line 1: bad option "foo": must
  be close, create, current, destroy,
  eval, exists, list, open, set,
  unset, or vars
```

CLR Usage Example
(automation)

```
proc threadStart { args } {
   set ::result $args; # do work here...
}

object import System.Threading

set t [object create -alias –parametertypes \
   ParameterizedThreadStart Thread threadStart]

$t Start foo; $t Join; unset t

$::result ToString
```

Expressiveness == Power

```
object load -import System.Windows.Forms

proc threadStart {} {
   [object create -alias Form] Show
   after 0 nop; vwait ::forever
}

[object create –alias \
      System.Threading.Thread threadStart] \
      Start
```

Native Library Example

(more automation)

```
set x [library declare –functionname \
   GetConsoleWindow -returntype IntPtr \
   -module [library load kernel32.dll]]

set hwnd [library call $x]
```

Tcl/Tk Example

(integration)

```
if {![tcl ready]} then {tcl load}

set interp [tcl create]

tcl eval $interp {eagle debug break}; # type "#go"

tcl unload
```

Custom Commands

- Together with minimal syntax and the ability to remove add, rename, or remove any command at any time, these are great for creating application-centric domain specific languages (DSL).

- Show example…

Interactive Debugging

- Single-step mode, breakpoints, and variable watches.
- Examine and modify interpreter state.
- Supports isolated evaluation.
- Scripting support via the [**debug]** command.

Interactive Debugging
(continued)

- Uses a customizable read-eval-print loop (REPL).
- Debugging “meta-commands” are prefixed with “#” (the Tcl comment character) having special meaning (i.e. they work) only when entered interactively.
- The **#help** meta-command may be used [by itself] to display the list of available meta-commands or with the syntax **#help <name>** to display usage information for a particular meta-command (e.g. **#help #vinfo**).
- Not yet integrated with Visual Studio.

Script Cancellation

(oddly similar to TIP #285, see http://tip.tcl.tk/285)

- Safely cancels a script being evaluated, synchronously or asynchronously.
- Example #1 (from C#):

```
Engine.CancelEvaluate(interpreter,
        true, null, ref result);
```

- Example #2 (from a script):

```
interp cancel -unwind
```

Variable Tracing

- Allows user-defined callback(s) to be executed when a variable is read, written, or deleted.
  - Currently, trace callbacks for a variable can only be specified upon variable creation (via the SetVariableValue or AddVariable APIs).
- Interpreter-wide variable traces are also supported.
  - They can monitor, modify, or cancel all requests to read, write, and delete any variable in the interpreter.

Anonymous Procedures

(compatible with Tcl 8.5)

```
set sum [list [list args] {
   expr [list [join $args +]]
}]

apply $sum 1 2 3; # returns 6
```

Closures

(using [**apply**] and [**scope**])

```
set sum [list [list name args] {
   scope create -open -args $name

   if {![info exists sum]} then {
       set sum 0
   }

   if {[llength $args] > 0} then {
       incr sum [expr [list [join $args +]]]
   }
}]

