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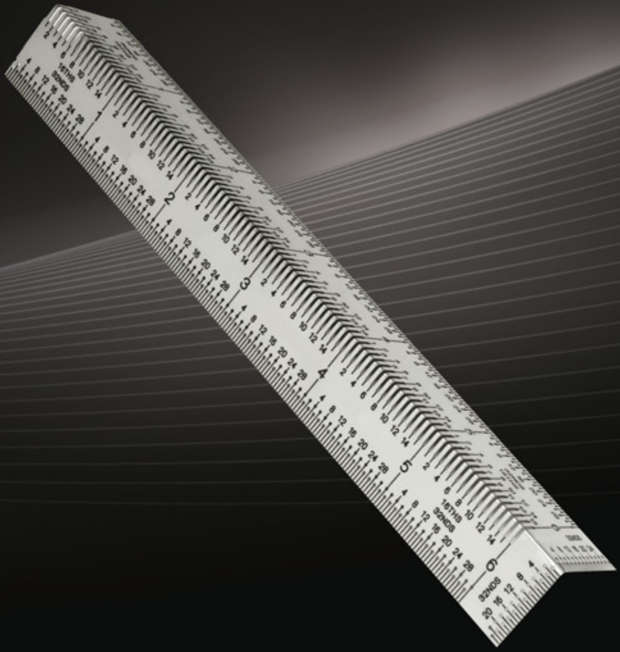
ASP.NET and AJAX: Architecting Web Applications



Dino Esposito

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To the people who help me to smile and often smile, play and laugh with me.

—Dino

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I owe you all the (non-rhetorically) monumental "Thank you" for being so kind, patient, and accurate.

—Dino

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Introduction

This book is the Web counterpart to another recently released book I co-authored with Andrea Saltarello: *Microsoft .NET: Architecting Applications for the Enterprise* (Microsoft Press, 2008). I wrote it, in part, in response to the many architectural questions—both small questions and big ones—that I was asked repeatedly while teaching ASP.NET, AJAX, and Silverlight classes.

Everybody in the industry is committed to AJAX. Everybody understands the impact of it. Everybody recognizes the enormous power that can be derived from its employment in real-world solutions.

Very few, though, know exactly how to make it happen. There are so many variations to AJAX and so many implementations that even after you have found one that suits your needs, you are left wondering whether that is the best possible option.

The fact is that AJAX triggered a chain reaction in the world of the Web. AJAX represents a change of paradigm for Web applications. And, as the history of science proves, a paradigm shift has always had a deep impact, especially in scenarios that were previously stable and consolidated.

I estimate that it will take about five years to absorb the word *AJAX* (and all of its background) into the new definition of the Web. And the clock started ticking about four years ago. The time at which we say "the Web" without feeling the need to specify whether it contains AJAX or not... well, that time is getting closer and closer. But it is not that time yet.

Tools and programming paradigms for AJAX, which were very blurry just a few years ago, are getting sharper every day. Whether we are talking about JavaScript libraries or suites of server controls, I feel that pragmatic architectures can be identified. You find them thoroughly discussed in Chapter 3, "AJAX Architectures."

Architecting a Web application today is mostly about deciding whether to prefer the *richness* of the solution over the *reach* of the solution. Silverlight and ASP.NET AJAX are the two platforms to choose from as long as you remain in the Microsoft ecosystem. But the rich vs. reach dilemma is a general one and transcends platforms and vendors. A neat answer to that dilemma puts you on the right track to developing your next-generation Web solution.

Who This Book Is For

I believe that this book is ideal reading for any professionals involved with the ASP.NET platform and who are willing or needing to find a solution that delivers a modern and rich user experience.

Companion Content

Examples of techniques and patterns discussed in the book can be found at the following site: *http://www.microsoft.com/learning/en/us/books/12926.aspx*.

Hardware and Software Requirements

You'll need the following hardware and software to work with the companion content included with this book:

- Nearly any version of Microsoft Windows, including Vista (Home Premium Edition, Business Edition, or Ultimate Edition), Windows Server 2003 and 2008, and Windows XP Pro.
- Microsoft Visual Studio 2008 Standard Edition, Visual Studio 2008 Enterprise Edition, or Microsoft Visual C# 2008 Express Edition, and Microsoft Visual Web Developer 2008 Express Edition.
- Microsoft SQL Server 2005 Express Edition, Service Pack 2 or Microsoft SQL Server 2005, Service Pack 3, or Microsoft SQL Server 2008.
- The Northwind database of Microsoft SQL Server 2000 is used to demonstrate data-access techniques. You can obtain the Northwind database from the Microsoft Download Center (*http://www.microsoft.com/downloads/details.aspx?FamilyID=06616212-0356-46A0-8DA2-EEBC53A68034&displaylang=en*).
- 1.6 GHz Pentium III+ processor, or faster.
- 1 GB of available, physical RAM.
- Video (800 by 600 or higher resolution) monitor with at least 256 colors.
- CD-ROM or DVD-ROM drive.
- Microsoft mouse or compatible pointing device.

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Chapter 4
A Better and Richer JavaScript

Language is the source of misunderstandings.

—Antoine de Saint-Exupery

Aside from the social implications of it, the Web 2.0 from a technology viewpoint is mostly about running more JavaScript code on the client. You can't just take the standard JavaScript language that most browsers support today and ask any developer to write immensely capable applications using it. As a projectwide approach, it just doesn't scale and work the way you might expect. JavaScript is not like, say, C#. JavaScript is a very special type of language; it's probably not the language everybody would choose to use today to power up the client side of the Web. However, it's the only common language we have, and we have to stick to it to reach the largest audience.

So what if you want (or more likely need) more power on the client?

Be ready to write more JavaScript code; more importantly, be ready to import more JavaScript code written by others. Either of these two ways of using JavaScript is OK, as they are not mutually exclusive options.

JavaScript is not the perfect language, and, amazingly, it was not designed to be the super language to rule the Web. JavaScript is popular, and this is its major strength and most significant weakness. It's a strength because it allows you to reach virtually every browser and every user; it's a weakness because its widespread use makes implementing any important change or extension painful in terms of achieving compatibility.

In summary, I firmly believe that for the time being you can't just transform JavaScript into something else that is radically different from what the language is today. However, the Web has repeatedly proven to be a surprisingly dynamic and agile environment; so who really knows what could happen in five years? Giving a judgment today, I would say that a winning approach needs to evolve the language without breaking compatibility with all of today's browsers. It ultimately means creating new libraries that add new features to the language. However, these libraries must be created using the same core language and, ideally, they should also be stacked up and composed together in a recipe that suits any given application.

In this chapter and the next, I'll review two JavaScript libraries that work well together today and that will probably evolve together in the near future: the Microsoft AJAX library and the jQuery library.

JavaScript Today

AJAX would not be possible without JavaScript. And this happens not because JavaScript is such a powerful language, but because JavaScript is so popular and built in nearly the same form in virtually all browsers released in the past five years.

Three ingredients, combined in the right doses, almost spontaneously originated the AJAX paradigm shift: a standard browser-hosted programming language (JavaScript), a standard object model to fully represent the document being viewed (the W3C's Document Object Model), and a sufficiently rich browser object model that includes the key *XMLHttpRequest* object.

