8

Sugar-coating the CLR with IronRuby

This chapter covers:

* Building DSL’s with Ruby
* Leveraging metaprogramming

In my dealings with other programmers I make it no secret how I feel about the ruby language. One of the aspects that appeal most to me is the malleability of the language. You can make it do a lot without the need for complicated parsers. So one of the things that are very easy to do in ruby is create internal domain specific languages (DSL’s) for a bunch of tasks, one such DSL is RSpec, which is used for Behavior Driven Development (BDD). And this chapter is going to explore some of the things you can create DSL’s for and more importantly how you can go about it. This chapter is by no means a complete explanation on the subject about DSL’s but offers a general introduction.

If you want to read a good book on building DSL’s I can recommend Ayende’s book, Building Domain Specific Languages in BOO (http://www.manning.com/rahien/), who does an excellent job at explaining the intricacies of building these tools with boo.

The original CLR languages are classes designed to use in a static language and perhaps even with intellisense in the back of the programmers mind. Needless to say the API’s don’t always flow as nicely as you’d like to and often don’t express what you want the computer to do as clearly as could be. Or you just want to improve on some bits and pieces of the API in those cases and many more a DSL might be exactly what you need. In this chapter we’ll integrate an existing DSL as an external DSL to C#. We’ll create an internal DSL to watch the file system for changes. As usual we’re first going to start with a minimum of background information about DSL’s.

8.1. What? Why? Who?

I think most of us have been there, you were solving a problem; it was a tough nut to crack but eventually you did. The problem you took so many approaches you’re code has looked better and if the next guy was an axe wielding psychopath, you’d probably just have enough time to arrange your own funeral. Luckily the axe-wielding psychopath is you in this case so that won’t happen but as Murphy’s law prescribes, there are a bunch of things that come up and more important tasks need to be handled first. Anyway I think you know where this is heading the time between writing the code and getting back into is long enough for it to not be fresh in the back of your head anymore and the code you wrote isn’t obvious when you glance at it. This is where DSL’s come in; the purpose is to make the intent of the programmer clearer to the person maintaining the code than to the computer.

There are a couple of variations of DSL’s and we’ll talk about the internal and external variants, but not about the visual DSL’s that seem to be popular in some circles or fluent interfaces which are really just a poor mans (language) internal DSL. I for one am still not convinced about the value of visual DSL’s as I seem to fight them more than get on with my job, I also feel very much out of the driver seat when using those. If all goes well and everything works then great but this is rarely the case. That could have more to do with me than with the actual tool. To me a programmer works at an abstract level where a designer works visually.

Ok that leaves us with the question so what’s the difference then between an internal and an external DSL. An internal DSL is one you craft with the same language that will consume it. Another name for an internal DSL would be embedded DSL and some examples within the Ruby language are Rake, RSpec, builder,… An external DSL is a DSL you or somebody else has built from scratch, often using a lexer and a parser to create an AST which can then be executed by the DSL host, examples of external DSL’s are SQL, FIT, configuration files, …

Good now that it’s established that all of us use DSL’s on an almost daily basis let’s start by the simplest case of just integrating a ruby DSL into a C# application.

8.2. A state machine integration

When I was preparing for this chapter, which was a direct consequence of some of the feedback I got from the reviewers, I asked the IronRuby community if they have .NET CLR a project they’d like to see ported to IronRuby as an example. I received a few emails and the project that stood out the most to me was the stateless project from Nicholas Blumhardt (http://code.google.com/p/stateless/), who also produced the excellent Autofac IoC container. After looking into that project a little bit closer it became clear that it was a port of a project on codeplex that uses boo as the language to create the DSL. Googling some more brings me to the statemachine gem, which sure looks like a really good match to both of the aforementioned projects.

At this point the plan changes and I’m going from: Okay I’m going to build a statemachine DSL to wouldn’t it be interesting to just make this DSL usable from C# somehow, so lets explore that a little, starting with the end result. I also want to make it clear that the codes and explanations provided are here to highlight the IronRuby with C# interaction, they are in no way criticism on the original C# example code.

8.2.1 The end goal of this exercise

At the end of this part in the book we should be able to run the Bug sample from the stateless project as shown in listing 8.1. It creates an instance of a C# bug class and moves that through a few states before closing the bug. We should be able to just take this Main method and replace the bug class with our implementation and it should still work.