apply $sum foo 1 2 3; # returns 6
```

Design Philosophy

- Tcl heavily influenced the design of Eagle. In particular:
  - It obeys the “Endekalogue” (i.e. the “11 rules” that make up the Tcl 8.4 syntax).
  - Everything is a string (EIAS).
  - Every command is a string; the first word is the name of the command and the rest are arguments to the command.
  - Commands are free to interpret their arguments however they wish.
  - Every list is a string; however, not every string is a “well-formed” list.
  - The language supplies primitives “pieces” that can be combined and/or composed in useful ways.

Design Philosophy
(continued)

- However, there are some differences in the design that reflect the differences in the underlying platforms:
  - Minimal per-thread data; most state is stored in the interpreter.
    - Interpreters may be used from any thread and/or from multiple threads simultaneously (i.e. they have no thread affinity).
    - Each thread does have its own call stack and current call frame; however, the global call frame is shared between all threads.
  - No interpreter-wide result (i.e. the result of the last evaluation, etc).
    - This merits special attention because it significantly reduces the coupling between components.

What is missing?

(from the Tcl/Tk perspective)

- No Tk commands.
- No argument expansion syntax (introduced in Tcl 8.5).
- No namespace support (except the global namespace).
- No asynchronous input/output.
- No **[binary]**, **[fblocked]**, **[fileevent]**, **[format]**, **[glob]**, **[history]**, **[memory]**, **[scan]**, or **[trace]** commands.
- No **http** or **msgcat** packages.
- No **registry** or **dde** packages.
- Minimal support for the **tcltest** package (just enough to run the test suite).
- For the **[open]** command, command pipelines and serial ports are not supported.