Separating these elements is almost impossible nowadays. JavaScript is more than a simple programming language and, as you'll see later in the chapter, modern libraries reflect that.

The Language and the Browser

JavaScript is a language tailor-made for the Web and, more specifically, for the browser. In fact, there's no compiler currently available that allows you to create binaries from a bunch of JavaScript source files.

The only exception I'm aware of is the Managed JScript compiler for the .NET Framework. However, I don't recall ever meeting someone who used it concretely to build applications and not simply as a proof of some concepts.

I won't stray too far from the truth by saying that there's no life for JavaScript outside the realm of a Web browser. Of course, this is largely due to where JavaScript originated and the purpose it fulfilled at the time. Let's briefly recall the origins of the language.

Original Goals of the Language

The first appearance of JavaScript as a browser-hosted language dates back to late 1995, when the first beta of Netscape Navigator 2 was released. JavaScript was introduced to give authors of Web documents the ability to incorporate some logic and action in HTML pages. Before then, a Web page was essentially a static collection of HTML tags and text. Historically, the first significant enhancement made to the syntax of HTML was the support for tags to include script code.

JavaScript was not designed to be a classic and cutting-edge programming language—not even by the standards of 15 years ago. The primary goal of its designers was to create a language that resembled a simpler Java that could be used with ease by nonexpert page authors.

To some extent, the design of JavaScript was influenced by many languages, but the predominant factor was simplicity. It was named JavaScript because the language was essentially meant to be a powerful language (like Java) but focused on scripting. No other relationships, beyond the deliberate reference in the name, exist between Java and JavaScript.

As a result, JavaScript is an interpreted and weakly typed language that also supports dynamic binding and objects. JavaScript, however, is not a fully object-oriented language.

Note Originally developed at Netscape by Brendan Eich, JavaScript was first named *LiveScript*. The name was changed to JavaScript when Netscape added support for Java technology in its Navigator browser. The *script* suffix was simply meant to be the script version of an excellent programming language like Java. In no way was the language supposed to be a spinoff of Java.

Later, Microsoft created a similar language for its Internet Explorer browser and named it JScript to avoid trademark issues. In 1997, JavaScript was submitted to the European Computer Manufacturers Association (ECMA) International for standardization. The process culminated a couple of years later in the standardized version of the language named ECMAScript.

The Scripting Engine

Being an interpreted language, JavaScript requires an ad hoc run-time environment to produce visible effects from the source code. The run-time environment is often referred to as the browser's *scripting engine*. As such, the JavaScript's run-time environment can be slightly different from one browser to the next. The result is that the same JavaScript language feature might provide a different performance on different browsers and might be flawed on one browser while working efficiently on another one.

This fact makes it hard to write good, cross-browser JavaScript code and justifies the love/hate relationship (well, mostly hate) that many developers have developed with the language over the years.

The diagram in Figure 4-1 shows the overall structure of a scripting engine.

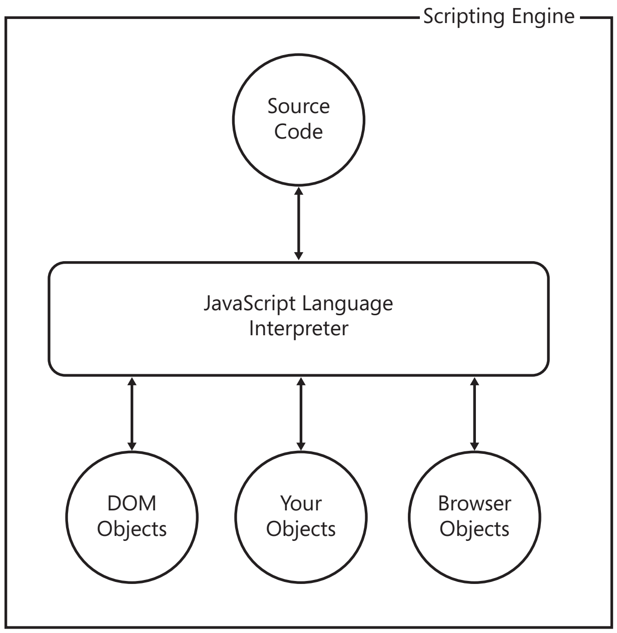


FIGURE 4-1 The browser's scripting engine

The engine is a component that is hosted in the browser and receives the source code to process. Armed with language knowledge, the engine can resolve any name in the source code that can be mapped to a syntax element—keywords, variables, local functions, and objects.

In addition, the source code processed within a Web browser is likely populated with specific objects coming from a variety of sources. For example, you can find DOM objects to access the content being displayed in the page as well as browser-specific objects such as *XMLHttpRequest* and *window*. Furthermore, any libraries you reference from the page are also published to the engine. After the script has been loaded, the browser runs the script through the engine. This action results in the functionality defined by the commands in the code.

As mentioned, although JavaScript is definitely a stable language that hasn't faced significant changes for 10 years now, virtually any broadly used library is packed with forks in code to distinguish the behavior of different browsers and ensure the same overall interface.

One of the first rules—if not the first rule—you should follow to write good AJAX applications is get yourself a powerful JavaScript library that adds abstraction and features to the JavaScript language and that works in a cross-browser manner.

Note As far as the ASP.NET platform is concerned, the good news is that you have neither to reinvent the wheel nor to invent your own wheel to proceed. In fact, the AJAX extensions to ASP.NET include a cross-browser core library that you can use as the foundation for any JavaScript code you might need beyond ready-made objects and functionalities.

Recognized Flaws

As you'll see in a moment, JavaScript has a number of drawbacks, both technical and infrastructural. In spite of all these factors, though, JavaScript works just great for the majority of Web applications. And nothing any better has been invented yet.

All things considered, the limitations of JavaScript can be summarized as two elements: it is an interpreted language, and it is not fully object oriented. The former drawback makes the language significantly slower than a compiled language. The latter makes it harder for developers to write complex code.

These were not limitations in the beginning, about 10 years ago. Nonetheless, they are now limitations that become more evident every day. Replacing JavaScript, however, is not something that can happen overnight.

JavaScript is so popular and widely used that making any breaking changes to it would break too many applications. Yet the direction that JavaScript is taking in light of AJAX addresses the two aforementioned limitations.

The Google Chrome browser (which you can read more about at *http://www.google.com/chrome*) comes with an open-source JavaScript engine that compiles source code to native machine code before executing it. As a result, Chrome runs JavaScript applications at the speed of a compiled binary, which is significantly better than any bytecode or interpreted code.

The Microsoft AJAX library, as well as other popular JavaScript libraries, such as Prototype, offers some built-in features to add inheritance to JavaScript objects and flavors of object orientation.

Note Chrome and its V8 JavaScript engine are taking an innovative approach to dealing with the growth in size and complexity of JavaScript code in AJAX applications. Other libraries are trying to offer more powerful instruments to raise the abstraction level of the original JavaScript language. We are not seeing either a brand new language or an improved core language, but something is happening on the client side to make JavaScript code more effective.

Pillars of the Language

In more than 10 years of existence, JavaScript has never been as central a technology in the world of Web computing as it is today following the arrival of AJAX. JavaScript code in the average Web page has grown from just a few lines of trivial code that just scripts page elements to hundreds of kilobytes of code providing rich object models, if not true frameworks.