Listing 8.1: The original stateless sample

class Program

{

static void Main(string[] args)

{

var bug = new Bug("Incorrect stock count");

bug.Assign("Joe");

bug.Defer();

bug.Assign("Harry");

bug.Assign("Fred");

bug.Close();

Console.ReadKey(false);

}

}

If we manage that I guess the application working with the Bug class will still be happy as it doesn’t know bug has changed internally to be very much improved, after all it will be using ruby for its stuff that’s an improvement in itself. The code listing above prints out the following messages to the screen:

+ivan@ivan-mbp:~/projects/gitosis/stateless/BugTrackerExample/bin/Debug

(master)» mono BugTrackerExample.exe

Joe, RE Incorrect stock count: You own it.

Joe, RE Incorrect stock count: You're off the hook.

Harry, RE Incorrect stock count: You own it.

Harry, RE Incorrect stock count: You're off the hook.

Harry, RE Incorrect stock count: Don't forget to help the new guy.

Fred, RE Incorrect stock count: You own it.

Fred, RE Incorrect stock count: You're off the hook.

So we get some output that shows the states and transitions with output the bug instance went through. We’re ready to begin converting the code from the stateless project to a ruby-enabled version.

8.2.2 Setting the stage for the example

As it turns out the statemachine gem uses a context to actually execute the application code so this example is going to be mostly about a quick demo for hosting this stuff in an existing application. So lets dive straight in with an example. The example, however, is a port of the Bug example of the stateless project, the C# version of the definition we’ll create in ruby is shown in listing 8.2.

Listing 8.2: The C# version of the statemachine definition

public class Bug

{

enum State { Open, Assigned, Deferred, Resolved, Closed }

enum Trigger { Assign, Defer, Resolve, Close }

State \_state = State.Open;

StateMachine<State, Trigger> \_machine;

StateMachine<State, Trigger>.TriggerWithParameters<string> \_assignTrigger;

string \_title;

string \_assignee;

public Bug(string title)

{

\_title = title;

\_machine = new StateMachine<State, Trigger>(() => \_state, s => \_state = s);

\_assignTrigger = \_machine.SetTriggerParameters<string>(Trigger.Assign);

\_machine.Configure(State.Open)

.Permit(Trigger.Assign, State.Assigned);

\_machine.Configure(State.Assigned)

.SubstateOf(State.Open)

.OnEntryFrom(\_assignTrigger, assignee => OnAssigned(assignee))

.PermitReentry(Trigger.Assign)

.Permit(Trigger.Close, State.Closed)

.Permit(Trigger.Defer, State.Deferred)

.OnExit(() => OnDeassigned());

\_machine.Configure(State.Deferred)

.OnEntry(() => \_assignee = null)

.Permit(Trigger.Assign, State.Assigned);

}

public void Close()

{

\_machine.Fire(Trigger.Close);

}

public void Assign(string assignee)

{

\_machine.Fire(\_assignTrigger, assignee);

}

public bool CanAssign

{

get

{

Console.WriteLine ("in Can Assign");

return \_machine.CanFire(Trigger.Assign);

}

}

public void Defer()

{

\_machine.Fire(Trigger.Defer);

}

void OnAssigned(string assignee)

{

if (\_assignee != null && assignee != \_assignee)

SendEmailToAssignee("Don't forget to help the new guy.");

\_assignee = assignee;

SendEmailToAssignee("You own it.");

}

void OnDeassigned()

{

SendEmailToAssignee("You're off the hook.");

}

void SendEmailToAssignee(string message)

{

Console.WriteLine("{0}, RE {1}: {2}", \_assignee, \_title, message);

}

}

I’m not going to explain the C# code above but I’ve included it to have something to contrast against later on. The first thing we need to do is make sure we’ve got the statemachine gem installed, by executing igem install statemachine.

» igem install statemachine

Successfully installed statemachine-0.4.1

1 gem installed

Installing ri documentation for statemachine-0.4.1...

Installing RDoc documentation for statemachine-0.4.1...

Now that we have the statemachine gem it might be a good idea to open its documentation so you can look up something if you need it.

Getting to the docs easily

The biggest part of the gems are distributed as ruby source files and most of them include documentation. That means you have all the information you need on your machine locally to figure out how to use certain libraries. In many cases the unit tests are also a part of the library and sometimes there is an examples directory to get you on your way.

Now how do you get to that documentation which is provided as html. There are 2 tools ruby provides for this. The first one is ri and you can interrogate it from the command line provided that the docs are generated beforehand.