- For the **[exec]** command, Unix-style input/output redirection and command pipelines are not supported.

Performance

(from the Tcl/Tk perspective)

- For some operations, Eagle can be up to up to two orders of magnitude slower than “real” Tcl.

- This is to be expected because Tcl is written in highly optimized C, has a mature byte-code compiler, and [most importantly] caches the computed internal representations of lists, integers, etc.

Where is the innovation?

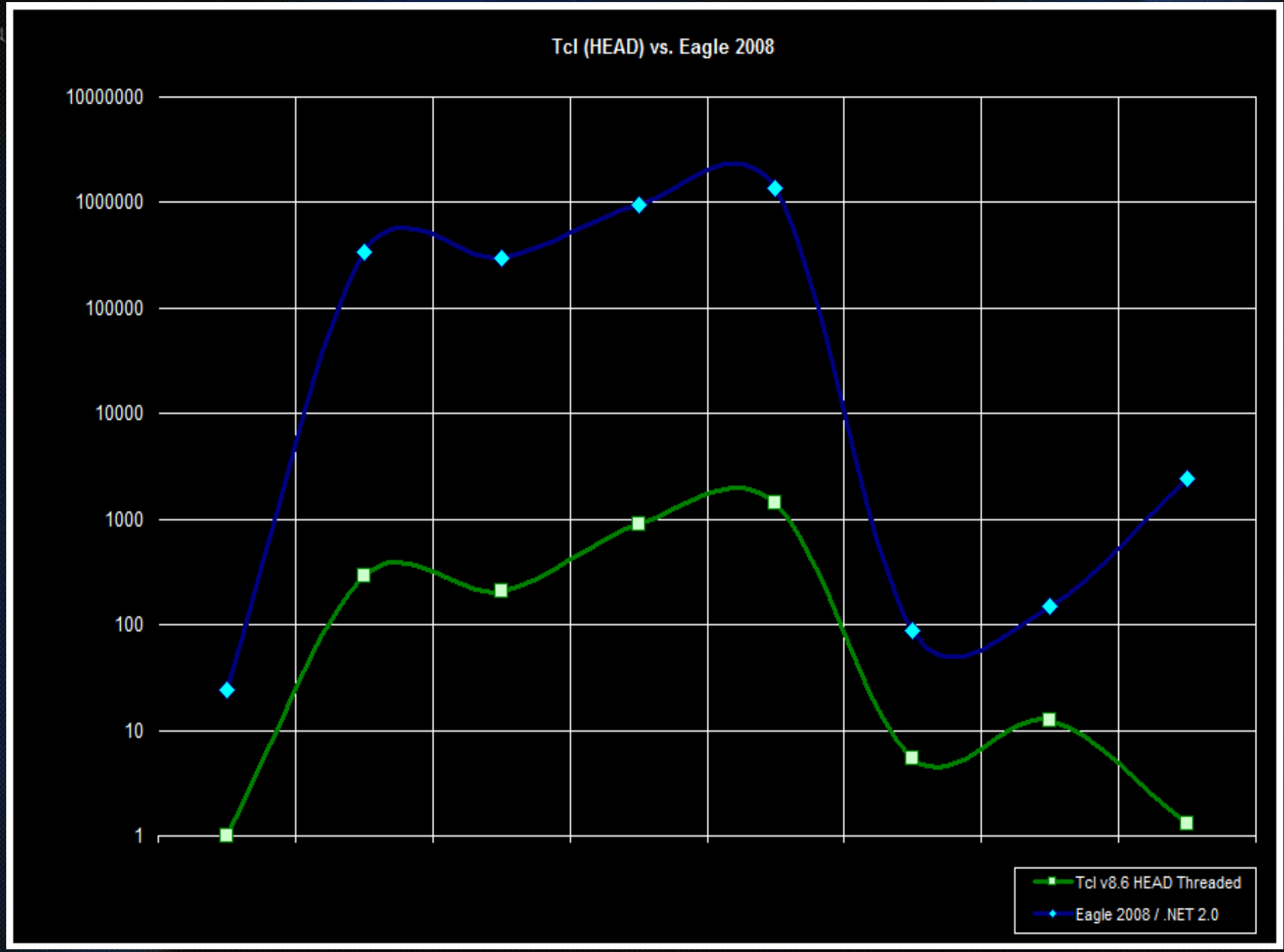
- The “host application is always right” attitude.
  - The IHost interface, etc.
- One interpreter, multiple threads, safely.
- The “universal option parser”.
- The seamless integration with CLR objects.
  - Full support for overload resolution, properties, methods, fields, and events.
- The built-in debugging support.
  - Yes, it’s not as smooth as Visual Studio; however, it is complete, lightweight, and does not need to be installed to function.