Because it was not created to be a spinoff of a true compiled programming language, JavaScript supports all the syntax elements of a common structured programming language, such as *if*, *switch*, *for*, and *while* statements. Types are not strongly enforced and are associated with values rather than with variables. Let's briefly review the pillars of the JavaScript language.

Note Any piece of source code written in JavaScript and completely delivered to a browser is immediately executable. Clearly, this provides the potential for malicious code to be downloaded and run on the client computer. To contain the risk, the browser runs any script within a *sandbox*. A sandbox is a virtual environment where hosted programs can perform only controlled actions and are typically not granted permissions to operate on the file system and the local hardware.

In addition, browsers also commonly restrict scripts from accessing any information from an external site. This is known as a *same origin policy*. Violating the same origin policy may result in a cross-site scripting attack.

Objects as Dictionaries

The JavaScript language allows you to use objects, but it doesn't natively support all principles of object-oriented programming (OOP), such as inheritance, encapsulation, and polymorphism. To some extent, some of these principles can be recognized here and there in the language's capabilities; however, JavaScript can't be described as a fully object-oriented (OO) language.

The primary reason for not cataloging JavaScript as an OO language is that the definition of an *object* you get from JavaScript is different from the commonly accepted idea of an object you get out of classic OO languages such as C++ or C#.

In C# and C++, you create new objects by telling the runtime which *class* you want to instantiate. A *class* is a fixed template used for the object creation. A class defines the properties and methods an object will have, and these properties and methods are forever fixed. In C# and C++, you can't manipulate the structure of an object by adding or removing properties and methods at runtime.

In JavaScript, objects are essentially dictionaries of values or associative arrays. An object is a container of name/value pairs that can be added at any time, and especially at runtime. In an attempt to express a JavaScript object via a C# notation, you would probably resort to something similar to the following:

```
Dictionary<string, object>
```

The property name is a string that acts as the key in the dictionary, as shown here:

```
var obj = new YourJavaScriptObject();
obj["Property"] = "Hello";
```

You can also use an alternate syntax based on the *dot* notation. The effect is the same:

```
obj.Property = "Hello";
```

JavaScript objects contain more than just a dictionary of values. In particular, they contain the *prototype* object. The prototype is like a directory that defines the public interface of the object. By acting on the prototype, you can augment the capabilities of the object in a fully dynamic manner.

Functions as Objects

Another fundamental characteristic of JavaScript is that functions are first-class language elements and objects themselves. In other words, functions might have properties and can be passed around and interacted with as you would do with any other object.

You can use the *new* operator with a function. When you do so, you get an entirely new object and can reference it internally using the *this* keyword. Just like any other object, the function has its own *prototype* property that determines the public interface of the new object:

```
MyPet = function (name, isDog)
{
   this._name = name;
   this._isDog = isDog;
}
MyPet.prototype = {
   get_Name = function() {return this._name;},
   get_IsDog = function()  {return this._isDog;}
}
```

Given the preceding code, you can use the *new* operator on the *MyPet* function and invoke the members in the prototype.

Dynamic Typing

The nature of objects and functions makes JavaScript a very dynamic language. Types are not an exception and don't force developers to follow strict rules as in a classic programming language.

Like many other scripting languages, JavaScript recognizes a few primitive types (string, number, date, Boolean) but doesn't let you declare a variable of a given, fixed type. Variables are untyped on declaration and can hold values of different types during their lifetime. As mentioned, in JavaScript types are associated with values rather than with variables.

```
x = "1";   // It is a string
x = 1;     // It is a number
```

For this reason, equality operators work in a slightly different manner. Given the following lines of code, what would be the result of the expression *x == y*?

```
x = "1";
y = 1;
```

If you look at the code from an OO perspective, you can have only one answer: *false*. Quite surprisingly, instead, in JavaScript *x==y* returns *true* because the comparison is made on the value, not the type. To get the expected result, you must switch to the === operator, which checks value *and* type.

JavaScript provides the *typeof* built-in function to test the type of an object. Another approach is *duck typing*. Duck typing basically consists of providing the freedom of invoking on an object any methods it *seems* to have. If it does not have a particular method, you just get a run-time exception. Duck typing originates from the statement: *If it walks like a duck and quacks like a duck, I would call it a duck*.

Closures and Prototypes

The three pillars of object orientation can be implemented in JavaScript to various degrees. For example, encapsulation is easy to get via the *var* keyword in a *closure* model. Encapsulation is impossible to achieve if you are working with a *prototype* model. The prototype model makes it easy to build inheritance, and polymorphism can be obtained via a combination of functions and duck typing.

There are two main models for designing classes in JavaScript: closures and prototypes. The models are not entirely equivalent, so choosing one over the other is a matter of evaluating the tradeoffs. Also, the performance you get for both models in the major browsers is not the same. Let's learn more about the closure model.

In the closure model, a custom object is a single function where all members are defined together within the same (closed) context, as shown here:

```
// The Person object is entirely defined here
Person = function()
{
    var _firstName;   // private member
    var _lastName;    // private member
    this.get_FirstName = function() { return this._firstName; }
    this.get_LastName = function() { return this._lastName; }
}
```

The use of the *var* keyword keeps a member declaration local to the context and ensures data encapsulation. Accessing *_firstName* and *_lastName* members from outside the closure is impossible, as is the case when accessing a private member from outside a class definition in C# or C++. Members not tagged with the *var* keyword are meant to be public. The object declaration occurs in a single place and through a unique constructor. Using objects built as closures can be memory intensive because a new instance is required for any work—just like in C# or C++.

The prototype model defines the public structure of the class through the built-in *prototype* object. The definition of an object, however, is not centered around a single point of scope. Here's how the object definition changes if you opt for the prototype model:

```
Person = function (firstName, lastName)
{
   this._firstName = firstName;
   this._lastName = lastName;
}
Person.prototype = {
   get_FirstName = function() {return this._firstName;},
   get_LastName = function()  {return this._lastName;}
}
```

As you can see, the object constructor and members are clearly separated. Members are shared by all instances and are private only by convention. Using the *var* keyword in the definition of, say, *_firstName* would make it private and inaccessible. On the other hand, not using the *var* keyword keeps the member public and therefore visible from the outside.

Because members of the *prototype* are global and static, the prototype model reduces the amount of memory required by each instance of the object and makes object instantiation a bit faster.

Note Prototypes have a good load time in nearly all modern-day browsers, and load times are excellent in Firefox. On the other hand, closures are faster than prototypes in all recent versions of Internet Explorer.

JavaScript (If Any) of the Future

Two pillars carry the whole weight of the Web: HTML and JavaScript. Neither of them seems to be entirely appropriate in the age of AJAX. And neither can be blissfully dismissed and replaced for compatibility and interoperability reasons. Regarding JavaScript, what can we do?

Like HTML, JavaScript is very efficient in doing the few and relatively simple things it was originally designed to do. The point is that the community of developers needs much more—more programming power and more performance.

Personally, I value programming power and language expressivity more than performance. To some extent, performance and JavaScript still sound to me like incompatible concepts.

Performance is especially relevant in a scenario where an ounce of performance lost in some task might be automatically multiplied by some factor, such as the growing number of requests. With JavaScript, frankly, there are no such risks. The JavaScript code runs on the client and on a computer that serves a single user at a time. There's no bad performance multiplier around.