You can generate the missing docs with the gem command rdoc. So for example for caricature you can do igem rdoc caricature and that should then generate the docs for the caricature gem.

To search for the documentation on the String class from the command-line, you would enter the command iri string. And that would then show you all the classes on your system that have a method with the word string in them and it allows you to drill down to the information you need.

While it is cool you get that kind of access to docs. I will generally use a web browser to go through the API documentation and I have a gems server running which serves me all those RDoc documentation files.

To start that server do igem server and afterwards you can open a brower and point it to <http://localhost:8808/> This will show you an overview of all the gems you have installed on your system and allows you to quickly go to the gem you want the documentation for.

This gets our ironruby set up correctly for the next steps and I’ll try to show you a typical workflow when building a ruby application. Next up: create the C# project.

8.2.3 Creating the C# project

The next thing to do is to open visual studio/monodevelop and create a new C# console application, I called mine BugTrackerStatemachine. Next we’ll have to add the references to the IronRuby libraries and then we’re ready to commence building the state machine. Figure 8.1 has the screenshot of the add reference dialog box on visual studio. I’ve extracted the zip file for IronRuby to C:\ironruby so this means the binaries are located in C:\ironruby\bin.

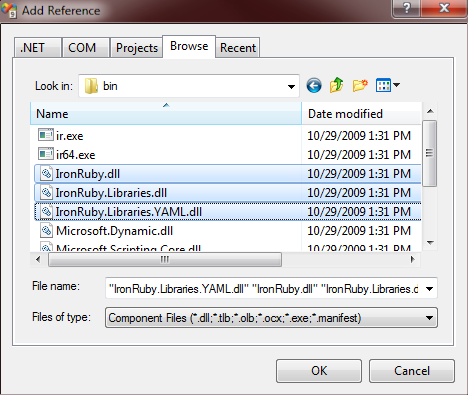


Figure 8.1 Add Ironruby references to the project

This particular example can be run on mono too so figure 8.2 shows the same dialog box but for monodevelop. I’ve extracted the ironuby zip file to my home directory so the binaries are located in ~/bin.

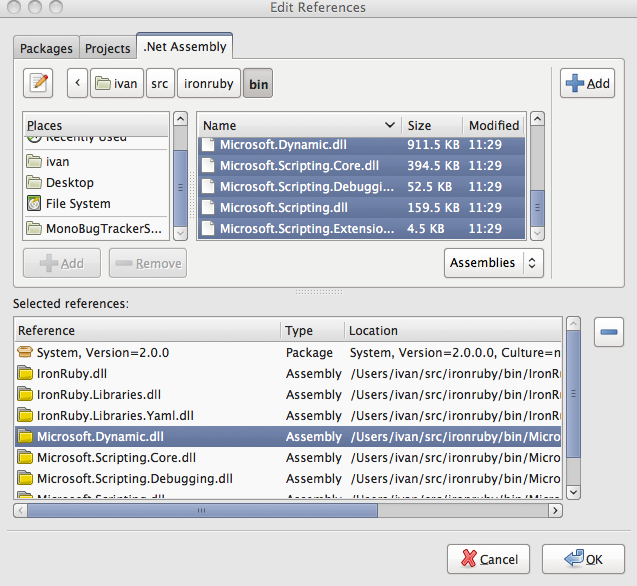


Figure 8.2: The MonoDevelop edit references dialog box

If you’ve followed along earlier and started the gem server then you can visit this url <http://localhost:8808/doc_root/statemachine-0.4.1/rdoc/classes/Statemachine/StatemachineBuilder.html> and that shows us that the statemachine builder takes a context, we’re going to take advantage of this fact to provide it with a C# context for this example. In this case I’ve chosen to use the context as the integration point because it was the most convenient and whenever something seems to fit I’ll try that first instead of swimming upstream.

8.2.4 Creating the definition in ruby

One might ask what’s the point of all this? We already have a perfectly good working solution in C# so why would I want to do this from with IronRuby. There are a number of reasons. While I can read the code from listing 8.2, it’s not as clear as it could be and it requires me to actually decipher the states in the constructor. If I want to make a change to the workflow I have to recompile my application while with the Ruby version you are able to change it at even run-time.

Tip:

You can use Ruby instead of XML for configuration tasks and not induce carpal tunnel syndrome for your fellow devs. It gives you the benefit that you can work with real types and you can properly unit test it while it’s still very much friendly for machines it will make a world of difference to your developers.