- Simple development / deployment model (i.e. the “add a reference and go experience”).

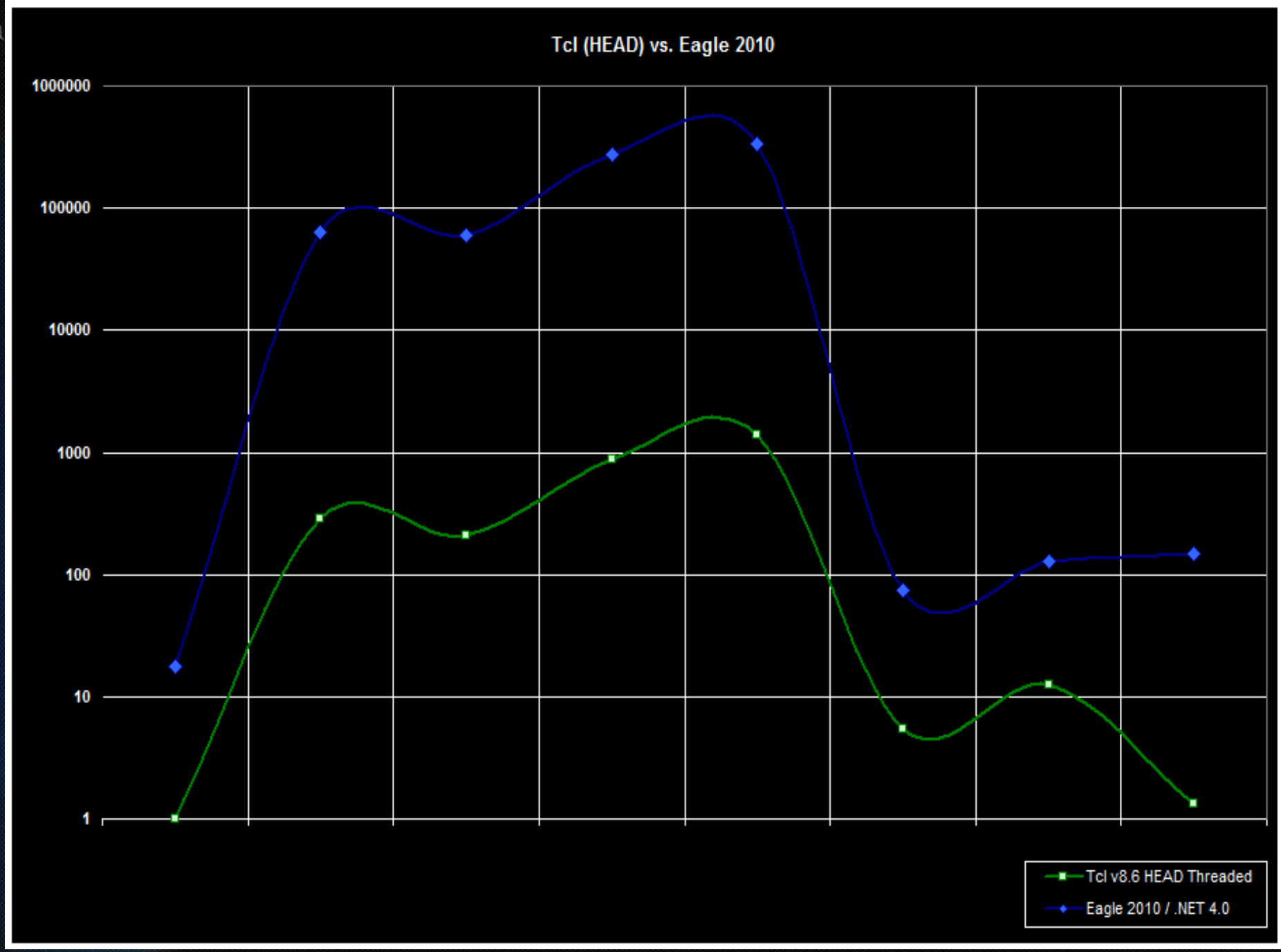
Why no compiler?

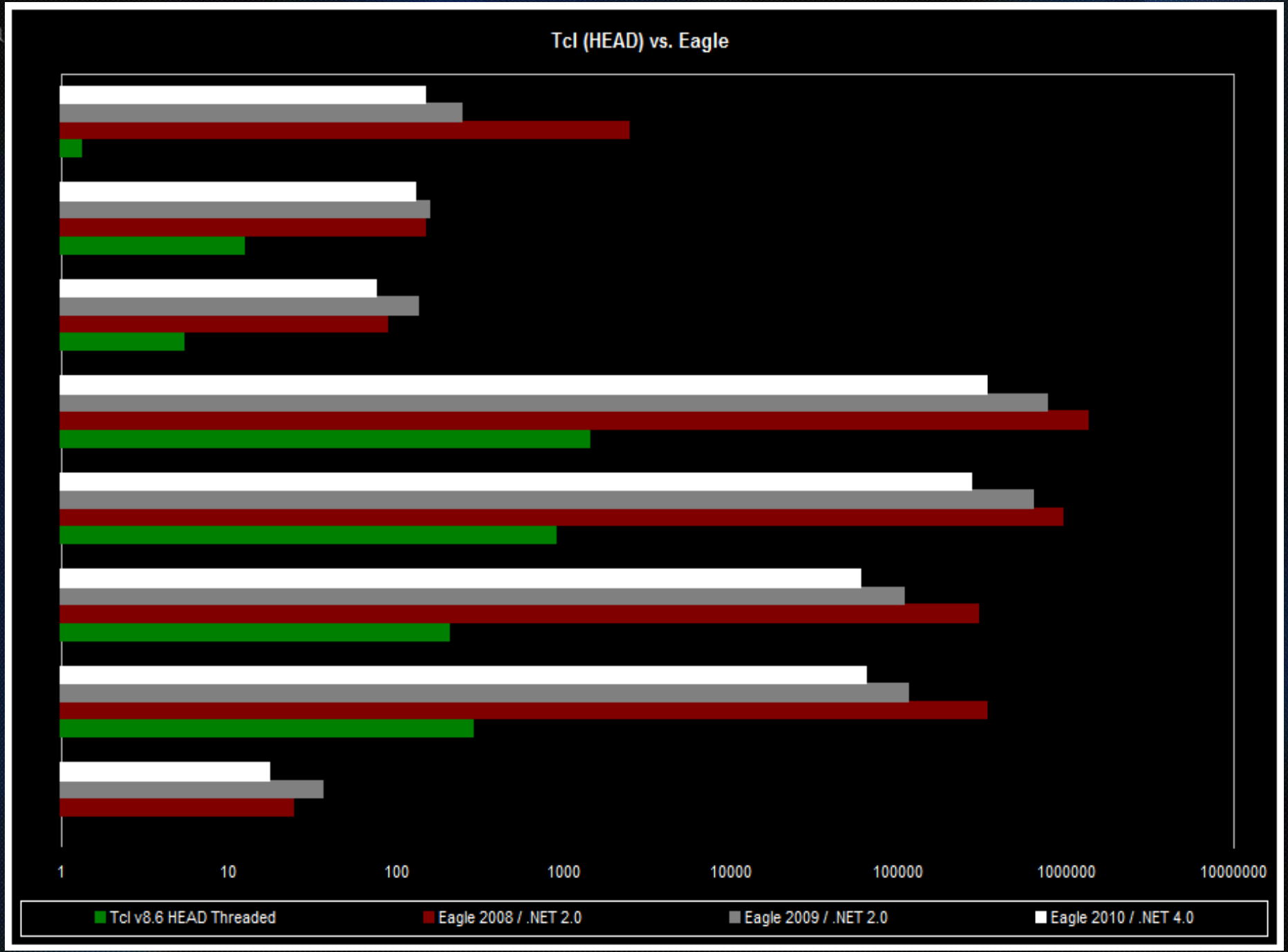
- Not enough time in the original schedule.
- Raw performance was not a primary consideration.
- Being correct, complete, and dynamic is more important than being fast.
- Long running scripts can be evaluated (and canceled as necessary) in secondary threads.
- The CLR just-in-time compiler is already pretty good.

Performance Problems

- Can be much slower than native Tcl, even for the simplest operations.
- Over time, targeted optimizations have been added for all critical code paths.

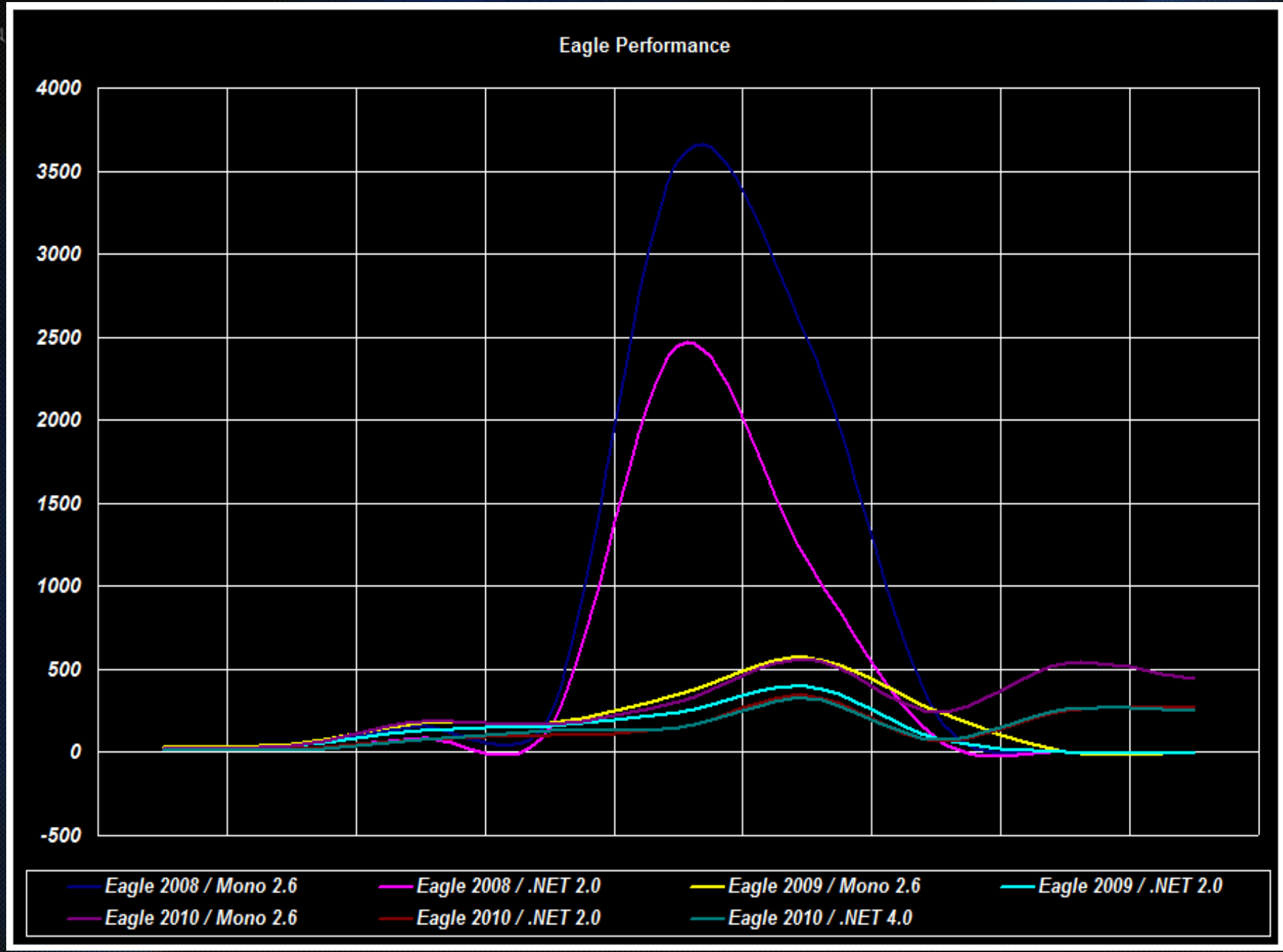

Tcl (HEAD) vs. Eagle 2008
10000000
1000000
100000
10000
1000
100
10
1
Tcl v8.6 HEAD Threaded
Eagle 2008 / .NET 2.0

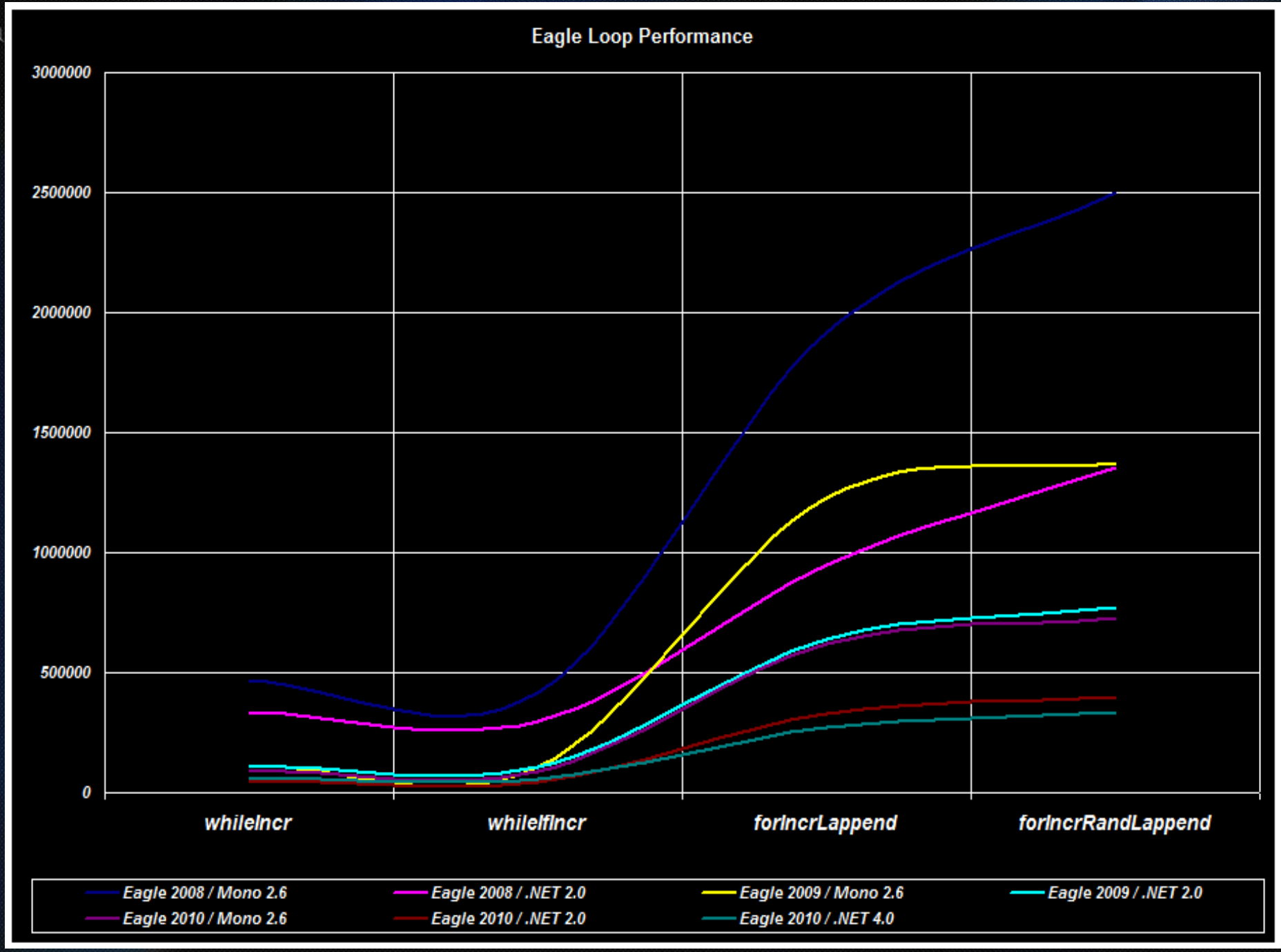

Tcl (HEAD) vs. Eagle 2010