JavaScript performance can become an issue—but not really a showstopper—only when you have so many lines of code (something like several hundred kilobytes) that it just takes too much to produce a user-friendly result.

Improving JavaScript might be desirable. But if so, how should that be done? There are two main schools of thought, plus a clever ploy.

Overhauling the Language

The specification for JavaScript 2.0 is currently being discussed and defined. You can find more details at *http://www.mozilla.org/js/language/evolvingJS.pdf*. JavaScript 2.0 is expected to be a significant overhaul of the language.

The most radical change that will come with JavaScript 2.0 is support for real classes and interfaces. The following syntax should be acceptable in the next version:

```
class Person
{
  this.FirstName = "dino";
  this.LastName = "esposito";
}
var p = new Person();
```

Compile-time type checking is another aspect waiting for improvement. A component that requires *strict* mode will have static type checking and a number of other checks performed before execution, such as verification that all referenced names are known and that only comparisons between valid types are made.

Namespaces and packages complete the set of hot features slated for the next JavaScript. A package is a library of code that is automatically loaded only on demand.

It's All About Security

Another camp sees the future of JavaScript in a different manner. This camp is well represented by Douglas Crockford—one of the creators of JSON. According to Douglas, security is the biggest concern for JavaScript developers. So by simply making JavaScript a more secure programming environment, we would make JavaScript a better environment.

Douglas suggests adding a *verifier* to analyze the source and spot unsafe code and a *transformer* to add indirection and run-time checks around critical instructions. More in general, the vision put forth by Douglas is centered on the idea of improving the language by making today's de facto standard solutions a native part of the language.

Google's V8 Engine

As mentioned, a new approach to JavaScript programming is coming out with Google's Chrome browser—the V8 engine. V8 is a new JavaScript engine specifically designed for optimized execution of *large* JavaScript applications.

The basic idea is that the browser operates as a just-in-time JavaScript compiler, wrapping functions into memory objects and turning them into machine code. In addition to dynamic machine-code generation, the increment of improved performance is the result of a couple of other factors: fast property access and efficient garbage collection. For more information, check out *http://code.google.com/p/v8*.

The Microsoft AJAX Library

A truly powerful JavaScript library today can't ignore the dependencies existing between the language itself and the Document Object Model (DOM) and Browser Object Model (BOM). Subsequently, a modern JavaScript library is made of three fundamental pieces: a flavor of object orientation, facilities for visual effects, and a network stack.

It is not coincidental that this is also the recipe for the Microsoft AJAX library—one of the pillars of the Microsoft strategy for AJAX. Initially developed to back up the ASP.NET AJAX Extensions 1.0, and successively integrated in ASP.NET 3.5, the library is still being improved and enhanced for ASP.NET 4.0.

The next release of ASP.NET is expected to ship a stronger and more powerful client platform that results from the integration of the newer AJAX library and the newest version of another quite popular and largely complementary library—the jQuery library.

Overview of the Library

The Microsoft AJAX library is written in JavaScript, although with a strong sense of object orientation. ASP.NET AJAX takes the JavaScript language to the next level by adding some type-system extensions, the notion of namespace and interface, plus facilities for inheritance. In addition, the ASP.NET AJAX JavaScript supports enumerations and reflection, and it has a number of helper functions to manipulate strings and arrays.

Constituent Files

The Microsoft AJAX library is coded using the base set of instructions that characterize the core JavaScript language, and it is persisted to a set of *.js* files. These *.js* files are not installed as distinct files on the Web server when you install ASP.NET. They are embedded as resources into the ASP.NET AJAX assembly—*system.web.extensions*. If you want them available as distinct files (for example, for your home perusal), go to *http://msdn2.microsoft.com/en-us/asp.net/bb944808.aspx*, check the license agreement, and get them as a single downloaded compressed file.

We already hinted at it in Chapter 2, "The Easy Way to AJAX," but let's briefly review in Table 4-1 the files that make up the library.

TABLE 4-1 Files That Form the Microsoft AJAX Library

Script	Description
MicrosoftAjax.js	A core part of the library, this file contains object-oriented extensions, the network stack, and a number of facilities, such as those for tracing and debugging.
MicrosoftAjaxWebForms.js	This file contains script functions to support ASP.NET partial rendering. In particular, it defines the client-side engine and programming interface for partial rendering.
MicrosoftAjaxTimer.js	This file contains the client-side programming interface of the *Timer* server control, a built-in control that comes with ASP.NET AJAX. The control creates a timer on the client and makes it post back upon timeout.

As you can see, these are plain JavaScript files that can be linked from any sort of Web page regardless of the technology it is written for—PHP, classic ASP.NET, ASP, or even plain HTML.

Linking the Microsoft AJAX Library

In ASP.NET 3.5 pages, you don't need to load files from the Microsoft AJAX library explicitly. This is a viable option when you don't have a customized version of the files to load. If you embed a *ScriptManager* control in your pages, the control will automatically recognize the Microsoft AJAX library files you need and will download them as required.

By default, script files will be extracted from the resources of the *system.web.extensions* assembly. If you hold your own copies of the scripts and want to reference them instead, you use the *ScriptManager* control as shown here:

```
<asp:ScriptReference Name="MicrosoftAjax.js"
                     Path="./MyScripts/MicrosoftAjax.js" />
```

You need the *Name* property to identify the name of the embedded resource that contains the client script file. The *Path* property can optionally be used to specify the physical server location where the named script file has to be loaded from.

When both *Name* and *Path* are specified, *Path* is the winner. Does it really make sense to specify both? Sure it does. When both properties are specified, you actually *replace* the standard *MicrosoftAjax.js* with the specified script.

Tip This trick can be used to take advantage of the script-related services of the *ScriptManager* control and also in scenarios where your pages are not dependent on the Microsoft AJAX library. By setting the *Name* property to *MicrosoftAjax.js* and the *Path* property to, say, *jquery.js*, you load *jQuery* instead of *Microsoft AJAX* while taking advantage of all the extra facilities of the *ScriptManager* control that we reviewed in Chapter 2. Read the full story at *http://weblogs.asp.net/bleroy/archive/2008/07/07/using-scriptmanager-with-other-frameworks.aspx*.

Note As general advice, I suggest that to reference a script file you don't strictly need the *ScriptManager* control. However, you should always consider using the *ScriptManager* control because of the handy services it provides, such as its ability to detect script duplicates and its free compression and localization.

No Bells and Whistles

As you'll see in greater detail in a moment, the Microsoft AJAX library provides core JavaScript services such as type extensions, OOP flavors, and an AJAX-enabled network stack. It doesn't provide any facilities for adding visual effects to your pages.

The integration between Microsoft AJAX library and jQuery that is coming out with the next version of ASP.NET will make up for this. You'll have a script framework that offers a richer JavaScript with advanced and commonly used widgets such as those provided by jQuery.

Let's dig out now the key capabilities of the Microsoft AJAX library.

JavaScript Language Extensions

The JavaScript language features a set of built-in objects, including *Function*, *Object*, *Boolean*, *Array*, *Number*, and *String*. All intrinsic objects have a read-only property named *prototype*. The *prototype* property provides a base set of functionality shared by any new instance of an object of that class.

New functionality can be added to each object by extending and improving its prototype. This is exactly what the Microsoft AJAX library does.