Another consequence of what we’re going to do is to separate the application logic from the infrastructural code so it ultimately results in a better separation of concerns, keep in mind that we are working with sample code here though. To be able to port the fluent interface shown in listing 8.2 let’s first determine what we don’t need. We won’t have to worry about enum values they are internal values for the state machine. Then, there is a bunch of noise to declare instance variables/fields with some generics, which we won’t need those either. Then there are 2 instance fields for the assignee and the title. That sounds pretty useful lets keep those but let’s replace them with public getters as that reflects a more useful bug object. So in our own C# application we now have a class that looks like listing 8.3.

Listing 8.3: including the necessary properties

public class Bug

{

public string Title { get; private set; }

public string Assignee { get; private set; }

public object Statemachine { get; set; } 1

}

1. the Statemachine property

The observant reader, as I’m sure you all are, will have noticed that there is a Statemachine property with a getter and setter on this class. This is a result from what I’ve read in the documentation of the statemachine gem. The following link shows the source of the context method on the statemachine builder and it sets a statemachine property: <http://localhost:8808/doc_root/statemachine-0.4.1/rdoc/classes/Statemachine/StatemachineBuilder.src/M000017.html>. So I’ve added that one too. We’ll also need a path to the ruby file but’s lets worry about that a little bit later and jump into the constructor where the statemachine is being defined. From that code we can derive that there are 4 states (Open, Assigned, Deferred and Closed) and 1 super state (Open). We can also see that from the 4 transitions (triggers) defined in that sample that there are only 3 in use (Assign, Defer and Close). This gives us a pretty good idea of what we’re going to put in our ruby state machine definition. The definition in listing 8.2 shows a few more items like the fact that an Assigned state has an OnEntryFrom and OnExit callbacks and the Deferred state has an OnEntry callback. Listing 8.4 shows the ruby equivalent of the C# state machine definition.

Listing 8.4: The state machine in Ruby

require 'rubygems'

require 'statemachine'

**inserted = ctxt** 6

Statemachine.build do

trans :open, :assign, :assigned, :on\_assigned 1

trans :assigned, :close, :closed

trans :assigned, :defer, :deferred

superstate :open do 2

state :assigned do

event :assign, :assigned, :on\_assigned 3

on\_exit :deassigned 4

end

end

state :deferred do

event :assign, :assigned, :on\_assigned

on\_entry :deassign 5

end

context inserted 7

end

1. transition and action

2. super state declaration

3. formal transition definition

4. on exit action

5. on entry action

6. bringing in the variable from the DLR scope

7. setting the context

This book is not about explaining the intrinsics of state machines but Micah the author of the statemachine gem does a pretty good job:

<http://blog.8thlight.com/articles/2006/11/17/understanding-statemachines-part-1-states-and-transitions>

<http://blog.8thlight.com/articles/2006/11/30/understanding-statemachines-part-2-actions>

<http://blog.8thlight.com/articles/2007/02/13/understanding-statemachines-part-3-conditional-logic>

<http://blog.8thlight.com/articles/2007/04/07/understanding-statemachines-part-4-superstates>

The statemachine gem takes the approach that a statemachine is defined by its transitions so we first define a transition (#1) for going from open to assigned and it invokes the action on\_assigned. This action will be invoked on the context (#7), to which we’ll return later. We define the transitions from the assigned state and proceed with creating a super state open (#2). This super state is the SubStateOf method in listing 8.2. Inside the super state we define a state assigned and this state has a reentry transition defined with the formal transition syntax (#3). The assigned state also defines an on\_exit action (#4). This action will also be invoked on the context (#7).

We move on to defining the deferred state. This state defines a transition back to assigned and it also defines an on\_entry action (#5). The implementations of this behavior will reside in our C# bug class. So the last thing left to explain is how we’re going to link the C# bug class with our Ruby state machine. The bolded text takes care of that and injects the ctxt variable into the scope by assigning it to the inserted variable (#6). We assign the inserted variable as context inside the Statemachine.build method (#7). By assigning it there it also checks for the statemachine setter on the context and if present it will set the statemachine to the current instance.

Why is there inserted = ctxt ?