1000000
100000
10000
1000
100
10
1
Tcl v8.6 HEAD Threaded
Eagle 2010 / .NET 4.0

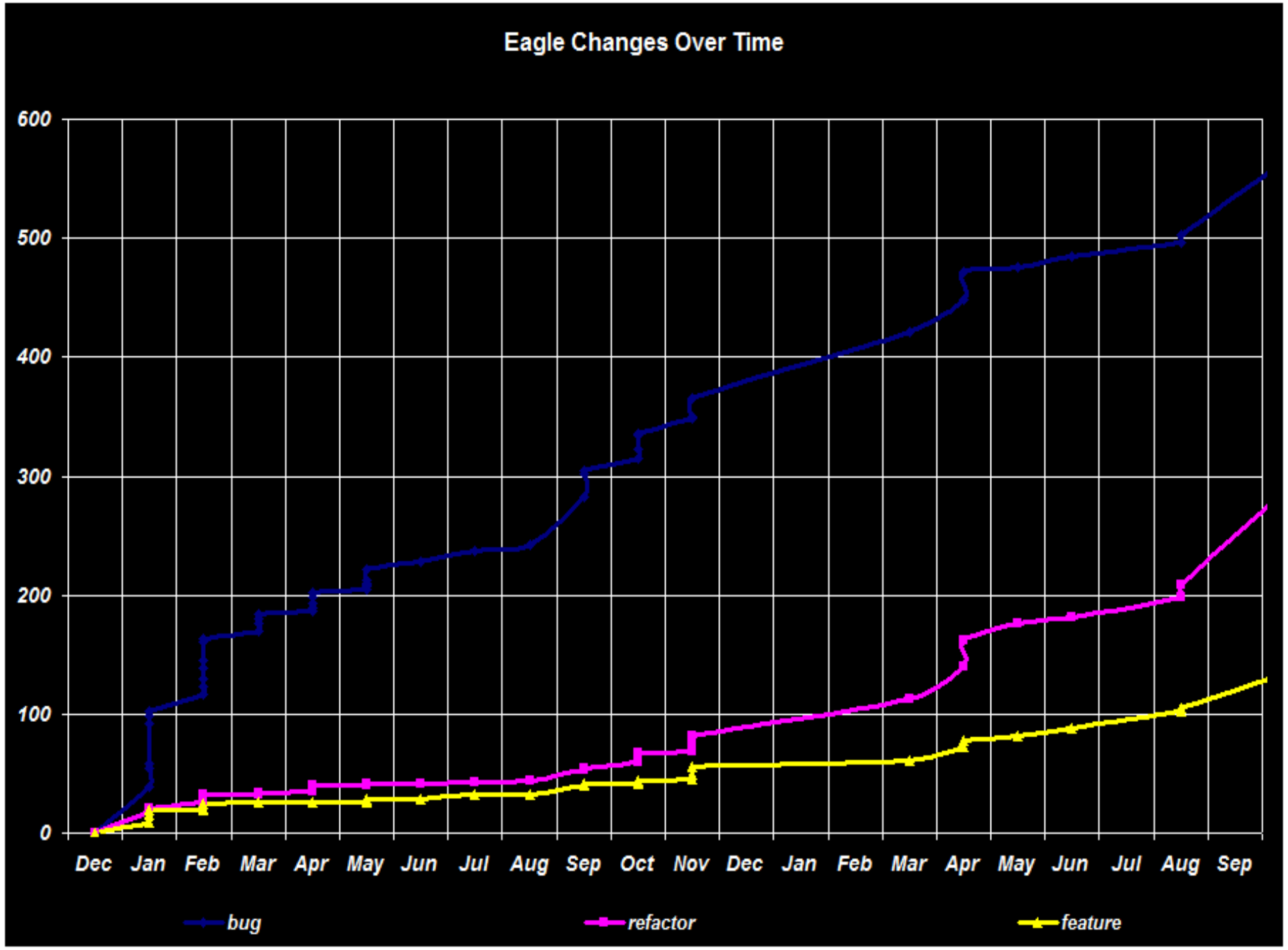

Tcl (HEAD) vs. Eagle
1
10
100
1000
10000
100000
1000000
10000000
Tcl v8.6 HEAD Threaded
Eagle 2008 / .NET 2.0
Eagle 2009 / .NET 2.0
Eagle 2010 / .NET 4.0

What is slow?

- Parsing strings into lists.
- Building lists from strings.
- Expression evaluation, primarily string-to-type conversions.
- All other performance issues are insignificant compared to these three.


Eagle Performance
4000
3500
3000
2500
2000
1500
1000
500
0
-500
Eagle 2008 / Mono 2.6
Eagle 2008 / .NET 2.0
Eagle 2009 / Mono 2.6
Eagle 2009 / .NET 2.0
Eagle 2010 / Mono 2.6
Eagle 2010 / .NET 2.0
Eagle 2010 / .NET 4.0


Eagle Loop Performance
3000000
2500000
2000000
1500000
1000000
500000
0
whileIncr
whileIfIncr
forIncrLappend
forIncrRandLappend
Eagle 2008 / Mono 2.6
Eagle 2008 / .NET 2.0
Eagle 2009 / Mono 2.6
Eagle 2009 / .NET 2.0