Primitive Types

The Microsoft AJAX library contains code that defines new objects and extends existing JavaScript objects with additional functionality. Table 4-2 lists the main global objects defined in the library and explains how they relate to original JavaScript types.

TABLE 4-2 Top-Level Objects in the Microsoft AJAX Library

Object	Description
Array	Extends the native *Array* object. This object groups static methods to add, insert, remove, and clear elements of an array. It also includes static methods to enumerate elements and check whether a given element is contained in the array.
Boolean	Extends the native *Boolean* object. This object defines a static *parse* method to infer a *Boolean* value from a string or any expression that evaluates to a *Boolean* value.
Date	Extends the native *Date* object with a couple of instance methods: *localeFormat* and *format*. These methods format the date using the locale or invariant culture information.

TABLE 4-2 Top-Level Objects in the Microsoft AJAX Library

Object	Description
Error	Defines a static create method to wrap the JavaScript *Error* object and add a richer constructor to it. This object incorporates a couple of properties—*message* and *name*—to provide a description of the error that occurred and identify the error by name. A number of built-in error objects are used to simulate exceptions. In this case, the *name* property indicates the name of the exception caught.
Function	Extends the native *Function* object. This object groups methods to define classes, namespaces, delegates, and a bunch of other object-oriented facilities.
Number	Extends the native *Number* object. This object defines a static *parse* method to infer a numeric value from a string or any expression that evaluates to a numeric value. In addition, it supports a pair of static formatting methods: *localeFormat* and *format*.
Object	Extends the native *Object* object. This object groups methods to read type information, such as the type of the object being used.
RegExp	Wraps the native *RegExp* object.
String	Extends the native *String* object. This object groups string manipulation methods, such as trim methods and *endsWith* and *startsWith* methods. In addition, it defines static *localeFormat* and *format* methods that are close relatives of the *String.Format* method of the managed *String* type.

After the Microsoft AJAX library has been added to an application, the following code will work just fine:

```
var s = "Dino";
alert(s.startsWith('D'));
```

The native JavaScript *String* object doesn't feature either a *startsWith* or an *endsWith* method; the extended AJAX *String* object, instead, does.

New Types

As mentioned, it's only in a future version of JavaScript that you can start creating new complex and custom types as you do today in classic object-oriented languages. The Microsoft AJAX library, though, provides its own application programming interface (API) to let you register new objects—essentially custom JavaScript functions—with the library and use them as classes with an object-oriented flavor.

No new keyword is added for compatibility reasons, but a couple of new methods must be used to wrap the definition of a new type, as shown next for the sample *MyClass* type:

```
Type.registerNamespace("Samples");
Samples.MyClass = function ()
{
  ⋮
}

// Other blocks of code here for class members
⋮
Samples.MyClass.registerClass("Samples.MyClass");
```

Enumerations are a special breed of a new type in JavaScript. As in the .NET Framework, an enumeration represents an easily readable alternative to integers. Here's a sample definition for an enumerated type in JavaScript:

```
Type.registerNamespace("Samples");

// Define an enumeration type and register it.
Samples.Color = function() {};
Samples.Color.prototype =
{
    Red:    0xFF0000,
    Blue:   0x0000FF,
    Green:  0x00FF00,
    White:  0xFFFFFF
}
Samples.Color.registerEnum("Samples.Color");
```

To register an enumerated type, you use a tailor-made registration function—the *registerEnum* function.

Shorthand Functions

I would find it hard to believe that most of you reading this book have never made the mistake of using the name of the HTML element in a page as a shortcut to get the corresponding DOM reference. Suppose you have a text box element named *TextBox1* in the client page. The following script code won't work on all browsers:

```
alert(TextBox1.value);
```

The correct form ratified by the World Wide Web Consortium (W3C) paper for the HTML DOM standard is shown here:

```
alert(document.getElementById("TextBox1").value);
```

The correct form is clearly more verbose and bothersome to write over and over again. The Microsoft AJAX library comes to the rescue with the *$get* global function. Simply put, the *$get* function is a shortcut for the *document.getElementById* function. If the Microsoft AJAX library is in use, the following expression is fully equivalent to the one just shown:

```
alert($get("TextBox1").value);
```

The *$get* function has two overloads. If you call *$get* passing the sole ID, the function falls back into *document.getElementById*. Alternatively, you can specify a container as the second argument, as shown here:

```
var parent = $get("Div1");
$get("TextBox1", parent);
```

If the container element supports the *getElementById* method, the function returns the output of *element.getElementById*; otherwise, the *$get* function uses the DOM interface to explore the contents of the subtree rooted in the element to locate any node with the given ID.

Although *$get* is only an alias for a regular JavaScript function, it is often mistaken for a new language element. Other similar shortcuts exist in the library to create objects and add or remove event handlers.

Note The *$get* function has a lot in common with jQuery's *$* root object. To be precise, early builds of the Microsoft AJAX library were still using the same *$* expression that was renamed later to avoid collisions. The *$get* object in the Microsoft AJAX library is merely a direct DOM selector that just filters by ID. The *$* object in jQuery, instead, is a full selector that supports a much richer CSS-based syntax to filter DOM elements to return.

Object-Oriented Extensions

In JavaScript, the *Function* object is the main tool you use to combine code with properties and forge new components. In the Microsoft AJAX library, the *Function* object is extended to incorporate type information, as well as namespaces, inheritance, interfaces, and enumerations.

Namespaces and Classes

A namespace provides a way of grouping and classifying the types belonging to a library. Not a type itself, a namespace adds more information to the definition of each type in the library to better qualify it.

All custom JavaScript functions belong to the global space of names. In the Microsoft AJAX library, you can associate a custom function with a particular namespace, for purely organizational reasons. When declaring a custom type in the Microsoft AJAX library, you can do as follows:

```
Type.registerNamespace("Samples");
Samples.Person = function Samples$Person(firstName, lastName)
{
    this._firstName = firstName;
    this._lastName = lastName;
}

// Define the body of all members
function Samples$Person$ToString()
{
   return this._lastName + ", " + this._firstName;
}
:
:

// Define the prototype of the class
Samples.Person.prototype =
{
    ToString:      Samples$Person$ToString,
    get_FirstName: Samples$Person$get_FirstName,
    set_FirstName: Samples$Person$set_FirstName,
    get_LastName:  Samples$Person$get_LastName,
    set_LastName:  Samples$Person$set_LastName
}

// Register the class
Samples.Person.registerClass("Samples.Person");
```

The *Type.registerNamespace* method adds the specified namespace to the run-time environment. In a way, the *registerNamespace* method is equivalent to using the *namespace {…}* construct in C#. The *Samples.Person* function defined following the namespace declaration describes a *Person* type in the *Samples* namespace. Finally, the newly defined function must be registered as a class with the Microsoft AJAX library framework. You use the *registerClass* method on the current function.

The *registerClass* method takes a number of parameters. The first parameter is mandatory, and it indicates the public name that will be used to expose the JavaScript function as a class. Additional and optional parameters (not shown in the preceding code) are the parent class, if there is any, and any interface implemented by the class. We'll get into this in just a moment.