That is because a variable you set with ScriptScope.SetVariable (later in this chapter) isn’t a ruby variable but rather a DLR variable. Here’s what Tomas Matousek, a Microsoft SDE on IronRuby, had to say on the subject:

**inserted = ctxt (#6)** calls a “ctxt” method on “self”. The hosting API injects method\_missing into the top-level singleton – you can see it by printing p self.method(:method\_missing). The implementation of that method\_missing looks into the scope for variables.

In the latter case, I assume, you instance\_eval the block against some object, right? Hence ctxt is an invocation on that object, which has no relationship with the scope.

This is completely correct. The Statemachine.build method actually really does use instance\_eval and this changes the context of the block to the instance that is executing the block. So all method calls are evaluated on the Statemachine instance instead of in the global scope. And that is why we have that line (#6) there.

At first I thought that setting a scope variable would be the same as declaring a variable in ruby but the 2 don’t match up completely.

That takes care of the ruby definition of the state machine and we’re ready to go back to our C# class to finish the integration. The first thing we’re going to do is host the ironruby runtime.

8.2.5 Hosting the IronRuby runtime

We’re moving back into C# now, to finish up our bug implementation, when we left it back in listing 8.3 our class had 3 properties but we’re going to need a few more. We will need the path to the definitions file so it can be overridden so we’ll make that a read/write property (#1) as shown in listing 8.5.

Listing 8.5: Instrumenting the Bug class with IronRuby

public class Bug

{

public string Title { get; private set; }

public string Assignee { get; private set; }

public object Statemachine { get; set; }

public string DefinitionPath { get; set; } 1

private ObjectOperations \_rubyOperations;

private static ScriptEngine \_engine = Ruby.CreateEngine(); 2

public Bug(string title)

{

DefinitionPath = Path.Combine(

Environment.CurrentDirectory, "definition.rb"

);

Title = title;

ExecuteRubyDefinition();

}

private void ExecuteRubyDefinition(){

\_rubyOperations = \_engine.CreateOperations(); 3

var scope = \_engine.CreateScope(); 4

scope.SetVariable("ctxt", this); 5

\_engine.ExecuteFile(DefinitionPath, scope); 6

}

}

1. The defintion path property
2. Creating the ruby engine
3. Getting the object operations helper
4. Creating a new scope
5. Setting a scope variable
6. Execute the state machine definition

We’re also going to need a ScriptEngine (lives in Microsoft.Scripting.Hosting), because these engines are pretty expensive to boot so I made it a static field on the bug class (#2). This way the engine gets booted when the type is initialized (not the instance) and only once during the run of the application. So if you have more classes that are going to use IronRuby it might pay not to have too many of those around and share them as much as possible, depending on your requirements.

We’re now entering the constructor and we initialize the definition path with a default path. We also initialize the Title property with the value from the constructor parameter and proceed with executing the ruby definition.

The first thing to notice is that we ask the script engine to create an object operations helper (#3). We’ll need this to invoke methods on our ruby state machine later on to replace the methods that have a call to \_machine.Trigger from the Bug class in listing 8.2. Next we create a scope (#4) so we can set variables for that scope before executing the file. We then set a variable ctxt to this instance of the bug in this scope (#5). And the last thing we do is we execute the file in the same scope (#6) so that it has access to the scope variable we set previously. This ctxt variable is then used to initialize the inserted variable in listing 8.4. And this brings us to the part where we have to implement the behavior (actions) on the Bug class.

8.2.6 Implementing the behavior on the Bug class

To implement the behavior on the class we can basically copy/paste the methods OnAssigned and OnDeassigned from the original example in listing 8.2 and change their visibility to public. This is shown in listing 8.6, the changes to these methods from the once you can find in listing 8.2 have been marked in bold.

8.6 Adding the actions to the bug class

**public virtual void Deassign(){**

**Assignee = null;**

**}**

public virtual void OnAssigned(string assignee)

{

if (Assignee != null && assignee != Assignee)

SendEmailToAssignee("Don't forget to help the new guy.");

Assignee = assignee;

SendEmailToAssignee("You own it.");

}

public virtual void Deassigned()

{

**if(Assignee != null)** SendEmailToAssignee("You're off the hook.");

}

public virtual void SendEmailToAssignee(string message)

{

Console.WriteLine("{0}, RE {1}: {2}", Assignee, Title, message);

}

The first thing that is different from the original listing is that we added a Deassign method. This just made it easier and more consistent for this chapter. The other change I made was checking if there is an Assignee before we alert them that they’re off the hook. This is because the stateless implementation and the ruby gem state machine behave slightly different. These methods implement the actions we use in listing 8.4, and we’re getting close to finishing this all we need to do now is make sure we can navigate between the states and to do that we’re going to use the object operations helper we created earlier on in listing 8.5. The transition actions (assign, defer, close) are created on the ruby state machine instance so we need to invoke some methods on that object and pass it a parameter as shown in listing 8.7.