Eagle 2010 / Mono 2.6
Eagle 2010 / .NET 2.0
Eagle 2010 / .NET 4.0


Eagle Changes Over Time
600
500
400
300
200
100
0
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
bug
refactor
feature

Architectural Problems, Part 1

- The interpreter class is still too large.
  - Break into multiple files or classes.
  - Move all entity management to a new component.

Major Components

Engine

- Script / File Evaluation
- Text / File Substitution
- Token Evaluation
- Command Execution
- Script Error Handling
- Host Integration
- Asynchronous Support
- Debugger Support

Parser

- Script Parser
- List Parser / Builder
- String Match “Parser”

Option Parser

Object Marshaller

Interpreter

“Entities”

- Resolvers
- Procedures
- Commands
- Operators
- Functions
- Other

- Test Infrastructure
- Static “Helpers”

Thread State

- Engine
- Interactive
- Variable
- Test

- Interactive Loop
- Global Call Frame
- Other Local / Shared State

Expression Parser

Expression Evaluator

Value

- String Conversions
- Operand Handling
- Number / Variant

Host Integration

Tcl/Tk Integration

Architectural Problems, Part 2

- The engine is very (too?) recursive.
- The components are too tightly coupled and have some circular dependencies.

The Mono Saga

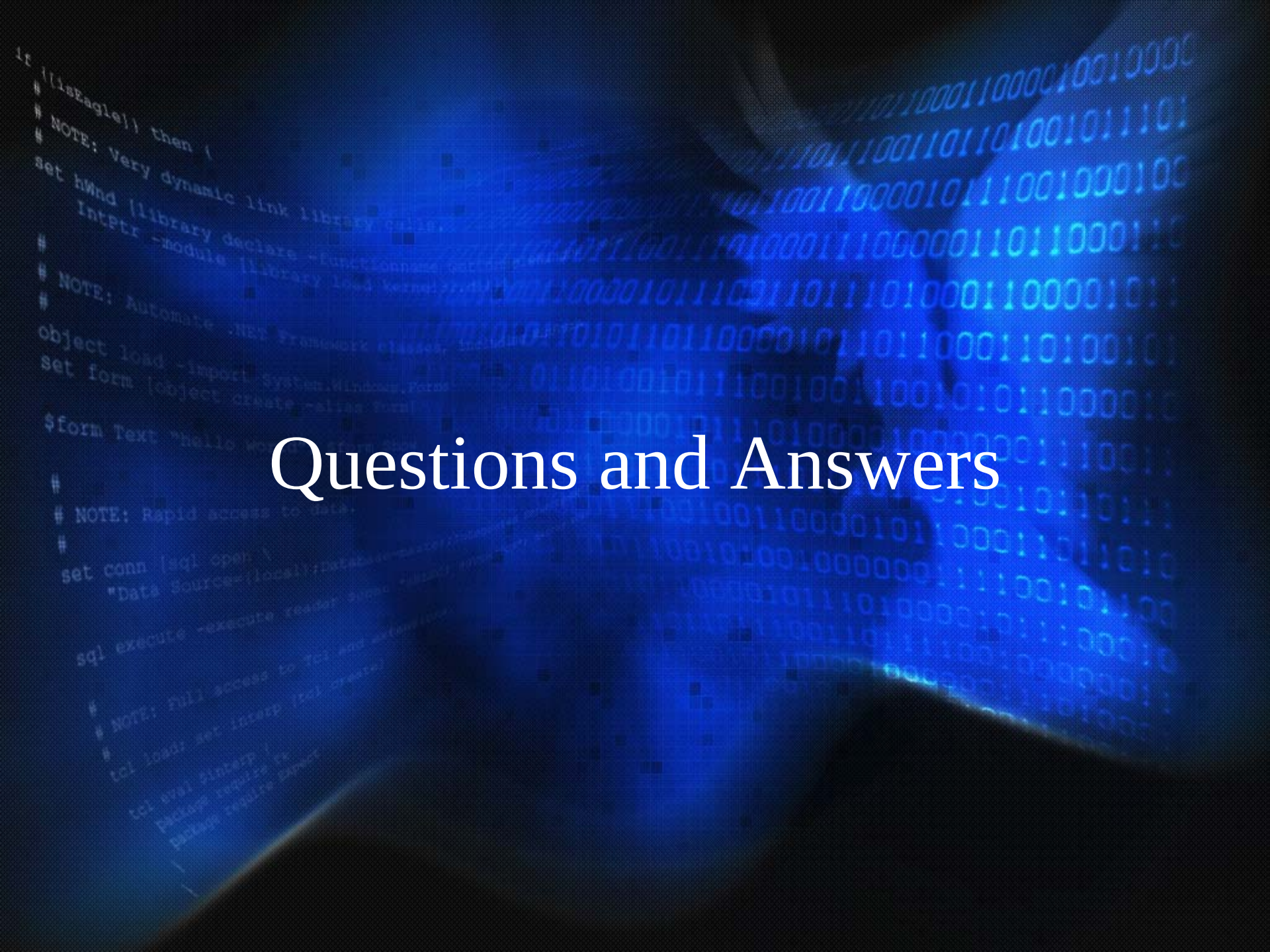
- Mono support was added in 2009.
- It has never been perfect because of serious bugs in the Mono platform.
- Eagle should build and run mostly correctly on recent versions of Mono (e.g. 2.6.7, 2.8, and 2.10) for Windows and Unix.

How can I help?

- Test in your environments and report any issues you find.
- Provide feedback in the form of feature requests, bug reports, or simply general comments.
- Contribute to the documentation and/or the test suite.
- Provide feedback, suggest features, or flames.

Where is it?

http://eagle.to/


Questions and Answers