The Microsoft AJAX library follows the prototype model (as opposed to closures) to define its own custom types. The goal of the ASP.NET AJAX team was to deliver a model that provided the best quality and performance on the largest number of browsers. Prototypes have a good load time in all browsers; and indeed, they have excellent performance in Firefox. Furthermore, prototypes lend themselves well, more than closures do, to debugging as far as object instantiation and access to private members are concerned.

Note In the definition of a new class, you can use an anonymous function or a named function. In terms of syntax, both solutions are acceptable. The convention, though, is that you opt for named functions and name each function after its fully qualified name, replacing the dot symbol (.) with a dollar symbol ($). The convention is justified by the help this approach provides to IntelliSense in Microsoft Visual Studio 2008.

Inheritance and Polymorphism

Let's now define a new class, *Citizen*, that extends *Person* by adding a new property: a national identification number. Here's the skeleton of the code you need:

```
// Declare the class
Samples.Citizen = function Samples$Citizen(firstName, lastName, id)
{
   ⋮
}

// Define the prototype of the class
Samples.Citizen.prototype =
{
   ⋮
}
```

```
// Register the class
Samples.Citizen.registerClass("Samples.Citizen", Samples.Person);
```

Note that the first argument of *registerClass* is a string, but the second one has to be an object reference. The second argument indicates the object acting as the parent of the newly created object. Let's flesh out this code a bit.

In the constructor, you'll set some private members and call the base constructor to initialize the members defined on the base class. The *initializeBase* method (defined on the revisited *Function* object you get from the library) retrieves and invokes the base constructor:

```
Samples.Citizen = function Samples$Citizen(firstName, lastName, id)
{
    Samples.Citizen.initializeBase(this, [firstName, lastName]);
    this._id = id;
}
```

You pass *initializeBase* the reference to the current object as well as an array with any parameters that the constructor to call requires. You can use the *[...]* notation to define an array inline. If you omit the *[...]* notation, be ready to handle a parameter count exception.

Quite often, developers derive a class because they need to add new members or alter the behavior of an existing method or property. Object-oriented languages define a proper keyword to flag members as overridable. How is that possible in JavaScript?

Any member listed in the prototype of an object is automatically public and overridable. Here's the prototype of the *Citizen* class:

```
Samples.Citizen.prototype =
{
    ToString:    Samples$Citizen$ToString,
    get_ID:      Samples$Citizen$get_ID
}
```

The class has a read-only *ID* property and overrides the *ToString* method defined in the parent class. Let's have a look at the implementation of the overriding method:

```
function Samples$Citizen$ToString()
{
    var temp = Samples.Citizen.callBaseMethod(this, 'ToString');
    temp += "  [" + this._id + "]";
    return temp;
}
```

You use *callBaseMethod* to invoke the same method on the parent class. Defined on the *Function* class, the *callBaseMethod* method takes up to three parameters: the instance, the name of the method, plus an optional array of arguments for the base method.

As mentioned earlier, the *ToString* method on the *Person* class returns a *LastName, FirstName* string. The *ToString* method on the *Citizen* class returns a string in the following format: *LastName, FirstName [ID]*.

Note When the prototype model is used, JavaScript has no notion of private members because no common closure can be provided for all methods contributing to the same object. As a result, private members are conventionally indicated by the underscore symbol (_) prefixing their names. They're still public and accessible, though.

Interfaces

An interface describes a group of related behaviors that are typical of a variety of classes. In general, an interface can include methods, properties, and events; in JavaScript, it contains only methods.

Keeping in mind the constraints of the JavaScript language, to define an interface you create a regular class with a constructor and a prototype. The constructor and each prototyped method, though, will just throw a not-implemented exception. Here's the code for the sample *Sys.IDisposable* built-in interface:

```
Type.registerNamespace("Sys");
Sys.IDisposable = function Sys$IDisposable()
{
    throw Error.notImplemented();
}
function Sys$IDisposable$dispose()
{
    throw Error.notImplemented();
}
Sys.IDisposable.prototype =
{
    dispose: Sys$IDisposable$dispose
}
Sys.IDisposable.registerInterface('Sys.IDisposable');
```

The following statement registers the *Citizen* class, makes it derive from *Person*, and implements the *IDisposable* interface:

```
Samples.Citizen.registerClass('Samples.Citizen',
           Samples.Person, Sys.IDisposable);
```

To implement a given interface, a JavaScript class simply provides all methods in the interface and lists the interface while registering the class:

```
function Samples$Citizen$dispose
{
   this._id = "";
}

Samples.Citizen.prototype =
{
   dispose: Samples$Citizen$dispose
   ⋮
}
```

Note, though, that you won't receive any run-time error if the class that claims to implement a given interface doesn't really support all the methods. You will receive an error if a caller happens to invoke an interface function your class didn't implement, so by convention all interface methods should be implemented.

If a class implements multiple interfaces, you simply list all required interfaces in the *registerClass* method as additional parameters. Here's an example:

```
Sys.Component.registerClass('Sys.Component', null,
      Sys.IDisposable,
      Sys.INotifyPropertyChange,
      Sys.INotifyDisposing);
```

As you can see, in this case you don't have to group interfaces in an array.

Framework Facilities

Many layers of code form the Microsoft AJAX library, including a layer specifically created to smooth the creation of rich UI controls with AJAX capabilities. (See *http://www.codeplex.com/AjaxControlToolkit* for example controls.) This particular aspect of the library, though, is expected to evolve significantly in the next release of ASP.NET.

Let's focus instead on other core facilities you find in the library, such as event handling, debugging, and networking. To start out, let's attack with reflection capabilities.

Reflection

While debugging some JavaScript code, isn't it a bit frustrating when you need to know the actual type of a variable and cannot get it exact? In general, *reflection* refers to the ability of a function to examine the structure of an object at runtime. When it comes to reflection, the JavaScript language doesn't offer much. The Microsoft AJAX library largely makes up for this.

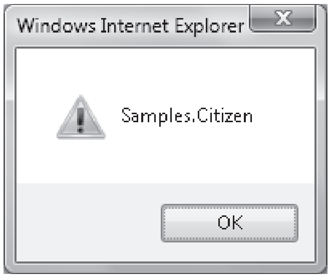
In plain JavaScript, the built-in *typeof* operator returns information about the type of the variable you are dealing with. The operator, though, is limited to the core set of JavaScript types. Let's consider the following code snippet:

```
Samples.Citizen = new function() {
   ⋮
}
var c = new Samples.Citizen();
alert(typeof c);
```

As expected, the displayed string is a generic *object*.

Adding a thick object-oriented infrastructure, the Microsoft AJAX library makes it easy to track the exact name of the pseudo-type of a given object. The following code returns a more precise message, as shown in Figure 4-2.

```
// Returns "Samples.Citizen"
var c = new Samples.Citizen();
alert(Object.getTypeName(c));
```



Samples.Citizen

FIGURE 4-2 The "real" type name of a JavaScript object

Whenever a new object is registered with the Microsoft AJAX framework, its name and pseudo-type are added to an internal list. Reflection functions just look up these internal dictionaries and return what they read.

Note I use the expression *pseudo-type* to indicate a type that has its own fully qualified name according to the Microsoft AJAX library, such as *Person* in the preceding code snippet. It should be noted, though, that at the lower level of the JavaScript engine there remains a plain *object* type.