Listing 8.7: Invoking members on the ruby class from C#

public virtual void Assign(string assignee){

\_rubyOperations.InvokeMember(Statemachine, "assign", assignee); 2

}

public virtual void Defer(){

\_rubyOperations.InvokeMember(Statemachine, "defer"); 1

}

public virtual void Close(){

\_rubyOperations.InvokeMember(Statemachine, "close");

}

1. Invoke a method on an object
2. Invoke a method with parameters

The first method from the above code listing we’re going to discuss is the Defer method. It uses the \_rubyOperations.InvokeMember (#1) method to execute a method on the ruby class. The ObjectOperations helper for the DLR has all kinds of goodness for interacting with dynamic language objects. It contains methods to interrogate those objects as well as methods to invoke members and manipulate the objects by adding methods or variables or … The second example (#2) shows invoking the assign method with a parameter. Listing 8.9 shows the completed listing for the Bug class. It’s only a little bit shorter than the C# version so there is no win in LOC there is a win in readability though.

Listing 8.9: the completed listing

public class Bug

{

public string Title { get; private set; }

public string Assignee { get; private set; }

public object Statemachine { get; set; }

public string DefinitionPath { get; set; }

private ObjectOperations \_rubyOperations;

private static ScriptEngine \_engine = Ruby.CreateEngine();

public Bug(string title)

{

DefinitionPath = Path.Combine(

Environment.CurrentDirectory, "definition.rb"

);

Title = title;

ExecuteRubyDefinition();

}

private void ExecuteRubyDefinition(){

\_rubyOperations = \_engine.CreateOperations();

var scope = \_engine.CreateScope();

scope.SetVariable("ctxt", this);

\_engine.ExecuteFile(DefinitionPath, scope);

}

public virtual void Deassign(){

Assignee = null;

}

public virtual void OnAssigned(string assignee)

{

if (Assignee != null && assignee != Assignee)

SendEmailToAssignee("Don't forget to help the new guy.");

Assignee = assignee;

SendEmailToAssignee("You own it.");

}

public virtual void Deassigned()

{

if(Assignee != null) SendEmailToAssignee("You're off the hook."); // Deassign needs Assignee

}

public virtual void SendEmailToAssignee(string message)

{

Console.WriteLine("{0}, RE {1}: {2}", Assignee, Title, message);

}

public virtual void Assign(string assignee){

\_rubyOperations.InvokeMember(Statemachine, "assign", assignee);

}

public virtual void Defer(){

\_rubyOperations.InvokeMember(Statemachine, "defer");

}

public virtual void Close(){

\_rubyOperations.InvokeMember(Statemachine, "close");

}

}

So we now have a completely compatible implementation of the Bug class or at least so we’d like to think, we still need to test it. I copied and pasted the code from listing 8.1 into the Main method of the console application we created in this chapter. I did change the names to make the outputs different.

+ivan@ivan-mbp:~/projects/ironruby-in-action/Samples/MonoBugTracker

(master)» mono MonoBugTrackerStatemachine.exe

Tom, RE The bug of bugs: You own it.

Tom, RE The bug of bugs: You're off the hook.

Ivan, RE The bug of bugs: You own it.

Ivan, RE The bug of bugs: You're off the hook.

Ivan, RE The bug of bugs: Don't forget to help the new guy.

Adam, RE The bug of bugs: You own it.

Adam, RE The bug of bugs: You're off the hook.

All done

Great! It looks like it all worked out nicely. So at this moment we’re compatible and our code will run on any .NET 2.0-enabled machine. At the moment of this writing the .NET framework just entered the Beta 2 stage for it’s 4.0 version. From a dynamic languages perspective this release is big. .NET 4.0 has a dynamic keyword which makes it possible to call methods on dynamic objects without the need to go through the object operations helper class. The next part of this chapter looks at what’s involved in making the bug sample work with .NET 4.0. If mono has progressed far enough by the time you read this they will also implement this dynamic keyword and so the next part should work on a mono box too, but for me currently it only works well on windows.