In the Microsoft AJAX library, reflection capabilities are offered as extensions of the *Type* object. These methods enable you to collect information about an object, such as what it inherits from, whether it implements a particular interface, and whether it is an instance of a particular class. Note that the *Type* class aliases the built-in JavaScript *Function* object. Therefore, many of the methods exposed through the general interface of the *Type* object are also available through the instance of any custom type (that is, function) you create.

Table 4-3 lists the members of the *Type* object, which is also a compendium of the reflection capabilities of the Microsoft AJAX library.

TABLE 4-3 Members of the *Type* Object

Member	Description
callBaseMethod	Invokes a base class method with specified arguments
getBaseMethod	Gets the implementation of a method from the base class of the specified instance
getBaseType	Gets the base type of the specified instance
getInterfaces	Returns the list of interfaces that the type implements
getName	Gets the name of the type of the specified instance
implementsInterface	Indicates whether a given instance implements the specified interface
inheritsFrom	Indicates whether the type inherits from the specified base type
initializeBase	Invokes the base constructor of a given type
isClass	Indicates whether the specified type is a Microsoft AJAX library class
isImplementedBy	Indicates whether the specified interface is implemented by the object
isInstanceOfType	Indicates whether the object is an instance of the specified type
isInterface	Indicates whether the specified type is an interface

TABLE 4-3 **Members of the *Type* Object**

Member	Description
isNamespace	Indicates whether the specified object is a namespace
Parse	Returns an instance of the type that is specified by a type name
registerClass	Registers an object as a Microsoft AJAX library class
registerEnum	Registers an object as a Microsoft AJAX library enumeration
registerInterface	Registers an object as a Microsoft AJAX library interface
registerNamespace	Creates a namespace

Finally, here's a brief example of how to use reflection in practice:

```
var t = Samples.Components.Timer;
var obj = new Samples.Components.Timer();
if (obj.isInstanceOfType(t))
{
   alert(t.getName() + " is a " + obj.getName() + ".");
}
```

The Application Object

The execution of each Web page that links the Microsoft AJAX library is controlled by an application object. This object is an instance of a private class—the *Sys._Application* class. An instance of the application object is created in the body of the library, specifically in the *MicrosoftAjax.js* file:

```
// Excerpt from MicrosoftAjax.js
Sys.Application = new Sys._Application();
```

If properly initialized, the application object invokes a pair of page-level callbacks with fixed names—*pageLoad* and *pageUnload*:

```
function pageLoad(sender, args)
{
   // sender is the Sys.Application instance
   // args   is of type Sys.ApplicationLoadEventArgs
   ⋮
}
function pageUnload(sender, args)
{
   // sender is the Sys.Application instance
   // args   is of type Sys.ApplicationLoadEventArgs
   ⋮
}
```

In particular, *pageLoad* is a good place for the page to perform any initialization tasks that require the Microsoft AJAX library. This is more reliable than using the *window*'s *onload* event.

The *pageLoad* callback receives a *Sys.ApplicationLoadEventArgs* data structure packed with the list of Microsoft AJAX library components already created and a Boolean flag to indicate that the callback is invoked within a regular postback or a partial rendering operation.

Beyond page loading events, the *Sys.Application* object serves one main purpose: providing access to client-side page components. Generally, the term *component* denotes an object that is reusable and can interact with other objects in the context of a framework. In the Microsoft AJAX framework, a component is a JavaScript object that inherits from the *Sys.Component* class. These objects are tracked by the library infrastructure and exposed via methods on the *Sys.Application* object.

In particular, the *findComponent* method scrolls the run-time hierarchy of Microsoft AJAX components for the current page until it finds a component with a matching ID. The method has two possible prototypes:

```
Sys.Application.findComponent(id);
Sys.Application.findComponent(id, parent);
```

The former overload takes the ID of the component, uses it to look up the component, and then navigates the hierarchy all the way down from the root. When a non-null *parent* argument is specified, the search is restricted to the subtree rooted in the context object. The *id* parameter must be a string; the *parent* parameter must be a Microsoft AJAX library object. The method returns the object that matches the ID, or it returns null if no such object is found.

The Microsoft AJAX library also supports a shortcut for retrieving run-time components—the *$find* method. The *$find* method is an alias for *findComponent*:

```
var $find = Sys.Application.findComponent;
```

You can use this method to locate all components created by server controls that use the Microsoft AJAX library (for example, extenders in the AJAX Control Toolkit and new controls in ASP.NET 4.0), as well as by your own JavaScript code. You can't use *$find* to locate DOM elements; for DOM elements, you must resort to *$get*.

String Manipulation

The *Sys.StringBuilder* class adds advanced text manipulation capabilities to Web pages based on the library. As the name suggests, the class mimics the behavior of the managed *StringBuilder* class defined in the .NET Framework.

When you create an instance of the builder object, you specify initial text. The builder caches the text in an internal array by using an element for each added text or line. The *Sys.StringBuilder* object doesn't accept objects other than non-null strings. You add text using the *append* and *appendLine* methods. The *toString* method composes the text by using the join method of the JavaScript array class.

```
// Build an HTML table as a string
var header = "<table><thead> ... </thead>";
var footer = "<tfoot> ... </tfoot></table>";
var builder = new Sys.StringBuilder(header);
⋮
builder.append(footer);
alert(builder.toString());
```

The Microsoft AJAX library *String* class is also enriched with a format method that mimics the behavior of the *Format* method on the .NET Framework *String* class:

```
alert(String.format("Today is: {0}", new Date()));
```

You define placeholders in the format string using *{n}* elements. The real value for placeholders is determined by looking at the *n*.th argument in the format method call.

Debugging

Another class that is worth mentioning is the *Sys._Debug* class. An instance of this internal class is assigned to the *Sys.Debug* global object:

```
Sys.Debug = new Sys._Debug();
```

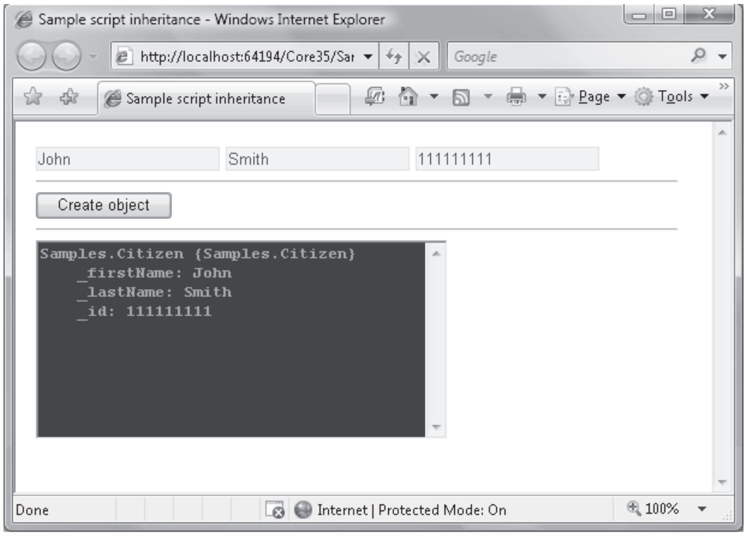
In your pages, you use the *Sys.Debug* object to assert conditions, break into the debugger, or trace text. For example, the *traceDump* method writes the contents of the specified object in a human-readable format in the Microsoft AJAX library trace area. The trace area is expected to be a <*textarea*> element with a mandatory ID of *traceConsole*. You can place this element anywhere in the page:

```
<textarea id="traceConsole" cols="40" rows="10" />
```

The *traceDump* method accepts two parameters, as shown here:

```
Sys.Debug.traceDump(object, name)
```

The *name* parameter indicates descriptive text to display as the heading of the object dump. The text can contain HTML markup. Figure 4-3 shows the output of a trace dump.


Sample script inheritance - Windows Internet Explorer
http://localhost:64194/Core35/Sar
Google
Sample script inheritance
Page
Tools
John
Smith
111111111
Create object
Done
Internet | Protected Mode: On
100%

```
Samples.Citizen {Samples.Citizen}
    _firstName: John
    _lastName: Smith
    _id: 111111111
```

FIGURE 4-3 The Microsoft AJAX library debugging tracer in action

You use the *clearTrace* method to clear the output console. The *fail* method breaks into the debugger and the method *assert* displays a message if the specified condition is false.

The Network Stack

The most relevant feature of an AJAX library is the ability to execute out-of-band Web requests from the client browser. In particular, AJAX extensions to ASP.NET let you invoke Web service methods without dismissing the currently displayed page. This ability leverages the networking support built into the Microsoft AJAX library.

In the Microsoft AJAX library, a remote request is represented by an instance of the *Sys.Net.WebRequest* class. Table 4-4 lists the properties of the class.

TABLE 4-4 Members of the *Sys.Net.WebRequest* Object

Member	Description
body	Gets and sets the body of the request
executor	Gets and sets the Microsoft AJAX library object that will take care of executing the request
headers	Gets the headers of the request
httpVerb	Gets and sets the HTTP verb for the request
timeout	Gets and sets the timeout, if any, for the request
url	Gets and sets the URL of the request

The *WebRequest* class defines the *url* property to get and set the target URL and the *headers* property to add header strings to the request. If the request is going to be a POST, you set the body of the request through the *body* property. A request executes through the method *invoke*. The *completed* event informs you about the completion of the request.

Each Web request is executed through an internal class—the Web request manager—that employs an "executor" to open the socket and send the packet. All executors derive from a common base class—the *Sys.Net.WebRequestExecutor* class.

The Microsoft AJAX library defines just one HTTP executor—the *Sys.Net.XMLHttpExecutor* class. As the name suggests, this executor uses the popular *XMLHttpRequest* object to execute the HTTP request.

The *Sys.Net.WebRequest* class is essentially a framework class that other higher level classes use, but page authors hardly ever use it. I've seen this class used only a few times in real-world JavaScript code. As you saw in Chapter 2, the ASP.NET AJAX framework makes it so easy to invoke a Web service method or perhaps a static method on a page that you hardly feel the need to invoke another type of HTTP endpoint.

If you need to download a resource such as a JavaScript file, you need quite a bit of code if you go through this class.

```
var endpoint = "ondemand.js";
var request = new Sys.Net.WebRequest();
request.set_url(endpoint);
request.add_completed(function() {...});
request.invoke();
```

With other AJAX libraries—for instance, jQuery—this code reduces to just one line. I'll return to jQuery in the next chapter.

Note All AJAX libraries are associated with the *XMLHttpRequest* browser object. So what else could an executor be other than a reference to the *XMLHttpRequest* browser object? In general, an HTTP executor is any means you can use to carry out a Web request. An alternative executor might be based on HTTP frames. The idea is to use a dynamically created inline frame to download the response of a given request and then parse that result into usable objects.

The Eventing Model

Building cross-browser compatibility for events is not an easy task. Internet Explorer has its own eventing model, and so do Firefox and Safari. For this reason, the event model of the Microsoft AJAX library is a new abstract API that joins together the standard W3C API and the Internet Explorer model. The new API is closely modeled after the standard W3C API.

In addition to using different method names (*add/removeEventListener* is for Firefox, and *attach/detachEvent* is for Internet Explorer), browsers differ in the way they pass event data down to handlers. In Internet Explorer, an event handler receives its data through the global *window.event* object; in Firefox, the event data is passed as an argument to the handler. In the Microsoft AJAX library, event handlers receive a parameter with proper event data.

Another significant difference is in the way mouse and keyboard events are represented. The Microsoft AJAX library abstracts away any differences between browsers by providing ad hoc enumerated types, such as *Sys.UI.Key* and *Sys.UI.MouseButton*. Here's some sample code:

```
function Button1_Click(e)
{
  if (e.button === Sys.UI.MouseButton.leftButton)
  {
    ⋮
  }
}
function keyboard_EnterPressed(e)
{
  if (e.keyCode === Sys.UI.Key.enter)
  {
    ⋮
  }
}
```

The Microsoft AJAX library provides a shorthand notation to create DOM event hookups and removal. For example, you can use the *$addHandler* and *$removeHandler* aliases to add and remove a handler. Here's the syntax:

```
$addHandler(element, "eventName", handler);
$removeHandler(element, "eventName", handler);
```

In many cases, you'll want to hook up several handlers to a DOM event for a component. Rather than manually creating all the required delegates and related handlers, you can use a condensed syntax to add and remove multiple handlers:

```
initialize: function()
{
   var elem = this.get_element();
   $addHandlers(
         elem,
         {[
            'mouseover': this._mouseHoverHandler,
            'mouseout': this._mouseOutHandler,
            'focus', this._focusHandler,
            'blur', this_blurHandler
         ]},
         this);
}
```

The *$clearHandlers* alias, conversely, removes all handlers set for a particular DOM element in a single shot.

If you write a component and wire up some events, it's essential that you clear all handlers when the component is unloaded, or even earlier, if you don't need the handler any longer. For example, you should do that from the component's *dispose* method to break circular references between your JavaScript objects and the DOM. Correctly applied, this trick easily prevents nasty memory leaks.

Summary

JavaScript is one of the pillars of the Web. Now that the arrival of AJAX is shaking the foundation of the Web, what about JavaScript? Is JavaScript going to change in the near future?

For years, the JavaScript language has remained very stable, and this stability created the environmental conditions for AJAX to flourish and thrive. AJAX means more and more code hosted and running within the client browser. This code can only be written in JavaScript.

The perception of a language is different when you have only a few lines of code to write as opposed to when you have to use it to write large sections of the application. For this more exacting job, JavaScript seems more inadequate every day. And JavaScript 2.0 is slowly but steadily emerging. JavaScript 2.0 is not a thing of the immediate future, though.

For now, a better and richer JavaScript is possible only through libraries that cover the parts of client-side programming that the language doesn't natively cover. Classes, networking, static type checking, and a common and cross-browser model for managing events and exploring the document are all features required in modern JavaScript code. Popular libraries, such as the Microsoft AJAX library, provide just this.

The key trait of the Microsoft AJAX library is the set of extensions to transform JavaScript into an object-oriented language. JavaScript is not a true OOP language even though it always has supported objects and also provides a rudimentary mechanism for prototyping classes and derived classes. The Microsoft AJAX library builds on top of this basic functionality to add namespace and interface support in addition to a number of helpful facilities.

In the next chapter, I'll cover another extremely popular library that addresses UI enhancements and makes it so easy and effective to add AJAX capabilities to Web pages. This library is jQuery.

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